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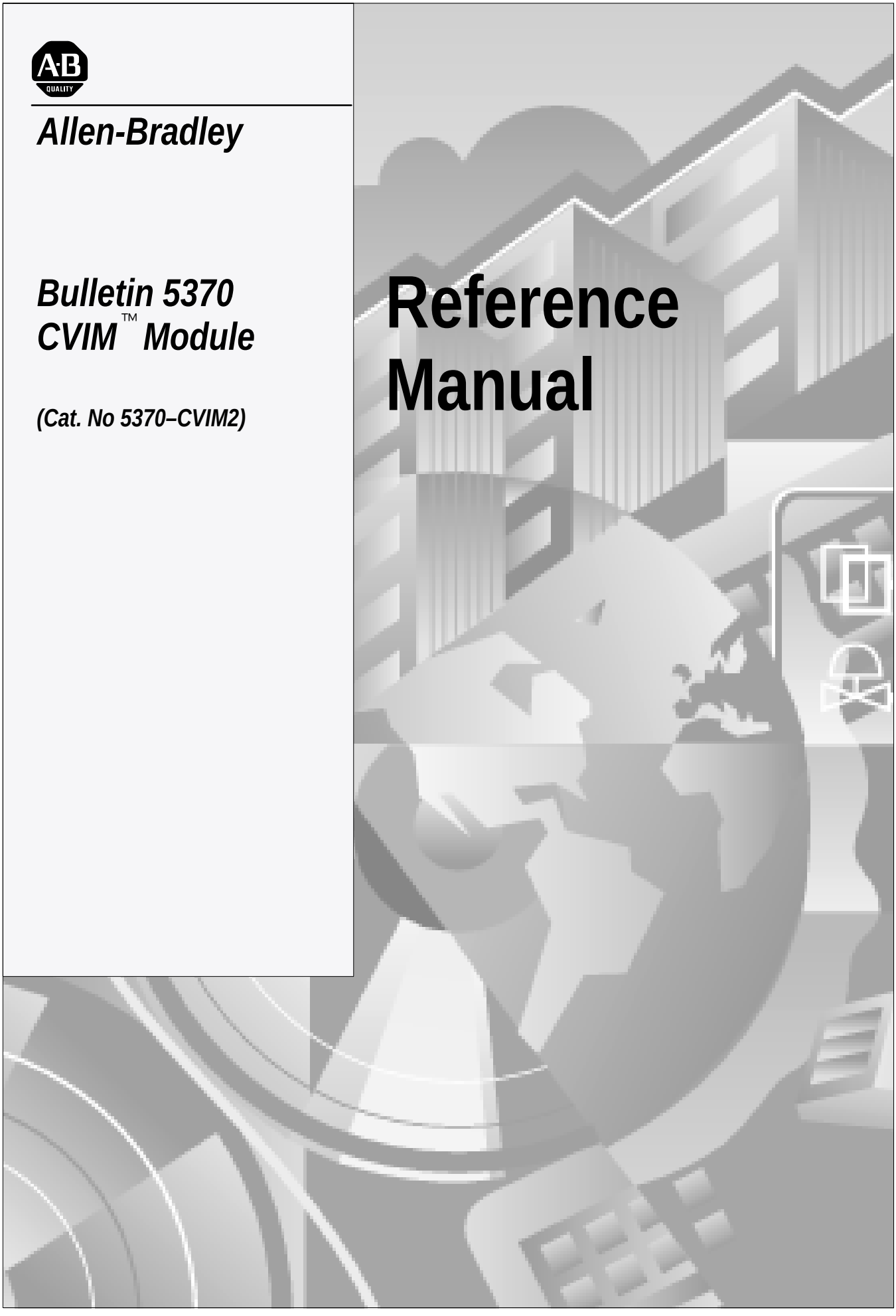
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Allen-Bradley

Bulletin 5370 CVIM™ Module

(Cat. No 5370–CVIM2)

Reference Manual



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Because of the variety of uses for the products described in this publication, those responsible for the application and use of this control equipment must satisfy themselves that all necessary steps have been taken to assure that each application and use meets all performance and safety requirements, including any applicable laws, regulations, codes and standards.

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Chapter 1

Hardware Connection and Powerup Check

This chapter shows you how to connect the CVIM2 system components and perform a powerup check.

CVIM2 System Components

The procedures in this chapter cover only those components that are related to the CVIM2 machine vision system, namely:

- CVIM2 module, Catalog No. 5370–CVIM2.
- Pyramid Integrator chassis:
  Four–slot chassis, Catalog No. 2801–NX3.
  Eight–slot chassis, Catalog No. 2801–NX4.
- Vision chassis, Catalog No. 2801–AM2
- Chassis power supply, Catalog No. 2801–NX2.
- RS–170 Video monitor: Color, 13–inch, rack–mounted, 115VAC, Catalog No. 2801–N8.
- VGA video monitor: Catalog No. 2711–M14; 2711–MT14.
- Light pen, Catalog No. 2801–N7.
- Camera, Catalog No. 2801–YC, –YD, and –YE.
- Interface modules:
  User interface box, Catalog No. 2801–N22.
  User interface box, Catalog No. 2801–N26.
  I/O interface box, Catalog No. 2801–N27.
  Interface board, Catalog No. 2801–JMB.
- Interconnecting cables.

Additional components may be required for some CVIM2 system configurations. These will be identified in the connection procedures.

For complete information on installing the CVIM2 system in its factory floor location, refer to the Allen–Bradley Pyramid Integrator Installation Manual, Publication 5000–6.2.10, which is supplied with the Pyramid Integrator chassis.

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Connecting CVIM2 System Components

Before you install the CVIM2 system at its factory–floor site, you may find it useful to connect the basic system components temporarily on a workbench or table top.

If, however, you intend first to install the CVIM2 system at its factory–floor site, refer to the following Allen–Bradley publications for site installation information.

- Pyramid Integrator Installation Manual, Publication No. 5000–6.2.10. Chapter 4, *Grounding the Components*, is of particular importance.
- Grounding and Wiring Guidelines, Publication No. 1777–4.1.
- Solid–state Control Safety Guidelines, Publication No. SGI–1.1.

After completing the site installation, return to this section.

Installing the CVIM2 Module

The CVIM2 module uses a DC–to–DC converter to supply power to the cameras. The converter gets its DC voltage from either the chassis power supply (+12VDC and –12VDC) or from an external DC power supply (+24VDC).

When using a 2801–NX3 or –NX4 chassis, here are the situations in which you must use an external DC power supply:

- More than three cameras are connected to a single CVIM2 module.
- Two or more CVIM2 modules are installed in a single chassis, and more than three *total* cameras are connected to the modules.
- Any of cameras #4, #5, or #6 are to be used, *regardless* of the total number of cameras used or the number of CVIM2 modules installed.

When using a 2801–AM2 vision chassis, an external DC power supply is not needed; however the CVIM2 module must have the DC voltage selection switch set to the 24V position. (The integrated power supply for the 2801–AM2 chassis provides both 12VDC and 24VDC. See Publication No. 2801–2.7, page 9, for more information about the 2801–AM2 vision chassis.)

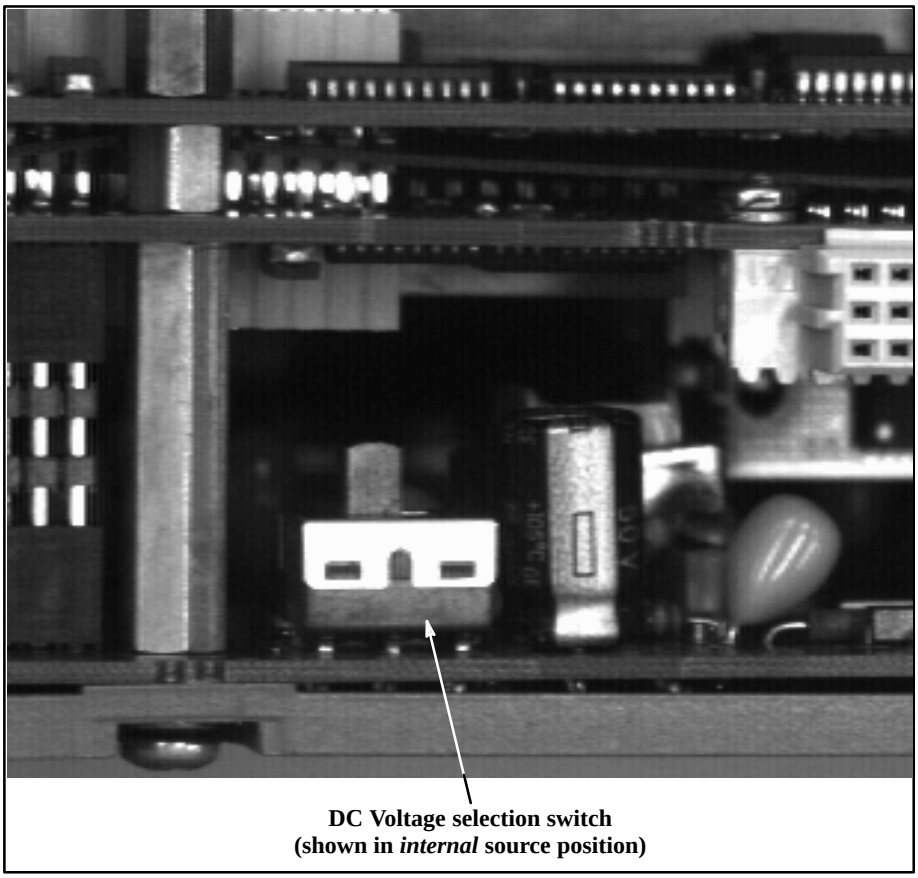
Use the following steps to set the DC voltage selection switch on the CVIM2 module:

1. Locate the DC voltage selection switch on the back of the CVIM2 module. Refer to Figure 1.1 (page 1–3).
2. Set the switch as shown in Figure 1.1 (the 12V setting) for applications using three *or fewer* cameras.
3. Set the switch to the 24V position for applications using *more than* three cameras, or using any of cameras #4, #5, or #6.

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4. Install the CVIM2 module in the chassis. Tighten the thumbscrews alternately until the module is fully seated in the chassis.

Figure 1.1 CVIM2 Module (back view): DC Voltage Selection Switch



Installing the Optional DC Power Supply Cable

If your application requires an external +24VDC power supply, you can use one of two Allen–Bradley DC power supply cables to connect the external +24VDC power supply to the Pyramid Integrator chassis power supply. The power supply must have sufficient capacity to power all of the cameras.

These are the Allen–Bradley DC power supply cables:

- Catalog No. 5120–CP3 — for applications *not* requiring a fan chassis (for cooling the Pyramid Integrator chassis power supply).
- Catalog No. 5120–CP2 — for applications using the eight–slot chassis and requiring a fan chassis.

Note that each cable has a set of four color–coded leads terminated with spade lugs.

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Attach the color–coded leads on the DC cable to the external DC power supply as follows:

1. Connect the *triple* red leads to the DC power supply's main "+ output" terminal.
2. If your DC power supply has a "+ sense" terminal, connect the *single* red lead to that terminal. Otherwise, connect the single red lead to the "+ output" terminal, along with the triple red leads.
3. Connect the *triple* black leads to the DC power supply's main "– output" terminal.
4. If your DC power supply has a "– sense" terminal, connect the *single* black lead to that terminal. Otherwise, connect the single black lead to the "– output" terminal, along with the triple black leads.
5. Connect the molded plug on the other end of the DC power supply cable to the Pyramid Integrator power supply front panel jack labeled "Fan Chassis."
6. If your application has a fan chassis and you are using the 5120–CP2 cable, connect the smaller molded plug to the jack in the fan chassis.

Finally, attach a line cord or other AC power supply cables to the DC power supply, as appropriate for your installation.

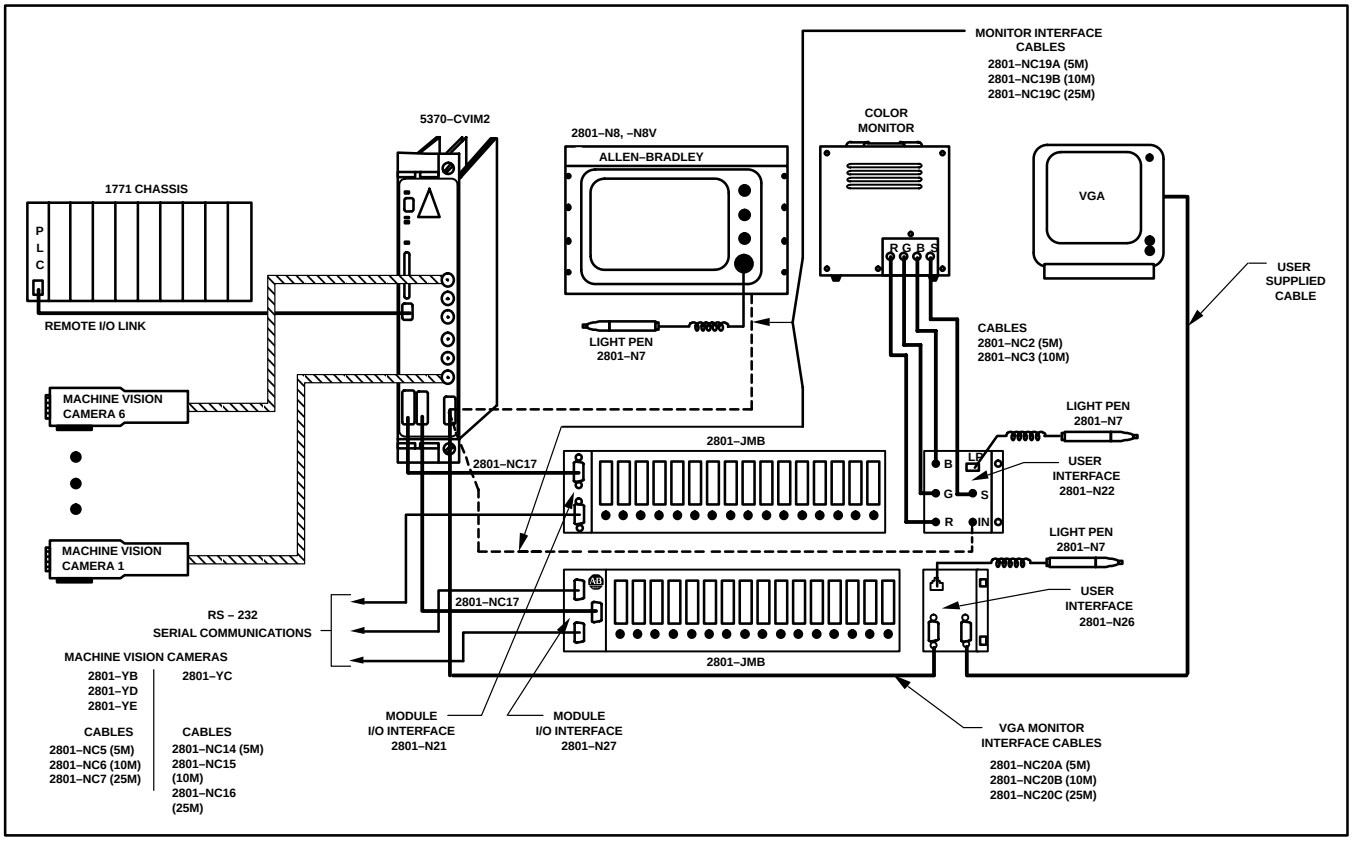
NOTE: Do *not* apply AC power to the DC power supply yet.

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Connecting the I/O and Camera Cables

Refer to the CVIM2 interconnect diagram (Figure 1.2) for the I/O and camera cable connections in the next steps.

Figure 1.2 CVIM2 Interconnect Diagram for I/O Cables



Connecting the I/O Interface Cable (2801–NC17, –NC17A)

Use the following steps to connect the I/O interface cable to the I/O interface module:

1. Locate the I/O interface cable, Catalog No. 2801–NC17 or –NC17A, and the I/O interface module, Catalog No. 2801–N21 or –N27.

   NOTE: The two ends of this cable are *identical*.
2. Connect either end of the cable to the Module I/O (or System I/O) connector on the CVIM2 front panel. Tighten the screws.
3. Connect the other end of the cable to the CVIM connector on the I/O interface module. Tighten the screws.

NOTE: The I/O interface cable can be connected directly from the CVIM2 module to I/O interface module 2801–N28 on the 2801–AM2 vision chassis.

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Connecting the User Interface Cable (2801–NC20A, B, C): VGA Monitor

Use the following steps to connect the user interface cable when a VGA monitor is to be used:

1. Locate the user interface cable, Catalog No. 2801–NC20A, B, or C, and the user interface module, Catalog No. 2801–N26.

   NOTE: The two ends of this cable are *identical*.
2. Connect either end of the cable to the User Interface connector on the CVIM2 front panel. Tighten the screws.
3. Connect the other end of the cable to the CVIM2 connector on the user interface module. Tighten the screws.
4. Connect the 15–pin connector on the VGA monitor cable to the VGA MONITOR connector on the user interface module.
5. Connect the light pen, if used, to the LIGHT PEN socket on the user interface module.

Connecting the User Interface Cable (2801–NC19A, B, C): N8 Monitor

Use the following steps to connect the user interface cable when an Allen–Bradley 2801–N8 color monitor is to be used:

1. Locate the user interface cable, Catalog No. 2801–NC19A, B, or C.
2. Connect the 15–pin connector on the cable to the User Interface connector on the CVIM2 front panel. Tighten the screws.
3. Connect the other end of the cable to the VIDEO INPUT connector on the rear panel of the N8 color monitor.
4. Connect the light pen, if used, to the LIGHT PEN socket on the N8 monitor front panel.

Connecting the User Interface Cable (2801–NC19A, B, C): Other RS–170 Monitors

Use the following steps to connect the user interface cable when a monitor other than the Allen–Bradley 2801–N8 is to be used:

1. Locate the user interface cable, Catalog No. 2801–NC19A, B, or C, and the user interface box, Catalog No. 2801–N22.
2. Connect the 15–pin connector on the cable to the User Interface connector on the CVIM2 front panel. Tighten the screws.
3. Connect the other end of the cable to the INPUT connector on the N22 box.
4. Connect the light pen, if used, to the LIGHT PEN socket on the user interface module.

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5. Connect the coaxial cables to the appropriate R, G, B, and SYNC connectors on the N22 module and the monitor.

Connecting the Camera Cable: 2801–YC Camera

Use the following steps to connect the appropriate camera cable when an Allen–Bradley 2801–YC camera is to be used:

1. Locate the appropriate camera cable, Catalog No. 2801–NC14, 15, or 16.
2. Connect one connector on the cable to the appropriate Camera connector on the CVIM2 front panel.
3. Connect the other connector on the cable to the appropriate connector on the camera.

Connecting the Camera Cable: 2801–YB, –YD, and –YE Camera

Use the following steps to connect the appropriate camera cable when an Allen–Bradley 2801–YB, –YD, or –YE camera is to be used:

1. Locate the appropriate camera cable, Catalog No. 2801–NC5, 6, or 7.
2. Connect the *male* connector on the cable to the appropriate Camera connector on the CVIM2 front panel.
3. Connect the *female* connector on the cable to the appropriate connector on the camera.

Connecting the Mouse Cable

Assuming that the I/O interface cable is attached to the Module I/O or System I/O connector on the CVIM2 front panel, connect the mouse cable to the PORT B connector on I/O interface box 2801–N27.

If you intend to use the PORT A connector, you must use a gender adapter between the mouse cable connector and the PORT A connector on the I/O interface box.

NOTE: You may need to configure the CVIM2 system to recognize the selected mouse port connection. The mouse configuration procedure is detailed in the *Configuring CVIM2 System for Mouse Operation* section on page 1–10.

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Powering Up CVIM2 System

At this point, with all basic system components connected, the CVIM2 system is ready for the powerup check.

Use the following steps to perform the powerup check:

1. Set the video monitor brightness and contrast controls to their midrange point or other appropriate preliminary point.



CAUTION: Verify that the AC voltage source is within limits for both the video monitor and the CVIM2 system.

2. Set the scan mode, if available on your monitor, to “under scan.”
3. Set the power switch to “off.”
4. Insert the monitor AC line cord into the AC power outlet.
5. Set the power switch to “on.”
6. Attach the CVIM2 system AC line cord or cable to the AC power outlet or source.
7. If your system is using an external +24VDC power supply, attach the AC line cord or cable to the AC power outlet or source.
8. Set the power switch to On. When you do, you should see the following results:
   - The DC OK light on the chassis power supply should turn on.
   - All LEDs on the CVIM2 front panel should light momentarily, after which the Pass/Fail LED should remain green.
   - In about five seconds, the banner message should appear on the monitor screen, similar to the screen shown in Figure 1.3 (page 1–9).
9. Verify that the light pen operates properly by moving it across the screen. The cursor pointer should follow the light pen’s movement. If it does *not*, verify that the DC voltage selection switch setting shown in Figure 1.1 (page 1–3) is set correctly for your application.
10. Verify that the light pen switch operates by picking one or more of the items on the main menu. In each case, a pull–down menu should appear.
11. If a mouse is connected to PORT A or PORT B on the I/O interface box, check the mouse for proper operation by moving it across a table top. The mouse pointer should follow the mouse’s movement. If not, refer to the *Configuring CVIM2 System for Mouse Operation* section on page 1–10.

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Figure 1.3 Example: Monitor Screen After Normal Powerup



If you have not yet installed the CVIM2 system at its factory–floor site, refer to the following Allen–Bradley manuals:

- Pyramid Integrator Installation Manual, Publication 5000–6.2.10.
- Grounding and Wiring Guidelines, Publication No. 1777–4.1.
- Solid–State Control Safety Guidelines, Publication No. SGI–1.1.

These manuals contain all the information required for panel– or rack–mounting, electrical grounding, and connecting to the I/O components.

You will have already performed in *this* chapter some of the steps described in the PI installation manual. When you encounter one of those steps, verify that you have performed it correctly, then continue.

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Configuring CVIM2 System For Mouse Operation

The CVIM2 system supports most serial mouse and trackball pointing devices that are IBM PC™ compatible. The following devices have been tested and have been found to work with the CVIM2 system:

- Logictech™ Model C7–3F–9F
- Logictech™ Model CC–93–9F
- Microsoft® Model LR 87483
- Mouse Systems Model 900800–001/A
- Clix Model CX–30
- Interlink Electronics Durapoint (exceeds NEMA 4X, 6P, and 13)
- Mouse Systems Model TP–305 (trackball)

After you power up the CVIM2 module, if the mouse pointer will not "track" the mouse as you move it across a table top or other flat surface, and you are using one of the above–listed devices, use the *light pen* to examine the current serial communication port configuration and reconfigure, if necessary, the specific port that you intend to use for mouse operation.

NOTE: When a port is configured for mouse operation, it *cannot* be used for other data communication purposes.

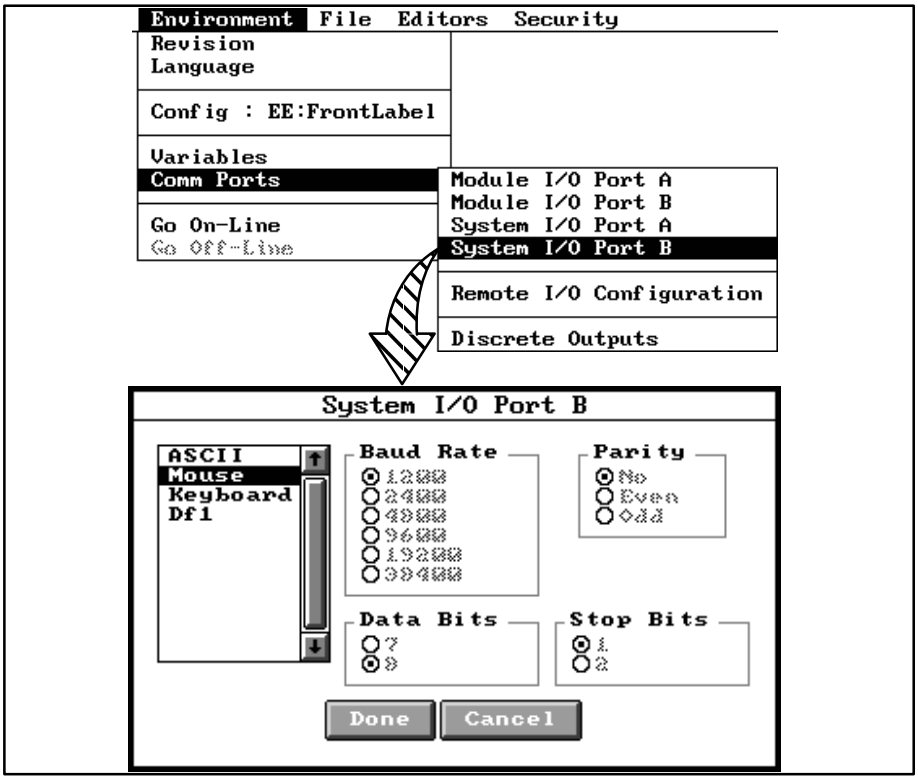
To configure a serial communication port for mouse operation, use the *light pen* to pick Environment in the main menu bar. When the Environment menu appears, pick Comm Ports. When you do, the Comm Ports menu appears, as illustrated by the example in Figure 1.4 (page 1–11).

In the example, it is assumed that the mouse is connected to PORT B of the I/O interface box and the I/O interface cable is connected to the System I/O connector on the CVIM2 front panel. In this case, you would pick System I/O Port B in the Comm Ports menu.

When you pick System I/O Port B, the System I/O Port B setup table appears, as shown in Figure 1.4. When you then pick Mouse in the small scrolling list, the appropriate mouse settings for baud rate, parity, data bit, and stop bit parameters in the setup table "lock" at the values shown in the figure.

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Figure 1.4 Example: Setting System I/O Port B to Mouse Function



Pick the Done button to save the port selections and exit the port setup table, then perform these steps to check mouse operation:

- Verify that the mouse operates properly by moving it across a table top. The mouse pointer should follow the mouse's movement.

  If the mouse pointer does not move at this time, cycle the CVIM2 power *off* (*for at least five seconds*), then *on*, to enable mouse pointer operation.

- Verify that the mouse buttons operate by picking one or more of the items on the main menu, using the *left* button. In each case, a pull–down menu should appear.

  (Note that the *center* mouse button can perform some of the functions of the left button, for example, picking and dragging a panel across the screen, selecting alternate panel sizes, and operating the scrolling functions. The *right* button can alternately position a panel *over* or *under* an overlapping panel.)

For more information about mouse operations, refer to the *Screen Pointer Functions* section of Chapter 2, *CVIM2 System Configuration: An Overview,* starting on page 2–9.

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Chapter 2

CVIM2 System Configuration: An Overview

This chapter discusses the basic phases of system configuration and the major configuration functions in each phase. The details of the inspection configuration process are provided in Chapter 3, *Image Acquisition Parameters*, and Chapter 4, *Inspection Configuration*.

The discussions that follow assume that all CVIM2 system parameters are set to their out–of–box *default* state. They also assume that you are already familiar with the CVIM2 user interface and with using the light pen and/or mouse to “navigate” the user interface.

After System Powerup

After a normal powerup, the monitor screen displays the CVIM2 “banner message,” as shown in Figure 2.1.

Figure 2.1 Example: Monitor Screen After Normal Powerup



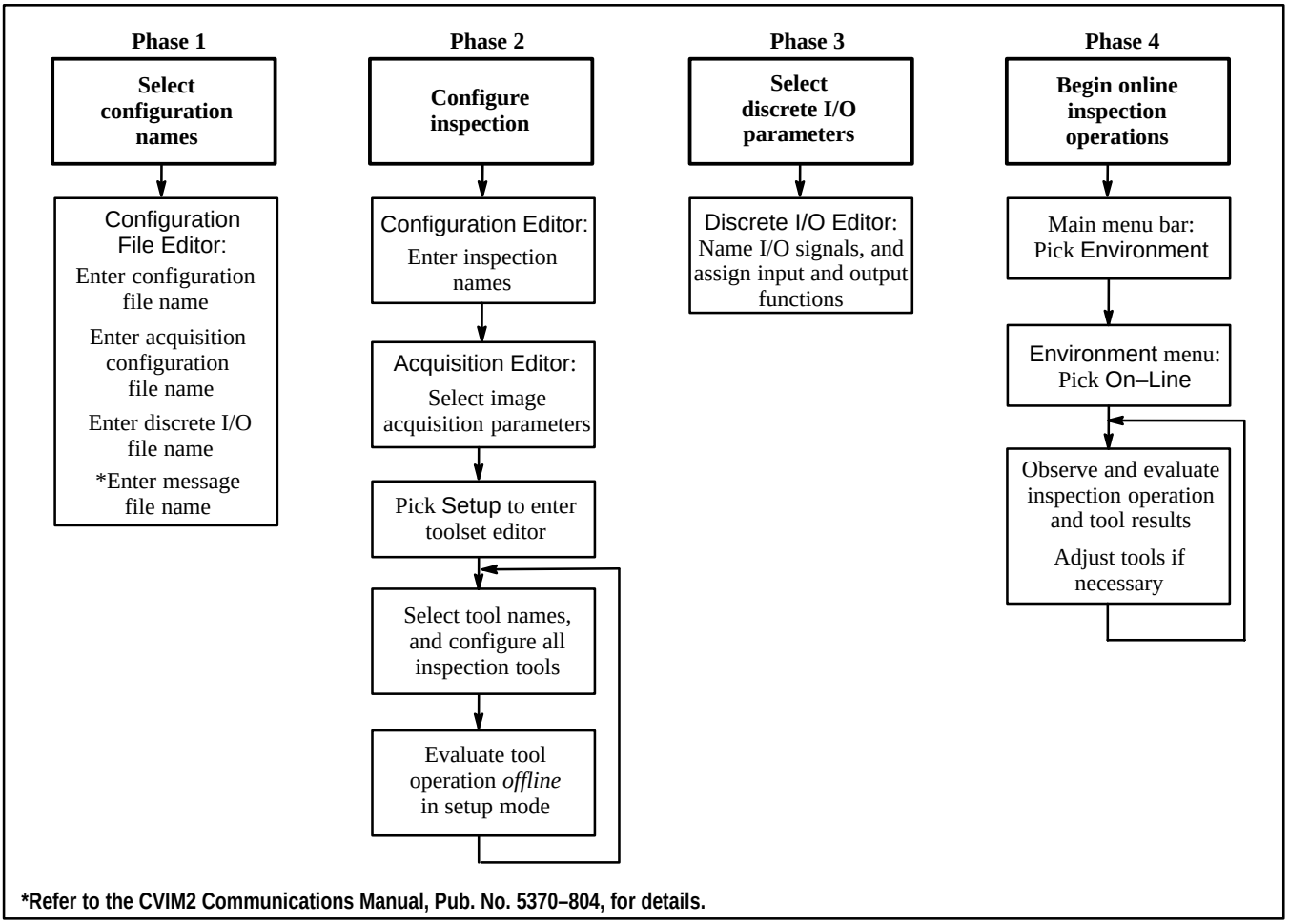
Note that the banner message indicates the current series and firmware revision levels of the CVIM2 system. Along the top margin is the main menu bar.

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CVIM2 Configuration: Four Basic Phases

Figure 2.2 is a chart showing four basic phases that are involved in configuring the CVIM2 system for a typical inspection application. Many details are intentionally omitted in order to emphasize the *overall* picture of the system configuration process.

Figure 2.2 Basic Phases of CVIM2 System Configuration



***Refer to the CVIM2 Communications Manual, Pub. No. 5370–804, for details.**

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Major Configuration Functions

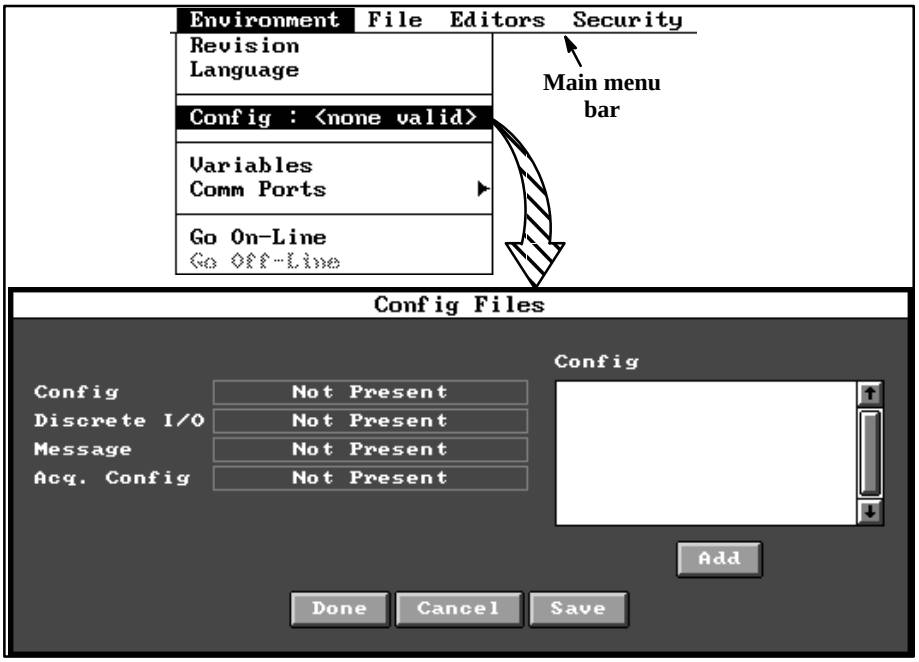
The remainder of this chapter describes the major configuration functions within each basic phase of the CVIM2 system configuration identified by the chart in Figure 2.2 (page 2–2).

Selecting Configuration File Names

Definition: A *configuration file* stores *information* about an *inspection application*, such as the names of the toolsets and the number of image buffers used.

The first step in Figure 2.2 is taken from the Config Files panel. You can access this panel from Environment in the main menu bar. When you pick Config in the Environment menu, the Config Files panel appears, as shown in Figure 2.3.

Figure 2.3 Initial Appearance of Config Files Panel



The panel is shown in its *initial* state, before any configuration files have been defined. At this time, you must enter an appropriate name in the Config and Acq. Config fields in order to continue with the configuration process.

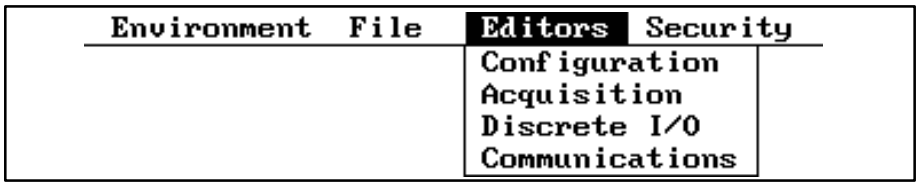
NOTE: You can add the Discrete I/O name and/or Message name at this time, or later. (Note that to access the Discrete I/O and Communications Editor panels, however, you must first enter names for these panels in the Config Files panel.)

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Picking the Editors Menu

The next step, after defining at least *one* configuration, is taken from the Configuration Editor panel. You can access this panel from Editors in the main menu bar. When you pick Editors, the Editors pulldown menu appears, as shown in Figure 2.4.

Figure 2.4 The Editors Pulldown Menu



Note also that you have four choices: Configuration, Acquisition, Discrete I/O, and Communications. Briefly, this is what they mean:

- Configuration — Use this editor to define one or more sets of inspection tools for your application.
- Acquisition — Use this editor to select the camera types, numbers of cameras, trigger sources for acquiring camera images, and other parameters relating to the acquisition of images.
- Discrete I/O — Use this editor to assign signals and select parameters for discrete inputs and outputs.
- Communications — Use this editor to create messages for data communications using serial I/O ports or the remote I/O port.

Selecting Configuration Parameters

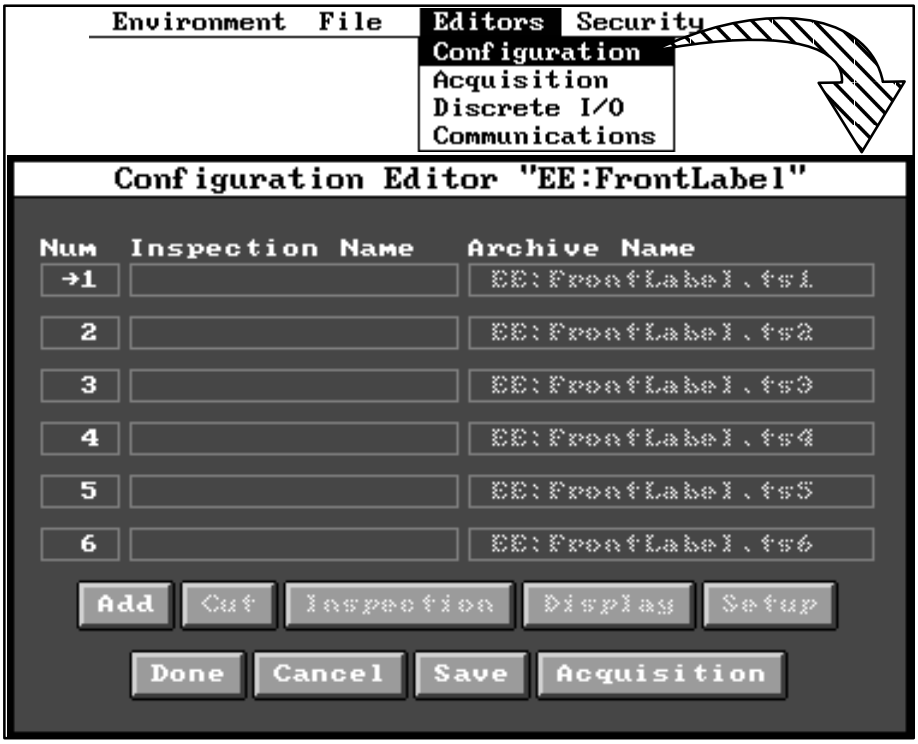
When you pick Configuration, the Configuration Editor panel appears, as shown in the example in Figure 2.5 (page 2–5).

The purpose of the Configuration Editor panel is to set up all of the inspection application requirements for a *single* configuration file. Using this panel, you can select the toolsets (up to six for one configuration file), configure all of the inspection tools, set various acquisition and inspection parameters, and perform the initial ("setup mode") evaluations of the tools' performance.

The CVIM2 system enters various *default* names for the toolsets (under the "Inspection Name" heading and the "Archive Name" heading); however, you can easily change any of these names to suit your inspection application.

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Figure 2.5 Example: Configuration Editor Panel With Six Inspections



When you finish the configuration of at least one toolset (and also select the image acquisition parameters, as described in the next section), you can exit the Configuration Editor panel and return to the main menu bar by picking the Done button.

When you place the CVIM2 system *online*, the system executes the currently selected configuration file. If the system is powered down, then powered up again, it will automatically begin online operations using the last selected configuration file — in this example, it would use the "FrontLabel" configuration file.

The CVIM2 system can store *multiple* configuration files in the CVIM2 system's memory; thus, you can easily *change* inspection applications by accessing the Config Files panel, highlighting (picking) another Config file name listed in that panel, and then picking the Done button.

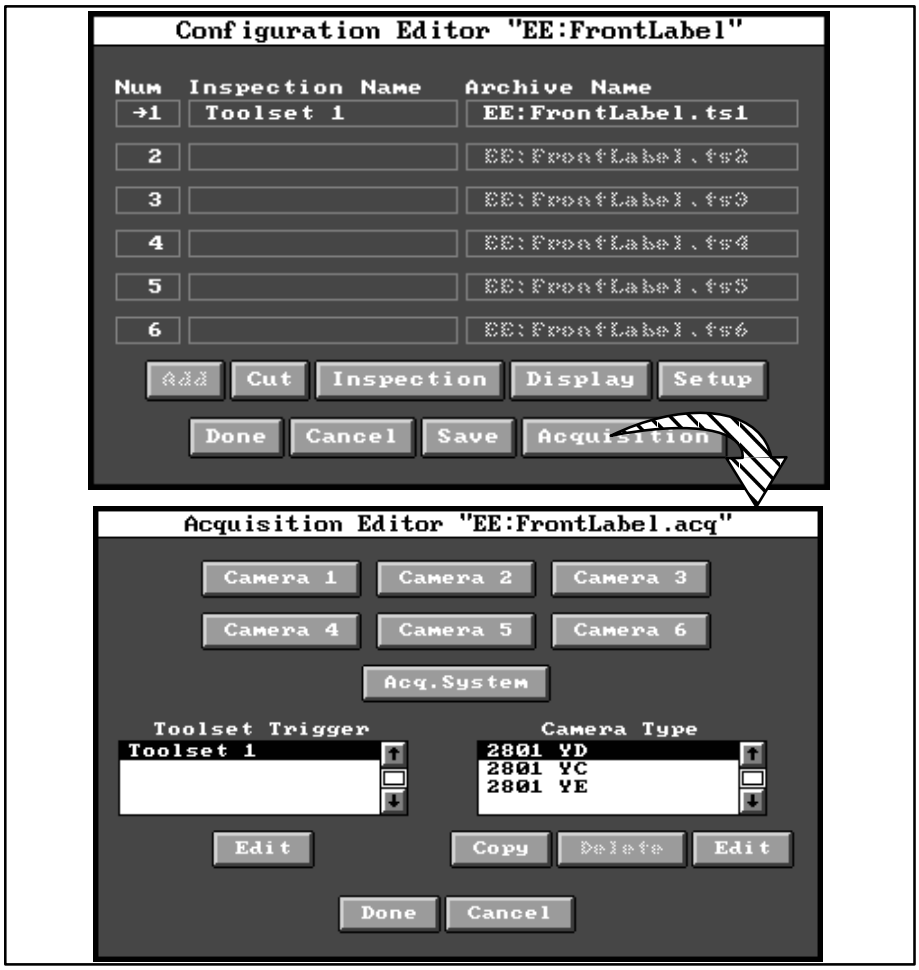
When you return to the Configuration Editor panel, the newly selected configuration file name will appear in the title bar of that panel.

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Selecting Image Acquisition Parameters

Your next step, after configuring a toolset, is to pick the Acquisition button in the Configuration Editor panel. When you pick this button, the Acquisition Editor panel appears, as shown in the example in Figure 2.6.

Figure 2.6 Example: The Acquisition Editor Panel



The Acquisition Editor panel provides access to all of the parameters and settings that the system uses to acquire an image for an inspection. The panel contains two scrolling lists and several buttons, which are described briefly as follows:

- **Camera 1 – 6** — The Camera 1 through Camera 6 buttons access the corresponding Camera setup panels, from which you can perform focus adjustments, light reference adjustments, and other related functions.
- **Acquisition Systems Settings panel** — The Acq.System button accesses the Acquisition System Settings panel, from which you can select a default camera enable synchronizing the CVIM2 system with external devices or another CVIM2 system, and/or selecting parameters for switching between camera banks 1 – 3 and 4 – 6.

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- **Toolset Trigger panel** — This scrolling list panel enables you to select a Toolset Trigger edit panel, from which you can edit various trigger parameters for a particular toolset. The adjacent Edit button selects the Toolset Trigger edit panel for the highlighted toolset trigger.
- **Camera Type panel** — This scrolling list panel enables you to select a Camera Type edit panel, from which you can edit various timing parameters for a particular camera type. The adjacent Edit button selects the Camera Type edit panel for the highlighted camera type. The Copy button selects the highlighted camera type for the purpose of creating a *non–standard* camera type and editing its parameters. The Delete button deletes the highlighted camera type (*non–standard* only).

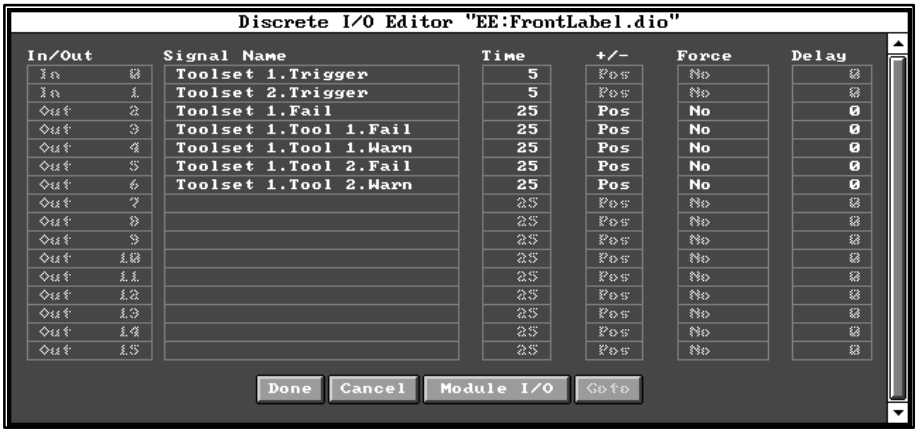
When you finish selecting the image acquisition parameters, you can exit the Acquisition Editor panel and return to the Configuration Editor panel by picking the Done button.

Selecting Discrete I/O Parameters

After configuring a toolset and selecting acquisition parameters, your next step is to pick Discrete I/O in the Editors menu. You can then select and configure the discrete inputs and outputs to be used in your application.

When you pick Discrete I/O, the Discrete I/O Editor panel appears, as shown in the example in Figure 2.7, *provided* that you have added a discrete I/O file name in the Config Files panel, as noted on page 2–3.

Figure 2.7 Example: The Discrete I/O Editor Panel



The purpose of the Discrete I/O Editor panel is to configure the trigger inputs and assign functions to the outputs as required for a particular application. Using this panel, you can assign signals to the trigger inputs and specify the minimum trigger signal pulse duration, and you can assign a specific function to each output, such as toolset failure, tool warning, and so on. When you finish, picking the Done button returns to the main menu bar.

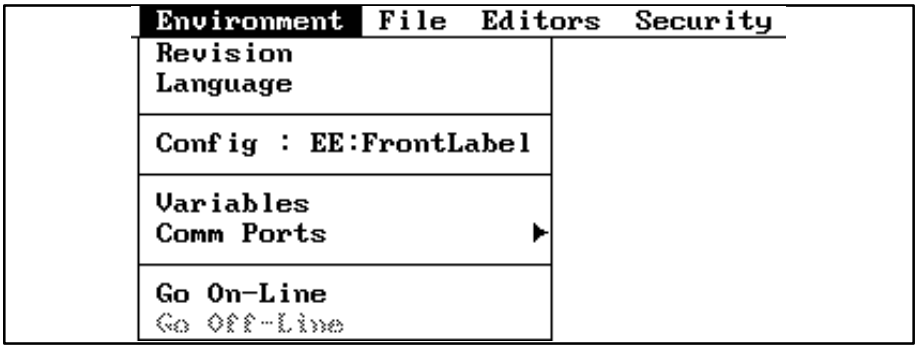
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Selecting Online Operation

Normally, your last step is to pick Go On–Line in the Environment menu. This enables the system to perform *online* inspection operations, which will begin immediately if the selected trigger source is active. During online operations, you can observe the camera image and inspection tool display and the inspection results data display at the same time.

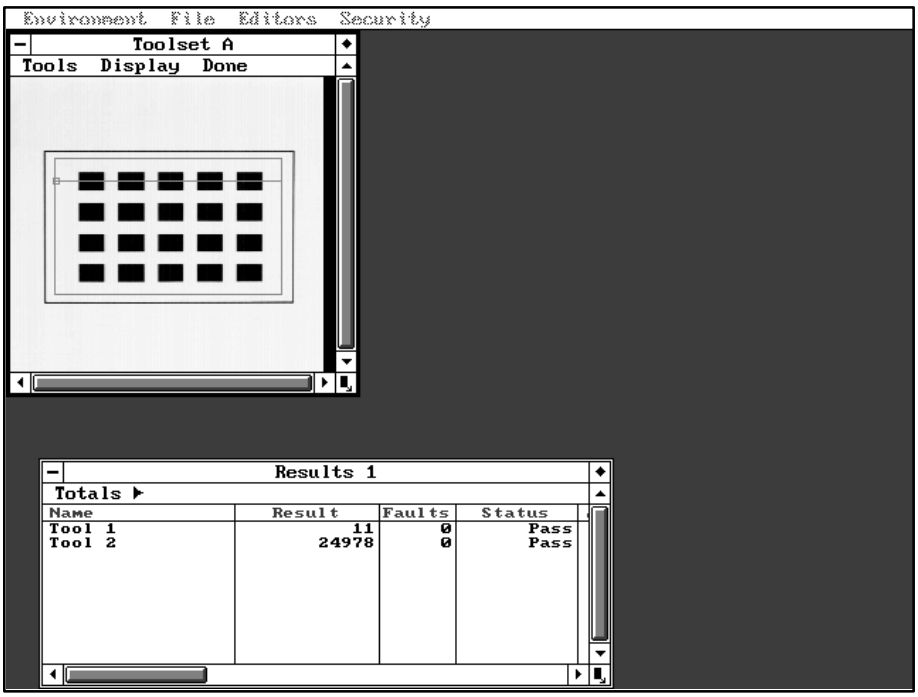
When you pick Environment, the Environment menu appears, as shown in the example in Figure 2.8.

Figure 2.8 Example: The Environment Menu



When you pick Go On–Line, the system displays the camera image and tools, and the inspection results data. Figure 2.9 shows an example of this.

Figure 2.9 Example: Online Screen Display



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The display panel shows the inspection tools over the inspected image. The menu bar in the display panel enables you to access these tools for the purpose of making minor adjustments, and for assigning “freeze” modes, which allow analysis of images in which one or more tools have failed their inspection tasks.

The results panel displays the basic inspection results for each tool listed; namely, the pass/fail status, the accumulated number of faults, and the numerical inspection result. The “Totals” item in the menu bar accesses additional results data, such as the number of missed triggers and various inspection timing data.

Screen Pointer Functions

The CVIM2 system uses a light pen and/or mouse to perform numerous screen pointer functions such as selecting menus and menu items, picking and placing tools, and positioning and sizing panels. Most of these functions are performed by positioning a screen pointer over an item on the screen and pressing the light pen tip against the screen, or “clicking” the left mouse button (that is, pressing and releasing the button quickly), if a mouse is used.

Light Pen and Mouse Operation

The light pen and mouse can perform the same screen pointer functions, but they differ in the method of performing those functions. Table 2.1 identifies the major differences in the operation of these two screen pointer systems.

Table 2.1 Comparison of Light Pen and Mouse Operation

Major Pointer Function	Mouse	Light Pen
Select or pick item (menu item, button, selector)	Position the pointer over an item on the screen, then press and release (“click”) the left button. The item under the pointer when the button is released is the one selected.	Position light pen tip over item on screen, then press and release light pen tip against screen
Drag (tool, tool end, panel, panel corner)	Position the pointer over an item, then press and hold the left button while dragging the item across screen. Release the button when the item is at its final position.	Position the light pen tip over an item on screen and press the tip against the screen until a cross (+) symbol appears. Release the light pen tip from the screen, then drag the item across screen. Press and release the tip against screen when the item is at its final position.

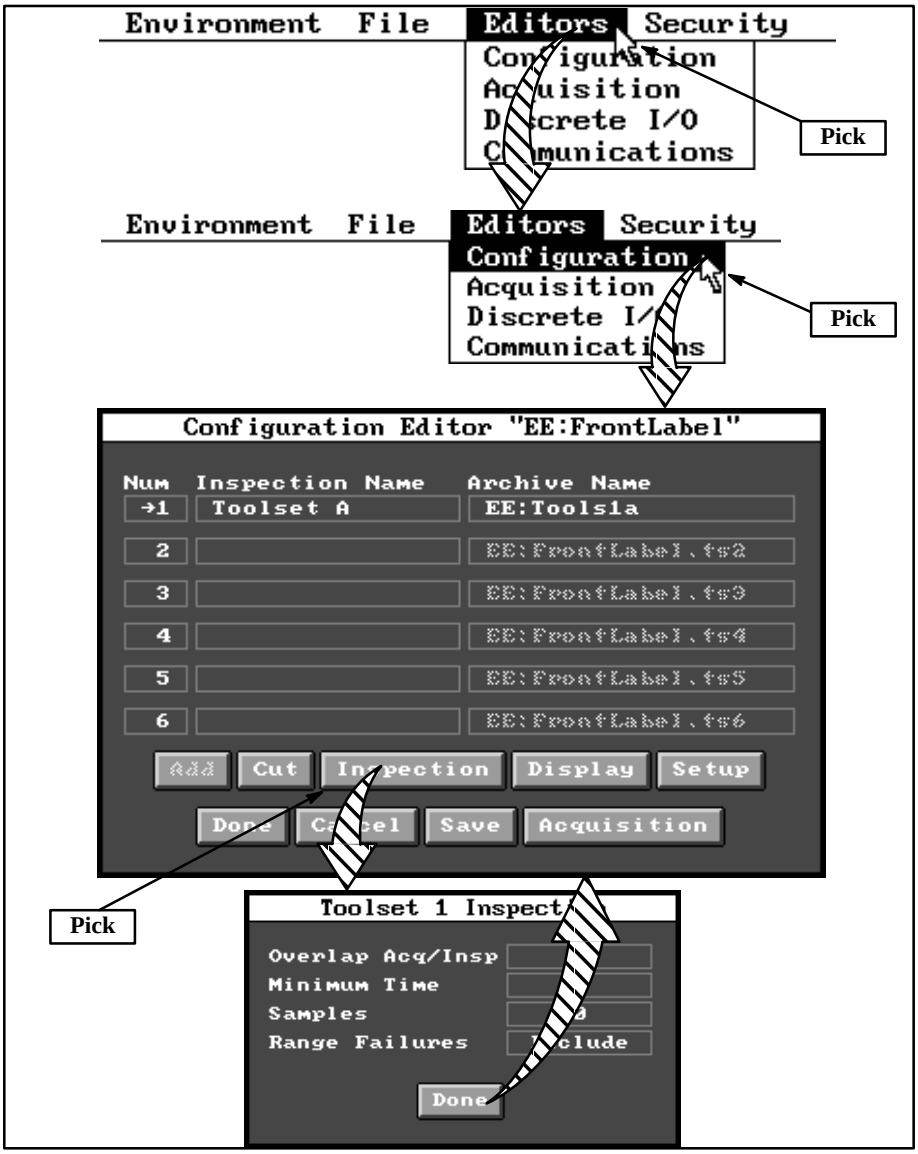
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NOTE: In the following discussions, the use of a *mouse* is assumed for the screen pointer functions. Table 2.1 compares equivalent light pen and mouse operation.

Figure 2.10 through Figure 2.12 (page 2–13) illustrate the screen pointer functions.

Figure 2.10 demonstrates a *sequence* of menu item and button picks, starting at "Editor" in the main menu bar. In this figure, the pointer is positioned over Editor in the main menu bar, and the left button is clicked, in order to select the Editor menu. The pointer is then positioned over Configuration in the Editor menu, and the left button is clicked, in order to select the Configuration Editor panel.

Figure 2.10 Example: Sequence of Menu and Panel Selections



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In the Configuration Editor panel, the pointer is positioned over the Inspection button, and the left mouse button is clicked, to select the Inspection panel. When the appropriate inspection parameters are entered, the pointer is placed over the Done button, and the left mouse button is clicked, to exit back to the Configuration Editor panel.

Figure 2.11 (page 2–12) demonstrates dragging a panel to a different position on the screen. The pointer can be placed anywhere in the title bar and the panel dragged to its final position.

Figure 2.12 (page 2–13) uses a "Results" panel to identify the symbols and points that are used for manipulating a panel on the screen (some of these points and symbols are also used on other panels). When picked, they perform specific functions, as follows:

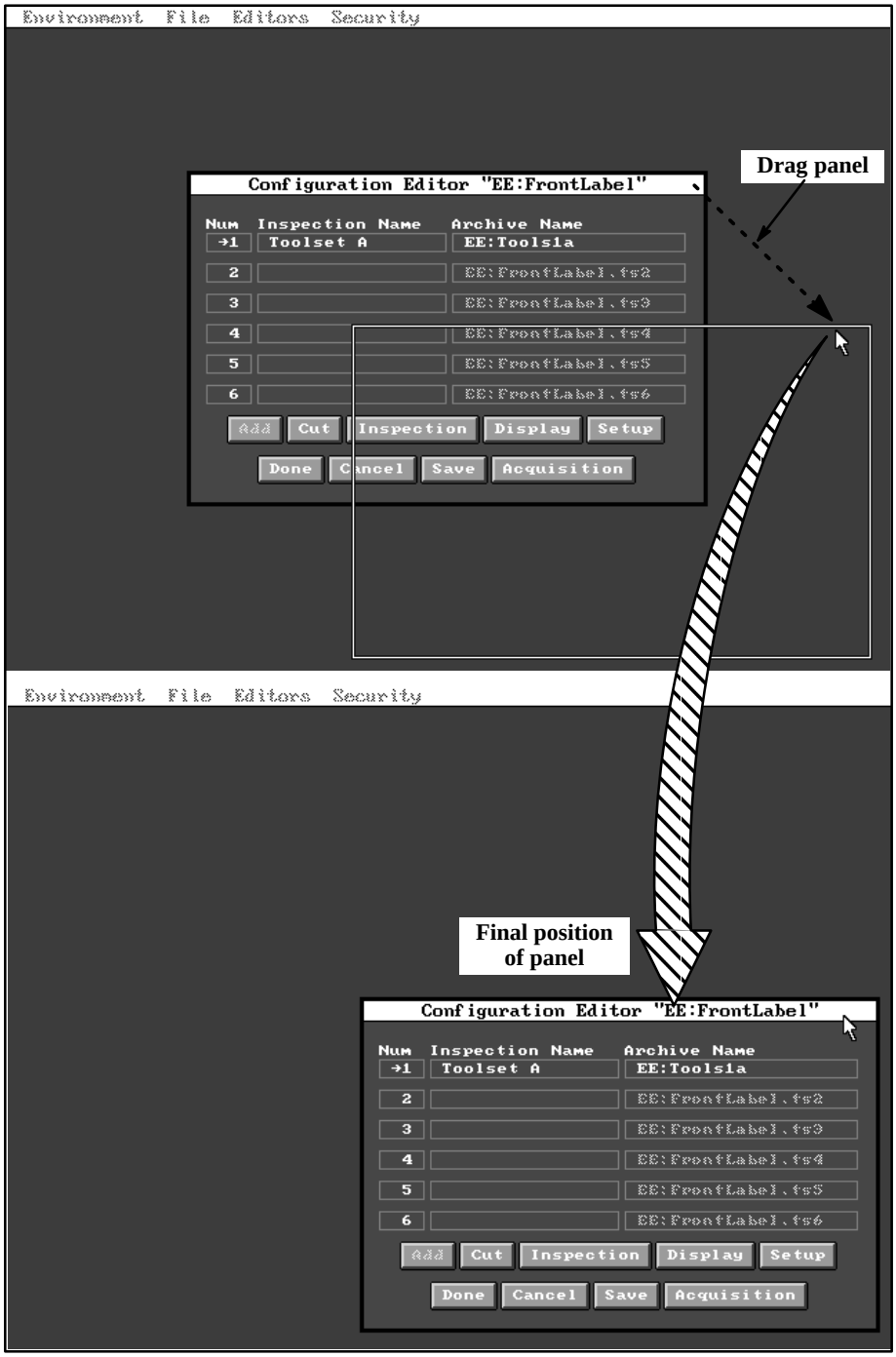
- **Expand/contract size symbol** — If you pick this symbol (♦) in the upper right corner, the panel will change to an alternate size (by *default*, it expands to the full screen size initially). When you pick the symbol again, the panel returns to its previous size.
- **Change panel size symbol** — You can change the panel size (without moving the panel) by picking and dragging this symbol in the lower right corner of the panel. The panel's upper left corner remains anchored.
- **Move panel** — You can move the panel (without changing its size) by picking anywhere in the title bar and dragging the panel across the screen. (See Figure 2.12.)
- **Display icon symbol** — If you pick this symbol (−) while the panel is displayed on the screen (expanded *or* reduced), it will contract into the icon form. When you pick the icon, the panel returns.
- **Scroll bar and arrows** — When the panel is not high enough to display all rows listed in it, you can pick the up or down arrows or the scroll bar on the right side of the panel to scroll panel contents up or down. Similarly, when the panel is not wide enough to display all of its columns, you can pick the left and right arrows or the scroll bar on the bottom of the panel to scroll the panel's contents right or left.

Center Button and Right Button

The center mouse button can perform some of the functions of the left button, for example, picking and dragging a panel across the screen, selecting alternate panel sizes, and operating the scrolling functions. The right button can alternately position a panel *over* or *under* an overlapping panel.

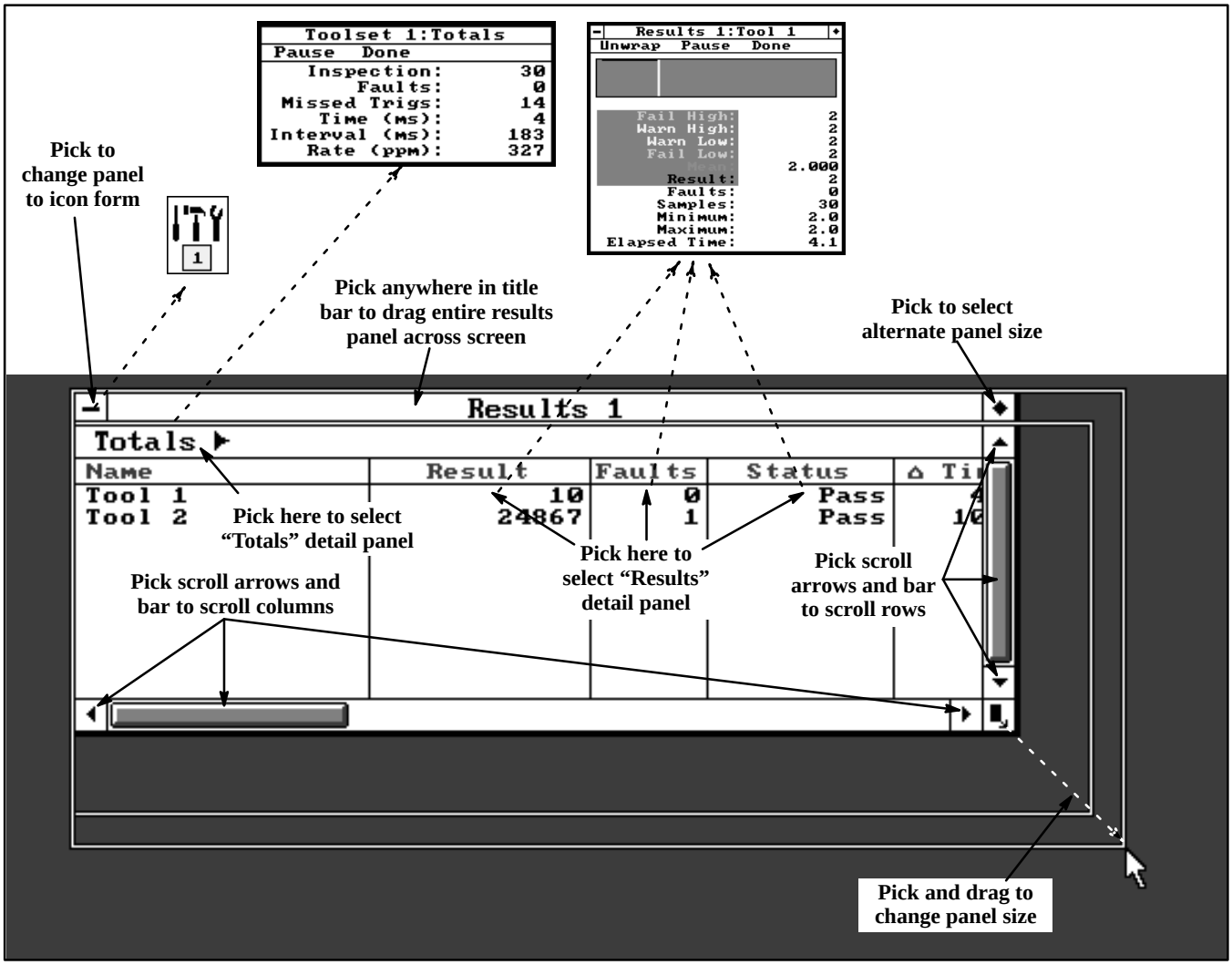
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Figure 2.11 Example: Moving a Panel Across the Screen



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Figure 2.12 Example: Panel Manipulation Functions

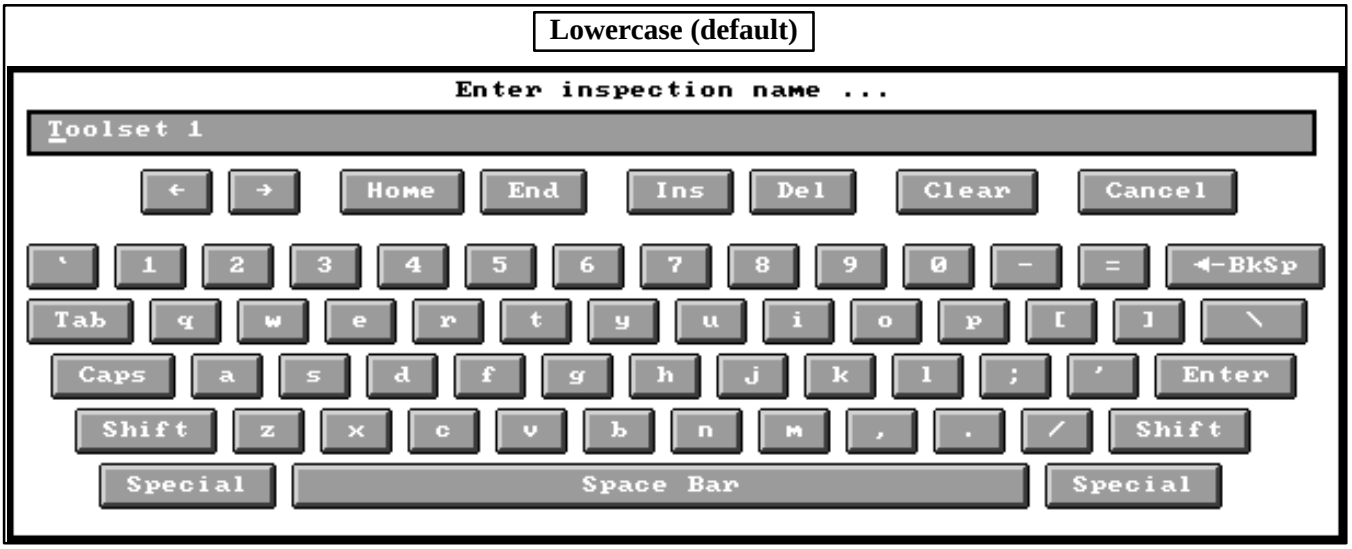


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Keyboard Functions

Throughout the configuration process, names must be entered for files, inspections, tools, and various other items. At each point where a name is required, a standard keyboard panel appears on the screen, as illustrated in Figure 2.13.

Figure 2.13 Example: The Keyboard Panel (Lowercase)



Note that the printable characters appear in lowercase by *default*.

Most of the keys are straightforward in their operation; that is, their functions are analogous to the keys on a computer keyboard. When you pick any *printable* character, it appears in the name bar immediately above the keys: The character in the key cap is the one that will appear in the name bar. The *maximum* number of characters that you can enter depends on the context.

Here is a brief description of the keys:

- **Alphanumeric keys** — These are the printable characters, and include lowercase and uppercase alpha characters, digits, and punctuation characters.
- **Tab key** — This key moves the cursor four places to the right of the previous tab stop.
- **Left and right arrow keys** — These keys move the cursor one place to the left or right.
- **Home key** — This key returns the cursor to the leftmost position.
- **End key** — This key moves the cursor one place to the right of the rightmost character in the name bar.
- **Ins (insert) key** — This key enables you to insert a character to the left of the present cursor position. When you pick the insert key, and the blinking cursor changes to a *block* (■), the *insert* mode is enabled. When you pick the insert key, and the cursor changes to an *underscore* (—), the *typeover* mode is enabled.

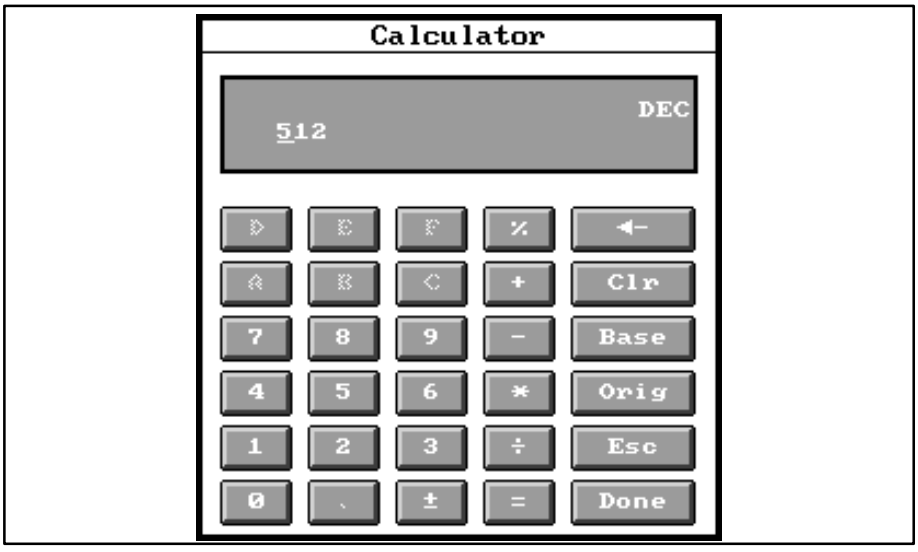
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- **Del (delete) key** — This key deletes the character at the cursor position.
- **Clear key** — This key clears all characters from the name bar.
- **Cancel key** — This key exits the keyboard panel without saving any new characters entered in the name bar.
- **BkSp (backspace) key** — This key moves the cursor one place to the left and *deletes* the character in that position.
- **Enter key** — This key saves all new characters entered in the name bar and exits the keyboard panel.
- **Caps key** — This key changes the alpha characters between uppercase and lowercase. The keyboard remains in the "caps" mode until you pick the caps key again.
- **Shift key** — This key changes all printable character between uppercase and lowercase. (The *default* setting is lowercase.) The keyboard returns to the lowercase mode when you pick one character.
- **Special key** — This key changes the keyboard to a special set of printable characters (lowercase only). The keyboard returns to the lowercase mode when you pick one character.

Calculator Keypad Functions

Throughout the configuration process, numeric parameters must be entered. At each point where such a parameter is required, a standard "calculator" keypad panel appears on the screen, as illustrated in Figure 2.14.

Figure 2.14 Example: The Calculator Keypad Panel



Note that the calculator keypad appears in the *decimal* mode by *default*.

Most of the keys are straightforward in their operation; that is, their functions are analogous to the keys on a hand held calculator. When you pick any digit,

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it appears in the display window above the keys. The *maximum* number of digits that you can enter is 10.

Some keys appear in *shaded type*, which indicates that they are *inactive* in the keypad's current mode of operation. For example, when the *decimal* mode is selected, the hexadecimal alpha keys are shaded.

Here is a brief description of the keys:

- **Digit keys** — These keys enter numeric digits in the display window.
- **Operator keys** — These keys perform mathematical operations on the numbers entered in the display window: The (÷) key performs a divide operation; the (*) key performs a multiply operation; the (+) key performs an addition operation; the (−) key performs a subtraction operation, and the (%) key performs a percentage operation. The (=) key completes the mathematical operation and displays the result in the display window.
- **Sign key** — The (±) key changes the sign of the operand to minus (−) if it is plus, or vice versa. (The plus sign is never displayed.)
- ***Decimal key** — This key is *active* only when floating point values are involved. At all other times the decimal (.) in the key appears in shaded type, indicating that the key is *inactive*.
- **Backspace (←) key** — This key moves the cursor one place to the left and *deletes* the digit at that position.
- **Clr (clear) key** — This key clears all digits from the display window.
- **Base key** — This key selects the "base" of the numbering system to be used: DEC for decimal (base 10), HEX for hexadecimal (base 16), BIN for binary (base 2), or OCT for octal (base 8). The various bases appear in succession when you pick this key repeatedly.

  Note that the digit keys that are non–functional with each base appear in shaded type; thus, all but digits 0 and 1 are shaded in the BIN mode.
- **Orig (original) key** — This key restores the original contents of the display window when the keypad first appeared.
- **Esc (escape) key** — This key exits the keypad without altering the original value that appeared in the display window.
- **Done key** — This key saves any changes to the original value in the display window and exits the keypad.

***** The calculator operates in the *integer* mode for most operations, and all fractional results from calculations are thus *truncated*. For example, the result from 100 ÷ 6 would appear in the calculator display window as 16, not 16.6667. Some operations, however, such as a gage using the linear measurement operation, use floating point numbers for inspection results. The decimal key is *active* when you set range limits for those results. Thus, the result from 100 ÷ 6 would appear in the display window as 16.667 in this case.

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Chapter 3

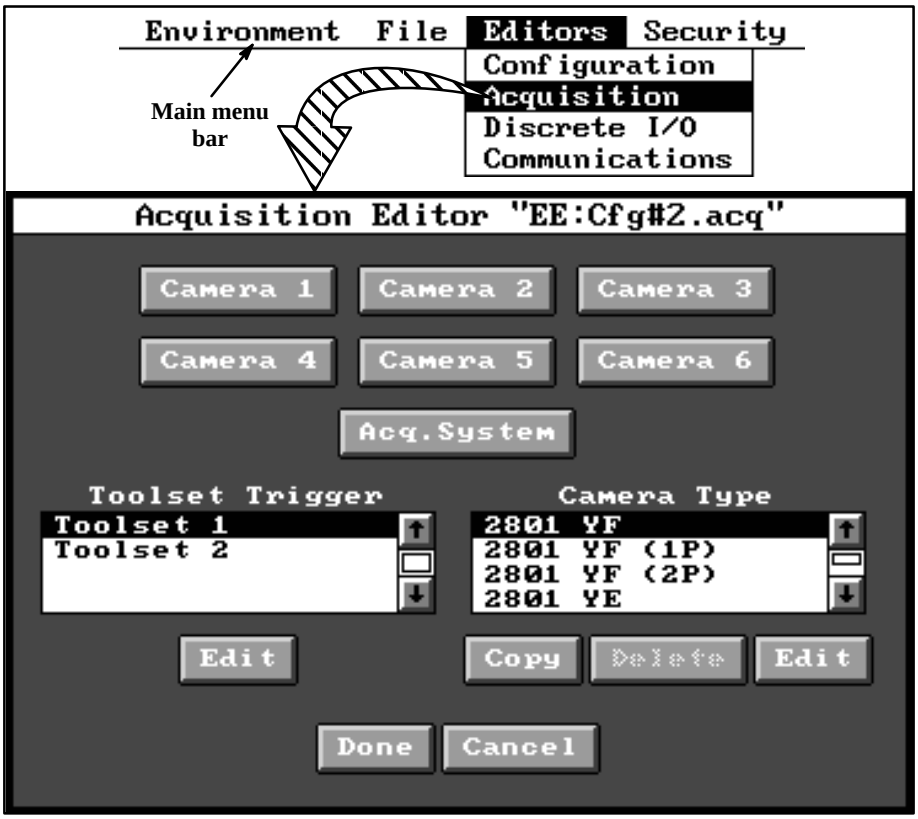
Image Acquisition Parameters

This chapter discusses the details of selecting the appropriate image acquisition parameters in preparation for configuring the inspection tools.

NOTE: During the inspection configuration process, you would normally access the image acquisition parameters through the Acquisition button in the Configuration Editor panel (see Chapter 4, *Inspection Configuration*; page 4–7). However, you can also access these parameters from the main menu bar through the Editors menu, as described in this chapter.

When you pick Acquisition in the Editors menu, the Acquisition Editor panel appears, as shown by the example in Figure 3.1.

Figure 3.1 Example: Selecting the Acquisition Editor Panel



The Acquisition Editor panel provides access to all of the parameters and settings that the system uses to acquire an image for an inspection. The panel contains two scrolling lists and several buttons, which are described briefly as follows:

- **Camera 1 – 6** — The Camera 1 through Camera 6 buttons access the corresponding Camera setup panels, from which you can perform focus adjustments, light reference adjustments, and other related functions.

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- **Acquisition Systems Settings panel** — The Acq.System button accesses the Acquisition System Settings panel, from which you can select a default camera, enable synchronizing the CVIM2 system with external devices or another CVIM2 system, and/or select parameters for switching between camera banks 1 – 3 and 4 – 6.
- **Toolset Trigger panel** — This scrolling list enables you to edit various trigger parameters for a particular toolset. The adjacent Edit button selects the Toolset Trigger edit panel for the highlighted toolset trigger.
- **Camera Type panel** — This scrolling list enables you to edit various timing parameters for a particular camera type. The adjacent Edit button selects the Camera Type edit panel for the highlighted camera type. The Copy button selects the highlighted camera type for the purpose of creating a *non–standard* camera type and editing its parameters. The Delete button deletes the highlighted camera type (*non–standard* only).

The following sections provide detailed information about all of the items listed above.

Camera Setup Panel

When you pick one of the Camera 1 through Camera 6 buttons in the Acquisition Editor panel, a Camera setup panel for the *selected camera number* appears, as shown by the Camera "Camera 1" panel in Figure 3.2.

Figure 3.2 Example: Selecting Camera Setup Panel for Camera 1



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The Camera setup panel contains a scrolling list panel, several parameter selection boxes, and several buttons, which are described briefly as follows:

- **Camera Type** — The Camera Type scrolling list enables you to select a camera *type* (such as 2801–YF) that pertains only to the *selected camera number* (this number corresponds to the camera port number on the CVIM2 module front panel).
- **Edit Camera Type** — The Edit Camera Type button accesses the Camera Type edit panel for the camera *type* highlighted in the adjacent Camera Type scrolling list. The Camera Type edit panel enables you to edit various timing parameters for the highlighted camera type.
- **H.Res** — This box selects either the full horizontal resolution capability of the camera in use, or just half of that resolution capability.
- **Fields** — This box selects one vertical field for half vertical resolution, or two vertical fields for full vertical resolution.
- **Focus Trigger** — This field selects either the internal trigger source or an external trigger source for focus operations. It applies to *the camera setup operation only.*
- **Rate Per Minute** — This field selects a trigger rate per minute when the *auto/internal* trigger source is selected as the focus trigger. It applies to *the camera setup operation only.*
- **Focus Source** — This field assigns a discrete input for the trigger signal when the *external* trigger source is selected. It applies to *the camera setup operation only.*
- **Shutter Speed** — This field is active only when a frame reset camera type (such as the 2801–YE) is selected. It accesses the calculator that is used to set the frame reset camera's shutter speed.
- **Focus Strobe** — This assigns a discrete output for the strobe signal. It applies to *the camera setup operation only.*
- **Focus** — The Focus button starts the focus function, which captures continuous camera images and enables the user to perform camera and lighting adjustments.
- **Light Reference** — The Light Reference button accesses the light reference adjustment panel, which can be used to maximize the contrast in the image.
- **Light Probe** — The Light Probe button accesses the light probe setup function, which can be used to set up lighting compensation for the inspection tools.
- **Calibrate** — The Calibrate button accesses the calibrate function, which which enables you to calibrate the image field to inches or centimeters ("world units") and perform measurements, such as linear gaging, in those units.
- **Done** — The Done button exits the Camera panel and returns to the Acquisition Editor panel.

The remainder of this section describes these functions, features, and parameters in detail.

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Camera Type Selection

This scrolling list panel lists the "standard" camera types that the Allen–Bradley Company supports, along with any *non–standard* camera types that have been user–configured in the Acquisition Editor panel. To select a camera type for the *current camera number*, highlight the camera type by picking its name.

You can edit various timing parameters for the highlighted camera type by picking the Edit Camera Type button and accessing the corresponding Camera Type edit panel. (For details about this panel, refer to the *Camera Type: Selection and Editing* section on page 3–33.)

Horizontal Resolution Selection

These are the two "H.Res", or horizontal resolutions:

- **Full** — This selects the full horizontal camera resolution equal to the Acq. Pixels setting in the Camera Type panel (typically 512 pixels).
- **Half** — This selects one half of the full horizontal camera resolution (typically 256 pixels — every *other* pixel is acquired).

Field Selections

The "Fields" selections are 1, First; 1, Same; and 2. Here is what they signify:

- **1, First** — This causes the system to acquire the *first* field (odd *or* even) to become available after any given trigger signal. The vertical resolution is one–half the Acq. Lines (1/2 Lines) setting in the Camera Type panel (typically 240 lines).
- ***1, Same** — This causes the system to acquire field 0 *only*. The vertical resolution is one–half the Acq. Lines (1/2 Lines) setting in the Camera Type panel (typically 240 lines).
- ***2** — This causes the system to acquire the image with full vertical resolution (typically 480 lines).

*These selections are significant only when an interlaced camera is used.

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Trigger/Rate/Source/Strobe Selections

These selections refer to the fields labeled Focus Trigger, Rate per Minute, Focus Source I/O, and Focus Strobe I/O.

The description and procedures for making these selections and assignments are the same as those described on page 3–45. The difference is that *these assignments apply only to the adjustment of the camera focus and lighting resolution*.

Shutter Speed Selection

The Shutter Speed field is active only when a frame reset camera type (such as the 2801–YE), or a *custom* frame reset camera type, is selected. This field enables access to the calculator pad, which is used to select a shutter speed setting, in microseconds, for the 2801–YE (or other) frame reset camera. The valid range for all cameras is 200 to 8000 microseconds.

Focus Function

When the auto/internal trigger source or a repeating external trigger source is active, the focus function can capture a series of camera images, which enables you to adjust the camera focus and aperture, and make the necessary lighting and workpiece staging adjustments.

To enter the focus function, pick the Focus button on the camera setup panel. Figure 3.3 (page 3–6) illustrates the screen with the focus function active.

NOTE: When using an external trigger source, if too much time elapses between trigger pulses (about five seconds), system warning message #3072 appears on the display, as shown in Figure 3.4 (page 3–6). If you see this message, you can either pick the Abort button to exit the focus function, or you can pick the Retry button to re–enable the focus function (when you expect a trigger signal to occur within five seconds).

When you are finished with the focus function, pick the Done button in the "Focus" box to return to the camera setup panel.

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Figure 3.3 Example: Camera Image With Focus Function Active

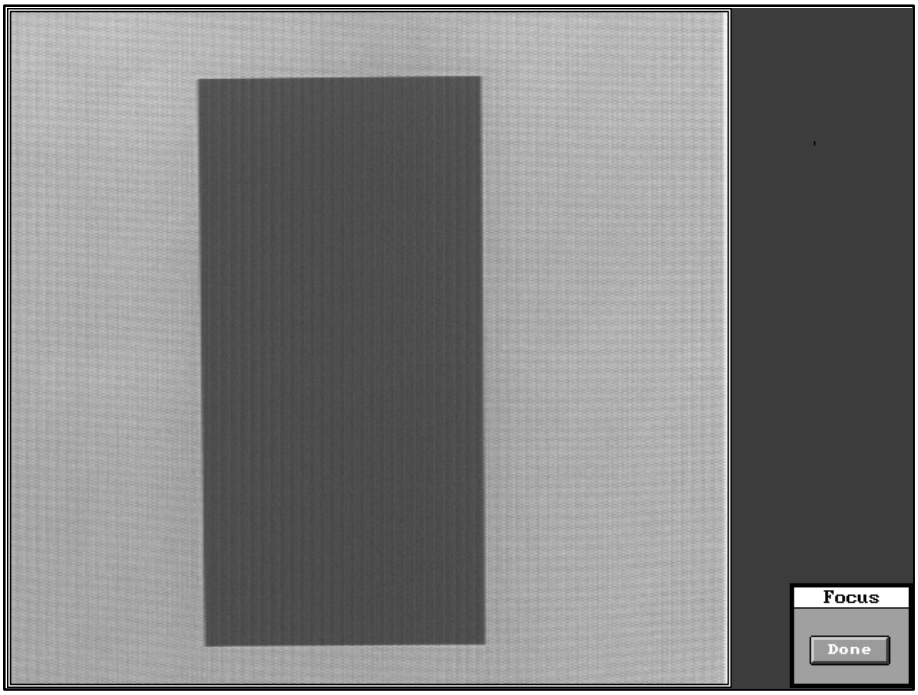


Figure 3.4 Trigger Time–out Warning Message



Light Reference Adjustment

The light reference adjustment function can be used to optimize the image contrast.

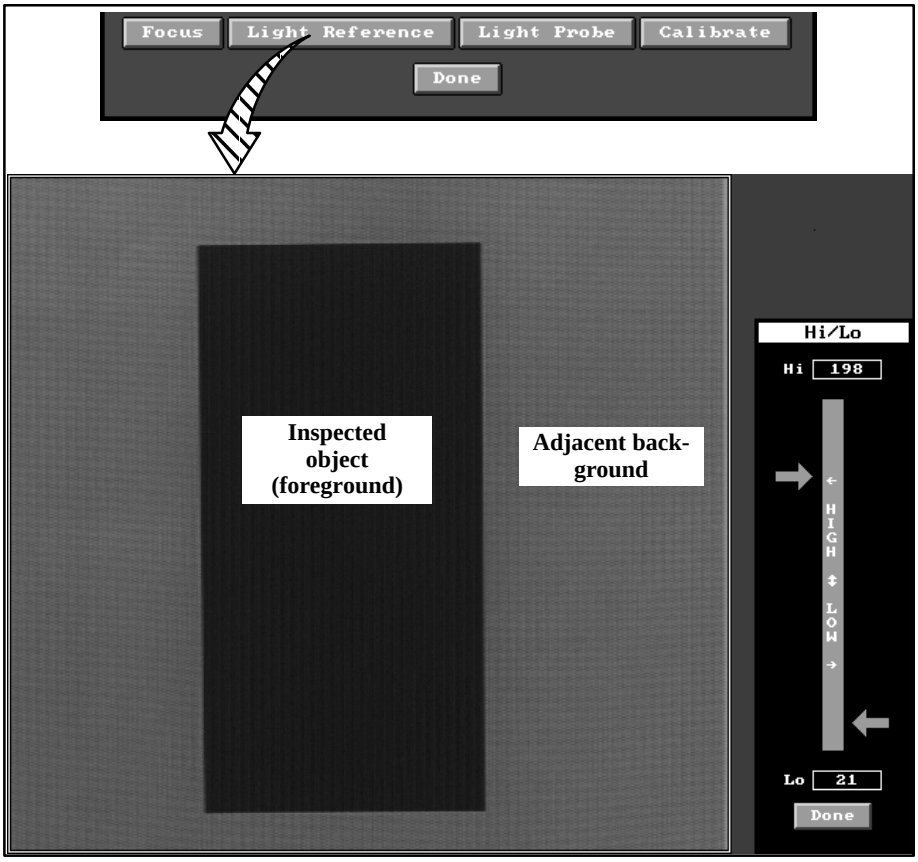
NOTE 1: *Adjust the light references before configuring any of the inspection tools.*

NOTE 2: *Before adjusting the light references, be sure the lighting and the camera focus and f–stop settings are optimized for your application.*

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When you pick the Light Reference button on the camera setup panel, the camera image appears along with the adjustment cursors, as shown in Figure 3.5.

Figure 3.5 Selecting Light Reference Adjustment



The degree of contrast within any given image is a function of the *difference* between the *darkest* and *lightest* pixels within that image. For example, if the brightness level of the inspected object were 130 (on a scale of 0 to 255) and the adjacent background were 165, the contrast difference between them may not be sufficient to allow reliable inspection tool operations.

By adjusting the light reference appropriately, you can enhance the “natural” image contrast by, in effect, expanding the existing *narrow* range (130–to–165, in the preceding example) to a *wider* range such as 70 to 180, thereby increasing the contrast and improving the inspection tool performance.

Your main objective in adjusting the light reference is to optimize the contrast between the inspected part of the workpiece and the adjacent background.

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Light Reference Settings

The light reference settings are adjusted by picking and dragging the *left* (Hi) and *right* (Lo) cursors up or down, or by picking a point along the left or right side of the slide bar. In the latter case, the cursor will jump to the location of the light pen/mouse cursor.

The two references select high and low brightness values or "cutoff points" that apply to *all* pixels within the image. They *interact* to affect the contrast in the entire image. Individually, the reference settings have the following effects:

- Hi **reference setting** — The Hi reference has a value within a range of 1 to 255, where 1 is the *lowest* brightness in this range and 255 is the *highest*. This setting determines the *upper limit* for the *brightness* of the lightest pixels in the gray scale image. (Note that the *lower* limit is bounded by the Lo reference setting; thus, if the Lo reference is set to 127, the Hi reference cannot be set *lower than* 128.)

  Thus, any pixels in the image whose *original* brightness is *higher* (that is, *lighter*) than the corresponding high reference will change to saturated (255) *white*. (Note that during the adjustment these parts will appear *green*, as explained later.)

- Lo **reference setting** — The Lo reference has a value within a range of 0 to 254, where 0 is the *lowest* brightness in this range and 254 is the *highest*. This setting determines the *lower limit* for the *brightness* of the darkest pixels in the gray scale image. (Note that the *upper* limit is bounded by the Hi reference setting; thus, if the Hi reference is set to 128, the Lo reference cannot be set *higher than* 127.)

  Thus, any pixels in the image whose brightness is *lower* (that is, *darker*) than the corresponding low reference will change to saturated (0) *black*. (Note that during the adjustment these parts will appear *blue*, as explained later.)

You can see the high and low values in the boxes above and below the slide bar. As you move each cursor up and down, the corresponding box displays the changes in the value.

NOTE: The CVIM2 system acquires a new image every time you move a light reference cursor. The *trigger* defined in the Setup Camera panel is used for this purpose. Usually, the Auto camera trigger is used when setting the light references; however, when using an external trigger source, if no trigger pulse occurs within about five seconds after you attempt to move a cursor, system warning message #3072 appears on the display, as shown in Figure 3.4 (page 3–6). If you see this message, you can either pick the Abort button to discontinue the attempt to move the cursor, or you can pick the Retry button to try again (when you expect a trigger signal to occur within five seconds).

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The *interactive result* of the two cursor settings is this: All portions of the image whose brightness values are *between* the high and low light reference values will have digitized pixel values between 0 and 255. Portions of the image that are *brighter than* the high reference will have a digitized pixel value of 255. Portions of the image that are *darker* than the low reference will have a digitized pixel value of 0.

Here is a methodical approach to setting the two cursors for *any* application:

1. Drag the Hi cursor up to its highest position (value: 255).
2. Drag the Lo cursor down to its lowest position (value: 0).
3. Use the Focus function to optimize the focus and set the camera and lighting for maximum brightness in an image of the parts to be inspected.

   NOTE: If image saturation or "blooming" occurs, reduce the image brightness by reducing the aperture, or, if practicable, by dimming the lighting.
4. Drag the Hi cursor slowly downward until a *green* color begins to appear in the brightest areas of the image. Then, drag the cursor gradually upward until the green color just barely disappears from the image.

   It is acceptable to let some portions of the image remain green (saturated white) if they are not used for inspection.
5. Drag the Lo cursor slowly upward until a *blue* color begins to appear in the darkest areas of the image. Then, drag the cursor gradually downward until the blue color just barely disappears from the image.

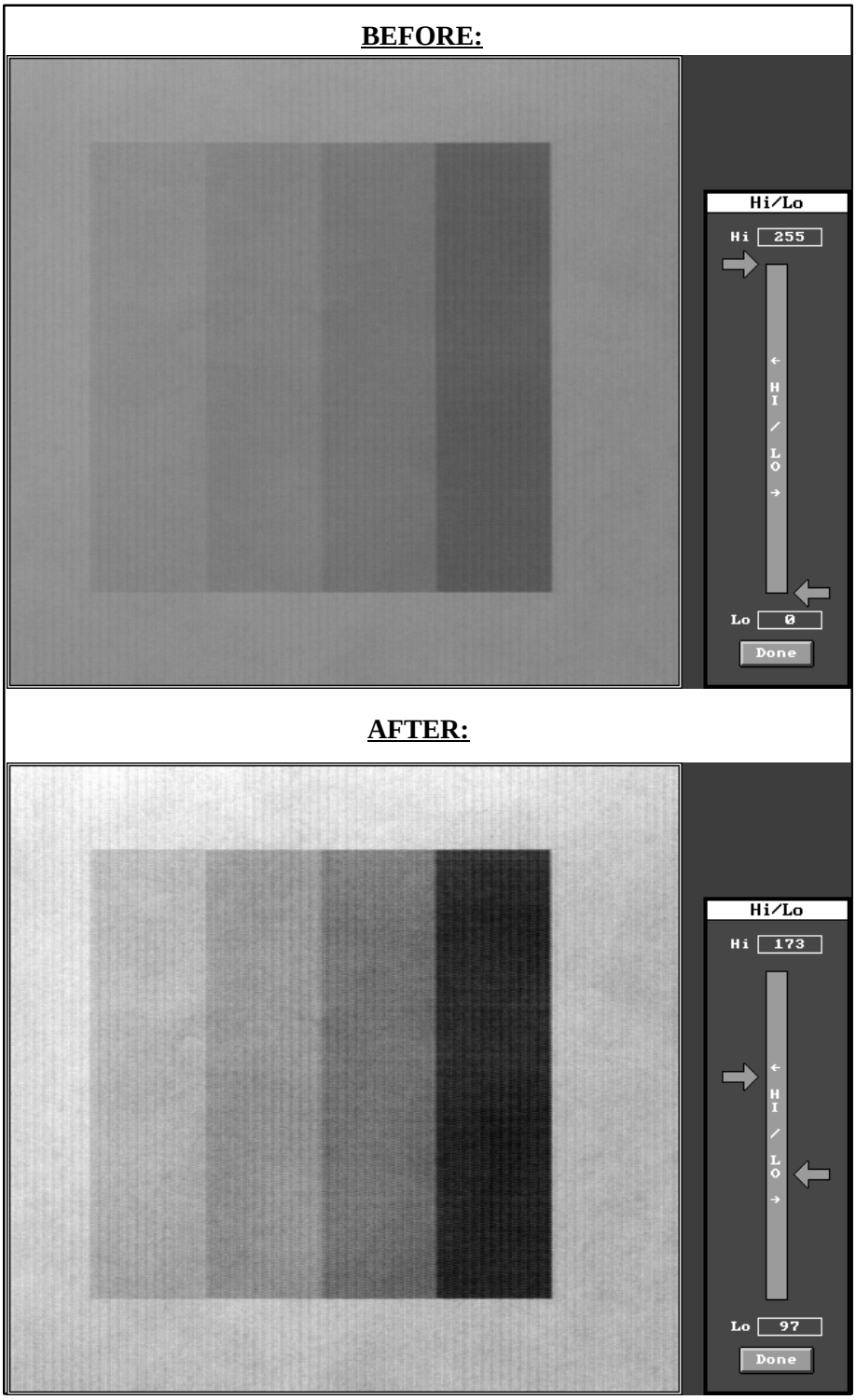
   It is acceptable to let some portions of the image remain blue (saturated black) if they are not used for inspection.

At this point, the *contras*t between all inspection–related parts of the image will be *maximized*. You may, however, still be able to improve the contrast by making slight changes to the lighting, camera aperture setting, and light references.

Figure 3.6 (page 3–10) provides an example of how a workpiece image might appear *before* and *after* maximizing the contrast.

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Figure 3.6 Example: Before and After Light Reference Adjustment



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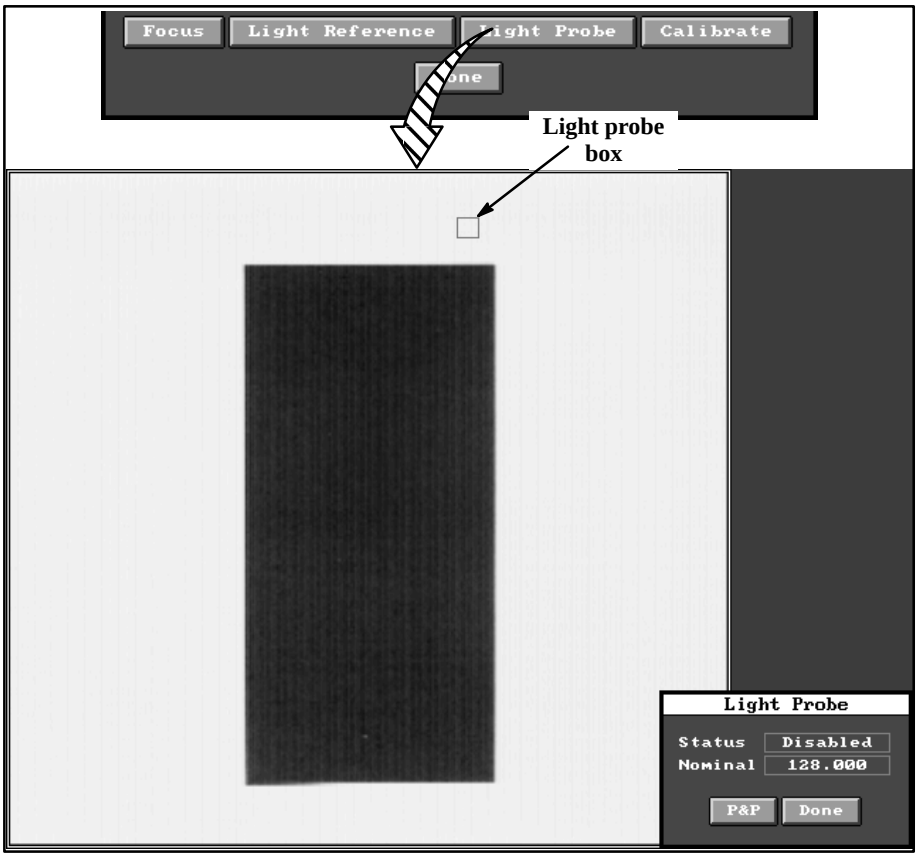
Light Probe Setup

The light probe tool provides a *lighting compensation* function, which enables the CVIM2 system to adjust to *changes* in the brightness of the image. One light probe is available for each camera.

The practical value of lighting compensation is its ability to adjust the light reference automatically for each acquisition and obtain consistent images over a range of lighting variations.

When you pick the Light Probe button on the camera setup panel, the camera image appears with the light probe "box," as shown in Figure 3.7.

Figure 3.7 Selecting Light Probe



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Light Probe Operation: General

The light probe tool is a small, special–purpose window or "box" that is positioned during configuration over a user–designated light reference "patch" somewhere in the top half of the image. Typically, the patch should be near the top of the image, and always at least eight raster lines above the *highest tool*. During inspection operations, the light probe measures the light intensity reflected from the reference patch on a scale of 0 to 255 (0 is the darkest light intensity and 255 is the brightest), and the CVIM2 system calculates the *average* value of the pixels within the light probe.

The light probe is a *pre*–inspection tool. Thus, when the light intensity changes from the original setting, the CVIM2 system uses the light probe's calculated value to *modify* gray scale values from the camera in order to produce the best match to the *original* image. When the image is thus compensated, the threshold and filter values for the inspection tools remain *valid*.

Note that the calculated average value reflects the brightness of the reference patch *relative to* the minimum and maximum values of 0 and 255. Therefore, in order to ensure adequate light compensation *flexibility*, the light reference patch should be a shade of gray that yields an initial value in the range of 160 to 200. This allows a margin for both an increase and a decrease in light intensity.

The basic steps for configuring the light probe for use are these:

- If a suitable background area is not available in the field of view, prepare a light– or medium–gray reference "patch" and position it within the image using the Focus function.
- Enable the light probe for use by setting the Enabled/Disabled button to Enabled.
- Position and "size" the light probe "box" over the reference area or "patch" using the P&P (pick and place) button.
- Store the initial calculated average brightness of the pixels in the light probe window, using the Nominal or "learn" function.

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Light Probe Panel

The Light Probe panel, shown in Figure 3.8, contains two fields and two buttons: The Status field, which enables or disables the light probe tool, and the Nominal field performs a "learn" operation, which causes the light probe tool to acquire a sample or "nominal" luminance reading.

Figure 3.8 Light Probe Panel



Status — The light probe *status* is indicated by the Status field in the Light Probe panel. By *default*, the status is Disabled.

When you pick the Status field, the status toggles from Disabled to Enabled, or vice versa, with the following effects:

- **Disabled** — This indicates that the light probe for the associated camera is inactive, and lighting compensation will not be provided.
- **Enabled** — This means that the light probe for the associated camera is active, and lighting compensation will be provided.

Nominal — The *nominal* value is indicated by the Nominal field in the Light Probe panel. When you pick the Nominal field, the light probe performs a "learn" operation, during which it calculates the *average luminance* of the pixels in the light probe box and displays the result in the Nominal field.

The P&P button enables you to position and "size" the light probe box, and the Done button exits the light probe setup and returns to the Camera panel.

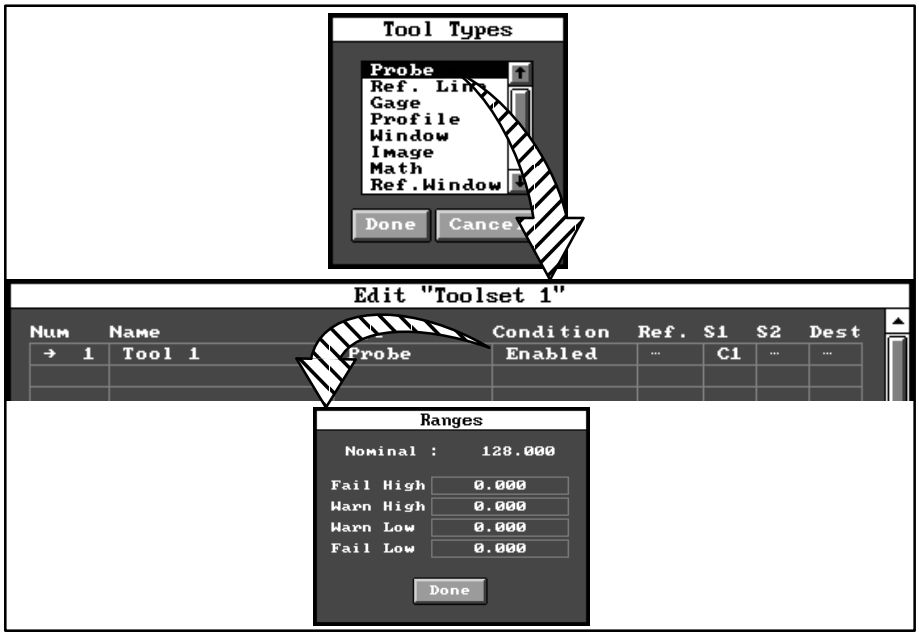
Light Probe "Tool Type" and Range Limits

Range limits can be selected for a light probe by selecting a Probe tool type in the toolset edit panel, as shown in Figure 3.9 (page 3–14).

When you pick Probe in the toolset edit panel, the Range panel appears, as shown in Figure 3.9. Note that the *nominal* value (from the "learn" operation described earlier) appears in the Range panel. Using the nominal value as the basis for determining the appropriate range limits, select the range limits as described in Chapter 7, *Inspection Tools*, on page 7–179.

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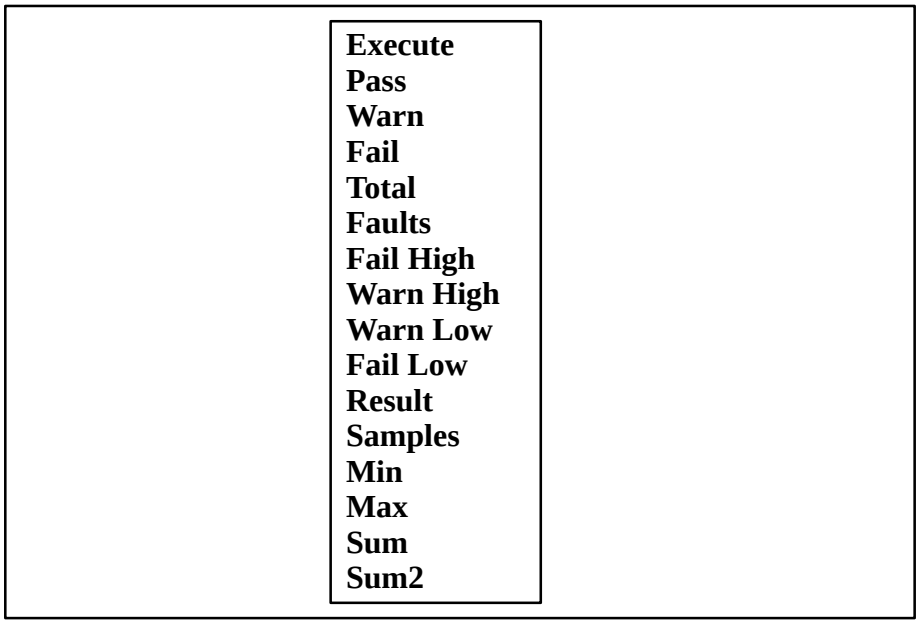
Figure 3.9 Selecting Probe Tool Type and Range Limit Panel



Light Probe Tool Results and Math Tool Formulas

This section discusses the expanded inspection results that are available to a math tool formula from a probe tool. Figure 3.10 illustrates the complete list when the Statistics option is enabled for the light probe tool.

Figure 3.10 Expanded Results Lists For Light Probe Tools in Math Formulas



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Here is a brief definition and explanation of each of the expanded result types listed in Figure 3.10.

- **Pass** — This returns a 1.000 when the tool has *passed* its inspection task, and 0.000 for all other conditions.
- **Warn** — This returns a "error code" when the tool is in a *warn* condition (and *not* in a *fail* condition) and 0.000 for all other conditions. The error code identifies a specific reason for the warning; for example, error code 1057.000 identifies "Low range warning" as the cause. The complete list of error codes and warn conditions appears in Appendix A of this manual.
- **Fail** — This returns a "error code" when the tool is in a *fail* condition and 0.000 for all other conditions. The error code identifies a specific reason for the failure; for example, error code 1045.000 identifies "High range fail" as the cause of the inspection failure. The complete list of error codes and fail conditions appears in Appendix A of this manual.
- **Fail High** — This returns a 1.000 when the inspection result from the tool has exceeded the *high* Fail limit and 0.000 when the result has *not* exceeded the *high* Fail limit.
- **Warn High** — This returns a 1.000 when the inspection result from the tool has exceeded the *high* Warn limit (and the tool is *not* in a *fail* condition) and 0.000 when the result has *not* exceeded the *high* Warn limit.
- **Warn Low** — This returns a 1.000 when the inspection result from the tool has exceeded the *low* Warn limit (and the tool is *not* in a *fail* condition) and 0.000 when the result has *not* exceeded the *low* Warn limit.
- **Fail Low** — This returns a 1.000 when the inspection result from the tool has exceeded the *low* Fail limit and 0.000 when the result has *not* exceeded the *low* Fail limit.
- **Result** — This returns the actual value of the light probe result; that is, the luminance value from the light probe tool. This value corresponds to the "learned" value that appears in the "Nominal" field of the Light Probe panel. Light probe results can range from 0.000 (darkest) to 255.000 (lightest).
- ***Samples** — This returns the current total number of inspection samples since the start of run operation.
- ***Min** — This returns the current *minimum* value of the inspection results since the start of the run operation.
- ***Max** — This returns the current *maximum* value of the inspection results since the start of the run operation.
- ***Sum** — This returns the current *sum* of all inspection results since the start of the setup or online run operation.
- ***Sum2** — This returns the current *sum* of the *squares* of all inspection results since the start of the setup or online run operation.

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*These expanded *statistical* results are available only when a tool is enabled for *statistics* operations, as indicated by Stats appearing in the Enabled column for the corresponding tool.

Calibration Setup

This section discusses the calibrate function, which enables you to calibrate the image field from each camera to inches, centimeters, or any other "world units" of your choice, and perform linear gaging operations (such as linear measure) in those units. Included in this discussion is a simple application example whose main purpose is to demonstrate the procedure for using the calibrate function.

The calibration function uses an X–axis and a Y–axis "gage" to detect the edges across the X and Y axes of a calibration object, which is an object of known dimensions. Each "gage" operates like a line gage performing a linear measurement operation — it returns a raw pixel count that you can then calibrate to world units.

Calibration Applications

Calibration applies *mainly* to linear and circular gaging operations, using *linear measure*, in applications that require uniform measurements of a workpiece in the X– and Y–axes that are typically stated in "world units," such as inches and centimeters.

Other uses include applying the "scaling" values, which are derived from the calibration operation, to a math tool formula set up to perform window area measurements in world units.

Calibration: Basic Steps

Here is a summary of the basic calibration steps, listed in their normal order of performance.

1. **Set up calibration object image** — acquire a camera image of an object of known dimensions to be used as the "calibration object" in the calibration procedure.
2. **Select calibrate function** — select the calibrate function in the appropriate Camera setup panel.
3. **Select calibration mode** — select the "Computed" or the "Absolute" calibration mode.

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4. **Enter scale factors** — For the Absolute calibration mode *only*, enter the appropriate scale factors for each calibration gage.
5. **"Pick and place" calibration gages** — For the Computed calibration mode *only*, position the calibration gages over the workpiece image as required. (For details, see Chapter 5, *Pick and Place Functions*.)
6. **Set thresholds** — For the Computed calibration mode *only*, set the threshold cursors to a point where the reference edges are *optimized* along the X and Y calibration gages (For details, see Chapter 8, *Threshold, Filters, and Morphology.*)
7. **Select offsets** — For the Computed calibration mode *only*, select the two offsets on each calibration gage that correspond to the desired points between which the calibration measurements must take place.
8. **Calibrate** — For the Computed calibration mode *only*, enter X– and Y–axis dimensions and perform the "learn" functions.
9. **Select scale factors** — For the Absolute calibration mode *only*, enter the scale factors.

Image Setup

In preparation for the calibration procedure, you must acquire a camera image of a "calibration object," which can be any object whose dimensions in the X and Y axes are accurate enough to be used as the basis for calibrating the tools in your application. If the actual object to be inspected is not available, you should use an object of similar size to perform the calibration.

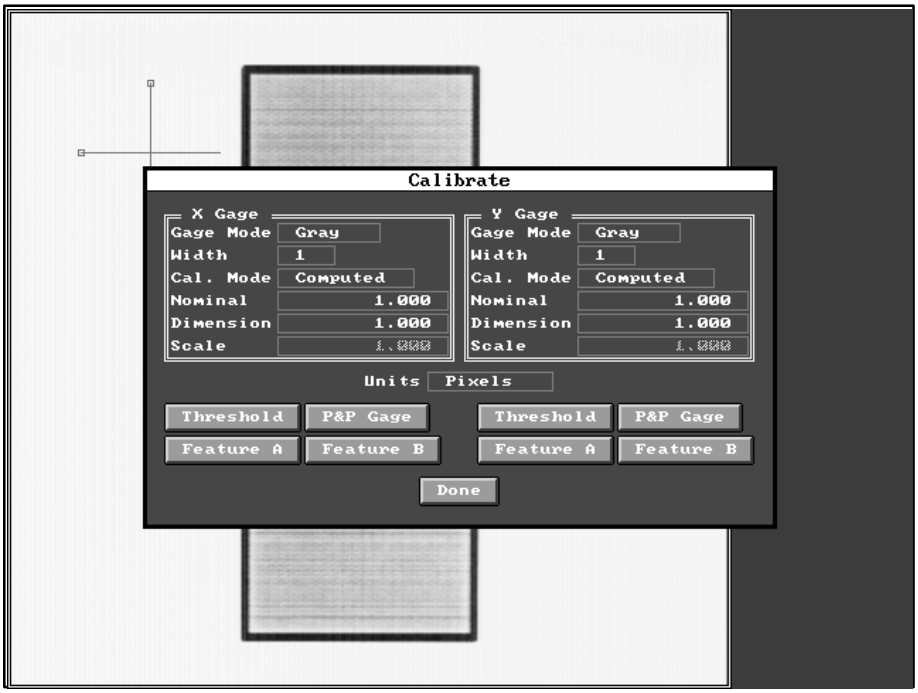
NOTE: You must select the camera *resolution* that you intend to use in your application *before* performing the calibration procedure. If you were to change the resolution selection *after* performing the calibration procedure, you would need to repeat the procedure.

Selecting Calibrate Function

After acquiring a camera image of your calibration object, your next step is to pick the Calibrate button on the appropriate Camera setup panel. When you do, the Calibrate panel and the X– and Y–axis calibration "gages" appear in the image field, as shown in Figure 3.11 (page 3–18).

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Figure 3.11 Calibrate Panel With X and Y Axis "Gages"



A calibration "gage" is essentially the same as a linear gage tool, but it has a few limitations that are appropriate to its use in the calibrate function.

The Calibrate panel has two sets of identical parameter selection fields and function selection buttons for the X–axis and Y–axis gages. These selection fields and buttons are described briefly, as follows:

- **Gage Mode** — This field selects either the *gray* scale mode or the *binary* mode of edge detection for the corresponding axis. Generally, you should select the same gaging mode for the calibrate gages *and* the gage tools in your application. The *default* gage mode is Gray. To change the gage mode, pick the gage mode field.
- **Width** — This field provides access to the selection of the gage width. The *default* setting is 1.
- **Cal. Mode** — This field selects either the Computed calibration mode or the Absolute calibration mode. The *default* is Computed. To change the calibration mode, pick the Cal.Mode field.
- **Nominal** — When you pick this field, the corresponding gage performs a linear measurement in *pixels*, with the results appearing in this field. The *default* value is 1.000.
- **Dimension** — Use this field to calibrate the X–axis or Y–axis by entering the *actual* dimension of the calibration object in "world units."

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- **Scale** — When the "Computed" calibration mode is selected, this field will display the computed "scale" value, which is the ratio of the "world units" dimension (such as inches) of the calibration object to the same dimension in *pixels* (the Nominal or "learned" value). When the "Absolute" calibration mode is selected, you can enter a predetermined scale value directly into this field.
- **P&P Gage** — The P&P Gage button activates the gage pick and place function. You can change the length and position of the calibrate gages, but you cannot rotate them from their X– or Y–axis orientation. For details about this function, see Chapter 5, *Pick and Place Functions*.
- **Threshold** — The Threshold button accesses the threshold cursors. For details about this function, see Chapter 8, *Thresholds, Filters, and Morphology.*
- **Feature A, Feature B** — The Feature A and Feature B buttons accesses the "feature," or edge selection panels for the respective features.
- **Units** — When you pick this field, a "typewriter" keyboard appears on the display, on which you can enter the appropriate name of the "world units" (such as "Inches").
- **Done** — When you pick the Done button, the system exits back to the Camera setup panel.

Calibrate Mode: Computed Mode vs Absolute Mode

The calibrate function provides two methods of calibration: the Computed mode, and the Absolute mode.

Computed mode — The calibrate function *defaults* to the Computed mode, which is the appropriate mode when you want the CVIM2 system to compute the calibration scale on the basis of you choice of "world units" (such as inches) per pixel. Using this mode, you position the calibration gages and perform a Nominal (or "learn") function to "learn" the calibration object dimension in *pixels*, then enter that dimension in world units (such as inches) to perform the scale computation.

Absolute mode — The Absolute mode is appropriate when you already know the scale values; that is, you know that each pixel in the image field represents *n* world units (such as inches), or fractions thereof. Using this mode, you simply enter the scale value, *n*. The calibration gages are not used.

Figure 3.12 (page 3–20) shows a Calibrate panel with the Computed mode selected for the X calibration gage and the Absolute mode selected for the Y calibration gage (normally, both calibration gages would use the *same* Cal.Mode selection).

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Figure 3.12 Calibrate Panel With Computed and Absolute Modes Selected



All parameter fields are shown in their *initial* state.

Note that in the Computed calibration mode the Scale field is *inactive* (shaded type), indicating that you cannot enter values into this field. It is for display only in the Computed mode. All of the other fields and buttons are *active*.

In the Absolute calibration mode, only the Cal.Mode and Scale fields are *active*, indicating that in this mode you can only enter a scale value or change the calibration mode.

Selecting Gaging Mode (Computed Mode Only)

Each of the calibrate gages can be configured to operate in *either* the binary gaging mode or the gray scale gaging mode, according to the requirements of the application.

- **Binary mode** — The binary gaging mode uses binarization thresholds to display and process pixels in two states, white and black. The only pixels displayed in binary are those that directly surround the gage in a box called the “area of interest.”

  The binary gaging mode is most appropriate when the inspected workpiece has a sharp black–and–white contrast with its background, such as when it is backlighted.

- **Gray scale mode** — The gray scale gaging mode detects edges and objects using the rate of change of the gray scale values of the pixels examined by the gage.

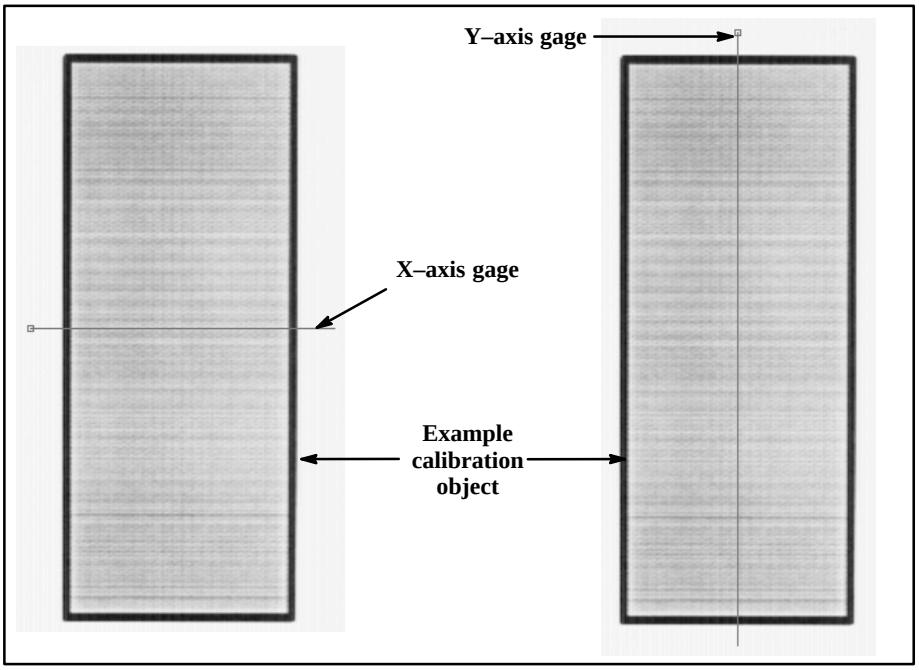
  Gray scale is appropriate when you need greater precision in linear measurements.

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Pick and Place Functions (Computed Mode Only)

After acquiring an appropriate camera image of the calibration object, as described under the *Image Setup* heading on page 3–17, you should pick the P&P Gage button for the X–axis (or Y–axis) gage, then position the gage so that it crosses the calibration object along the X–axis (or Y–axis). Figure 3.13 shows the X–axis and Y–axis gages positioned across an example calibration object.

Figure 3.13 Calibration Gages Positioned Over Example Calibration Object



If necessary, refer to Chapter 5, *Pick and Place Function*, for information about pick and placing gages.

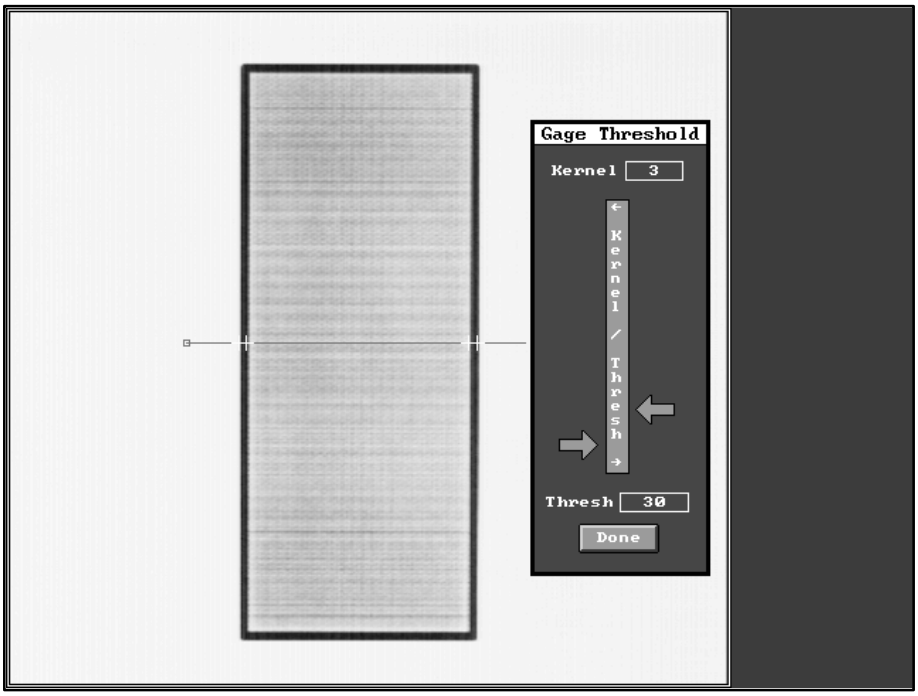
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Threshold Adjustments and Offset Selections (Computed Mode Only)

After positioning a gage across the calibration object, perform the threshold adjustment, whichever is appropriate for the selected gaging mode (binary or gray scale). For information about these adjustments, refer to Chapter 8 under the *Gaging Tools: Binary Threshold Procedures* or *Gaging Tools: Gray Scale Edge Detection*.

The threshold adjustments should be performed so that they result in cross (+) symbols appearing on the two *reference* edges on the calibration object, as illustrated by the example in Figure 3.14.

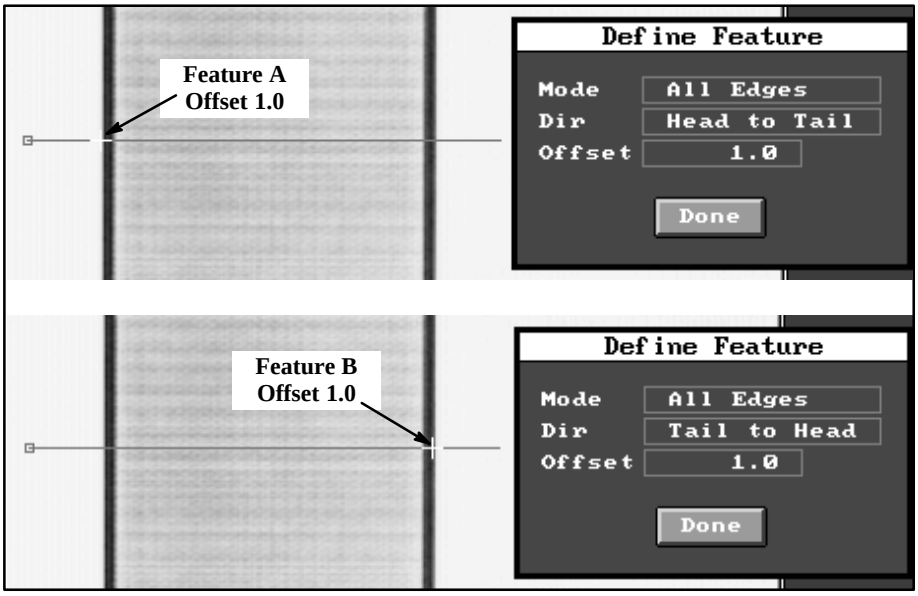
Figure 3.14 Example: Threshold Adjustment (Gray Scale Mode)



If additional +'s appear along the gage, as shown in Figure 3.14, pick the Feature A and Feature B buttons in the Calibrate panel to select the *offsets* that correspond to the proper reference edges. This is shown by the example in Figure 3.15 (page 3–23). In the example, offset 1.0 is selected for both "Feature A" and "Feature B." These offsets correspond to the *outside* edges on the calibration object.

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Figure 3.15 Example: Offset Selection



Units Selection

Selecting the "world units" involves simply selecting the appropriate name, such as "Inches," for the calibrated measurements. When you pick the Units field, a "typewriter keyboard" appears on the display. Initially, the name "Pixels" appears in the Units field and in the keyboard name field. To select a different world units name, pick the characters of that name, then pick the Enter button on the keyboard.

NOTE: The choice of world units *name* has *no* effect on the scale computations. It is for display purposes only.

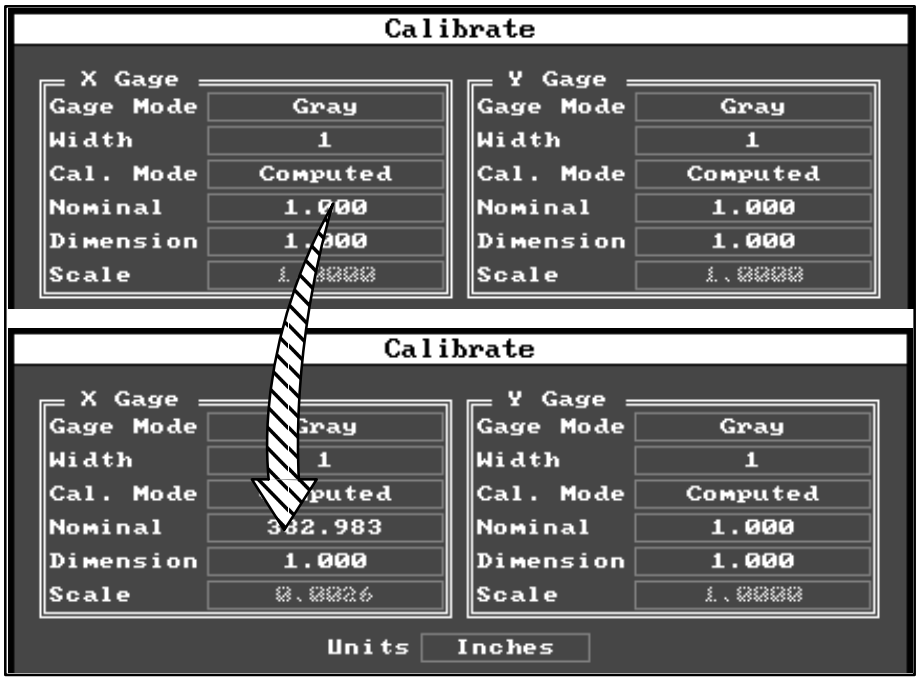
Performing Scale Computation (Computed Mode Only)

The scale computation is performed in two steps: determining ("learning") the distance between the two offsets on the calibration gage *in pixels*, and entering the distance between those offsets in "world units," such as inches.

The calibration object shown in Figure 3.14 (page 3–22) and Figure 3.15 provides an example for illustrating a scale computation. When you pick the Nominal field (which *initially* is always 1.000), the gage performs the learn operation, as shown in Figure 3.16 (page 3–24). The gage measures the distance between the Feature A and Feature B offsets along the X calibration gage and displays the result, *in pixels*, in the Nominal field.

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Figure 3.16 Example: Performing Nominal or "Learn" Operation



Note that the distance between the Feature A and B offsets — the Nominal value — is 382.983 *pixels*. Note also that the Scale value is now 0.0026, which is the ratio of the current Dimension value (1.000, the *default* value) to the current Nominal value (382.983). Thus, 1 ÷ 382.983 = 0.0026 (this is rounded to four places for display purposes *only*; the *actua*l value, stored in memory, is based on 32–bit floating point calculations).

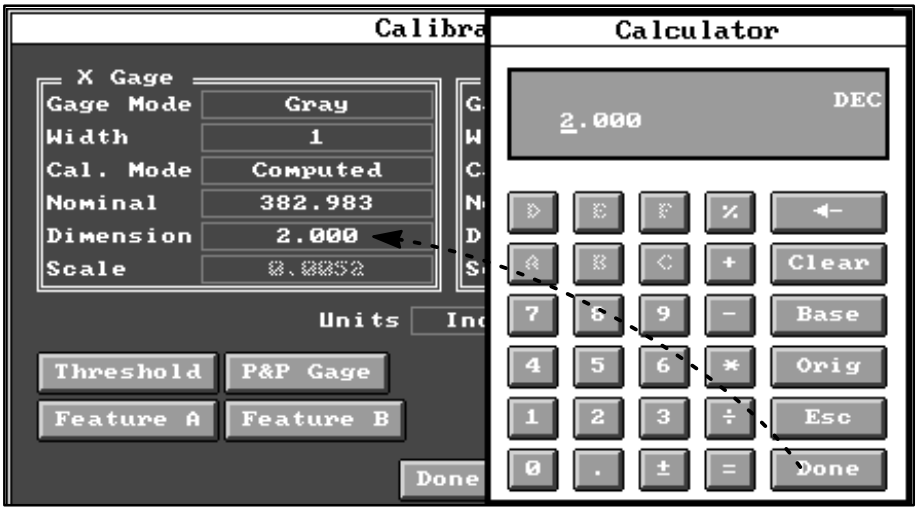
To complete the scale computation, and thereby calibrate the distance between the Feature A and B offsets to the "world units" distance of 2.000 *inches* (in this example), pick the Dimension field. When you do, the "calculator pad" appears. Enter 2.000 in the calculator and pick the Done button. At that point, the Scale value will be recomputed, and will appear as "0.012" in the Scale field, as shown in Figure 3.17 (page 3–25).

After completing the scale computation for one calibration gage, repeat the process for the other gage.

After completing the scale computation for *both* calibration gages, pick the Done button to exit the Calibrate panel and return to the selected Camera setup panel. Subsequent linear measurements by gages using images from the selected camera will be returned in inches (in this example).

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Figure 3.17 Performing Scale Computation to "Real World" Measurement Units

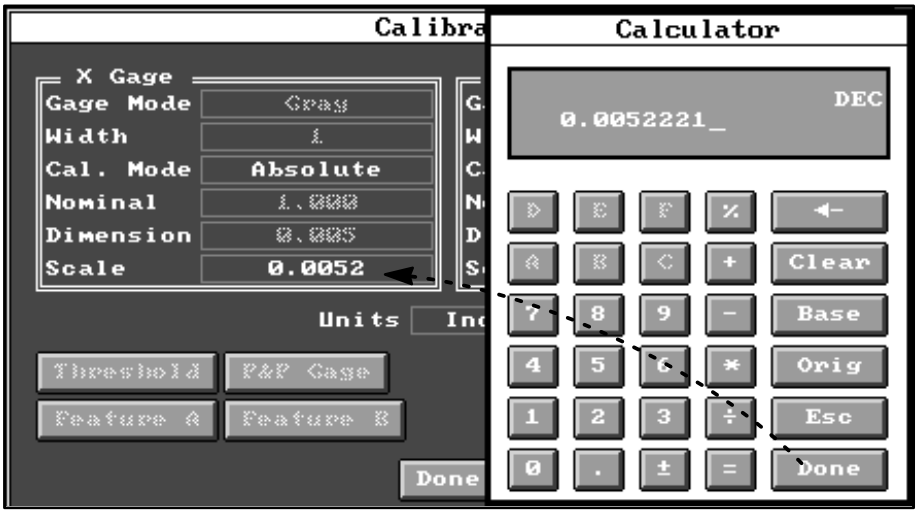


Entering Scale Value (Absolute Mode Only)

For applications in which the scale value can be calculated on the basis of specific lens sizes and settings, and where the exact relationship between pixels in the image field and "world units" values can be determined, you can select the Absolute calibration mode can enter the scale values directly into the Scale field.

Thus, if you determined that 382.983 pixels in the image field was equivalent to 2.000 inches (to borrow from the example in Figure 3.17), you would divide 2.000 by 382.983 to calculate the scale value (0.0052221, in this case) and enter that value *directly* into the Scale field, as shown in Figure 3.18.

Figure 3.18 Example: Entering Predetermined Scale Value (Absolute Mode)



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Note that the scale value that you entered (0.0052221) is *rounded* to four places (0.0052) in the Scale field; however, the original value is stored in memory exactly as you entered it.

After entering the predetermined scale values for *both* axes, pick the Done button to exit the Calibrate panel and return to the selected Camera setup panel. Subsequent linear measurements by gages using images from the selected camera will be returned in Inches (in this example).

Acquisition System Settings

When you pick the Acq.System button in the Acquisition Editor panel, the Acquisition System Settings panel appears, as shown in Figure 3.19.

Figure 3.19 Selecting the Acquisition System Settings Panel



The Acquisition Systems Settings panel selects the default camera type, the horizontal and vertical sync sources, and camera bank switching parameters. The panel contains a scrolling list and several parameter selection fields, which are described briefly as follows:

- **Default Camera Type panel** — This scrolling list panel enables you to select a *default* camera type. This camera type sets the horizontal and vertical timing and scan modes for the entire system.
- **Horizontal Reference box** — This box selects either the internal or an external horizontal reference source.
- **Vertical Reset Source box** — This box selects either the internal or an external vertical reset source.
- **Bank Switch Mode** — This field selects the bank switch mode. The choices are "On Command" or "Automatic."

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- **Bank Switch Command Input** — This field selects the bank switch command input assignment on either the Module I/O or the System I/O. It is active only when the "On Command" bank switch mode is selected.
- **Bank Switch State Output** — This field selects the bank switch command output source (from either the Module I/O or the System I/O) when the bank switch mode is "On Command."

Default Camera Type

The CVIM2 system uses the *default* camera type as the basis for determining the horizontal and vertical frequencies that regulate the "squareness" of the pixels in the camera image. Thus, for example, when the 2801–YC camera is selected as the *default* camera type, images from a 2801–YC camera will contain the *squarest* possible pixels, while images from *other* cameras (such as the 2801–YD) will not be square.

For applications using more than one camera type, the *default* camera type should be selected for the camera(s) whose inspection tasks (such as rotation finder) are the most sensitive to pixel squareness.

Horizontal Reference Source

For most applications, the CVIM2 system can supply horizontal timing or "sync" signals for all cameras on the basis of the horizontal reference for the *default* camera type. For some applications, however, an *external* horizontal timing source may be required. Here are two such application situations requiring an external horizontal reference:

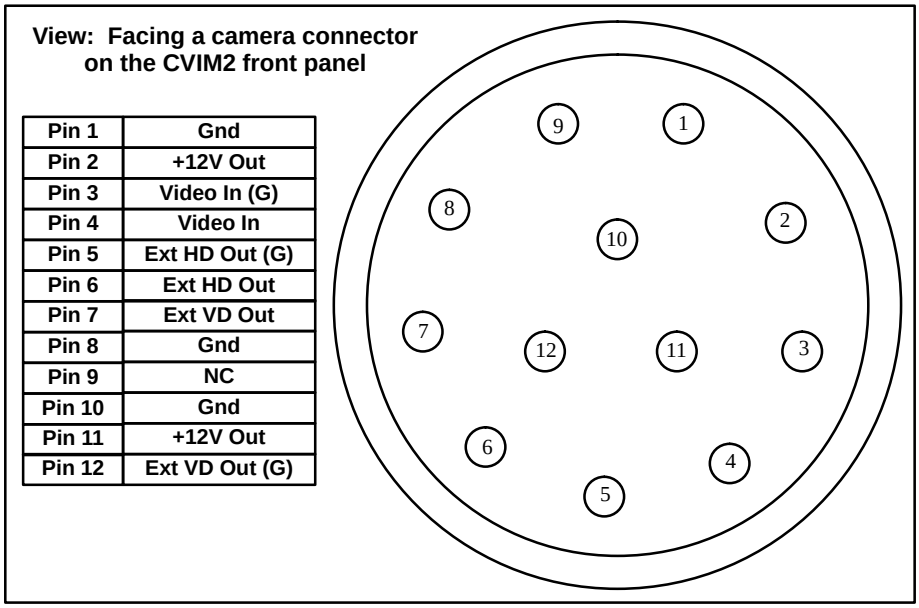
- A *non–standard* camera is used, and it generates its own horizontal timing signals and *cannot* be driven from the CVIM2 system.
- A "genlock" timing device is used to synchronize all CVIM2 systems and cameras when multiple systems and/or cameras are used.

In either of these situations, "External, Cam.4 In" should be selected in the H.Reference box. In addition, a cable from the external synchronizing source must be attached to the camera #4 input on the CVIM2 front panel.

NOTE: The Allen–Bradley Company does not supply cables for connecting external timing sources to the camera connectors on the CVIM2 front panel. Thus, when a cable must be fabricated, use the pinout diagram shown in Figure 3.20 (page 3–28) as the basis for wiring the cable.

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Figure 3.20 Pinout Diagram: CVIM2 Front Panel Camera Connector



Vertical Reference Source

For most applications, the CVIM2 system can supply vertical timing or "sync" signals for all cameras. However, for some applications (except those using *frame reset* cameras) an *external* vertical timing source, synchronous or asynchronous, may be required. Here are three application situations using an external vertical reference:

- A *non–standard* camera is used, and it generates its own vertical (and horizontal) timing signals and *cannot* be driven from the CVIM2 system.
- A "genlock" timing device is used to synchronize all CVIM2 systems and cameras when multiple systems and/or cameras are used.
- Two CVIM2 systems are used, and camera #1 on one system (the *master*) supplies vertical (but *not* horizontal) "sync"to camera #1 on the other system (the *slave*) through the camera #4 connector on each system. Cameras #2 and #3 on the two systems can be linked in a similar manner through the camera #5 and #6 connectors on each system.

In the first two situations, where both the vertical *and* the horizontal timing signals must be synchronized externally "External, Synchronous, Cam.4 In" must be selected in the Vertical Reset Source box. In the third situation, where only the vertical timing signals are synchronized, "External, Asynchronous, Cams.4, 5 and 6 In" must be selected.

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Camera Bank Switching

The CVIM2 system can service three cameras inputs at one time: cameras #1, #2, and #3, *or* cameras #4, #5, and #6. The bank switch function provides a means of switching between the two "banks" of cameras while the system is operating *online*. (By *default*, cameras #1, #2, and #3 are always selected after system powerup.)

NOTE: In order to use camera inputs #4, #5, and/or #6, you must install an external +24VDC power supply as described in Chapter 1, *Hardware Connection and Powerup Check*.

Bank Switch Mode

The bank switching function can be initiated either *on command*, from a signal on a discrete *input*, or *automatically*, from a trigger signal to the unselected camera bank. You can choose the switching mode by picking the Bank Switch Mode field in the Acquisition System Settings panel. When you pick this field, it toggles from On Command to Automatic, or vice versa.

On Command — This bank switch mode requires using a discrete input to select the appropriate camera bank. For this purpose, you must pick the Bank Switch Command Input field to select an available input in either the Module I/O or the System I/O discrete I/O editor panel.

When a *signal level change* occurs on the assigned input, the system *switches* from one camera bank to the other. Thus, if cameras #1, #2, and #3 are currently active, and the bank switch signal level is *asserted*, the system will deactivate cameras #1, #2, and #3 and activate cameras #4, #5, and #6. Subsequently, when the bank switch signal level *drops*, the system will activate cameras #1, #2, and #3 and deactivate cameras #4, #5, and #6.

A delay will occur from the moment that the bank switch input level changes until the system is ready to process triggers, as follows:

- Polling latency delay: approximately 25ms to respond to the level change, *plus*
- Bank switch delay:
  - — Cameras across banks #1 and #4, #2 and #5, or #3 and #6 are *compatible* (that is, both are free–running cameras, such as the 2801–YC or –YD, or both are frame reset cameras, such as the 2801–YE): approximately 80ms, *or*
  - — Cameras across banks #1 and #4, #2 and #5, or #3 and #6 are *not compatible* (that is, one is a free–running camera, such as the 2801–YC or –YD, and the other is a frame reset camera, such as the 2801–YE): approximately 200ms.

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Note that the delays are *cumulative*; that is, the total delay consists of the polling latency *plus* one of the two bank switch delays.

Automatic — This bank switch mode causes the CVIM2 system to switch automatically to the inactive camera bank when it receives a trigger corresponding to one of the unselected bank's cameras. Thus, if cameras #1, #2, and #3 were currently selected and a trigger arrived for camera #4, the bank switch to cameras #4, #5, and #6 would take place automatically.

A delay will occur from the start of a trigger until the system is ready to process the trigger, as follows:

- When the trigger queue is empty, no acquisition is in progress, a bank switch is required to process the trigger, and *either*:
  - — Cameras across banks #1 and #4, #2 and #5, or #3 and #6 are *compatible* (that is, both are free–running cameras, such as the 2801–YC or –YD, or both are frame reset cameras, such as the 2801–YE): approximately 40ms, *or*
  - — Cameras across banks #1 and #4, #2 and #5, or #3 and #6 are *not compatible* (that is, one is a free–running camera, such as the 2801–YC or –YD, and the other is a frame reset camera, such as the 2801–YE): approximately 160ms.
- When the trigger queue is *not* empty, it is placed in the trigger queue, and processing is delayed further until all previous triggers are processed (all triggers are handled *sequentially*).

Note that the delays are *cumulative*; that is, the total delay consists of the trigger queue delay *plus* one of the bank switch delays.

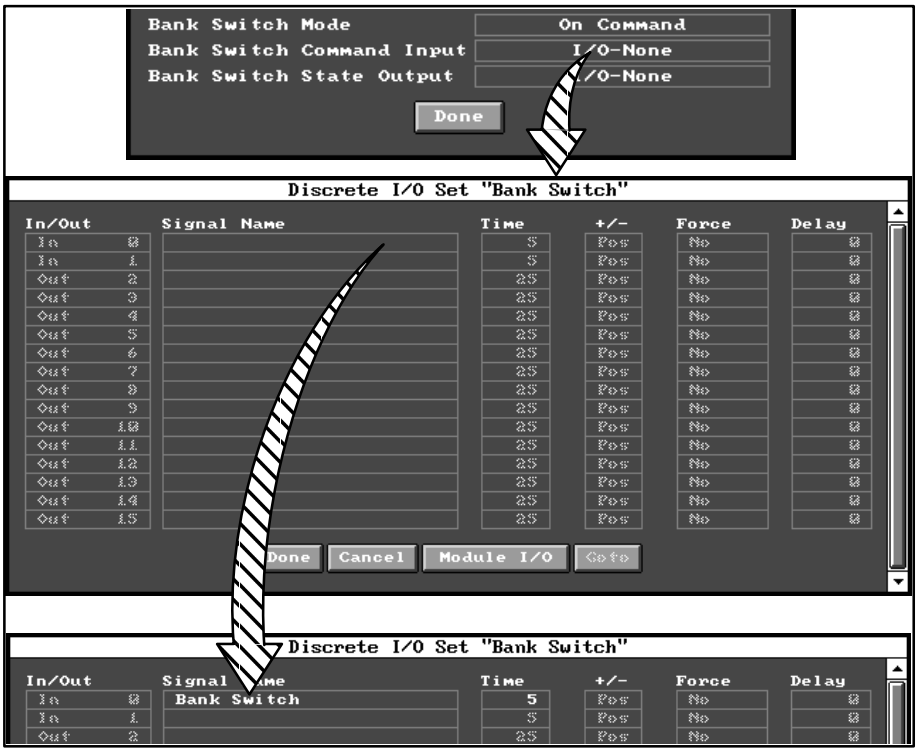
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Bank Switch Command Input

The Bank Switch Command Input field is active only when the On Command bank switch mode is selected. This field accesses a discrete I/O edit panel, where you can assign the Bank Switch command to one of the Module I/O or System I/O inputs, and thereby control bank switching from your process equipment.

When you pick the Bank Switch Command Input field in the Acquisition System Settings panel, the Module I/O panel appears, as shown in Figure 3.21.

Figure 3.21 Example: Assigning Bank Switch to Module I/O Input 0



(Note that the Module I/O panel always appears first by *default*. If you want to assign the bank switch function to a System I/O input, you can pick the Module I/O button to access the I/O Device panel, from which you can then select the System I/O panel.)

As the example in Figure 3.21 illustrates, when you pick the "In 0" field in the Module I/O panel, "Bank Switch" appears in the field, indicating that it is now assigned as Module I/O input 0. (Note that you can *remove* Bank Switch from input 0 by picking the same field again.)

After assigning the bank switch function to the appropriate input, pick the Done button to exit back to the Acquisition System Settings panel.

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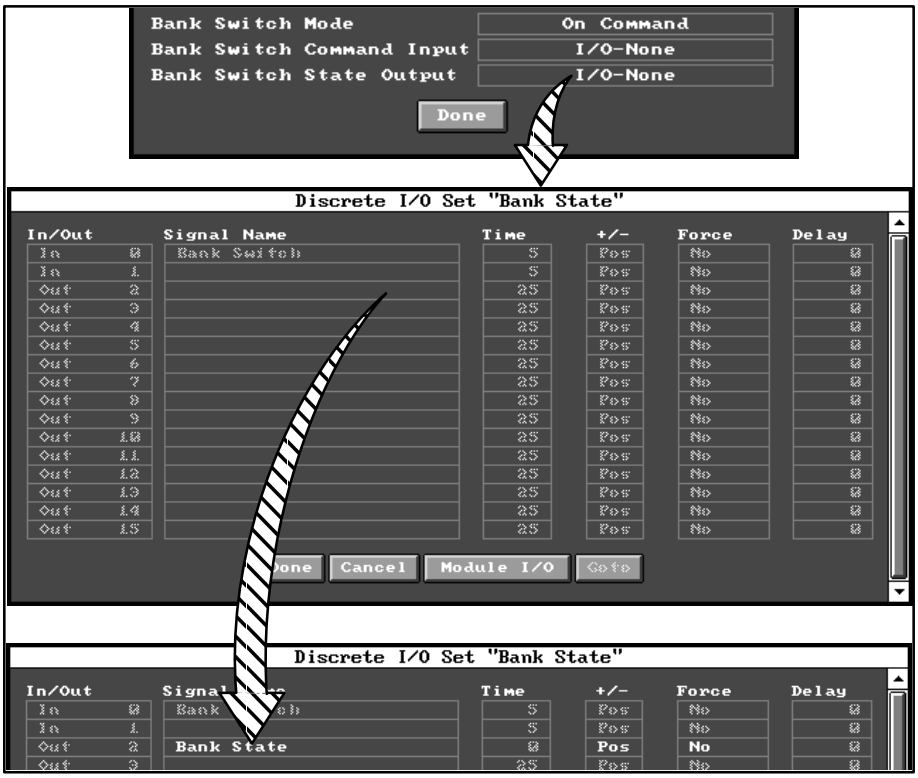
Bank Switch State Output

The Bank Switch State Output field accesses a discrete I/O edit panel, where you can assign the Bank State status signal to one of the Module I/O or System I/O outputs, and thereby enable the CVIM2 system to signal your process equipment when a bank switch has occurred.

NOTE: The Bank State signal is always *inactive* when cameras #1, #2, and #3 are active, and is always *active* when cameras #4, #5, and #6 are selected.

When you pick the Bank Switch State Output field in the Acquisition System Settings panel, the Module I/O panel appears, as shown in Figure 3.22.

Figure 3.22 Example: Assigning Bank State to Module I/O Output 2



(Note that the Module I/O panel always appears first by *default*. If you want to assign the Bank State signal to a System I/O output, you can pick the Module I/O button to access the I/O Device panel, from which you can then select the System I/O panel.)

As the example in Figure 3.22 illustrates, when you pick the "Out 2" field in the Module I/O panel, "Bank State" appears in the field, indicating that it is now assigned as Module I/O output 2. (Note that you can *remove* Bank State from output 2 by picking the same field again.)

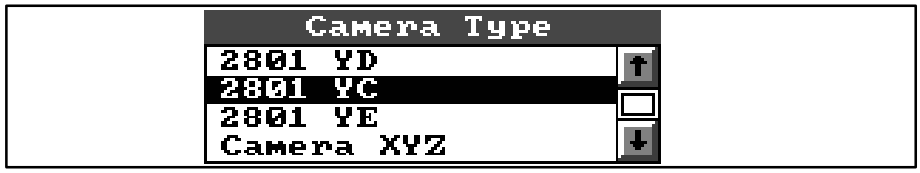
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After assigning the bank state status to the appropriate output, pick the Done button to exit back to the Acquisition System Settings panel.

Camera Type: Selection and Editing

The Camera Type scrolling list, as shown in Figure 3.23, appears in two places: the Acquisition Editor panel, and all of the Camera panels.

Figure 3.23 Example: Camera Type Scrolling List Panel



This list shows all of the "standard" cameras that the Allen–Bradley Company supports, along with any number of *non–standard* cameras (such as "Camera XYZ" in the example) that a user has configured for use with the CVIM2 system.

The *highlighted* camera name in the scrolling list is the currently *selected* camera type (2801 YC in the example). To select another name, just pick the name. When you do, the new name is highlighted and the previous name is *un*highlighted.

In the Acquisition Editor panel, you can edit some of the selected camera's timing parameters, and you can copy a listed camera type to create a new non–standard camera type under a different name.

In a Camera panel, the selected camera type should correspond to the type that will be connected to the camera port whose number is shown in the Camera panel title bar (such as "Camera 1"). In addition, you can edit some of the selected camera's timing parameters.

Camera Type Edit Panel

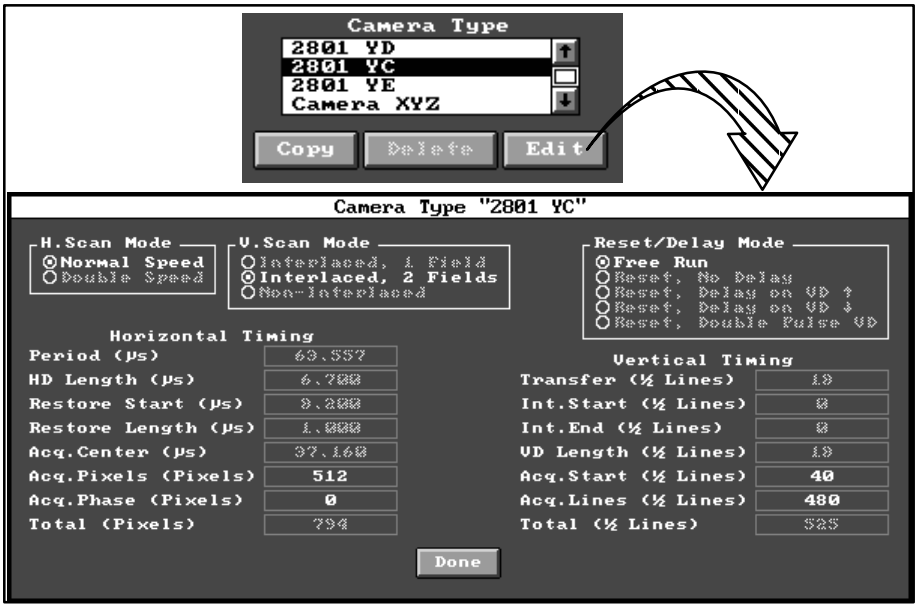
The Camera Type edit panel contains several parameter selection boxes and fields pertaining to the camera timing and scan modes for each camera type. For the *standard* Allen–Bradley cameras (2801–YC, –YD, YE, and YF), most of these parameters are inaccessible — they cannot be changed. For *non–standard* camera types, however, most of the parameters are accessible and can be changed to whatever values are appropriate for a particular non–standard camera.

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Editing Standard Allen–Bradley Cameras

When you highlight one of the standard camera types in the Camera Type scrolling list panel and then pick the Edit button below the panel, a Camera Type edit panel appears. Figure 3.24 shows the edit panel for the 2801–YC "standard" camera. The parameters shown in *shaded* type are the ones that *cannot* be changed for standard Allen–Bradley cameras. For these cameras, only a few of the horizontal and vertical timing parameters can be changed.

Figure 3.24 Example: Selecting Camera Type Edit Panel



Although these parameters *can* be adjusted, the *default* values for the current standard Allen–Bradley cameras are normally appropriate for most applications.

The *effect* of adjusting the Horizontal Timing parameters is described briefly, as follows:

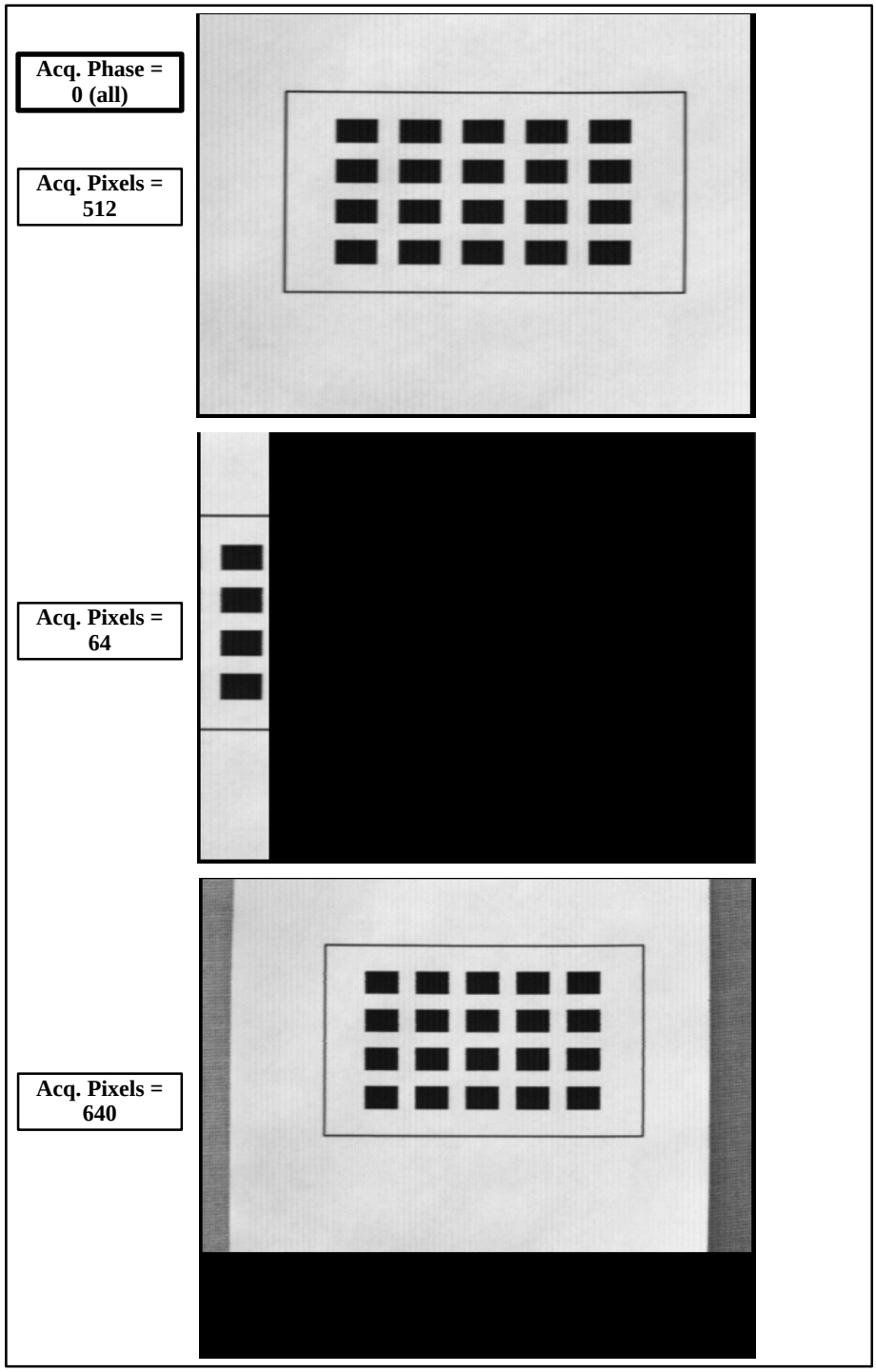
Acq. Pixels (Pixels) — This parameter indicates the number of pixels that are acquired across the image *horizontally.* Normally, the *default* setting of 512 is appropriate; however, the Acq.Phase (Pixels) value can be set within the following range:

$$64 \leqq \text{Value} \leqq 640 - 2(\text{Acq. Phase})$$

Figure 3.25 (page 3–35) shows the effects of changing the value of the Acq. Pixels (Pixels) parameter to 640 (the maximum) and 64 (the minimum). As the examples in Figure 3.25 show, the effect of *increasing* the value is to acquire the image, up to its *full width* (640 pixels), while the effect of *decreasing* the value is to truncate the image *equally* on both sides of the image. In this case, only the *center* 64 pixels of the image is acquired.

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Figure 3.25 Example: Effect of Different Acq.Pixels Settings on Displayed Image



Acq. Phase (Pixels) — The acquired pixels are normally *centered* within the camera's field of view (centered on pixel 320 out of 640). By changing the value of the Acq. Phase (Pixels) parameter, you can shift the center of the acquired region left or right. Normally, the *default* setting of 0 is appropriate;

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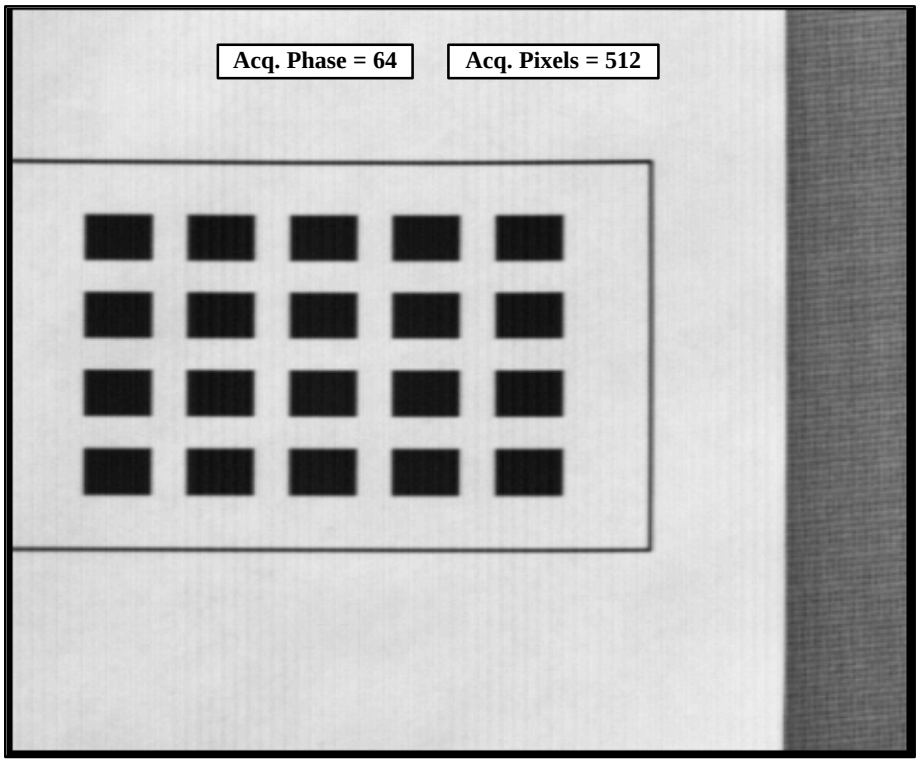
however, the Acq.Phase (Pixels) value can be set within the following range:

$$-(640 - \text{Acq. Pixels}) \div 2 \leqq \text{Value} \leqq +(640 - \text{Acq. Pixels}) \div 2$$

NOTE: Changing the Acq. Pixels and Acq. Phase values does *not* affect the image acquisition time.

The example in Figure 3.26 shows the effect of changing the value of the Acq. Phase (Pixels) parameter to 64 (with the Acq. Pixels (Pixels) parameter set to 512, in this case). Note that this image appears shifted to the *left*, compared to the "512" image shown in Figure 3.25 (page 3–35). In fact, the leftmost 64 pixels of the image are truncated in this case.

Figure 3.26 Example: Effect of Maximum Acq. Phase Setting on Displayed Image



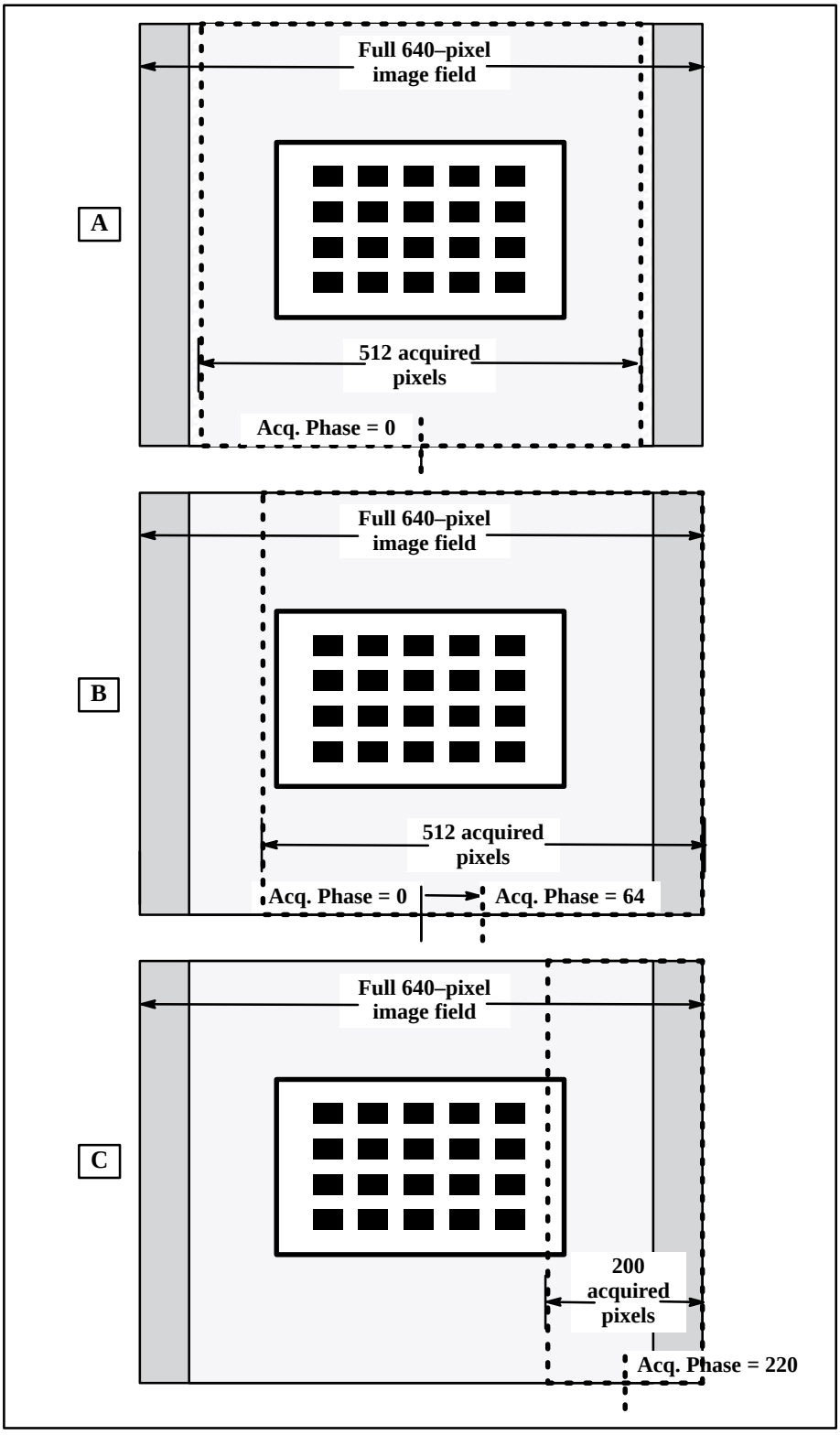
In Figure 3.27 (**A**) on page 3–37, the dotted lines show that the *center* of the 512 acquired pixels is *centered* in the full 640–pixel image when Acq. Phase (Pixels) is set is 0. In Figure 3.27 (**B**), the dotted lines show that the *center* of the 512 acquired pixels has moved 64 pixels to the *right* when the Acq. Phase (Pixels) is set is 64 (this is the example shown in Figure 3.26).

Note that the *reverse* would be true if the Acq. Phase (Pixels) were set to –64. In that case, the displayed image would appear shifted to the *right*.

In another example, shown in Figure 3.27 (**C**), if you wanted only the *rightmost* 200 pixels in the image to be acquired, you could set Acq. Phase (Pixels) to 220 and Acq. Pixels (Pixels) to 200.

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Figure 3.27 Example: Effect of Acq. Phase Settings on Acquired Pixels



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The *effect* of adjusting the Vertical Timing parameters is described as follows:

Acq.Start (1/2 Lines) — This parameter indicates the point at which the image acquisition begins for the purpose of image processing and display. Normally, the *default* setting of 40 is appropriate; however, the Acq.Start (1/2 Lines) value can be set within the following range:

$$40 \leqq \text{Value} \leqq 40 + (480 - \text{Acq. Lines})$$

Acq.Lines (1/2 Lines) — This parameter indicates the number of half–lines of the image field that are acquired, beginning at the starting point set by the Acq.Start (1/2 Lines) parameter. Normally the *default* value of 480 is appropriate; however, the Acq.Lines (1/2 Lines) value can be set within the following range:

$$64 \leqq \text{Value} \leqq 520 - \text{Acq. Start}$$

Figure 3.28 (page 3–39) illustrates three image displays in which the Acq.Lines (1/2 Lines) values are set to 480 (*default*), 240 and 64.

As the examples in Figure 3.28 show, the effect of *decreasing* the value of the Acq.Lines (1/2 Lines) parameter is to reduce the number of half–lines acquired, and the result is to decrease the image height.

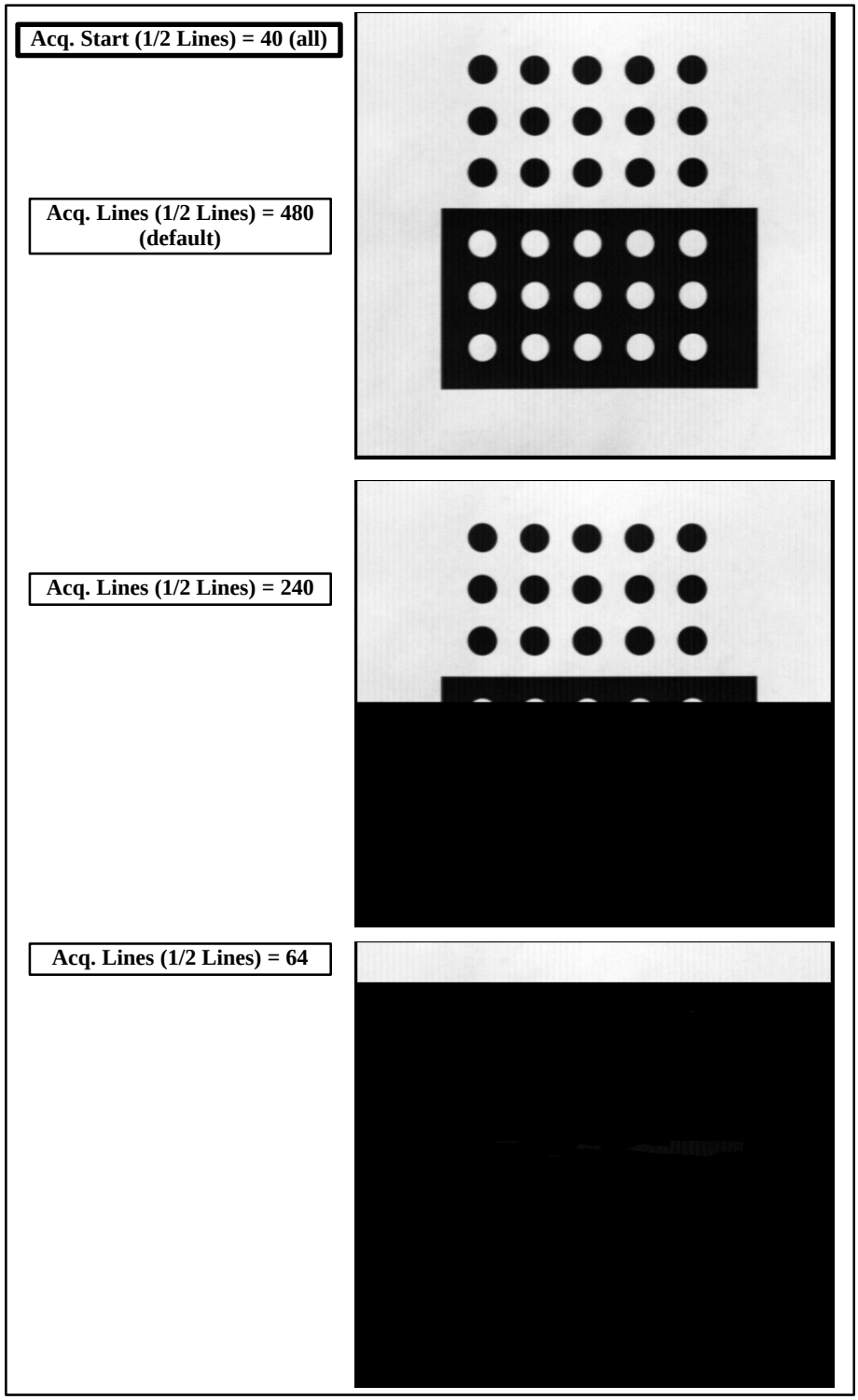
Changing *both* of these parameters might be useful in a situation in which a narrow, horizontally oriented inspected object lies in a narrow band at the center (or lower) part of the image. In this case, you could set the Acq.Start (1/2 Lines) parameter to, for example, 220, and set the Acq.Lines (1/2 Lines) parameter to 64. The result would be a vertically narrow image with just enough room to contain the inspected object.

Figure 3.29 (page 3–40) illustrates the result, using a pen as the inspected object. In this example, the pen was located in a lower part of the unmodified *full* image, whereas the *vertically truncated* image containing the pen appears “justified” at the *top* of the image display.

In *all* cases the sum of the Acq.Start (1/2 Lines) setting and the Acq.Lines (1/2 Lines) setting cannot exceed 523. Any combination of the two parameters is acceptable whose sum does not exceed 523.

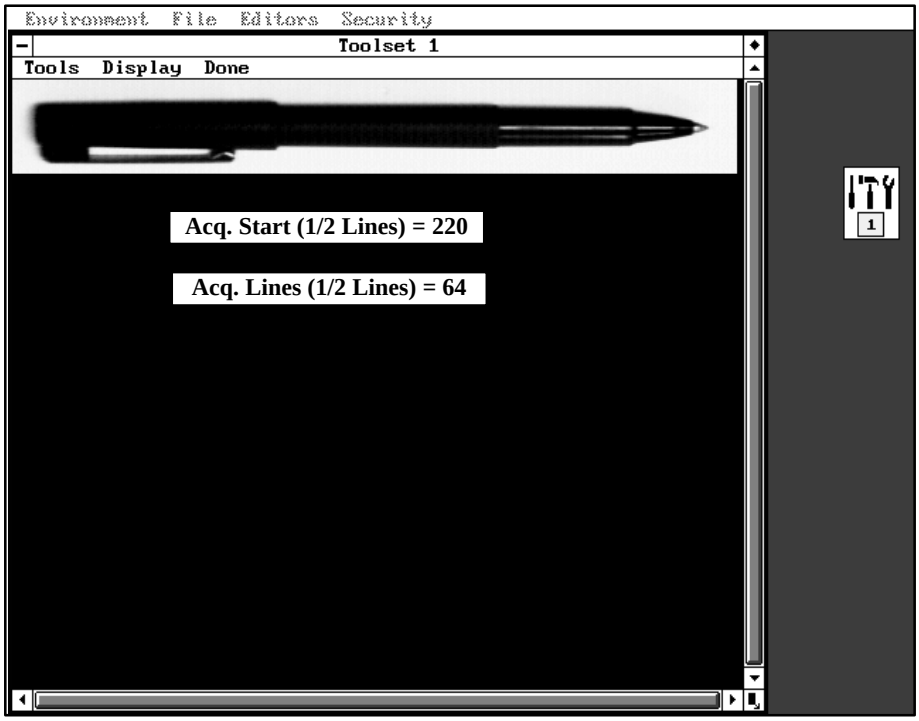
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Figure 3.28 Example: Effect of Various Acq. Lines (1/2 Lines) Settings on Image



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Figure 3.29 Example: Effects of Changing Horizontal Image Acquisition Parameters



Editing Non–Standard Cameras

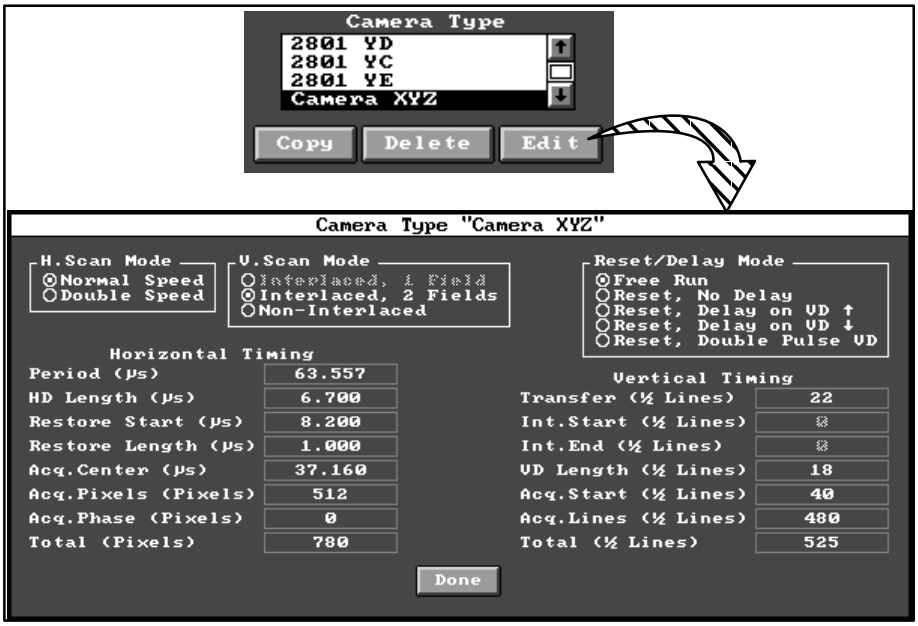
A *non–standard* camera is any camera other than the Catalog No. 2801–YC, –YD, –YE, or –YF cameras that the Allen–Bradley Company offers. In order to accommodate a non–standard camera, you must "create" a new camera type under an appropriate name, then access that camera's edit panel and enter the timing and scan mode parameters that are appropriate for that camera.

This is done by highlighting one of the standard camera types, then picking the Copy button to "copy" that camera type under a *different* name, one that is appropriate for the camera type.

When you highlight a non–standard camera type in the Camera Type scrolling list panel, and then pick the Edit button below the panel, a Camera Type edit panel appears. Figure 3.30 (page 3–41) illustrates this with the example "Camera XYZ" non–standard camera. Note that most of the parameter selections in this edit panel are shown in *light* type, which indicates that they can be changed.

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Figure 3.30 Setup Camera Type Panel: Camera XYZ



Most of the data for these parameter selections can be obtained from the user and/or service manuals that are supplied with the *non–standard* camera. Here is a brief description of each parameter selection field and box in the Camera Type edit panel.

- **H.Scan Mode** — This box selects either a normal speed or a double speed scan mode. The basic difference is that a normal speed camera acquires 240 vertical lines of data in 17ms, while a double speed camera acquires 480 vertical lines of data (a “full” frame) in 17ms. The double speed camera also has frame reset capability.
- **V.Scan Mode** — This box selects interlaced operation using one or two fields, or non–interlaced operation, according to the camera type in use. For the 2801–YC and –YD cameras, Interlaced, 2 Fields is selected, while for the 2801–YE frame reset camera, Interlaced, 1 Field is selected. In each case, the other selections are *inactive* (shaded type), and cannot be selected. For *non–standard* cameras, the V.Scan mode selection can be determined from the camera manufacturer’s specifications.
- **Reset/Delay Mode** — This box selects the free running mode or one of the reset/delay modes, according to the camera type in use. For the 2801–YC and –YD cameras, Free Running is selected, while for the 2801–YE frame reset camera, Reset, Double Pulse VD is selected. In each case, the other selections are *inactive* (shaded type), and cannot be selected. For *non–standard* cameras, the appropriate Reset/Delay mode selection can be determined from the camera manufacturer’s specifications.

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- **Period (µs)** — This is amount of time required to scan one horizontal line. It is equal to the *reciprocal* of the horizontal frequency. (For the 2801–YC camera, the horizontal frequency is 15.734KHz; thus, the period is 1 ÷ 15.734KHz = 63.557µs.)
- **HD Length** — This is the duration, stated in microseconds, of the "active low" HD (horizontal drive) pulse provided to the camera from the CVIM2 system.
- **Restore Start (µs)** — This is starting point of the DC restore pulse, which the CVIM2 system uses during each horizontal line to "sample" the analog composite video signal at a time when the camera sees "black." (For the 2801–YC camera, the center of this pulse is located halfway between 6.3µs and 10.8µs after the start of the horizontal drive pulse; thus, the *start* of the restore start pulse is 8.2µs after the start of the horizontal drive pulse.)
- **Restore Length (µs)** — This is the *duration* of the DC restore pulse. (For the 2801–YC camera, it is 1µs.)
- **Acq. Center (µs)** — This is the center of the image sensing area (the acquired picture), in microseconds, after the start of the horizontal drive pulse. (For the 2801–YC camera, it is 37.20µs after the start of the HD pulse.)
- **Acq.Pixels (Pixels)** — Refer to the *Editing Standard Allen–Bradley Cameras* section for details.
- **Acq.Phase (Pixels)** — Refer to the *Editing Standard Allen–Bradley Cameras* section for details.
- **Total (Pixels)** — This value represents the number of times that the CVIM2 system "samples" each horizontal line of the analog composite video signal from the camera in the process of *digitizing* the video signal.

  NOTE: The frequency range limit of the CVIM2 system is 10MHz to 20MHz. Since the frequency is a function of the camera's *period* and the Total (Pixels) selection, any combination of these values must lie within that range. The frequency is the reciprocal of the camera's *period* divided by the *total pixels*; or stated another way, the *total pixels* divided by the *period*. For example, the period of the 2801–YC camera is 63.557µs, and the total pixels is 794. Thus, the frequency is 794 ÷ 63.557µs, or 12.5MHz, which is well within the CVIM2 system's frequency range limits.
- **Transfer (1/2 Lines)** — This value applies only to free–running, interlaced CCD cameras. "Transfer" refers to the process by which image data is transferred from the image sensor to the shift register for the current image field. During this time, the CVIM2 will not fire a strobe.

  The Transfer value indicates the time, stated in 1/2 lines, *around* which a strobe will not be fired. For the 2801–YC camera, the Transfer value is the 16 half lines, and the transfer time is two half lines *before* to two half lines *after* this point. Thus, the CVIM2 system will not fire a strobe during that interval.

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NOTE: For MOS–type cameras, which do not use shift registers, the Transfer value can be set to –1 to *disable* the strobe–inhibiting period. These cameras have no restrictions as to when the strobe can be fired.

- **Int. Start (1/2 Lines)** — This value applies only to frame reset cameras. Int. Start is the time, stated in 1/2 lines, after the assertion of the first vertical drive (VD) pulse. This is the point at which the camera starts image integration.
- **Int. End (1/2 Lines)** — This value applies only to frame reset cameras. Int. End, stated in 1/2 lines, indicates the point at which a frame reset camera stops image integration.

  For cameras using the Reset, Delay on VD ↓ selection, it is the time after the active–low vertical drive (VD) pulse goes "up" (high) that the camera stops image integration. For cameras using the Reset Double Pulse VD selection, it is the time after the assertion of the second VD pulse. This is the point at which the camera stops image integration.

  For cameras using the Reset, Delay on VD ↑ and Reset, No Delay selections, Int. End has no meaning.
- **VD Length (1/2 Lines)** — This value is the duration, stated in 1/2 lines, of the "active low" VD (vertical drive) pulse from the CVIM2 system. (For frame reset cameras using the Reset, Delay on VD ↓ selection, the length increase by the amount of the selected shutter speed.)
- **Acq. Start (1/2 Lines)** — Refer to the *Editing Standard Allen–Bradley Cameras* section for details.
- **Acq. Lines (1/2 Lines)** — Refer to the *Editing Standard Allen–Bradley Cameras* section for details.
- **Total (1/2 Lines)** — This value is the total number of half lines that the camera system uses in one cycle. For the Allen–Bradley standard cameras, Total is always 525.

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Trigger Setup Panel

When you highlight a toolset trigger name in the Toolset Trigger scrolling list and then pick the Edit button below the list, the corresponding Toolset Trigger setup panel appears, as shown in Figure 3.31.

Figure 3.31 Example: Selecting Trigger Setup Panel



NOTE: Initially, the term "None" appears in this list. A toolset trigger name will appear in the Toolset Trigger list *only* after an inspection name has been defined for a toolset in the Configuration Editor panel, as described in Chapter 4, *Inspection Configuration*, on page 4–9.

The selections in the Toolset Trigger setup panel determine the camera port, the trigger source, and four of the discrete I/O settings for *online* inspection operations. These selections apply *only* to the particular toolset named in the title bar of the Toolset Trigger panel. Thus, in the example in Figure 3.31, the toolset is named "Toolset 12."

Here is a brief description of the selections in the Toolset Trigger panel:

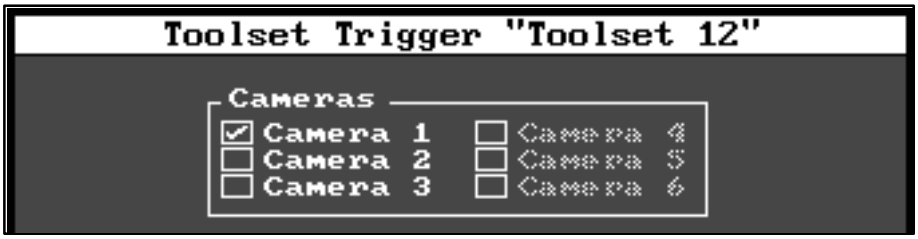
- **Cameras** — This selects the camera(s) to be used for the toolset.
- **Trigger** — This selects the trigger source for the toolset.
- **Rate per Minute** — When "Auto" is selected as the (internal) trigger source, this selects the number of trigger signals per minute.

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- **Source I/O** — When “I/O” is selected as the (external) trigger source, this selects the discrete input in the Discrete I/O Edit panel.
- **Strobe I/O** — When a strobe light is to be used, this selects the discrete output for the strobe trigger.
- **Ack I/O** — For applications requiring the trigger ACK signal, this selects a discrete output for the signal.
- **Nak I/O** — For applications requiring the trigger NAK signal, this selects a discrete output for the signal.

NOTE 1: The trigger source and signal assignments can be applied *only* to cameras 1, 2, and/or 3, *or* cameras 4, 5, and/or 6. This is shown in Figure 3.32. Camera #1 is selected initially by *default*.

Figure 3.32 Example: Inactive Camera Selections in Toolset Trigger Panel



NOTE 2: When camera 4, 5, or 6 is used, an external +24VDC power supply must be used, as described in Chapter 1, *Hardware Connection and Powerup Check*, of this manual, and the Allen–Bradley Pyramid Integrator Installation Manual, Publication 5000–6.2.10, which is supplied with the Pyramid Integrator chassis.

The trigger selection field in the Toolset Trigger panel, shown in Figure 3.33, offers *two* choices of trigger operation based on an internal source (Auto) or an external source (I/O). Figure 3.33 shows that Auto is currently selected. To “toggle” to I/O, pick the Trigger field. To toggle back to Auto, pick the field again.

Figure 3.33 Trigger Selection Field in Trigger Setup Panel

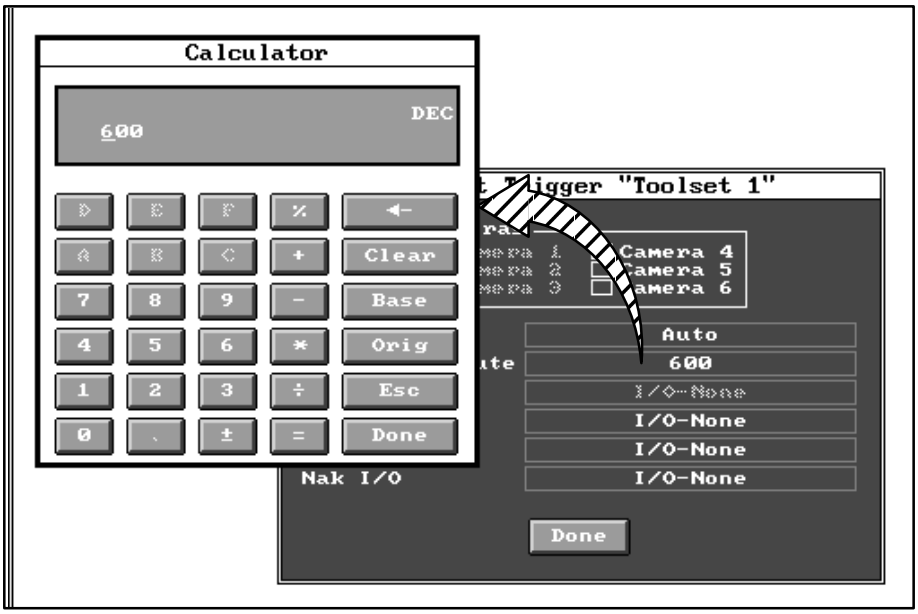


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The Auto selection uses the CVIM2 system's *internal* trigger source, whereas the I/O selection uses one of the discrete inputs for an *external* trigger source.

The internal trigger's default trigger signal rate is 600 triggers per minute. To change the rate, pick the Rate per Minute field. When you do, the "calculator pad" appears, as shown in Figure 3.34. Enter any value within a range of 30 to 3600 by picking the appropriate digits for that value, then picking the Done button (in the calculator pad).

Figure 3.34 Using Calculator Pad to Change Internal Trigger Rate



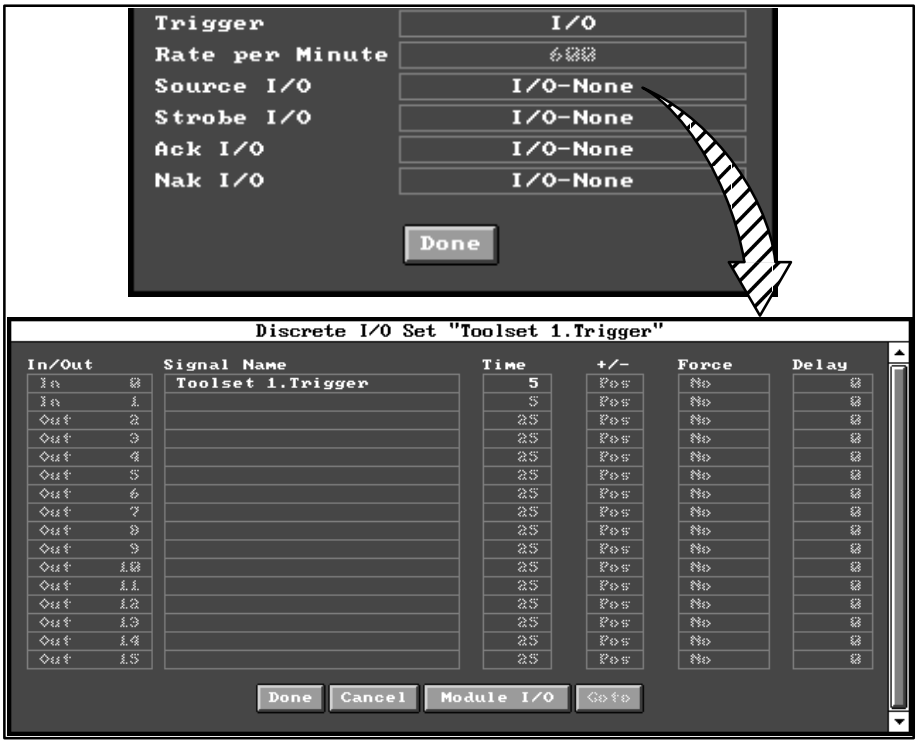
To select an external trigger source, you must assign the current inspection to one of the discrete trigger inputs. Pick the Trigger field to toggle it to "I/O," then pick the Source I/O field. When you do, the Discrete I/O Set Signal panel appears, as shown in the example in Figure 3.35 (page 3–47).

As an example, if you want to assign inspection #1 to the "In 0" input, simply pick the "In 0" input line, and the trigger name will appear on the "In 0" line, as shown by "Toolset 1.Trigger" in Figure 3.35.

The strobe signal and the trigger NAK and ACK signals can be assigned to discrete outputs in a similar manner. Refer to Chapter 9, *Discrete I/O Assignments*, page 9–9, for more information about these signals.

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Figure 3.35 Example: Assigning Inspection to Discrete Input



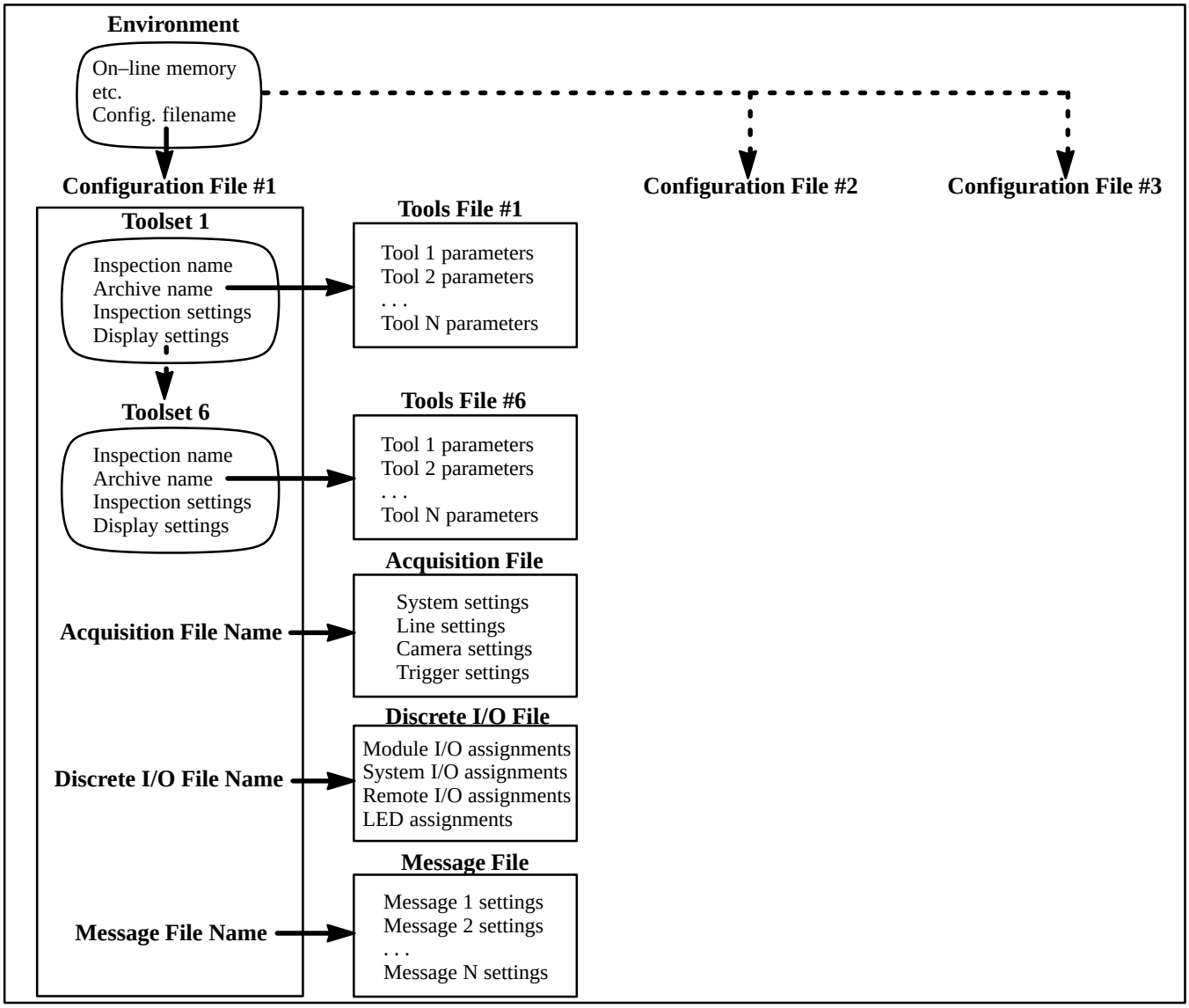
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Chapter 4

Inspection Configuration

The CVIM2 system can be configured to perform a single inspection or multiple related inspections. Each inspection involves the selection of parameters that define the inspection sequence, the I/O interface, camera usage, and communication messages. These parameters are stored in various files that are referred to collectively as a *configuration*. A configuration *file* is used to *link* all of the parameter files required for the single inspection or multiple related inspections. Figure 4.1 illustrates the relationship between a configuration file and the tool, discrete I/O, acquisition, and communication files.

Figure 4.1 Configuration File Organization



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Typically, a configuration file is given a name that indicates its role in the overall inspection application. Similarly, each toolset is named for its role. (For example, the configuration file, toolset, and tool archive file might be named "32oz Bottle," "FrontLabel," and "32ozFrontLbl," respectively.) The user places the CVIM2 system online by selecting one configuration file by its name, then selecting the *online* mode.

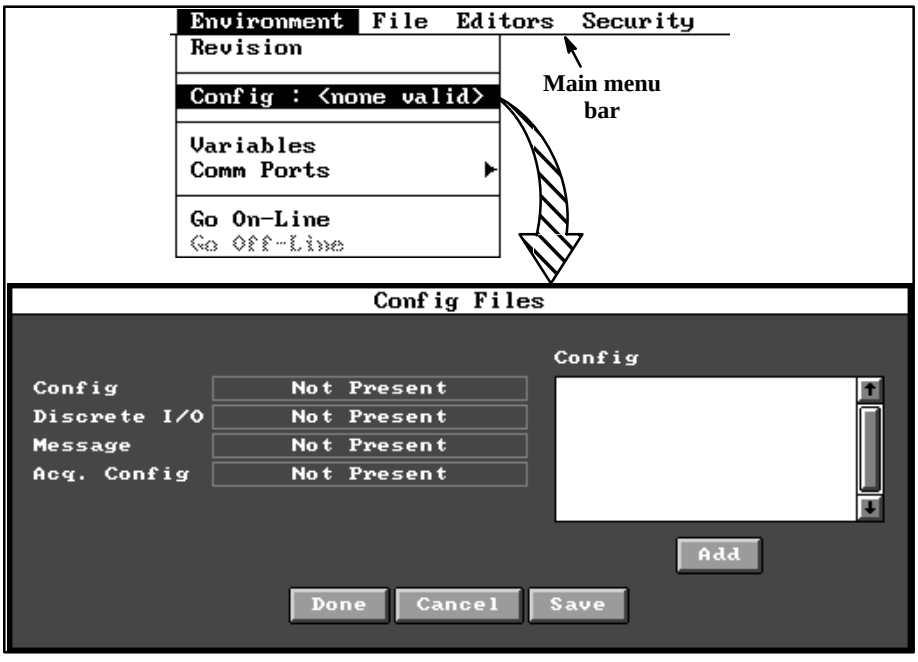
This chapter discusses the process of inspection configuration, which involves naming a configuration file and selecting a camera source, trigger source, and one or more inspection tools for at least one inspection.

Configuration Process

The first step in the configuration process is to create a *configuration file*. As shown in Figure 4.1, this file will contain inspection and display settings, and the *names* of *other* files that contain the inspection tools for each toolset, the discrete I/O settings, the acquisition settings, and the communication message definitions.

The configuration process begins when you pick Environment in the main menu bar, then pick Config in the Environment menu. When you do, the Config Files panel appears *initially* as shown in Figure 4.2.

Figure 4.2 Initial Appearance of Config Files Panel



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Note that the Config Files panel contains several data entry fields and "buttons." Here is a brief description of their functions:

- **Config** — Pick this field to select the current list of Config file names and/or enter new Config file names.
- ***Discrete I/O** — Pick this field to select the current list of Discrete I/O file names and/or enter new Discrete I/O file names.
- ***Message** — Pick this field to select the current list of Message file names and/or enter new Message file names.
- ***Acq. Config** — Pick this field to select the current list of Acq. Config file names and/or enter new Acq. Config file names.

  When you pick one of the above fields, the name (such as Config in Figure 4.2) appears above the "scrolling" list, and the corresponding file names (if any) appear in that list. In Figure 4.2, no Config file names have yet been selected; thus, the scrolling list is empty.
- **Add** — Use the Add button to add new entries in the Config Files panel.
- **Save** — Use the Save button to save the entries in the Config Files panel without exiting to the main menu bar.
- **Done** — Use the Done button to save the entries in the Config Files panel and exit to the main menu bar.
- **Cancel** — Use the Cancel button to exit to the main menu bar without saving any *new* entries that you set up while in the Config Files panel.

*The *names* of the discrete I/O, message, and acquisition files will all be stored in the configuration file.

Two file types *must* be named in order to complete a configuration file: A Config file type, and an Acq. Config file type.

When you pick the Config field, then pick the Add button, the keyboard panel appears as shown in Figure 4.3 (page 4–4).

The message at the top of the keyboard panel instructs you to: "Enter a file name . . ." That name will become the new Config file name.

When you enter a new Config file name in the keyboard (for example, FrontLabel) and then pick the Enter key, the FrontLabel name appears in the scrolling list, as shown in Figure 4.4 (page 4–4). (Note that the new Config file name also appears in the Config field since it is currently *highlighted* in the list.)

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Figure 4.3 Selecting New “Config” File Name

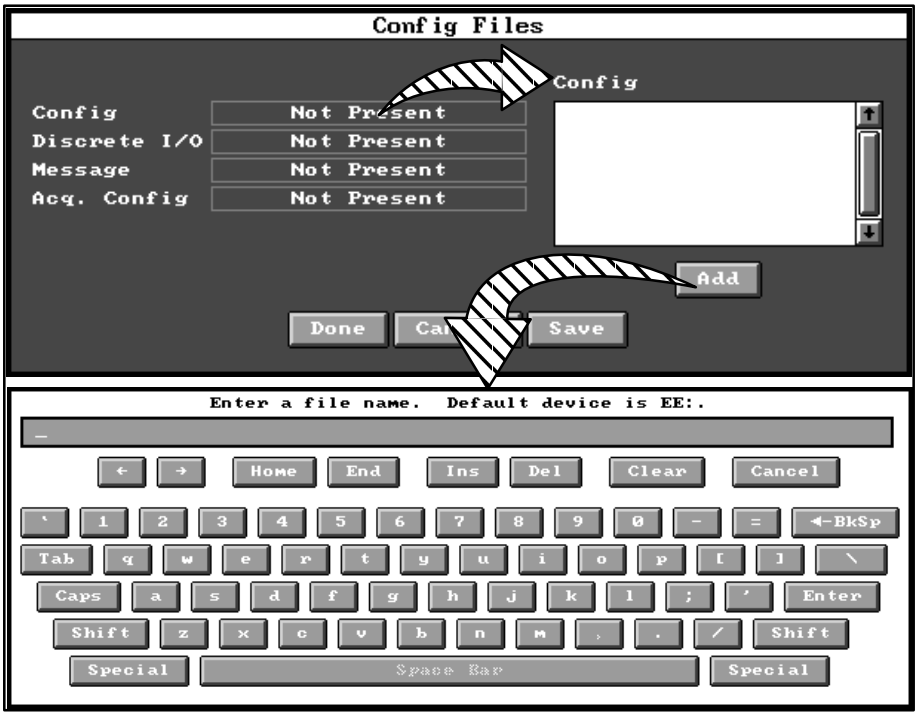
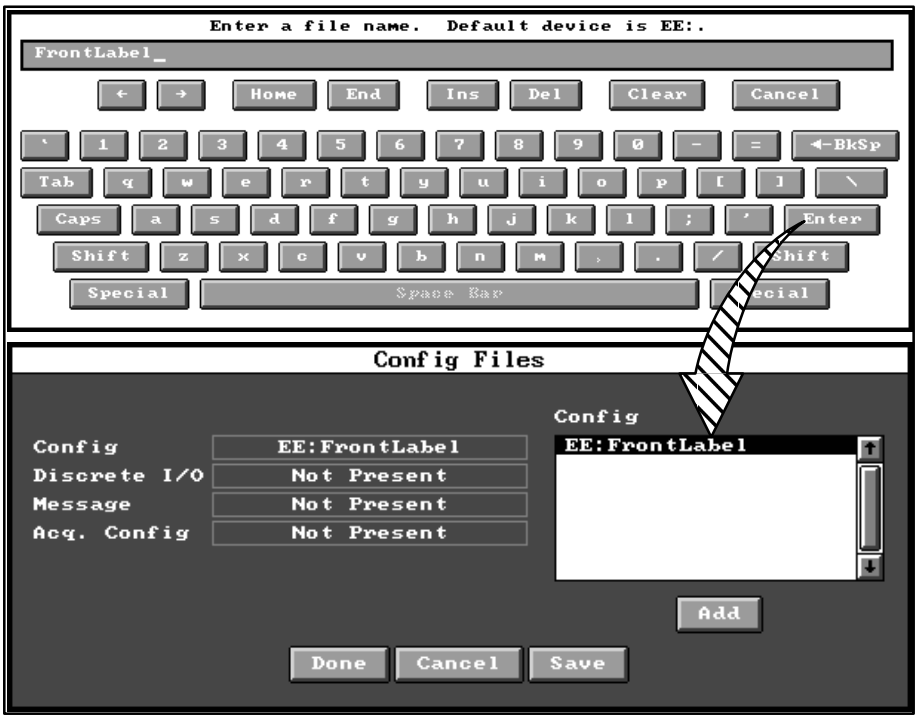


Figure 4.4 Example: Configuration Files Panel With New “Config” Name Entered



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NOTE: If you attempt to exit the Config Files panel at this time by picking the Done button, the following message will appear:

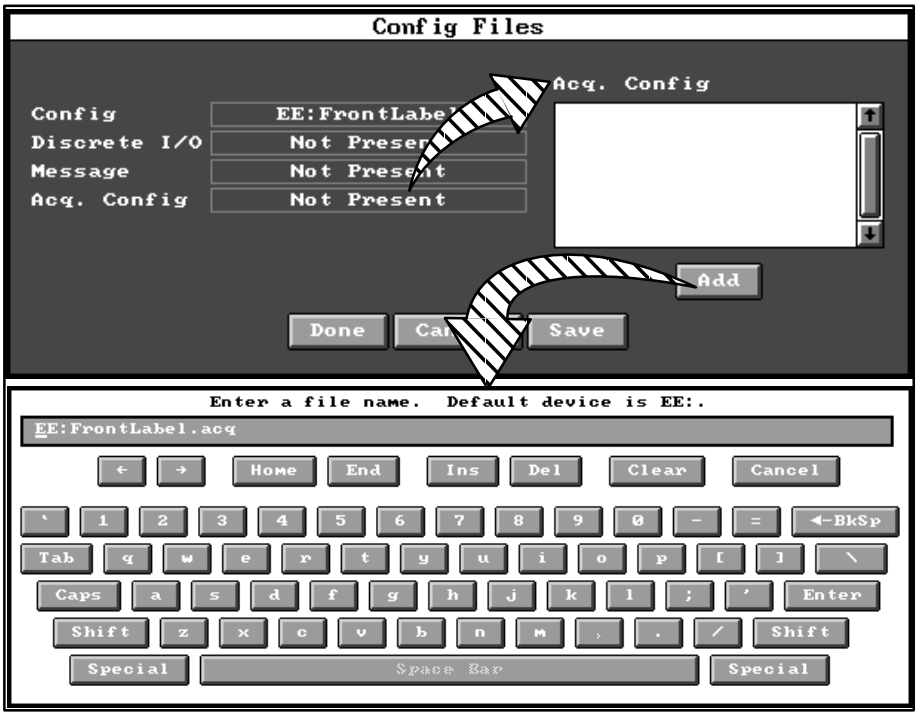


This message indicates that the specified configuration file, "EE:FrontLabel," *must* contain the name of an "Acq. Config" file. You must enter an Acq. Config file name before exiting the Config Files panel. A similar message will appear if you attempt to exit without entering a "Config" file name.

If this message appears, pick the OK button to return to the Config Files panel and enter an Acq. Config file name.

When you pick Acq. Config field, then pick the Add button, the keyboard panel appears as shown in Figure 4.5.

Figure 4.5 Selecting New "Acq. Config" File Name



The message at the top of the keyboard panel instructs you to: "Enter a file name . . ." That name will become the name of your new Acq. Config file. Note that the name "EE:FrontLabel.acq" appears in the keyboard name field. This name is derived from the Config file name currently appearing in

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the Config field. You can use this name, if it is appropriate for your application, or you can enter a different name.

When the appropriate Acq. Config file name is in the keyboard, and you pick the Enter key, that file name appears in the scrolling list, as shown for the Config file name in Figure 4.4 (page 4–4). (Note that the new name also appears in the Acq. Config field since it is currently *highlighted* in the list.)

If you exit the Config Files panel at this time by picking the Done button, the following message will appear briefly . . .

```
Configuration save complete
```

. . . after which the system will exit to the main menu bar.

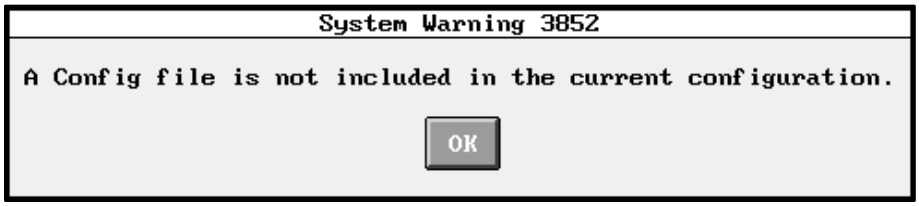
At this point, a *minimum* "configuration" has been named, and you can now pick the Configuration Editor panel from Editor in the main menu bar, as described in the next section, *Configuration Editor Panel*.

To enter the Discrete I/O and/or Message file names before exiting the Config Files panel, use the procedure described above to enter those file names.

Configuration Editor Panel

The main purpose of the Configuration Editor panel is to designate the inspection parameters and inspection tool sets for each toolset in a configuration file.

NOTE: Before you can select the Configuration Editor panel, you must first create or select a configuration file with a valid Config file name, as described in the preceding section, *Configuration Process*; otherwise, the following message will appear when you attempt to select the Configuration Editor panel:

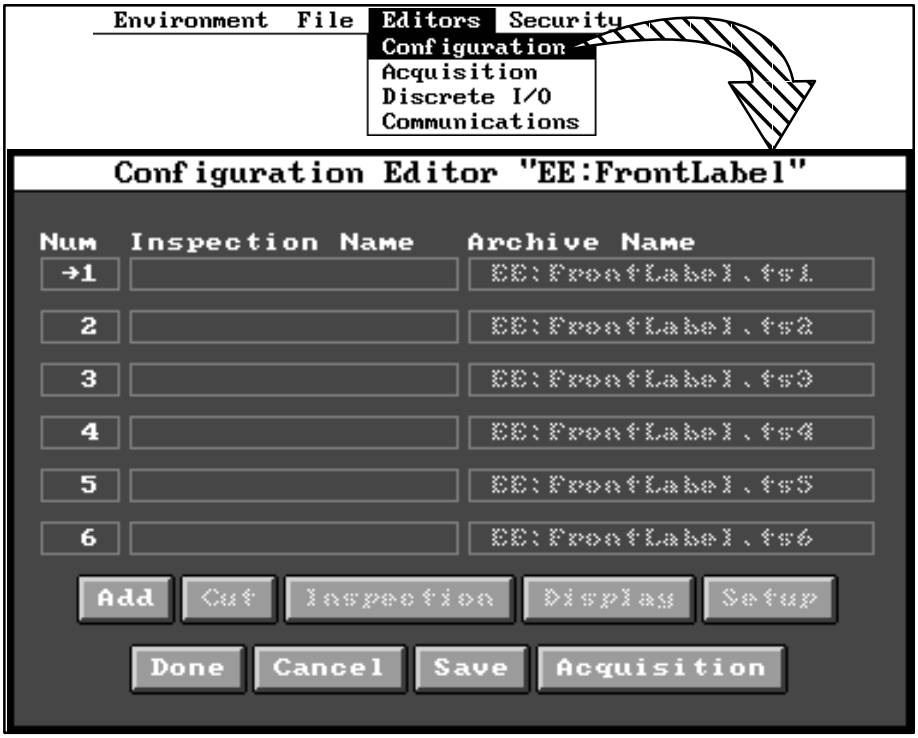


If this message appears, you must pick the OK button, then select the Config Files panel (see Figure 4.2, page 4–2) to set up (and select) at least one configuration before proceeding.

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Assuming that at least one configuration has been set up and selected, when you then pick Editor in the main menu bar, and then pick Configuration in the Editor menu, the Configuration Editor panel appears, as shown in Figure 4.6.

Figure 4.6 Example: Configuration Editor Panel With Six Inspections



Note that the configuration editor panel contains several data entry fields and "buttons." Here is a brief description of their functions:

- **Num** — This field contains the *number* of a "toolset," such as 1, 2, or 3. (This number is *fixed* — you cannot change it.)
- **Inspection Name** — The inspection name is used to identify a toolset for I/O, communication, and display purposes. Use this field to select a name (up to 15 characters) for a toolset. (The *default* inspection names for the six toolsets are Toolset 1, Toolset 2, and so on.)
- **Archive Name** — The "archive name" identifies the *device* and *file* in which the inspection tools are stored. Use this field to enter a name (up to 16 characters) of either a *new* file of inspection tools or an *existing* file of inspection tools. (By *default*, the archive names for the six toolsets take this form: EE:*config filename*.ts1, EE:*config filename*.ts2, and so on).
- **Add** — Use the Add button to add new toolsets in the Configuration Editor panel. (Alternatively, you can pick the inspection name field to perform this function.)

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- **Cut** — Use the Cut button to delete the toolset that has the cursor arrow (→) alongside the toolset number. Thus, if the cursor arrow is located at number 2, the toolset at that location will be deleted.
- **Inspection** — Use the Inspection button to access a toolset's Inspection parameter selection panel.
- **Display** — Use the Display button to access a toolset's Display parameters selection panel.
- **Setup** — Use the Setup button to access the image/tool display panel and the tool configuration setup panel.
- **Done** — Use the Done button to save the entries in the Configuration Editor panel and exit to the main menu bar.
- **Cancel** — Use the Cancel button to exit to the main menu bar without saving any *new* inspection names or any parameters that you set while in the Inspection and/or Display panels. (However, tools that you configured *and saved* while in the Setup panel, and parameters that you entered *and saved* while in the Acquisition Editor panel, will remain as you saved them.)
- **Save** — Use the Save button to save additions and/or changes to the contents of the Configuration Editor panel *without* exiting the panel.
- **Acquisition** — Use the Acquisition button to access the Acquisition Editor panel (see Chapter 3, *Image Acquisition Parameters*).

Inspection Names and Archive Names

As noted earlier, a configuration file (such as FrontLabel) can contain up to six toolsets. Each toolset specifies camera and trigger sources and a set of inspection tools. The "inspection name" and the "archive name" of each toolset appear in the Configuration Editor panel.

An *inspection name* (such as Toolset 1) identifies one toolset for I/O, communication, and display purposes. In a given application, the inspection name of a given toolset is normally the *same* for all configurations.

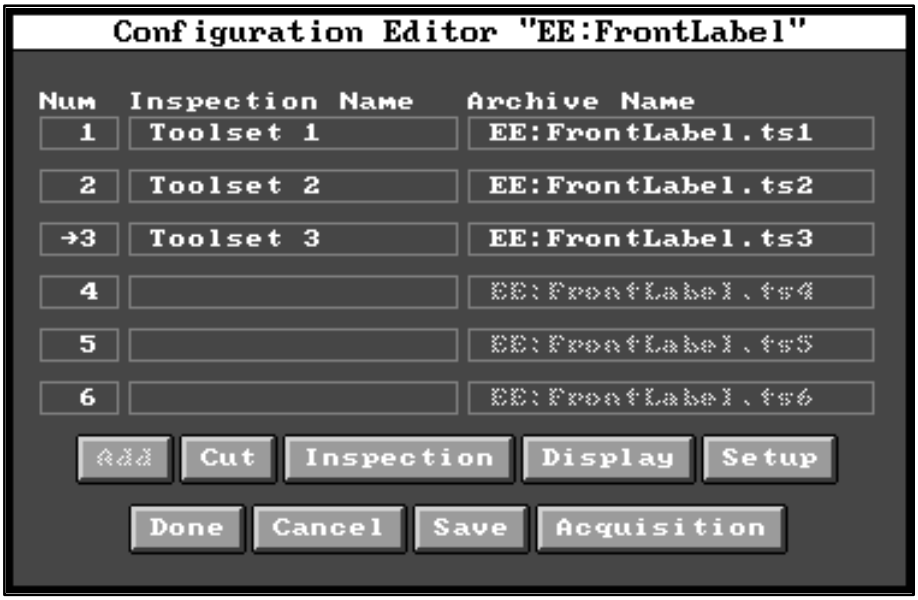
An *archive name* (such as EE:FrontLabel.ts1) identifies a file that consists of one or more inspection tools (gages, windows, and so on) that are configured *together* for a specific inspection task. In a given application, the archive name of a given toolset is normally *different* for each configuration.

Figure 4.7 (page 4–9) illustrates the Configuration Editor with three toolsets defined.

Each of the three toolsets that make up the "FrontLabel" configuration has an Inspection Name and an Archive Name associated with it.

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Figure 4.7 Example: Configuration Editor Panel With Three inspections Defined



Basic Configuration Procedure

The basic configuration procedure described in this section begins with the Configuration Editor panel as shown in Figure 4.6 (page 4–7) and steps through the *major* system configuration tasks, which are these:

- Selecting an inspection name.
- Configuring acquisition parameters.
- Selecting inspection parameters.
- Selecting image/results display parameters.
- Setting up inspection tools.
- Selecting discrete I/O functions.

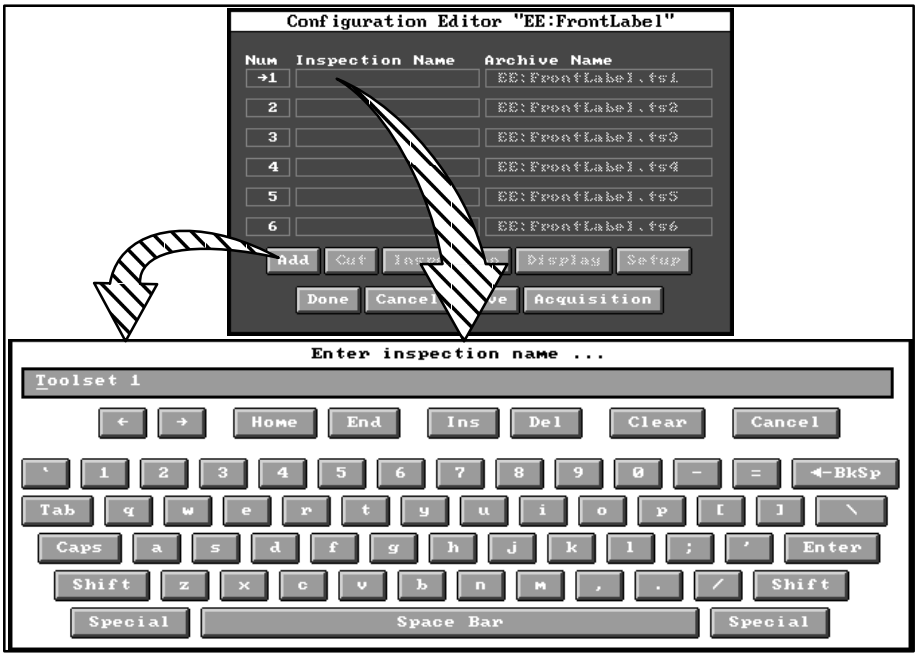
Selecting Inspection Name

Note that the Configuration Editor panel in Figure 4.6 contains no inspection names. Consequently, the Cut, Inspection, Display, and Setup buttons are *inactive* (shaded). The Add, Done, Cancel, and Acquisition buttons are all *active* (white).

The first task, therefore, is to add a toolset by picking the Add button, or by picking an Inspection Name field, as shown in Figure 4.8 (page 4–10). Using either method, the keyboard appears, as shown in Figure 4.8.

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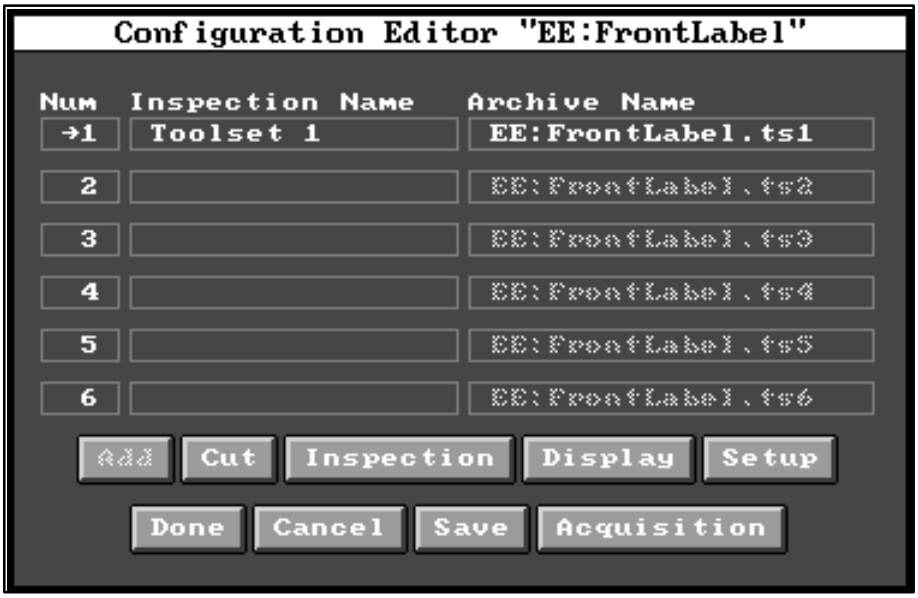
Figure 4.8 Selecting an Inspection Name



The *default* inspection name, Toolset 1, appears in the keyboard name bar initially. You can either accept the default inspection name (if it has not already been used), or you can select a *new* name.

If you select the default inspection name, the Configuration Editor panel will appear as shown in Figure 4.9.

Figure 4.9 Configuration Editor Panel With First Inspection Named



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Note that the *default* inspection name (Toolset 1) now appears in the first field under Inspection Name, and the *default* archive name (EE:FrontLabel.ts1) appears under Archive Name.

Configuring Acquisition Parameters

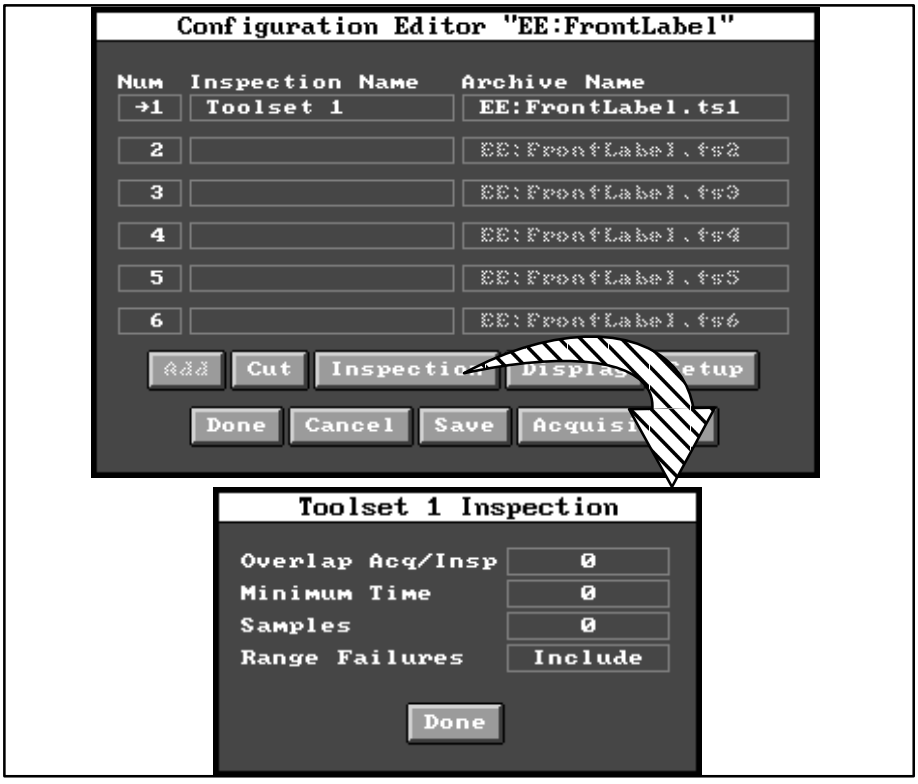
NOTE: The default acquisition parameters are sufficient for obtaining images without a strobe light or external trigger. You can skip directly to the *Setting Up Inspection Tools* section on page 4–20 if you are just getting started.

At this point you should pick the Acquisition button and configure the image acquisition parameters, which involves the selection of toolset trigger, camera, and acquisition system parameters. For details about these parameters, refer to Chapter 3, *Image Acquisition Parameters*.

Selecting Inspection Parameters

The Inspection setup panel is accessible from the Configuration Editor panel, as shown in Figure 4.10, by picking the Inspection button.

Figure 4.10 Selecting Inspection Panel



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Note that the Inspection panel, unlike the Acquisition Editor panel, shows inspection settings for a *single* toolset.

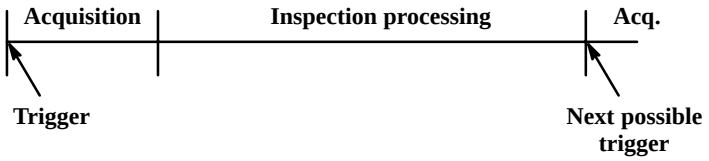
The parameters listed in the Inspection panel, and the methods of setting them, are described as follows:

- **Overlap Acq/Insp** — This parameter can be set to a range of 0 to 20. If it is set to 0, the system cannot acquire a new image until it finishes processing the last image. If it is set to a value greater than 0, the system can acquire new images while it is still processing a previous image.
- **Minimum Time** — This parameter sets the amount of time, in milliseconds, that tool inspection results will be *delayed* following the start of each inspection cycle. This value can be set as required to synchronize the CVIM2 system output with the user's process equipment. The valid range is 0 to 5000 milliseconds.
- **Samples** — This parameter sets the size of a block of "sample" inspections that the CVIM2 system will use to calculate statistics for a particular tool.
- **Range Failures** — This function can be set to Include or Exclude. If Range Failures is set to Include, the CVIM2 system will include "failed" tool results in statistical calculations. ("Failed" means tool results that lie beyond any of the range limits.) If Range Failures is set to Exclude, the system will exclude failed tool results from calculations.

Overlap Acq/Insp

This selection enables the CVIM2 system to *overlap* the image acquisition and inspection processing functions, and thereby acquire and store a "burst" of images before all images have been processed. The setting of the Overlap Acq/Insp parameter determines the maximum number of images that the system is allowed to store while image processing is still in progress.

If this parameter is set to 0 when a trigger occurs, the system acquires an image, then processes it, then acquires the next image, processes it, and so on, in *serial* fashion. Thus, the total time for the entire cycle is the image acquisition time *plus* the image processing time, as shown below:

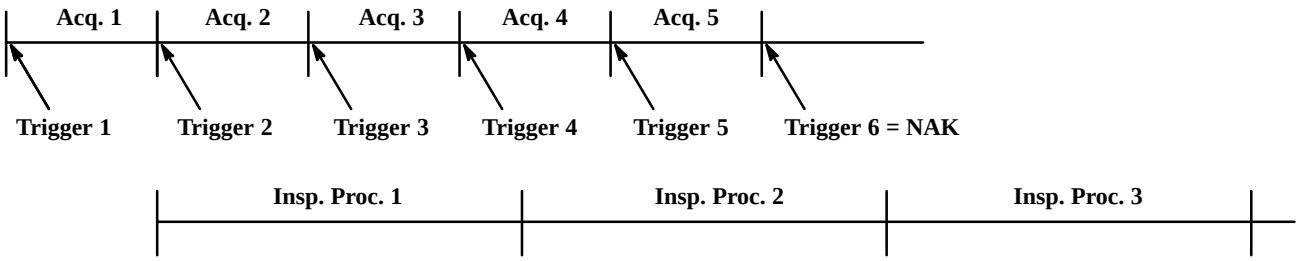


If this parameter is set to 1 (or more) when a trigger occurs, the system will acquire the first image and begin processing it. The system can then begin acquiring *another* image if a trigger signal arrives *before* the system finishes processing the *first* acquired image. *The setting of the* Overlap Acq/Insp *parameter determines the number of images that may be overlapped before a trigger NAK is issued.*

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In the following example, the Overlap Acq/Insp parameter is set to 3, which means that the CVIM2 system is configured to store up to three images before the image processing for the *previous* image is completed. In this case, if another trigger occurs *before* that completion, the system will issue a trigger NAK.

Overlap example with Overlap Acq/Insp **parameter set to 3**



In the example, a series of six triggers occurs. The interval between these triggers is as short as possible consistent with *completing* each image acquisition.

The sequence of events is as follows:

- Trigger 1 occurs and starts the image 1 acquisition.
- When image 1 has been acquired, processing begins on image 1. This releases the storage resource used by image 1 and makes it available for *another* image acquisition (image 2). At the same time, trigger 2 occurs to start the image 2 acquisition.
- Before image 1 has been processed, two more images will have been acquired and stored (images 2 and 3), and another image acquisition will have begun (image 4).
- Midway through the image 4 acquisition, processing for image 1 ends and processing for image 2 begins. This releases the storage resource used by image 2 and makes it available for *another* image acquisition (image 5).
- Before image 2 processing is complete, three images will have been acquired and stored (images 3, 4, and 5). This is the *maximum* that is allowed by the Overlap Acq/Insp parameter (3) in this example.
- *Also* before the second image processing is complete, trigger 6 occurs. Since three images are *already* stored, and the system cannot store a fourth image (in this example), it issues a Trigger NAK signal in response to trigger 6.

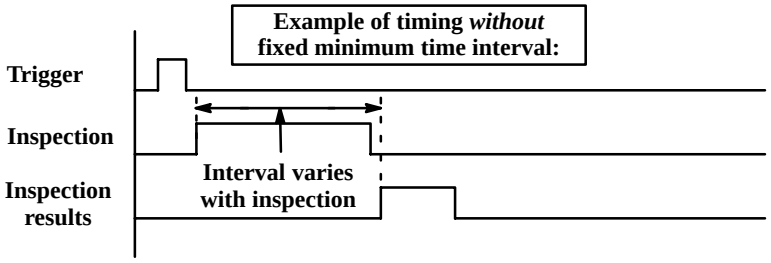
NOTE: The *maximum* setting for the Overlap Acq/Insp parameter is 20; however, because of the limitations of the image memory buffers, the maximum setting in a *particular* application depends on whether the system can be placed *online*. If the system will *not* go online with the current setting, that setting may have to be reduced, or other adjustments may need to be made, to enable the system to go online.

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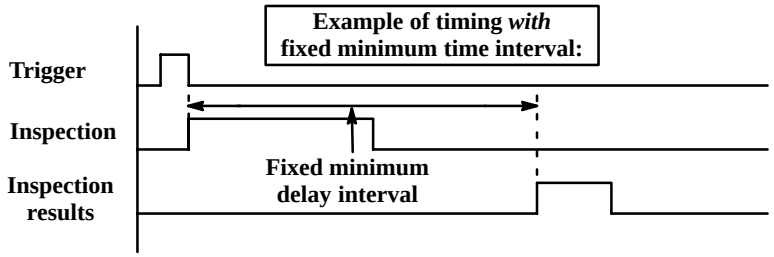
Minimum Time

The Minimum Time field enables you to specify a fixed *minimum time* interval (in milliseconds) between the *start of an inspection* and the *availability of inspection results*. The effect is to *delay* the inspection results in order to ensure that they are always available to a host system on a timely basis. The valid range for the time interval is 0 to 5000 milliseconds.

The relation of the inspection start to the inspection results *without* a fixed minimum time interval (that is, a setting of 0) is shown below:



The relation of the inspection start to the inspection results *with* a fixed minimum time interval (that is, a setting of more than 0) is shown below:



Samples

The Samples field enables you to select an appropriate “sample” size, ranging from 0 to 65535, for each toolset in a configuration. This value determines the number of “sample” inspection results that the CVIM2 system must acquire in order to calculate statistical data for a particular tool. (Note that this function applies only to a tool for which statistics collection can be selected, such as a window tool, and for which the Statistics box has been checked in the Options selection panel for that tool.)

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For example, when the sample size is set to 100 for a particular window tool, the CVIM2 system compiles a block of inspection results from 100 consecutive window inspections and calculates a set of statistical values (*maximum*, *minimum*, *mean*, and *standard deviation*) from those results. The system then places the set of statistical values in the window tool's detail panel, where you can view them, and stores them in a results block, where a host computer can access them.

When the system acquires the *next* block of 100 inspection results, it uses these results to calculate a *new* set of statistical values and *overwrite* the *previous* set of values.

The main advantage of setting a sample size is to identify trends in the inspection results more easily and quickly.

Range Failures

The Range Failures field enables you to either *include* or *exclude* "failed" tool results from the statistics calculations for all tools in a specific toolset. (Note that the term "failed," as used in this context, refers to any tool result that is *above* the fail *high* limit, or is *below* the fail *low* limit.)

If Range Failures is set to Include, the CVIM2 system accumulates statistics for *all* inspected parts, and it *includes* failed tool results in statistical calculations for the specified toolset.

If Range Failures is set to Exclude, the system accumulates statistics only for "good" parts, and it *excludes* failed tool results from such calculations.

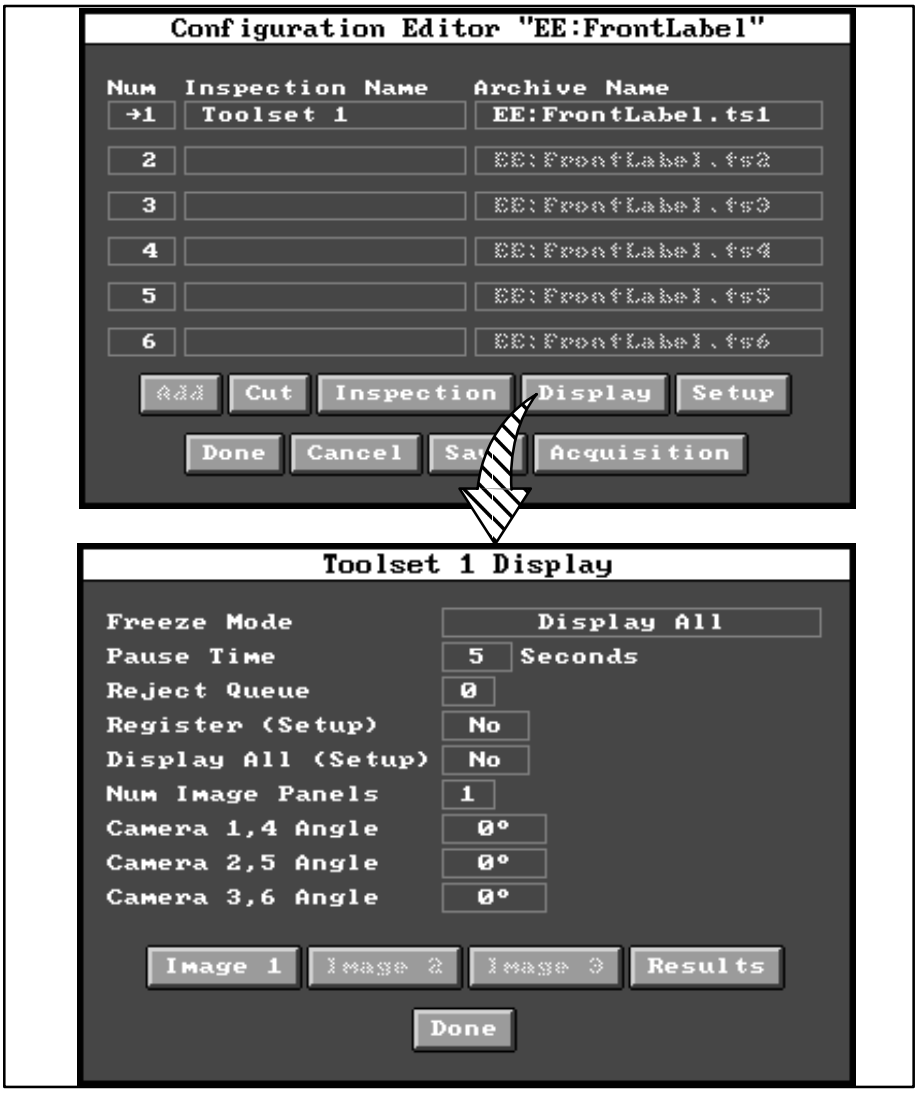
Note that the Range Failures function applies only to a tool for which statistics collection can be selected, such as a window tool, and for which the Statistics box has been checked in the Options selection panel for the tool.

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Selecting Display Parameters

The Display setup panel is accessible from the Configuration Editor panel, as shown in Figure 4.11, by picking the Display button.

Figure 4.11 Selecting Display Panel



Here is a brief description of each parameter field in the Display panel:

- **Freeze Mode** — This parameter determines the *default* image "freeze" mode that prevails when an inspection tool failure or other "reject" condition occurs during *online* operations: display all camera images regardless of reject condition; pause the reject image for n seconds (where n = 1 to 30 seconds); freeze first *n* rejects; and freeze last *n* rejects (where *n* is the number of reject images that the reject queue can hold).

  The freeze mode operations are described in detail in Chapter 10, *Environment Menu Selections*, starting on page 10–16.

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- **Pause Time** — This parameter sets the amount of time that the online camera image pauses after a reject condition when the "pause" freeze mode has been selected. The allowable range is 1 to 30 seconds. The *default* time is 5 seconds.
- **Reject Queue** — This parameter sets the number of extra image buffers allocated to save "rejected" images during freeze mode operation. For most applications, a setting of 0 enables the CVIM2 system to save one rejected image, while a setting of 1 enables the system to save one *additional* rejected image. For some very high speed applications, a setting of 1 may be required to guarantee that the first rejected image is saved. For details about the freeze mode operations, refer to Chapter 10, *Environment Menu Selections*, under the *Display* heading on page 10–16.
- **Register (Setup)** — This parameter selects the *default* state of the register function in the toolset edit panel. "Yes" causes the function to be *active* whenever the toolset edit panel is accessed during setup operations, while "No" has the opposite effect.
- **Display All (Setup)** — This parameter selects the *default* state of the display function in the toolset edit panel. "Yes" causes the function to be *active* whenever the toolset edit panel is accessed during setup operations, while "No" has the opposite effect.
- **Num Image Panels** — This parameter selects the number of image display panels that can appear during run operations for the currently selected toolset. Each camera being used in the toolset can have an associated image display panel. The *default* value is 1, and the valid range is 1 – 3.
- **Camera 1, 4 Angle** — This parameter can be set to rotate the camera #1 and #4 image field and tool graphics *clockwise* by 90°, 180°, or 270°.
- **Camera 2, 5 Angle** — This parameter can be set to rotate the camera #2 and #5 image field and tool graphics *clockwise* by 90°, 180°, or 270°.
- **Camera 3, 6 Angle** — This parameter can be set to rotate the camera #3 and #6 image field and tool graphics *clockwise* by 90°, 180°, or 270°.

  NOTE: The camera angle settings will affect the image field in the image display panel *only* when it is displaying inspection results. The image field will appear in its normal, non–rotated orientation during tool configuration.

Here is a brief description of each button in the Display panel:

- **Image 1, 2, 3** — Use the Image 1, Image 2, or Image 3 button to select the *image display* setup panel for the currently selected toolset. When you pick one of the *active* (not shaded) buttons, a corresponding image display setup panel appears. By *default*, the Image 1 button is active and the Image 2 and Image 3 buttons are shaded.

  The value in the Num Image Panels field of the Display panel determines which buttons are active (since "1" is the lowest number, the Image 1 button is *always* active). Entering a "2" in the Num Image Panels field of the Display panel activates the Image 2 button, while entering a "3" activates both the Image 2 *and* the Image 3 buttons.

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- **Result** — Use the Results button to select the *results display* setup panel for the currently selected toolset.
- **Done** — Use the Done button to save the entries in the Display panel and exit to the Configuration Editor panel.

Setting Up Image Display Panels

When you pick one of the active image buttons on the Display panel, the corresponding image display setup panel appears, as is illustrated in Figure 4.12.

Figure 4.12 Selecting Image Display Setup Panel



Here is a brief description of each field in the image display panel:

- **Title** — This field enables the user to select an appropriate name or "title" for the corresponding image display panel. By *default*, the title is *initially* the name of the toolset (image display #1), or the toolset name and image panel number (image panel #2 and #3). Thus, the default titles for the three Toolset 1 image panels would be Toolset 1, Toolset 1 (2), and Toolset 1 (3).
- **Tool Display** — This field enables the user to select the *default* setting for the online image display panels. The choices are these: Image Only, Failed Tools, and All Tools.
- **Scale** — This field enables the user to select the scale of the camera image that appears in the *online* image display panels, as follows: A scale of "1" displays the acquired image at its original size, but may only show a portion of the camera image if the display panel is smaller.

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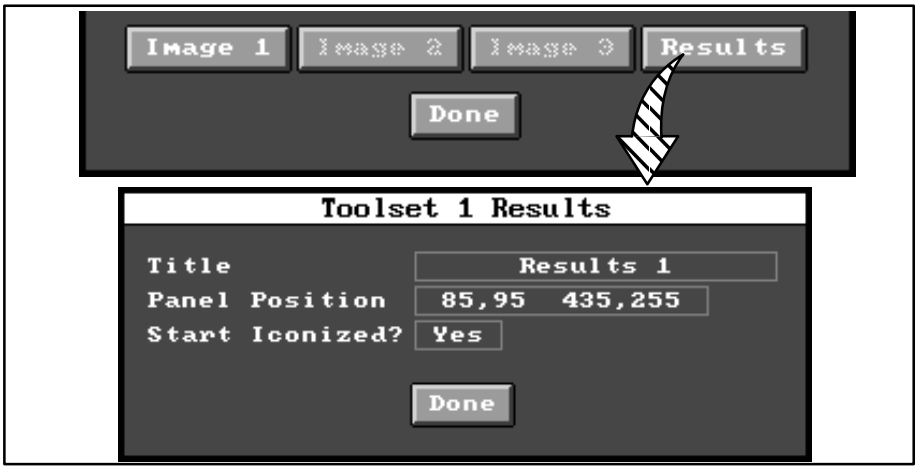
A scale of "To Fit" displays the entire camera image *completely* within the image display panel, regardless of the panel's size. Since the "To Fit" mode may cause the image to be "shrunken" to fit in the panel, some image details may not be displayed.

- **Panel Position** — This parameter reflects the X– and Y–axis coordinates of the upper–left and lower–right corners, respectively, of the image panel for *currently selected* toolset in the Configuration Editor panel (as illustrated in Figure 4.15 on page 4–22). When you pick the Panel Position field, the image panel (and the results panel) for the selected toolset appear on the screen, and both panels are accessible for resizing and repositioning on the screen. (The image and results panels for *other* toolsets are also available at this time; however, they may appear on the screen as *icons*.)
- **Start Iconized ?** — This field enables the user to determine whether online operations begin with the full image display panel on the screen ("No"), or with an icon representing the panel appearing at the right side of the screen ("Yes"). The *default* selection is "No."
- **Source Image** — This field enables the user to select the camera source, if the current toolset has been configured to use more than one camera.

Setting Up Results Display Panels

When you pick the Results button on the Display panel, the Results display setup panel for the currently selected toolset appears, as is illustrated in Figure 4.13.

Figure 4.13 Selecting Results Display Setup Panel



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Here is a brief description of each field in the Results display setup panel:

- **Title** — This field enables the user to select an appropriate name or "title" for the results display panel that corresponds to the currently selected toolset. By *default*, the initial title is "Results" plus the *position number* of the toolset in the Configuration Editor panel. Thus, the default titles of the results panels for toolsets #1, #3, and #6 would be Results 1, Results 3, and Results 6, respectively.
- **Panel Position** — This parameter reflects the X– and Y–axis coordinates of the upper–left and lower–right corners, respectively, of the results display panel for *currently selected* toolset in the Configuration Editor panel (as illustrated in Figure 4.15 on page 4–22). When you pick the Panel Position field, the results display panel for the selected toolset appears on the screen, and is is accessible for resizing and repositioning on the screen. (The image and results display panels for *other* toolsets are also available at this time; however, they may appear on the screen as *icons*.)
- **Start Iconized ?** — This parameter determines whether online operations begin with the results display panel on the screen ("No"), or with an icon representing the panel appearing at the right side of the screen ("Yes"). The *default* selection is "No."

Setting Up Inspection Tools

NOTE: This section covers only the *general* configuration procedures. For detailed information about the inspection tool types and tool operations, refer to Chapter 7, *Inspection Tools*.

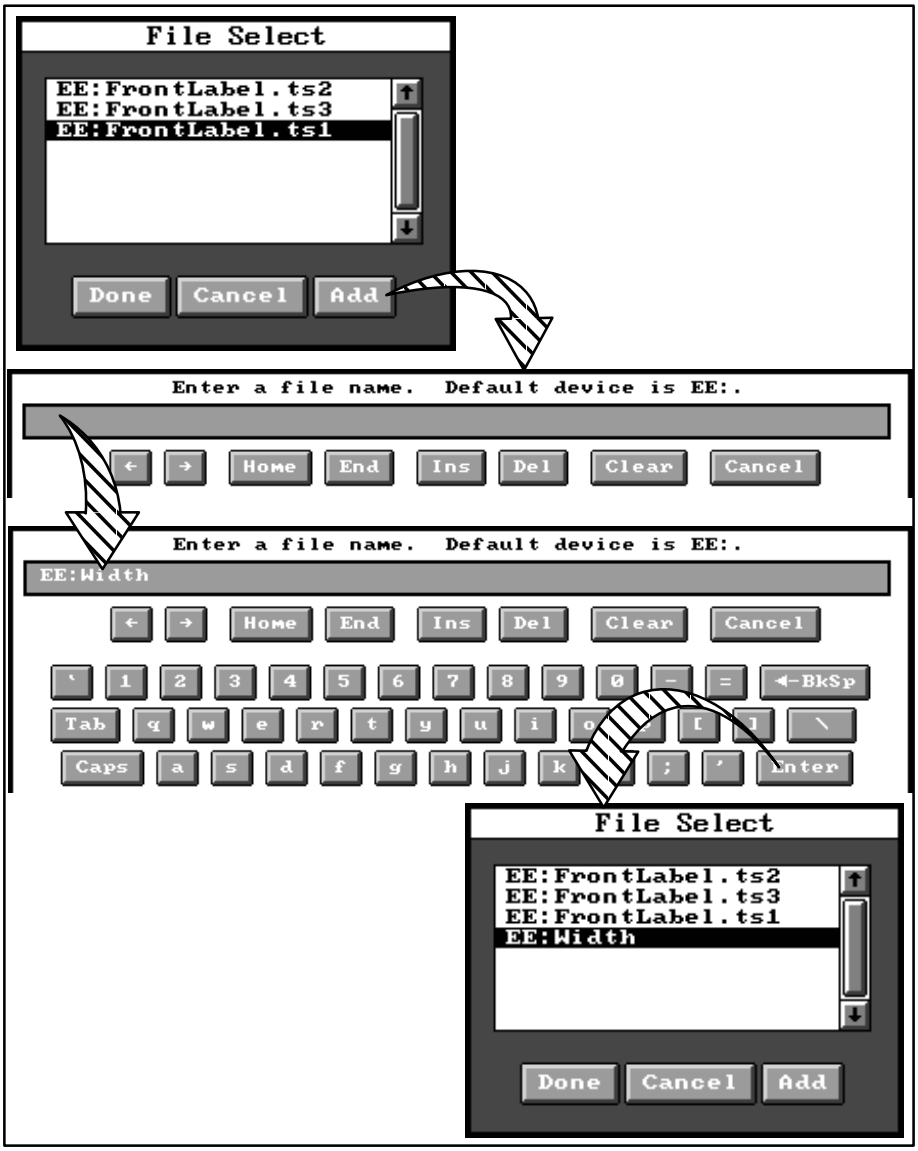
Assuming that the Configuration Editor panel contains the "Toolset 1," "Toolset 2," and "Toolset 3" inspections (as shown in Figure 4.7 on page 4–9), continue the configuration procedure with the following steps:

1. If you want to change the archive name "EE:FrontLabel.ts1" to some other name, pick the field containing the EE:FrontLabel.ts1 name. When you do, the File Select panel appears on the screen, as shown in Figure 4.14 (page 4–21).

   Pick the Add button to access the keyboard. Enter the new archive name, then pick the Enter key to save the name, exit the keyboard, and return to the File Select panel. Pick the Done button to exit back to the Configuration Editor panel.
2. The small arrow (→) alongside the toolset number indicates which toolset is currently selected. Pick "1" to select the first toolset.

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Figure 4.14 Example: File Select Panel



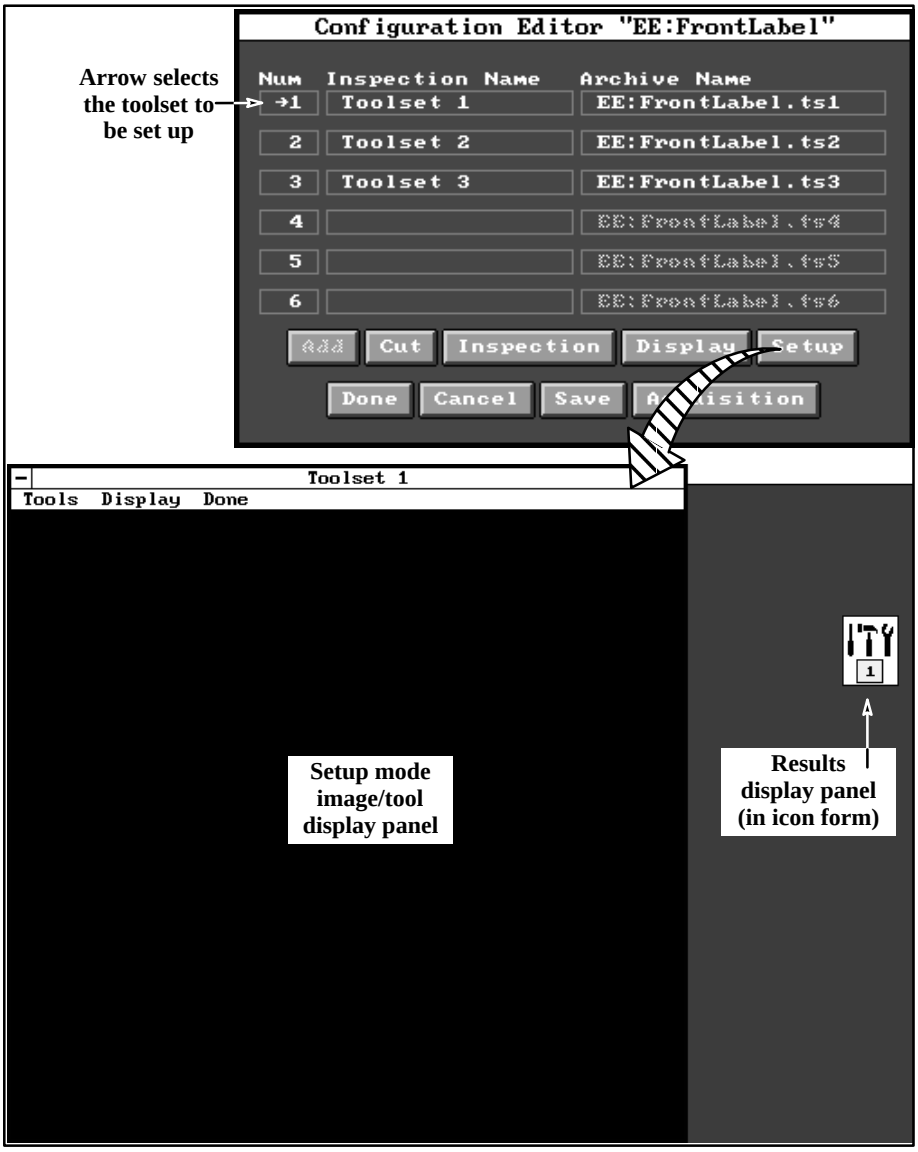
3. Pick the Setup button. When you do, the *setup mode* image/tool display panel (named "Toolset 1" in this example) appears on the screen, as shown in Figure 4.15 (page 4–22). This panel is blank (dark) initially.

   The purpose of the setup mode image/tool display panel is to display a camera image during CVIM2 system setup so that you can configure the inspection tools and evaluate their performance *offline* before placing the system *online*.

   (Also appearing, possibly in *icon* form, is the results display panel. This panel is described in detail in Chapter 10, page 10–17, in the *Inspection Results Display Panel* section.)

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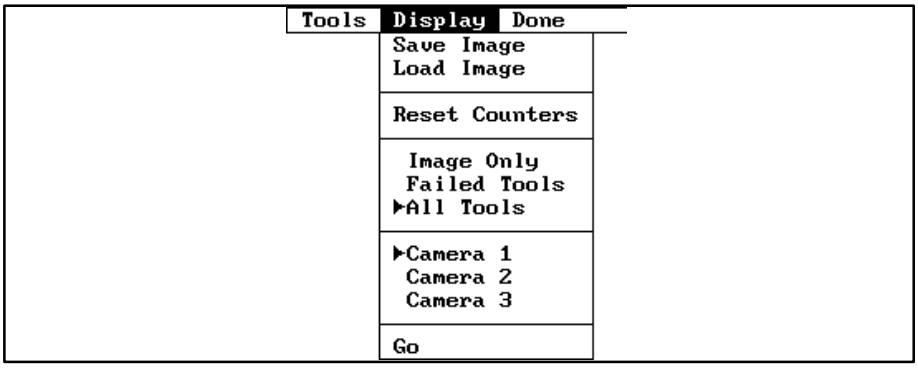
Figure 4.15 Offline Image/Tool Display Panel



4. Pick Display in the menu bar. When you do, the Display menu appears, as shown in Figure 4.16 (page 4–23). (This example illustrates how the Display menu appears when more than one camera input has been selected.)

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Figure 4.16 Display Menu Example



The Display menu determines the appearance of the setup mode image/tool display panel during tool evaluation. The five sections in this menu have these meanings:

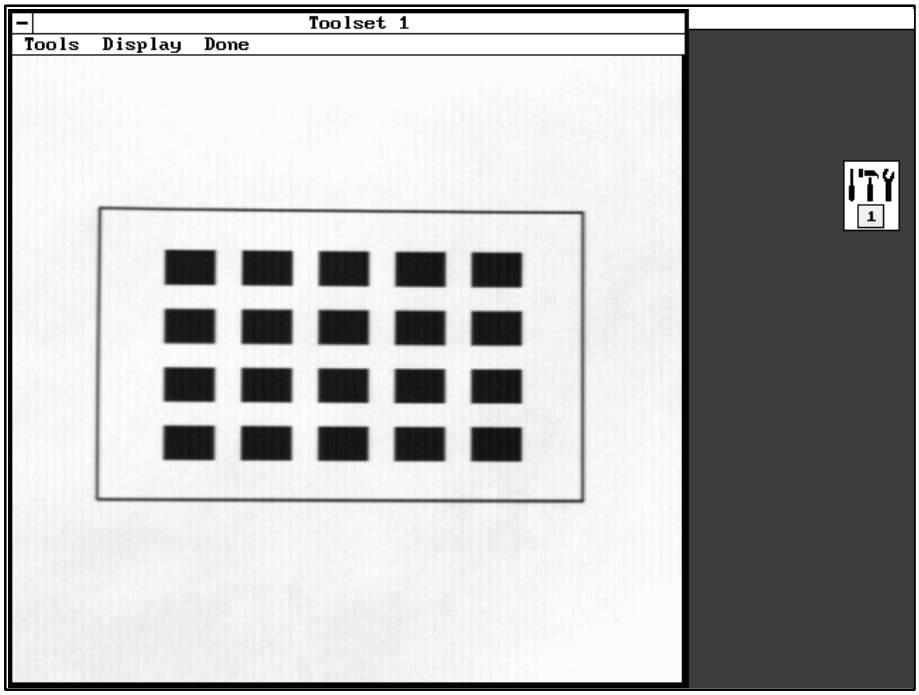
- The top section enables you to save an image in compressed form, and reload the image later.
- The second section enables you to reset counters and statistics in the results panels and the results detail panels.
- The third section determines what will appear in the display panel during tool evaluation operations: all enabled inspection tools, the failed tools only, or the camera image only.
- The fourth section appears only when two or three camera inputs have been assigned to the current toolset's trigger.
- The bottom section enables you to start (and stop) the tool evaluation operations.

Note that a cursor (➤) points to All Tools, while another cursor points to Camera 1. These are the current *default* settings for the display mode and camera selections.

5. Pick Go. When you do, the image/tool display panel is enabled, with these results:
   - If the Auto trigger source is selected, a continuous series of camera images will appear on the screen immediately, such as is shown in Figure 4.17 (page 4–24).
   - If an external trigger source is selected, the system must receive a trigger signal in order to display a camera image.
   - If inspection tools had been previously configured (and All Tools selected), those tools would also appear at this time.

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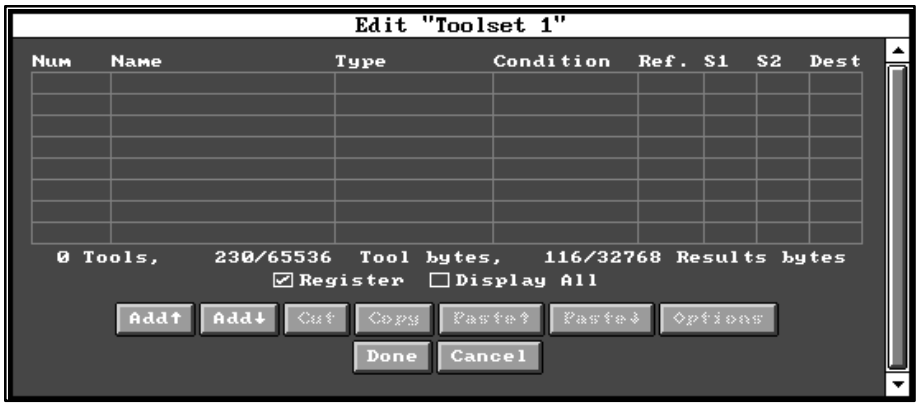
Figure 4.17 Example: Camera Image in Setup Mode Image/Tool Display Panel



6. If an external trigger source is used, send a trigger signal to the CVIM2 system. When you do, a camera image appears in the display panel.
7. Pick Tools in the menu bar. When you do, the toolset edit panel (the inspection tool setup panel) appears over the image/tool display panel, as shown in Figure 4.18.

   Initially, the toolset edit panel is empty, as shown in Figure 4.18. To enter the first inspection tool, continue with these steps:

Figure 4.18 Initial State of the Toolset Edit Panel



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8. Pick the Add↓ or Add↑ button. When you do, the Tool Types menu appears, as shown in Figure 4.19.

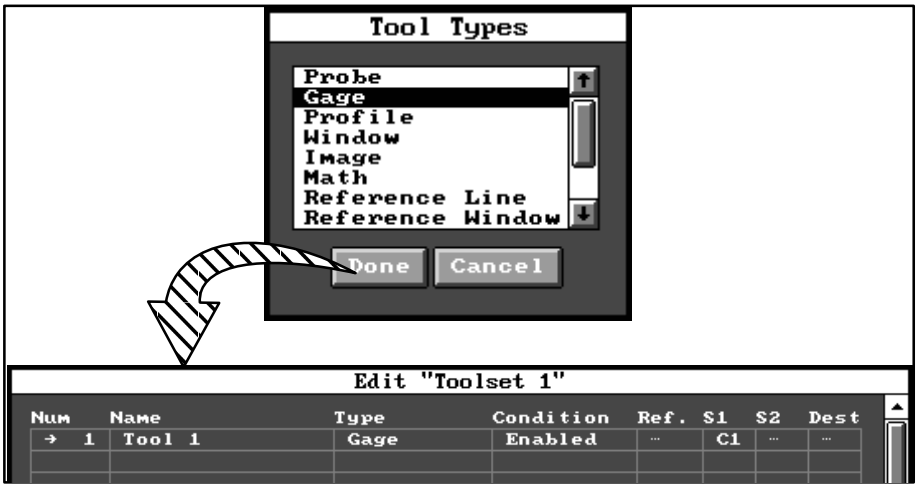
Figure 4.19 Tools Types Menu



The Tool Types menu is a "scrolling list" that contains all of the inspection tool types that are available for any inspection application. (As noted earlier, this section covers only the *general* configuration procedures. For detailed information about the inspection tool types, refer to Chapter 7, *Inspection Tools*.)

9. Highlight (pick) one of the tool types, then pick the Done button. When you do, the toolset edit panel reappears with the new tool type ("Gage," in this example) entered in the topmost line, as shown in Figure 4.20.

Figure 4.20 Example: Selecting First Inspection Tool in Toolset Edit Panel



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10. To access the tool for configuration purposes, pick the field with the tool type in it (in this example, pick the "Gage" field). When you do, the toolset edit panel is replaced by the tool edit panel, as shown in Figure 4.21.

Figure 4.21 Example: Tool Edit Panel for Gage



NOTE: The *default* parameters in this example tool edit panel pertain to the "Gage" inspection tool. At this point in the configuration process you would configure this specific inspection tool. (Chapter 7, *Inspection Tools*, contains all of the configuration details for gages and other inspection tools.)

11. After you finish configuring the inspection tool, pick the Done button. When you do, the toolset edit panel reappears over the image/tool display panel.
12. If you need to configure additional inspection tools, repeat step 8. through step 11. as many times as needed to configure all required tools.
13. When you have completed all of the required tool configurations, pick the Done button on the toolset edit panel to save all newly configured inspection tools in the toolset archive file. When you do, the toolset edit panel disappears.
14. Pick Done in the menu bar of the image display panel. When you do, the display panel disappears and the Configuration Editor panel reappears.
15. Pick the Done button in the Configuration Editor panel. When you do, the Configuration Editor disappears, and the configuration file is saved.

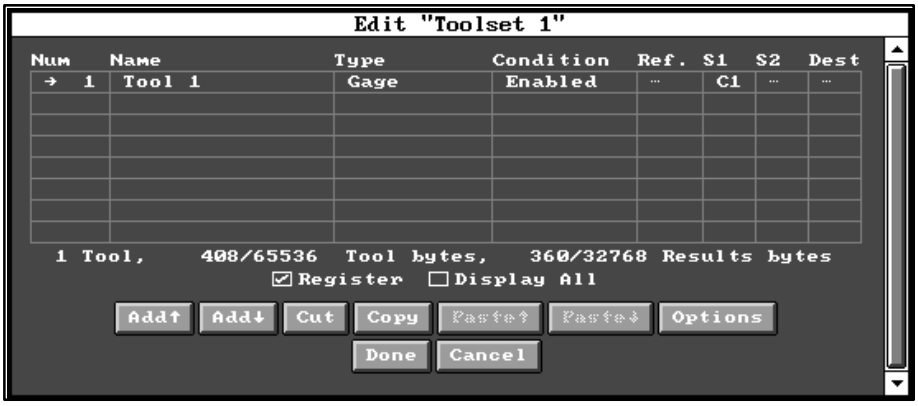
This completes the procedure for creating a configuration file.

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Toolset Edit Panel: Miscellaneous Functions

This section provides some details about various functions and features in the toolset edit panel that are not covered in the *Basic Configuration Procedure* section (page 4–9). Figure 4.22 is an example of the toolset edit panel with a single tool selected.

Figure 4.22 Example: Toolset Edit Panel



Data Fields and Buttons

Note that the toolset edit panel contains several data entry fields, “buttons,” check boxes, and data displays.

Here is a brief description of each *data entry field* in the toolset edit panel:

- **Num** — This field contains the *sequence number* of an inspection tool: #1, #2, #3, and so on. It indicates the *order* in which the CVIM2 system processes the tool. (This is important for applications using reference tools and image tools.) The cursor arrow (→) indicates the currently selected sequence number for the purpose of adding, cutting, copying, or pasting a new inspection tool (see the add, cut, copy, and paste descriptions below).
- **Name** — Use this field to select a name for an inspection tool. (The default names for the inspection tools are Tool 1, Tool 2, and Tool 3, and so on, but you can change them to suit your application.)
- **Type** — This field indicates the inspection tool type (gage, window, and so on). Pick this field to open the tool definition dialog field.
- **Condition** — Use this field to enable or disable the selected inspection tool, and to select other conditions that determine whether the tool will execute.

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- **Ref.** — Use this field to select a reference tool for the purpose of providing shift and/or rotation compensation for the selected inspection tool.
- ***S1** — Use this field to select the *primary* image source for a tool from a camera (such as C1) or from an image buffer (such as P1 or B1). The *default* image source selection is the lowest camera number when more than one camera is used.
- ***S2** — Use this field to select the *secondary* image source (for a tool that requires one) from a camera (such as C1) or from an image buffer (such as P1 or B1). By *default*, this field has no selection; also, the field is shaded when the selected tool cannot use a secondary image source.
- ***Dest** — Use this field to select a destination buffer (such as P1 or B1) for an image tool, profile tool, rotation finder tool, or window tool. A destination buffer supplies a processed image to the source tool or to other tools in the same toolset. By *default*, P1 is automatically selected for an image tool, profile tool, and rotation tool.

*For more information about the destination buffers, refer to the *Destination Buffers* section on page 4–30.

Here is a brief description of each *button* in the toolset edit panel:

- **Add**↑ — Use the Add↑ button to select a new inspection tool and insert it *before* (above) the inspection tool whose sequence number has the cursor arrow (→) alongside it. Thus, if the cursor arrow is located at sequence number 4, the *new* tool will occupy sequence number 4, while the tool previously at sequence number 4 will move to sequence number 5.
- **Add**↓ — Use the Add↓ button to select a new inspection tool and insert it *after* (below) the inspection tool whose sequence number has the cursor arrow (→) alongside it. Thus, if the cursor arrow is located at sequence number 3, the *new* tool will occupy sequence number 4, while the tool previously at sequence number 4 will move to sequence number 5.
- **Cut** — Use the Cut button to delete (and save in a "clipboard") the inspection tool whose sequence number has the cursor arrow (→) alongside it. Thus, if the cursor arrow is located at sequence number 2, the tool at that location will be deleted, and the tool previously at sequence number 3 will move to sequence number 2.
- **Copy** — Use the Copy button to copy into a "clipboard" the inspection tool whose sequence number has the cursor arrow (→) alongside it. After copying, the next step is pasting the copied tool (see the **Paste**↑ and **Paste**↓ button descriptions below).

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- **Paste↑** — Use the Paste↑ button to "paste" a copied inspection tool from the "clipboard" and insert it *before* (above) the inspection tool whose sequence number has the cursor arrow (→) alongside it. Thus, if the cursor arrow is located at sequence number 4, the pasted tool will occupy sequence number 4, while the tool previously at sequence number 4 will move to sequence number 5.
- **Paste↓** — Use the Paste↓ button to "paste" a copied inspection tool from the "clipboard" and insert it *after* (below) the inspection tool whose sequence number has the cursor arrow (→) alongside it. Thus, if the cursor arrow is located at sequence number 3, the pasted tool will occupy sequence number 4, while the tool previously at sequence number 4 will move to sequence number 5.
- **Options** — Use the Options button to make the following selections from each tool's Options selection panel:

  — Enable or disable statistics calculation (for certain tools).

  — Enable or disable display of tool graphic in the image field.

  — Enable or disable display of tool results in toolset Results panel.

  — Enable or disable *toolset* failures from individual *tool* failures.

  — Select a group *number* for each tool in a toolset.

  Refer to the *Options Selection Panel* section on page 4–31 for additional information.
- **Done** — Use the Done button to save all newly selected tools and exit the toolset edit panel. Refer to the *Alternate Toolset Save Option* section on page 4–34 for additional information.
- **Cancel** — Use the Cancel button to exit the toolset edit panel *without* saving any newly selected tools.

Here is a brief description of the *check boxes* in the toolset edit panel:

- **Register** — The Register check box is used during *setup* operations to perform the "register" function, which is active when a check mark (√) appears in the box. The purpose of this function is to enable a user to realign tools to a workpiece that shifted in the image field during *run* operations. This function will be *active* when "Yes" is selected in the Register field of the Display edit panel ("Yes" is the *default* setting), and *inactive* when "No" is selected. For details about the register function, refer to *Toolset Register Function* section on page 4–35.
- **Display All** — The Display All check box is used during *setup* operations to perform the "display all" function, which is active when a check mark (√) appears in the box. The purpose of this function is to display *all* tools in the current toolset edit panel, whether or not they are *enabled*. By *default*, this function will be *active* when "Yes" is selected in the Display field of the Display edit panel, and *inactive* when "No" is selected.

  When the display function is *active*, all tools are displayed in their currently configured positions. The currently selected tool appears in *red*; all other tools appear in *green*. When the function is *inactive*, only the currently selected tool appears in the display.

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Here is a brief description of the *data fields* that appear above the check boxes in the toolset edit panel:

- **Tools** — This field indicates the number of inspection tools in the current toolset edit panel. The example toolset edit panel in Figure 4.22 (page 4–27) shows this as 1 Tool.
- ***Tool bytes** — The first part of this field indicates the amount of memory bytes required by the current set of tools in the toolset edit panel, while the second part shows the total amount of system memory available for tools. The example toolset edit panel in Figure 4.22 (page 4–27) shows this as 408/65536 Tool bytes.
- ***Results bytes** — The first part of this field indicates the amount of memory dedicated to tool results for the current set of tools in the toolset edit panel, while the second part shows the total amount of system memory available for tool results. The example toolset edit panel in Figure 4.22 (page 4–27) shows this as 360/32768 Results bytes.

*The CVIM2 system automatically allocates memory space for tools and tool results as needed. If additional memory is required for a toolset or for results, refer to Appendix B and the *Variables* section of Chapter 10 (page 10–3) for information about setting environment variables.

Destination Buffers

A destination buffer (such as P1 or B1) is required for an image tool, profile tool, and rotation finder tool, since the main function of these tools is to supply processed images either to themselves or to other tools that follow them in the same toolset.

A destination buffer *must* be selected for any window tool that is to be configured to use the Two Pass function. In this case, the destination buffer must be selected in the toolset edit panel *before* the Two Pass function can be enabled in the window tool's tool edit panel. In addition, a destination buffer can be selected for a window tool when the only function of the buffer is to provide a processed image source for tools that follow the window tool in the toolset edit panel.

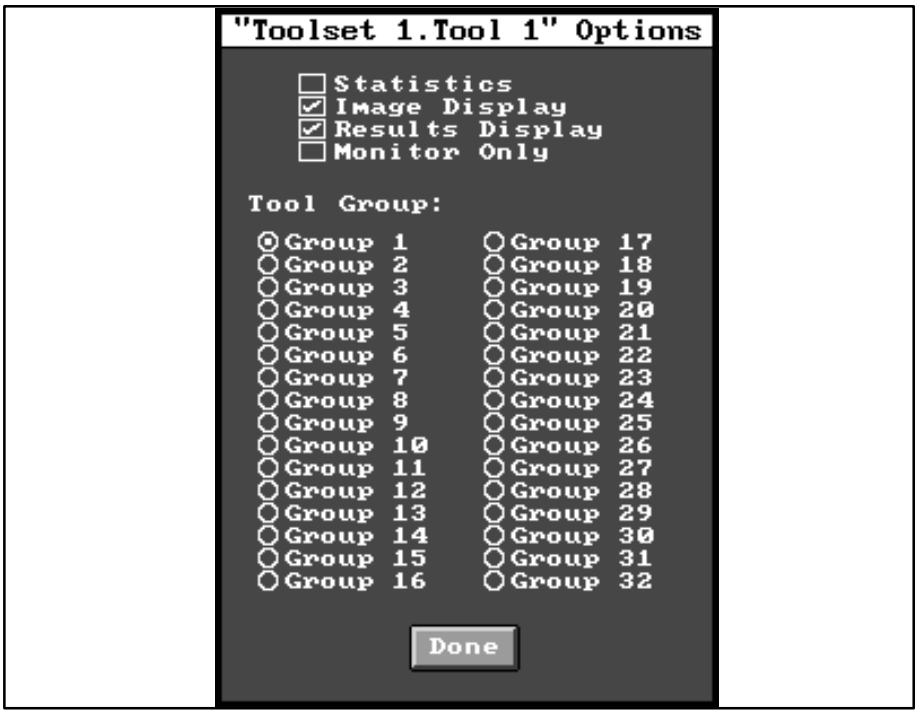
The two types of buffer, P1, P2, and P3, and B1, B2, and B3, perform the same function of storing a processed image; however, they differ in their duration of storage. The Px buffers are always released at the end of the current inspection cycle, while the Bx buffers can be used in some circumstances to store a processed image *beyond* the current instruction cycle, and make it available to *subsequent* inspections.

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Options Selection Panel

When you pick the Options button, the Options selection panel (for the *selected tool*) appears, as shown by the example in Figure 4.23. Note that the selected tool is indicated by the cursor arrow ⟨→) in the Num field of the toolset edit panel.

Figure 4.23 Example: Options Selection Panel



The first four options in the Options selection panel are *enabled* or *disabled* by alternately picking the check box alongside each option. When a check appears in a check box, the corresponding option is *enabled*, and the option is *disabled* when the check box is empty. The options are described briefly as follows:

- **Statistics** — When the Statistics function is enabled, statistics calculations are performed for the currently selected tool. *Note*: The Statistics box is shaded for tools that do not support statistics calculations (such as reference tools).
- **Image display** — When the Image Display function is enabled, the graphics symbols for the currently selected tool appear in the image field during inspection operations (setup mode and online).
- **Results display** — When the Results Display function is enabled, the results data from the currently selected tool appear in the Results panel during inspection operations (setup mode and online).
- **Monitor only** — When the Monitor Only function is enabled for a particular *tool*, the "Pass/Fail" results from that *tool* are prevented from affecting the "Pass/Fail" results for the corresponding *toolset*. You can use

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the Monitor Only function to prevent a *toolset* from failing while still receiving graphical Pass/Fail feedback from a particular *tool* within the toolset.

For example, with Monitor Only *enabled*, the Pass/Fail results from tool #1 of toolset #1 will *not* affect the Pass/Fail results of toolset #1. Conversely, with Monitor Only *disabled*, the tool #1 results will affect the toolset #1 results in the normal manner.

NOTE: If a discrete output is assigned to report the Pass/Fail status of a particular tool, the Monitor Only function, when *enabled* for that tool, will *not* affect the discrete output Pass/Fail status.

- **Tool Group** — Each tool in a toolset can be assigned a tool "group number" from 1 to 32, and the "Pass," "Fail," and "Execute" results selections for each *group* of tools can then be used in communications with a host system and in math tools.

  By default, each tool is initially assigned to group 1; thus, if no other group numbers are designated, all tools within a toolset will belong to group 1.

  For communications *results definitions*, the results selections have the following functions:

  — **Execute Groups** — This refers to the "execute" status of *all* groups of tools in the toolset. This result source returns a 32–bit result in which the least significant bit represents group 1 and the most significant bit represents group 32. Within each bit position, a logic "1" indicates that at least *one* tool in the group executed, while a logic "0" indicates that *no* tool in the group executed.

  — **Pass Groups** — This refers to the "pass" status of *all* group of tools in the toolset. This result source returns a 32–bit result in which the least significant bit represents group 1 and the most significant bit represents group 32. Within each bit position, a logic "1" indicates that *all* tools in the corresponding group *passed*, while a logic "0" indicates that at least *one* tool in the group *failed*.

  — **Fail Groups** — This refers to the "fail" status of *all* group of tools in the toolset. This result source returns a 32–bit result in which the least significant bit represents group 1 and the most significant bit represents group 32. Within each bit position, a logic "1" indicates that at least *one* tool in the group *failed*, while a logic "0" indicates that *all* tools in the group *passed*.

  — **Execute Group#** — This refers to the "execute" status of one or more groups of tools in the toolset. The starting and ending group numbers are specified by the #Index and #End Index values. This result source returns a logic "1" if *any* tool in *any* of the specified groups *executes* during the inspection cycle, and a logic "0" if *no* tool in *any* group executes.

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— **Pass Group#** — This refers to the “pass” status of one or more groups of tools in the toolset. The starting and ending group numbers are specified by the #Index and #End Index values. This result source returns a logic “1” if *all* tools in *all* of the specified groups *pass*, and a logic “0” if *any* tool in *any* group *fails*.

— **Fail Group#** — This refers to the “fail” status of one or more groups of tools in the toolset. The starting and ending group numbers are specified by the #Index and #End Index values. This result source returns a logic “1” if *any* tool in *any* of the specified groups *fails*, and a logic “0” if *all* tools in *all* of the group *pass*.

For communications *inspection events*, the results selections have the following functions:

— **Execute Group#** — This refers to the “execute” status of one group of tools in the toolset. The “#” represents a “Result Index” value, which is the number of the group to be specified as the active inspection event. The specified group generates an inspection event when *any* tool in the group *executes*.

— **Pass Group#** — This refers to the “pass” status of one group of tools in the toolset. The “#” represents a “Result Index” value, which is the number of the group to be specified as the active inspection event. The specified group generates an inspection event when *all* tools in the group *pass*.

— **Fail Group#** — This refers to the “fail” status of one group of tools in the toolset. The “#” represents a “Result Index” value, which is the number of the group to be specified as the active inspection event. The specified group generates an inspection event when *any* tool in the group *fails*.

For *math tool formulas*, the results selections have the following functions:

— **Execute Group#** — This refers to the “execute” status of one group of tools in the toolset. The “#” represents the number of the group whose execute status is to be returned. The specified group returns a logic “1” if *any* tool in the group *executes*, and a logic “0” if *no* tool in the group executes.

— **Pass Group#** — This refers to the “pass” status of one group of tools in the toolset. The “#” represents the number of the group whose pass status is to be returned. The specified group returns a logic “1” if *all* tools in the group *pass*, and a logic “0” if *any* tool in the group *fails*.

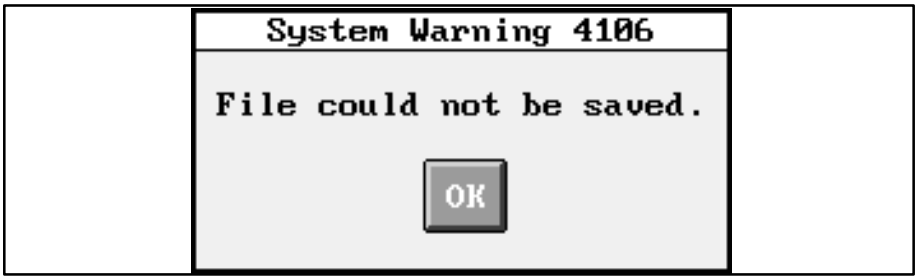
— **Fail Group#** — This refers to the “fail” status of one group of tools in the toolset. The “#” represents the number of the group whose fail status is to be returned. The specified group returns a logic “1” if *any* tool in the group *fails*, and a logic “0” if *all* tools in the group *pass*.

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Alternate Toolset Save Option

If, after you add tools to a toolset, the proposed storage device (such as "EE:") is *full* and *cannot* accept the enlarged toolset file, a warning message will appear when you pick the Done button, as shown in Figure 4.24:

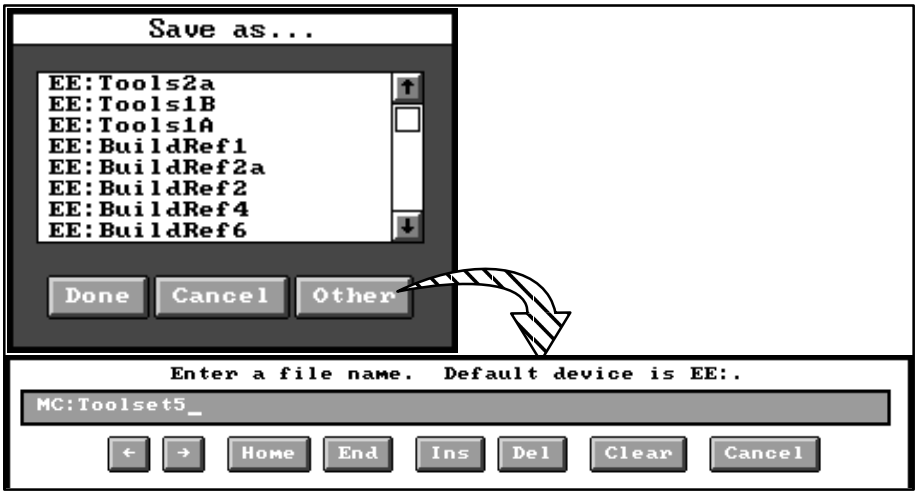
Figure 4.24 Warning Message When Toolset File Cannot Be Saved in Current Device



In order to save an amended toolset when you see this warning message, you must select an alternate storage device, such as the memory card, "MC:"

To save the toolset changes, pick the OK button on the warning message panel. When you do, the "Save as . . ." panel appears, as shown in Figure 4.25.

Figure 4.25 Selecting a New Device For Toolset Storage



NOTE: If you were to pick the Cancel button on the "Save as . . ." panel at this time, the panel would exit back to the toolset edit panel. If you then picked the Cancel button in the toolset edit panel, any changes that you made to the toolset would be *lost*.

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Pick the Other button to access the keyboard, as shown in Figure 4.25, and enter the new device name and tool file name (such as "MC:Toolset5" in the figure). Pick the Enter key to enter the new name, exit the keyboard, and return to the Save as . . . panel (the new device/tool file name will appear at the bottom of the list in this panel).

Pick the Done button on the Save as . . . panel to return to the toolset edit panel. To save the amended toolset in the new device (and exit the toolset edit panel), pick the Done button on the toolset edit panel. At this point, the "Saving toolset . . ." message should appear.

Toolset Register Function

The *tool register function* shifts and/or rotates the entire camera image as needed in order to move the *new workpiece image* to the same position that the *original workpiece image* occupied within the image field, thereby enabling you to adjust or reposition any of the existing inspection tools and/or add new tools.

The register function works only for tools that receive position compensation from a *reference tool* that locates the shifted workpiece. Further, the reference tool must be properly configured *and* must be able to locate the workpiece on the current image.

When you activate the register function, the entire image field shifts/rotates so that the current inspection tool lies over the workpiece image in the *same relationship* as it did *before* the workpiece image shifted/rotated. Then, you can select the inspection tools and "fine tune" their position and/or size over the workpiece just as though the workpiece shift/rotation had not taken place.

Figure 4.26 through Figure 4.31 illustrate the register function. Figure 4.26 (page 4–36) shows a Y', Y then X reference line tool and a window in their *original* positions over a workpiece image.

Figure 4.27 (page 4–36) shows the same tools after the workpiece image has shifted and rotated in the image field while in setup display mode (or online operation). The reference line tool has supplied shift and rotation compensation to the window, which remains correctly positioned over the workpiece image.

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Figure 4.26 Example: Original Positions of Tools and Workpiece Image

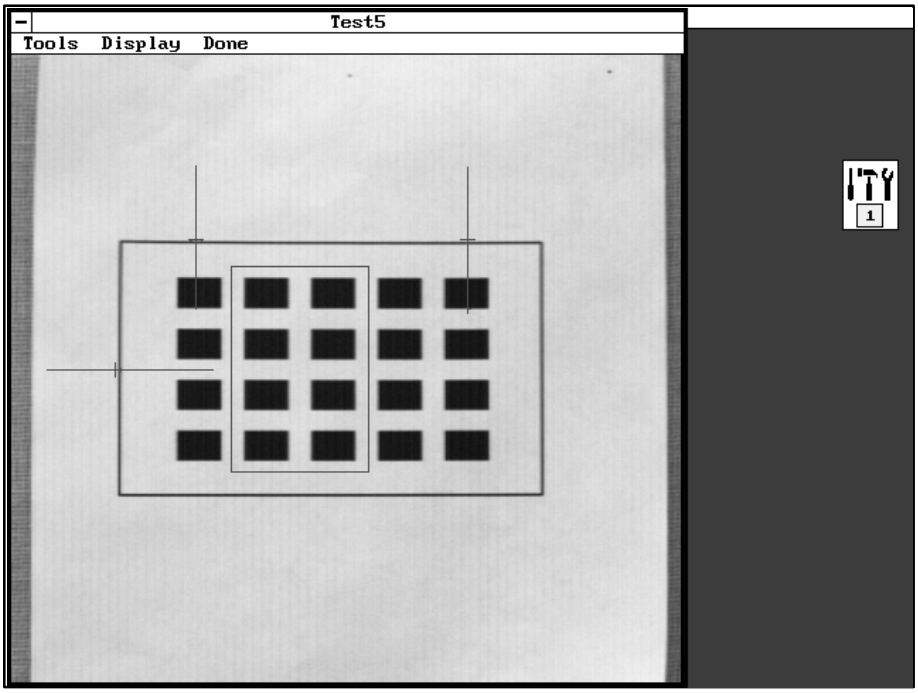
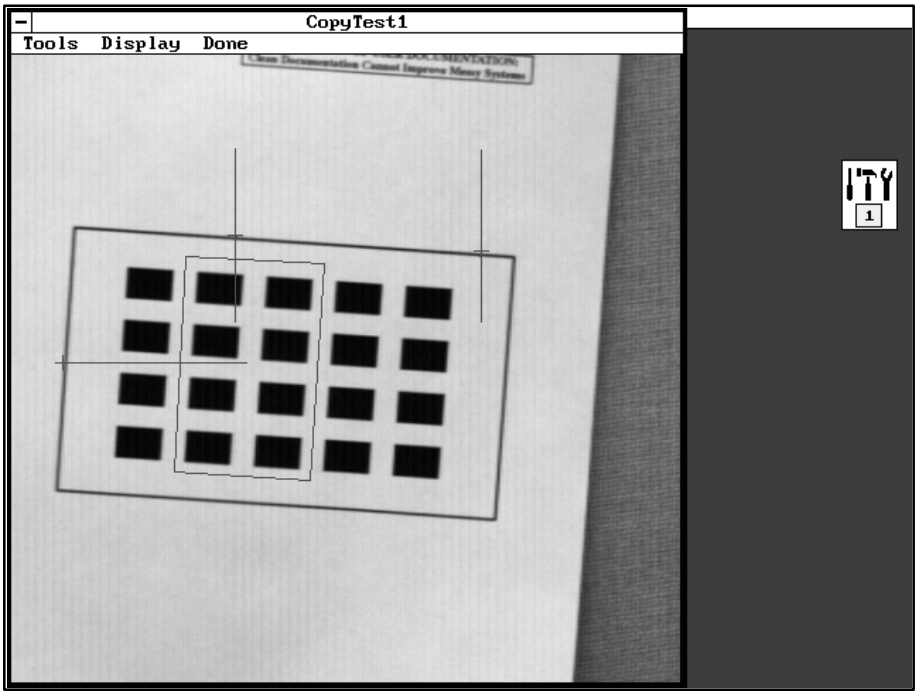


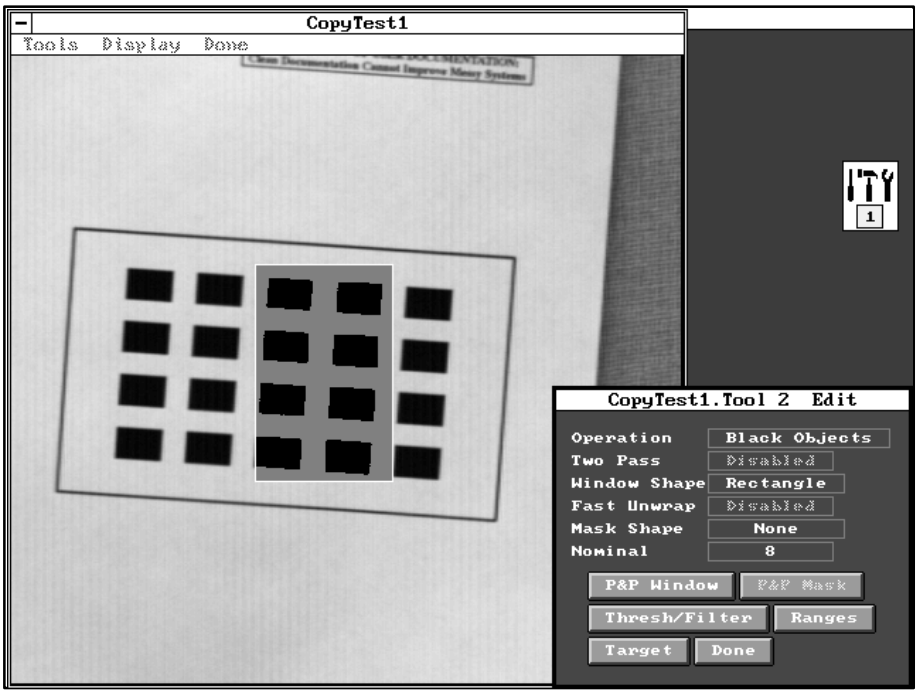
Figure 4.27 Example: Shifted and Rotated Window and Workpiece Image



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When you *exit* the setup display mode (or online operation) and return to the reference line edit panel, then select the window for the purpose of changing the window's position and/or size over the workpiece image *without* first selecting the tool register function, you will find the workpiece image and window relationship appearing as shown in Figure 4.28.

Figure 4.28 Example With Tool Register Function OFF



In this case, you would *not* be able to reposition the window accurately, nor set up new range limits or other parameters. To solve this problem, you can pick the Register box on the toolset edit panel. When you do, a check (√) appears in the box, and the Register function is *active*. The immediate result is that the entire camera image shifts and rotates so that the workpiece image is positioned as it was when the "nominal" position of the reference line tool was "learned." This is shown in Figure 4.29 (page 4–38).

With the workpiece image shifted and rotated back to its original position, you can now reposition and/or resize the window as shown in Figure 4.30 (page 4–38).

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Figure 4.29 Example With Tool Register Function ON

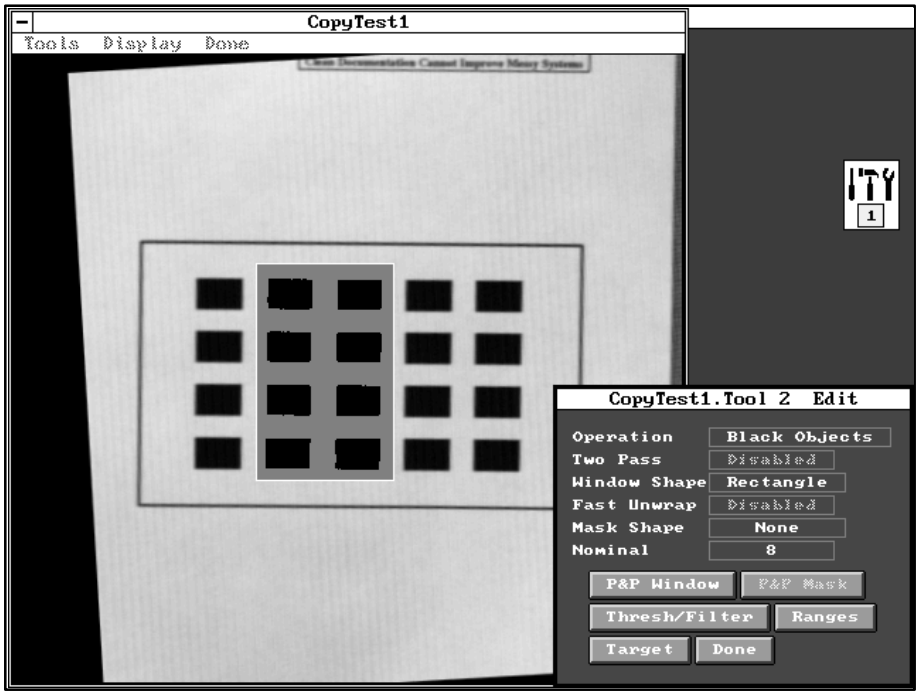
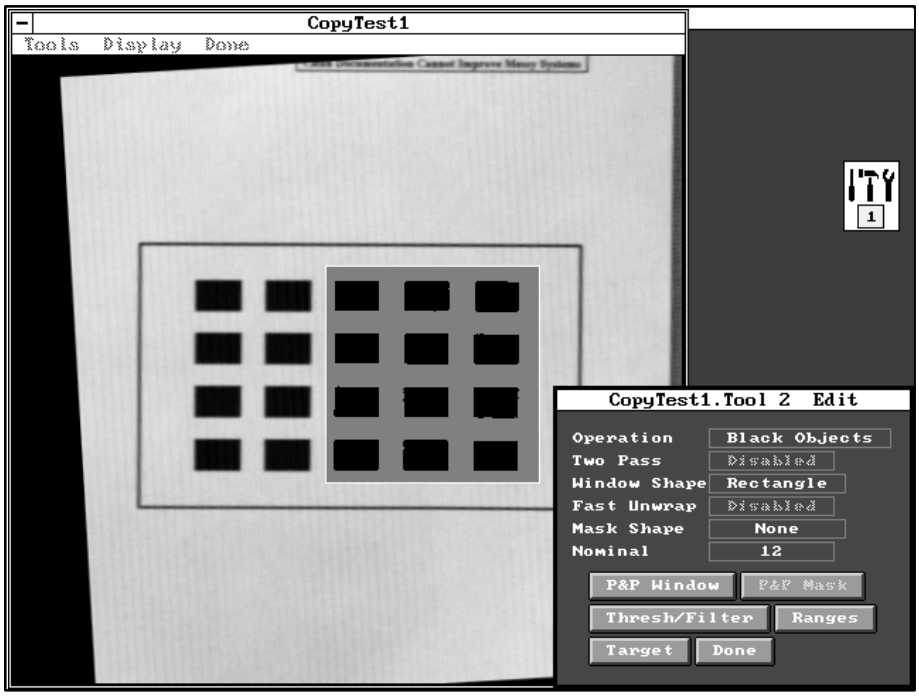


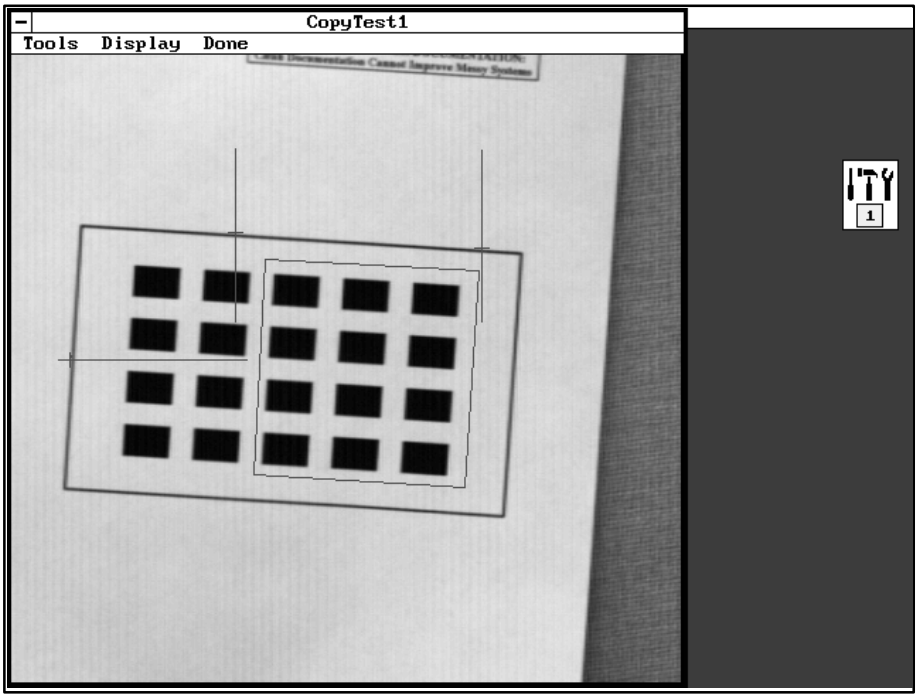
Figure 4.30 Example: Altering Window Over Shifted and Rotated Workpiece Image



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When you return again to setup display or online operations, the newly altered window will appear correctly positioned over the workpiece image as shown in Figure 4.31.

Figure 4.31 Example: Altered Window Shifted and Rotated



Each time you enter the toolset edit panel, the Register function will be restored to its *default* setting, as specified in the Display panel (see the *Selecting Display Parameters* section of this chapter, on page 4–16, for details).

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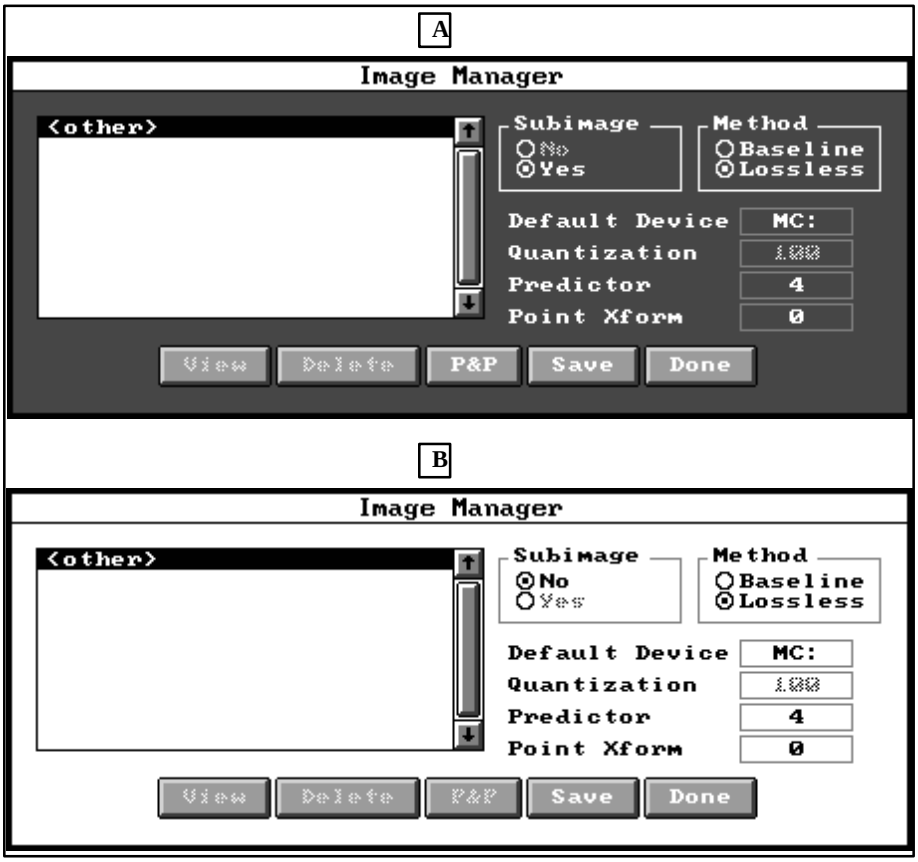
Image Manager Panel

The Image Manager panel enables you to archive full images or parts of images (called subimages). Full images are typically archived for troubleshooting, documentation of the original setup environment, and retention of rejected parts, while subimages are archived during configuration for use as features and templates with tools such as reference window, feature finder, and image tools.

Both types of images are archived as files on devices (memory) such as EE: and MC:.

During configuration, when you pick the Image Name field in the reference window or feature finder tool edit panel, or the Template field in the image tool edit panel, the Image Manager panel appears as shown in Figure 4.32 (**A**). During *online* operations, when you pick Save Image in the Display menus, the Image Manager panel appears as shown in (**B**).

Figure 4.32 Image Manager Panel: Two Forms



The parameter selections in the Image Manager panel provide a number of choices for compressing and storing images and for converting images to forms that are compatible with other image processing systems.

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Note that the panel contains several selection fields, data entry fields, and "buttons." Here is a brief description of their functions:

- **Subimage** — The selection in this field determines whether or not a *subimage* is to be selected. If Yes, you can specify an image whose size can range from 8 pixels square up to the entire image field. If No, you can store only the entire image field.

  The *fixed default* is Yes when the Image Manager panel is selected while configuring a reference window, feature finder, or image tool. The *fixed default* is No when the Image Manager panel is selected during *online* operation.

- **Method** — The selection in this field determines whether Baseline or Lossless compression method is to be used when archiving the image. With the Baseline method, the compression ratios are higher, but some image data is lost. With the Lossless method, the compression ratios are lower, but there is no loss of image data.
- **Default Device** — This field enables you to select the default memory "device" in which to archive the images or subimages. Initially, the default device is MC:, which is the external memory card.
- **Quantization** — This field is active only when you select the Baseline compression method. It enables you to select the level of "quantization," which is a variable (range: 5 to 500) that determines the degree of compression. Generally, the higher the quantization, the higher the compression (and image data loss). The *default* value is 100.
- **Predictor, Point Xform** — These fields are active only when you select the Lossless compression method, which causes all image files to be stored in JPEG form. The Predictor and Point Xform parameters enable you to *adjust* the file storage in order to make the image files compatible with other JPEG–based systems.
- **View** — Use the View button to view the highlighted image file.
- **Delete** — Use the Delete button to delete the highlighted image file.
- **P&P** — Use the P&P button to activate the "pick and place" function. This function is active *only* for subimages.
- **Save** — Use the Save button to save or archive the current image.
- **Done** — Use the Done button to exit the Image Manager panel.

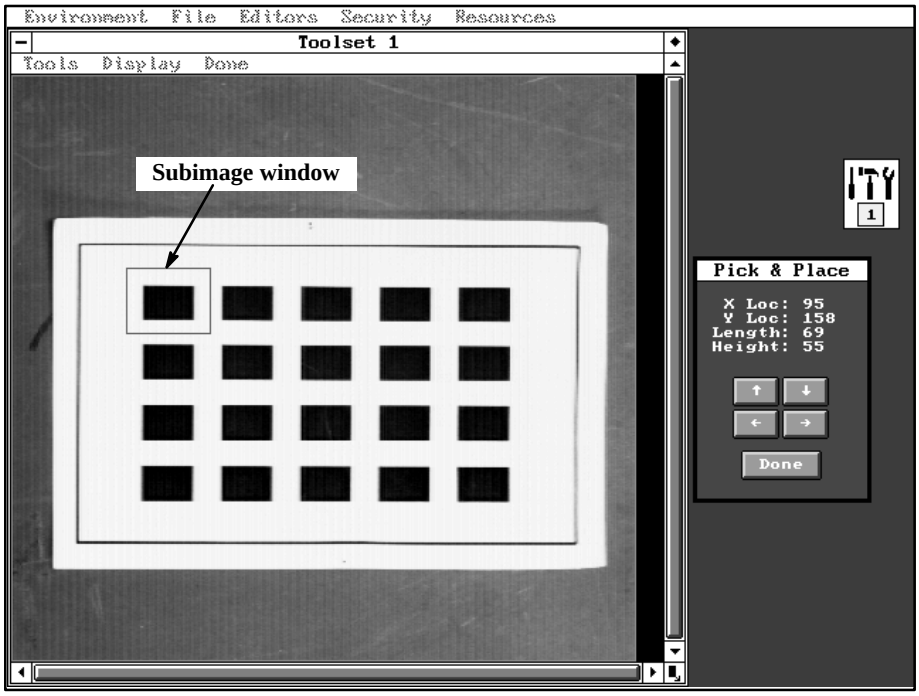
NOTE: For technical information about the Quantization, Predictor, and Point Transform selections, refer to the JPEG (Joint Photographic Experts Group) specification for "Digital compression and coding of continuous–tone still image," ISO/IEC DIS 10918–1.

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Configuring Subimage

The Image Manager provides a “pick and place” function to set the position and size of the subimage window. To configure a subimage, pick the P&P button, then position the window over the appropriate feature in the image field and set window’s size, as illustrated by the example in Figure 4.33.

Figure 4.33 Example: Subimage Window Positioned Over Feature



Before saving the feature image, check the Default Device field. Initially, the default device is “MC:,” which is the memory card. If you expect to save all (or most) feature image files in this device, leave it as “MC:.” If, however, you want to use another device, you can *change* the default device by picking the Default Device field and selecting another device from the Devices selection panel.

To save a feature image, pick the Save button. When you do, the keyboard panel appears with this instruction in the title bar:

```
Enter a file name. Default device is MC:.
```

To store an image file in the *default* device, enter a file name such as . . .

Feature1

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To store an image in a *different* device, enter the device name, a colon, and a file name, such as . . .

EE:feature1

In all cases, after entering the appropriate image name in the keyboard panel, pick the Enter key. When you do, the CVIM2 system begins saving the subimage and displays this message:

```
Saving Image
Please Wait
```

When the CVIM2 system finishes saving the subimage, it displays this message:

```
  Done saving image
Compression ratio 2:1
```

The compression ratio value appearing in the message is *truncated*; thus, 2:1 could actually be 2.9:1. Also, the actual compression ratio value varies with the details in the subimage. For *lossless* compression, however, it cannot exceed the theoretical limit of 4:1.

After a period of time that varies according to the size of the subimage, the "Done" message disappears and the Image Manager panel reappears. Note that the newly saved image file appears as "EE:image1 1, 55x59x8" in the scrolling window, as shown in Figure 4.34.

Figure 4.34 Example: Image Manager Panel After Saving Image



The "EE:image1" identifies the memory device and filename of the image file. The "1," indicates that the image is a *gray scale* image (currently, this value is always "1"). The "55x59x8" indicates the image file size in *pixels*.

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Pick the Done button to exit the Image Manager panel back to the appropriate tool edit panel or online display.

NOTE: The EE: and/or MC: devices may be useful for saving subimages while *testing* reference window or feature finder tools. However, when testing is *completed*, transferring those subimages to the V1: or V2: devices will release space in the EE: device, or allow removal of the MC: device.

Configuring Full Image

Configuring a full image involves the same steps as configuring a subimage except that no pick and place function is necessary or possible.

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Chapter 5

Pick and Place Functions

This chapter discusses the procedures for positioning the various CVIM2 inspection tools within the image field and/or changing their size and shape. This is called the “pick and place” function, and it can be performed using either the light pen or the mouse.

Pick and Place Terms

Here are some basic pick and place terms used in this manual:

1. **Pick** — This is the name for the latching effect that occurs when you press the light pen tip against a tool (or click the mouse cursor on it). After you *pick* a tool or tool part, you can move (“drag”) the tool (or tool part) across the image field.
2. **Drag** — This is the name for the act of moving a tool (or tool part) to a new position on the image field.
3. **Place** — This is the name for the latching effect that occurs when you press the light pen tip against a tool (or click the mouse cursor on it) after dragging a tool (or tool part) to a new position on the image field. When you *place* a tool, it remains in its new position until you pick and place it again.
4. **Pick and place points** — These are the points (or, more precisely, *regions*) at which you must point or aim the light pen or mouse cursor to pick a tool in order to move it, change its size, or change its orientation in the image field.
5. **Vernier arrows** — These are four graphic “arrow” buttons that enable you to “fine tune” the position, size, or shape of a tool, one pixel at a time, by picking the arrow button that corresponds to the desired direction: up, down, left, or right.

   The tool (or tool part) will move one pixel each time you pick an arrow button. Note that the tool may not always *appear* to move in the display panel, especially when display panel has been reduced to a small size on the monitor screen.

   Auto repeat — If you press and hold the light pen tip against the arrow button (or place the mouse cursor on the button and press and hold the mouse button), the tool will move repeatedly, one pixel at a time, until you release the light pen tip or mouse button.

The remaining sections of this chapter cover the pick and place procedures for each type of inspection tool.

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Linear Gages

When you pick the P&P Gage button in the gage *edit* panel (during setup mode) or the gage *adjust* panel (during *online* operation), the gage color changes from red to *green*, and the Pick & Place panel appears, as shown in Figure 5.1.

Figure 5.1 Example: Pick and Place Panel for a Line



The Pick & Place panel for the line gage contains the following data display fields and buttons:

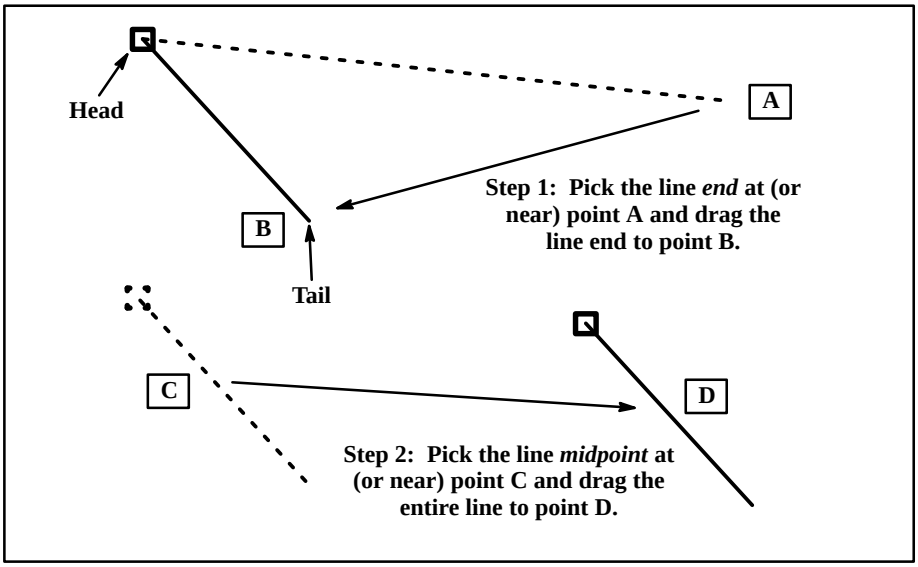
- **X1 Loc; Y1 Loc** — These two fields display, respectively, the current X and Y coordinates of the "head" of the gage.
- **X2 Loc; Y2 Loc** — These two fields display, respectively, the current X and Y coordinates of the "tail" of the gage.
- **Arrow buttons,** ↑, ↓, ←, and → — When you pick an arrow button, by *default* the *entire line* moves one pixel in the direction of the corresponding arrow. If, however, you have just picked and placed the "head" or "tail" of the line, the arrow buttons will then affect that part of the line *only.*
- **Done** — When you have set the line's position and size as required for the application, pick the Done button to exit the pick and place function and return to the tool edit or adjust panel.

The green gage color indicates that the gage is enabled for pick and place operations. Figure 5.2 (page 5–3) demonstrates the pick and place operation as it pertains to a linear gage. Using pick and place, you can change the length and angle of a linear gage and position the gage anywhere, so long as it lies entirely within the image field.

NOTE: Before using the buttons, you must first "click" the light pen or mouse pointer anywhere outside the image display panel (except in the A–B "Help" icon) in order to "activate" the Pick & Place panel. The panel is active when its border changes to solid black.

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Figure 5.2 Example: Using Pick and Place to Alter a Line



Reference Lines

The pick and place function operates the same with a reference line as it does with a line gage, except that since a reference line can lie *only* on either the X–axis or the Y–axis, it can be shortened or lengthened only along its designated axis, within the limits of the image field. It can, however, be positioned anywhere, so long as it lies entirely within the image field.

Arc Gages

When you select an arc gage and then pick the P&P Gage button in the gage edit panel, the gage color changes from red to *green*, and the Pick & Place panel appears, as shown in Figure 5.3.

Figure 5.3 Example: Pick and Place Panel for an Arc



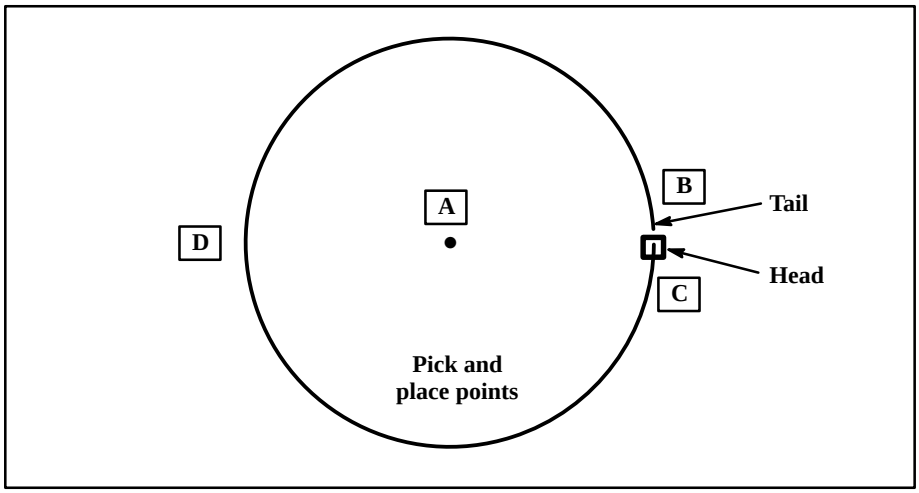
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The Pick & Place panel for the arc gage contains the following data display fields and buttons:

- **X Cen; Y Cen** — These two fields display, respectively, the current X and Y coordinates of the center point of the arc.
- **Radius** — This field displays the current arc radius in pixels.
- **Theta** — This field displays the current location, in radians, of the "head" of the arc, with respect to the 3 o'clock position of the arc. The radian value increases clockwise from that point.
- **Radians** — This field displays the current arc size in radians.
- **Arrow buttons,** ↑, ↓, ←, and → — When you pick an arrow button, by *default* the *entire arc* moves one pixel in the direction of the corresponding arrow. If, however, you have just picked and placed the "head" or "tail" of the arc, the arrow buttons will affect that part of the arc *only.*
- **Done** — When you have set the arc's position and size as required for the application, pick the Done button to exit the pick and place function and return to the tool edit or adjust panel.

Figure 5.4 shows how an arc appears in its *default* state after you pick the P&P Gage button. Note that in this state the arc is nearly a full circle, with the two ends at the 3 o'clock position nearly touching.

Figure 5.4 Pick and Place Points for an Arc



As Figure 5.4 shows, pick and place points are located at the arc center (A), the "head" and "tail" (B and C), and the midpoint (D) between (B and C).

The function of point (A) depends on which of the two pick and place *modes* you select: fixed center, or fixed ends. When you select the *fixed center* mode, the center (indicated by the •) remains anchored in the image field; whereas, when you select the *fixed ends* mode, the two ends of the arc remain anchored in the image field.

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When you select the *Fixed Center* mode, the pick and place operations for an arc gage have the following functions:

- **Arc ends** — These pick and place points enable you to change the number of degrees of arc from either end of the arc.
- **Center of arc** — This pick and place point enables you to change the position of the entire arc within the image field.
- **Arc midpoint** — This pick and place point enables you to change the *radius* of the arc while the number of degrees in the arc remains constant.

Figure 5.5 (page 5–6) demonstrates the operation of *all* pick and place operations for an arc in the *fixed center* mode:

- **Example 1:** The right end of the arc is picked at point C, dragged in a circular motion to point C′, and then placed at point C′, thereby decreasing the number of degrees in the arc (the arc radius remains the same).
- **Example 2:** The center of the arc is picked at point A, the entire arc is dragged to point A′, and is then placed at point A′ (the number of degrees in the arc and the arc radius are not changed).
- **Example 3:** The midpoint of the arc is picked at point D and is dragged to point D′, thereby uniformly increasing the *radius* of the arc (the number of degrees in the arc remains the same).

When you select the *fixed ends* mode, the pick and place operations for an arc have the following functions:

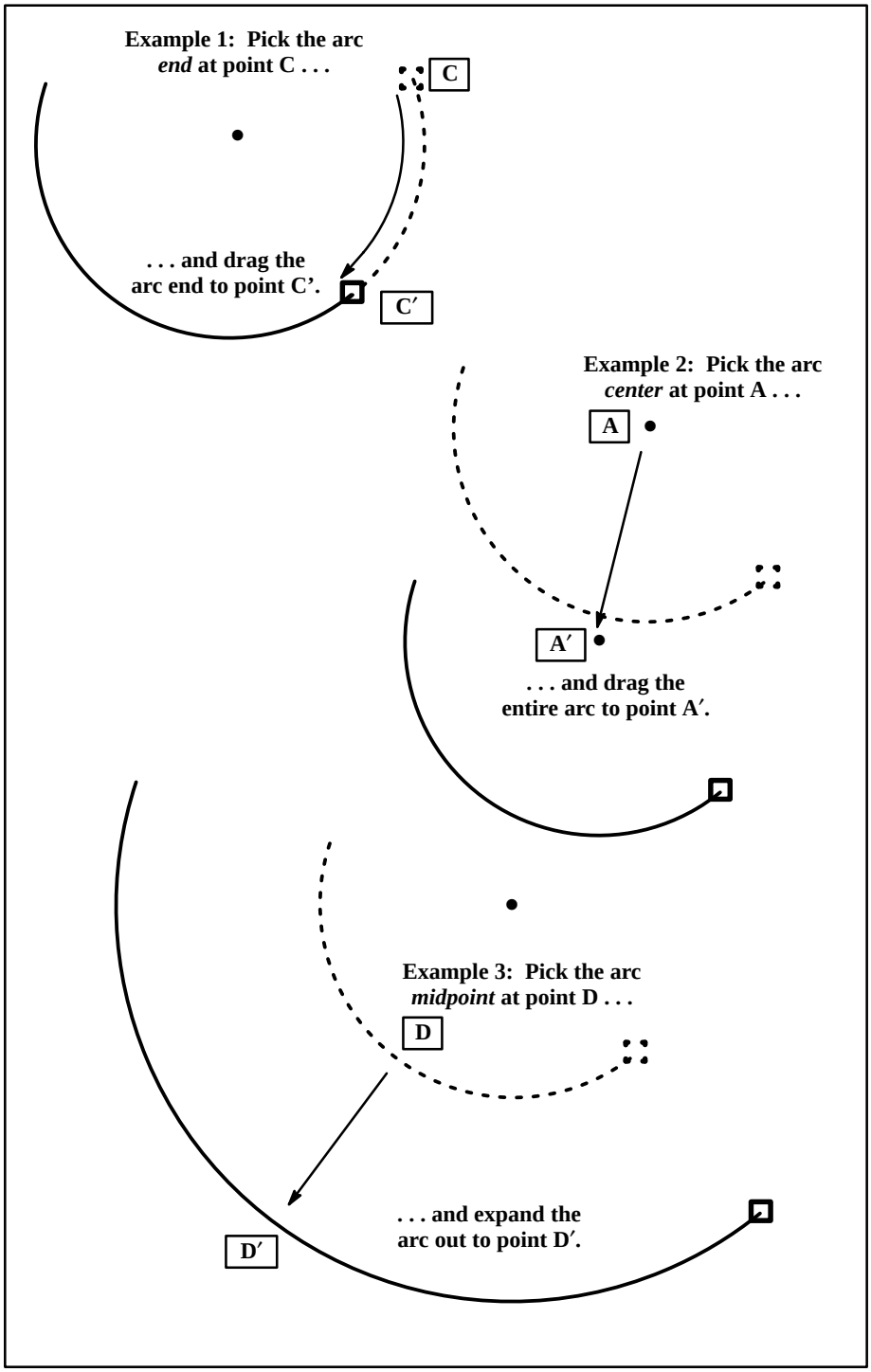
- **Arc ends; center of arc** — These pick and place points have the same functions in the *fixed ends* mode as they do in the *fixed center* mode.
- **Arc midpoint** — This pick and place point enables you to change the number of degrees of arc and the radius of the arc while the two ends of the arc remain anchored. This point can move *only* in a direction that is perpendicular to a line drawn through the two ends (regardless of their orientation in the image field); otherwise, the movement is restricted only by the limits of the image field.

Figure 5.6 (page 5–7) demonstrates the operation of the arc midpoint in the *fixed ends* mode (the other pick and place points operate the same as in the *fixed center* mode).

- **Example 1:** The arc midpoint is picked at point D, dragged *upward* to point D′, and then placed at point D′. In this example, the number of degrees in the arc *decrease*, but the radius of the arc *increases*.
- **Example 2:** The arc midpoint is picked at point D, dragged *downward* to point D′, and then placed at point D′. In this example, both the radius of the arc and the number of degrees in the arc *increase*.

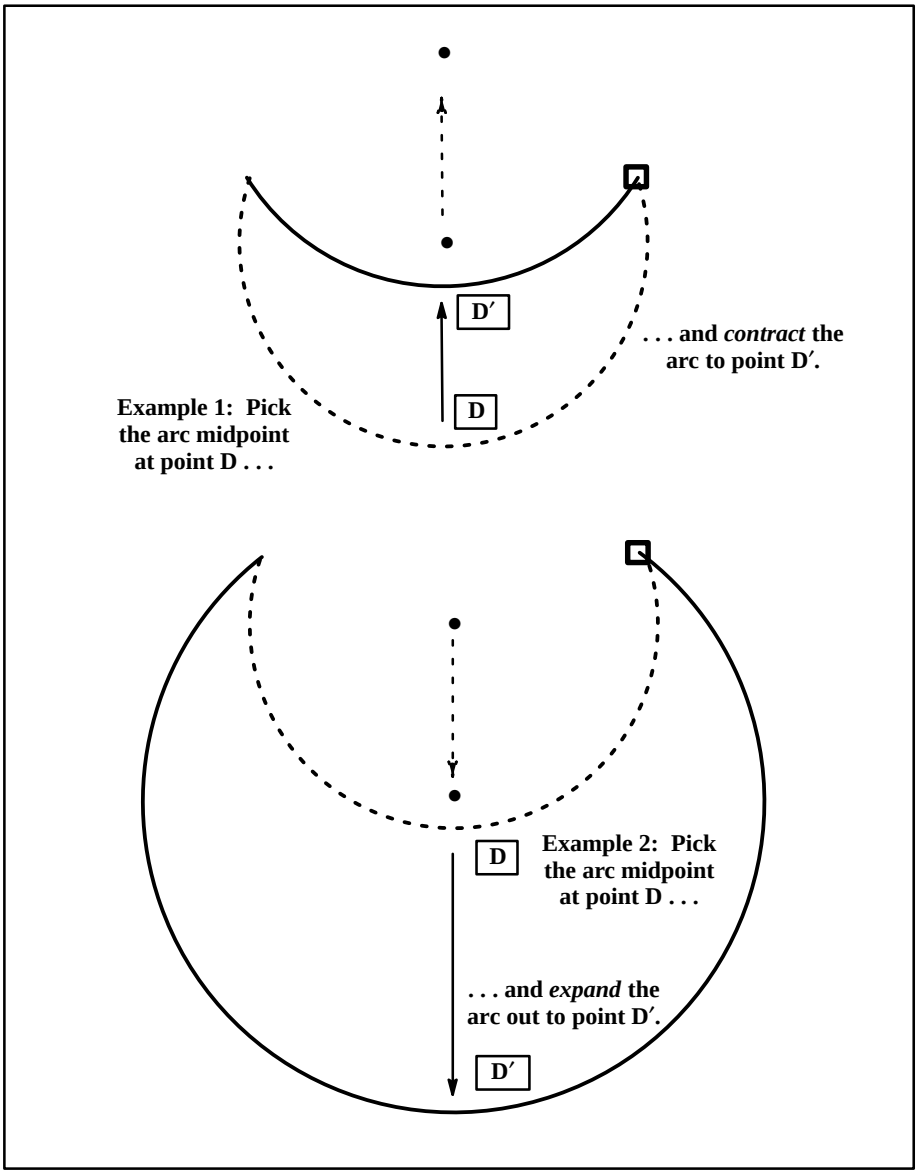
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Figure 5.5 Example: Using Pick and Place to Alter an Arc *(Fixed Center* Mode)



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Figure 5.6 Example: Using Pick and Place to Alter an Arc (*Fixed Ends* Mode)



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Rectangular Windows

When you select a *rectangular* window shape and then pick the P&P Window button in the window tool edit panel, the rectangular window Pick & Place panel appears, as shown in Figure 5.7.

Figure 5.7 Example: Pick and Place Panel for Rectangular Window



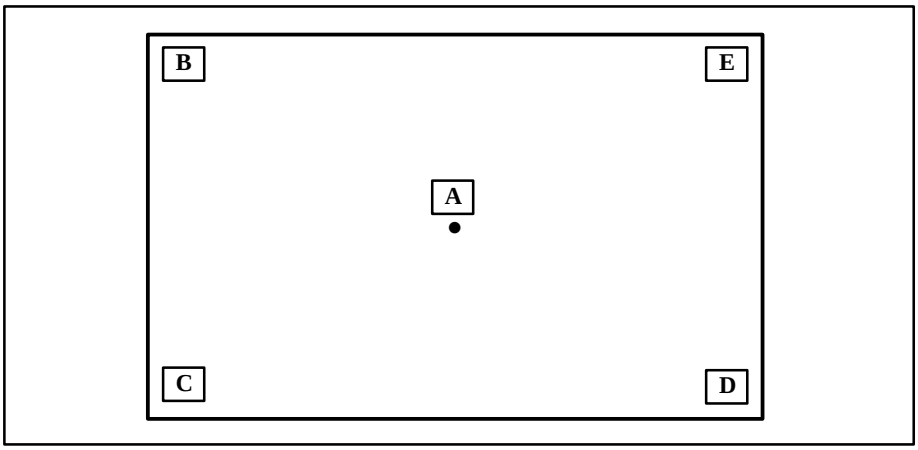
The rectangular window Pick & Place panel contains the following data display fields and buttons:

- **X Loc; Y Loc** — These two fields display, respectively, the current X and Y coordinates of the *upper–left corner* of the rectangular window.
- **Length** — This field displays the window length (X–axis) in pixels.
- **Height** — This field displays the window height (Y–axis) in pixels.
- **Arrow buttons,** ↑, ↓, ←, and → — When you pick an arrow button, by *default* the *entire window* moves one pixel in the direction of the corresponding arrow. If, however, you have just picked and placed one corner of the window, the arrow buttons will affect that part of the window *only.*
- **Done** — When you have set the window position and size as required for the application, pick the Done button to exit the pick and place function and return to the tool edit panel.

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As Figure 5.8 shows, pick and place points are located at the window center (A) and at the four corners (B, C, D, and E).

Figure 5.8 Pick and Place Points for a Rectangular Window



These pick and place points have the following functions:

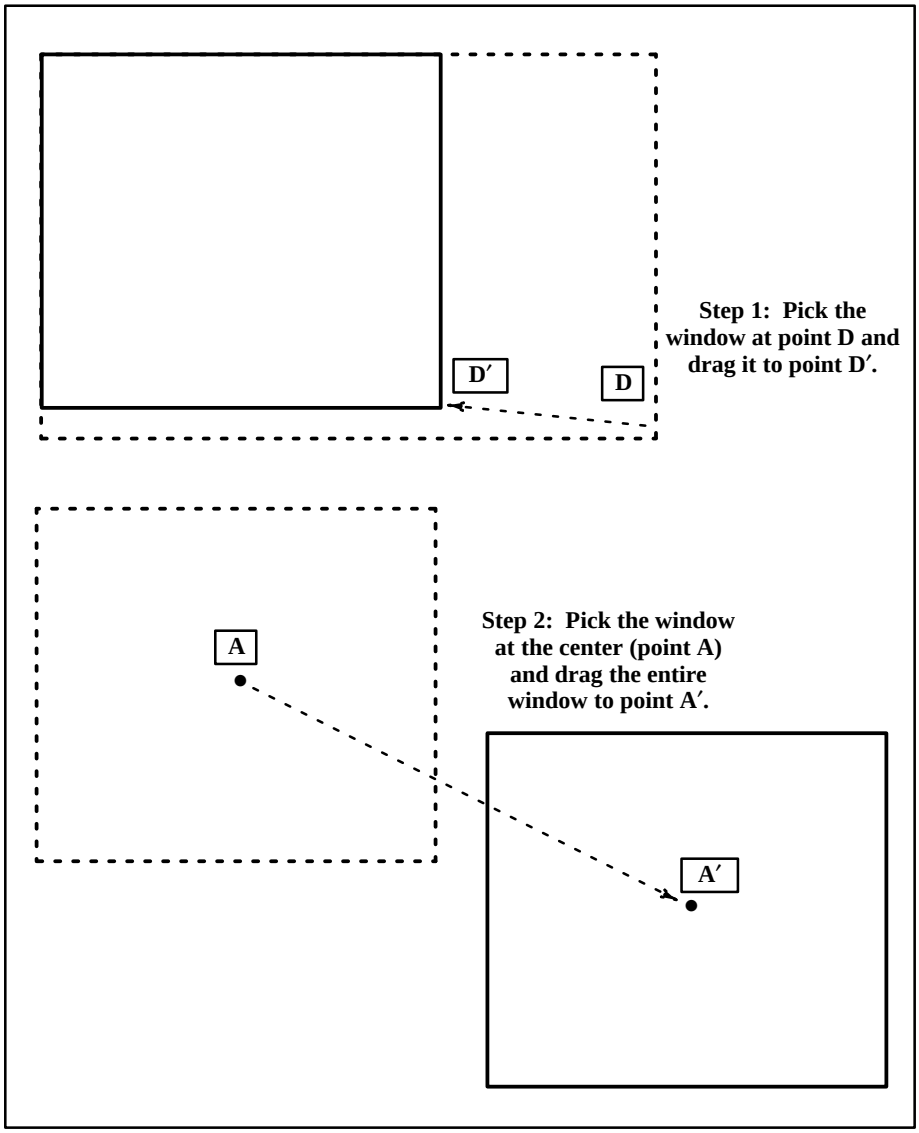
- **Center of window** — The center pick and place point enables you to move the *entire window* anywhere within the image field *without* changing the window's shape or size.
- **Corners** — The corner pick and place points enable you to drag each window corner in any direction. The corner opposite the picked corner always remains anchored. Thus, you can change the window size anywhere between its smallest size and the limits of the image field.

Figure 5.9 (page 5–10) provides two examples that demonstrate the operation of all pick and place operations for a rectangular gage:

- **Example 1:** The lower–right corner of the window is picked at point D, dragged to point D′, and then placed at point D′, thereby decreasing the size and changing the shape of the window.
- **Example 2:** The center of the window is picked at point A, and the entire window is dragged to point A′, and then placed at point A′.

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Figure 5.9 Example: Using Pick and Place to Alter a Rectangular Window



Note that all four of the corner pick and place points operate the same way: The picked corner can be dragged around the image field, along with the two adjacent sides, while the opposite corner remains anchored.

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Elliptical Windows

When you select an *elliptical* window and then pick the P&P Window button in the window edit panel, the window color changes from red to *green*, and the Pick & Place panel appears, as shown in Figure 5.10.

Figure 5.10 Example: Pick and Place Panel for Elliptical Window



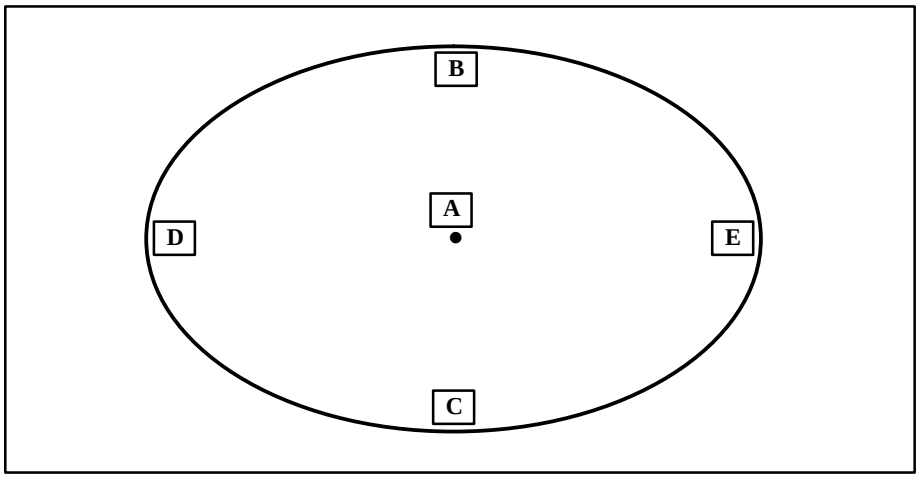
The elliptical window Pick & Place panel contains the following data display fields and buttons:

- **X Cen; Y Cen** — These two fields display, respectively, the current X and Y coordinates of the *center* of the elliptical window.
- **Major** — This field displays the length of the *major axis* (along the X–axis), in pixels.
- **Minor** — This field displays the length of the *minor axis* (along the Y–axis), in pixels.
- **Arrow buttons,** ↑, ↓, ←, and → — When you pick an arrow button, by *default* the *entire window* moves one pixel in the direction of the corresponding arrow. If, however, you have just picked and placed one side of the window, the arrow buttons will affect that part of the window *only.*
- **Done** — When you have set the window position and size as required for the application, pick the Done button to exit the pick and place function and return to the tool edit (or adjust) panel.

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Figure 5.11 shows the pick and place points that apply to an elliptical window. (Note that the *default* elliptical window appears as a circle.)

Figure 5.11 Pick and Place Points for an Elliptical Window



Note that pick and place points are located at the center of the window (A) and at the cardinal positions (B, C, D, and E) around the circumference of the window. These pick and place points have the following functions:

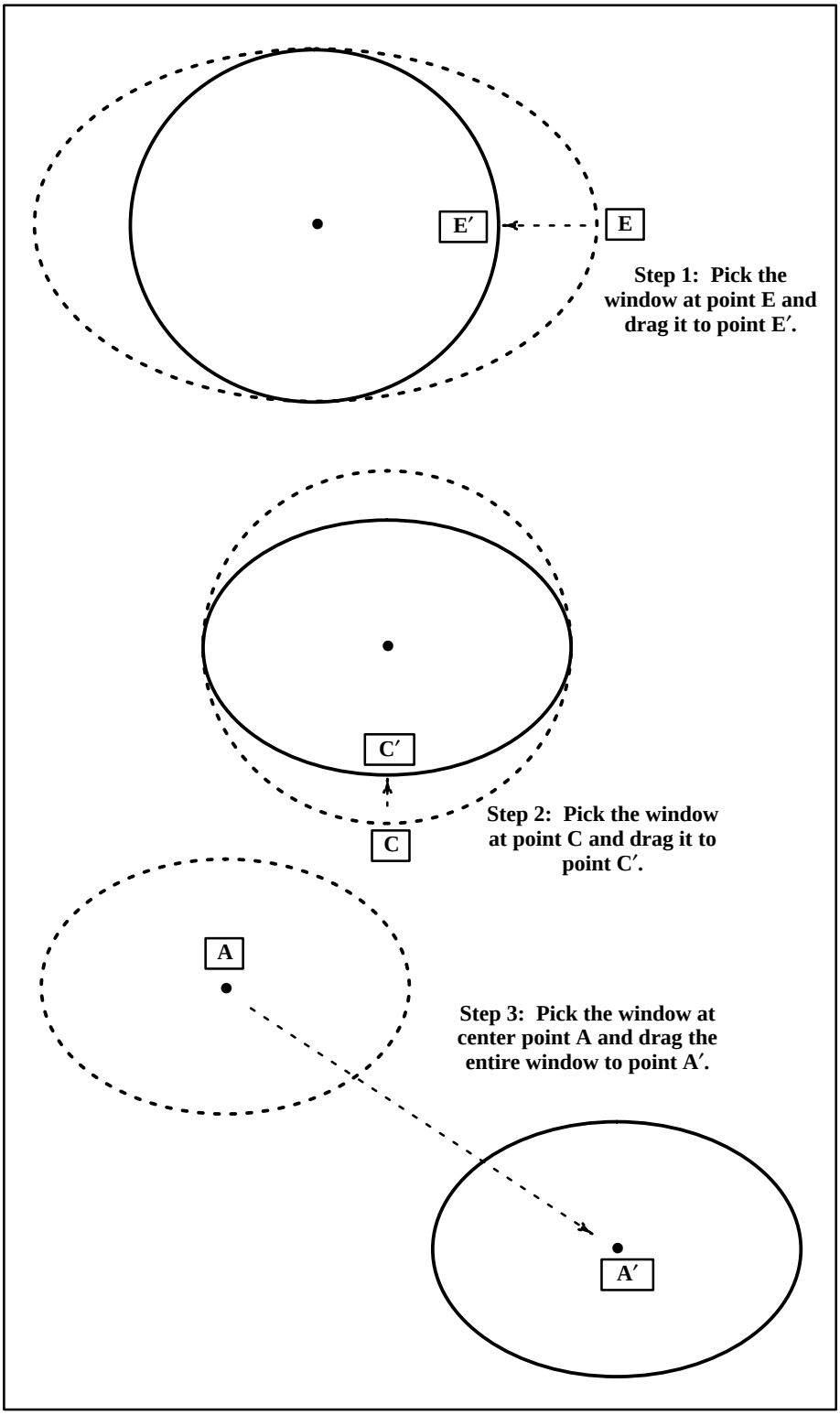
- **Center of window** — The center pick and place point enables you to move the *entire window* anywhere within the image field *without* changing the window's shape or size.
- **Circumference points** — The circumference pick and place points enable you to drag the circumference either toward or away from the center of the ellipse, while the *center* point remains anchored. Thus, you can drag the right and left sides to the right and left, and the top and bottom sides up and down. The effect is to stretch or compress the ellipse, and thereby change both the size and shape of the elliptical window.

Figure 5.12 (page 5–13) demonstrates the operation of the elliptical window pick and place points in three steps, as follows:

- **Step 1:** The window is picked at point E, dragged to point E′, and then placed at point E′. This *decreases* the *width* of the ellipse.
- **Step 2:** The window is picked at point C, dragged to point C′, and then placed at point C′. This *decreases* the *height* of the ellipse.
- **Step 3:** The window is picked at center point A, the entire window is dragged to point A′, and it is then placed (unaltered) at point A′.

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Figure 5.12 Example: Using Pick and Place to Alter an Elliptical Window

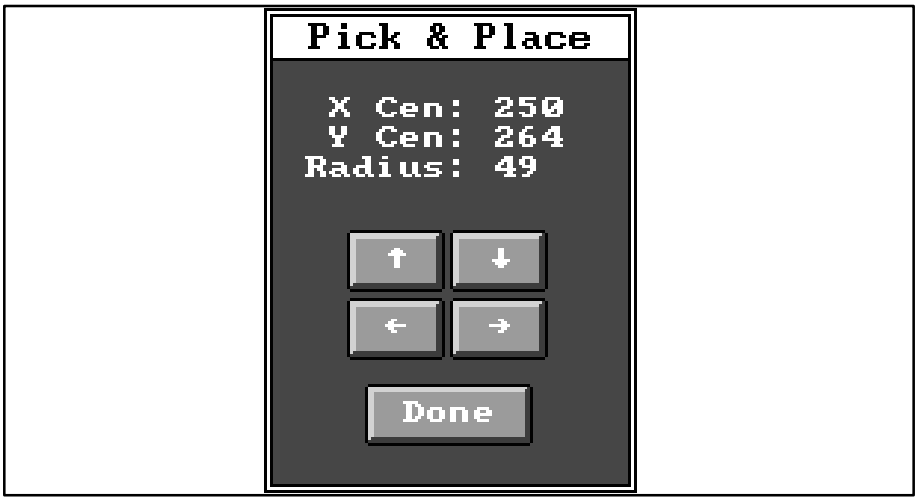


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Circular Windows

When you select an *circular* window and then pick the P&P Window button in the window edit panel, the window color changes from red to *green*, and the Pick & Place panel appears, as shown in Figure 5.13.

Figure 5.13 Example: Pick and Place Panel for Circular Window



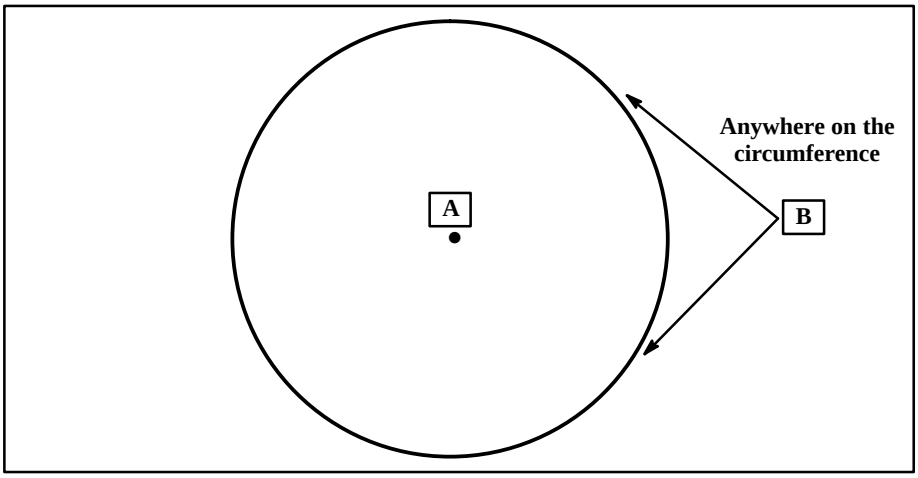
The circular window Pick & Place panel contains the following data display fields and buttons:

- **X Cen; Y Cen** — These two fields display, respectively, the current X and Y coordinates of the *center* of the circular window.
- **Radius** — This field displays the window radius, in pixels.
- **Arrow buttons,** ↑, ↓, ←, and → — When you pick an arrow button, by *default* the *entire window* moves one pixel in the direction of the corresponding arrow. If, however, you have just picked and placed one side of the window, the arrow buttons will affect that part of the window *only.*
- **Done** — When you have set the window position and size as required for the application, pick the Done button to exit the pick and place function and return to the tool edit (or adjust) panel.

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Figure 5.14 shows the pick and place points that apply to a circular window.

Figure 5.14 Pick and Place Points for a Circular Window



Note that pick and place points are located *anywhere* on the circumference of the window and at the center of the window. These pick and place points have the following functions:

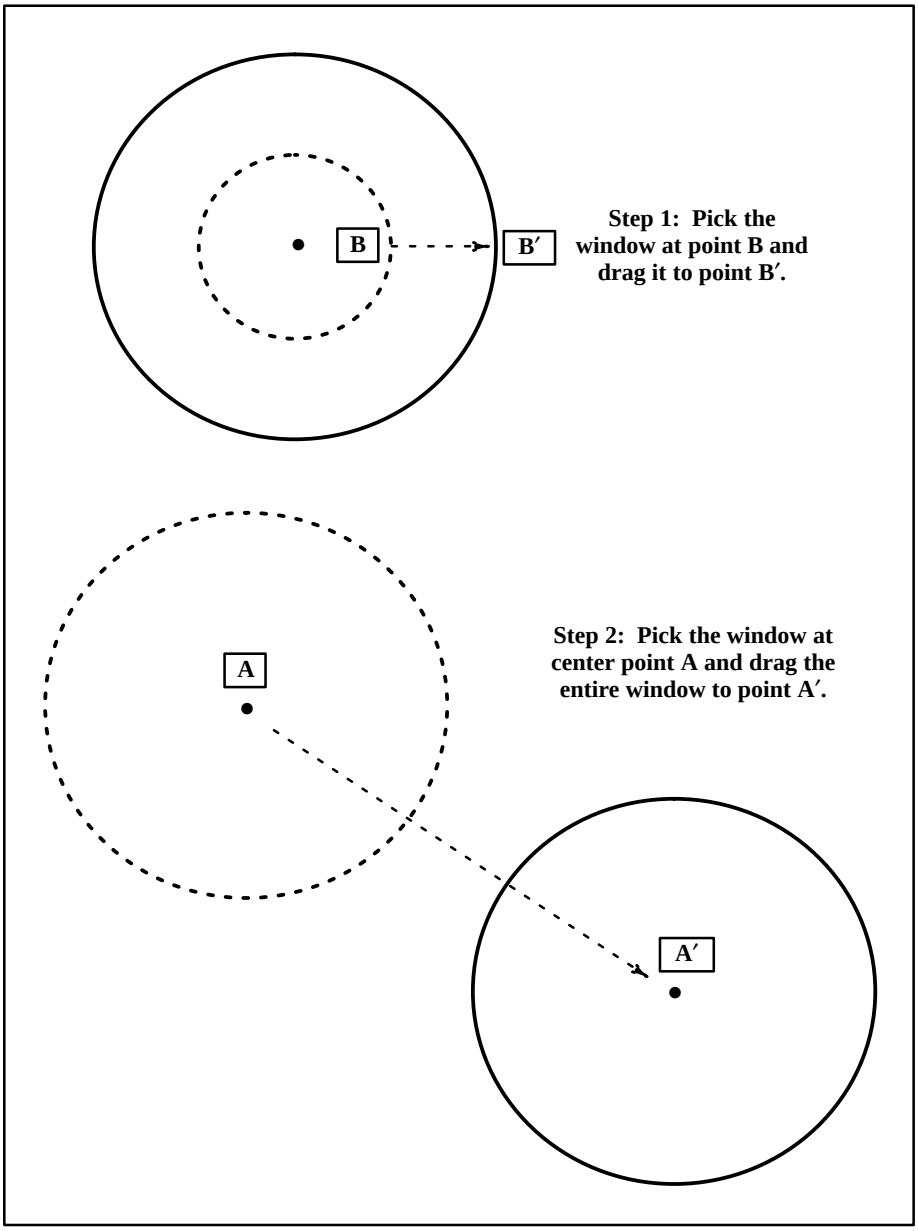
- **Center of window** — The center pick and place point enables you to move the *entire window* anywhere within the image field *without* changing the window's size.
- **Circumference** — The entire circumference is a pick and place point for the purpose of changing the window's size or radius.

Figure 5.15 (page 5–16) demonstrates the operation of the circular window pick and place points in two steps, as follows:

- **Step 1:** The window is picked at point B, dragged to point B′, and then placed at point B′. This *increases* the *radius* of the circle.
- **Step 2:** The window is picked at the center point A, the entire window is dragged to point A′, and it is then placed (unaltered) at point A′.

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Figure 5.15 Example: Using Pick and Place to Alter a Circular Window



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Arc Ring Windows

When you select the arc ring shape for a window tool and then pick the P&P Window button in the window edit panel, the *arc ring* window color changes from red to *green*, and the Pick & Place panel appears, as shown in Figure 5.16.

Figure 5.16 Example: Pick and Place Panel for Arc Ring Window



The arc ring window Pick & Place panel contains the following data display fields and buttons:

- **X Cen; Y Cen** — These two fields display, respectively, the current X and Y coordinates of the *center* of the arc ring window.
- **O Rad** — This field displays the radius of the *outer* ring, in pixels.
- **I Rad** — This field displays the radius of the *inner* ring, in pixels.
- **Theta** — This field displays the current location, in radians, of the "head" of the arc ring, with respect to the X–axis 0° point. The radian value increases clockwise from that point.
- **Radians** — This field displays the current arc ring size in radians.
- **Arrow buttons,** ↑, ↓, ←, and → — When you pick an arrow button, by *default* the *entire arc ring window* moves one pixel in the direction of the corresponding arrow. If, however, you have just picked and placed one side of the inner or outer ring, the arrow buttons will affect that part of the window *only.*
- **Done** — When you have set the window position and size as required for the application, pick the Done button to exit the pick and place function and return to the tool edit panel.

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When you pick the P&P Dest button in the window edit panel, the *destination* window color changes from red to *green*, and the corresponding Pick & Place panel appears. Since the pick and place functions for the destination window are the same as for the rectangular window, refer to the *Rectangular Windows* section on page 5–8 for details.

NOTE: The destination window should always be configured with the vertical axis *longer than* the horizontal axis, since the image data is displayed *vertically.* The *aspect ratio* should be adjusted as needed to optimize the appearance of the part or item being inspected.

Figure 5.17 (upper part) shows how an arc ring appears in its *default* state. Note that in this state the arc ring window is nearly a full circle, with the two ends of the arc ring nearly touching at the X–axis 0° point.

Figure 5.17 Pick and Place Points for an Arc Ring Window

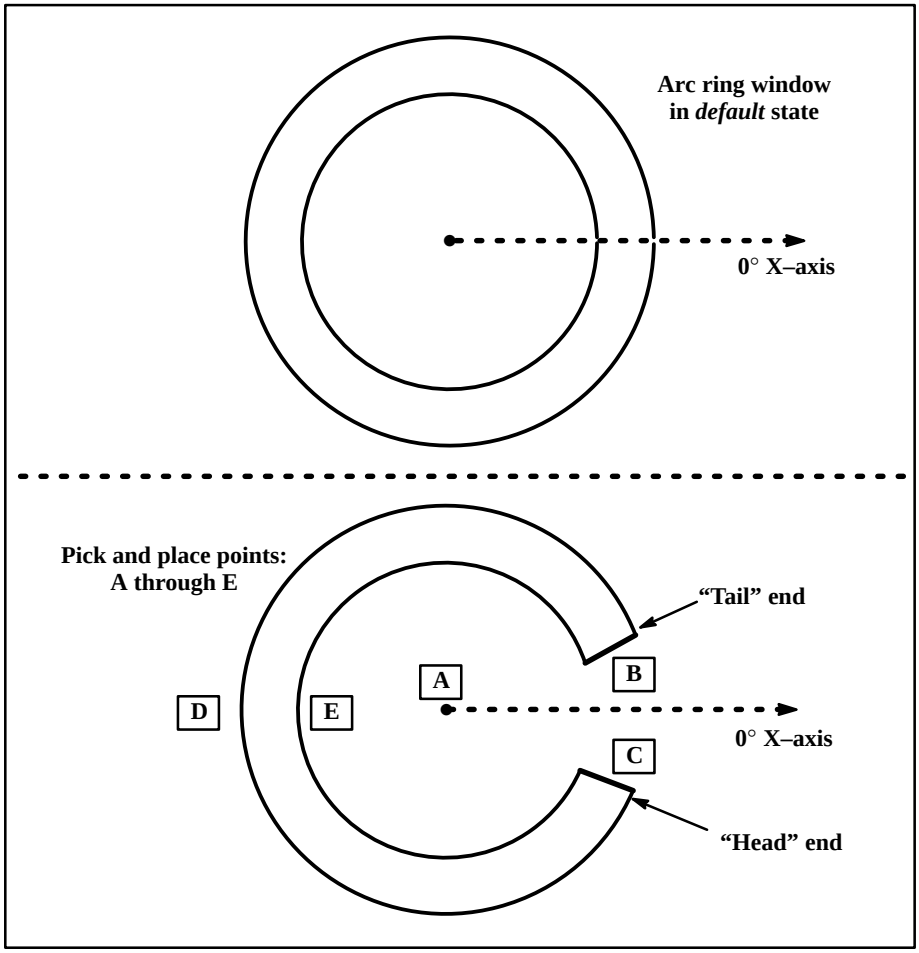


Figure 5.17 (lower part) shows where the pick and place points are located: at the arc ring center (A), the two ends (B and C), and the midpoint between the two ends for the *outer* ring (D) and the *inner* ring (E).

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The function of points (D) and (E) depends on which of the two pick and place *modes* you select: fixed center, or fixed ends. When you select the *fixed center* mode, the center (indicated by the •) remains anchored in the image field. In this mode, the diameter of the picked ring changes, while the diameter of the other ring remains unchanged. When you select the *fixed ends* mode, however, the two ends of the arc ring remain anchored in the image field. In this mode, the radii of both rings change in lockstep, and the spacing between them remains constant.

When you select the *Fixed Center* mode, the pick and place operations for an arc ring window have the following functions:

- **Arc ring ends** — These pick and place points enable you to change the number of radians of arc from either end of the arc ring.
- **Center of arc ring** — This pick and place point enables you to change the *position* of the arc ring window within the image field.
- **Arc ring midpoint** — This pick and place point enables you to change the *radius* of the picked ring (outer *or* inner), while the number of *radians* in the picked ring remains constant (and the *un*picked ring remains unchanged).

Figure 5.18 (page 5–20) demonstrates the operation of *all* pick and place operations for an arc in the *fixed center* mode:

- **Example 1:** The right end of the arc ring is picked at point C, dragged in a circular motion to point C′, and then placed at point C′, thereby decreasing the number of radians in the arc ring (the arc radius remains the same).
- **Example 2:** The center of the arc ring is picked at point A, the entire arc is dragged to point A′, and is then placed at point A′ (the number of radians in the arc ring and the arc ring radius are not changed).
- **Example 3:** The midpoint of the *outer* arc ring is picked at point D and is dragged to point D′, thereby uniformly increasing the *radius* of the outer arc (the number of radians in the arc remains the same, and the *inner* arc is unchanged).

When you select the *fixed ends* mode, the pick and place operations for an arc ring have the following functions:

- **Arc ring ends; center of arc ring** — These pick and place points have the same functions in the *fixed ends* mode as they do in the *fixed center* mode.
- **Arc ring midpoint** — This pick and place point enables you to change the number of radians of arc and the radius of the arc ring while the two ends of the *outer* arc ring remain anchored. This point can move *only* in a direction that is perpendicular to a line drawn through the two ends (regardless of their orientation in the image field); otherwise, the movement is restricted only by the limits of the image field.

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Figure 5.18 Example: Using Pick and Place to Alter an Arc *(Fixed Center* Mode)

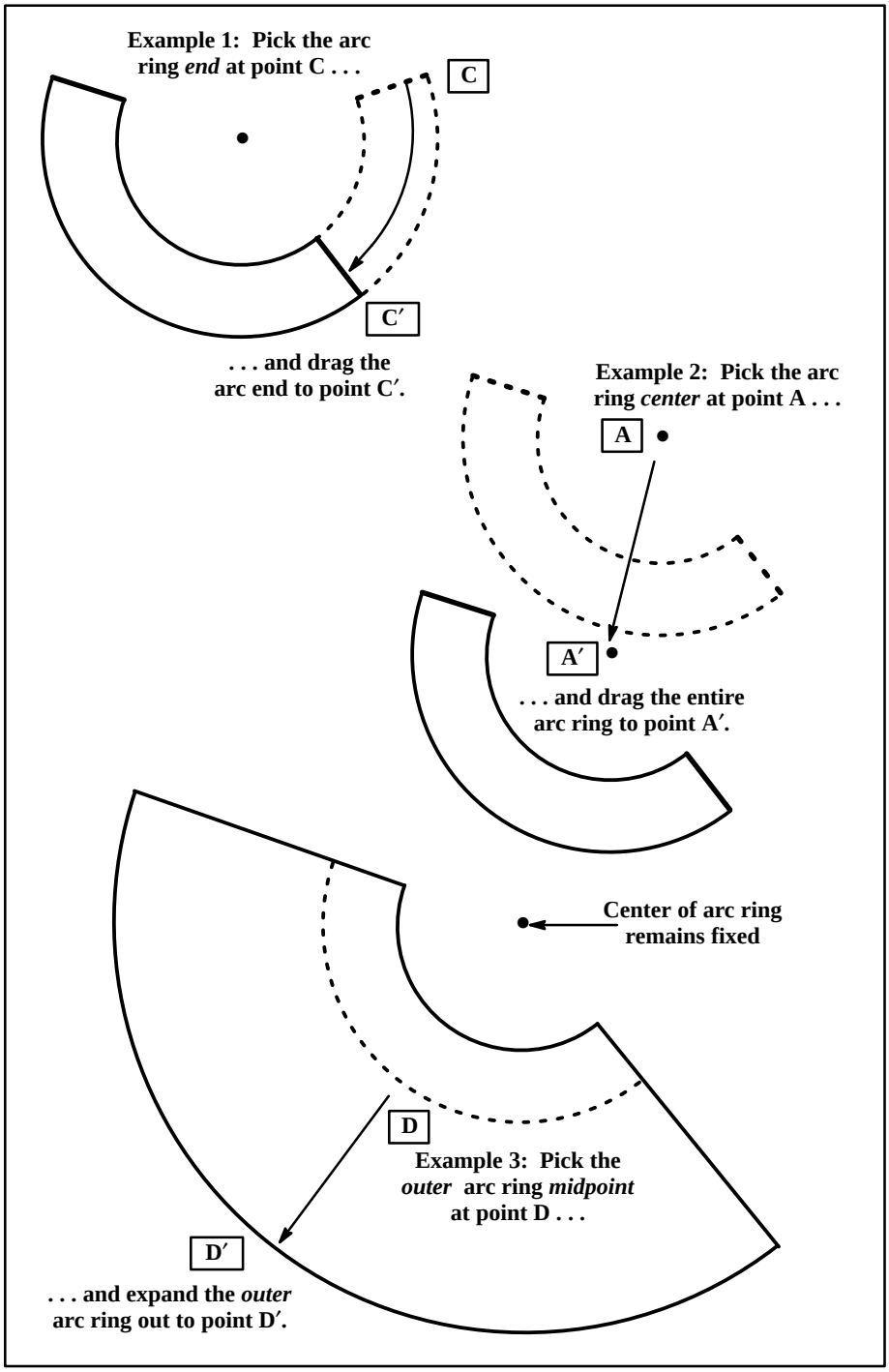
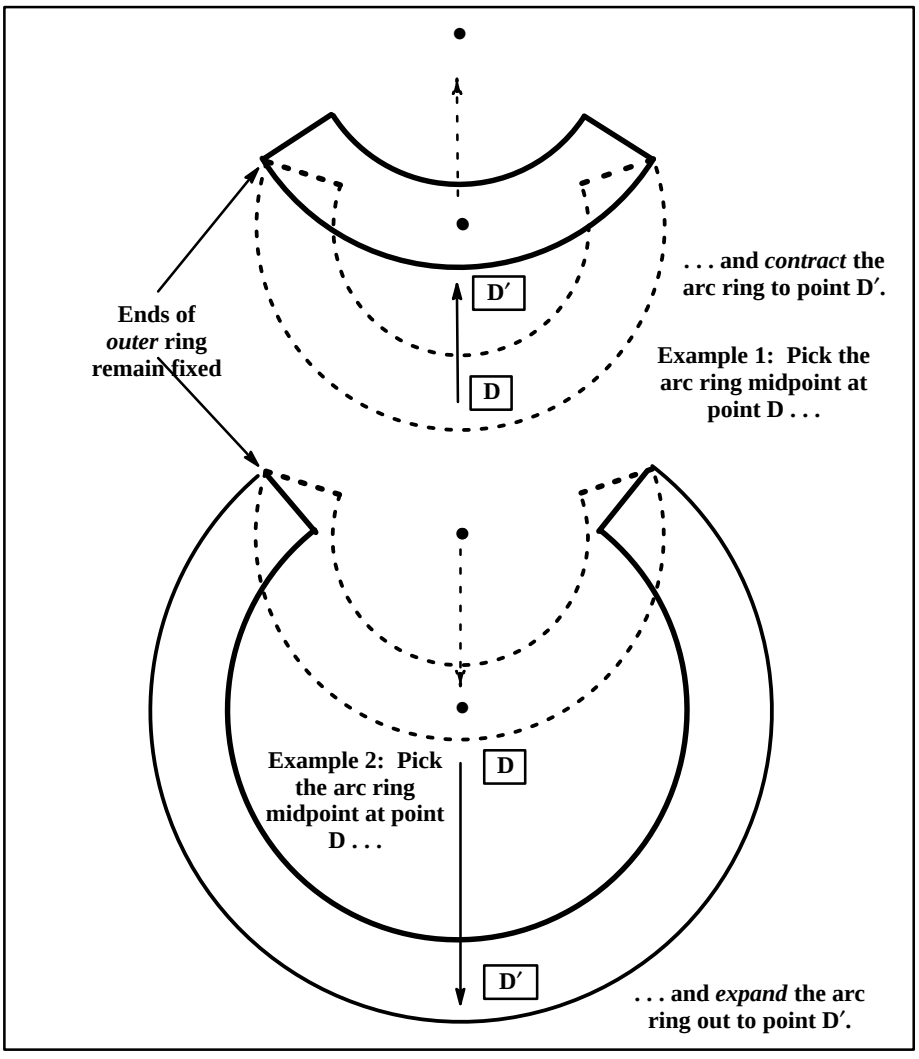


Figure 5.19 (page 5–21) illustrates the operation of the arc ring midpoint in the *fixed ends* mode (the other pick and place points operate the same as in the *fixed center* mode).

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- **Example 1:** The arc ring midpoint is picked at point D, dragged *upward* to point D′, and then placed at point D′. In this example, the number of radians in the arc ring *decrease*, and the radius of the inner and outer rings will *increase*.
- **Example 2:** The arc ring midpoint is picked at point D, dragged *downward* to point D′, and then placed at point D′. In this example, the number of radians in the arc ring and both radii *increase*.

Figure 5.19 Example: Using Pick and Place to Alter an Arc (*Fixed Ends* Mode)



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Polygon Windows

When you select a *polygon* window and then pick the P&P Window button in the window edit panel, the window color changes from red to *green*, and the Pick & Place panel appears, as shown in Figure 5.20.

Figure 5.20 Example: Pick and Place Panel for Polygon Window



The polygon window Pick & Place panel contains the following data display fields and buttons:

- **Vertices** — This field displays the number of vertices in the current polygon window.
- **Vertex #** — This field displays the number of the last vertex to be moved using the *Move Vertex* pick and place mode.

  The vertices are numbered according to their positions on the *default* polygon. Thus, the numbers start at #0 and increase clockwise. (Vertex number 0 *always* remains *fixed* relative to the polygon, regardless of how the polygon is altered subsequently.)
- **X Loc; Y Loc** — The X Loc field displays the window length (X–axis), and the Y Loc field displays the window height (Y–axis), in pixels.
- **P&P function selections** — These circles enable you to select the specific pick and place function.
- **Arrow buttons,** ↑, ↓, ←, and → — When Move Polygon is selected and you pick an arrow button, the *entire window* moves one pixel in the direction of the corresponding arrow.

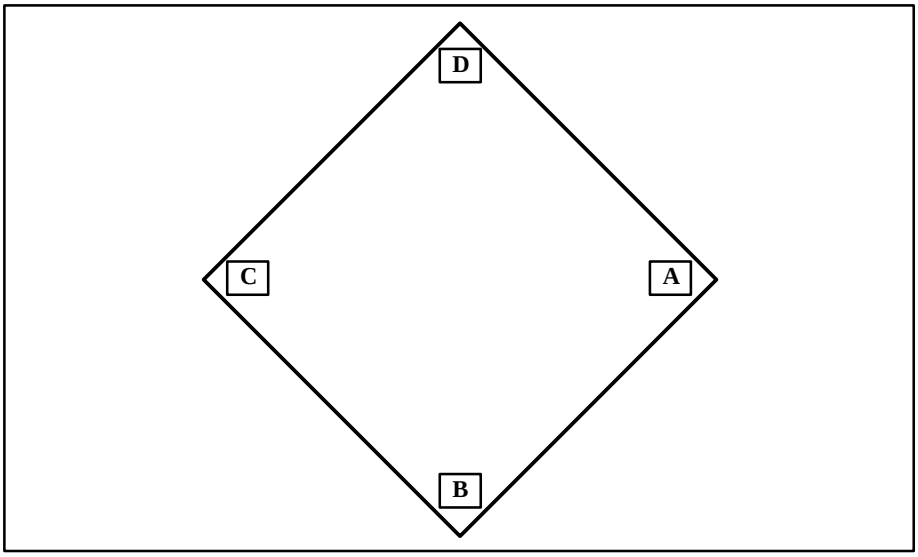
  When Move Vertex is selected, you must "double–click" on the vertex whose position you want to "fine tune" before the arrow buttons can have any effect.
- **Done** — When you have set the window position and size as required for the application, pick the Done button to exit the pick and place function and return to the tool edit panel.

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Figure 5.21 shows how a polygon window appear in the *default* state after you select the pick and place function. It also shows the pick and place points that apply when a polygon window is in the *Move Vertex* mode, the *default* mode. (The other modes are *Move Polygon*, *Add Vertex*, and *Delete Vertex*.)

NOTE: In the *Move Polygon* mode, you can pick the polygon from any point in the image field and drag the entire polygon, unaltered, anywhere around the image field.

Figure 5.21 Pick and Place Points for a Polygon Window –– *Move Vertex* Mode



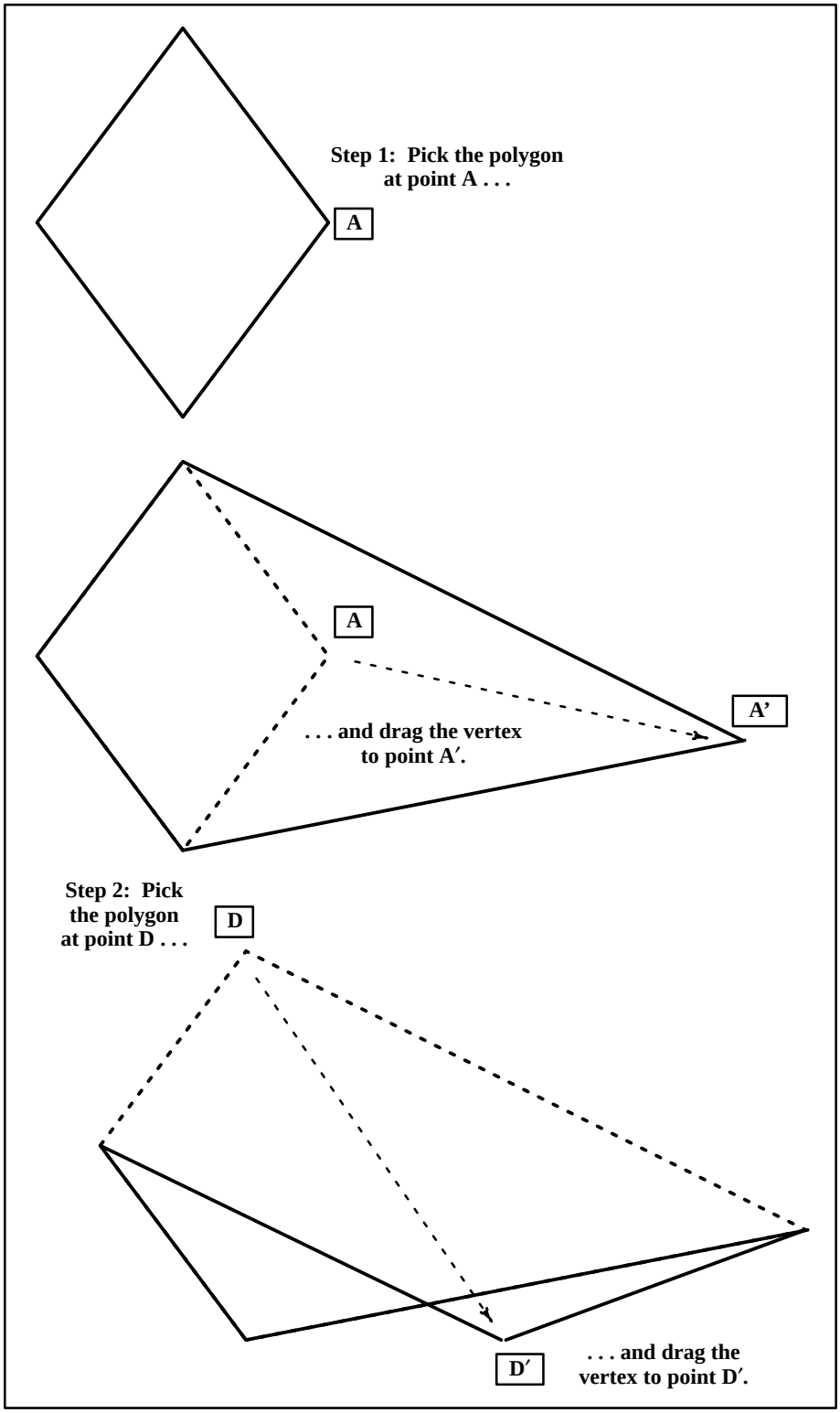
The *Move Vertex* pick and place points are located at each vertex on the window (A, B, C, and D), as shown in Figure 5.20. These pick and place points enable you to drag a vertex *anywhere* within the image field. There are no restrictions on its movement; thus, for example, you can drag a vertex across one of the polygon's sides.

Figure 5.22 (page 5–24) demonstrates the operation of the *Move Vertex* pick place points in the following steps.

- **Step 1:** The vertex is picked at point A, dragged to point A′, and then placed at point A′. This *increases* the *width* of the polygon.
- **Step 2:** The vertex is picked at point D, dragged through the bottom side to point D′, and then placed at point D′. This has the effect of creating two three–sided polygons, joined at a vertex.

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Figure 5.22 Example: Using the *Move Vertex* Pick and Place Points to Alter a Polygon Window

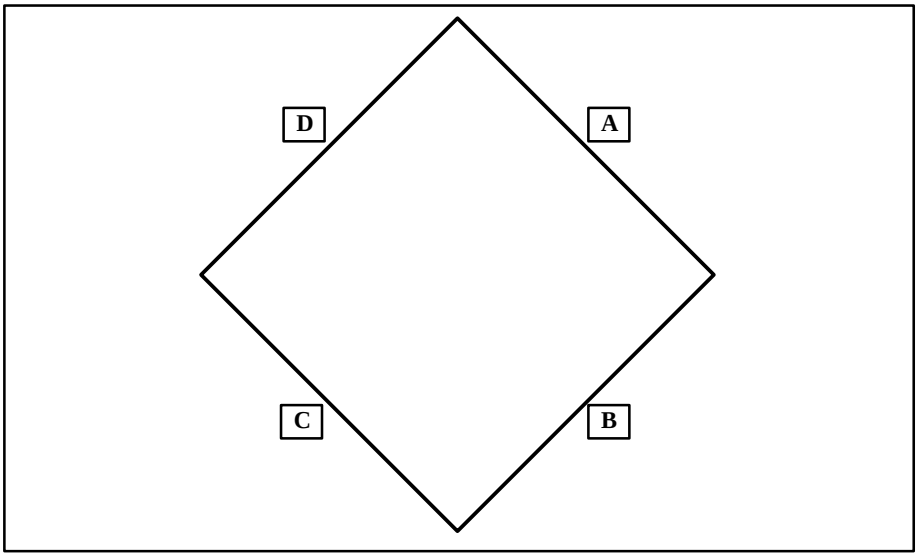


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For the *Add Vertex* mode, the pick and place points enable you to *separate* the corresponding polygon sides into two parts, forming two sides and a new vertex. The maximum number of vertices (and sides) is 16.

The pick and place points for the *Add Vertex* mode are located as shown in Figure 5.23.

Figure 5.23 Pick and Place Points for a Polygon Window –– *Add Vertex* Mode



Note that the pick and place points are located at the midpoint along each side of the polygon window.

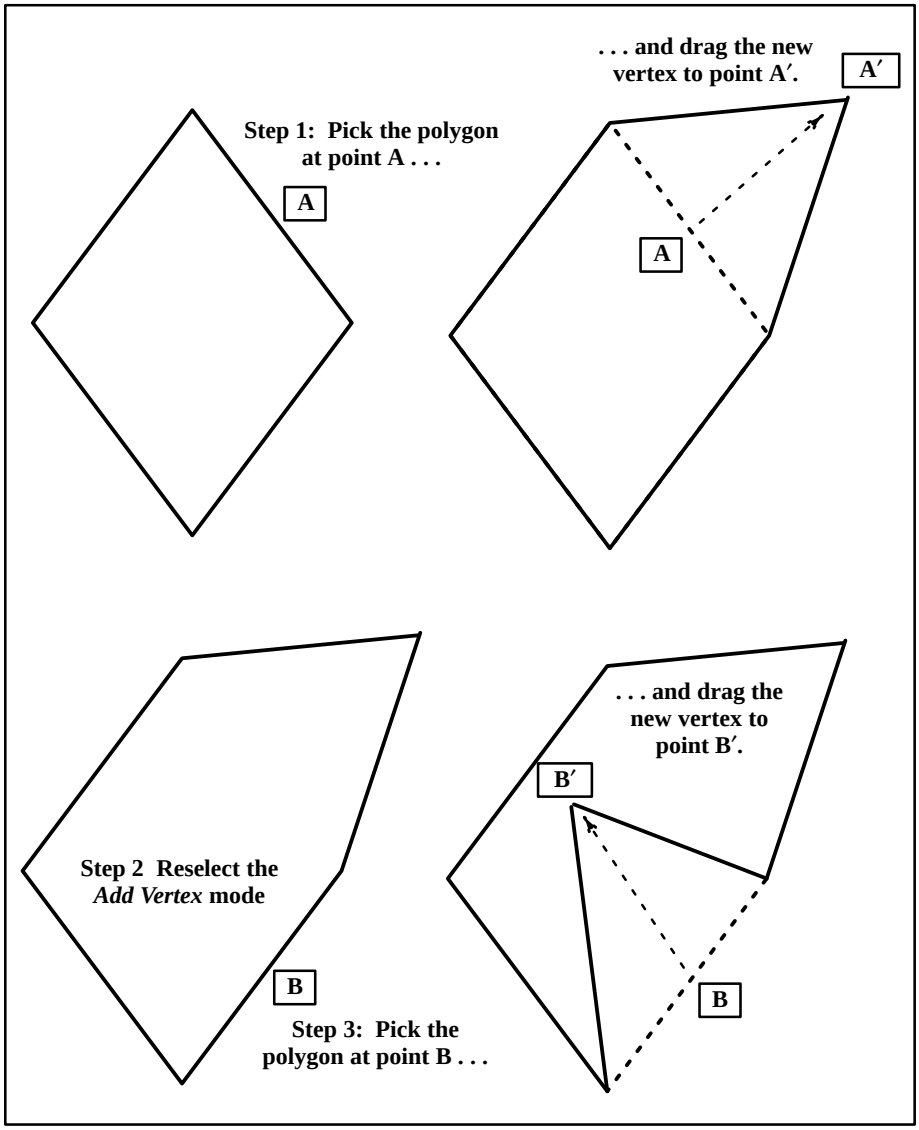
Figure 5.24 (page 5–26) demonstrates the operation of the *Add Vertex* pick and place points in the following steps:

- **Step 1:** The polygon side is picked at point A, and the first new vertex is dragged to point A′, and is then placed at point A′.

  NOTE: When you add a vertex, the pick and place mode automatically changes back to *Move Vertex*. Thus, to add *another* vertex, you must reselect the *Add Vertex* mode.
- **Step 2:** The *Add Vertex* mode is reselected.
- **Step 3:** The polygon side is picked at point B, the second new vertex is dragged to point B′, and is then placed at point B′.

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Figure 5.24 Example: Using the *Add Vertex* Pick and Place Points to Alter a Polygon Window



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The *Delete Vertex* pick and place points are located at each vertex on the window (1, 2, 3, and 4), as shown in Figure 5.25. These pick and place points enable you to join the two sides adjacent to a vertex into one side, thus eliminating both the vertex and one side.

Figure 5.25 Pick and Place Points for a Polygon Window –– *Delete Vertex* Mode

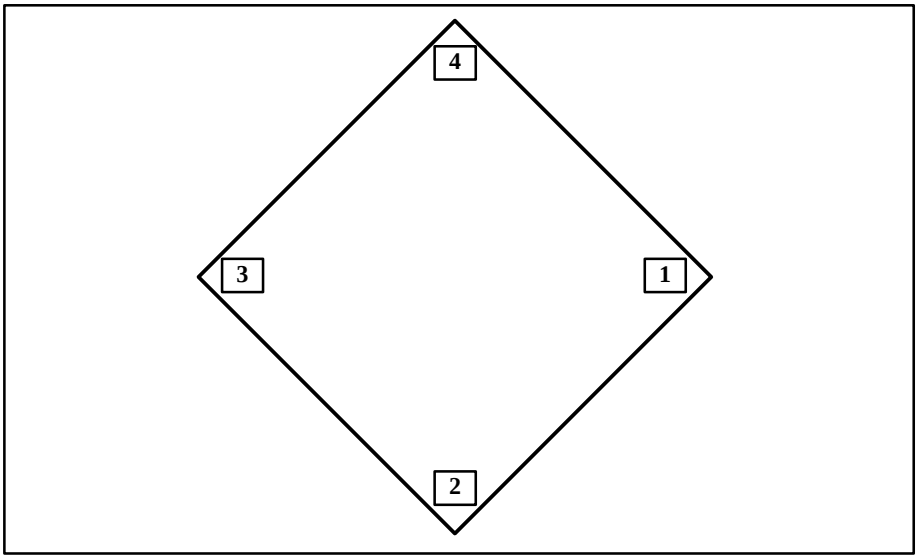


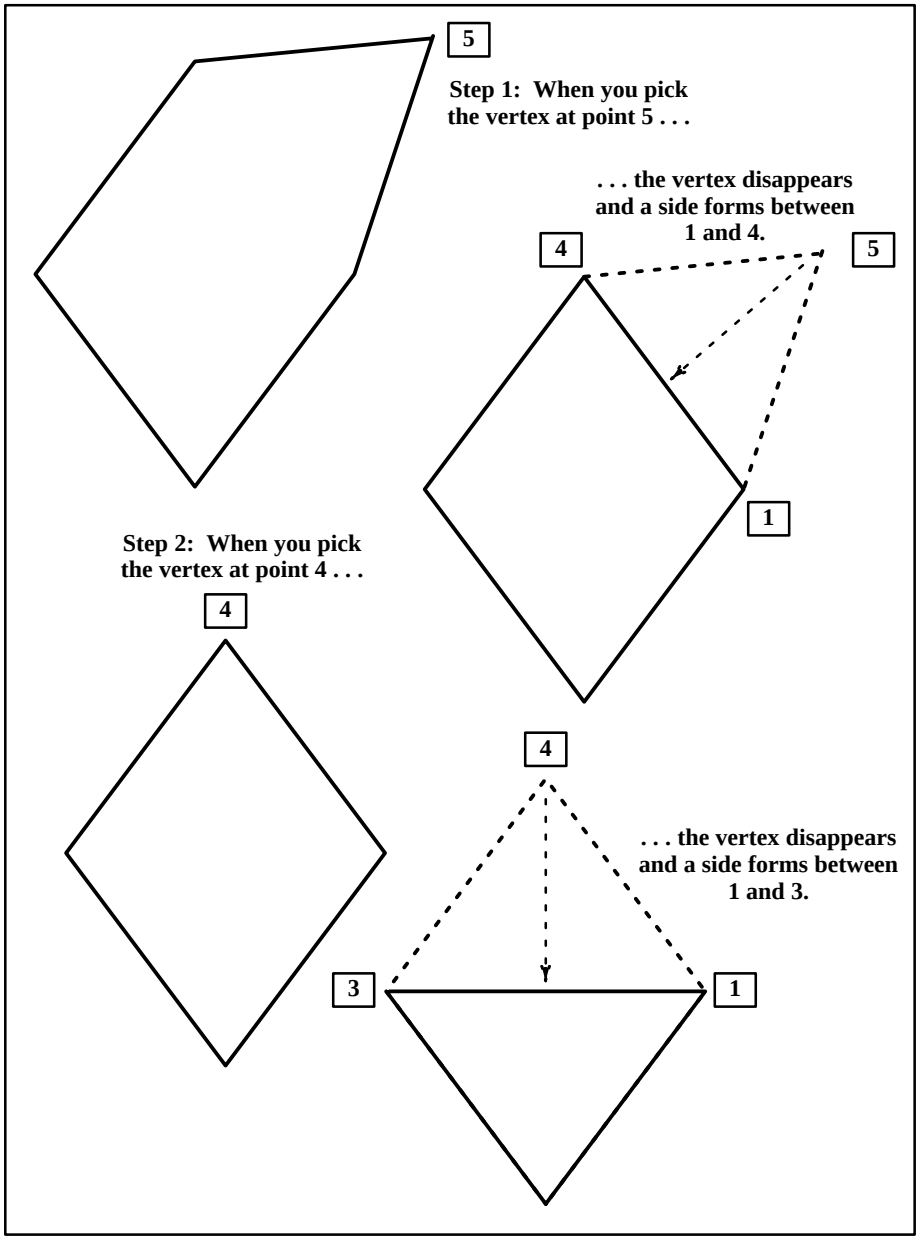
Figure 5.26 (page 5–28) demonstrates the operation of the *Delete Vertex* pick and place points in the following steps:

- **Step 1:** When the vertex is picked at point 5, the vertex disappears, and the two adjacent sides join into one side from 1 to 4.
- **Step 2:** When the vertex is picked at point 4, the second vertex disappears, and the two adjacent sides join into one side from 1 to 3.

NOTE: A polygon *must* have at least three sides; thus, when a polygon is reduced to three sides, the *Delete Vertex* mode changes to the *Move Vertex* mode, and the *Delete Vertex* mode becomes unavailable.

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Figure 5.26 Example: Using the *Delete Vertex* Pick and Place Points to Alter a Polygon Window



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Light Probes

A light probe (one is assigned to each camera) can be picked and placed anywhere within the top half of the image field; however, its size and shape can be changed only within certain limits: The smallest size is 8 pixels long by 8 pixels high, and the largest size is 32 pixels long by 64 pixels high (these sizes will vary with different camera resolution settings).

The P&P button in the Probe panel activates the light probe for repositioning and resizing; that is, after picking that button you can pick the light probe in one of its four corners to change its size, or you can pick it in the center to move it without changing its size.

When you pick the P&P button, the light probe changes color from red to green, indicating that it is enabled for "pick and place" operations. At the same time, the Pick & Place panel appears on the screen, as shown in Figure 5.27.

Figure 5.27 Example: Pick and Place Panel for a Light Probe



The Pick & Place panel for the light probe contains the following data display fields and buttons:

- **X Loc** — This indicates the current X coordinate, in pixels, of the upper–left corner of the probe box from the left side of the screen.
- **Y Loc** — This indicates the current Y coordinate, in pixels, of the upper–left corner of the probe box from the top of the screen.
- **Length** — This indicates the current length of the probe box, in pixels.
- **Height** — This indicates the current height of the probe box, in pixels.
- **Arrow buttons,** ↑, ↓, ←, and → — When you pick an arrow button, by *default* the *entire light probe* moves one pixel in the direction of the corresponding arrow. If, however, you have just picked and placed one corner of the light probe, the arrow buttons will affect that part of the light probe *only.*
- **Done** — When you finish the pick and place operations, picking the Done button returns to the camera setup panel.

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Chapter 6

Reference Tools

This chapter provides detailed information about the reference line tool, the reference window tool, the rotation finder tool, and the build reference tool.

All of these tools detect workpiece shift and/or rotation in the image field and apply shift and/or rotation compensation to all associated inspection tools so that they maintain the same relation to the workpiece image before the workpiece shifted and/or rotated.

NOTE: A basic rule applies to a reference tool's *sequence position* in the toolset edit panel. It is this: A reference tool must always *precede* all tools that are intended to derive position compensation from it. Thus, for example, if tool #1 were a gage, tool #2 a window, tool #3 a rotation finder, and tool #4 another gage, only tool #4 could be referenced to tool #3, the rotation finder.

Reference Line Tool

This section discusses the reference line tool and the shift and rotation compensation that it can provide to other tools.

Once you have selected a reference line tool, you can configure it for an inspection application by picking the Ref. Line field in the toolset edit panel. When you do, the reference line edit panel appears, as shown by the example in Figure 6.1 (page 6–2).

Note that in Figure 6.1 the reference line tool is shown in its *default* position on the screen. Note also that the *default* reference line tool "operation" is X only — a *single* operation. (Other tool operations use two or three lines or axes. All of the reference line tool operations are illustrated later in this chapter.)

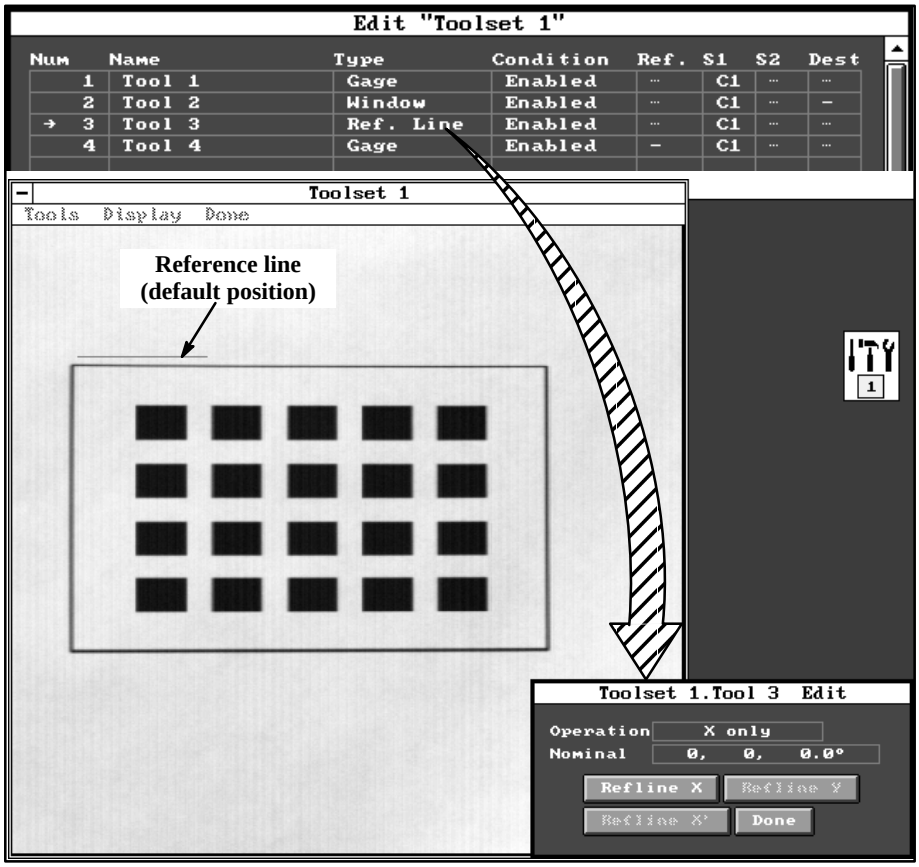
The reference line edit panel (named "Toolset 1.Tool 3 Edit" in Figure 6.1) contains the following data fields and buttons:

- **Operation** — This field provides access to the selection of one of the six reference line tool "operations."
- **Nominal** — When you pick this field, the currently selected and configured reference line tool stores the current part position, to be used during inspection to compute the workpiece's offset from the "nominal" position.
- **Refline X** — This button accesses the configuration panel for the X–axis of the reference line.
- **Refline Y** — This button accesses the configuration panel for the Y–axis of the reference line.

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- **Refline X′, Refline Y′** — This button accesses the configuration panel for either the X′– or the Y′–axis of the reference line, according to the selected operation.

Figure 6.1 Example: Selecting the Reference Line Edit Panel



The remainder of this section discusses reference line tool configuration from the perspective of the data fields and buttons in the reference line edit panel.

Overview: Reference Line Tool Configuration

A reference line tool can be selected when the toolset edit panel is on the screen. Starting from the main menu bar, the selection path to this panel is as follows: **Editors** → **Configuration** → **Setup** → **Tools**. This selection path is shown by the example in Chapter 7, *Inspection Tools*, Figure 7.2 (page 7–3).

Here is a summary of the basic reference line tool selection and configuration steps, listed in their normal order of performance. These steps are common to all six reference line tool operations (except as noted):

1. **Select reference line tool operation** — select one of the six reference line tool operations according to the application requirements.

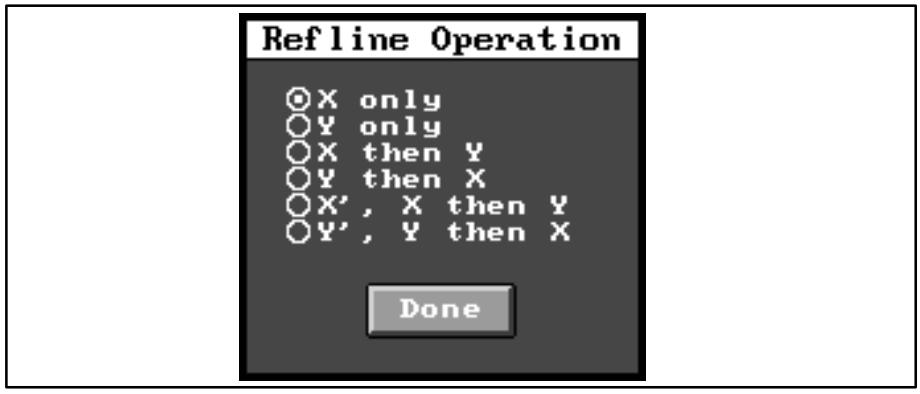
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2. **Configure each axis:**
   a. **Select mode** — select either the binary mode or the gray scale mode.
   b. **"Pick and place"** — position the axis over the workpiece as required.
   c. **Adjust thresholds** — adjust the binary (or gray scale) thresholds, as required for edge detection.
   d. **Define features** — select the point that will be used to locate the workpiece along the axis.
3. **Learn nominal values** — perform a "learn" operation to store the "nominal" values — the data that indicate the workpiece's *initial* position.

Reference Line Tool Operations

As noted earlier, there are six reference line tool operations, each of which involves one, two, or three lines or "axes." When you pick the Operation field in the reference line edit panel, the Refline Operation selection panel appears, as shown in Figure 6.2.

Figure 6.2 The Refline Operation Selection Panel



The exact function that a reference line tool performs depends on which one of the six "operations" has been selected. These operations use one, two, or three reference line axes. The three–axis operation is capable of providing rotation compensation.

Note that this selection panel lists the six reference line tool operations as follows: X only and Y only, which use one axis; X then Y and Y then X, which use two axes; and X' , X then Y and Y' , Y then X, which use three axes. These operations differ mainly in the number of axes used and in the order of their evaluation.

Table 6.1 (page 6–4) summarizes the reference line tool operations listed in the Refline Operation selection panel.

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The sections following Table 6.1 provide detailed descriptions of the six reference line tool operations and how they apply shift and/or rotation compensation to the associated inspection tool during setup and online operations.

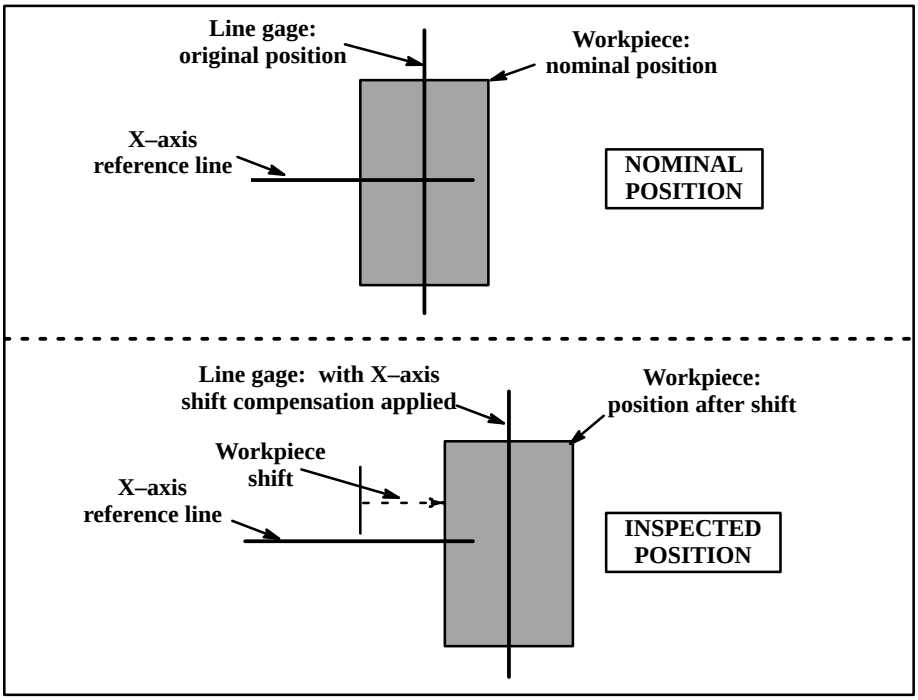
Table 6.1 Reference Line Operations: Summary

Reference Line Operation	Functions
X only	Compensates for horizontal (X–axis) shift only.
Y only	Compensates for vertical (Y–axis) shift only.
X then Y	Compensates for horizontal (X–axis) shift first, then vertical (Y–axis) shift.
Y then X	Compensates for vertical (Y–axis) shift first, then horizontal (X–axis) shift.
X', X then Y	Compensates for horizontal (X–axis) shift and rotation (two X axes) first, then vertical (Y–axis) shift.
Y', Y then X	Compensates for vertical (Y–axis) shift and rotation (two Y axes) first, then horizontal (X–axis) shift.

X only

The X only operation consists of a single reference line that lies along the horizontal (X) axis of the image field. X only is appropriate in applications where workpiece shift is expected in the X–axis, but not in the Y–axis. Figure 6.3 shows an X only reference line detecting X–axis workpiece shift and applying X–axis shift to a line gage.

Figure 6.3 Example: Using an X Only Reference Line Operation

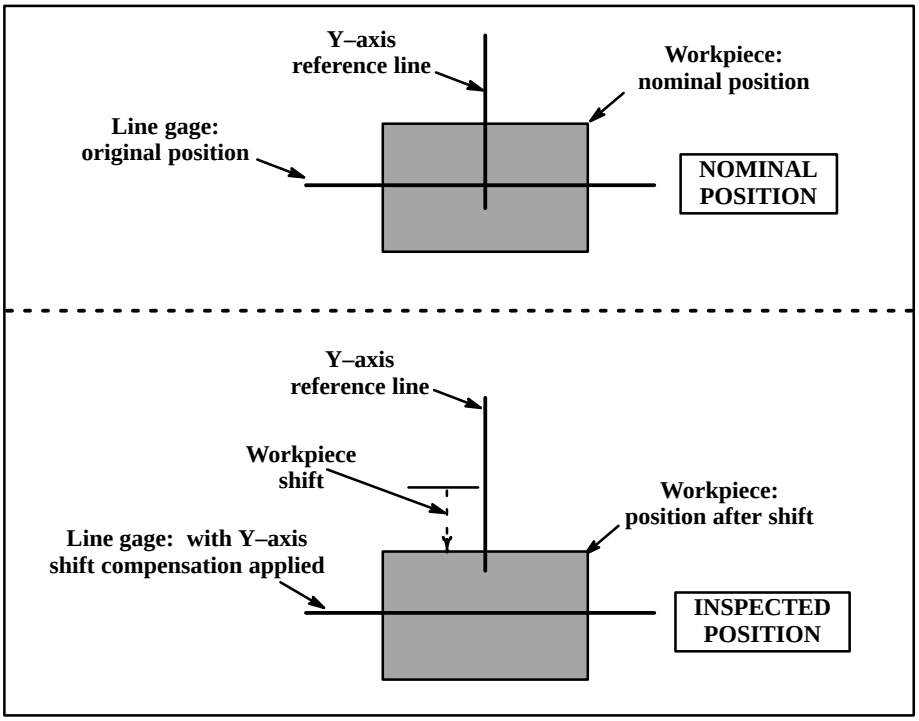


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Y only

The Y only operation consists of a single reference line that lies along the vertical (Y) axis of the image field. Y only is appropriate in applications where workpiece shift is expected in the Y–axis, but not in the X–axis. Figure 6.4 shows a Y only reference line detecting Y–axis workpiece shift and applying Y–axis shift to a line gage.

Figure 6.4 Example: Using a Y Only Reference Line Operation



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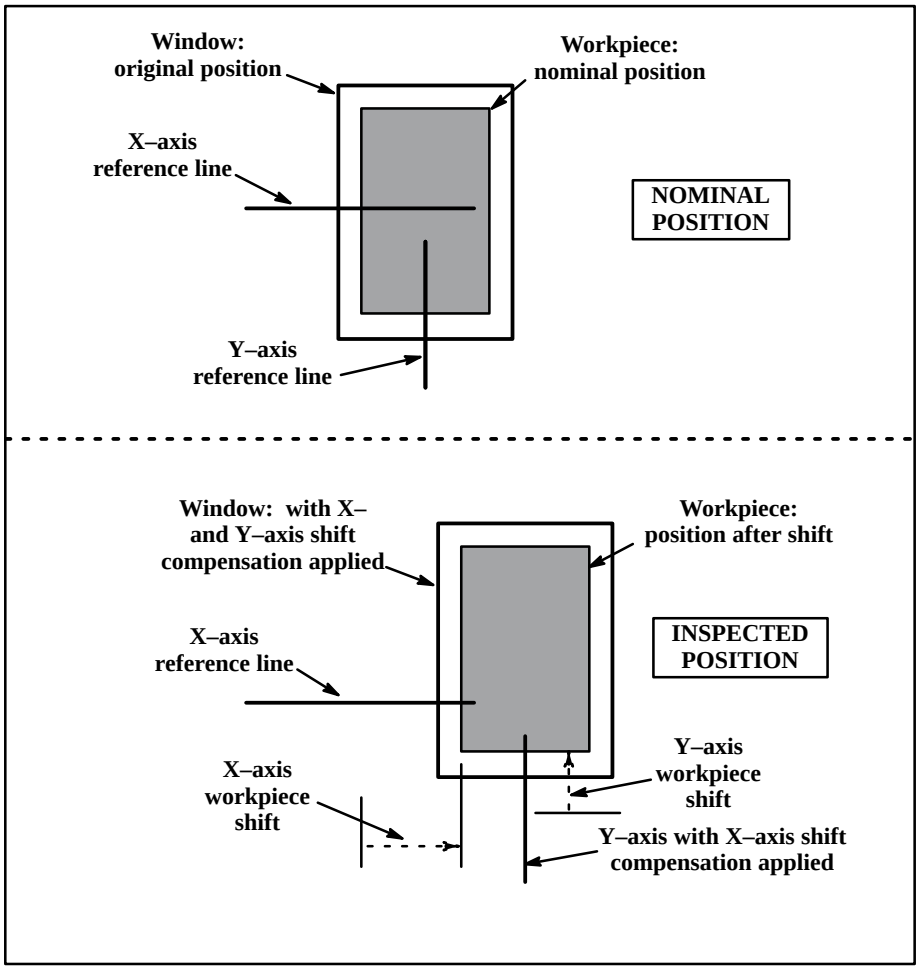
X then Y

The X then Y reference line operation consists of *two* reference lines, one that lies along the horizontal (X) axis of the image field, and one that lies along the vertical (Y) axis. This operation is appropriate in applications where workpiece shift is expected in both the X–axis *and* the Y–axis, but with *more* shift occurring along the X–axis. (No workpiece *rotation* is expected.)

In operation, the X then Y reference line operation evaluates the X–axis *first* to determine the X–axis shift. It applies X–axis shift compensation to the Y–axis *before* evaluating the Y–axis.

Figure 6.5 illustrates the X then Y reference line operation detecting X–axis workpiece shift, applying X–axis shift to the Y–axis, then detecting Y–axis shift in the same workpiece and applying the combined X–Y shift to the associated window.

Figure 6.5 Example: Using an X Then Y Reference Line Operation



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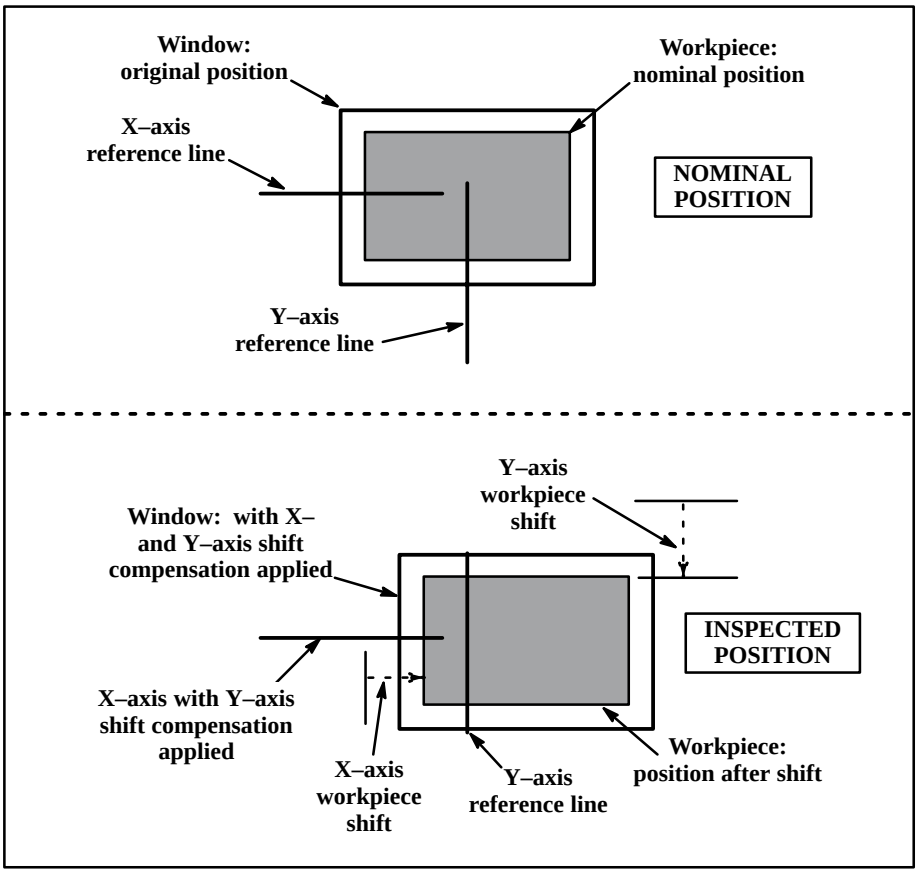
Y then X

The Y then X reference line operation consists of two reference lines, one that lies along the vertical (Y) axis of the image field, and one that lies along the horizontal (X) axis. This operation is appropriate in applications where workpiece shift is expected in both the X–axis *and* the Y–axis, but with *more* shift occurring along the Y–axis. (No workpiece *rotation* is expected.)

In operation, the Y then X reference line operation evaluates the Y–axis *first* to determine the Y–axis shift. It applies Y–axis shift compensation to the X–axis *before* evaluating the X–axis.

Figure 6.6 illustrates the Y then X reference line operation detecting Y–axis workpiece shift, applying Y–axis shift to the X–axis, then detecting X–axis shift in the same workpiece and applying the combined X–Y shift to the associated window.

Figure 6.6 Example: Using a Y Then X Reference Line Operation



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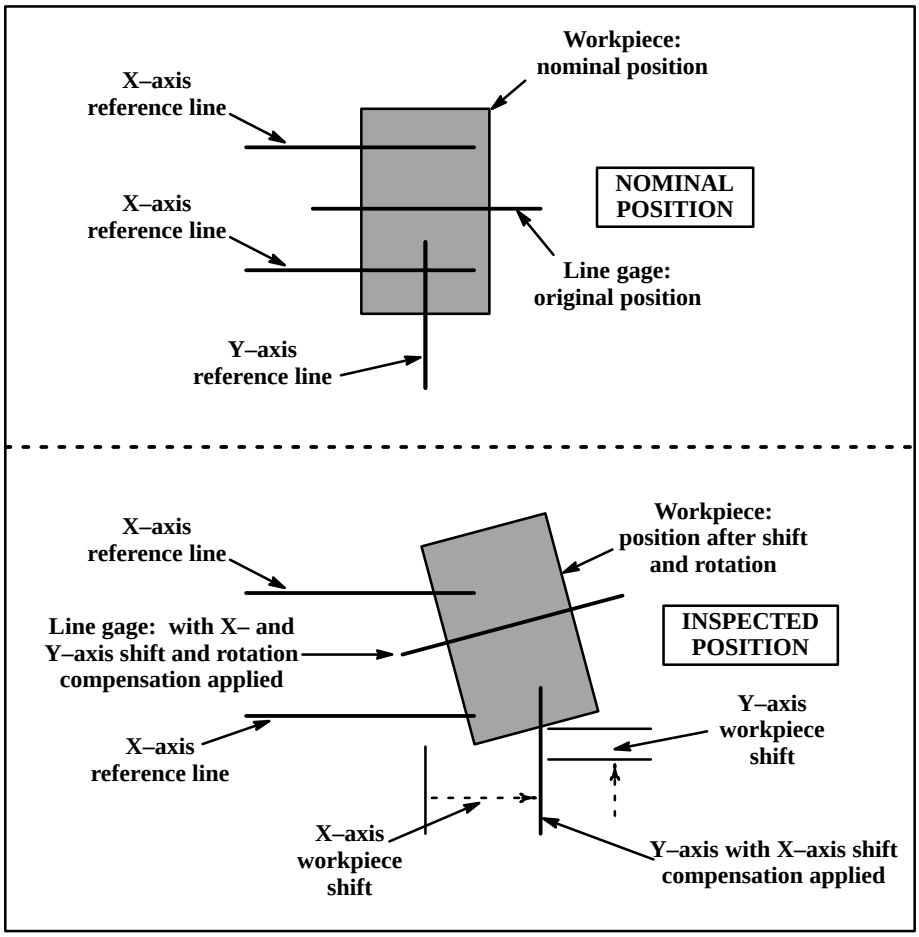
X', X then Y

The X', X then Y reference line operation consists of three reference lines, two that lie along the horizontal (X) axis of the image field, and one that lies along the vertical (Y) axis. This operation is appropriate in applications where workpiece shift and *rotation* are expected.

In operation, the X', X then Y reference line operation evaluates the two X–axes *first* for X–axis shift and for rotation, using the *difference* in the *amount* of shift along both X–axes to calculate the number of degrees of rotation. It applies X–axis shift compensation to the Y–axis, as required, *before* evaluating the Y–axis for workpiece shift. (Note that the Y–axis is *not rotated* prior to analysis.)

Figure 6.7 illustrates the three X', X then Y reference lines detecting a shifted and rotated workpiece, applying the X–axis shift to the Y–axis, then detecting Y–axis shift in the same workpiece and applying the combined X–Y shift *and rotation* to the associated line gage.

Figure 6.7 Example: Using the X', X Then Y Reference Line Operation



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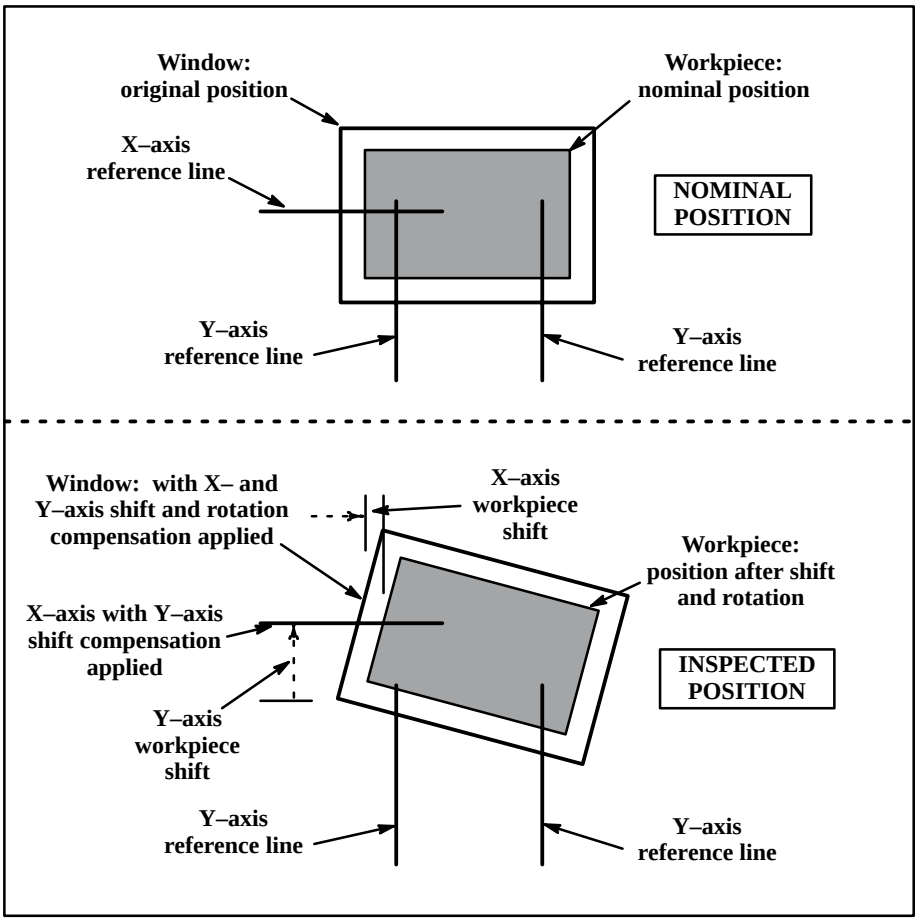
Y', Y then X

The Y', Y then X reference line operation consists of three reference lines, two that lie along the vertical (Y) axis of the image field, and one that lies along the horizontal (X) axis. This operation is appropriate in applications where workpiece shift and *rotation* are expected.

In operation, the Y', Y then X reference line operation evaluates the two Y–axes *first* for Y–axis shift and for rotation, using the *difference* in the *amount* of shift along both Y–axes to calculate the number of degrees of rotation. It applies Y–axis shift compensation to the X–axis, as required, *before* evaluating the X–axis for workpiece shift. (Note that the X–axis is *not rotated* prior to analysis.)

Figure 6.8 illustrates the three Y', Y then X reference lines detecting a shifted and rotated workpiece, applying the Y–axis shift to the X–axis, then detecting X–axis shift in the same workpiece and applying the combined X–Y shift *and rotation* to the associated line gage.

Figure 6.8 Example: Using the Y', Y Then X Reference Line Operation



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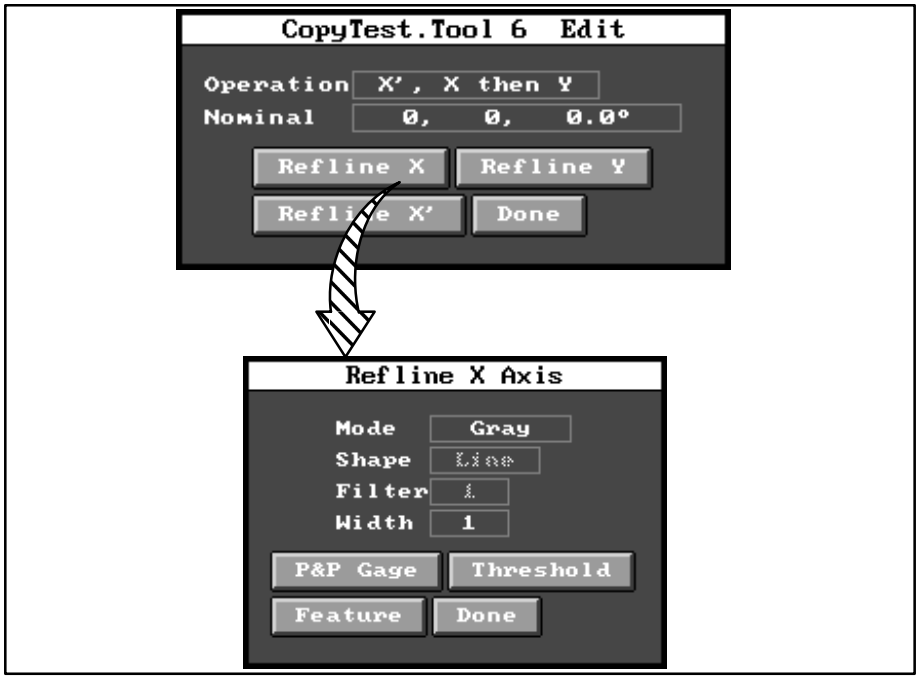
Reference Line Tool Configuration

This section discusses the configuration steps that are accessed from the Refline buttons in the reference line tool edit panel. Note that the Refline buttons that are *active* (white type) at any one time depend on the currently selected operation. Thus when X only is selected, for example, only the Refline X button is active.

For the purposes of this discussion, the X', X then Y three–axis reference line tool operation is assumed to have been selected in the Refline Operation selection panel (Figure 6.2, page 6–3), and the reference line edit panel is displayed on the screen as shown in Figure 6.9.

From that starting point, the configuration process begins when you pick the Refline X button on the reference line edit panel and the Refline X–axis configuration panel appears, as shown in Figure 6.9.

Figure 6.9 Selecting the Refline X–axis Configuration Panel



The Refline X–axis and Refline Y–axis configuration panels (not shown) contain the same data fields and buttons as the Refline X–axis panel in Figure 6.9, above. Thus, the following descriptions of apply to all three of these axis configuration panels.

- **Mode** — This field enables the selection of either the binary edge detection or the gray scale edge detection.
- **Shape** — This field is *inactive* (shaded type) for reference line tool purposes, since there is no circular or "arc" reference line tool.

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- **Filter** — This field provides access to the selection of one of the ten levels of “noise” filtering for the workpiece image. This field is *active* only when the *binary imaging mode* is selected.
- **Width** — This field provides access to the selection of one of the five preset reference line widths.
- **P&P Gage** — The P&P Gage button provides access to the “pick and place” function for the current axis (the X–axis, in this case).
- **Threshold** — The Threshold button provides access to the threshold–setting function, which enables you to modify the edge detection parameters.
- **Feature** — The Feature button provides access to the selection of the *group* of reference points (“mode”), the *specified reference point* (“offset”), and the *search direction*.
- **Done** — The Done button saves the currently selected configuration settings for this axis, then exits the axis configuration panel and returns to the reference line edit panel.

Mode Selection

When configuring each reference line axis, you must select an edge detection mode that is appropriate for the particular workpiece image. Here is a description of each imaging mode:

- **Binary mode** — The binary edge detection mode thresholds pixels in the image to two states, white and black. The thresholded (or binary) image is displayed in a region that directly surrounds the reference line in a box called the “area of interest.” (This box serves as a visual aid for setting the binary threshold, which is described in Chapter 8 under the *Gaging Tools: Binary Threshold Procedures* heading.)

  The binary imaging mode is most appropriate when the inspected workpiece has a sharp black–and–white contrast with its background, such as when it is backlighted.
- **Gray scale mode** — The gray scale edge detection mode detects edges by looking for points at which the image brightness changes substantially over a short distance. (Gray scale threshold procedures are described in Chapter 8 under the *Gaging Tools: Gray Scale Threshold Procedures* heading.)

  The gray scale edge detection mode is most appropriate when the image cannot be easily segmented using a binary threshold.

Shape Selection

This selection is inactive (shaded type) since it does not apply to reference line tools. It is active only for the configuration of line gages.

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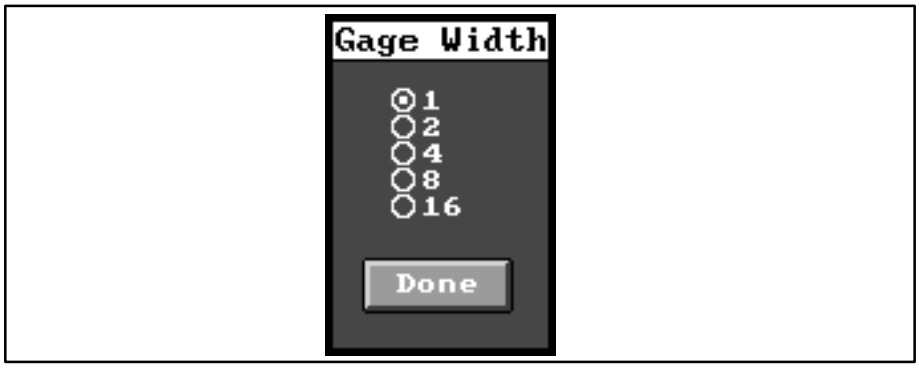
Filter Function

The filter function is active only when the *binary gaging mode* is selected. It is described in Chapter 8, *Threshold, Filters, and Morphology*, under the *Binary Filter* heading.

Line Width Selection

The Gage Width selection menu provides five preset line widths, as shown in Figure 6.10. The *default* line width selection is "1."

Figure 6.10 The Line Width Selection Menu



The "width" of the reference line axis is stated in pixels; thus, for example, an X–axis reference line 150 pixels long will be eight pixels wide if "8" is selected. (The line's appearance on the screen, however, does *not* change with different width selections: It always appears as a single–width line.)

When a width of "1" is selected, the pixels along the *length* of the reference line axis are evaluated *only* according to the threshold and filter settings, for a *binary* axis, or the kernel and threshold settings, for a *gray scale* axis.

When a width of "2" or more is selected, the pixels across the *width* of the axis (at each point on the axis) are *averaged first*, after which the *average value* is evaluated according to the threshold or threshold/filter settings as described above.

The averaging works like this: At each point along a reference line axis, the brightness values (from 0 to 255) of all pixels across the *width* of the axis are summed, then divided by the width. For example, if you selected a width of 8, and the pixels across the width at one point along the axis were 145, 148, 150, 156, 167, 164, 172, and 170, the sum (1272) divided by 8 equals 159, the average brightness value across the axis at that point. The value "159" is then evaluated according to the threshold and filter settings. In this example, if a binary threshold were set to 160, the *average* brightness value would be on the *low* side of the threshold even though several of the pixels at that point across the axis were *higher than* 160.

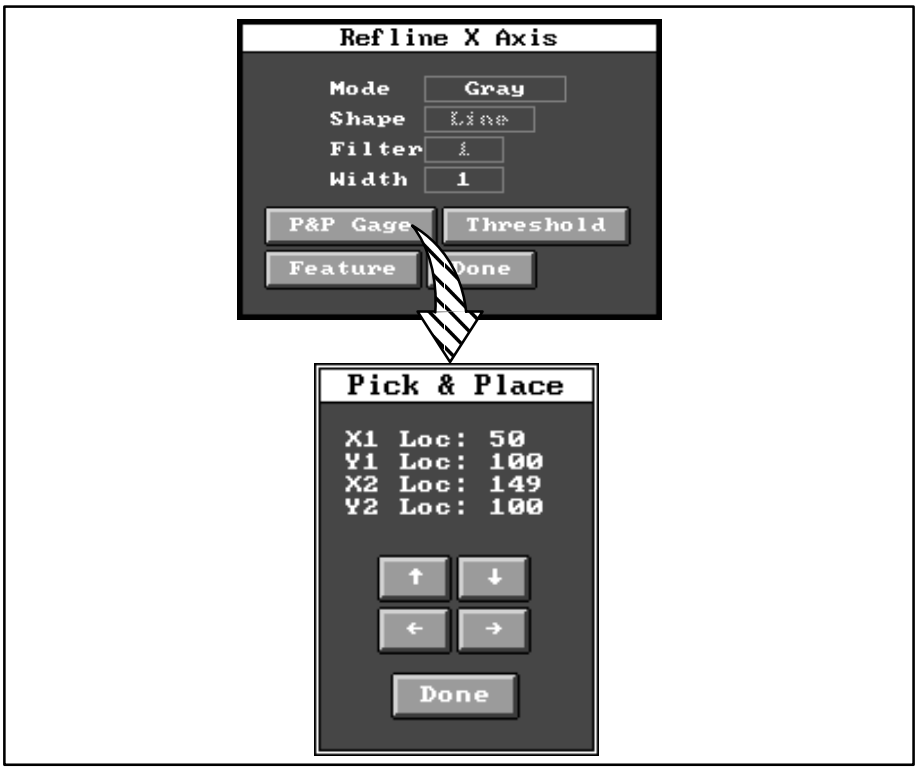
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NOTE: Wide gages are less likely to detect image features that are narrow and perpendicular to the gage. Thus, a wide gage can be useful for detecting wide edges while ignoring dirt or other "noise" along the edge. The width setting *may* change the speed of the tool; however, the change in speed is application dependent.

Pick and Place Function

When you pick the P&P Gage button on the axis configuration panel, the Pick & Place panel appears, as shown in Figure 6.11, and the pick and place function is activated. For details about the pick and place function as it pertains to the reference line tool, refer to Chapter 5, *Pick and Place Functions*.

Figure 6.11 Example: Selecting the Pick & Place Panel



Threshold Setting Function

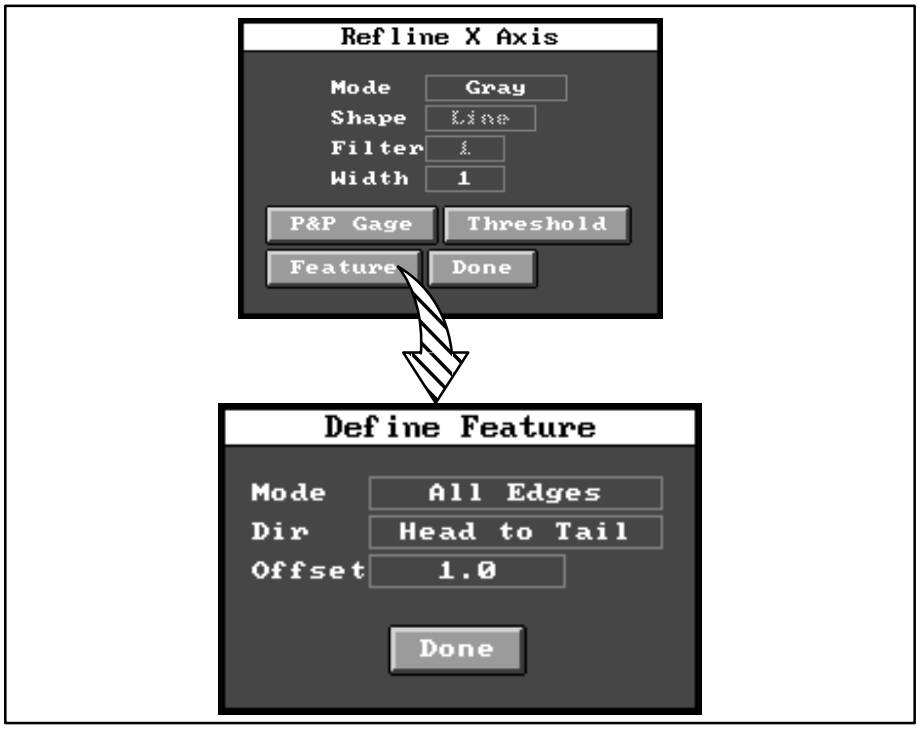
For details about the threshold setting functions as they pertain to the reference line tool, refer to Chapter 8, *Thresholds, Filters, and Morphology.*

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Feature Selection

When you pick the Feature button on the axis configuration panel, the Define Feature panel appears, as shown in Figure 6.12.

Figure 6.12 Example: Selecting the Define Feature Panel



The thresholding/filtering settings, along with the width selection, determine which light/dark transitions along a reference line axis are detected as edges. The purpose of the *feature selection process* is to specify which *one* of these edges (or midpoints between edges) is to be used as the *one* basis for calculating shift and/or rotation compensation for the associated axis.

The edge selection process also identifies the edge search *direction* and the edge search *mode*.

Here is a brief description of the reference point selection *functions*:

- **Mode** — This function selects a feature *mode*, which identifies a *range* of edges within which a reference line searches for the *specified reference point*.
- **Search Direction** — This function selects the *direction* of the search for the *specified reference point* along a reference line axis.
- **Offset** — This function identifies which edge (or midpoint between consecutive edges) along the length of a reference line axis is to be used as the basis for calculating shift/rotation compensation values.

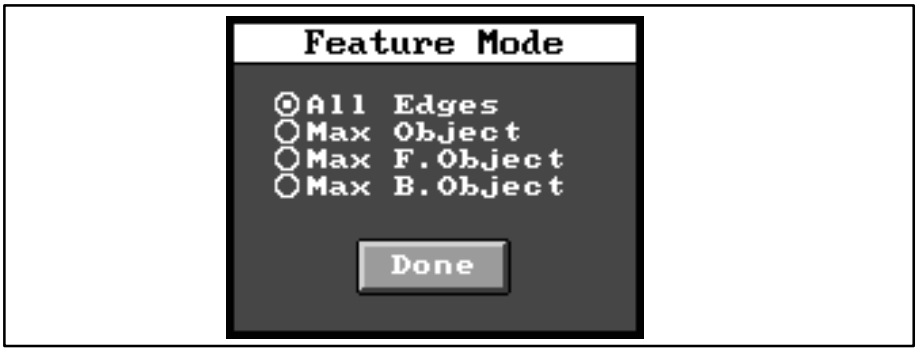
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Mode

The *mode* selects a particular group of edges that a reference line evaluates when searching for the *specified reference point*.

When you pick the Mode field in the Define Feature menu, the Feature Mode menu appears on the screen, as shown in Figure 6.13.

Figure 6.13 The Feature Mode Menu



The operation of the four feature modes is described briefly as follows:

1. **All Edges** — This feature mode causes the reference line to include all detected "edges" along its length in its search for the *specified reference point* (this includes *edges* and *all midpoints* between each pair of consecutive edges, the *center* of the reference line axis, and the *starting* end of the axis).
2. **Max Object** — This feature mode restricts the search for the *specified reference point* to the leading edge and the midpoint of the *largest* identified "object" along the length of the reference line axis.
3. **Max F. Object** — This feature mode restricts the search for the *specified reference point* to the leading edge and the midpoint of the *largest* identified "foreground object" along the length of the reference line axis.
4. **Max B. Object** — This feature mode restricts the search for the *specified reference point* to the leading edge and the midpoint of the *largest* identified "background object" along the length of the reference line axis.

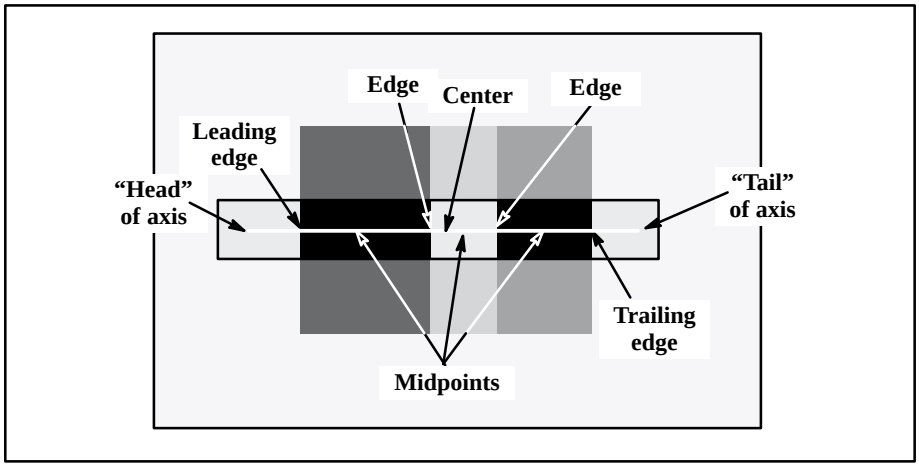
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All edges — The *all edges* feature mode enables you to specify a reference point on a reference line axis from the following points on the axis:

- All *edges* detected as a result of the threshold/filter settings.
- The *head* of the axis when using the head–to–tail search direction, or the *tail* of the axis when using the tail–to–head search direction.
- The *midpoints* between adjacent pairs of edges.
- The *center point* between the leading edge and the trailing edge on the axis.

Figure 6.14 uses the binary gaging mode to illustrate the potential reference points with the *all edges* feature mode.

Figure 6.14 Example: All Edges Along a Reference Line Axis



Max Object — The *maximum object* feature mode enables you to specify a reference point on a reference line axis from the following points on the axis:

- The leading edge of the maximum–size object along the axis.
- The midpoint between the leading edge and the trailing edge of the maximum–size object.

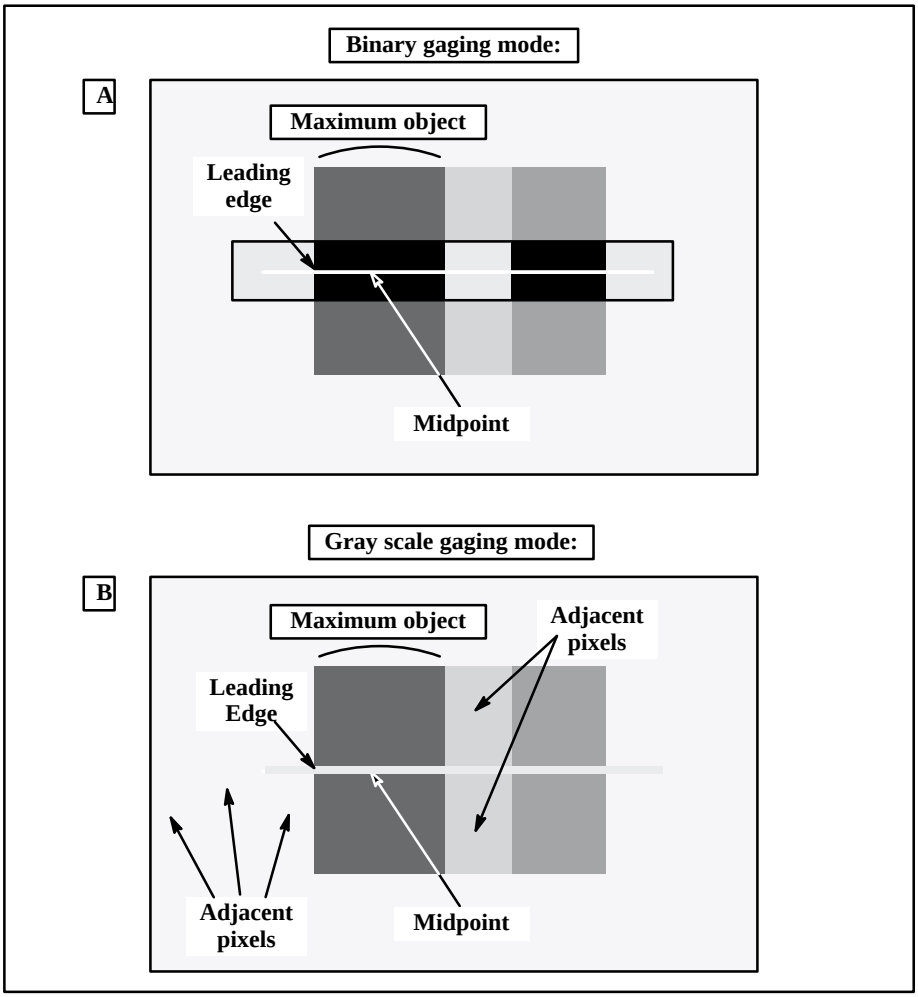
Figure 6.15 (page 6–17) uses both the binary gaging mode and the gray scale gaging mode to identify the potential *maximum object* reference points.

Note in Figure 6.15 that the term "maximum object" has a different meaning for binary and gray scale gaging modes, as follows:

Binary gaging mode — The maximum object is the one with the greatest number of consecutive white *or* black pixels between the first and last detected edges on the axis. In example (**A**), above, *leftmost* object has the greatest number of consecutive pixels, which are, in this case, *black* pixels.

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Figure 6.15 Example: Maximum Objects (Binary and Gray Scale)



Gray scale gaging mode — The maximum object is the one with greatest number of consecutive pixels (between the first and last detected edges) that are either *lighter than* or *darker than* the *adjacent* pixels — the pixels on *both sides* of the object. In example (**B**), above, the *leftmost* object has the greatest number of consecutive pixels that are, in this case, *darker than* the adjacent pixels.

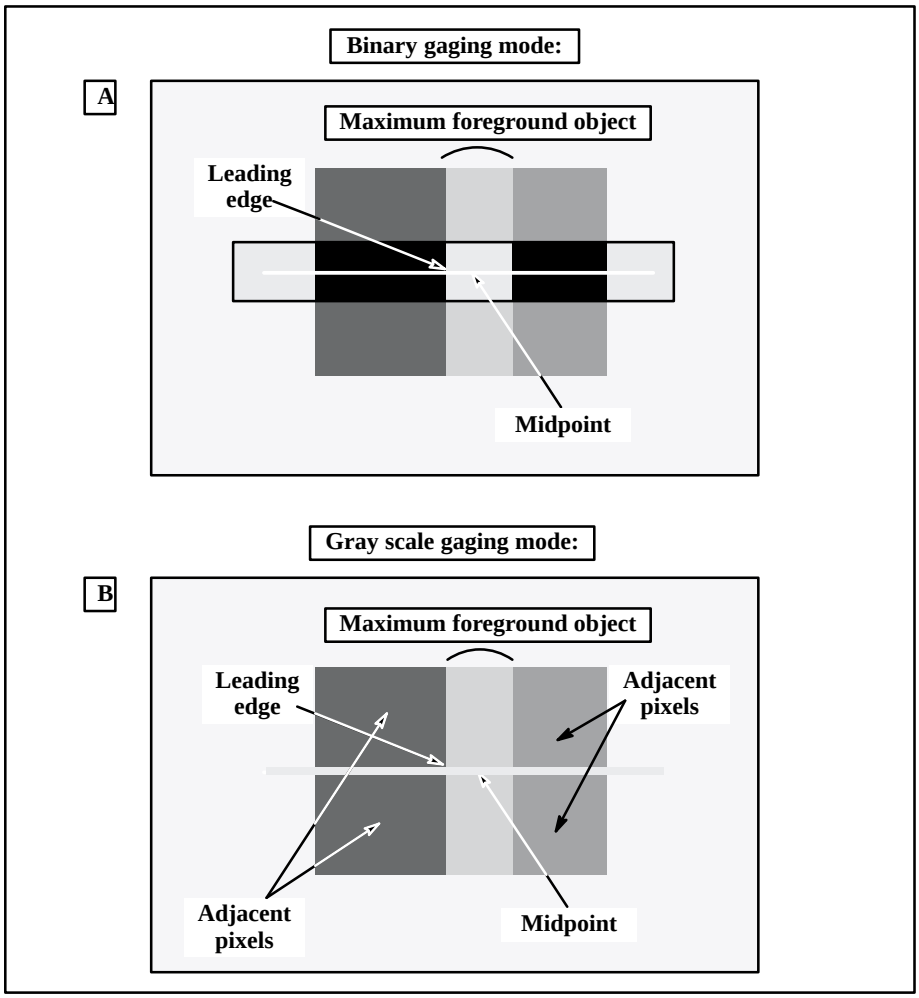
Max F. Object — The *maximum foreground object* feature mode enables you to specify a reference point on a reference line axis from the following points on the axis:

- The leading edge of the maximum–size object along the axis.
- The midpoint between the leading edge and the trailing edge of the maximum–size object.

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Figure 6.16 uses both the binary gaging mode and the gray scale gaging mode to identify the potential *maximum foreground object* reference points.

Figure 6.16 Example: Maximum Foreground Objects (Binary and Gray Scale)



Note in Figure 6.16 that the term “foreground object” has a different meaning for binary and gray scale gaging modes, as follows:

Binary gaging mode — The maximum foreground object is the one with the greatest number of consecutive *white* pixels between the first and last detected edges on the axis. In example (**A**), above, the *center* object has the greatest number of consecutive white pixels.

Gray scale gaging mode — The maximum foreground object is the one with greatest number of consecutive pixels (between the first and last detected edges) that are *lighter than* the *adjacent* pixels — the pixels on *both* sides of the object. In example (**B**), above, the *center* object has the greatest number of consecutive pixels that are, in this case, *lighter than* the adjacent pixels.

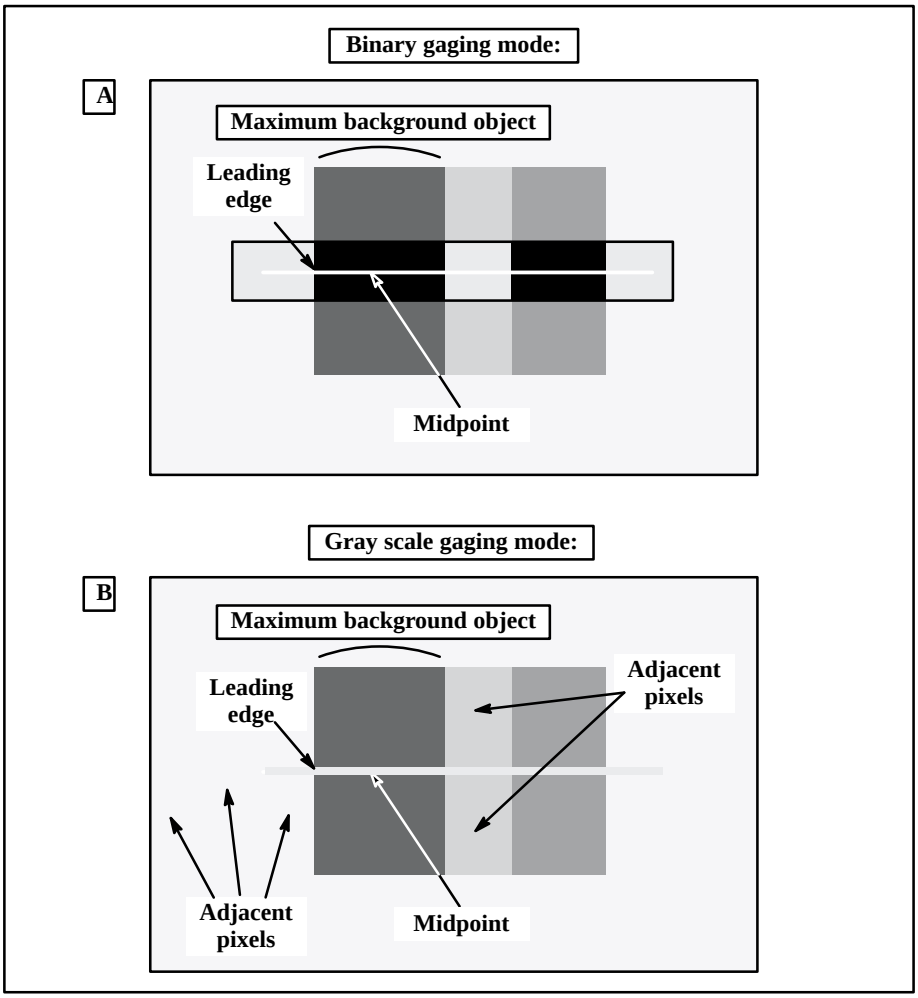
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Max B. Object — The *maximum background object* feature mode enables you to specify a reference point on a reference line axis from the following points on the axis:

- The leading edge of the maximum–size object along the axis.
- The midpoint between the leading edge and the trailing edge of the maximum–size object.

Figure 6.17 uses both the binary gaging mode and the gray scale gaging mode to identify the potential *maximum background object* reference points.

Figure 6.17 Example: Maximum Background Objects (Binary and Gray Scale)



Note in Figure 6.17 that the term “background object” has a different meaning for binary and gray scale gaging modes, as follows:

Binary gaging mode — The maximum background object is the one with the greatest number of consecutive *black* pixels between the first and last detected edges on the axis. In example (**A**), above, the *leftmost* object has the greatest number of consecutive black pixels.

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Gray scale gaging mode — The maximum background object is the one with greatest number of consecutive pixels (between the first and last detected edges) that are *darker than* the *adjacent* pixels — the pixels on *both sides* of the object. In example (**B**), above, the *leftmost* object has the greatest number of consecutive pixels that are, in this case, *darker than* the adjacent pixels.

The choice of feature mode should be based upon which one provides the most *reliable* reference point for your application. The example in Figure 6.18 (page 6–21) illustrates this concept by showing how Max B. Obj can be used to "track" the maximum object on a workpiece.

In this example, the objective of the inspection application is to measure a hole in the widest part of the workpiece (the "maximum object") in a situation where the *workpiece* — and thus the maximum object — can appear in either a *left* or *right* orientation within the image field.

In example (**A**), the hole appears on the left. The reference line correctly identifies the maximum object and applies shift compensation (if needed) to the window in order to keep it over the hole.

In example (**B**), the hole appears on the right. Again, the reference line correctly identifies the maximum object and applies shift compensation to the window in order to keep it over the hole.

If the All Edges feature mode had been used in this case, a specific reference point, such as the leftmost edge, would *not* have detected the alternating position of the hole in the image field. This is because it "sees" *only* the leftmost edge, regardless of the orientation of the workpiece in the image field.

Direction

The "direction" is the direction used to search for edges along the length of the reference line axis. The two available choices are these: Head to Tail and Tail to Head.

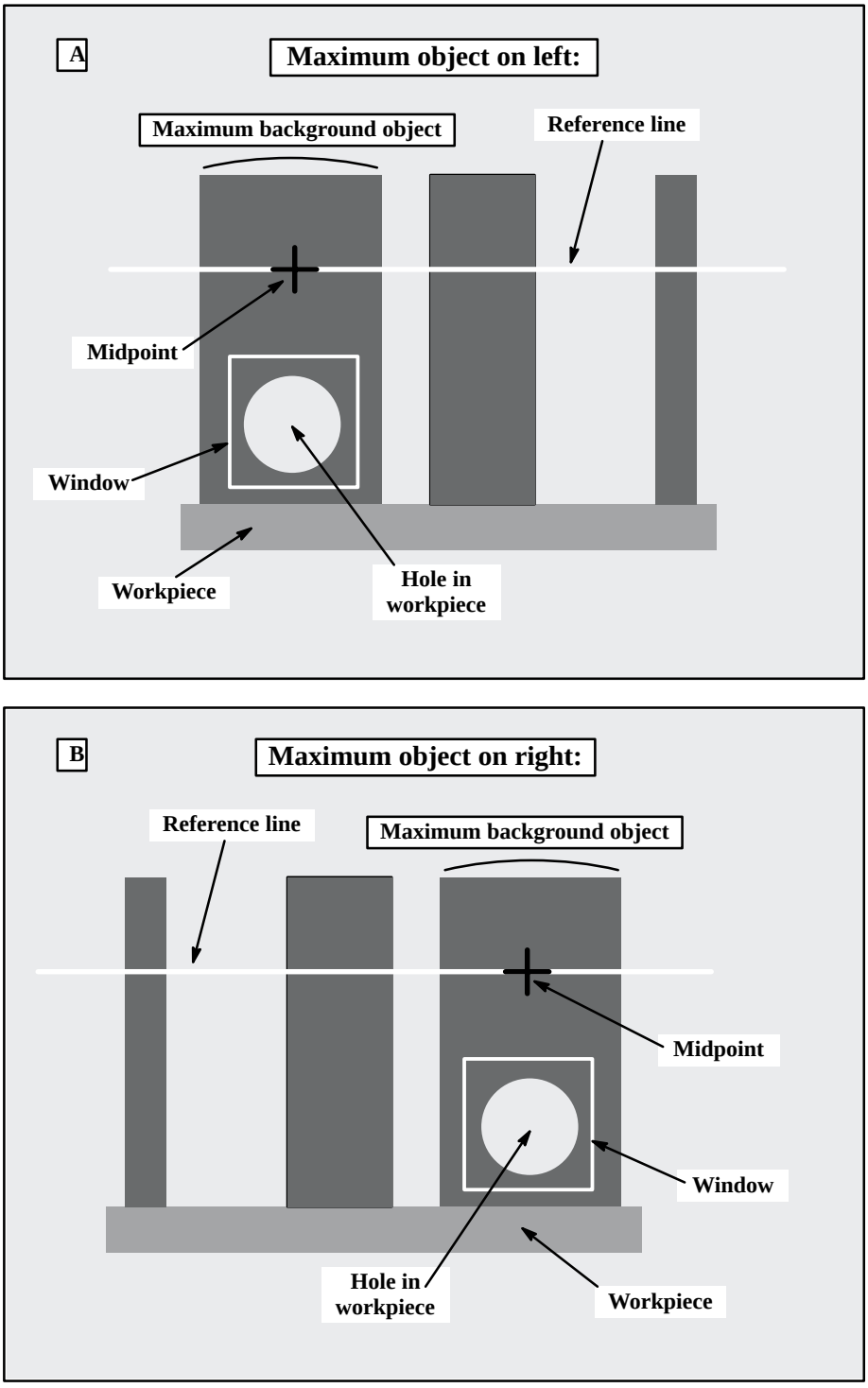
When you pick the Dir menu field (in the Define Feature menu) successively, it toggles to the *opposite* direction. Thus, Head to Tail changes to Tail to Head, and vice versa.

Head to Tail causes the edge search to begin at the "head" (X1, Y1) of the reference line axis; Tail to Head causes the edge search to begin at the "tail." For X–axis reference lines, the head is, by *default*, at the left end; for Y–axis reference lines, the head is, by *default*, at the upper end. The head and tail positions, however, can be reversed using the pick and place function.

The choice of search direction should be based upon which one leads most *directly* to the specified reference point. Normally, the *best* search direction is the one in which a *false* edge is least likely to be encountered.

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Figure 6.18 Example: Using Maximum Object to Track Part of Workpiece



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Offset

The “offset” function enables you to identify *one* point along each reference line axis as the *specified feature* to provide shift and/or rotation compensation to the associated inspection tools.

The current feature location is identified on the screen by a “+” symbol. You can change the offset location by picking the Offset menu field successively.

When you pick the Offset menu field successively, the feature marker (+) moves along the reference line axis in the selected *search direction*. The starting offset location is always labeled “fixed.” The next offset location is always labeled “center.”

The remaining offset locations, when All Edges is the selected define feature *mode*, are numbered as follows: edge #1. 1.0; midpoint #1, 1.5; edge #2, 2.0; midpoint #2, 2.5, and so on, until the *last* midpoint location is reached. After that, the offset marker returns to the starting location (“fixed”) and the cycle begins again. Figure 6.14 (page 6–16) illustrates the offset locations for the All Edges mode.

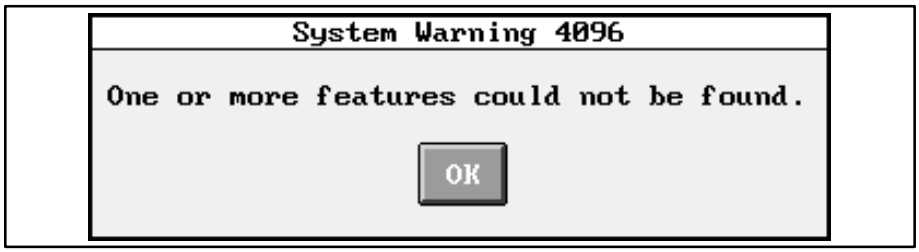
Nominal (“Learn”) Function

When the Nominal field in the reference line tool edit panel is picked, it causes the currently selected *and configured* reference line tool to store the “nominal” position of the X– and Y–axis coordinate data, as well as angular data, and to display that data in the Nominal field. In order to use this feature, however, you must first configure the reference line tool completely.

When you pick the Nominal field, the “learned” data appearing in the Nominal field indicates, from left to right, an X–axis coordinate, a Y–axis coordinate, and an angle (θ).

NOTE: If the warning message shown in Figure 6.19 appears after you pick the Nominal field, it indicates a problem with some aspect of the feature configuration. Pick the OK button to exit this message.

Figure 6.19 Warning Message: One or More Features Not Found

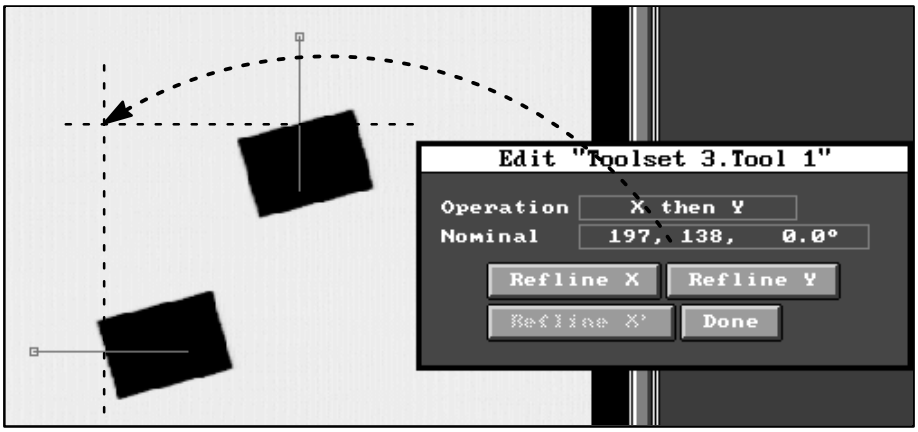


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If *one* axis is used (X only or Y only), the “learned” X and Y coordinates appearing in the Nominal field identify the location of the reference feature. The angle (θ) is always 0.000.

If *two* axes are used (X then Y or Y then X), the “learned” X and Y coordinates appearing in the Nominal field identify the location of the *intersection* of a *horizontal* line drawn through the Y–axis reference feature and a *vertical* line drawn through the X–axis reference feature. The angle (θ) is always 0.000. Figure 6.20 illustrates the intersection of the two lines.

Figure 6.20 Example: “Learned” Coordinates With Two–Axis Reference Line

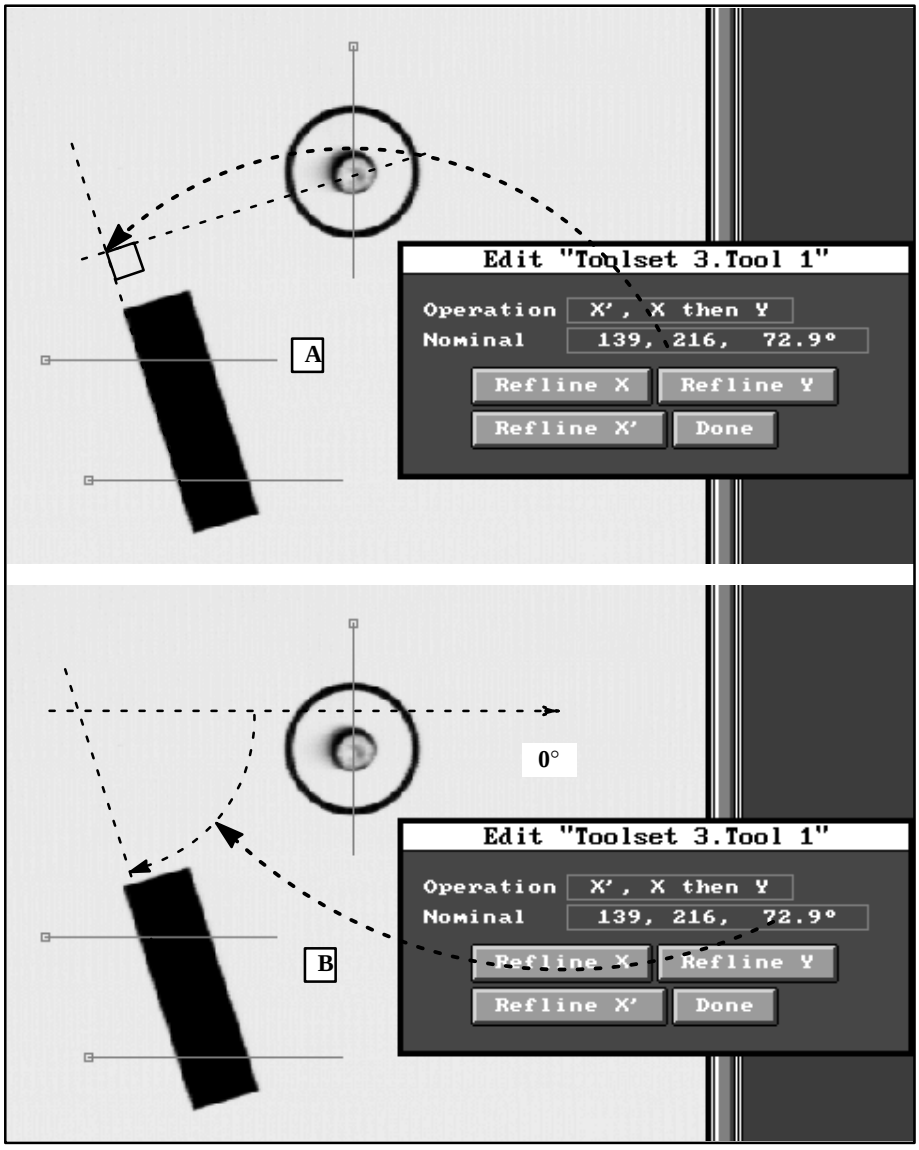


If *three* axes are used (X’, X then Y or Y’, Y then X), the “learned” X and Y coordinates appearing in the Nominal field identify the location of the *intersection* of a line drawn through the two X–axis reference features (for X’, X then Y) and a second line drawn through the Y–axis reference feature and *perpendicular* to the first line. Figure 6.21 (**A**) on page 6–24 illustrates the right angle intersection of the two lines.

The “learned” angle (θ) in the Nominal field indicates the *clockwise* rotation of a line drawn through the two X–axis reference features (again, for X’, X then Y in this case) relative to the 0° axis of the image field. Figure 6.21 (**B**) on page 6–24 illustrates the how the rotation angle is determined. Note that this result is true when the X axis lies closer to the intersection than the X’ axis. If the positions of these two axes were *reversed*, the angle (θ) would be 180° *clockwise* from the 72.9° in this example, or 252.9°.

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Figure 6.21 Example: “Learned” Coordinates With Three–Axis Reference Line

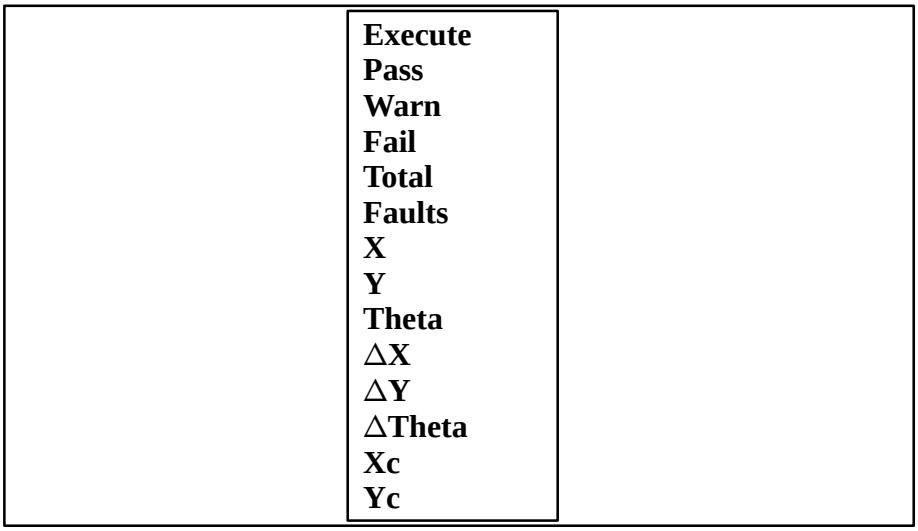


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Reference Line Tool Inspection Results and Math Tool Formulas

This section discusses the expanded inspection results that are available to a math tool formula from a reference line tool. As Figure 6.22 shows, the expanded inspection results for a reference line tool appear in one list.

Figure 6.22 Expanded Results Lists For Reference Line Tools in Math Formulas



Here is a brief definition and explanation of each of the expanded result types listed in Figure 6.22.

- **Execute** — This returns a 1.000 when the tool has *executed* its inspection task, and 0.000 for all other conditions.
- **Pass** — This returns an 1.000 when the tool has *passed* its inspection task, and 0.000 for all other conditions.
- **Warn** — For reference tools, Warn always returns 0.000.
- **Fail** — This returns a "error code" when the tool is in a *fail* condition and 0.000 for all other conditions. The error code identifies a specific reason for the failure; for example, error code 1038.000 identifies "One or more features could not be found" as the cause of the inspection failure. The complete list of error codes and fail conditions appears in Appendix A of this manual.
- **Total** — This returns the total number of inspections performed.
- **Faults** — This returns the total number of faults detected.
- **X** — This returns the current X coordinate of the principal reference point, as follows:
  - — For one–axis operations (X only and Y only), it is the X coordinate of the single reference feature.
  - — For two–axis operations (X then Y and Y then X), it is the X coordinate of the intersection of horizontal and vertical lines drawn through the two reference features, as shown in Figure 6.20 (page 6–23).

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— For three–axis operations (X′, X then Y and Y′, Y then X), it is the X coordinate of the intersection of lines drawn through the three reference features, as shown in Figure 6.21 (page 6–24).

- **Y** — This returns the current Y coordinate of the principal reference point, as follows:
  — For one–axis operations (X only and Y only), it is the Y coordinate of the single reference feature.
  — For two–axis operations (X then Y and Y then X), it is the Y coordinate of the intersection of horizontal and vertical lines drawn through the two reference features, as shown in Figure 6.20 (page 6–23).
  — For three–axis operations (X′, X then Y and Y′, Y then X), it is the Y coordinate of the intersection of lines drawn through the three reference features, as shown in Figure 6.21 (page 6–24).
- **Theta** — When a three–axis reference line tool is used, this returns the current value of the rotation angle, in degrees, between a line connecting the reference features on the X and X' (or Y and Y') and the 0° X–axis of the image field. When a one– or two–axis reference line tool is used, Theta always returns 0.000.
- **ΔX** — This returns the *change* from the nominal or "learned" X coordinate of the principal reference point.
- **ΔY** — This returns the *change* from the nominal or "learned" Y coordinate of the principal reference point.
- **ΔTheta** — This returns the *change* from the nominal or "learned" value of the rotation angle, in degrees, when a three–axis reference line tool is used. When a one– or two–axis reference line tool is used, ΔTheta always returns 0.000.
- **Xc** — This returns the same value as **X**.
- **Yc** — This returns the same value as **Y**.

Reference Window Tool

This section discusses the reference window tool and the shift and rotation compensation that it can provide to other tools.

Reference Window Tool: Basic Elements

A reference window tool consists of a number of basic *elements*, which are described briefly as follows:

Reference window tool — This term refers to the whole reference window tool; that is, each instance of "Ref. Window" in the toolset edit panel. Each reference window tool consists of two separately configurable "features," Feature A and Feature B.

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Feature window — This window defines a small portion of the image field that contains a unique workpiece feature. The “feature image” is stored in memory during configuration, and it is the “template” that the reference window tool uses when it searches for a matching feature on a workpiece.

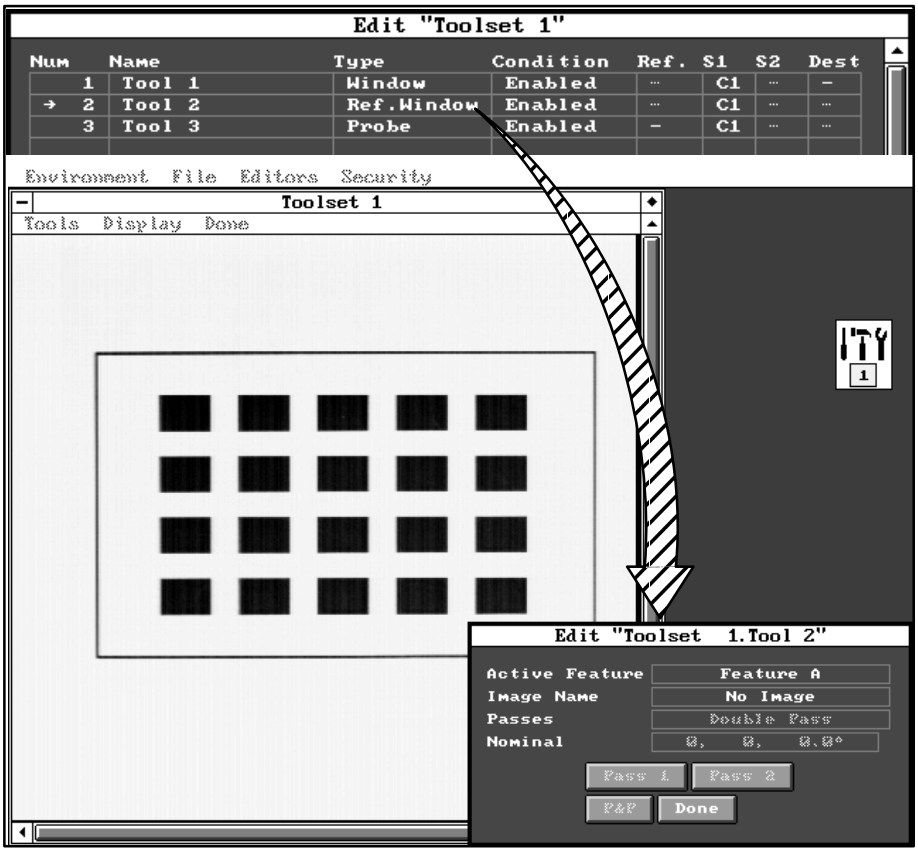
Search window — This window defines the portion of the image field within which the smaller *feature window* searches for a particular workpiece feature.

When *one* feature is enabled, the reference window tool can provide only shift compensation; when *two* features are enabled, the tool can provide shift and rotation compensation.

Reference Window Tool Edit Panel

Once you have added a reference window tool to the toolset edit panel, you can configure it for an inspection application by picking the Ref. Window field in the panel. When you do, the reference window tool edit panel appears, as shown by the example in Figure 6.23.

Figure 6.23 Example: Selecting the Reference Window Tool Edit Panel



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The reference window edit panel (named "Edit Toolset 1.Tool 2" in Figure 6.23) contains several fields and buttons, which are described briefly, as follows:

- **Active Feature** — This field selects either Feature A or Feature B as the "active feature" to be configured. When you pick this field, Feature A toggles to Feature B, or vice versa.
- **Image Name** — This field identifies the name of the currently selected feature image (or "No Image," if none is selected). When you pick this field, the Image Manager panel appears, which is used to save or select an image file for the feature window.
- **Passes** — This field selects either Single Pass or Double Pass, which is the number of passes the feature window makes through the search window. When you toggle this field, Single Pass toggles to Double Pass, or vice versa.
- **Nominal** — When you pick this field, the currently selected and configured reference window tool stores the current part position, to be used during inspection to compute the workpiece's offset from the "nominal" position.
- **Pass 1** — The Pass 1 button selects the First Pass panel, from which you can select the parameters that the feature window uses to scan the search window on the first (or only) pass.
- **Pass 2** — The Pass 2 button selects the Second Pass panel, from which you can select the parameters that the feature uses to scan the search window on the second pass.
- **P&P** — The P&P button provides access to the "pick and place" function for the current search window.
- **Done** — The Done button saves the currently selected configuration settings for this feature, then exits the tool edit panel and returns to the toolset edit panel.

The remainder of the reference window tool section discusses the configuration process from the perspective of the fields and buttons in the tool edit panel.

Overview: Reference Window Tool Configuration

A reference window tool can be selected when the toolset edit panel is on the screen. Starting from the main menu bar, the selection path to this panel is as follows: **Editors** → **Configuration** → **Setup** → **Tools**. This selection path is shown by the example in Chapter 7, *Inspection Tools*, Figure 7.2 (page 7–3).

Here is a summary of the basic selection and configuration steps for a reference window tool, listed in their normal order of performance.

1. **Select active feature** — select one of the two "active features."

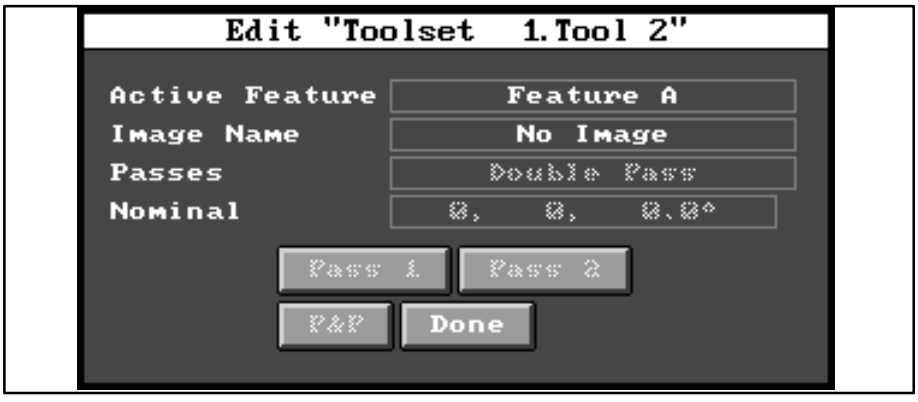
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2. **Save feature image:**
   a. **"Pick and place"** — position the feature window over the appropriate feature on the workpiece image.
   b. **Select feature image compression parameters**
   c. **Specify file name** — use the Image Manager to enter a device code and feature name, then store the feature image in a file on the selected device.
3. **Configure search window:**
   a. **"Pick and place"** — position the search window over the appropriate part of the workpiece image.
   b. **Select number of passes** — select the number of passes (one or two) that the feature window will make through the search window.
   c. **Select "pass" parameters** — select the appropriate masking, scaling, and other parameters for each "pass."
4. **Repeat Steps 1 – 3 for a second feature, if required.**
5. **Learn nominal values** — perform a "learn" operation to "learn" and store the "nominal" values — the data that indicate the workpiece's *initial* position.

Reference Window Tool Configuration

This section discusses the configuration steps that are accessed from the fields and buttons in the example reference window tool edit panel shown in Figure 6.24. Note that most of these fields and buttons are *inactive* (shaded) until the appropriate points are reached in the configuration process.

Figure 6.24 Example: Reference Window Tool Edit Panel



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Active Feature Selection

For the purposes of this discussion, the configuration process begins with the selection of the “active feature”; that is, Feature A or Feature B. The selected feature is “active” for the purposes of configuration.

Feature Image Configuration

The next step is the configuration and selection of a feature image (or *no* image, which disables the feature). A feature image is a “template,” stored in a file, that the reference window tool uses to locate a specific feature in the search window. This step is initiated when you pick the Image Name field in the reference window tool edit panel (see Figure 6.24).

Selecting Image Manager Panel

When you pick the Image Name field in the tool edit panel, the Image Manager panel appears, as shown in Figure 6.25.

Figure 6.25 Selecting Image Manager Panel



The function of the Image Manager panel is to provide a number of choices for compressing and storing images. (This panel is discussed in detail in Chapter 4, *Inspection Configuration*, under the *Image Manager Panel* heading on page 4–40.)

As it is used with reference windows, the Image Manager panel is restricted to compressing and storing *subimages* only. Also, the “Lossless” (*default*) compression method is normally used since reference window feature images are usually quite small, and compressing them further does not save a significant amount of memory. Furthermore, any loss of feature image data (that would result from using the “Baseline” compression method) may make the operation of the reference window less reliable. Finally, the Predictor and Point Xform selections should remain at their *default* values of 4 and 0, respectively.

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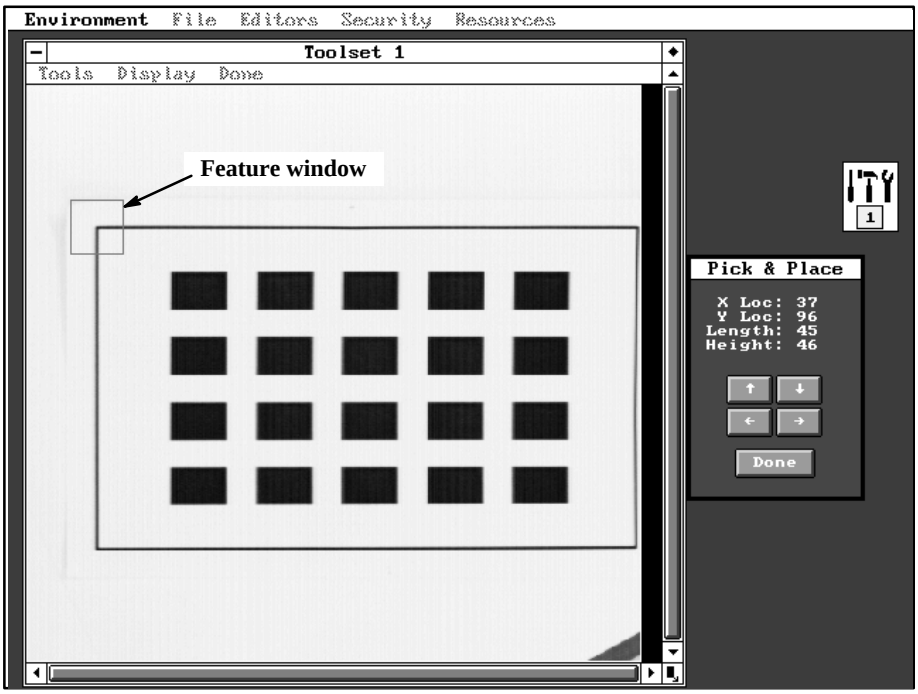
NOTE: Predictor and Point Xform are included in the Image Manager panel mainly to enable image data interchange with other systems. For technical information about these selections, refer to the JPEG (Joint Photographic Experts Group) specification for "Digital compression and coding of continuous–tone still image," ISO/IEC DIS 10918–1.

Thus, for the purpose of configuring a reference window tool, the Image Manager panel is used to *configure* the appropriate feature image and to *store* that feature image in a *lossless* compressed file (in most cases).

Saving Feature Image

The Image Manager provides a "pick and place" function to set the position and size of the feature window. To configure the feature image, pick the P&P button, then position the feature window over an *appropriately unique feature* in the workpiece image and set window's size, as illustrated by the example in Figure 6.26.

Figure 6.26 Example: Positioning the Feature Window Over Workpiece Feature



Before saving the feature image, check the Default Device field. Initially, the default device is "MC," which is the memory card. If you expect to save all (or most) feature image files in this device, leave it as "MC." If, however, you want to use another device, you can *change* the default device by picking the Default Device field and selecting another device from the Devices selection panel.

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To save a feature image, pick the Save button. When you do, the keyboard panel appears with this instruction in the title bar:

```
Enter a file name. Default device is MC:.
```

To store an image file in the *default* device, enter a file name such as . . .

feature1

To store an image in a *different* device, enter the device name, a colon, and a file name, such as . . .

EE:feature1

In all cases, after entering the appropriate image name in the keyboard panel, pick the Enter key. When you do, the CVIM2 system begins saving the subimage and displays this message:

```
Saving Image
 Please Wait
```

When the CVIM2 system finishes saving the image, it displays this message:

```
  Done saving image
Compression ratio 2:1
```

The compression ratio value appearing in the message is *truncated*; thus, 2:1 could actually be 2.9:1. Also, the actual compression ratio value varies with the details in the feature image, but in any case it cannot exceed the theoretical limit of 4:1 (for *lossless* compression).

After two or three seconds, the “Done” message disappears and the Image Manager panel reappears. Pick the Done button to exit back to the tool edit panel.

When the tool edit panel reappears, as shown in Figure 6.27, note that the new feature image name now appears in the Image Name field, and all of the fields and buttons are now *active*.

Figure 6.27 Example: Tool Edit Panel After Configuring and Selecting a Feature Image



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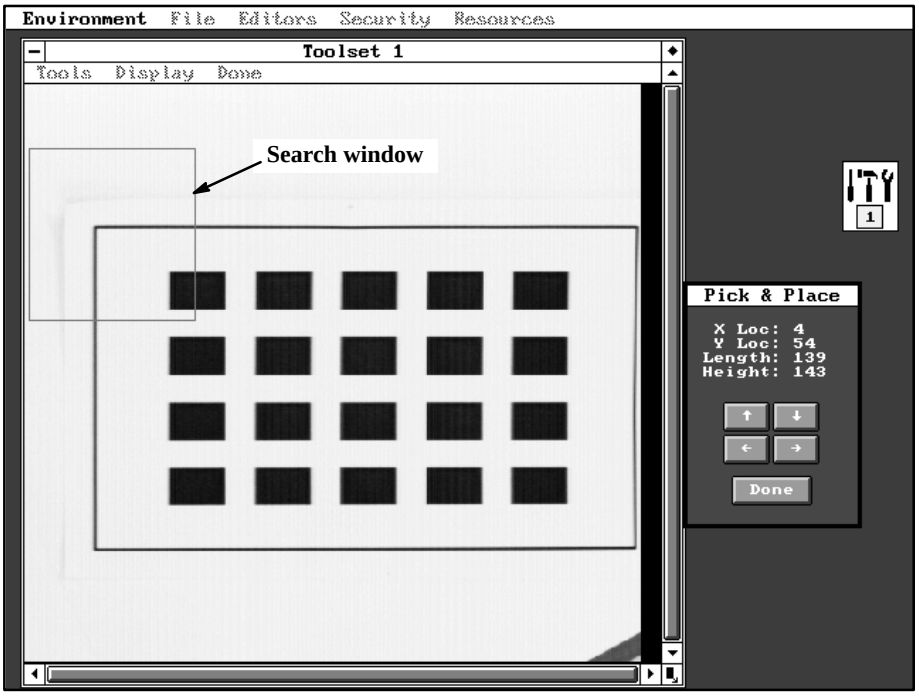
NOTE: The EE: and/or MC: devices may be useful for saving subimages while *testing* reference window tools. However, when testing is *completed*, transferring those subimages to the V1: or V2: devices will release space in the EE: device, or allow removal of the MC: device.

Search Window Configuration

The next step in the configuration process is to “pick and place” the search window over the appropriate portion of the image field. This is the area in which the feature window will search for the feature image during setup and online operations. Generally, the window should be only as large as necessary to include the anticipated workpiece *position changes* within the image field, since the larger the search window, the longer the search time.

To activate the search window’s pick and place function, pick the P&P button. Then, position the search window over the appropriate search area in the workpiece image and set the window’s size, as illustrated by the example in Figure 6.28. Pick the Done button in the Pick & Place panel to exit back to the tool edit panel.

Figure 6.28 Example: Positioning the Search Window in Image Field



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Single Pass vs Double Pass

You can configure a reference window tool so that the feature window makes either one or two “passes” through the search window. In most cases, two passes are more efficient than one pass: The first pass locates the feature *approximately*, after which the second pass locates the feature more precisely, but with a smaller region to search.

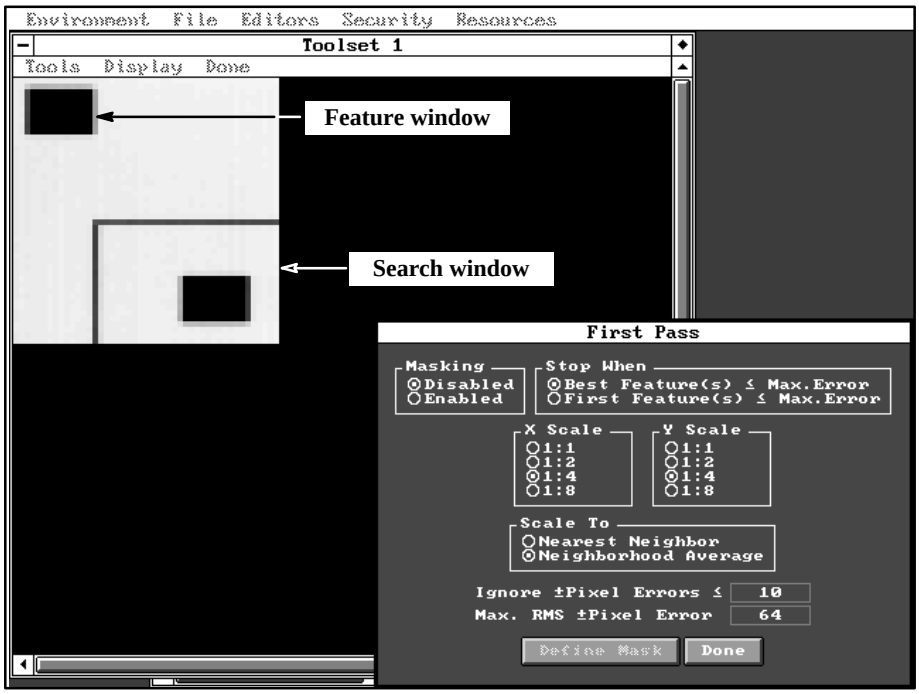
The choice of Single Pass or Double Pass depends the details of your application; thus, some trial and observation may be required in order to determine which choice is the most effective and efficient.

To select Double Pass when Single Pass is showing (or vice versa), pick the Passes field to toggle to the other choice. (Note that Double Pass is the *default* selection. When you toggle to Single Pass, the Pass 2 button becomes *shaded*, indicating that it is inactive.)

First Pass Configuration

When you pick the Pass 1 button, the First Pass configuration panel appears on the display, as illustrated in Figure 6.29. (Also appearing are the feature and search windows with their images altered according to the *default* parameter settings in the First Pass panel. These are explained in the masking and scaling sections.)

Figure 6.29 Example: First Pass Configuration Panel



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The First Pass panel contains several selection fields, data entry fields, and buttons, which are described briefly, as follows:

- **Masking** — This field selects Enabled or Disabled for the masking function. The *default* is Disabled.
- **Stop When** — This field selects either the "Best" or the "First" match of the feature in the search window to the stored feature image in the feature window. The *default* is "Best."
- **X Scale** — This field selects the scaling ratio for pixels along the X–axis in the feature and search windows. The *default* is 1:4.
- **Y Scale** — This field selects the scaling ratio for pixels along the Y–axis in the feature and search windows. The *default* is 1:4.
- **Scale To** — This field selects either the "Nearest Neighbor" or the "Neighborhood Average" as the basis for the scaling function. The *default* is "Neighborhood Average."
- **Ignore ±Pixel Errors** — This field is used to adjust the sensitivity of the reference window tool. It determines how closely the template must match the image on a *per pixel* basis. The *default* value is 10.
- **Max. RMS ±Pixel Errors** — This field determines the average acceptable deviation between the template and image. The *default* value is 64.
- **Define Mask** — The Define Mask button activates the Threshold/Filter function, which is used to "define" the mask on the feature image.
- **Done** — The Done button saves the currently selected configuration settings for the First Pass function, then exits the First Pass panel and returns to the tool edit panel.

Masking Function

The masking function can be used to "mask" edge pixels within the feature image or "template" when those pixels are not only *unnecessary* for template–matching purposes, but create errors large enough to cause the reference window tool to fail.

In general, masking is likely to be needed whenever a feature image contains many edge pixels relative to the number of pixels in the feature image (area). These edge pixels may yield large matching errors when the image is compared to a corresponding image in the search window, and the reference window tool may fail because of the matching errors along the edges.

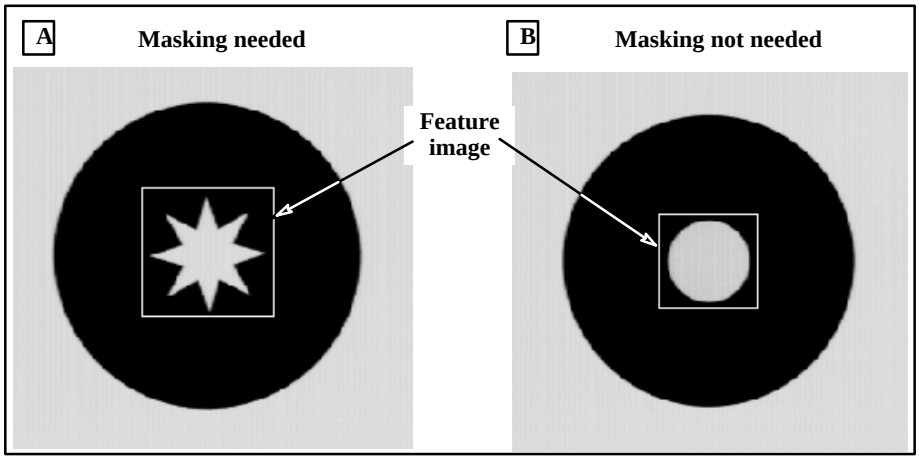
Figure 6.30 (page 6–36) provides two examples to illustrate when masking is needed (**A**) and when it may *not* be needed (**B**).

In example (**A**), the feature image contains many sharply defined edges. The edge pixels in this image can cause large matching errors, and the tool may fail. With masking *enabled*, however, the edges of the feature image can be ignored, and the likelihood of a match increased accordingly.

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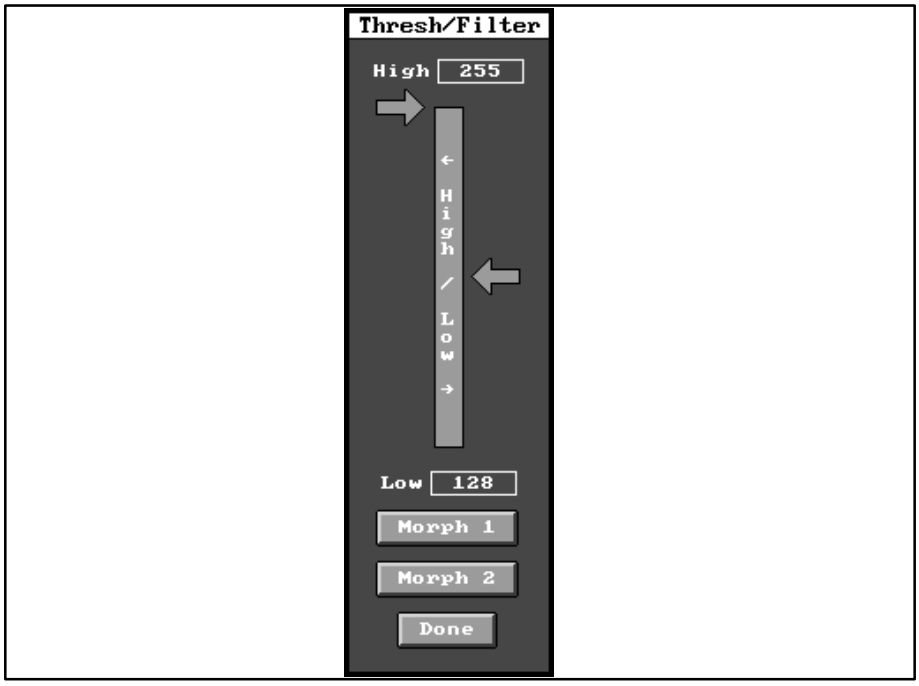
In example (**B**), the feature image contains fewer sharply defined edges. The edge pixels in this image will cause minimal matching errors, usually not enough to require masking. In this case, masking can be *disabled*.

Figure 6.30 Examples: Masking Needed vs Masking Not Needed



Note in Figure 6.29 (page 6–34) that masking is disabled by *default*. When masking is enabled, the Define Mask button becomes active. When you pick the Define Mask button, the Thresh/Filter adjustment panel appears, as shown in Figure 6.31.

Figure 6.31 Threshold/Filter Adjustment Panel for Masking Function



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This panel contains a pair of threshold adjustment cursors and two morphology buttons, Morph 1 and Morph 2, which are used to create the mask.

The cursors adjust the high and low masking thresholds, and the *default* threshold settings are 255 and 128, respectively. The morphology buttons access two stages of morphology operations, and the *default* morphology selections are “MAX–MIN” for Morph 1 and “Identity” for Morph 2. If no changes are made, these *default* settings will be used.

NOTE: The default morphology selections should not be altered except for more *advanced* masking applications. For more information about morphology functions, refer to Chapter 8, *Thresholds, Filters, and Morphology.*

The combined effect of the *default* morphology settings is to identify areas of high contrast. These “edge” areas are then used as a mask (and are shown in *green*), and they are thus ignored during template matching operations.

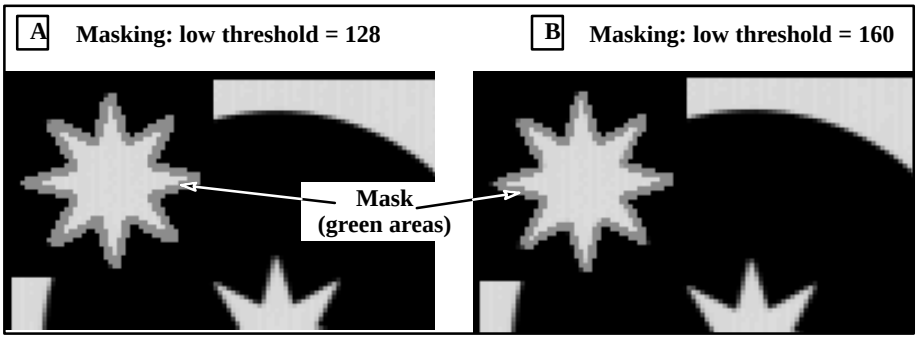
During reference window operation, as the feature window searches for a match in the search window, it *ignores* the masked pixels in the feature image and uses only the non–green (that is, gray scale) pixels as the template.

The function of the *threshold* adjustments is to determine how strong an edge pixel must be to be masked.

Figure 6.32 illustrates adjusting the masking threshold on the feature image shown in Figure 6.30 (**A**). Note that when the Define Mask button is picked, this image appears in the upper–left corner of the screen display *superimposed* on the search window image, as illustrated earlier in Figure 6.29 (page 6–34).

In Figure 6.32 (**A**), with the low threshold set to the default value of 128, the mask (green areas) appears somewhat larger than required to cover the edge pixels. When the low threshold is set to 160 (in this example), the mask is reduced so that it covers only the edge pixels.

Figure 6.32 Threshold Adjustment to Optimize Masking Effect



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Stop When Selection

The "Stop When" selection field enables you to select either "First Feature(s)" or "Best Feature(s)" as the basis for deciding when a template match has occurred and the feature window can *stop* searching. Since the feature window scans the search window in a left–to–right, top–to–bottom pattern, "First" causes the search to stop when the feature window finds the *first* template match that satisfies the parameter selections in the First Pass panel. "Best" causes the feature window to scan the *entire* search window and to select the *best* template match (which may also be the *first* when there is only one match).

Figure 6.33 (page 6–39) illustrates the difference between First and Best. In Figure 6.33 (**A**), the feature window is shown in position over the original feature image (note that the X and Y coordinates are 293 and 198). In (**B**), the search window is shown in position over the search area.

In (**C**), with the reference window tool in operation and First Features(s) selected, the feature window finds the *first* feature in the upper–left corner of the search window (it qualifies as a match according to the current parameter settings in the First Pass panel). This, however, is *not* the desired feature (the X and Y coordinates are 141 and 193), and the RMS error is 18.915.

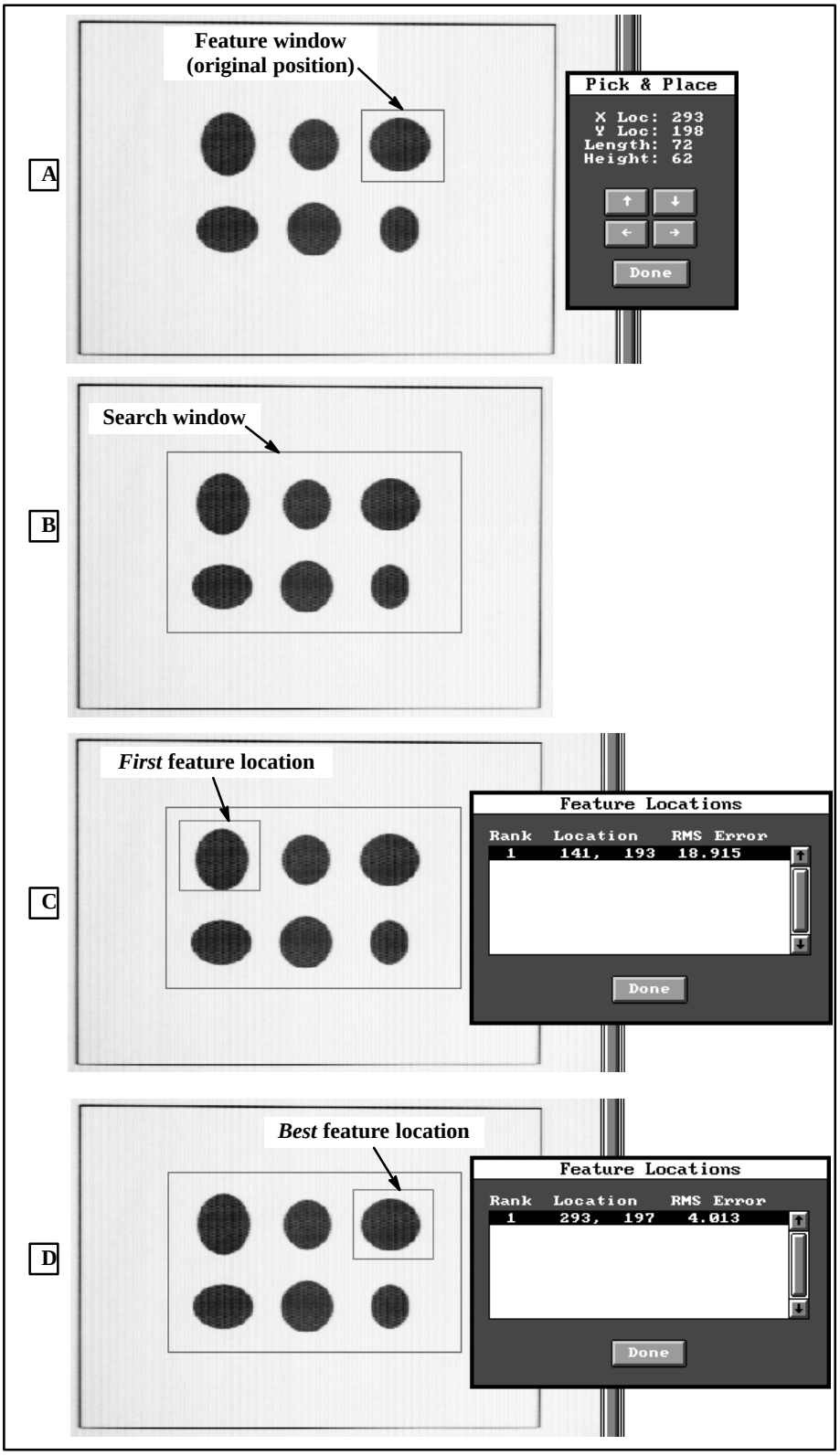
In (**D**), with Best Feature(s) selected, the feature window finds the *best* feature at almost *exactly* the location of the original feature window. In this case, the X and Y coordinates are 293 and 197, and the RMS error is 4.013, which is a better match.

"Best" will require more time, since the feature window must always search the entire search window, but it will usually give you better positional accuracy, and it will also provide a true measure of the "worst case" inspection cycle time.

NOTE: During configuration, "Best" can be useful to find the "RMS Error" value for the best match, and to use that value as the basis for determining the appropriate "Max. RMS ±Pixel Error" setting. This is discussed later in the *Pixels Error Parameter Selections* section.

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Figure 6.33 Examples: Comparing First Feature Image With Best Feature Image

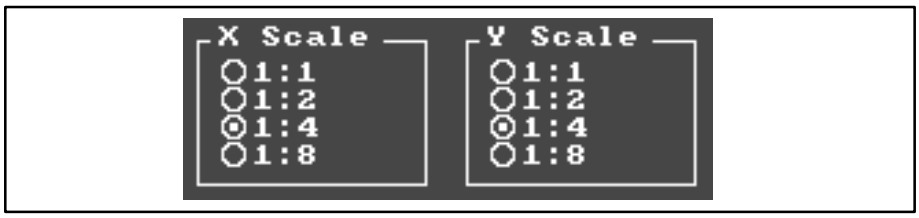


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X Scale, Y Scale Selections

The X Scale and Y Scale "compression" ratio selections, shown in Figure 6.34, determine the ratio of pixel averaging or "compression" to be used on the images in the feature and search windows.

Figure 6.34 X Scale and Y Scale Ratio Selections



The scaling trade–offs are these: The higher the numeric ratio, the lower the image resolution but the faster the search. Conversely, the lower the numeric ratio, the higher the image resolution, but the slower the search.

As Figure 6.34 shows, the scaling ratios are 1:1, 1:2, 1:4 (*default*), and 1:8. The concept is this: For a 1:*x* ratio, *x* pixels are replaced with *one* pixel whose gray scale value equals the *average* gray scale value of the *x* pixels.

Figure 6.35 (page 6–41) illustrates this concept using the 1:4 ratio for both X Scale and Y Scale. With the 1:4 scaling ratio selected, the 16 gray scale values of each 4–by–4 block of pixels are averaged ("compressed") to *one* gray scale value in *one* pixel.

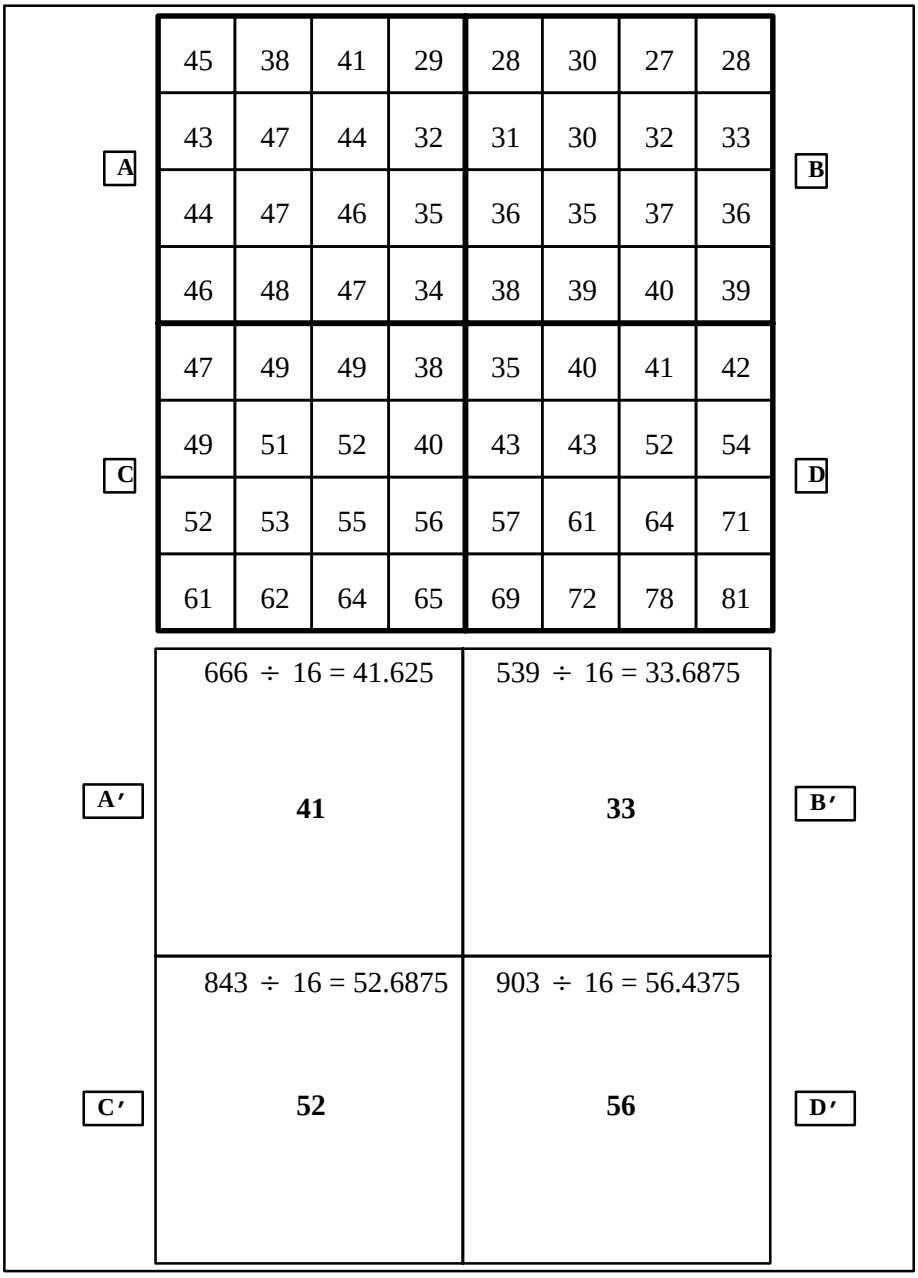
Figure 6.35 shows four such 4–by–4 blocks of pixels: A, B, C, and D. Thus, block (**A**) is compressed to a single "pixel" (**A′**) whose gray value is 41, block (**B**) is compressed to a single "pixel" (**B′**) whose gray value is 33, and so on.

This "compression" applies to the images in both the feature window and the search window. The result is that since *both* images have fewer pixels, the *effectively smaller* feature window requires less time to search the *effectively smaller* search window.

In some applications, an *asymmetrical* scaling selection may be appropriate. In such cases, high resolution (1:1 ratio) may be required on one axis in order to avoid loss of necessary detail, but low resolution (such as 1:4 or 1:8) may be acceptable on the other axis because details are not present or are not important for template–matching purposes.

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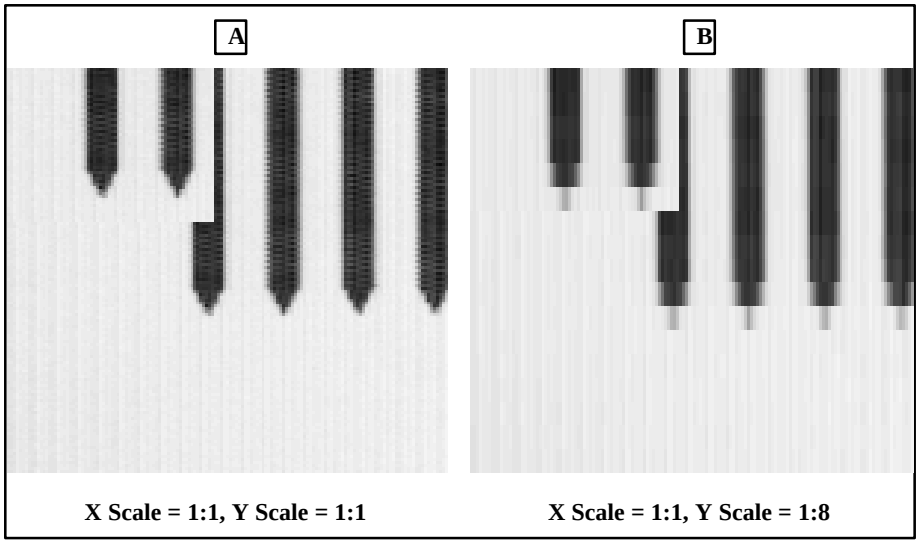
Figure 6.35 Example: Pixel Averaging Using X and Y Scaling at 1:4 Ratio



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Figure 6.36 illustrates using high resolution on the X–axis and low resolution (1:8) on the Y–axis. The feature in this example is a multi–pin connector, and the objective of the reference window tool is to locate and track the lower portions of the leftmost two pins.

Figure 6.36 Examples: Using Asymmetrical X and Y Scaling Ratios



The figure shows how the feature and search images appear using 1:1 scaling on both axes in (**A**), and using 1:1 on the X–axis and 1:8 on the Y–axis in (**B**). Notice that the horizontal resolution in (**B**) is the same as in (**A**); and, although the vertical resolution has been changed, that change has *no effect* on accuracy in this example.

The major difference is in the inspection cycle time: Using 1:1 on *both* axes requires 725ms for each inspection cycle, while using 1:1 on the X–axis and 1:8 on the Y–axis requires only 70ms — one–tenth as much time.

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Scale To Selections

The Nearest Neighbor and Neighborhood Average "scale to" selections, shown in Figure 6.37, have *no effect* when the X scale and Y scale selections are *both* 1:1 — they are applicable only when the X scale and/or Y scale selections are *other than* 1:1.

Figure 6.37 Scale To Selections



Neighborhood Average — This is the *default* selection. The template match is based on the average gray value of the scaled neighborhood.

Nearest Neighbor — The template match is based on picking the value of the pixel that is in the *upper–left corner* of a block of pixels, such as "45" in block "**A**" of Figure 6.35 (page 6–41). (In this case, "nearest neighbor" would result in a single pixel with a gray scale value of 45.*)* Nearest neighbor is a somewhat faster approximation for template matching purposes than neighborhood average, but gives a less accurate approximation of the image.

Pixel Error Parameter Selections

The Ignore $\pm$Pixel Errors $\leq$ and Max. RMS $\pm$Pixel Error parameters determine, for the purposes of template matching, the extent to which the gray values of the pixels in the *search image* are permitted to deviate from the gray values of the pixels in the *feature image* and still achieve a successful template match.

Ignore $\pm$Pixel Errors $\leq$ — This parameter sets the value at (or below) which pixel gray value mismatches ("pixel errors") are ignored during the search operation. The *default* setting is 10.

The term "error" refers to *any* difference between the gray value of a pixel in the feature image and the gray value of the corresponding pixel in the search image. For example, if the gray value of a particular feature image pixel were 20 and the corresponding search image pixel were 25, the error would be 5. With the "Ignore" setting at the default value (10), the reference window would ignore this error. If, however, the corresponding search image pixel were 31, the error would be 11, and the reference window would recognize that error.

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In a typical system, small gray value variations or “dithering” may be present from the following sources:

- Thermal “noise” in the camera system.
- Fluctuations in the lighting used.
- The use of “baseline” compression when the feature image is stored (the decompressed image used during the search operation may not match the original image *exactly*).
- Variations in part position.
- Variations from part to part.

The “Ignore” parameter can be adjusted so that the reference window will ignore these variations and will recognize as errors only those variations resulting from actual feature mismatches.

In general, you should set the “Ignore” parameter as low as possible, consistent with the expected variations resulting from dither and other system causes.

Max. RMS ±Pixel Error — This parameter sets the *maximum* RMS (root mean square) error that is acceptable for the purpose of template matching.

During a search operation, the reference window calculates the difference between the gray value of each pixel in the feature image and the gray value of each corresponding pixel in the search image. Each difference that is *higher than* the “Ignore” parameter is squared, and all of the squared differences are then summed for a given feature position. The sum of these squares is divided by the number of pixels in the feature image, and the square root of that value is then calculated. The square root is the RMS error for a particular point in the search operation. A “match” will occur only if the RMS error is at or below the “Max. RMS” parameter.

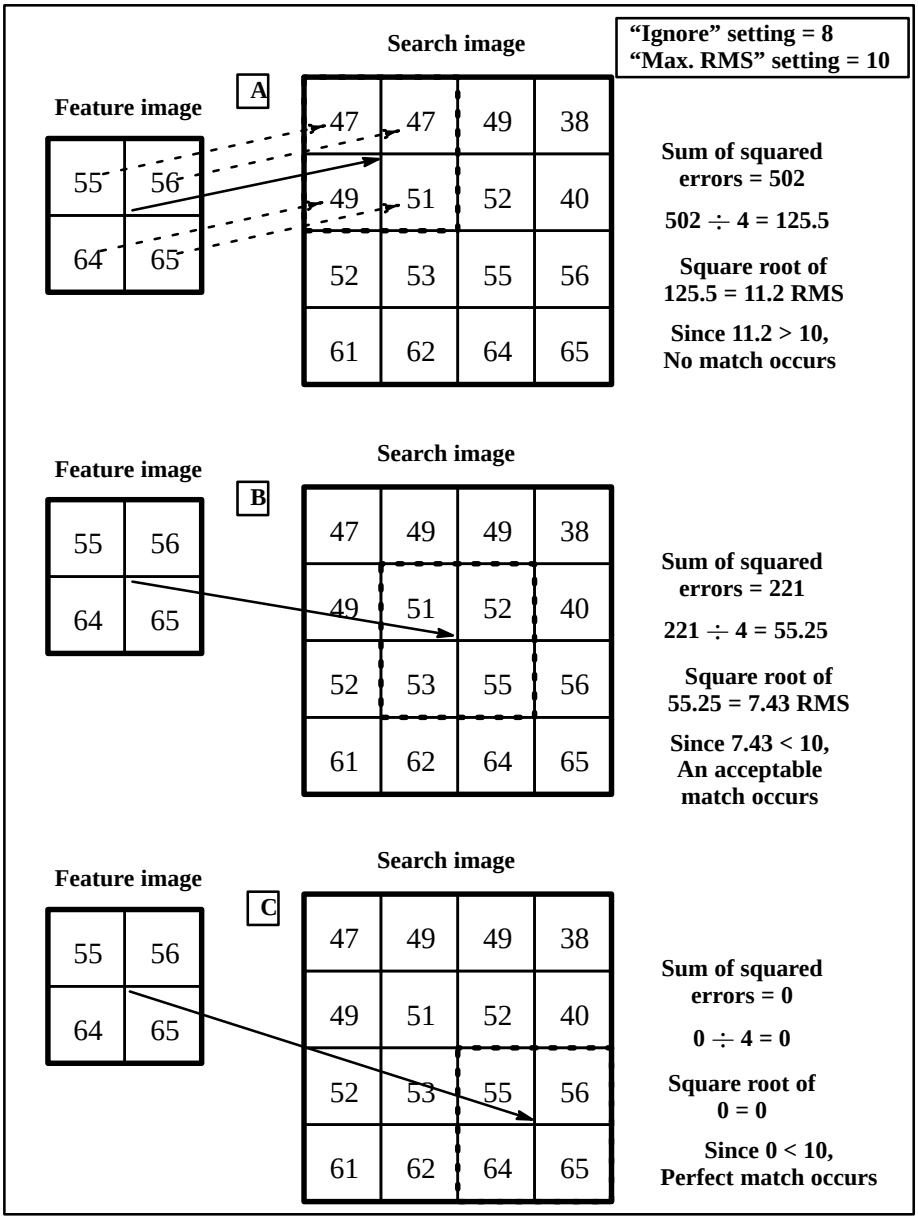
The reason for using the RMS method of processing pixel errors is that it more closely approximates the kind of template matching that a human observer would perform. As one example, if each of the four pixels in a 2–by–2 feature image had a difference of exactly 1 with each corresponding search image pixel, the RMS error would be 1. As another example, if the feature image had differences of 0 on three pixels, and 4 on the fourth pixel, the RMS error would be 2.

To a human observer, the first example would be a closer match than the second. Generally, a large number of small differences yields a *good* match, and a small number of large differences yields a *bad* match. As these examples indicate, using the RMS imposes a higher penalty on large pixel errors than on small pixel errors.

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Figure 6.38 provides three examples to illustrate the results of RMS calculations. In these examples, the feature image is shown at three different points in the search image during a search operation. The gray values are shown for each pixel in the feature and search images.

Figure 6.38 Examples: Three RMS Calculations During Search Operation



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In example (**A**), the difference between 55 and 47 is 8. Since this pixel error is equal to the "Ignore" parameter, it is ignored. For the remaining pixels, the differences are 9, 15, and 14, respectively. Since all of these pixel errors are higher than 8, they are recognized. The squares are 81, 225, and 196, and the sum of these squares is 502. Since the feature image contains four pixels, 502 ÷ 4 = 125.5. The square root of 125.5 is 11.2, which exceeds the "Max. RMS" parameter. Thus, at this point in the search operation, a match does *not* occur.

Example (**B**) illustrates an acceptable match, since the calculated RMS is less than the "Max. RMS" parameter. Example (**C**) illustrates a *perfect* match, with the calculated RMS at 0.0.

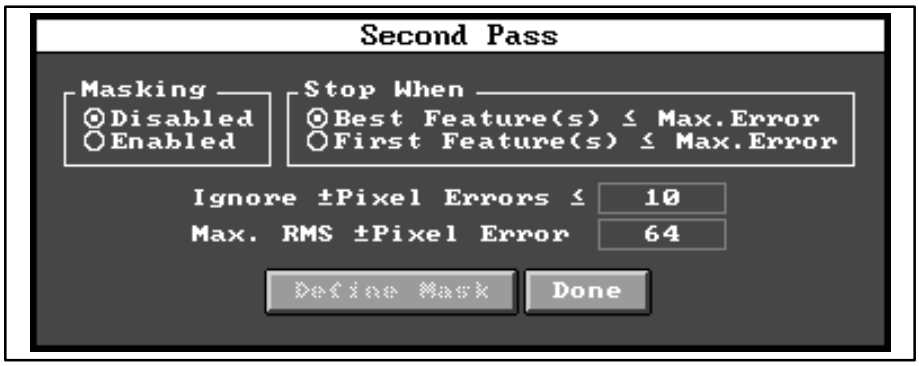
Starting with the "Max. RMS" parameter set to the *default* value (64), one method for determining the most appropriate RMS parameter value for your application is to select "Best" in the "Stop When" selection field and then perform a Nominal or "learn" operation as described in the *Nominal ("Learn") Function* section. This will calculate the RMS value for the *best* template match.

The "Max. RMS" parameter value should be set slightly higher, initially, than the "Best" calculated value, and tool operation should be evaluated using this value. The *final* value, however, should be the one that provides the most reliable template matching under the operating conditions of your application. This means, ideally, that the reference window should *always* find the *correct* feature when it is in the search window, and should *never* falsely identify a *different* feature.

Second Pass Configuration

When you pick the Pass 2 button in the reference window tool edit panel, the Second Pass configuration panel appears on the display, as illustrated in Figure 6.39. (Also appearing are the feature and search images.)

Figure 6.39 Example: Second Pass Configuration Panel



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Note that the Second Pass panel is a scaled down version of the First Pass panel. It has only the Masking and Stop When selection fields and the "Ignore" and "Max. RMS" pixel error parameter entry fields. X and Y scaling is fixed at the 1:1 ratio. The same *defaults* are used. For information about these parameters, refer to the *First Pass Configuration* section.

When Double Pass is enabled (*default*), the second pass operates on the results created by the first pass operation. The principal advantage of using two passes is the achievement of high resolution in coordinate and angle results *without* the significant speed penalty that usually occurs when using one pass with high resolution scaling (1:1) for X and Y axis scaling.

During the second pass, the feature window searches only in the part of the search window in which the first pass located a feature — it does *not* search the whole search window — thereby saving considerable time in many cases.

Table 6.2 demonstrates the speed difference for one feature (A or B) using the *same* feature image and search image for single pass and double pass. These results are derived from an actual setup in which the "pick and place" coordinates of the feature image were 120 and 143 for the X–axis and Y–axis, respectively.

Table 6.2 Example: Comparison of Single Pass and Double Pass Performance

Operation	Scaling	Masking	Coordinates (X, Y)	Time for "Best"	Time for "First"
Single Pass	1:1 for X and Y axes	Enabled	120, 143	1980ms	350ms
Double Pass: First Pass	1:8 for X and Y axes	Enabled	119, 139	Not used	10ms
Double Pass: Second Pass	1:1 for X and Y axes (not user selectable)	Enabled	120, 143	28ms	Not used

Note that when using single pass with high resolution scaling (1:1 for X and Y axes), the coordinates were located at 120 and 143, the original locations, but the processing times were quite long: 350ms for "First," and 1980ms (almost two seconds) for "Best."

However, when using a double pass with low resolution scaling (1:8 for X– and Y–axes), the first pass requires only 10ms to locate the feature *approximately,* and the second pass requires only an additional 28ms to locate the feature more *precisely.* Note that in this example the coordinates of the located feature are the *same* as in the original feature image: 120 and 143. The total time is 38ms for the double pass operation vs at least 350ms for the single pass operation.

NOTE: If you are using a reference window for *rotation* compensation, return to page 6–30 and repeat the configuration process for Feature B.

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Nominal ("Learn") Function

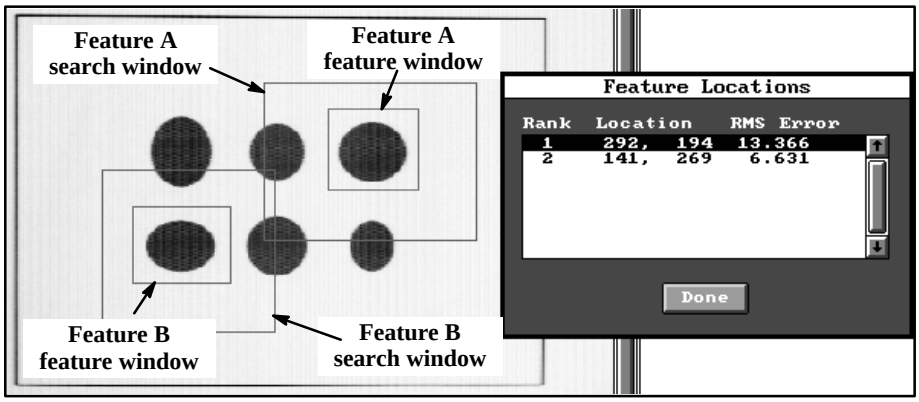
As noted on page 6–28, the Nominal field in the reference window tool edit panel, when picked, causes the currently selected *and configured* reference window tool to store the "nominal" position of the X and Y coordinate data, as well as angular data, and to display that data in the Nominal field. Additional data appears in a Feature Locations panel.

When you pick the Nominal field, the Feature Locations panel appears on the display, and the feature and search windows lie over the image, as shown in Figure 6.40.

If *one* feature is active (Feature A *or* Feature B), the X and Y coordinates (under the Location heading in the Feature Locations panel) identify the location of the *upper–left corner* of the single feature window.

If *two* features are active (Feature A *and* Feature B), the X and Y coordinates identify the location of the *midpoint* on a line connecting the upper–left corners of the two feature windows. Figure 6.40 illustrates the appearance of the Feature Locations panel when *both* features (A and B) are active.

Figure 6.40 Example: Feature Locations Panel



The three columns in the Feature Locations panel are defined as follows:

- **Rank** — This identifies the feature as follows: When only one feature (A or B) is used, it always appears as rank 1. When both features (A and B) are used, rank 1 pertains to Feature A and rank 2 pertains to Feature B. (The currently *highlighted* feature in the panel corresponds to the *green* feature window in the image field.)
- **Location** — This identifies the X and Y coordinates of the upper–left corner of each feature window.
- **RMS Error** — This displays the calculated RMS (root mean square) error for each feature (refer to the *Pixel Error Parameter Selections* section on page 6–43 for details about RMS error calculations).

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When you pick the Done button to exit the Feature Locations panel, the "learned" data appear in the Nominal field and indicate, from left to right, an X coordinate, a Y coordinate, and an angle (θ).

NOTE: If the warning message shown in Figure 6.41 appears after you pick the Nominal field, it indicates a problem with some aspect of the feature configuration. Pick the OK button to exit this message.

Figure 6.41 Warning Message: One or More Features Not Found



If *one* feature is active (Feature A *or* Feature B), the "learned" X and Y coordinates in the Nominal field identify the location of the *center* of the single feature window. Since no angular measurement is involved in this case, the angle (θ) is always 0.0°.

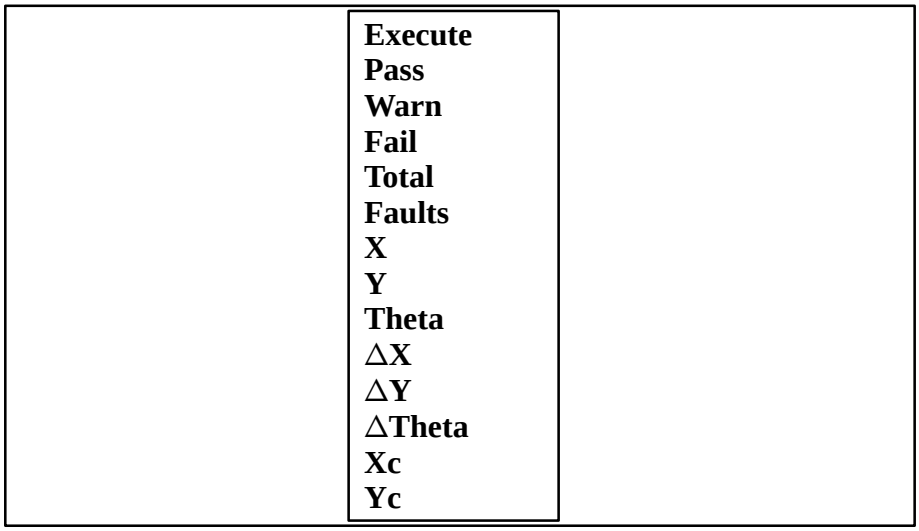
If *two* features are active (Feature A *and* Feature B), the "learned" X and Y coordinates in the Nominal field identify the location of the *midpoint* on a line connecting the *centers* of the two feature windows. The angle (θ) indicates the relation of that line to the X–axis of the image field.

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Reference Window Tool Inspection Results and Math Tool Formulas

This section discusses the expanded inspection results that are available to a math tool formula from a reference window tool. As Figure 6.42 shows, the expanded inspection results for a reference window tool appear in one list.

Figure 6.42 Expanded Results Lists For Reference Window Tools in Math Formulas



Here is a brief definition and explanation of each of the expanded result types listed in Figure 6.42.

- **Execute** — This returns a 1.000 when the tool has *executed* its inspection task, and 0.000 for all other conditions.
- **Pass** — This returns a 1.000 when the tool has *passed* its inspection task, and 0.000 for all other conditions.
- **Warn** — For reference tools, Warn always returns 0.000.
- **Fail** — This returns an "error code" when the tool is in a *fail* condition and 0.000 for all other conditions. The error code identifies a specific reason for the failure; for example, error code 1038.000 identifies "One or more features could not be found" as the cause of the inspection failure. The complete list of error codes and fail conditions appears in Appendix A of this manual.
- **Total** — This returns the total number of inspections performed.
- **Faults** — This returns the total number of faults detected.
- **X** — This returns the nominal or "learned" X coordinate of the center of the feature when *one* feature is used, or the midpoint between the centers of the two features when *two* features are used.
- **Y** — This returns the nominal or "learned" Y coordinate of the center of the feature when *one* feature is used, or the midpoint between centers of the two features when *two* features are used.

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- **Theta** — When a two–feature reference window tool is used, this returns the nominal or “learned” value of the rotation angle, in degrees, between a line connecting the *centers* of the two features, and the X–axis of the image field. When one feature is used, theta returns 0.000.
- **ΔX** — This returns the *change* from the nominal or “learned” X coordinate of the principal reference point.
- **ΔY** — This returns the *change* from the nominal or “learned” Y coordinate of the principal reference point.
- **ΔTheta** — This returns the *change* from the nominal or “learned” value of the rotation angle, in degrees, between a line connecting the *centers* of the two features, and the X–axis of the image field. When one feature is used, ΔTheta returns 0.000.
- **Xc** — This returns the *current* X coordinate of the *center* of the feature when one feature is used, or the *midpoint* between the centers of the two features when *two* features are used.
- **Yc** — This returns the *current* Y coordinate of the *center* of the feature when one feature is used, or the *midpoint* between the centers of the two features when *two* features are used.

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Rotation Finder Tool

This section discusses the rotation finder tool and the rotation compensation that it can provide to other tools.

The rotation finder tool is a reference tool used to find the orientation of a rotated circular object so that other inspection tools can be positioned to match the object's rotation, and thereby remain properly aligned to that object.

A rotation finder tool consists of two main components: a circular "source" window, and a rectangular "destination" window. The circular source window consists of an inner ring and a concentric outer ring. It "unwraps" the image area lying between its two rings and displays the unwrapped image in the rectangular "destination" window.

Separately, a "feature window" is accessed from the Image Manager panel. The feature window is placed over a region in the destination window that contains a unique pattern, and the image of that pattern (the "feature image") is then saved in an image file.

During run operations, the feature window searches the destination window for a match to the previously saved feature image. When it finds a match to the feature image, the rotation finder tool calculates its rotation value and provides the corresponding rotation offset to the associated inspection tools.

After a rotation finder tool has been entered in a toolset edit panel, the corresponding tool edit panel can be accessed by picking "Rotation Finder" in the toolset edit panel. Initially, the rotation finder tool edit panel appears as shown by the example in Figure 6.43 (page 6–53).

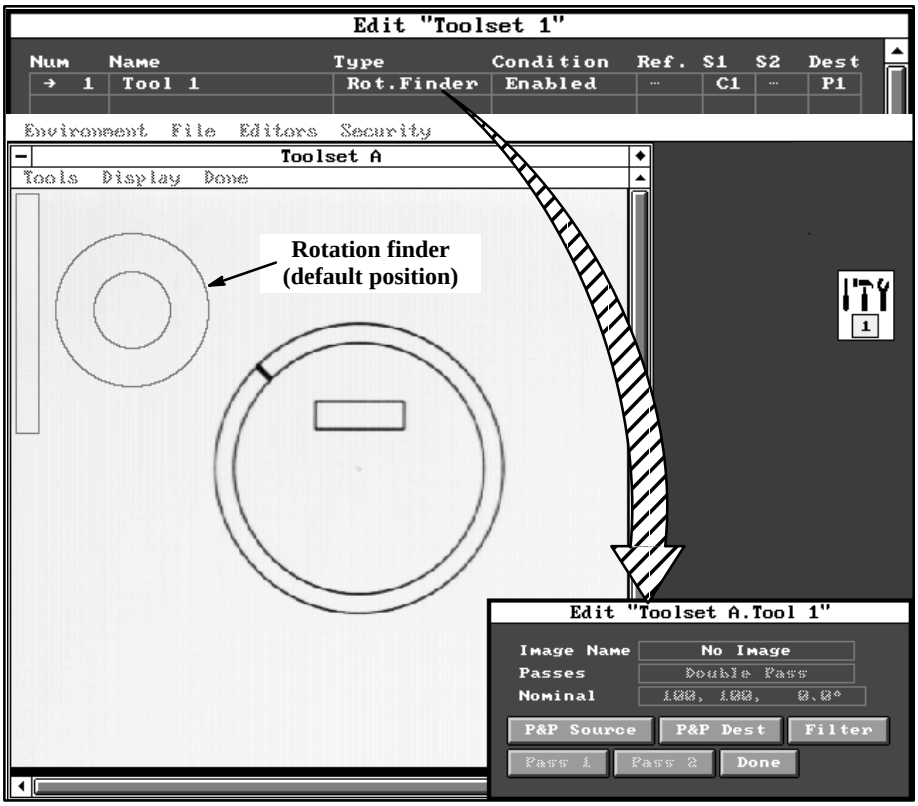
The two main window components of the rotation finder tool are shown in their *default* positions on the screen. (The feature window appears *only* when the Image Manager panel is selected.)

The tool edit panel (named "Toolset A.Tool 1 Edit" in Figure 6.43) contains several data fields and buttons, which are described briefly as follows:

- **Image Name** — This field identifies the name of the currently selected feature image (or "No Image," if none is selected). When you pick this field, the Image Manager panel appears, which is used to save or select an image file for the feature window.
- **Passes** — This field selects either Single Pass or Double Pass, which is the number of passes the feature window makes through the search window. When you pick this field, Single Pass *toggles* to Double Pass, or vice versa.
- **Nominal** — When this field is picked after the rotation finder tool is configured, the tool "learns" the "nominal" locations of the circular object's center and the rotation angle of the feature image. During run operations, the tool uses these values to compute its rotation and shift from its "nominal" position.

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Figure 6.43 Example: Selecting the Rotation Finder Tool Edit Panel



- ***P&P Source** — The P&P Source button activates the source window pick and place function.
- ***P&P Dest** — The P&P Dest button activates the destination window pick and place function.
- **Filter** — The Filter button accesses the morphology filter function. For details about this function, see Chapter 8, *Thresholds, Filters, and Morphology.*
- **Pass 1** — The Pass 1 button selects the First Pass panel, from which you can select the parameters that the feature window uses to scan the destination window on the first (or only) pass.
- **Pass 2** — The Pass 2 button selects the Second Pass panel, from which you can select the parameters that the feature uses to scan the destination window on the second pass.
- **Done** — When you pick the Done button, the system exits back to the toolset edit panel.

*For details about the above “pick and place” functions, see Chapter 5, *Pick and Place Functions*.

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Overview: Rotation Finder Tool Configuration

A rotation finder tool can be selected when the toolset edit panel is on the screen. Starting from the main menu bar, the selection path to this panel is as follows: **Editors** → **Configuration** → **Setup** → **Tools**. (This selection path is shown by an example in Chapter 7, *Inspection Tools*, Figure 7.2 on page 7–3.)

Here is a summary of the basic selection and configuration steps for a rotation finder tool, listed in their normal order of performance.

1. **Configure source window** — position the circular source window over the appropriate part of the workpiece image.
2. **Configure destination window** — set the rectangular destination window to an appropriate size.
3. **Select filter function** — if appropriate, perform morphology filtering on destination window image.
4. **Save feature image** — use the Image Manager panel for the following tasks:
   a. **"Pick and place" feature window** — position the feature window over the appropriate feature on the destination window image.
   b. **Select feature image compression parameters**
   c. **Specify file name** — to enter a device code and feature name, then store the feature image in a file on the selected device.
5. **Configure feature window:**
   a. **Select number of passes** — select the number of passes (one or two) that the feature window will make through the search window.
   b. **Select "pass" parameters** — select the appropriate masking, scaling, and other parameters for each "pass."
6. **Learn nominal values** — perform a "learn" operation to "learn" and store the "nominal" values — the data that indicate the workpiece's *initial* position.

Rotation Finder Tool Configuration: Example

Figure 6.44 (page 6–55) through Figure 6.52 (page 6–61) illustrate an extended example in which a rotation finder tool is configured to detect rotation of a small black "index mark" in a circular object. When it detects a rotated index mark, the rotation tool applies rotation compensation to an associated line gage tool, which is positioned horizontally over a small rectangular object inside the circular object.

NOTE: The rotation finder tool's source window must always be aligned with the center of rotation of the circular object. In addition, if the circular object is expected to *shift* in the image field, a reference line tool will be needed to compute the shift and apply the corresponding shift compensation to the source window. (Used with a reference line tool, the rotation finder tool will also supply *shift* compensation to the associated tools.)

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Figure 6.44 illustrates the initial image of the circular object, the index mark on the circular object, and the rectangular object.

Figure 6.44 Initial Image for Rotation Finder Tool Example

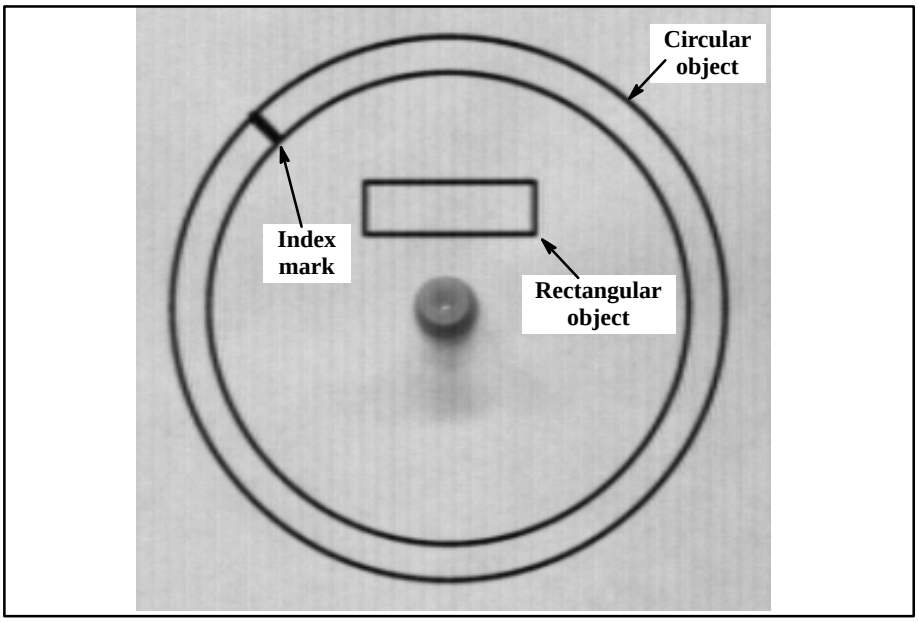


Figure 6.45 illustrates the relation between the reference line tool, rotation finder tool, and gage tool in the toolset edit panel. In this example, the rotation finder tool (Tool 2) receives X– and Y–axis shift compensation from the reference line tool (Tool 1), and the gage tool (Tool 3) receives rotation and shift compensation from the rotation finder tool.

Figure 6.45 Example: Relation Between Reference Line, Rotation Finder, and Gage Tools in Toolset Edit Panel

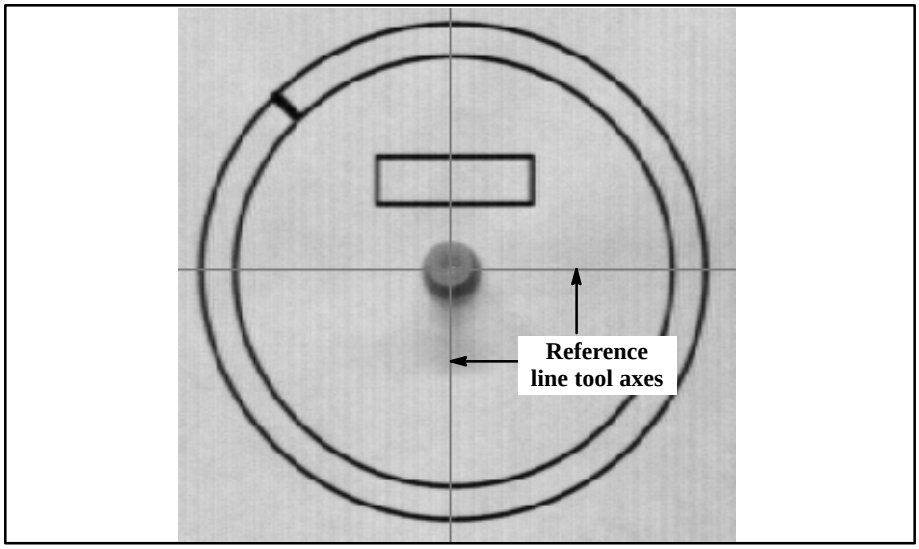
Edit "Toolset 1"

Num	Name	Type	Condition	Ref.	S1	S2	Dest
→ 1	Tool 1	Ref. Line	Enabled	…	C1	…	…
2	Tool 2	Rot.Finder	Enabled	1	C1	…	P1
3	Tool 3	Gage	Enabled	2	C1	…	…

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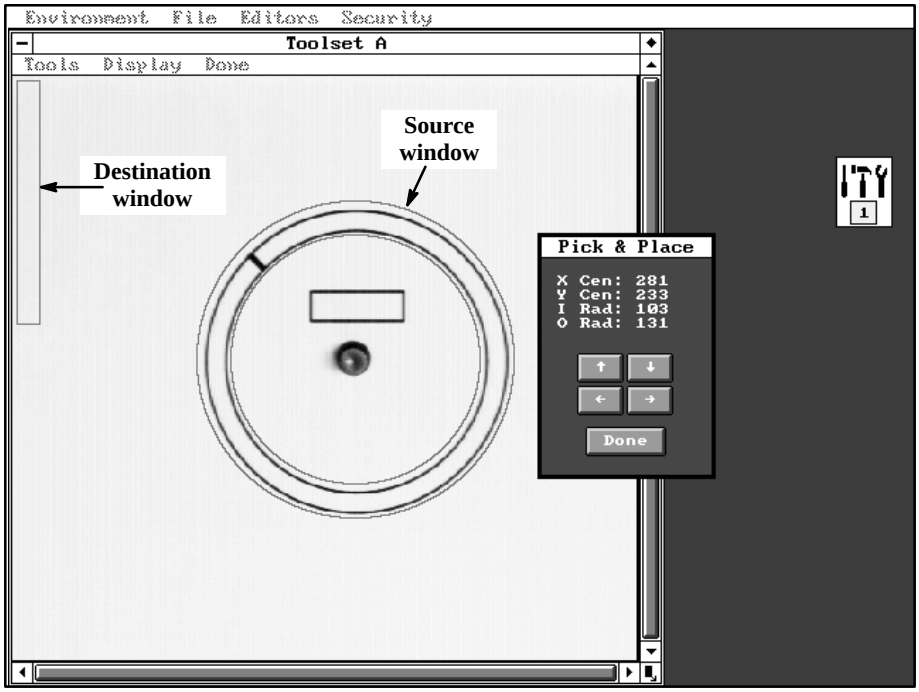
The reference line tool is configured for “X then Y” operation, with the X– and Y–axes crossing through the center of the circular object, as shown in Figure 6.46. The function of the tool is to locate the *center* of the circular object; thus, offsets (such as “Center”) should be selected for this purpose.

Figure 6.46 Example: X Then Y Reference Line Configured Over Circular Object



The source window is centered over the circular object as shown in Figure 6.47, and its rings are set so that the circular object nearly fills the space between them.

Figure 6.47 Example: Source Window Rings Positioned Over Circular Object



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Here are the criteria for positioning the inner and outer rings of the *source* window:

- The source window should be centered on the circular object. The center location can be obtained from the “nominal” X– and Y–axis coordinates reported by the reference line tool.
- The region between the inner and outer rings must contain a distinct “index” feature such as a hole, tab, or rivet.
- For the best rotational accuracy, the feature should be consistent from object to object, and should be located as far as possible from the center of the circular object.

When the source window has been resized and repositioned appropriately, as illustrated by the example in Figure 6.47 (page 6–56), and the source window’s pick and place function has been exited, the image area between the two rings of the source window appears in the destination window, *unwrapped*.

Here are the criteria for positioning the *destination* window:

- The destination window must be tall enough to provide the optimal angular resolution.

  A shorter destination window will make the tool run faster, but it will provide less angular resolution.
- The destination window should be as narrow as possible, provided that the “index” feature remains a distinct pattern within the unwrapped image. If the possibility of confusion exists between the chosen index feature and another region of the unwrapped image, then widening the destination will give better reliability but slower speed.

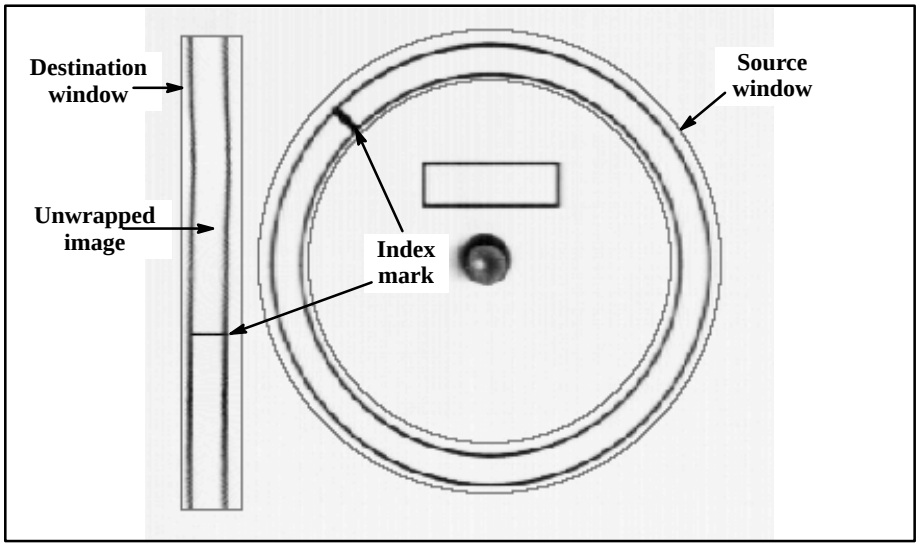
Figure 6.48 (page 6–58) illustrates how the unwrapped image of the circular object (see Figure 6.47) appears in the destination window after the destination window has been appropriately resized and repositioned. Note the relative position of the “index mark” in the two windows.

At this point, morphology filtering could be used (by picking the Filter button) to enhance the index feature in the destination window, if desired. The rotation finder tool is sensitive to variations in lighting and part color from one inspection to the next; however, this sensitivity can be reduced by applying a “MAX – MIN” operation, followed by a “MAX” operation.

The next task is the selection of the “feature image” in the destination window. For this purpose, the Image Manager panel is accessed by picking the Image Name field in the tool edit panel. (For general details about the Image Manager panel, refer to the *Image Manager Panel* section on page 4–40 of Chapter 4, *Inspection Configuration*. For additional details, refer to the *Feature Image Configuration* section on page 6–30 of this chapter.)

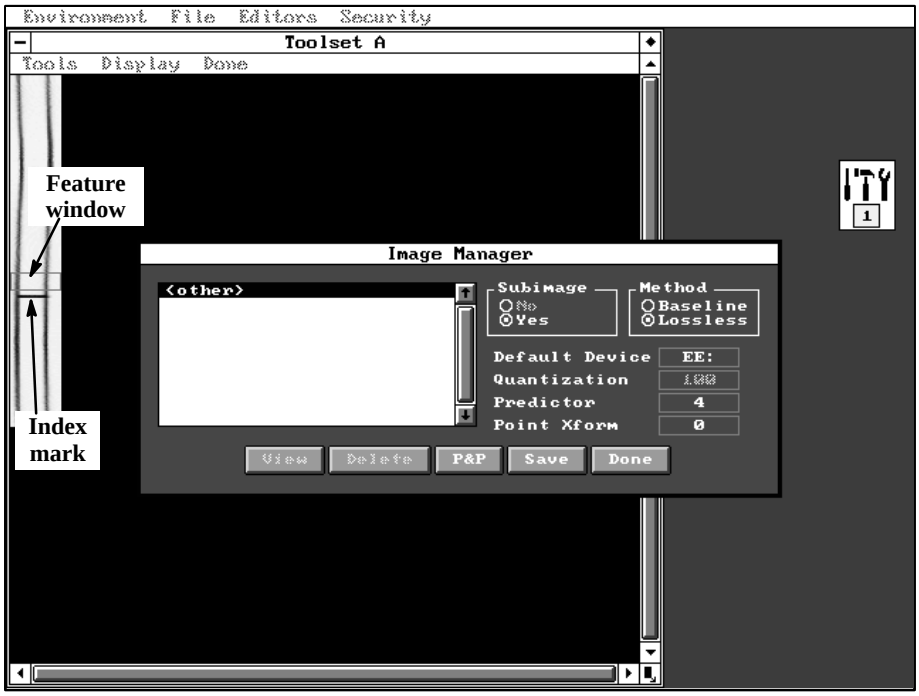
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Figure 6.48 Example: Repositioned Destination Window With Unwrapped Image



When the Image Name field is picked, the Image Manager panel appears on the screen as shown in Figure 6.49. Note that the destination window now contains a small feature window.

Figure 6.49 Example: Destination Window After Picking Image Manager Panel



At this point, the Image Manager panel's functions are used to position the feature window around the "index mark" in the destination window, and then save the resulting feature image in an image file.

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The feature window should be positioned so that it covers the smallest possible region that contains a feature with a distinct pattern (such as an index mark) — one that will not be mistaken for another region of the destination image.

NOTE: The unwrapped image in the destination window represents *more than* 360° of the *original* image. This ensures that the destination image contains a *complete* feature, even when that feature is located near the 0° point.

After the feature window has been properly positioned in the destination window, the feature window's image must be saved under an appropriate file name. The Image Manager panel can then be exited.

When the tool edit panel reappears, the Image Name field contains the file name of the newly created image file (assuming that a different file name was *not* selected), as shown in Figure 6.50. In addition, the Passes field and the two "pass" buttons are now active.

Figure 6.50 Example: Tool Edit Panel After Selecting Image File Name



The rotation finder tool must be configured so that the feature window makes either one or two "passes" through the destination window as it searches for a match to the stored feature image (the "index mark"). In most cases, two passes are more efficient than one pass: The first pass locates the feature *approximately*, after which the second pass locates the feature more precisely, but with a smaller region to search.

The choice of Single Pass or Double Pass depends the details of your application; thus, some trial and observation may be required in order to determine which choice is the most effective and efficient. In all cases, the objective is to optimize the search process for the best combination of speed and accuracy.

The "pass" parameters are configured in the First Pass and Second Pass panels, and these panels are selected by picking the Pass 1 and Pass 2 buttons, respectively.

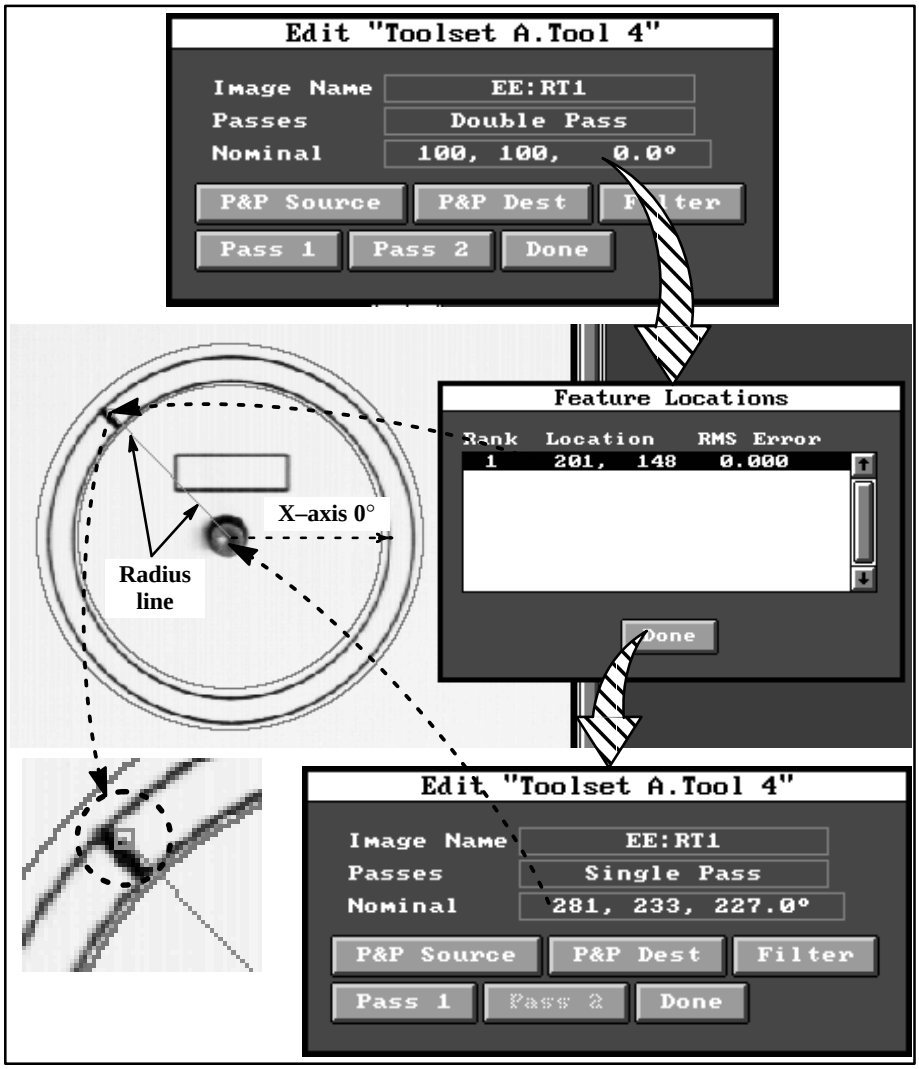
For complete details about the pass parameters and configuration, refer to the *Reference Window Tool* section of this chapter, starting at the *Single Pass vs Double Pass* heading on page 6–34.

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After the pass configuration is complete, a “learn” operation must be performed by picking the Nominal field in the tool edit panel. This establishes the “nominal” coordinates and rotation angle of the rotation finder tool, and thereby *enables* it to be used by other tools as a rotation compensation source.

When the Nominal field is picked, the Feature Locations panel appears first, as shown by Figure 6.51. Note that a radius line extends from the center of the circular object to the index mark.

Figure 6.51 Example: Rotation Finder “Learning” Nominal Values



The values appearing in the Feature Locations panel reflect the X– and Y–axis coordinates of the “head” of the radius line, along with the RMS error, which is the calculated RMS (root mean square) error for the feature (the index mark in this example). For details about RMS error calculations, refer to the *Pixel Error Parameter Selections* section on page 6–43.

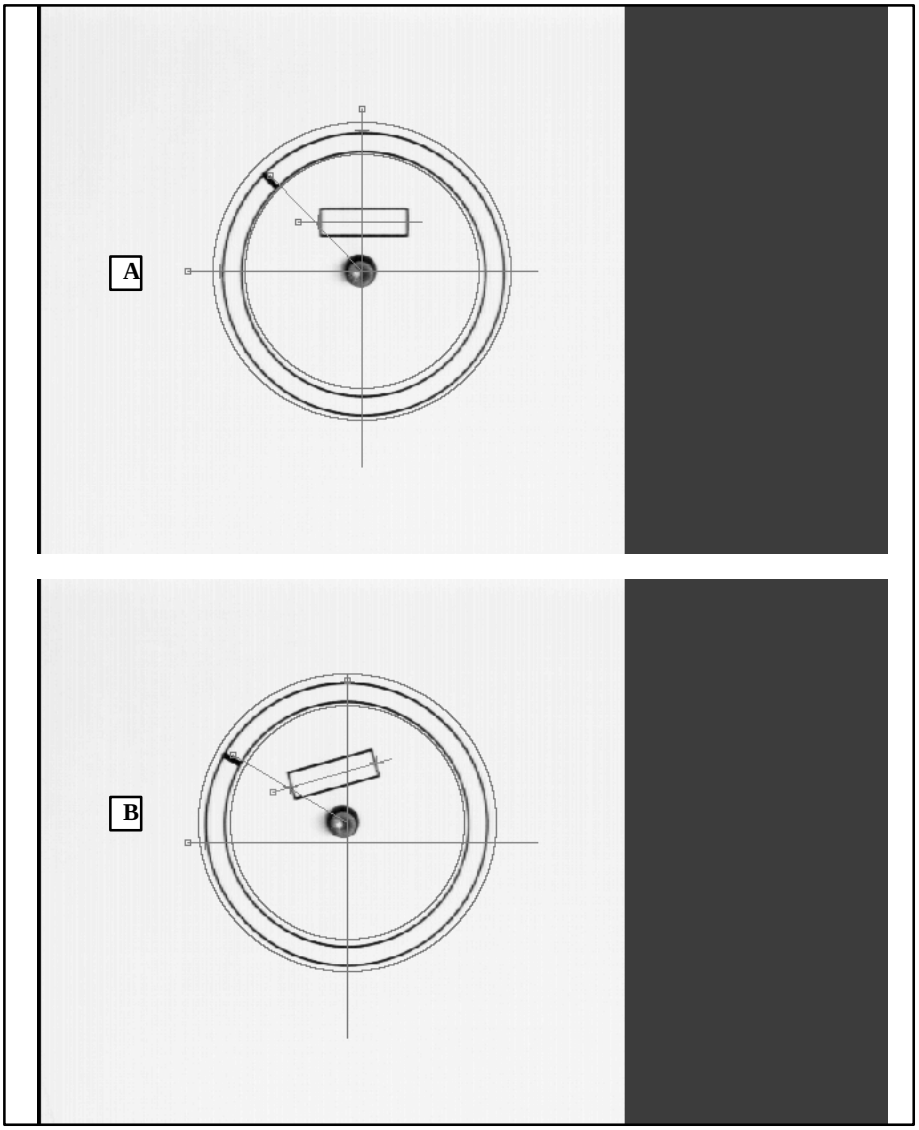
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When the Done button is picked on the Feature Locations panel, the Nominal field in the tool edit panel displays the X– and Y–axis coordinates of the center of rotation (281 and 233), along with the angular position of the index mark (227.0°) relative to the 0° point on the X–axis. (In this example, the index mark is located 227.0° *clockwise* from the 0° point.)

At this point, the rotation finder configuration is complete, and it can be used as a reference for inspection tools that follow it in the toolset edit panel.

Figure 6.52 illustrates the rotation finder tool in operation. In this case, (**A**) shows the circular and rectangular objects in their *original* locations, while (**B**) shows these objects after they have *shifted* and *rotated*. Note that the line gage tool remains properly positioned over the shifted and rotated rectangular object.

Figure 6.52 Example: Rotation Finder Tool in Operation (Setup Mode)

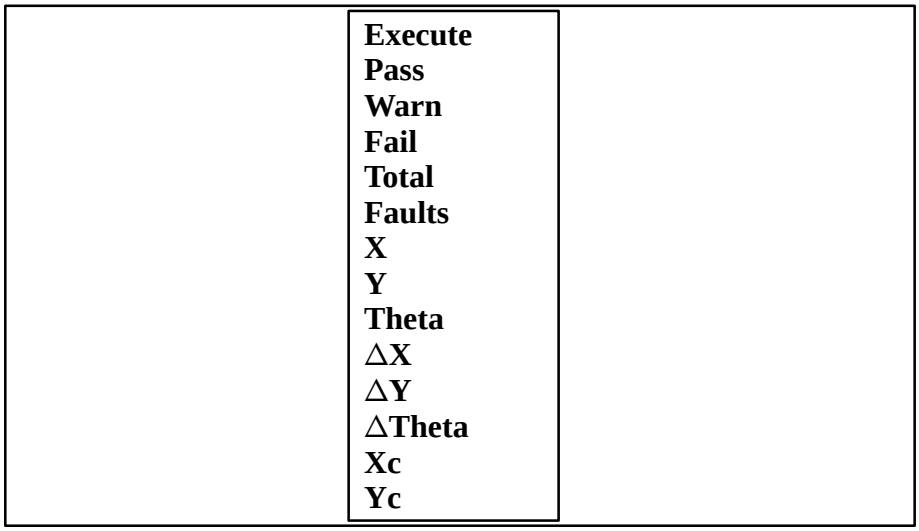


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Rotation Finder Tool Inspection Results and Math Tool Formulas

This section discusses the expanded inspection results that are available to a math tool formula from a rotation finder tool. As Figure 6.53 shows, the expanded inspection results for a rotation finder tool appear in one list.

Figure 6.53 Expanded Results Lists For Rotation Finder Tools in Math Formulas



Here is a brief definition and explanation of each of the expanded result types listed in Figure 6.53.

- **Execute** — This returns a 1.000 when the tool has *executed* its inspection task, and 0.000 for all other conditions.
- **Pass** — This returns a 1.000 when the tool has *passed* its inspection task, and 0.000 for all other conditions.
- **Warn** — For reference tools, Warn always returns 0.000.
- **Fail** — This returns a "error code" when the tool is in a *fail* condition and 0.000 for all other conditions. The error code identifies a specific reason for the failure; for example, error code 1038.000 identifies "One or more features could not be found" as the cause of the inspection failure. The complete list of error codes and fail conditions appears in Appendix A of this manual.
- **Total** — This returns the total number of inspections performed.
- **Faults** — This returns the total number of faults detected.
- **X** — This returns the current X coordinate of the center of rotation.
- **Y** — This returns the current Y coordinate of the center of rotation.
- **Theta** — This returns the current value of the angular position, in degrees, of the index mark relative to the 0° point on the X–axis.

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- **ΔX** — This returns the *change* from the nominal or “learned” X coordinate of the center of rotation.
- **ΔY** — This returns the *change* from the nominal or “learned” Y coordinate of the center of rotation.
- **ΔTheta** — This returns the *change* from the nominal or “learned” value of the angular position, in degrees, of the index mark relative to the 0° point on the X–axis.
- **Xc** — This returns the same value as “**X**”.
- **Yc** — This returns the same value as “**Y**”.

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Build Reference Tool

This section discusses the build reference tool and the shift and rotation compensation that it can provide to other tools.

A *reference line*, *reference window*, or *rotation finder tool* provides shift and/or rotation compensation to other tools that have the *same* X– and Y–axis orientation in the image field as the reference tool (whether or not the images are all from the same camera). It derives the coordinate and angle references values that it uses for its compensation functions *directly*, from its own lines or windows.

A *build reference tool*, however, can "build" a reference tool using results data from other tools (such as gage and window tools), along with other values (such as constants), as the source of its coordinate and angle reference values. In addition, it can use images from different cameras having *different* X– and Y–axis orientations in the image field than the tool(s) to which the position compensation is applied.

A build reference tool uses a series of "formulas" to derive its coordinate and angle reference values. A *separate* formula is used to derive each of these values. Each formula is entered and configured using the same formula entry keyboard that is used with a *math tool*. A build reference tool can be configured to use any of the three references alone, or together in any combination.

In some applications, tool results data derived from formulas can be used *directly* as reference coordinates and/or angles. In other applications, results data must be manipulated mathematically before being used as references.

Once the required formulas are configured, a build reference tool "learns" the initial or "nominal" X–axis, Y–axis, and/or the "theta" angle values, like a conventional reference tool, in order to provide shift and/or rotation compensation to other tools. After "learning" these nominal values, a build reference tool operates exactly like a conventional reference tool; that is, it supplies shift and/or rotation compensation to tools that *follow* it in the toolset edit panel.

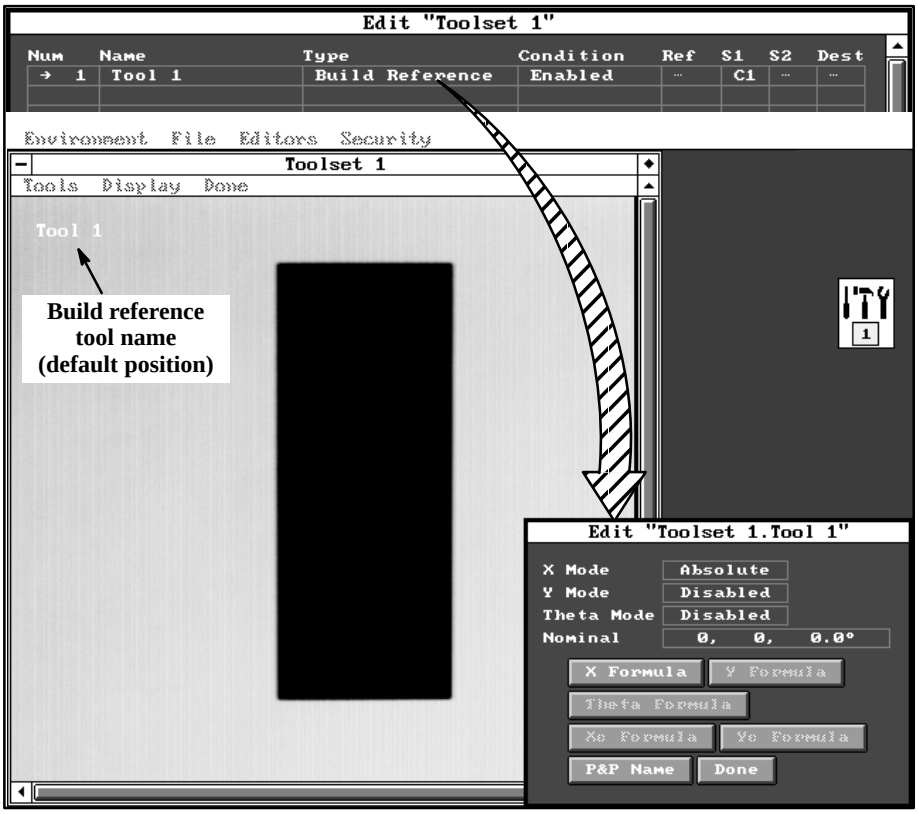
After selecting a build reference tool in a toolset edit panel, you can configure it for an inspection application by picking the Build Reference field in the toolset edit panel. When you pick Build Reference, the build reference tool edit panel appears on the screen, as shown by the example in Figure 6.54 (page 6–65). (Note that the build reference tool *name* also appears, and it is shown in its *default* position on the screen.)

The build reference tool edit panel (named Edit "Toolset 1.Tool 1" in Figure 6.54) contains several data fields and buttons, which are described briefly as follows:

- **X Mode** — This field selects the mode for the X–axis coordinate calculation as Absolute, Delta, or Disabled.
- **Y Mode** — This field selects the mode for the Y–axis coordinate calculation as Absolute, Delta, or Disabled.

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Figure 6.54 Example: Selecting the Build Reference Tool Edit Panel



- **Theta Mode** — This field selects the mode for the theta angle calculation as Absolute, Delta, or Disabled.
- **Nominal** — When you pick this field, the selected and configured build reference tool stores the current position reference data, to be used during inspection to compute the workpiece's offset from the "nominal" position.
- **X Formula** — The X Formula button is active *only* when the X Mode selection is Absolute or Delta. It accesses the formula entry keyboard, which enables you to enter the "formula" that will acquire an X–axis *reference value* for the build reference tool's X–axis shift compensation calculation.
- **Y Formula** — The Y Formula button is active *only* when the Y Mode selection is Absolute or Delta. It accesses the formula entry keyboard, which enables you to enter a "formula" that will acquire a Y–axis *reference value* for the build reference tool's Y–axis shift compensation calculation.
- **Theta Formula** — The Theta Formula button is active *only* when the Theta Mode selection is Absolute or Delta. It accesses the formula entry keyboard, which enables you to enter a "formula" that will acquire a theta angle value for the build reference tool's rotation compensation calculation.

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- **X_c Formula** — The Xc Formula button is active *only* when the Theta Mode selection is Absolute or Delta. It accesses the formula entry keyboard, which enables you to enter a "formula" that will acquire an X–axis coordinate value of the *center of rotation* for the build reference tool's rotation compensation calculation.
- **Y_c Formula** — The Yc Formula button is active *only* when the Theta Mode selection is Absolute or Delta. It accesses the formula entry keyboard, which enables you to enter a "formula" that will acquire an Y–axis coordinate value of the *center of rotation* for the build reference tool's rotation compensation calculation.
- **P&P Name** — The P&P Name button activates the pick and place function for the tool name field in the image field.
- **Done** — When you pick the Done button, the system exits back to the toolset edit panel.

Overview: Build Reference Tool Configuration

A build reference tool can be selected when the toolset edit panel is on the screen. Starting from the *main menu bar*, the selection path to this panel is as follows: **Editors** → **Configuration** → **Setup** → **Tools**. (This selection path is shown by an example in Chapter 7, *Inspection Tools*, Figure 7.2 on page 7–3.)

Here is a summary list of the *basic* build reference selection and configuration steps, listed in their normal order of performance:

1. Select build reference tool.
2. Configure formula for X–axis coordinate, if appropriate.
3. Configure formula for Y–axis coordinate, if appropriate.
4. Configure formula for theta angle coordinate, if appropriate.
5. Configure formula for X_c–axis coordinate, if appropriate.
6. Configure formula for Y_c–axis coordinate, if appropriate.
7. "Pick and place" tool name field, if appropriate.
8. Learn nominal value(s), if appropriate.

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Examples: Build Reference Tool Configuration and Operation

This section provides a few simple examples whose purpose is to:

- Identify the basic steps in the process of configuring a build reference tool.
- Indicate the concepts employed by the build reference tool.
- Illustrate the build reference tool's operating modes (X Mode, Y Mode, and Theta Mode).

A build reference can be configured to calculate shift and/or rotation compensation using either *absolute* position values or *delta* (relative) position values. The difference is described as follows:

- *Absolute* —Using the *absolute* method, the build reference tool uses stored ("learned") position values (which are based on the *absolute* X–axis, Y–axis, and theta values in the image) as the basis for providing shift and/or rotation compensation. This is the method used by the reference line and reference window tools.

  First, the tool calculates the *difference* between a *stored* absolute value of a *specific reference* (coordinate or angle) and the *current* absolute value of the same *reference* (that is, its value obtained from the *current* inspection cycle). Then, it applies the *difference* value to all referenced tools and repositions them from their *original* ("learned") positions by the amount of the calculated *difference* value.
- *Delta* — Using the *delta* method, the build reference tool does *not* store ("learned") position values as the basis for providing shift and/or rotation compensation. Instead, the tool calculates position compensation *only* on the basis of values entered in the formula(s), and uses the formula results values to shift and/or rotate all referenced tools from their *current* positions in accordance with those results values.

Note that these examples are *not* intended to show you how to configure the build reference tool for your application or for any *specific* application.

Example: X Mode Operation

This example uses a window tool (Tool 1) to supply X–coordinate data to a build reference tool (Tool 2), which, in turn, supplies "X–only" shift compensation to two gage tools (Tool 3 and Tool 4). (Although the example is set up for X Mode operation, the same principles apply to the Y Mode operation.)

Figure 6.55 (page 6–68) shows how the four tools are arranged in the toolset edit panel. Their *order* in the panel, from top to bottom, determines the order in which they are processed.

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Figure 6.55 Example: Relation Between Window, Build Reference, and Gage Tools in Toolset Edit Panel

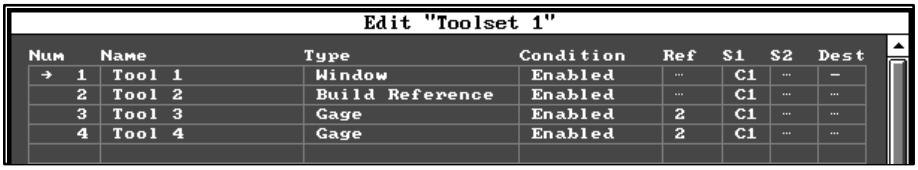
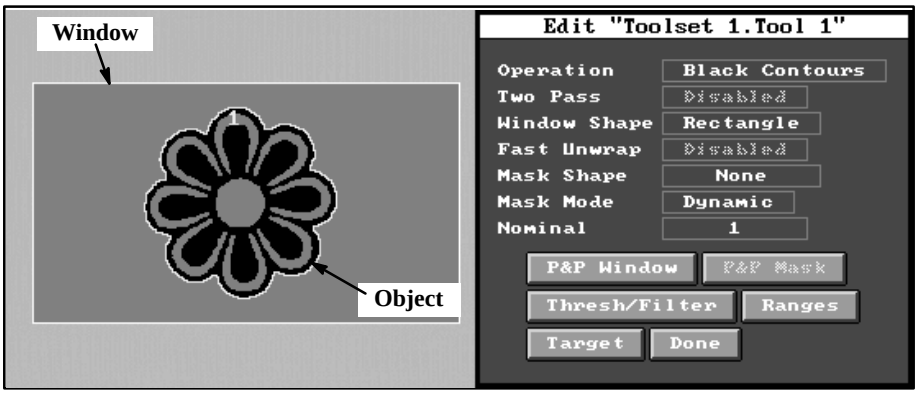


Figure 6.55 also indicates the *relation* between the four tools: The window tool must be processed *first* in order to supply data to the build reference tool; the build reference tool must be processed *second* in order to supply "X–only" shift compensation to the gage tools; and the gage tools must be processed *last* because they require the results from the preceding two tools.

In this example, the window tool is positioned over the object as shown in Figure 6.56, and it is configured for the Black Contours operation. The window tool's horizontal size, and its initial position over the object, are determined by the expected extent and direction of the object's shift along the X–axis. (Since no *vertical* shift is expected in this example, the window tool's vertical size can be minimized.)

Figure 6.56 Example: Window Tool Positioned Over Object



The "X Center" *measurement function* is selected for the window tool's Black Contours operation. This function calculates the X–axis coordinate of the *center* of an object, and the resulting value will be supplied to the build reference tool for use in its "X–only" reference operation.

Initially, the build reference tool edit panel appears as it is shown in Figure 6.57 (page 6–69). Note that "Absolute" appears in the X Mode field, while the other mode fields are *disabled*. These are the *default* selections for this tool edit panel. (The effects of using the "Absolute" and "Delta" methods of calculating shift and/or rotation compensation are discussed later.)

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Figure 6.57 Initial Appearance of Build Reference Tool Edit Panel



Note also that the X Formula button is *active* (unshaded). This button is used, in this example, to configure a formula that will acquire the "X Center" coordinate value from the appropriate object in the window tool. (The other "formula" buttons are *inactive* at this time because the corresponding "mode" selections are "Disabled.")

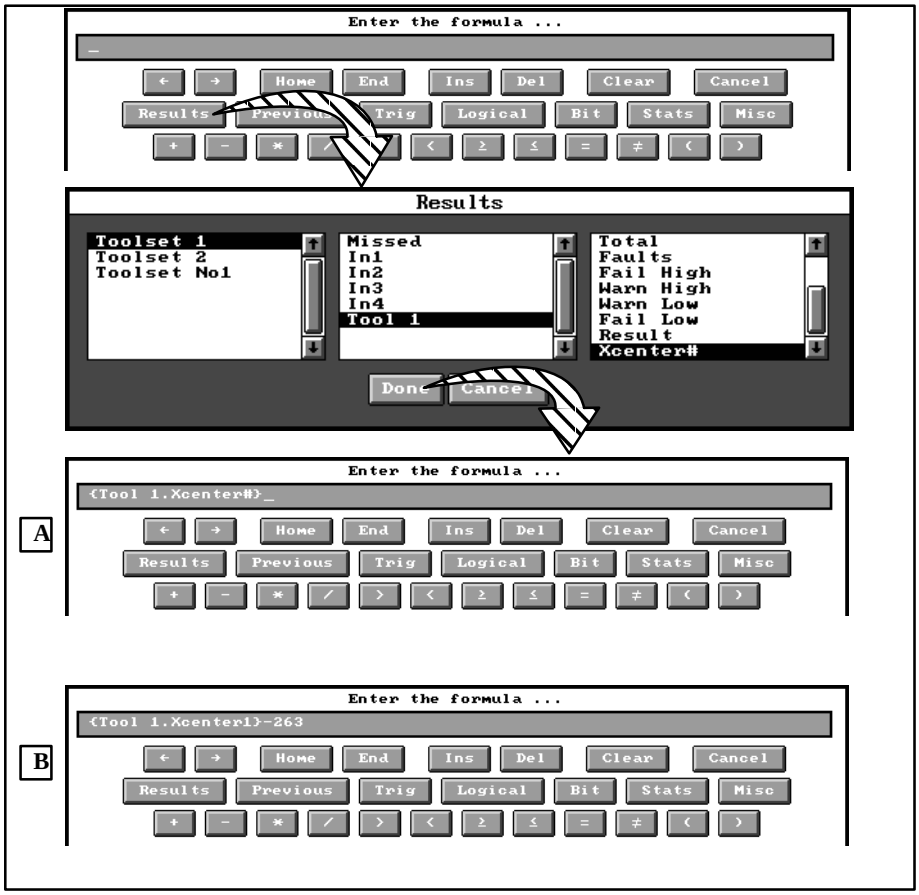
When you pick the X Formula button, the formula entry keyboard appears, the upper portion of which is shown in Figure 6.58 (page 6–70). For this example, a formula is entered that will acquire the window tool's *current* "X Center" coordinate value for an object. (Note that an object *number* is not specified in the formula; thus, the "#" sign in the formula must be replaced with the number of the object whose "X Center" value is to be acquired. In this case, the "#" sign must be replaced with the number "1.")

In Figure 6.58 (**A**), the formula applies to the "Absolute" method; that is, it only acquires the current X Center coordinate value from the window tool.

In Figure 6.58 (**B**) the formula applies to the "Delta" method. It *also* acquires the current X Center coordinate value from the window tool, but it then subtracts from that value a *constant* value (which, in this case, represents an *initial* value of X Center).

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Figure 6.58 Example: Entering X Mode Formula for Absolute and Delta Methods



When you pick the Enter key on the formula entry keyboard, the formula is saved, and the build reference tool edit panel reappears, as shown in Figure 6.59 (**A**) (page 6–71).

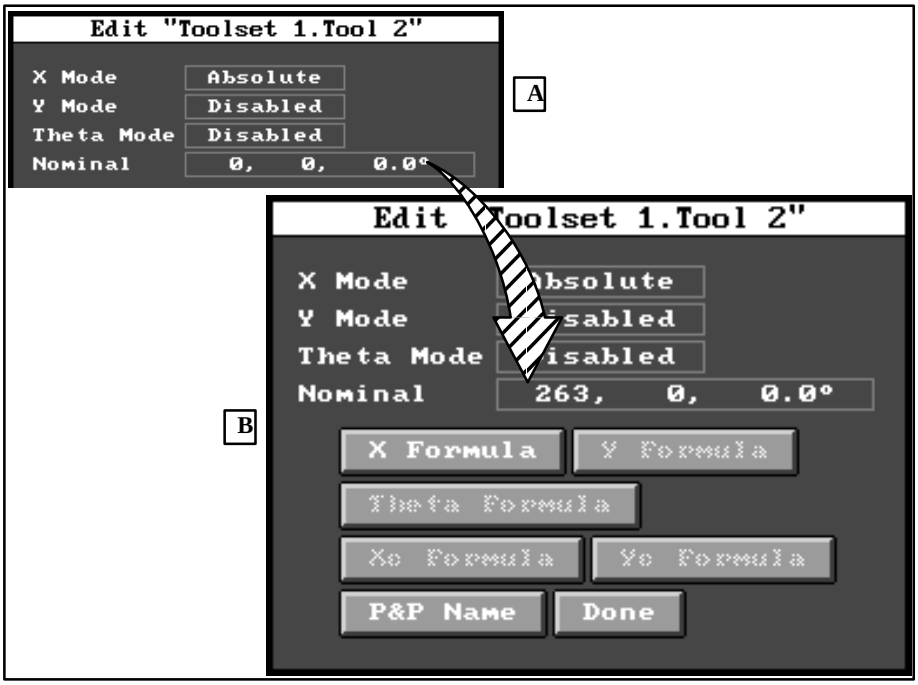
For the "Absolute" method, when you then pick the Nominal field, the build reference tool uses the formula to acquire and "learn" the window tool's "X Center" coordinate value, and that value (263) appears as the X–axis value in the Nominal field, as shown in Figure 6.59 (**B**). (Note that because the Y and theta modes are *disabled* in this example, their values in the Nominal field remain 0.)

For the "Delta" method, which does *not* use a stored ("learned") reference value, picking the Nominal field will "exercise" the formula and return a result, but it is not necessary to pick this field for the build reference tool to operate properly.

At this point, the configuration process is *completed* for the build reference tool in this example. The build reference tool is now ready to supply "X Center" shift compensation to the two gage tools.

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Figure 6.59 Example: "Learning" Nominal Values for Build Reference Tool



The difference in the operation of the build reference tool when using the absolute and delta calculation methods is illustrated as follows:

Absolute — During each inspection cycle, the build reference tool uses the formula to acquire the *current* absolute X Center coordinate value from the window tool. It then *subtracts* the *stored* ("learned") coordinate value (263 pixels in this example) from the *current* coordinate value and uses the *difference* value to shift the gage tools as follows: A *positive* difference value will shift both gage tools to the *right*, while a *negative* difference value will shift the tools to the *left*.

For instance, if the object (see Figure 6.56, page 6–68) shifts *right*, and the window tool returns a current X center coordinate value of 283, the build reference tool will subtract 263 from 283, yielding a difference of +20. This is the number of pixels that the gage tools will be shifted to the *right*.

Delta — During each inspection cycle, the build reference tool uses the formula to acquire the *current* absolute X Center coordinate value from the window tool. It then *subtracts* from that value the *constant* in the formula (263, for example) and uses the calculated *difference* value to shift the gage tools as follows: A *positive* difference value will shift both gage tools to the *right*, while a *negative* difference value will shift the tools to the *left*.

For instance, if the object (see Figure 6.56) shifts *left*, and the window tool returns a current X center coordinate value of 243, the build reference tool will subtract 263 (the constant) from 243, yielding a difference of –20. This is the number of pixels that the gage tools will be shifted to the *left*.

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Example: Theta Operation

This section provides a simple example that illustrates a theta operation using the "Absolute" method of operation. In this example, a build reference tool is configured to provide only *rotation* compensation to a pair of gage tools.

Specifically, this example uses a window tool (Tool 1), configured for the Black Contours operation, to supply theta angle and centroid coordinate values to a build reference tool (Tool 2). Tool 2 then applies these values as *rotation* compensation to each of two gage tools (Tool 3, Tool 4), whose function is to measure the height and width of the object. For the purposes of this example, the object is assumed to *rotate* in the image field.

Figure 6.60 shows how these four tools are arranged in the toolset edit panel. Their *order* in the panel, from top to bottom, determines the order in which they are processed.

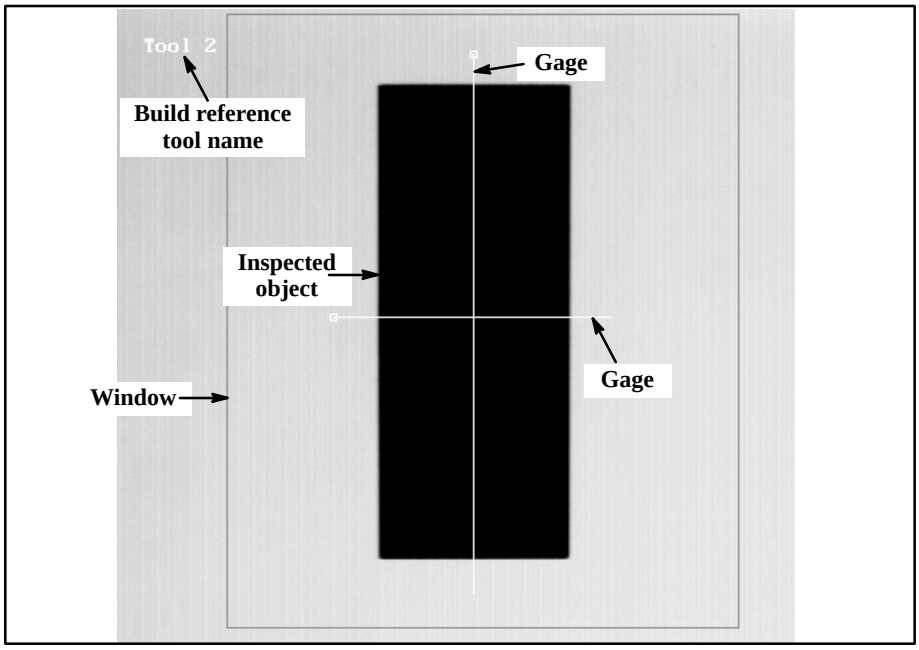
Figure 6.60 Example: Relation Between Window, Build Reference, and Gage Tools in Toolset Edit Panel

Edit "Toolset 1"

Num	Name	Type	Condition	Ref	S1	S2	Dest
1	Tool 1	Window	Enabled	…	C1	…	–
2	Tool 2	Build Reference	Enabled	…	C1	…	…
3	Tool 3	Gage	Enabled	2	C1	…	…
→ 4	Tool 4	Gage	Enabled	2	C1	…	…

Figure 6.61 shows the window tool in this example positioned over a dark rectangular object. The two gage tools are positioned vertically and horizontally across the object.

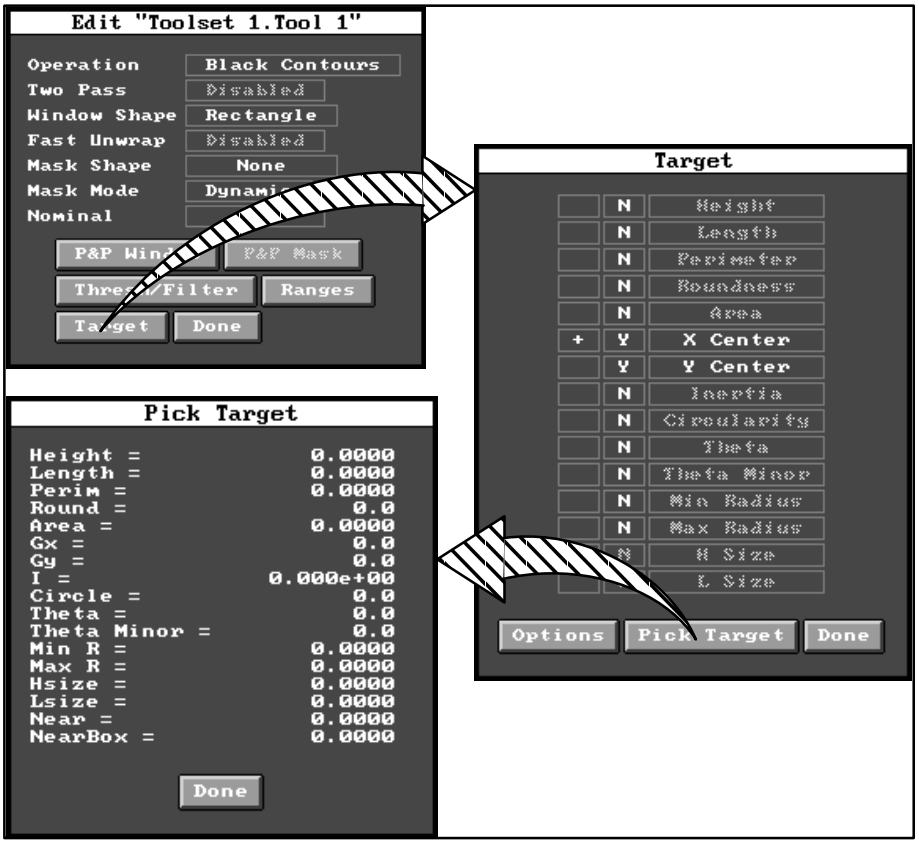
Figure 6.61 Example: Setup of Window and Gage Tools



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The window tool, using the Black Contours operation, is further configured to supply the X–axis and Y–axis coordinates of the object's centroid, and theta, which is the angle between the object's major axis and the X–axis of the image field. These values result from the X Center, Y Center, and Theta parameters selected in the Target panel, as shown in Figure 6.62, and are the *reference* values that the build reference formula will "learn" and use during operation.

Figure 6.62 Example: Selecting Contour Parameters for Use in Build Reference Tool



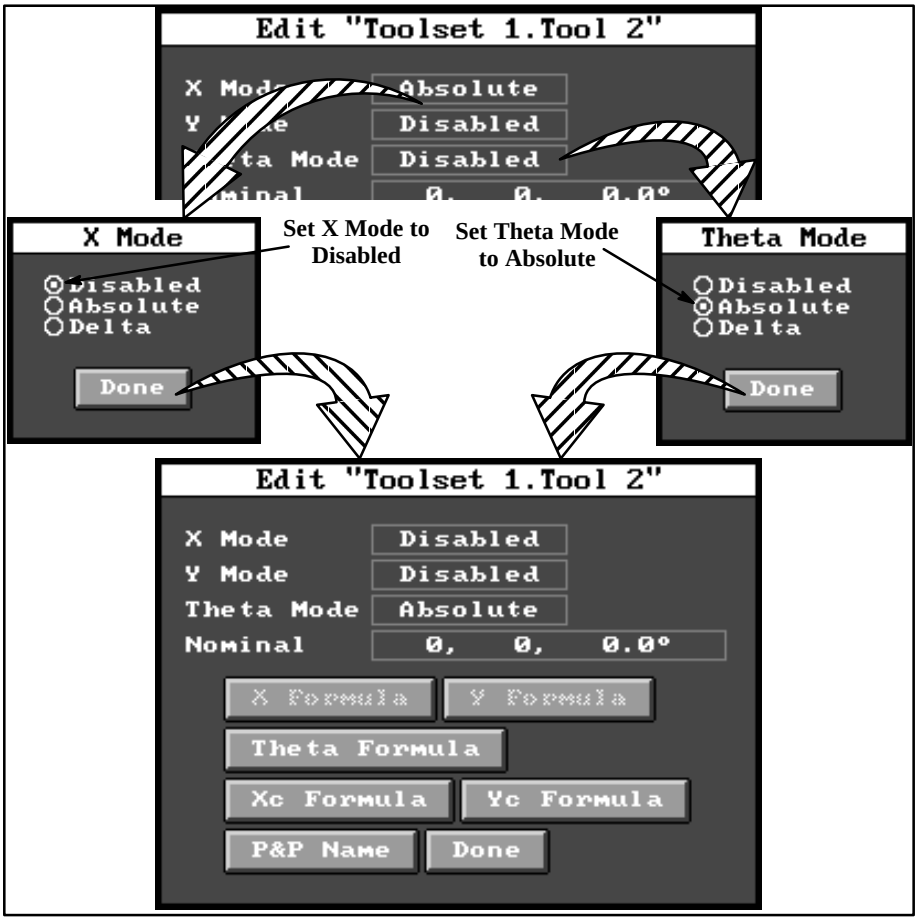
During operation, the task for the build reference tool in this example is to calculate the difference, if any, between the "learned" theta angle and the theta angle of the *current* inspected object, and to apply that angular *difference* as rotation compensation to the two gage tools.

Initially, the build reference tool edit panel appears as it is shown in Figure 6.57 (page 6–69). Note that "Absolute" is selected in the X Mode field, while the other mode fields are *disabled*. These are the *default* selections for this tool edit panel.

Since the theta mode *only* is used in this example, the X Mode field must be set to "Disabled" and the theta mode *enabled* by selecting "Absolute" in the Theta Mode selection panel. Figure 6.63 (page 6–74) illustrates the general method for making these selections.

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Figure 6.63 Disabling X Mode, Enabling Theta Mode

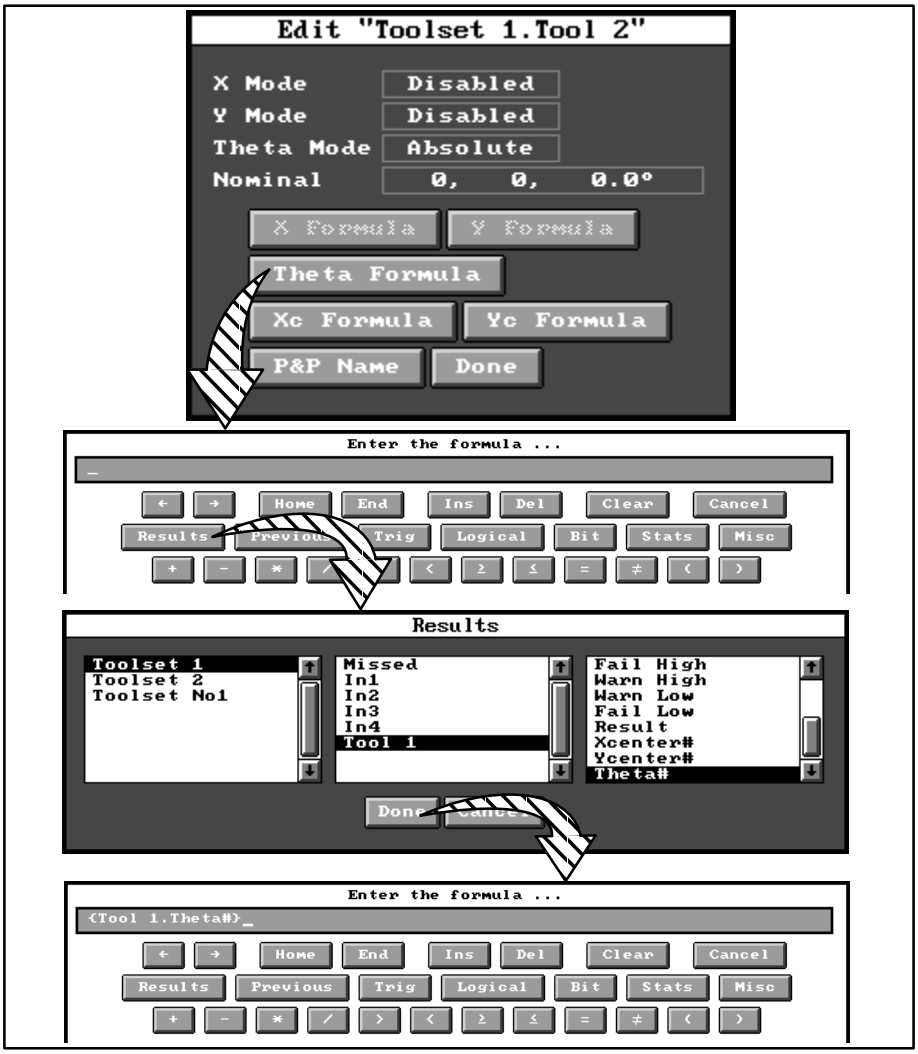


After the appropriate mode selections have been made, when the tool edit panel reappears, "Disabled" will appear in the X Mode field, and "Absolute"will appear in the Theta Mode field, as shown in Figure 6.63. In addition, the X Formula button will be *inactive* (shaded), while the Theta Formula, Xc Formula, and Yc Formula buttons will be *active*.

When you pick the Theta Formula button, the formula entry keyboard appears, the upper portion of which is shown in Figure 6.64 (page 6–75). For this theta mode example, a theta formula is needed that will acquire the theta angle of the object from the window tool. This formula is entered into the keyboard as shown in Figure 6.64.

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Figure 6.64 Example: Entering Theta Formula in Keyboard



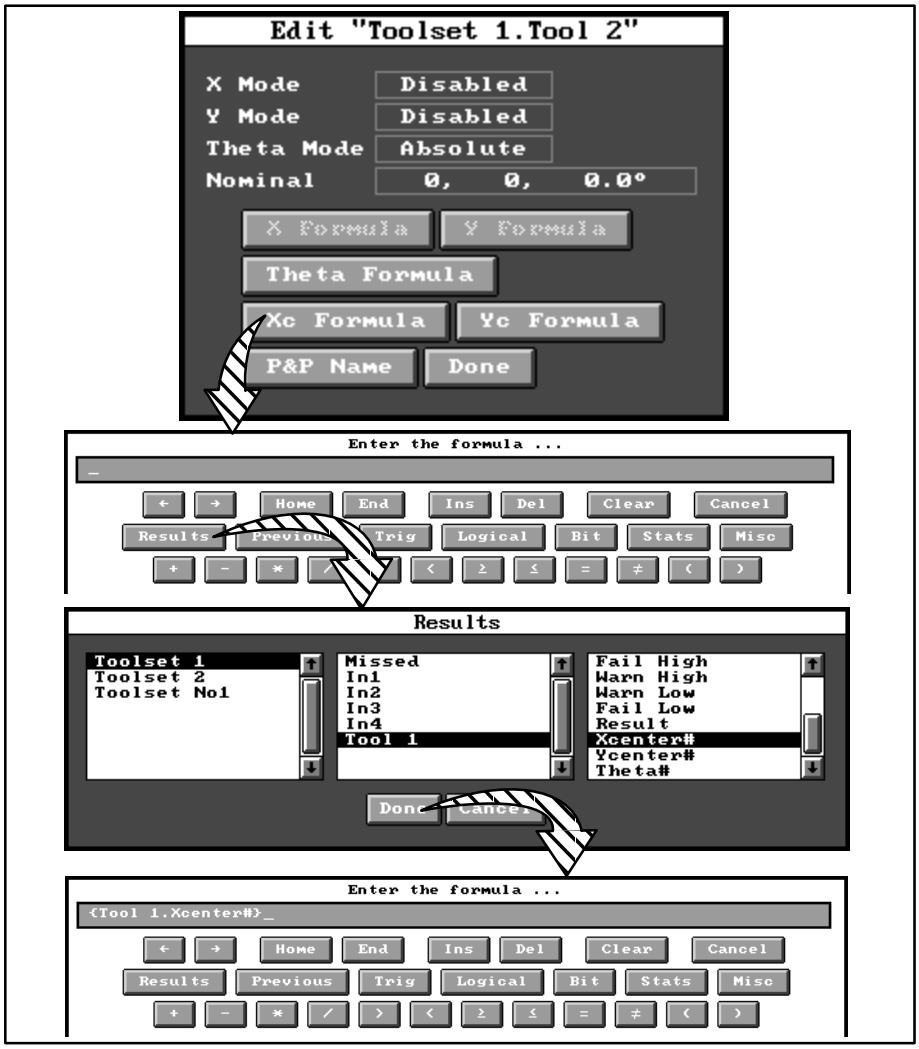
NOTE: The formula is "{Tool 1.Theta#}." The "#" sign must be *replaced* with the *contour number*, which, in this example, is "1." Thus, the formula must be amended to "{Tool 1.Theta1}," and the formula will then return the theta angle of contour #1 in the window tool (the dark object).

A theta operation requires also that the "center of rotation" data be acquired. This is accomplished using the Xc Formula and Yc Formula buttons, as illustrated by Figure 6.65 (page 6–76).

When you pick the Xc Formula button, the formula entry keyboard appears, the upper portion of which is shown in Figure 6.65. For this theta mode example, an X_C formula is needed that will acquire the X–axis coordinate of the object's centroid from the window tool. This formula is entered into the keyboard as shown in Figure 6.65.

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Figure 6.65 Example: Entering X_C Centroid Coordinate Formula in Keyboard



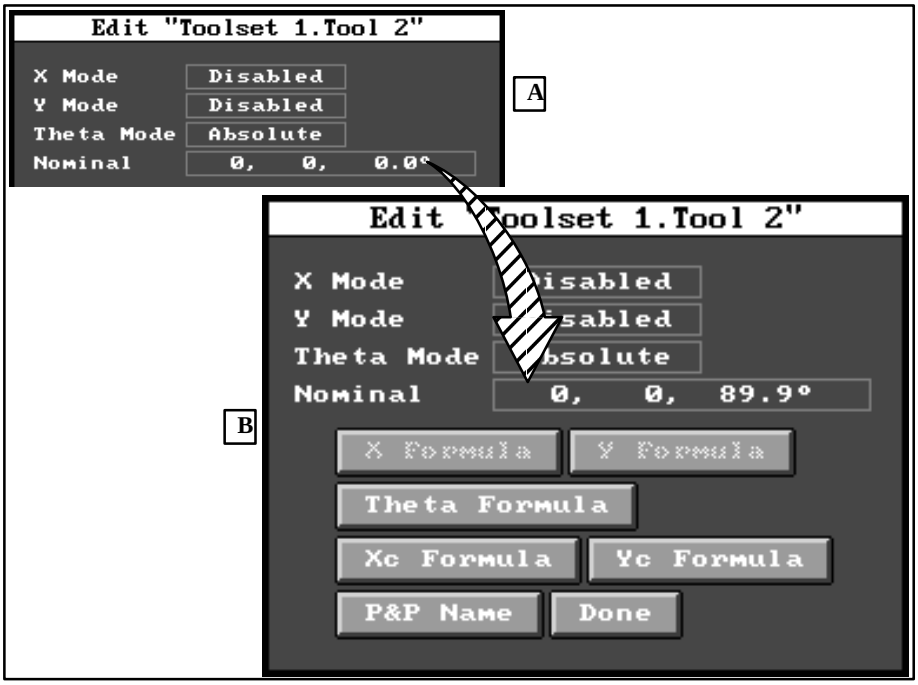
NOTE: The formula is "{Tool 1.Xcenter#}." The "#" sign must be *replaced* with the *contour number*, which, in this example, is "1." Thus, the formula must be amended to "{Tool 1.Xcenter1}," and the formula will then return the X–axis coordinate of the centroid for contour #1 in the window tool (the dark object).

The formula entry process illustrated in Figure 6.65 can be *repeated* to set up a Y_C formula that will acquire the Y–axis coordinate data.

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When all three formulas are entered and saved, and the build reference tool edit panel reappears, when you then pick the Nominal field, as shown in Figure 6.66, the build reference tool uses the three formulas to “learn” the window tool’s theta angle, and that angle (89.9°) appears in the Nominal field, as shown in (**B**). (Note that because the X and Y modes are *disabled* in this example, their values in the Nominal field remain 0.)

Figure 6.66 Example: “Learning” Nominal Values for Build Reference Tool



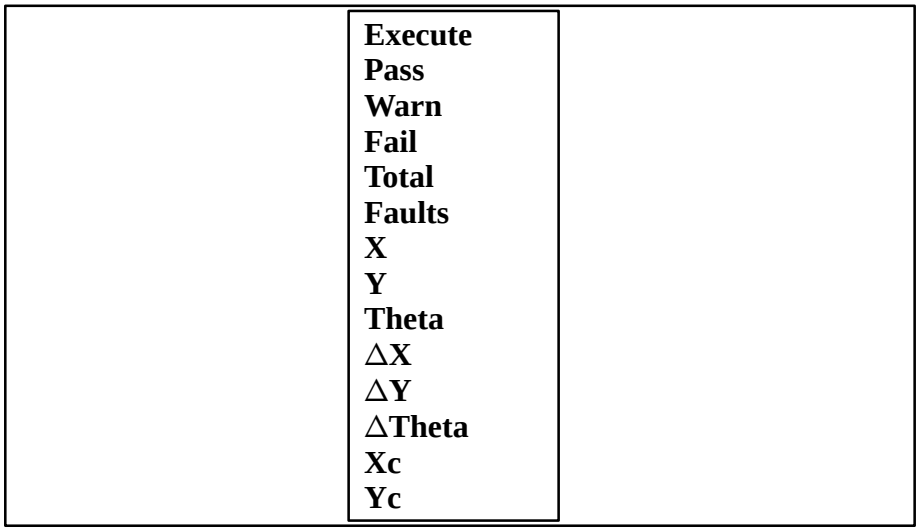
At this point, the configuration process is *completed* for the build reference tool in this example. The build reference tool is now ready to supply rotation compensation to the two gage tools.

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Build Reference Tool Inspection Results and Math Tool Formulas

This section discusses the expanded inspection results that are available to a math tool formula from a build reference tool. As Figure 6.67 shows, the expanded inspection results for a build reference tool appear in one list.

Figure 6.67 Expanded Results Lists For Build Reference Tools in Math Formulas



Here is a brief definition and explanation of each of the expanded result types listed in Figure 6.67 (page 6–78).

- **Execute** — This returns a 1.000 when the tool has *executed* its inspection task, and 0.000 for all other conditions.
- **Pass** — This returns a 1.000 when the tool has *passed* its inspection task, and 0.000 for all other conditions.
- **Warn** — For reference tools, Warn always returns 0.000.
- **Fail** — This returns a "error code" when the tool is in a *fail* condition and 0.000 for all other conditions. The error code identifies a specific reason for the failure; for example, error code 1049.000 identifies "Could not access result" as the cause of the inspection failure. The complete list of error codes and fail conditions appears in Appendix A of this manual.
- **Total** — This returns the total number of inspections performed.
- **Faults** — This returns the total number of faults detected.
- **X** — This returns the current value of the X result from the X Formula in the build reference tool. (It is 0.000 if the X Mode is Enabled, but has no usable X Formula, or it is Disabled.)
- **Y** — This returns the current value of the Y result from the Y Formula in the build reference tool. (It is 0.000 if the Y Mode is Enabled, but has no usable Y Formula, or it is Disabled.)

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- **Theta** — This returns the current value of the theta result, in degrees, from the Theta Formula in the build reference tool. It is 0.000 in the following situations:
  - — The Theta Mode is Disabled.
  - — The Theta Mode is Enabled, but the Theta Formula, X_c Formula, or Y_c Formula is *unusable* for any reason.
- **ΔX** — This returns the *change* from the nominal or "learned" X value.
- **ΔY** — This returns the *change* from the nominal or "learned" Y value.
- **ΔTheta** — This returns the *change* from the nominal or "learned" Theta value, in degrees.
- **Xc** — This returns the current value of the X result from the X_c Formula in the build reference tool. It is 0.000 in the following situations:
  - — The Theta Mode is Disabled.
  - — The Theta Mode is Enabled, but the Theta Formula, X_c Formula, or Y_c Formula is *unusable* for any reason.
- **Yc** — This returns the current value of the Y result from the Y_c Formula in the build reference tool. It is 0.000 in the following situations:
  - — The Theta Mode is Disabled.
  - — The Theta Mode is Enabled, but the Theta Formula, X_c Formula, or Y_c Formula is *unusable* for any reason.

Tool Register Function

From time to time you may need to *readjust* inspection tools in an existing configuration file and/or add *new* tools to the file. A problem could occur if you were unable to position the workpiece image to *exactly* the same place in the image field that it occupied when you originally configured the tools. If not, you would probably need to reconfigure *all* of the tools in the toolset — a process that could be quite time consuming.

However, if these tools were already "referenced" to reference tools in the original configuration, you could use the *tool register function* to move the new workpiece image to the same position in the image field as the *original* workpiece image.

The *tool register function* shifts and/or rotates the entire camera image as needed in order to move the *new workpiece image* to the same position that the *original workpiece image* occupied within the image field, thereby enabling you to adjust or reposition any of the existing inspection tools and/or add new tools.

Then, when you return to setup or online operations, *all* of the inspection tools will be *properly registered to the new workpiece image*.

Refer to Chapter 4, *Inspection Configuration*, on page 4–35 for a detailed example of the tool register function.

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Chapter 7

Inspection Tools

This chapter provides detailed information about all CVIM2 inspection tools (except reference tools), including all configuration considerations that are unique to the individual tools. Reference tools are discussed in Chapter 6, *Reference Tools*.

For information about picking and placing inspection tools, see Chapter 5, *Pick and Place Functions*. For information about inspection tool threshold settings, filter selections, and morphology, see Chapter 8, *Threshold, Filters, and Morphology.*

The inspection tools include the following types:

- Gage tool: line, arc, and circle.
- Window tool: rectangle, circle, ellipse, arc ring, and polygon.
- Image tool: rectangle, quad, perspective, and arc ring.
- Profile tool: rectangle only.
- Multiple gage tool: line only.
- Multiple window tool: rectangle only.

Overview: Inspection Tool Selection Process

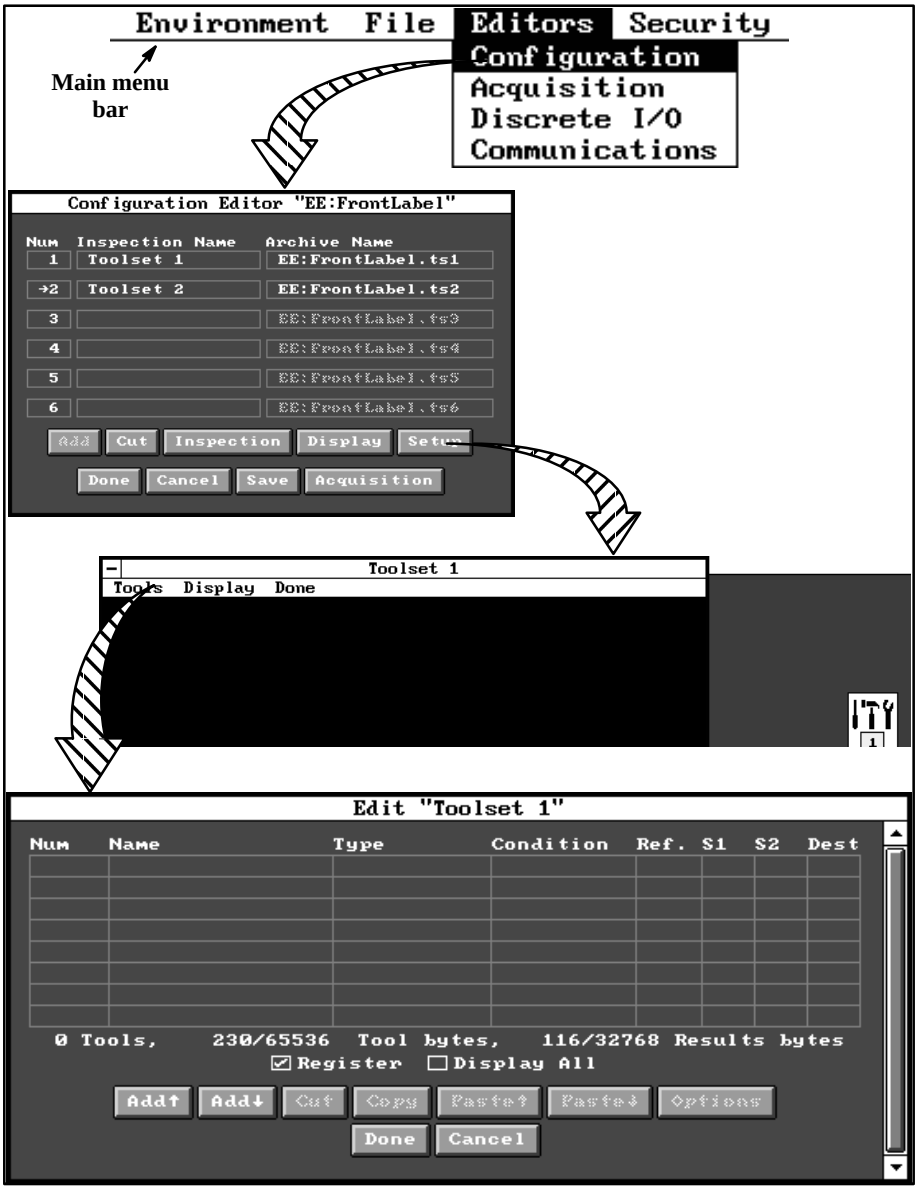
An inspection tool can be selected when the toolset edit panel is on the screen. This selection path is illustrated by the example in Figure 7.1 (page 7–2).

Note that the toolset edit panel in Figure 7.1 (named "Toolset 1 Edit") contains *no* inspection tools initially.

To *add* an inspection tool to the toolset, pick the Add↓ (or Add↑) button, as illustrated by the example in Figure 7.2 (page 7–3). When the Tool Types panel appears, highlight the appropriate tool type (such as Gage), then pick the Done button. The inspection tool ("Gage," in this example) will then appear under the "Type" heading in the toolset edit panel.

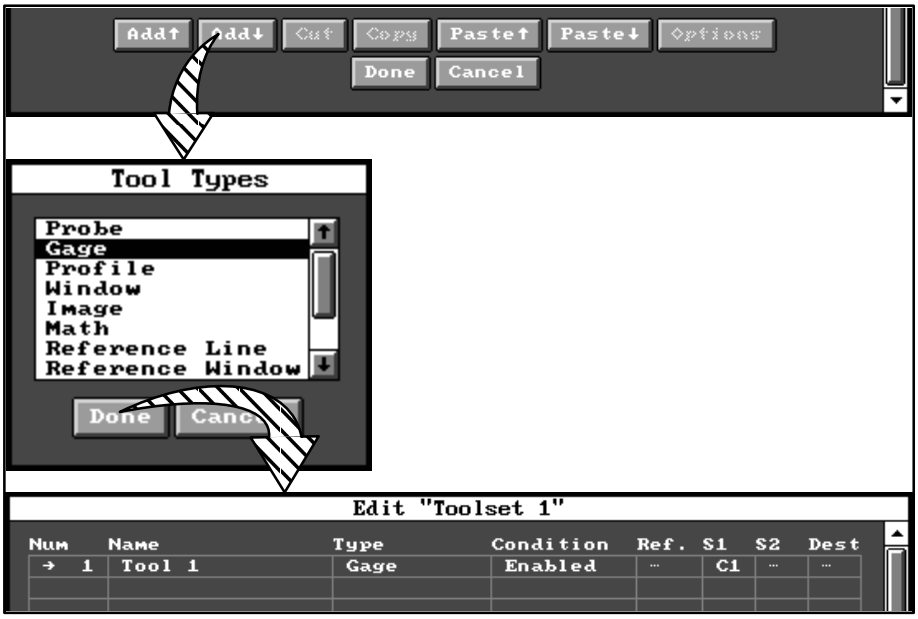
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Figure 7.1 Example: Selection Path for the Toolset Edit Panel



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Figure 7.2 Example: Adding an Inspection Tool



Gage Tool

This section discusses line gage shapes, gaging modes, and the inspection functions (“operations”) that the line gages can perform.

Once you have selected a gage as outlined in the *Overview: Inspection Tool Selection Process* section (page 7–1), you can configure it for an inspection application by picking the Gage field in the toolset edit panel. When you do, the gage tool edit panel appears, as shown by the example in Figure 7.3 (page 7–4).

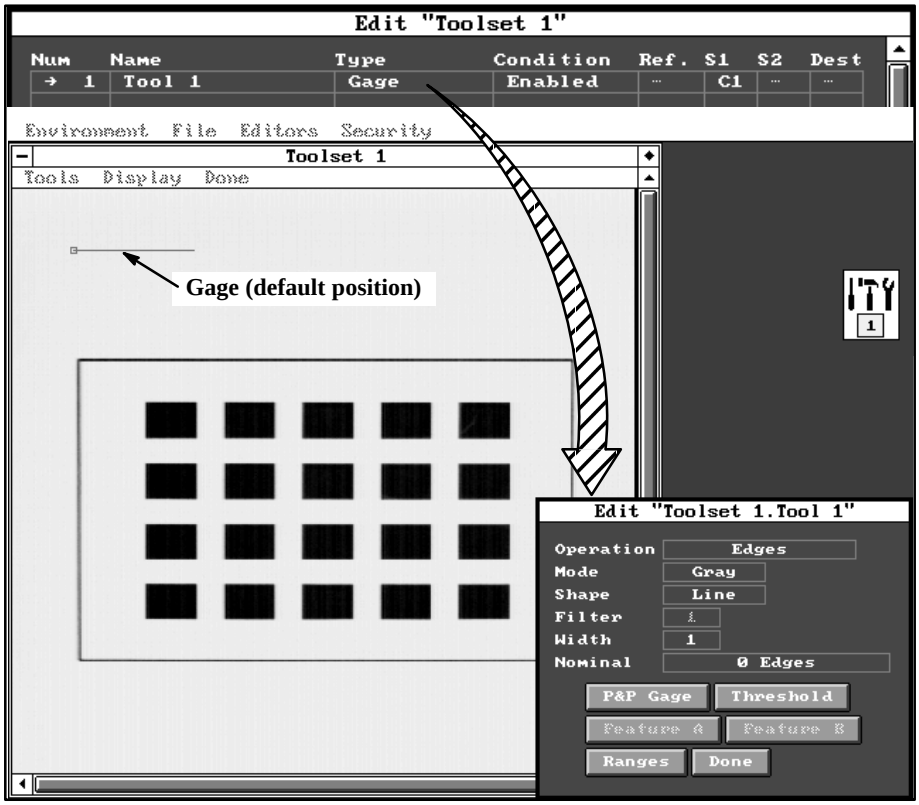
Note that in Figure 7.3 the gage is shown in its *default* shape (line) and position on the screen.

The gage tool edit panel (named Edit “Toolset 1.Tool 1” in Figure 7.3) contains several data fields and buttons, which are described briefly as follows:

- **Operation** — This field provides access to the selection of one of the gage “operations.” The *default* gage operation is Edges — an edge–counting operation.
- **Mode** — When you pick this field, the currently selected gaging mode toggles to the other gaging mode. Thus, Binary toggles to Gray, and vice versa. The *default* gaging mode is Gray.
- **Shape** — This field provides access to the selection of the gage shape, which is Line, for a straight linear gage, or Arc, for a partially circular gage, or Circle, for a fully circular gage. The *default* shape is Line.

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Figure 7.3 Example: Selecting the Gage Edit Panel



- **Filter** — This field provides access to the selection of the gage filter function, which can remove small pixel groups that are considered "noise" in an inspection application. The *default* setting is 1. For details about this function, see Chapter 8, *Thresholds, Filters, and Morphology.*
- **Width** — This field provides access to the selection of the gage width. The *default* setting is 1.
- **Nominal** — When you pick this field, the currently selected and configured gage performs a *test* operation, and the resulting inspection results data appear in this field. The type of results data depends on the selected gage operation. The *initial* value is 0.
- **P&P Gage** — The P&P Gage button activates the gage pick and place function. For details about this function, see Chapter 5, *Pick and Place Functions*.
- **Threshold** — The Threshold button accesses the threshold cursors. For details about this function, see Chapter 8, *Thresholds, Filters, and Morphology.*

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- **Feature A, Feature B** — The Feature buttons accesses the “feature,” or edge selection panels for the respective features. This function is accessible only for certain gage operations.
- **Ranges** — The Ranges button accesses the range–selection panel, which defines limits for gage inspection results.
- **Done** — When you pick the Done button, the system exits back to the toolset edit panel.

Overview: Gage Configuration

A gage can be selected when the toolset edit panel is on the screen. Starting from the main menu bar, the selection path to this panel is as follows: **Editors** → **Configuration** → **Setup** → **Tools**. This selection path is shown by the example in Figure 7.1 (page 7–2).

Here is a summary list of the basic gage selection and configuration steps, listed in their normal order of performance. These steps are common to all gage operations (except as noted):

1. Select gage operation.
2. Select the gage shape.
3. Select gaging mode.
4. “Pick and place” the gage.
5. Adjust edge detection parameters.
6. Select the width, filter, and threshold.
7. Learn nominal value.
8. Select ranges.

Gage Shape

Each of the gages can be configured as a line gage, an arc gage, or a circle gage, according to the requirements of your application.

When configuring a gage, the gage shape should be your *first* selection.

- **Line gage** — A line gage is defined by two points. You can place it anywhere within the image and set it to any length and any angle.
- **Arc gage** — An arc gage is defined by a center point, a radius, a starting angle, and an ending angle. You can place it anywhere within the image and set it to any radius and any degree of arc.
- **Circle gage** — A circle gage is defined by a center point and a radius. You can place it anywhere within the image and set it to any radius.

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Gaging Mode

Each of the gages can be configured to operate in *either* the binary gaging mode or the gray scale gaging mode, according to the requirements of the application.

- **Binary mode** — The binary gaging mode uses binarization thresholds to display pixels in two states, white and black. The only pixels displayed in binary are those that directly surround the gage in a field called the "area of interest."

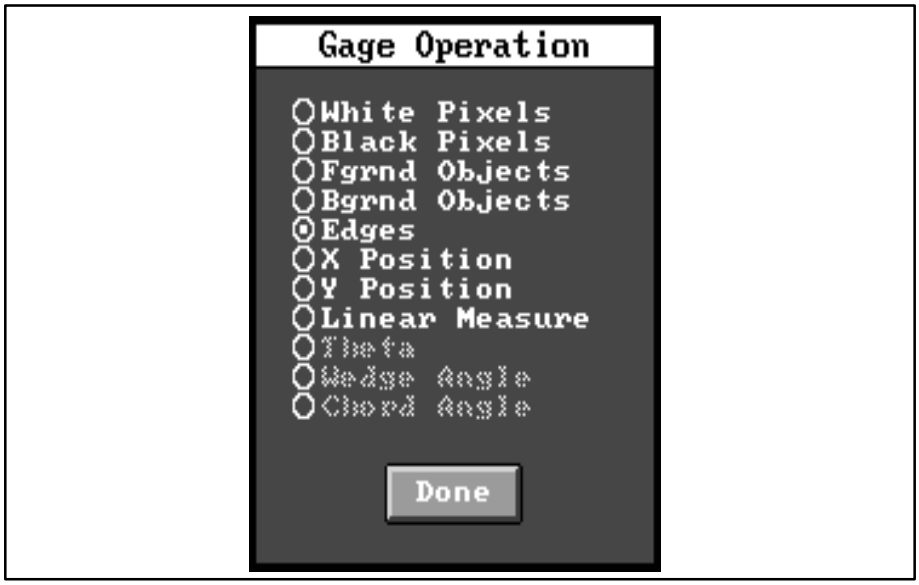
  The binary gaging mode is most appropriate when the inspected workpiece has a sharp black–and–white contrast with its background, such as when it is backlighted. You must select this mode for the black pixel and white pixel operations.
- **Gray scale mode** — The gray scale gaging mode detects edges and objects using the rate of change of the gray scale values of the pixels examined by the gage.

  Gray scale is appropriate when you need greater precision in linear measurements.

Gage Operations

When you pick the Operation field in the gage tool edit panel, the Gage Operation selection panel appears, as shown in Figure 7.4.

Figure 7.4 Gage Operation Selection Panel



Note that while Figure 7.4 lists all of the gage operations, the last three selections in this are *shaded*, which indicates that they cannot be selected. The reason, in this case, is that the selected gage shape is Line, and these selections apply only when the Arc or Circle gage shape is selected.

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Table 7.1 lists all of the gage operations, along with the applicable gage shape and gaging mode.

Table 7.1 Summary of Gage Operations

Gage Operation	Gage Shape	Gaging Mode
White pixels	Line, arc, circle	Binary
Black pixels	Line, arc, circle	Binary
Foreground objects	Line, arc, circle	Binary, gray scale
Background objects	Line, arc, circle	Binary, gray scale
Edges	Line, arc, circle	Binary, gray scale
X position	Line, arc, circle	Binary, gray scale
Y position	Line, arc, circle	Binary, gray scale
Linear measure	Line, arc, circle	Binary, gray scale
Theta	Arc, circle	Binary, gray scale
Wedge angle	Arc, circle	Binary, gray scale
Chord angle	Arc, circle	Binary, gray scale

NOTE: All but the last three gage operations apply to the line, arc, and circle gages. The last three apply only to arc and circle gages.

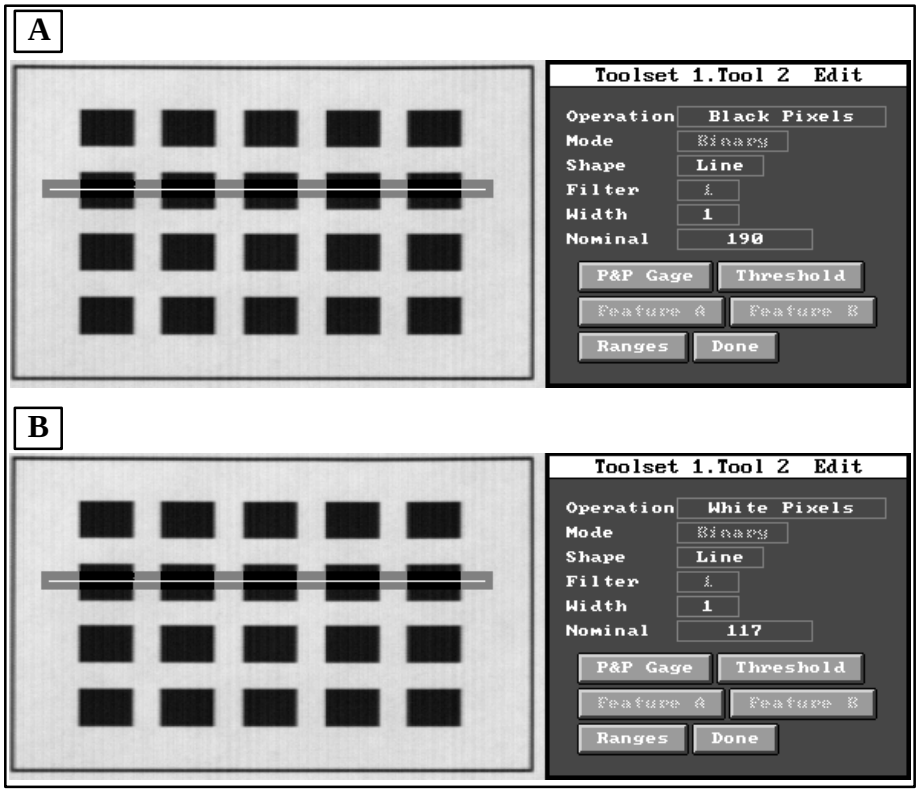
White Pixels; Black Pixels

These two gage operations are available only when you select the *binary gaging mode*. The pixel counting operations count the total number of white or black pixels along the full length of the gage. Figure 7.5 (A) (page 7–8) shows a linear gage performing a *black* pixel counting operation across a workpiece, while (B) shows the same gage performing a *white* pixel counting operation across the same workpiece.

Note that *black* pixel count (190 pixels in the A example) is the total of the pixels in all of the black rectangles, while the *white* pixel count (117 in the B example) is the total of the pixels in all of the white spaces between the black rectangles, plus the white area on each end of the gage.

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Figure 7.5 Examples: Counting Black Pixels and White Pixels Across a Workpiece



Foreground Objects; Background Objects

These two gage operations are available with both gaging modes. The object counting operations count the total number of “foreground” or “background” objects along the length of the gage.

In the context of gage operations, the terms “foreground” and “background” have specific, and different, meanings for the *binary* gaging mode and the *gray scale* gaging modes. These are described in the following sections.

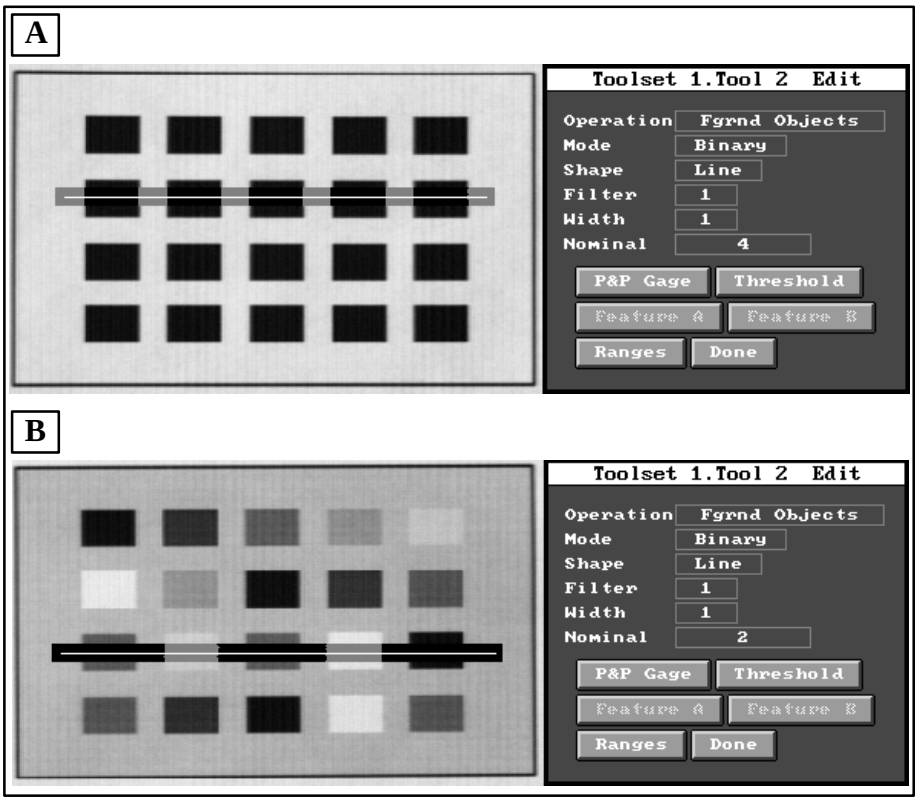
Binary Gaging Mode: Foreground Objects

Foreground objects are those objects containing *white* pixels that lie *completely between* the first and last detected edges on the axis. In example (**A**) of Figure 7.6 (page 7–9), the four foreground (white) objects correspond to the four white spaces between the black rectangles. Note that the white areas at each end of the gage do *not* qualify as foreground objects, since they are *outside* the first and last detected edges on the gage.

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In example (**B**) of Figure 7.6, the two foreground (white) objects correspond to the two white rectangles. These rectangles stand out in the binarized image as a consequence of the settings of the binary thresholds.

Figure 7.6 Examples: Counting Foreground Objects (Binary)



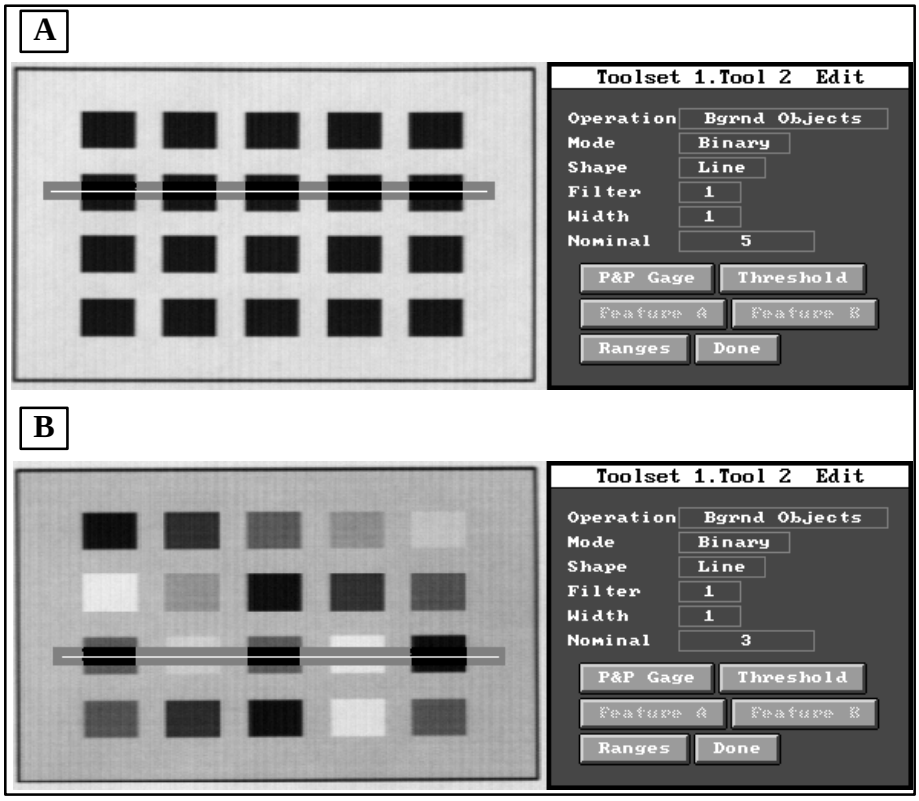
Binary Gaging Mode: Background Objects

Background objects are those objects containing *black* pixels that lie *completely between* the first and last detected edges on the axis. In example (**A**) of Figure 7.7 (page 7–10), the five background (black) objects correspond to the five black rectangles.

In example (**B**) of Figure 7.7, the three background (black) objects correspond to the three dark rectangles in the image. These objects stand out in the binarized image as a consequence of the settings of the binary thresholds.

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Figure 7.7 Examples: Counting Background Objects (Binary)



Gray Scale Gaging Mode: Foreground Objects

Foreground objects are those objects that lie *completely between* the first and last detected edges, and whose pixels are *lighter than* the *adjacent* pixels — the pixels on *both* sides of the object. (Note that the edges stand out as a consequence of the settings for edge detection parameters.)

Example (**A**) of Figure 7.8 (page 7–11) is a straightforward example in which four foreground (light) objects correspond to the four white spaces between the black rectangles.

Example (**B**) of Figure 7.8 is a more complex example in which four foreground (light) objects are identified. The first two foreground objects pertain to the two lightest rectangles, since the pixels *within* each of these rectangles are *lighter than* the pixels *adjacent to* each rectangle. The second two "objects" *include* the first pair; that is, the first two objects are "nested" inside the second two objects.

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Figure 7.8 Examples: Counting Foreground Objects (Gray Scale)

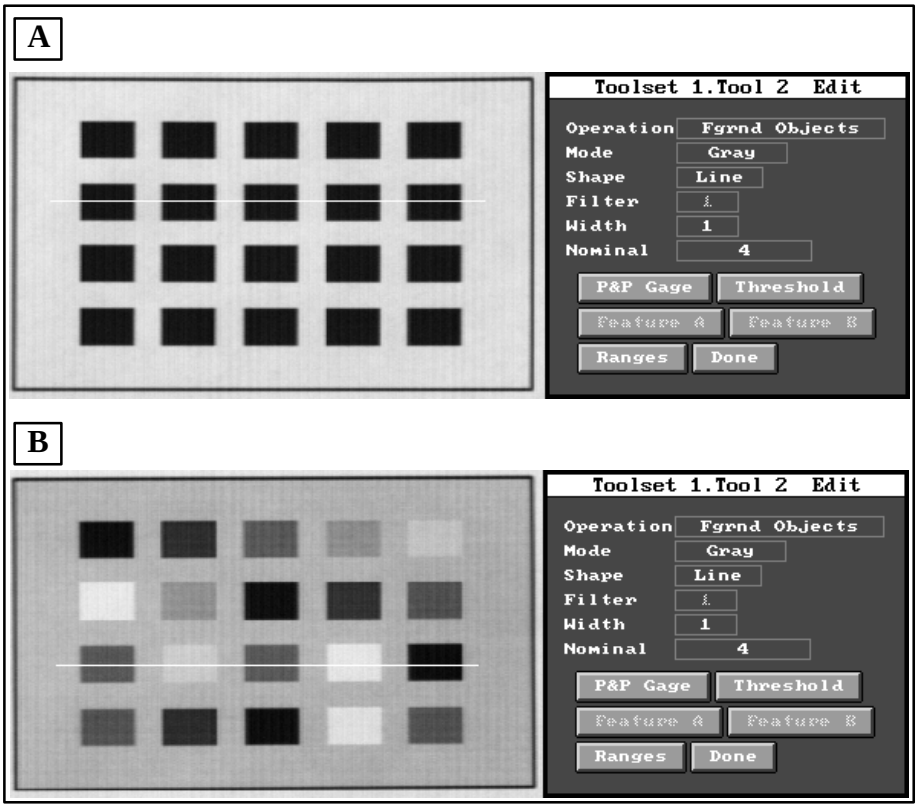
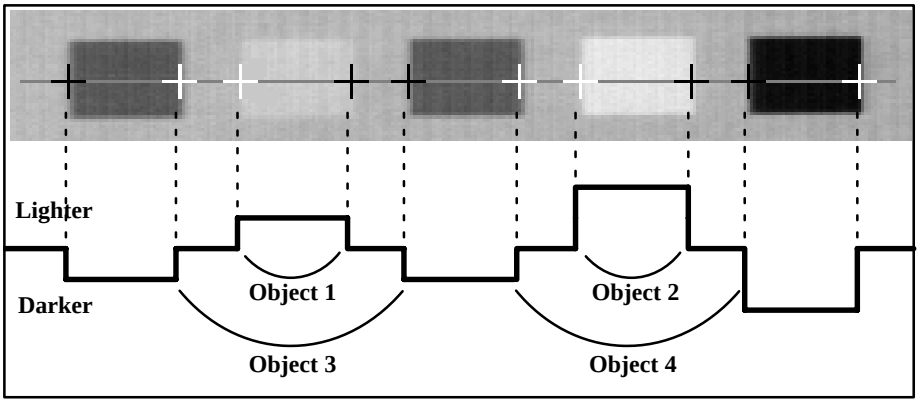


Figure 7.9 uses a graph to illustrate the *relative* gray scale values along the gage, and to demonstrate that both sets of objects satisfy the definition that a foreground object is one whose pixels are *lighter than* the *adjacent* pixels. Thus, object 1 is nested in object 3, and object 2 is nested in object 4, in this example.

Figure 7.9 Example: Identifying Foreground Objects (Gray Scale)



Note that in both examples in Figure 7.8 the white areas at each end of the gage do *not* qualify as foreground objects, since they are *outside* the first and last detected edges on the gage.

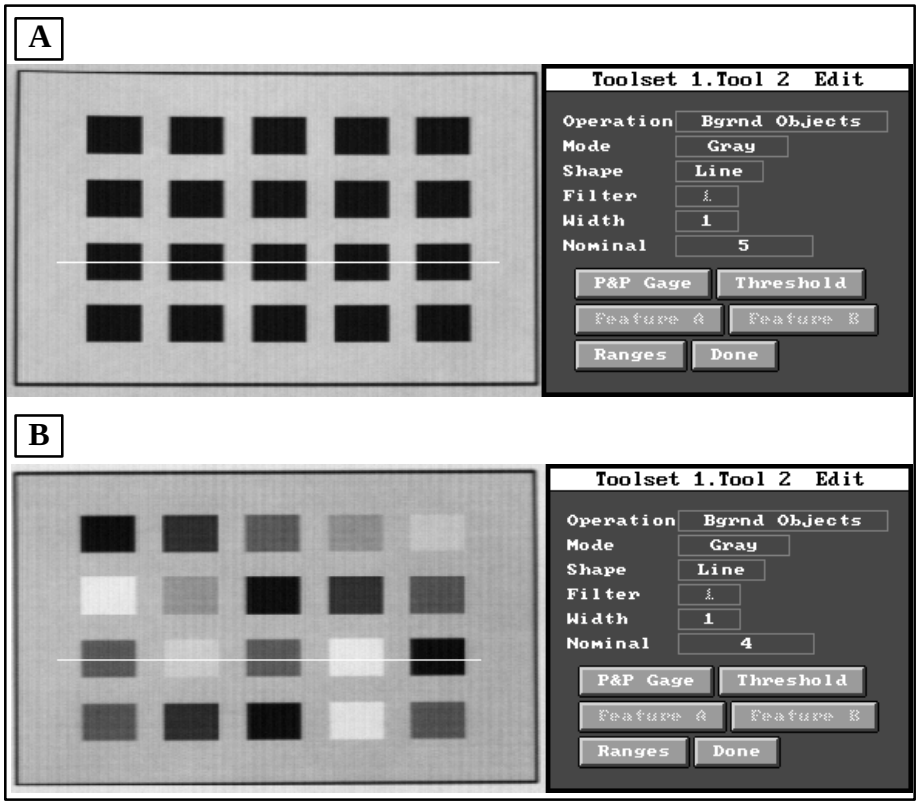
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Gray Scale Gaging Mode: Background Objects

Background objects are those objects that lie *completely between* the first and last detected edges, and whose pixels are *darker than* the *adjacent* pixels — the pixels on *both* sides of the object. (Note that the edges stand out as a consequence of the settings for edge detection parameters.)

Example (**A**) of Figure 7.10 is a straightforward example in which five background (dark) objects are identified that correspond to the five black rectangles.

Figure 7.10 Examples: Counting Background Objects (Gray Scale)

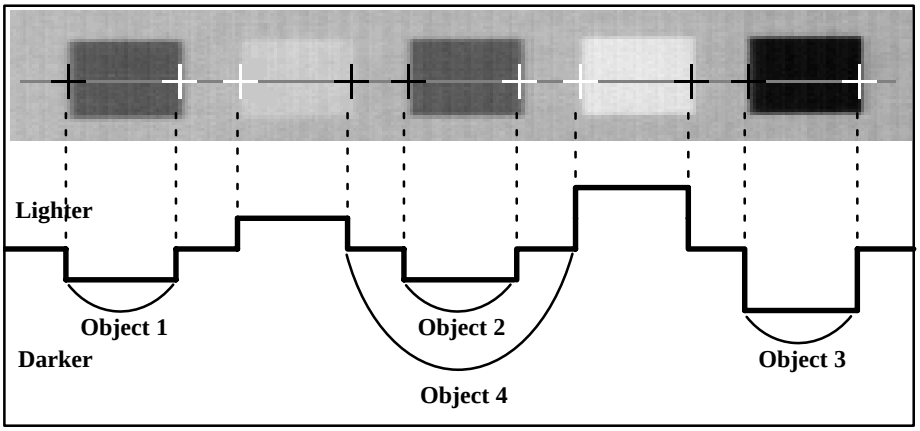


Example (**B**) of Figure 7.10 is a more complex example in which four background (dark) objects are identified. The first three background objects pertain to the three darkest rectangles, since the pixels *within* each of these rectangles are *darker than* the pixels *adjacent to* each rectangle. The fourth "object" *includes* the second of the first three objects; that is, the second object is "nested" inside the fourth object.

Figure 7.11 (page 7–13) uses a graph to illustrate the *relative* gray scale values along the gage, and to demonstrate that both sets of objects satisfy the definition that a background object is one whose pixels are *darker than* the *adjacent* pixels. Thus, object 2 in this example is nested in object 4.

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Figure 7.11 Example: Identifying Background Objects (Gray Scale)



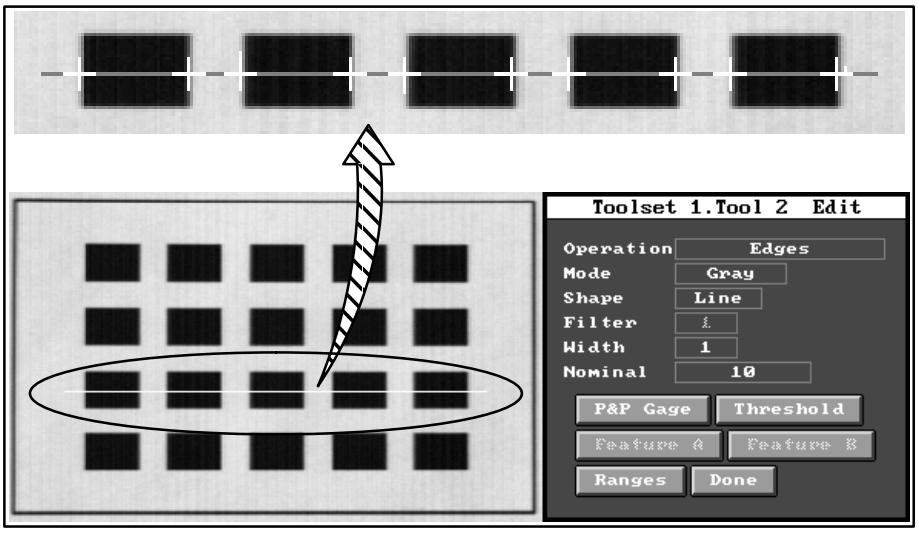
Edges

This gage operation is available when you select either the *binary gaging mode* or the *gray scale gaging mode*. The edge counting operation counts the total number of edges that are detected along the length of the gage.

Figure 7.12 illustrates a linear gage using the edge counting operation. In this example, the gray scale gage finds ten edges, one on each side of the black rectangles.

Note that the upper part of Figure 7.12 shows the ten edges as you would see them after setting the edge detection parameters. Each detected edge is indicated by a cross (+) symbol.

Figure 7.12 Example: Counting Edges

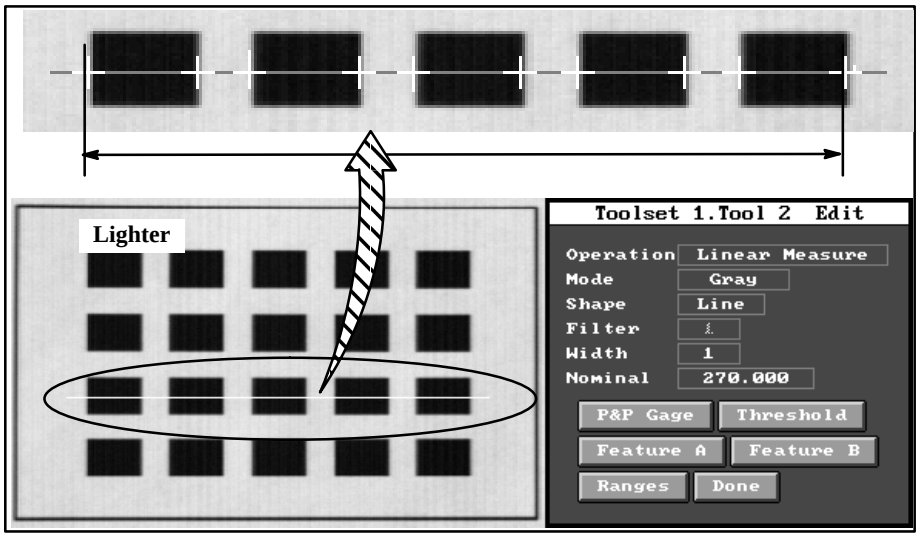


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Linear Measure

This gage operation is available when you select either the *binary gaging mode* or the *gray scale gaging mode*. The linear measure operation measures the distance between any two edges along the length of the gage. Figure 7.13 shows a linear gage using the linear gaging operation.

Figure 7.13 Example: Measuring the Distance Between Two Edges



Note that the upper part of Figure 7.13 shows all ten edges as you would see them after setting the edge detection parameters. Each detected edge is indicated by a cross (+) symbol.

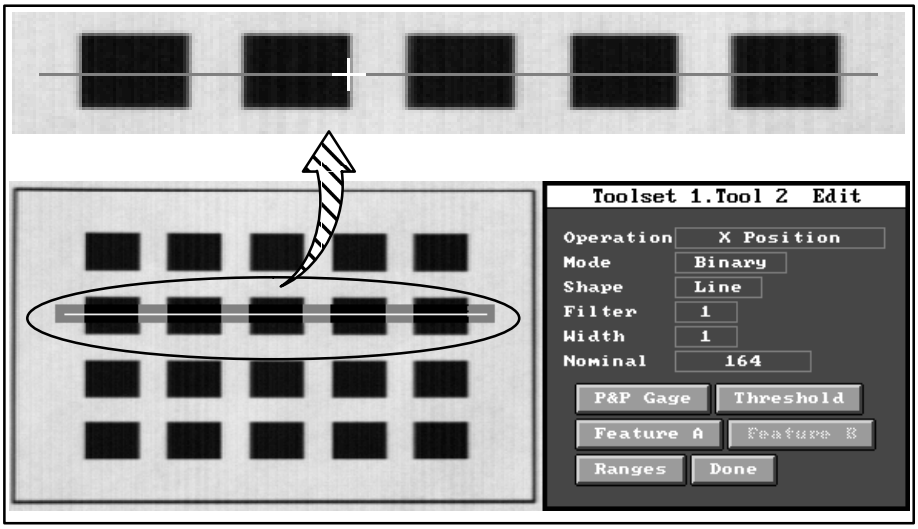
X Position

This gage operation is available when you select either the *binary gaging mode* or the *gray scale gaging mode*. The X position operation measures the absolute horizontal position of a specified edge along the length of a gage. The X position is reported in pixels, with the origin (0 coordinate) being the left boundary of the image.

Figure 7.14 (page 7–15) shows a linear gage using the X position operation. In this example, the X position of the selected edge is 164 pixels from the left boundary of the image.

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Figure 7.14 Example: Reporting the X Coordinate of a Single Edge

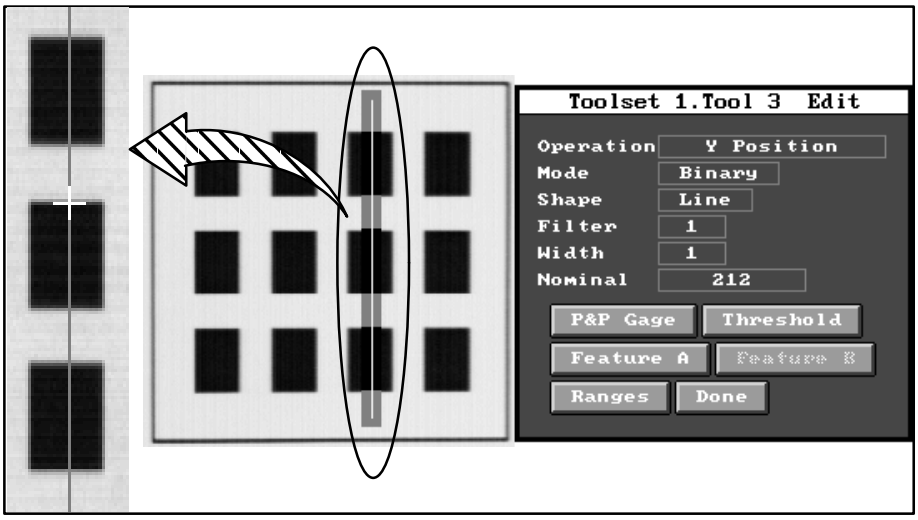


Y Position

This gage operation is available when you select either the *binary gaging mode* or the *gray scale gaging mode*. The Y position operation measures the absolute vertical position of a specified edge along the length of a gage. The Y position is reported in pixels, with the origin (0 coordinate) being the top boundary of the image.

Figure 7.15 shows a linear gage using the Y position operation. In this example, the Y–axis position of the selected edge is 212 pixels from the top boundary of the image.

Figure 7.15 Example: Reporting the Y Coordinate of a Single Edge



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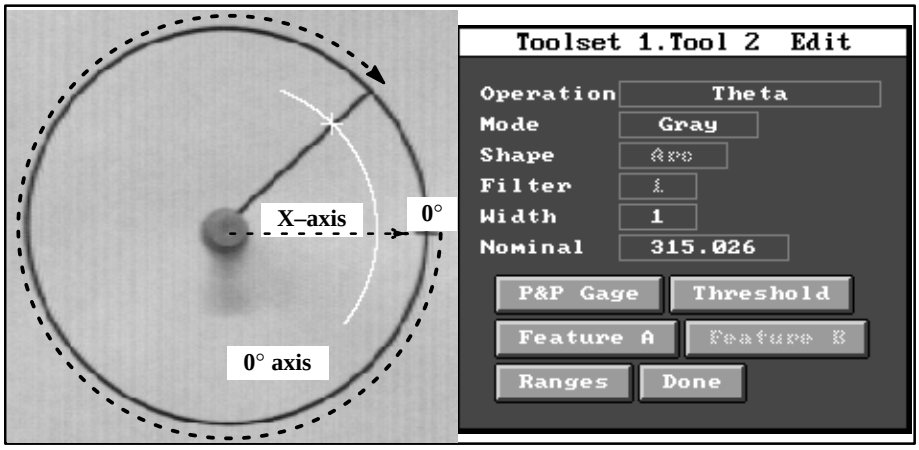
NOTE: The following gage operations apply only to arc gages. For information about the pick and place operations that are unique to arc gages, refer to Chapter 5, *Pick and Place Functions*, under the *Arc Gages* heading on page 5–3.

Theta (Arc and Circle Gage Only)

This gage operation is available for arc and circle gages using either the *binary gaging mode* or the *gray scale gaging mode*. The theta operation measures the absolute angle of arc defined by an edge on an arc gage. The angle is reported in degrees relative to the X–axis (at the 0° position) and measuring *clockwise* from the origin.

Figure 7.16 shows an example of an arc gage using the theta operation to measure the angle formed by a radius of a circle and the X–axis.

Figure 7.16 Example: Measuring the Theta Angle



Note that the measured angle for any edge is independent of the number of degrees of arc of the arc gage, or whether the search direction is head–to–tail or tail–to–head.

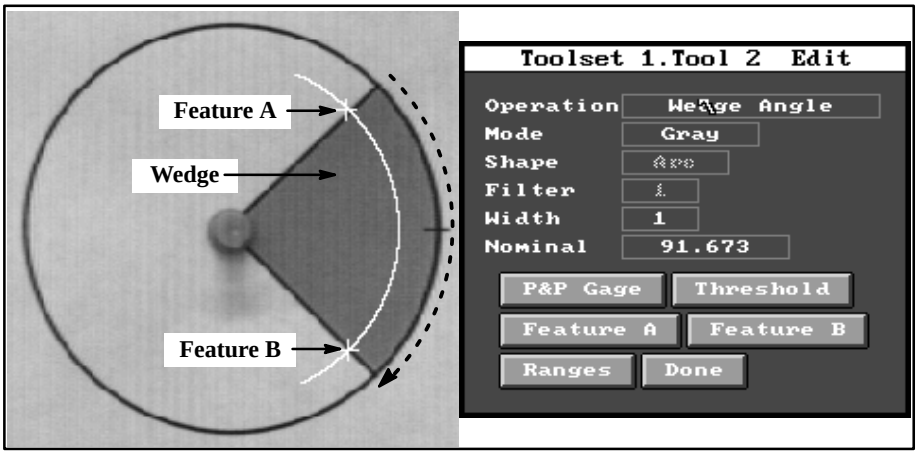
Wedge Angle (Arc and Circle Gage Only)

This gage operation is available for arc and circle gages using either the *binary gaging mode* or the *gray scale gaging mode*. The wedge angle operation measures the relative angle of arc between two edges on the arc gage. The value is reported in degrees and is measured *clockwise* from the first edge (feature A) and the second edge (feature B).

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Figure 7.17 shows an arc gage using the wedge angle operation to measure a "wedge" angle formed by two edges ("features") on the arc gage and the implied center of the gage.

Figure 7.17 Example: Measuring the Wedge Angle



The wedge angle operation always measures the angle from feature A on the gage *clockwise* to feature B. In the example, feature A is located at 315° relative to the X–axis, and feature B is located at 45°. Thus, the wedge angle is about 90° in this example. (If the positions of features A and B were *reversed*, the wedge angle would be about 270°.)

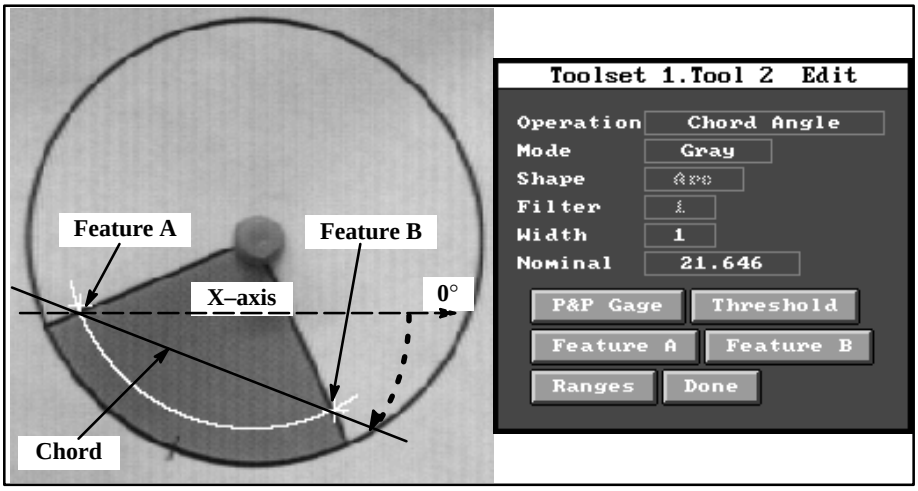
Chord Angle (Arc and Circle Gage Only)

This gage operation is available for arc and circle gages using either the *binary gaging mode* or the *gray scale gaging mode*. The chord angle operation measures the absolute orientation of the chord formed between two edges (features A and B) on an arc gage. The value is reported in degrees and is measured *clockwise* from the *origin* (the 0° position of the X–axis). Feature A is located on the X–axis and is the center of rotation.

Figure 7.18 (page 7–18) shows an arc gage using the chord angle operation to measure the angle between a chord across the arc gage and the X–axis. In this example, with feature A located on the X–axis, feature B is rotated about 22° clockwise from the X–axis. If the positions of features A and B were reversed, the chord angle would be about 202°.

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Figure 7.18 Example: Measuring the Chord Angle



Feature Selection Functions

The following six gage operations employ “features” to identify the edges used for a measurement: X position, Y position, linear measure, theta, wedge angle, and chord angle.

A gage can detect several edges, of which only one or two are required for the measurement. Thus, the edge selection functions enable you to select particular edges, or other features related to the edges, and determine other aspects of the search for these edges, including search direction and search mode. These subjects are discussed in detail in this section.

When you pick either of the Feature buttons on the tool edit panel, a Define Feature selection panel appears, as shown in Figure 7.19 (page 7–19).

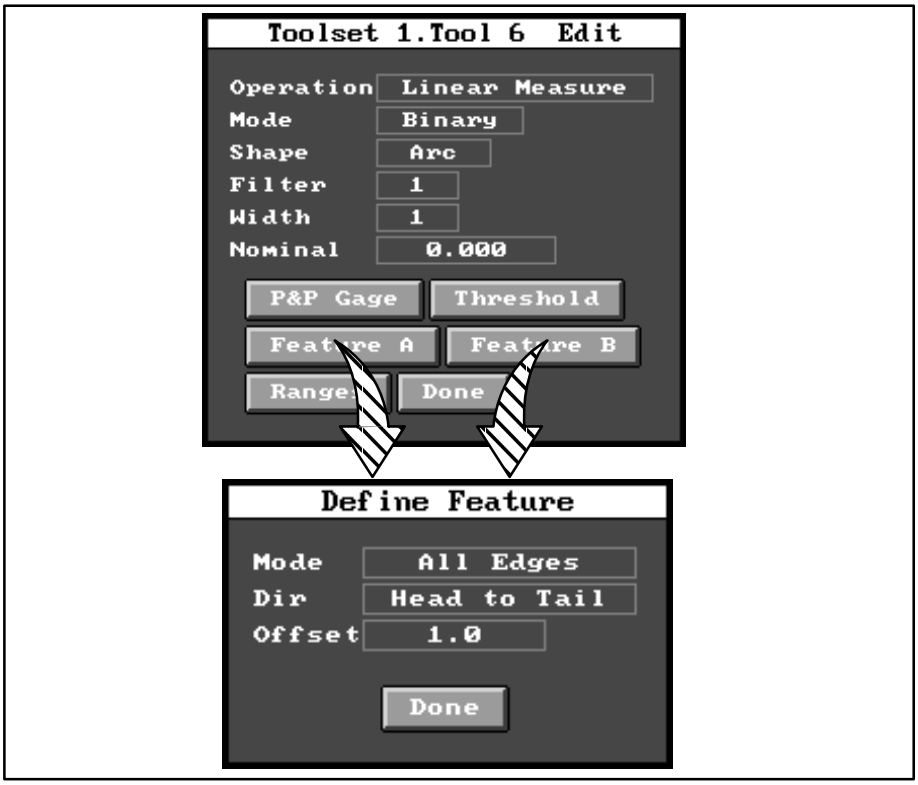
The threshold and filter settings, along with the width selection, determine which light/dark transitions along a gage are detected as edges. The purpose of the *feature selection function* is to specify which of these edges (or midpoints between edges) are to be identified as “features,” used as the basis for the inspection operation. Each of these features is defined by an *offset*.

Note that some gage operations, such as X Position, need to specify only *one* feature, while other operations, such as Linear Measure, need to specify *two* features. In the first case, only the Feature A button is *active*; in the second case, the Feature A button and the Feature B button are both *active*.

In addition to specifying the appropriate offsets, the feature selection process also specifies the edge search *direction* and the edge search *mode*.

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Figure 7.19 Example: Selecting the Define Feature Selection Panel



Here is a brief description of the feature selection *functions*:

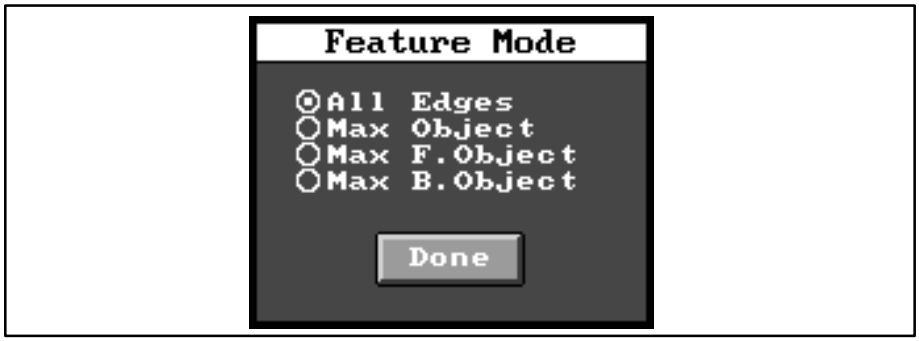
- **Mode** — The *mode* function selects a particular group of edges that a gage evaluates when searching for a *specified feature*.
- **Dir** — The *search direction* function selects the direction of the search for the *specified features* along the length of the gage.
- **Offset** — The *offset* function enables you to identify *one* edge, or a midpoint between two edges, as the *specified* feature.

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Mode

When you pick the Mode field in the Define Feature menu, the Feature Mode selection menu appears on the screen, as shown in Figure 7.20.

Figure 7.20 Feature Mode Selection Menu



The feature modes are described briefly as follows:

- **All Edges** — This feature mode causes the gage to include all detected "edges" along its length in its search for a *specified feature* (this includes *edges* and *all midpoints* between each pair of consecutive edges, the *center* between the extreme edges, and the *starting* end of the gage).
- **Max Object** — This feature mode restricts the search for a *specified feature* to the leading edge and the midpoint of the *largest* identified "object" along the length of the gage.
- **Max F. Object** — This feature mode restricts the search for a *specified feature* to the leading edge and the midpoint of the *largest* identified "foreground object" along the length of the gage.
- **Max B. Object** — This feature mode restricts the search for a *specified feature* to the leading edge and the midpoint of the *largest* identified "background object" along the length of the gage.

NOTE: The terms "foreground object" and "background object" have different meanings for binary and gray scale gaging modes. Refer to the *Foreground Objects; Background Objects* section on page 7–8 for definitions of these terms.

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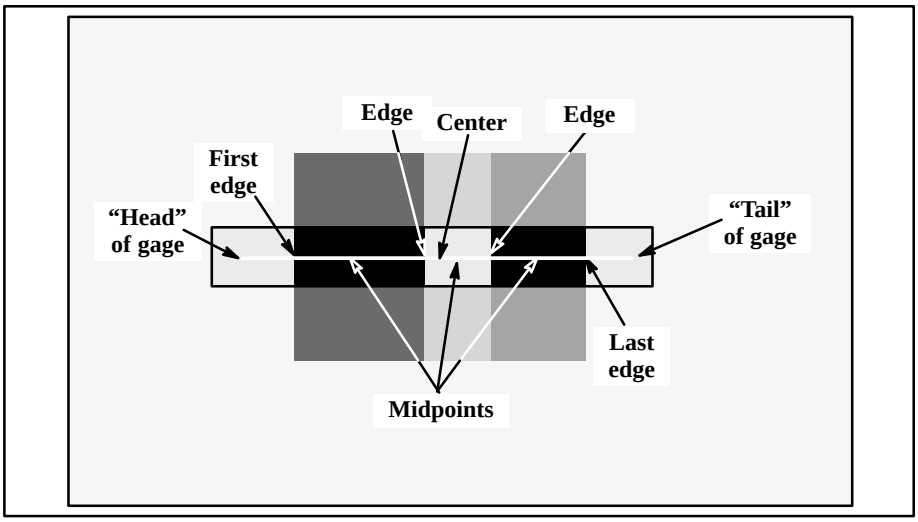
All Edges

The *all edges* feature mode enables you to specify an edge from among the following points along the length of the gage:

- All *edges* detected as a result of the threshold/filter settings.
- The *head* of the gage when using the head–to–tail search direction, or the *tail* of the gage when using the tail–to–head search direction.
- The *midpoints* between adjacent pairs of edges.
- The *center point* between the first edge and the last edge.

Figure 7.21 uses a linear gage and the binary gaging mode to illustrate the potential edges with the *all edges* feature mode enabled.

Figure 7.21 Example: All Edges Along a Line Gage



Max Object

The *maximum object* feature mode enables you to specify an edge from among the following points on the gage:

- The first edge (offset 0.0) of the maximum–size object.
- The midpoint (Center) between the first edge and the last edge of the maximum–size object.

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Max F. Object

The *maximum foreground object* feature mode enables you to specify an edge from among the following points on the gage:

- The first edge (offset 0.0) of the maximum–size foreground object.
- The midpoint (Center) between the first edge and the last edge of the maximum–size foreground object.

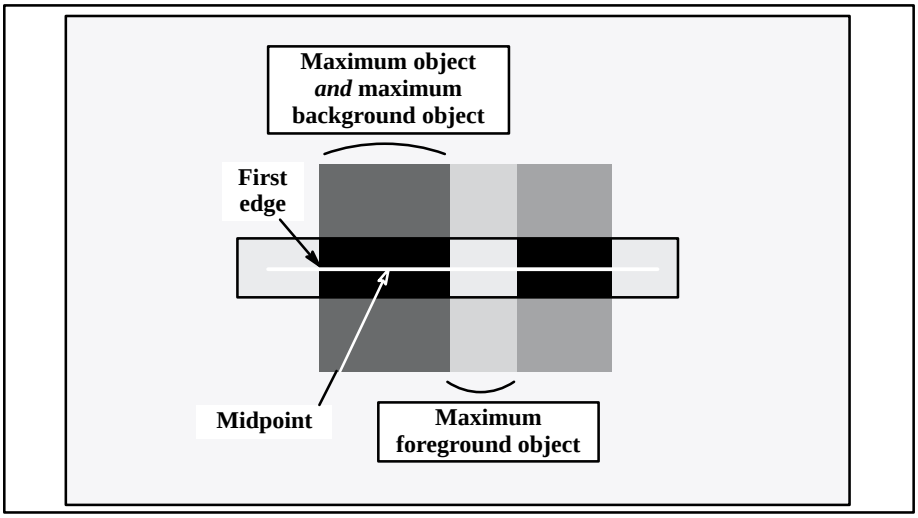
Max B. Object

The *maximum background object* feature mode enables you to specify an edge from among the following points on the gage:

- The first edge (offset 0.0) of the maximum–size background object.
- The midpoint (Center) between the first edge and the last edge of the maximum–size background object.

Figure 7.22 uses a linear gage and the binary gaging mode to illustrate all three of the "object" feature mode selections.

Figure 7.22 Example: Three Object Feature Modes



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Direction

The *search direction* is the direction used to search for an edge along the length of the gage. The two available choices are these: Head to Tail and Tail to Head.

When you pick the Dir menu field (in the Define Feature menu) successively, it toggles to the *opposite* direction. Thus, Head to Tail changes to Tail to Head, and vice versa.

Head to Tail causes the edge search to begin at the "head" of the gage; Tail to Head causes the edge search to begin at the "tail." Note that in the Pick & Place panel, the position of the head of the gage is defined by the X1 and Y1 coordinates, while the position of the tail is defined by the X2 and Y2 coordinates.

The choice of search direction should be based upon which one leads most *directly* to the specified edge. Normally, the *best* search direction is the one in which a *false* edge is least likely to be encountered.

Offset

The current *offset* location is identified on the screen by a "+" symbol. You can change the offset location by picking the Offset field successively.

When you pick the Offset menu field successively, the offset marker (+) moves along the line gage in the selected *search direction*. The displayed offset will be one of these:

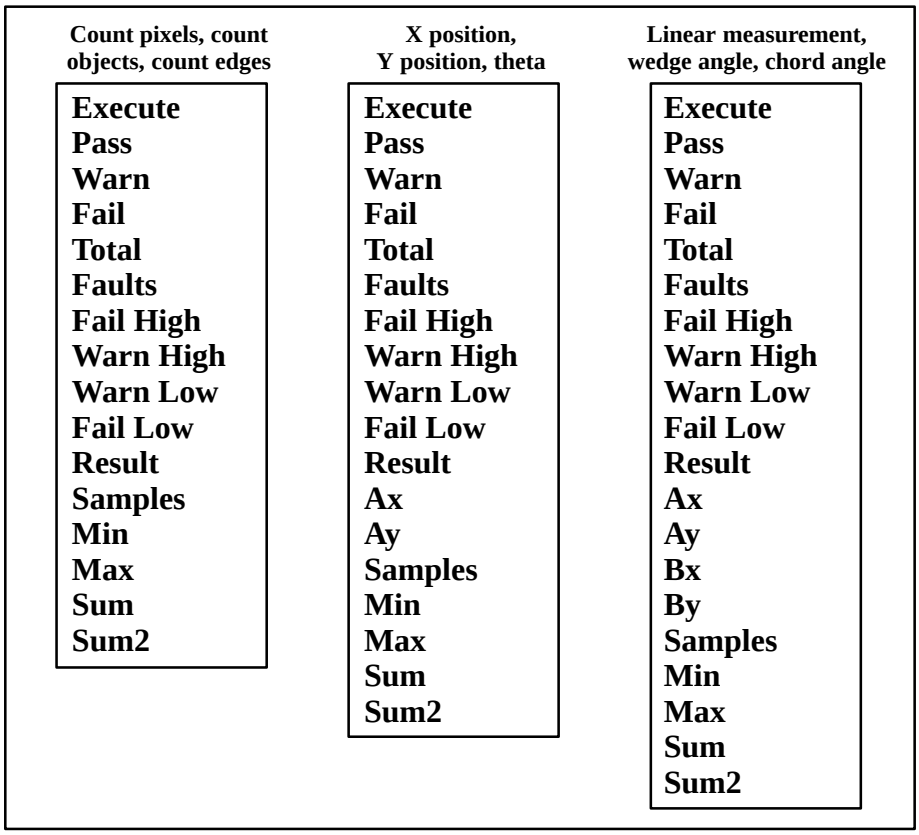
- **Fixed** — This refers to the head of the gage for the head–to–tail search direction, or the tail for the tail–to–head search direction.
- **Center** — This refers to the midpoint between the first edge and the last edge.
- **1.0, 2.0, etc.** — This refers to an edge specified by number.
- **1.5. 2.5, etc.** — This refers to a midpoint between two adjacent edges.

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Gage Tool Inspection Results and Math Tool Formulas

This section discusses the inspection results that are available to a math tool formula from a gage tool. The specific set of results depends on the specific gage tool operation. As Figure 7.23 shows, the inspection results that correspond to any particular gage tool *operation* will appear in one of three lists.

Figure 7.23 Expanded Results Lists For Gage Tools in Math Formulas



Here is a brief definition and explanation of each of the gage result types listed in Figure 7.23:

- **Execute** — This returns a 1.000 when the tool has *executed* its inspection task, and 0.000 for all other conditions.
- **Pass** — This returns a 1.000 when the tool has *passed* its inspection task, and 0.000 for all other conditions.
- **Warn** — This returns an "error code" when the tool is in a *warn* condition (and *not* in a *fail* condition) and 0.000 for all other conditions. The error code identifies a specific reason for the warning; for example, error code 1057.000 identifies "Low range warning" as the cause. The complete list of error codes appears in Appendix A of this manual.

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- **Fail** — This returns an “error code” when the tool is in a *fail* condition and 0.000 for all other conditions. The error code identifies a specific reason for the failure; for example, error code 1045.000 identifies “High range fail” as the cause of the inspection failure. The complete list of error codes and fail conditions appears in Appendix A of this manual.
- **Total** — This returns the total number of inspections performed.
- **Faults** — This returns the total number of faults detected.
- **Fail High** — This returns a 1.000 when the inspection result from the tool has exceeded the *high* Fail limit and 0.000 when the result has *not* exceeded the *high* Fail limit.
- **Warn High** — This returns a 1.000 when the inspection result from the tool has exceeded the *high* Warn limit (and the tool is *not* in a *fail* condition) and 0.000 when the result has *not* exceeded the *high* Warn limit.
- **Warn Low** — This returns a 1.000 when the inspection result from the tool has exceeded the *low* Warn limit (and the tool is *not* in a *fail* condition) and 0.000 when the result has *not* exceeded the *low* Warn limit.
- **Fail Low** — This returns a 1.000 when the inspection result from the tool has exceeded the *low* Fail limit and 0.000 when the result has *not* exceeded the *low* Fail limit.
- **Result** — This returns the actual value of the inspection result; that is, the measurement, count, or other numeric result from the gage tool. This value corresponds to the “learned” value that appears in the “Nominal” field of the gage tool edit panel.
- **Ax** — This value pertains *only* to a gage tool configured for linear measurement, X or Y position, theta, wedge, or chord operations. “Ax” returns the value of the X coordinate of Feature A.
- **Ay** — This value pertains *only* to a gage tool configured for linear measurement, X or Y position, theta, wedge, or chord operations. “Ay” returns the value of the Y coordinate of Feature A.
- **Bx** — This value pertains *only* to a gage tool configured for linear measurement, wedge, or chord operations. “Bx” returns the value of the X coordinate of Feature B.
- **By** — This value pertains *only* to a gage tool configured for linear measurement, wedge, or chord operations. “By” returns the value of the Y coordinate of Feature B.
- ***Samples** — This returns the current total number of inspection samples since the start of run operation.

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- ***Min** — This returns the current *minimum* value of the inspection results since the start of the run operation.
- ***Max** — This returns the current *maximum* value of the inspection results since the start of the run operation.
- ***Sum** — This returns the current *sum* of all inspection results since the start of the setup or online run operation.
- ***Sum2** — This returns the current *sum* of the *squares* of all inspection results since the start of the setup or online run operation.

*These *statistical* results are available only when a tool is enabled for *statistics* operations, as indicated by a checked Statistics box in the tool's Options selection panel.

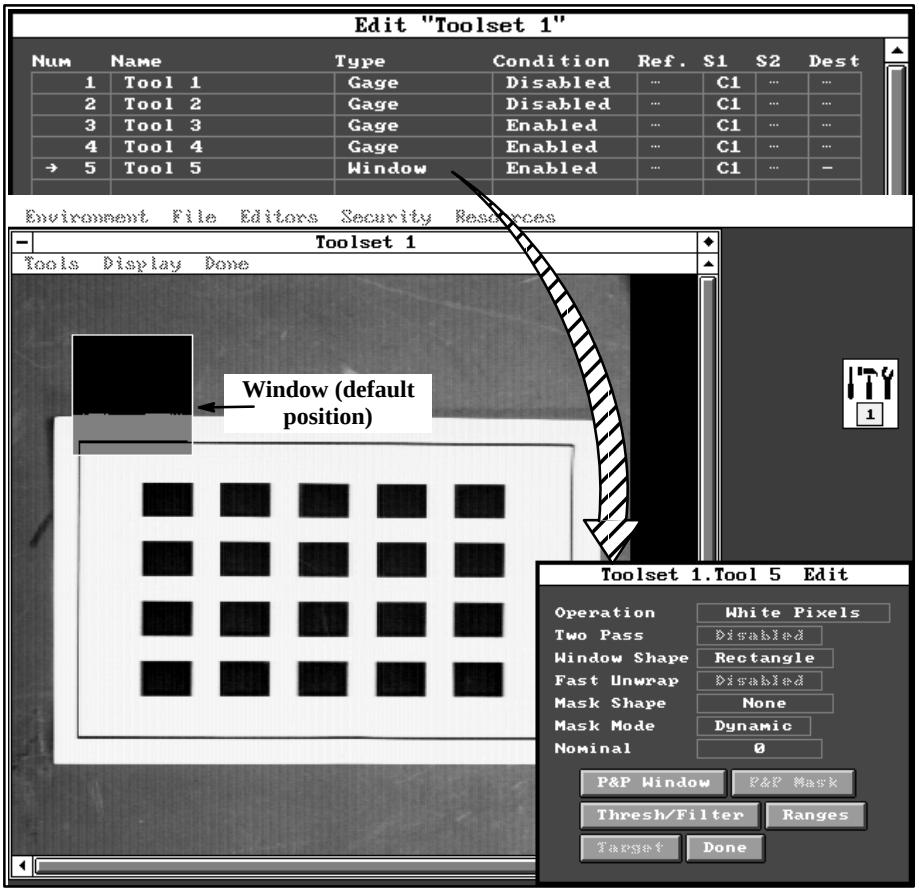
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Window Tool

This section discusses windows and the inspection functions (“operations”) that the windows can perform.

Once you have selected a window as outlined in the *Overview: Inspection Tool Selection Process* section (page 7–1), you can configure it for an inspection application by picking the Window field in the toolset edit panel. When you do, the window tool edit panel appears, as shown by the example in Figure 7.24.

Figure 7.24 Example: Selecting the Window Tool Edit Panel



Note that in Figure 7.24 the window is shown in its *default* shape (rectangle) and position on the screen.

The window tool edit panel (named “Toolset 1.Tool 5 Edit” in Figure 7.24) contains several parameter selection fields and buttons, which are described briefly as follows:

- **Operation** — This field provides access to the selection of one of the window “operations.” The *default* window operation is White Pixels, which is a pixel–counting operation.

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- **Two Pass** — This field is *active* only after a destination buffer is assigned to a window tool. When Two Pass is enabled, the window tool performs a *second* image processing pass, during which it eliminates inside border pixels that are actually artifacts of the morphology processing used on the *first* processing pass. (The destination buffer appears in Figure 7.24 as "P1" under the "Dest." in the toolset edit panel. Note that while this buffer is *required* for Two Pass operation, it is also available to other tools as an alternate S1 image source.)
- **Window Shape** — Use this field to pick one of five window shapes, according to the requirements of your application.
- **Fast Unwrap** — This field is *active* only when the Arc Ring window shape is selected. When enabled, the "unwrap" function operates faster, but requires about 1K bytes more memory.
- **Mask Shape** — Use this field to pick one of three mask shapes, when appropriate for your application. The *default* selection is None.
- **Mask Mode** — Use this field to pick either the Dynamic or the Static mask mode. The difference is that the *dynamic* mode runs somewhat slower, but uses less image memory; whereas, the *static* mode runs faster, but requires more image memory. The *default* selection is Dynamic.
- **Nominal** — When you pick this field, the currently selected and configured window performs a *test* operation, and the resulting inspection results data appear in this field. The type of results data depends on the selected window operation. The *initial* value is 0.
- **P&P Window** — The P&P Window button activates the window pick and place function. For details about this function, see Chapter 5, *Pick and Place Functions*.
- **P&P Mask** —— The P&P Mask button activates the window mask pick and place function.
- **Thresh/Filter** — The Thresh/Filter button accesses the threshold and/or morphology filter selection panels. For details about this function, see Chapter 8, *Thresholds, Filters, and Morphology.*
- **Ranges** — The Ranges button accesses the range–selection panel, which defines limits for window inspection results.
- **Target** — The Target button is *active* only for object–counting window operations. When you pick this button, you access the cursors that set the high and low area limits for the inspected objects.
- **Done** — When you pick the Done button, the system exits back to the toolset edit panel.

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Overview: Window Configuration

A window can be selected when the toolset edit panel is on the screen. Starting from the main menu bar, the selection path to this panel is as follows: **Editors** → **Configuration** → **Setup** → **Tools**. This selection path is shown by the example in Figure 7.1 (page 7–2).

Here is a summary list of the *basic* window selection and configuration steps, listed in their normal order of performance:

1. Select the appropriate window operation.
2. Select the window shape.
3. "Pick and place" the window.
4. Select the mask shape and mode.
5. "Pick and place" the mask.
6. Select threshold/filter. (For details, see Chapter 8, *Thresholds, Filters, and Morphology.*)
7. Learn the nominal value.
8. Select the ranges.

Window Shape

Each of the windows can be configured as a rectangle, circle, ellipse, arc ring, or polygon, according to the requirements of your application. Note that you can "pick and place" the window anywhere within the image field and set it to any size, so long as it remains entirely within the image field.

When you pick the Window Shape field in the window tool edit panel, the Window Shape selection panel appears, as shown in Figure 7.25.

Figure 7.25 Window Shape Selection Panel



Here is a brief description of the window shapes:

- **Rectangle** — The sides of a rectangular window are aligned with the vertical and horizontal axes of the image field (except when receiving rotation compensation from a reference tool).
- **Circle** — The circle window consists of a single circle–shaped window that can be adjusted in size (radius) and position.

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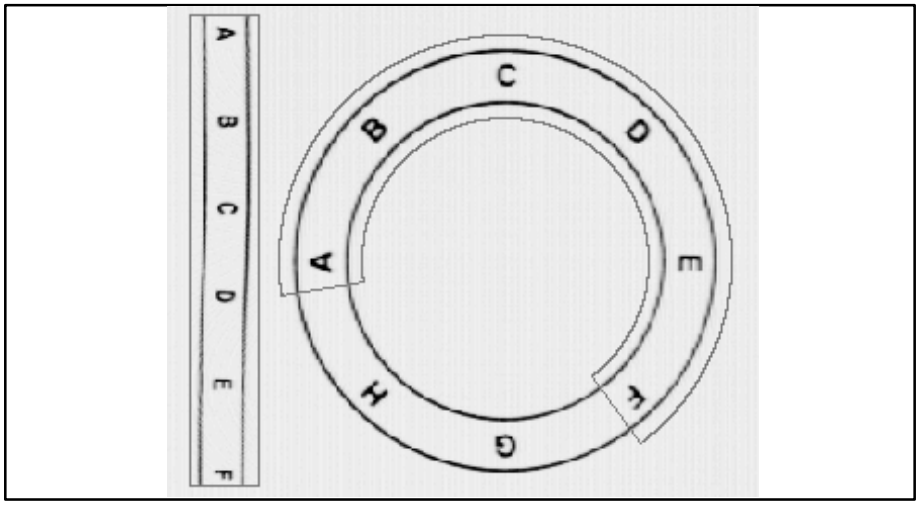
- **Ellipse** — The axes of an elliptical window are always aligned with the vertical and horizontal axes of the image field.
- **Arc Ring** — The arc ring window consists of a concentric outer and inner arc ring, connected at each end of the arc, and a separate rectangular "destination" window. The image area between the arc rings is "unwrapped" and displayed in the destination window.
- **Polygon** — A polygonal window can have any number of sides from three to 16. You can configure a polygonal window so that it conforms to virtually any shape.

The *arc ring* "shape" window has unique capabilities that *differ* from the functions of the other window shapes (rectangle, ellipse, circle, and polygon). In particular, an arc ring window can perform an "unwrap" function, which can be used to examine circular features and, by "unwrapping" them, process them as though they were linear.

An arc ring window consists of a circular "image" window and a rectangular "destination" window. The image window consists of an outer arc and a concentrically positioned inner arc, with the two ends connected. The arc size (in degrees) can be increased to 360°, or decreased to a size (in degrees) that varies with the radius of the inner arc.

Figure 7.26 illustrates the unwrapping effect of an arc ring window, with the circular array of letters in the image window appearing as a linear array in the destination window.

Figure 7.26 Example: Unwrapping Effect of Arc Ring Window



The pick and place procedure for the arc ring window is comparable to the procedure for arc gages, while the pick and place procedure for the destination window is the same as for rectangular windows. For details, refer to Chapter 5, *Pick and Place Functions.*

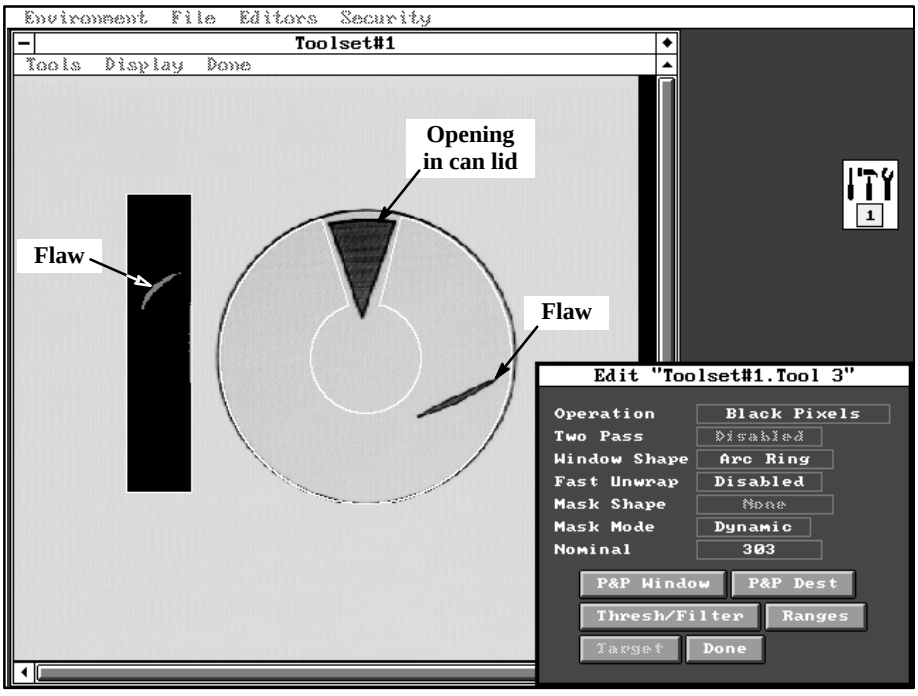
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NOTE: The destination window is normally configured with the vertical axis *longer than* the horizontal axis, since the unwrapped image data is displayed *vertically.* The *aspect ratio* of the destination window should be adjusted as needed to *optimize* the appearance of the part or item being inspected.

In operation, the arc ring window processes (and "unwraps") the image area lying between the inner and outer rings of the image window, then displays the unwrapped and processed image *vertically* in the destination window.

Figure 7.27 is an example that illustrates using an arc ring window to detect a flaw in a can lid. In this example, the image window is centered over the circular lid, and the arc is positioned to *exclude* the wedge–shaped opening in the lid, which is regarded as a *normal* feature of the lid.

Figure 7.27 Example: Using Arc Ring Window to Detect Flaw



Note that the portion of the lid within the image window has a slit in it, which is regarded a *flaw* in this example. The flaw also appears in the destination window, which is positioned alongside to the left.

In this example, the window is configured to count black pixels, since any flaw in the can lid would be recorded as black pixels. Ideally, *no* black pixels would be detected, and the black pixel count would thus be zero. As Figure 7.27 shows, however, the flaw has resulted in a black pixel count of 303, which appeared in the Nominal field following a "learn" operation.

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Window Operations

When you pick the Operation field in the window tool edit panel, the Window Operation selection panel appears, as shown in Figure 7.28.

Figure 7.28 Window Operation Selection Panel



Table 7.2 lists all of the window operations, along with the applicable window shapes and mask availability.

Table 7.2 Summary of Window Operations

Window Operation	Window Shape	Mask?
White pixels	All	Yes*
Black pixels	All	Yes*
White contours	All	Yes*
Black contours	All	Yes*
Luminance	Rectangular and arc ring	No

*Not available with a polygonal window

White Pixels; Black Pixels

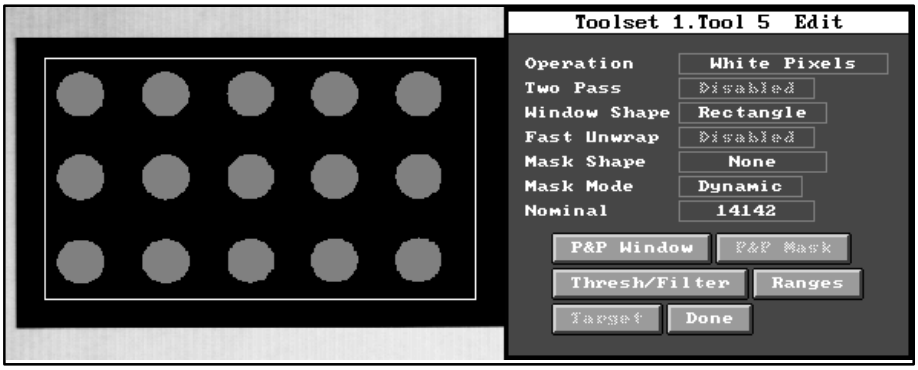
These two operations count the number of black or white *pixels* within the window boundaries. Since the image within the window is binarized, the workpiece features become either white or black, according to the threshold settings.

The main purpose of a pixel–counting window operation is to measure the *total area*, in pixels, of the specified workpiece feature(s).

Figure 7.29 (page 7–33) is an example that illustrates using a rectangular window and the white pixel–counting operation to measure the total area of the 15 *white* circular features on a *black* workpiece.

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Figure 7.29 Example: Using the White Pixel Counting Operation

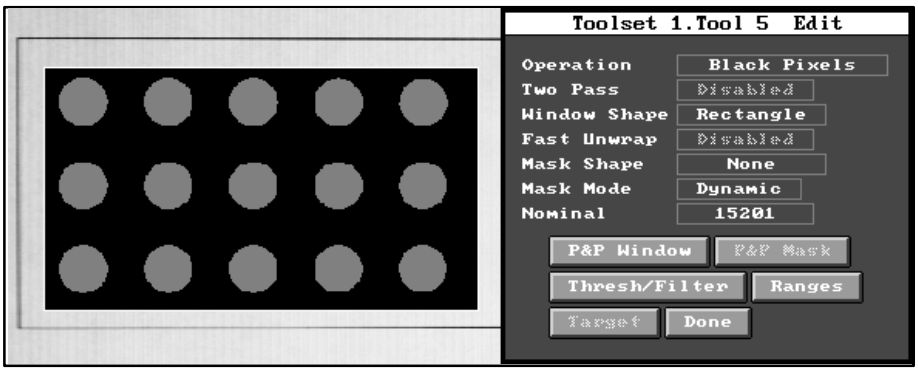


Note in Figure 7.29 that the "Nominal" value shows a total of 14142 white pixels — the sum of the white pixels in the 15 circular features.

NOTE: When counting black pixels, the image will be *inverted* so that the black pixels are displayed as white pixels on the screen, and vice versa.

Figure 7.30 is an example that illustrates using a rectangular window and the *black* pixel–counting operation to measure the total area of 15 *black* circular features on a *white* workpiece. In this example, the workpiece and its features are the *same size* as the workpiece and features in Figure 7.29.

Figure 7.30 Example: Using the Black Pixel Counting Operation



Note in Figure 7.30 that the "Nominal" value shows a total of 15201 black pixels — the sum of the black pixels in the 15 circular features (even though the "black" features appear *white* on the screen).

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White Contours; Black Contours

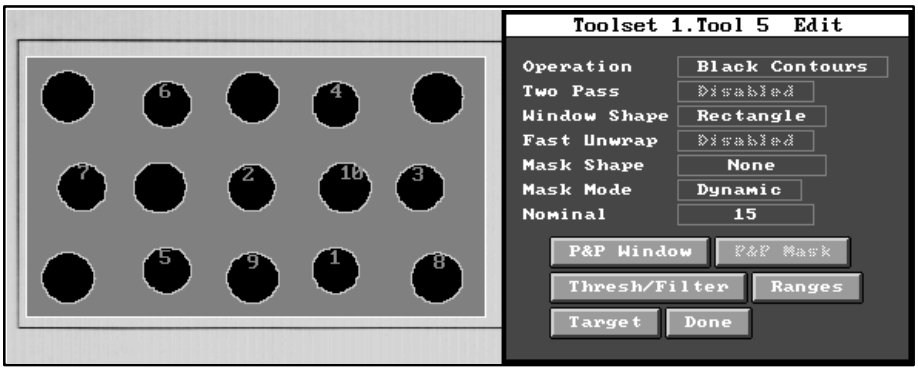
These two operations identify black or white *objects* within the window boundaries. The image is binarized into groups of black and white features called contours, and each contour can be analyzed on the basis of its area, shape, orientation, and/or other physical characteristics.

A contour window counts all contours whose color (black or white) and selected physical measurements qualify them as *objects*.

The *inspection result* is the *number* of contours that qualify as objects. For example, if a window contains 18 black features, but only 12 satisfy *all* of the measurement limits, the result from the contour operation will be to identify and count 12 objects.

Figure 7.31 shows a window using the black contours operation to count the number of black objects within the window's boundaries.

Figure 7.31 Example: Using the Contour Operation



For the purposes of this discussion, an *object* is a *contour* whose area and/or other measurement criteria meet user–specified limits.

White object: a group of contiguous white pixels surrounded by black pixels (within the window boundary).

Black object: a group of contiguous black pixels surrounded by white pixels (within a window boundary).

Both objects can range in size from one pixel to the total number of pixels in the window.

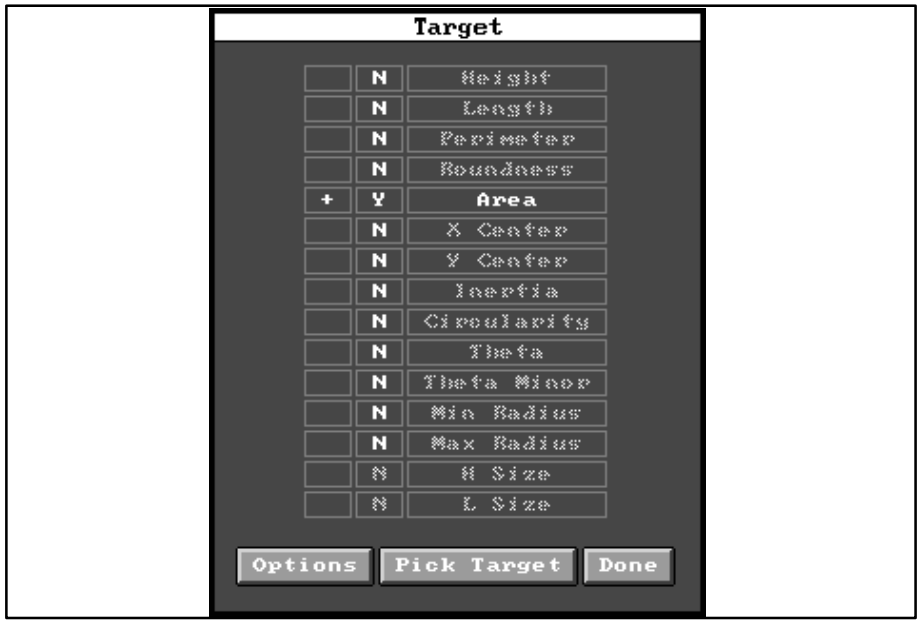
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Target Panel

The Target panel enables you to specify the measurement functions that determine which contours the window will identify and count as “objects.”

When you pick the Target button in the window tool edit panel, the Target panel appears on the screen, as shown in Figure 7.32.

Figure 7.32 Target Panel



Here is a brief description of the fields and buttons in the Target panel.

- **Contour measurement fields** — These fields enables you to “activate” the specific measurement functions that the contour window uses for a particular inspection application. The measurement functions evaluate each contour in the window, and it is their *collective criteria* that differentiates contours that qualify as “objects” from those that do not. The “Area” measurement function is activated by *default*.
- **Options** — When you pick the Options button, the Contour Options selection panel appears on the screen. This panel enables you to select the window border color, include or exclude “holes” in contours, the maximum number of measurement results to be stored, and the “nearest neighbor” function.
- **Pick Target** — When you pick the Pick Target button, the Pick Target display panel appears on the screen. This panel displays all of the measurement functions. If you pick any contour, measurement values for that contour will appear alongside each listed measurement function.
- **Done** — When you pick the Done button, the system exits back to the tool edit panel.

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Contour Measurement Fields

The contour measurement fields consist of three columns whose contents and functions are described briefly as follows:

Right Column — This column contains the full list of contour measurement functions. Here is a brief description of each:

- ***Height** — This is the distance, in pixels, from the topmost to the bottommost part of the object,.
- ***Length** — This is the distance, in pixels, from the leftmost to the rightmost part of the object.
- ***Perimeter** — This is the distance, in pixels, around the object.
- ***Roundness** — This is a percentage measure of the degree to which the *perimeter* of an object is circular. Thus, a perfectly circular perimeter would yield 100% with the roundness measurement.
- ***Area** — This is the area of the object, in pixels.
- **X Center** — This is the position of the centroid of the object, in pixels, along the X–axis of the image field.
- **Y Center** — This is the position of the centroid of the object, in pixels, along the Y–axis of the image field.
- **Inertia** — This is a measure of the distribution of mass in an object.
- **Circularity** — This is a percentage measure of the degree to which the *overall* object is circular, not just the perimeter. Thus, an object may have high circularity even when the perimeter is *not* circular (example: a gear with its teeth).
- **Theta** — This is a measure of the angle between the *major* axis of an object and the X–axis of the image field.
- **Theta Minor** — This is a measure of the angle between the *minor* axis of an object and the X–axis of the image field.
- **Min Radius** — This is the distance, in pixels, from the centroid of an object to the *nearest* point on the contour of the object.
- **Max Radius** — This is the distance, in pixels, from the centroid of an object to the *farthest* point on the contour of the object.
- ****H Size** — This is the length of an object along its *minor* axis.
- ****L Size** — This is the length of an object along its *major* axis.

*****These measurement functions are *always* calculated, even if they are not enabled. Each of the remaining functions require *additional* calculation time; thus, selecting one (or more) of these functions will increase the *total* calculation time.

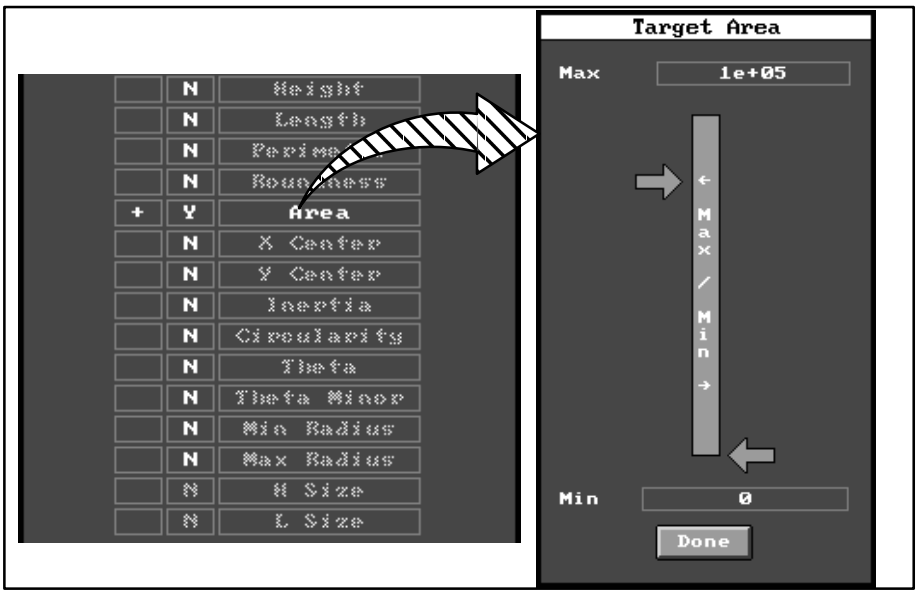
******These measurement functions are active only for Catalog No. 5370–CVIM2AC, which is a CVIM2 module equipped with an Advanced Contour Extractor (ACE) daughter board.

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NOTE: You can change the *status* of each measurement function to either *active* or *inactive*, according to whether it is required for a particular inspection application.

When you pick an active measurement function *name* in the measurement configuration table, such as "Area," a "Target" slide bar panel appears, as illustrated by the "Target Area" slide bar panel in Figure 7.33.

Figure 7.33 Example: Selecting "Target" Slide Bar Panel for Area Measurement Limits



Here is a brief description of each item in the slide bar panel. (The Target Area slide bar panel serves as an example for the other measurement functions, since they all use the same kind of slide bar panel.)

- **Slide bar** — The function of the slide bar cursors is to set high ("Max") and low ("Min") limits for the *area* of the contours that you want to be counted as *objects*.
- **Max** — Picking this field enables you to enter directly the *maximum* area (in pixels) of the contours to be counted as *objects*. This is used in place of the slide bar to enter values directly and will also *rescale* the slide bar on the basis of the value entered.
- **Min** — Picking this field enables you to enter directly the *minimum* area (in pixels) of the contours to be counted as *objects*. This is used in place of the slide bar to enter values directly and will also *rescale* the slide bar on the basis of the value entered.
- **Done** — When you pick the Done button, the system exits back to the Target panel.

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Note in Figure 7.33 that the Max and Min values are 100000 (using scientific notation: 1e+05) and 0, respectively. These are the *default* area values in pixels. In this case, since the area of each black object in the window lies *somewhere* between 0 and 100000 pixels (and no other measurement functions are active) each contour has a yellow border.

If you already know the maximum and minimum area values for your application, you can enter those values *directly* by picking the Max and Min fields. If not, you can use the Pick Target function to measure the area of the appropriate objects, then enter the appropriate high and low area limit values *directly* into the Max and Min fields. (Refer to the *Pick Target Panel* section, on page 7–43, for details.)

As a result of these Max and Min settings, the contour window will count as objects *only those contours of the selected color whose area is within the selected limits.*

Generally, contours that satisfy the limits of *all* of the *active* measurement functions (when two or more measurement functions are active) are displayed with a *yellow* border, and thus qualify as objects. On the other hand, if *no* measurement functions are active, *all* contours (of the selected color) qualify as objects.

NOTE: In some cases there may be *too many* contours to process; thus, *no* contours will be displayed *regardless* of the status of the measurement functions or their limit settings, and no objects will be counted. An appropriate error message will be displayed when you select "Nominal" to "learn" the number of objects. If this occurs, you can increase the "scratch" memory size in the configuration editor (Inspection panel) or use morphology to decrease the complexity of the image.

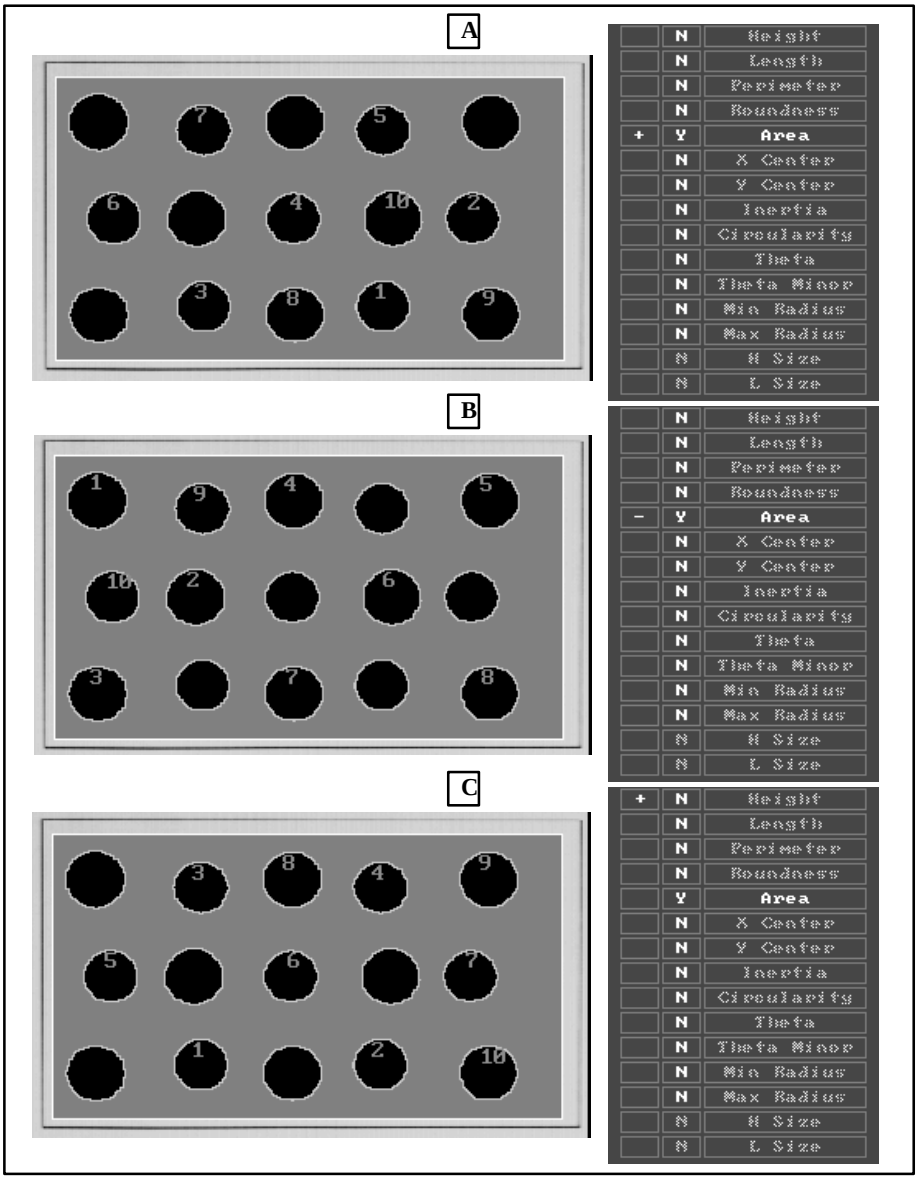
Center Column — This column selects the *status* of a measurement function as *active* (Y) or *inactive* (N). When a specific measurement function is *active*, its range limits determine which contours qualify as objects *insofar as that measurement function is concerned*. However, in order for any contour to qualify as an object, its measurement values must satisfy the limits of *all* active measurement functions.

Left Column — This column uses a "+" or "−" symbol to select *one* of the measurements as the basis for *ordering* the contours in the image field. Contours are ordered in either *ascending* or *descending* order according to the selected measurement parameters. Ordering the contours is provided for math tools and communication messages.

The *order* of the numbers is determined by both the selected measurement and the symbol. Figure 7.34 (page 7–39) provides some examples that illustrate this relationship. Note the changes in the locations of the numbers.

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Figure 7.34 Examples: Selecting Basis for Numbered Displays



In example (**A**), the "+" symbol appears on the "Area" line. The numbers 1 through 10 identify the objects, on the basis of their *area*, in *ascending* order — from the smallest to the largest of the 15 objects in the window. In this example, the smallest object (1) contains 1047 pixels, and the largest object (10) contains 1246 pixels. The areas of objects 2 through 9 lie between these two values.

In example (**B**), the "–" symbol appears on the "Area" line. The numbers 1 through 10 identify the objects on the basis of their *area* — in *descending* order — from the largest to the smallest. In this example, the largest object (1) contains 1309 pixels, and the smallest (10) contains 1080 pixels. The

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areas of objects 2 through 9 lie between these two values. Thus, the window measures the *largest* ten objects.

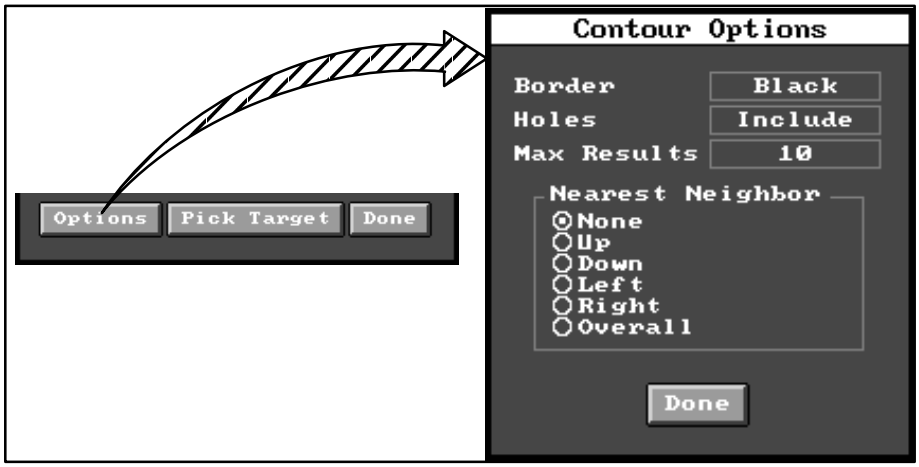
In example (**C**), the "+" symbol appears on the "Height" line. The numbers 1 through 10 identify the objects on the basis of their *height* — in *ascending* order — from the shortest to the tallest. In this example, the shortest object (1) is 34 pixels in height, and the tallest object (10) is 38 pixels in height. The heights of objects 2 through 9 lie between these two values. Thus, the window measures the *shortest* ten objects.

NOTE: The status of a measurement function (Y = *active*; N = *inactive*) has no effect on the sorting function. Also, the *maximum* possible number of numbered objects (when *all* contours are recognized as objects) can be limited by the current Max Results setting. Thus, in the examples above, all 15 contours are recognized as objects, but since the Max Results setting is 10, only the first ten are numbered and measured.

Contour Options Panel

When you pick the Options button in the Target panel, the Contour Options selection panel appears, as shown by Figure 7.35.

Figure 7.35 Selecting Contour Options Panel



Here is a brief description of the fields and button in the Contour Options selection panel.

- **Border** — This field selects either a white border or a black border for the window, with the following consequences:
  - — If the border color selection is Black, any *black* group of pixels that touches the border is not a contour.
  - — If the border color selection is White, any *white* group of pixels that touches the border is not a contour.

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- **Holes** — This field determines whether to Include or Exclude "holes" in contours (for example, white holes in black features) in calculating the area, X and Y centers, inertia, circumference, and theta of the contours.
- **Max Results** — This field enables you to enter the maximum number of *measurement results* that can be stored in memory. The *default* setting is 10. The range limits are 0 and 100.
- **Nearest Neighbor panel** — This selection panel enables you to activate the nearest neighbor function and select a *direction* for the "Nearest" and "NearestBox" contour measurement functions.
- **Done** — When you pick the Done button, the system exits back to the Target panel.

Here are some *additional* details about the Max Results and Nearest Neighbor functions:

Max Results function — The Max Results number, as noted above, limits the number of measurements whose results values are stored in memory. Thus, if the contour window recognizes 15 contours as objects, but Max Results is set to 10, then only the measurement results for objects 1 through 10 can be stored.

The specific results values that are stored depend on which measurement functions are *active*. For example, if the Area and Height measurement functions are both active (a "Y" symbol alongside), the results data from these two measurement functions will be stored for all objects up to the Max Results number.

The utility of the stored results data is that they can be accessed by math tool formulas and by the communications message editor. For information about these uses of the results data, refer to the *Math Tool* section in Chapter 7, *Inspection Tools*, and the *CVIM2 Communications Reference Manual*.

Nearest Neighbor function — This function identifies the object that is the "nearest neighbor" to a target object according to user specified *direction* criteria, and it returns *two* values for the distance, in pixels, between the target object and its "nearest neighbor," as follows:

1. The "Near" value, which is the distance between the *centroid* of one object and the *centroid* of the nearest object, and
2. The "NearBox" value, which is the distance between the closest edges of one object's *bounding box* and the nearest object's bounding box.

These two values are available as "expanded results" in a math tool formula that references a window tool that is configured for a contour operation.

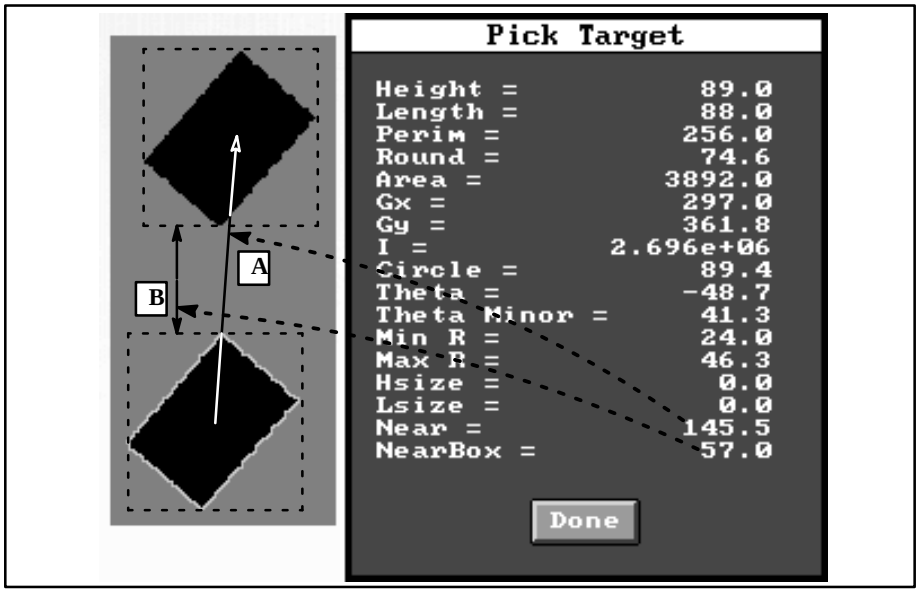
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The Nearest Neighbor selection panel (Figure 7.35, page 7–40) enables you activate the nearest neighbor function and select a *direction* in which to search for the nearest neighbor, as follows:

- **None** — This selection *disables* the nearest neighbor function.
- **Up, Down, Left, Right** — These selections correspond to the *nearest neighbor* above, below, to the left of, and to the right of the target object.
- **Overall** — This selection corresponds to the nearest neighbor in *any* direction.

Figure 7.36 is an example that compares the "Near" result, which measures the distance between two objects' *centroids*, and the "NearBox" result, which measures the distance between two objects' *bounding boxes*.

Figure 7.36 Example: Comparing "Near" and "NearBox" Results



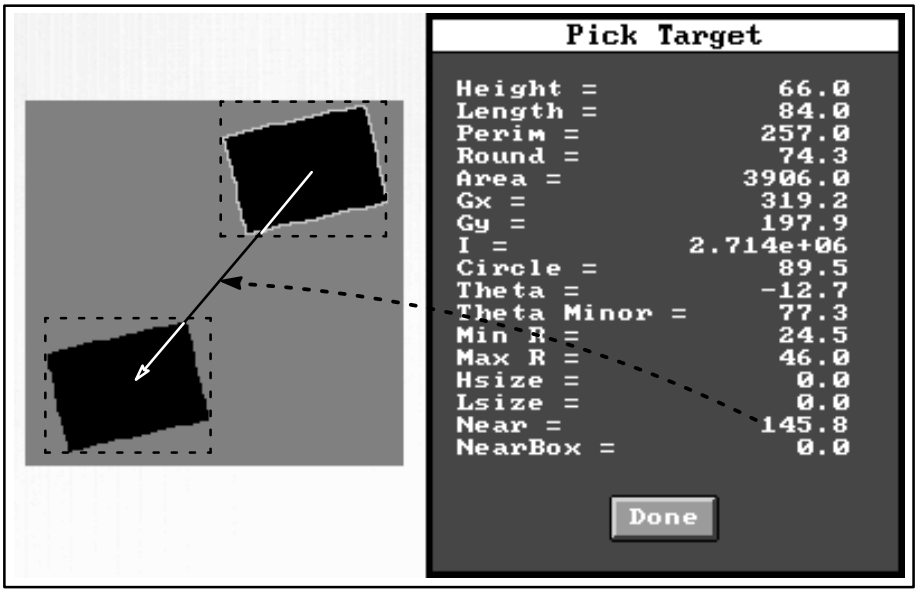
In this example, "Up" was selected in the Nearest Neighbor selection panel, and the *lower* of the two objects was then picked (it has a red border when picked). Note that the distance (**A**) between the *centroids* of the two objects is 145.5 pixels, while the distance (**B**) between the closest edges of the two objects' *bounding boxes* is 57.0 pixels.

When a direction such as "Up" is selected in the Nearest Neighbor panel, the bounding boxes of the target object and the nearest "Up" object must *overlap* in a *vertical* direction in order for the "Up" object to be detected. In Figure 7.36, the bounding boxes clearly do overlap in the vertical direction; thus, when the *lower* object is picked, the two values are calculated. (Note that if the *upper* object were picked, in this example *no* values would be calculated because there is no object above it in the window.)

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In Figure 7.37, however, the orientation of the two objects precludes any overlap of the objects' bounding boxes in either the vertical or the horizontal direction. Thus, neither "Near" or "NearBox" values are calculated when "Up," "Down," "Left," or "Right" directions are selected, regardless of which object is picked as the "target." In this example "Overall" was selected, and only the "Near" value (the distance between centroids) is calculated as 145.8 pixels.

Figure 7.37 Example: No Overlap of Objects' Bounding Boxes



NOTE: Range limits cannot be set *directly* for the two nearest neighbor values, as they can for contour measurement values. If, however, any range limits are required for the "Near" or "NearBox" values, they can be implemented in a math tool formula.

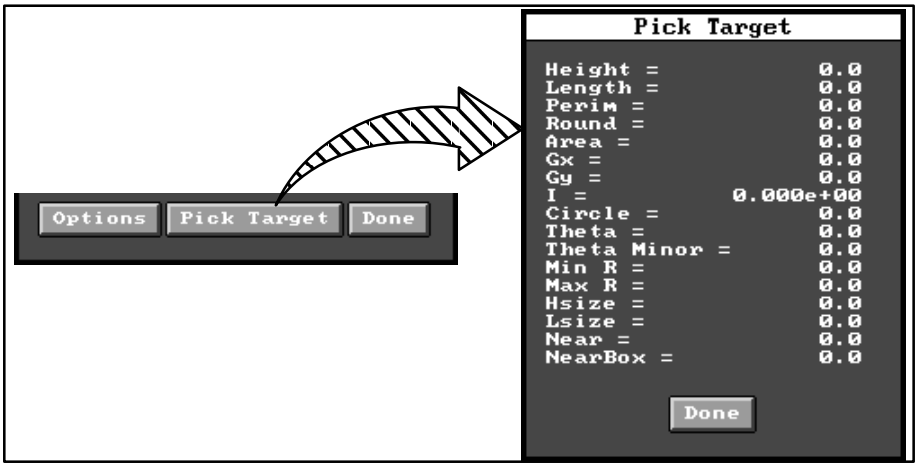
Pick Target Panel

When you pick the Pick Target button in the Target panel, the Pick Target panel appears, as shown by the example in Figure 7.38 (page 7–44).

The left column in this panel lists all of the contour measurement functions, and the right column displays the measurement results values for these measurement functions. (Initially, these values are all zero.)

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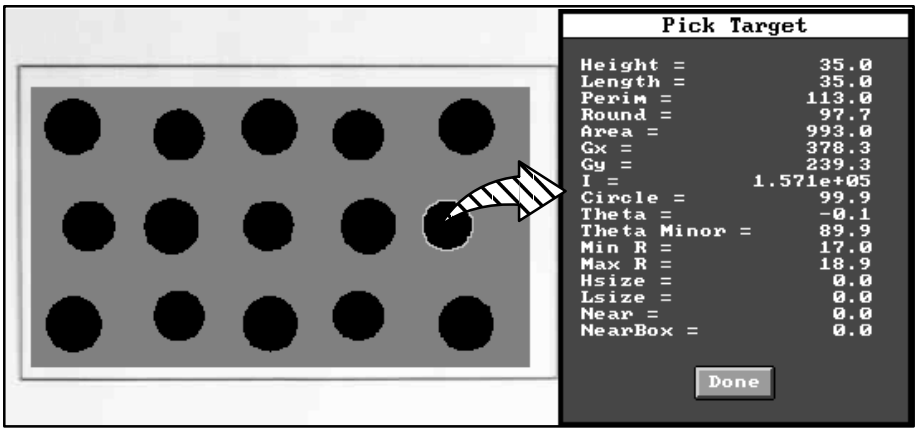
Figure 7.38 Example: Selecting Pick Target Panel



When you pick one of the objects in the image field, the measurement results values for that object appear in the right column of the Pick Target panel, as illustrated by the example in Figure 7.39.

NOTE: The picked object's border is highlighted in *green* when *all* of its measurement results values lie within the limits selected for the *active* measurement functions (that is, the measurement functions with "Y" selected in the Target panel. See Figure 7.33 on page 7–37). The object's border is highlighted in *red* if *any* of these values lie outside a selected limit.

Figure 7.39 Example: Picking Contour to Get Measurement Data



You can use the Pick Target function to obtain and record the measurement data from all of the appropriate objects. You can then return to the slide bar panels for the active measurement functions and enter the appropriate minimum and maximum limit values *directly* into the corresponding Min and Max fields.

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Contour Measurement Functions

The contour measurement functions described earlier are mostly self explanatory. Thus, the height, length, perimeter, area, X and Y center (of *centroid*, not midpoint), and minimum and maximum radius measurement functions are relatively straightforward in concept and implementation. Roundness, circularity, inertia, and theta are less intuitive, however, and are therefore discussed here in more detail.

Roundness — Roundness is a measure of how close an object is to being a perfect circle when the perimeter is smooth and crisp. The measurement is expressed in percentages, with 100 percent being a theoretically perfect circle. (A straight line will yield a "roundness" of about 1 or 2 percent.) The formula that the CVIM2 system uses to calculate roundness in *percent* is:

$$\left(\frac{4\pi A}{P^2}\right) \times 100$$

. . . where A is the area value and P is the perimeter value.

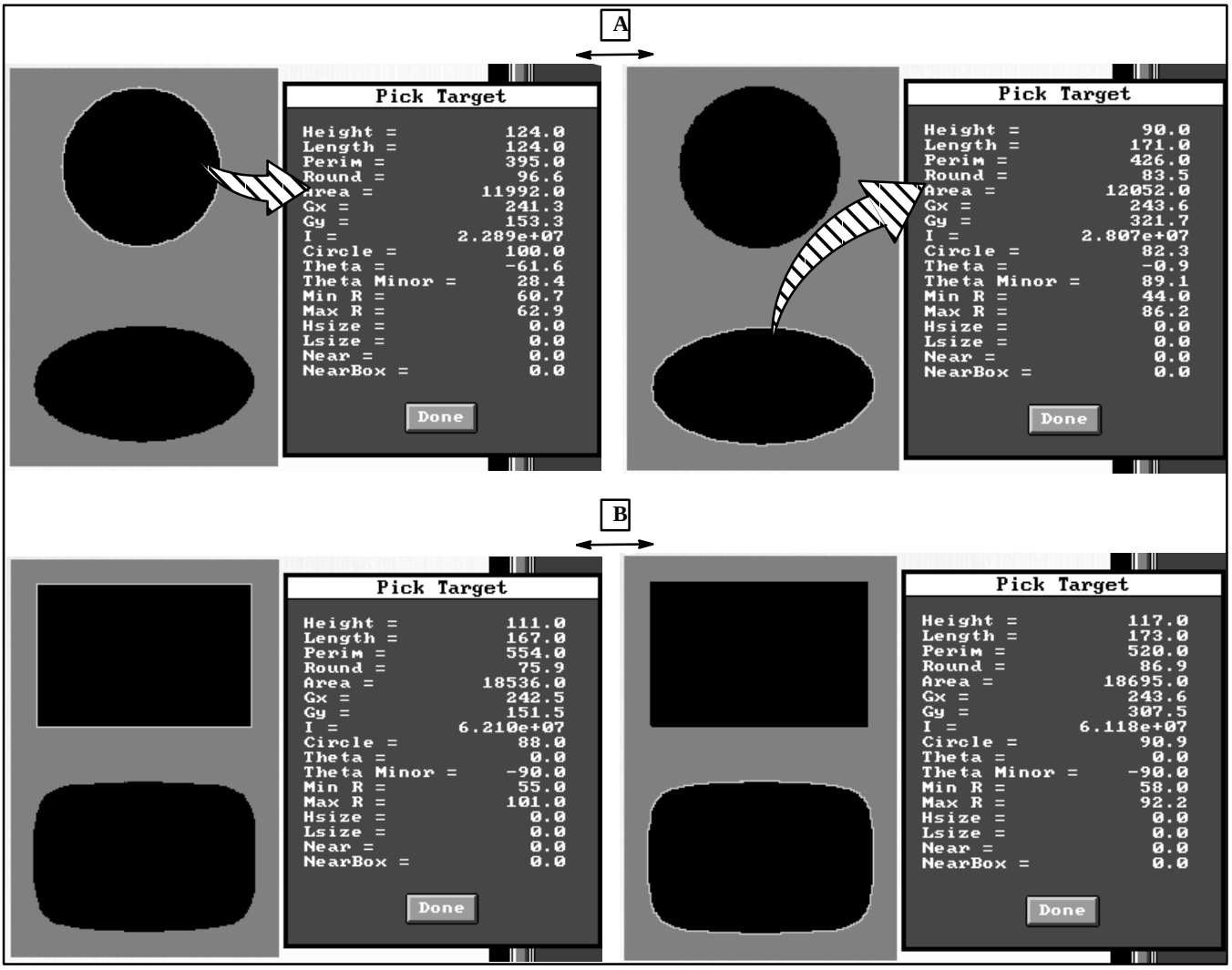
Figure 7.40 (**A**) (page 7–46) compares the roundness of two figures, a circle (1) and an ellipse (2), whose *area* measurements are very close (11,992.0 pixels for the circle and 12,052.0 pixels for the ellipse), but whose *roundness* values are noticeably different (96.6% for the circle and 83.5% for the ellipse). Thus, the roundness measurement function could be used to differentiate two objects such as these.

Figure 7.40 (**B**) compares the "roundness" of two rectangular figures, one with sharply squared corners (2) and the other with rounded corners (1), whose *area* measurements are very close (18,536.0 pixels for the squared rectangle and 18,695.0 pixels for the rounded rectangle), but whose *roundness* values are noticeably different (75.9% for the squared rectangle and 86.9% for the rounded–corner rectangle). Thus, the roundness measurement function could also be used to differentiate two *non–round* objects such as these.

The roundness measurement function works best when the perimeter is smooth and regular and conforms to the basic shape of the object. When the perimeter is fuzzy or convoluted, however, the roundness value can be lowered considerably compared to an object of the same basic shape, but with smooth, regular perimeter. In such cases, the circularity measurement function may be required.

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Figure 7.40 Example: Comparing Roundness of Various Shapes



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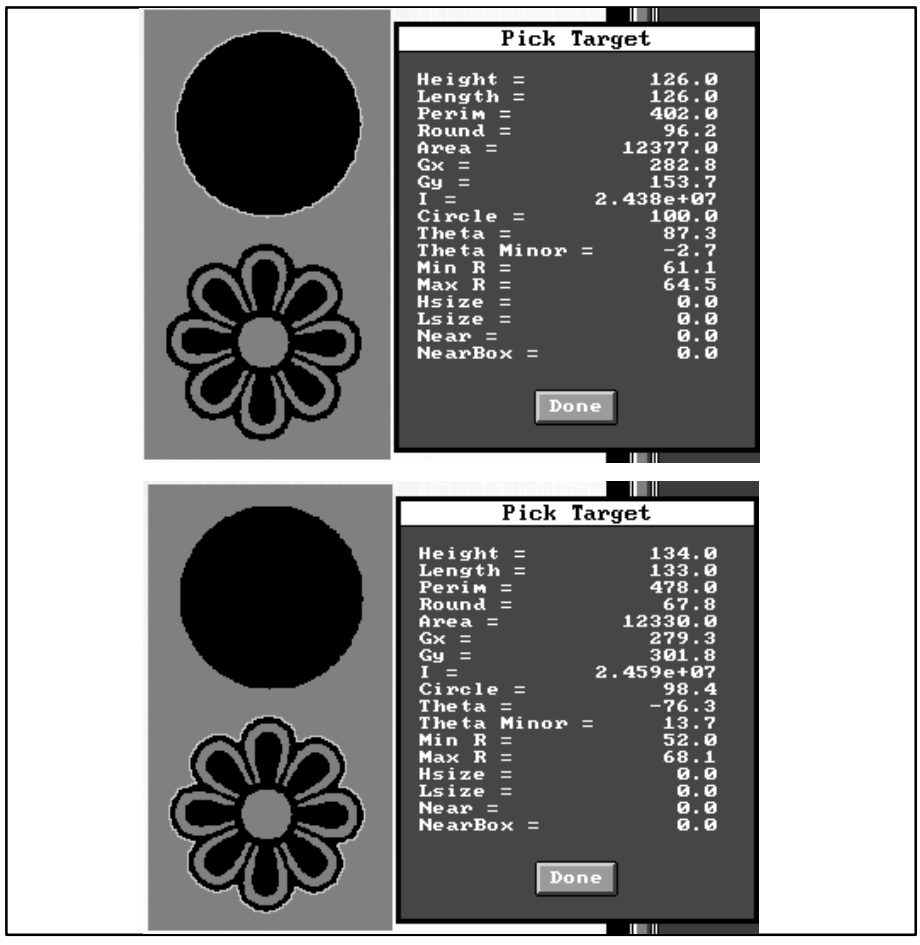
Circularity — Circularity is a measure of how close the basic shape of an object is to being a perfect circle, and it is expressed in percentages, with 100 percent being a theoretically perfect circle. Circularity measurement is especially useful when the perimeter of an otherwise circular object is fuzzy or convoluted. The formula that the CVIM2 system uses to calculate circularity in *percent* is . . .

$$\left(\frac{A^2}{2\pi \times I}\right) \text{ x } 100$$

. . . where A is the area value and I is the inertia value.

For example, in Figure 7.41, the two shapes are both basically circular and have similar areas (12,377.0 for the circle vs 12,330.0 for the “flower” shape). The circle has a regular, smooth perimeter, which results in a *roundness* of 96.2%, while the flower shape has a convoluted perimeter, and therefore has a *roundness* of only 67.8%. Note, however, that the circle has a *circularity* of 100.0%, and the flower has a *circularity* of 98.4%. This indicates the ability of the circularity measurement function to ignore the effects of a convoluted edge.

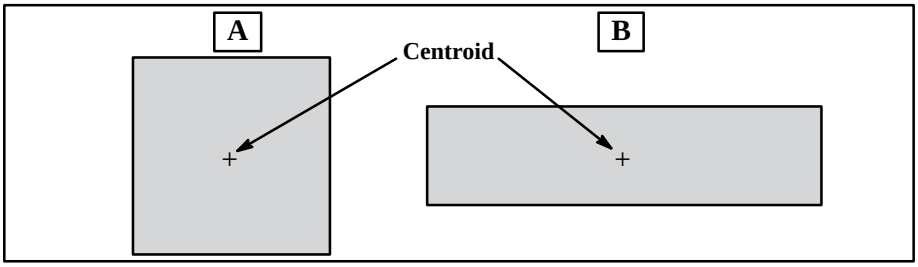
Figure 7.41 Example: Comparing Circularity to Roundness



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Inertia — The sum, over all pixels within the contour, of the squared distance from the centroid to each pixel. This is equivalent to the moment of inertia of the contour if rotated about its centroid. A contour with its mass distributed close to its centroid, such as (**A**) in Figure 7.42, has less inertia than a contour of the same area with its mass widely distributed, such as (**B**) in Figure 7.42.

Figure 7.42 Example: Inertia of Two Objects With Identical Areas



Theta — Theta measures the angle between the *major* axis of an object and the X–axis of the image field (assuming 0° at the 3 o'clock position). Since a clearly definable major axis is required for this measurement function to work properly, it cannot be used with circular objects.

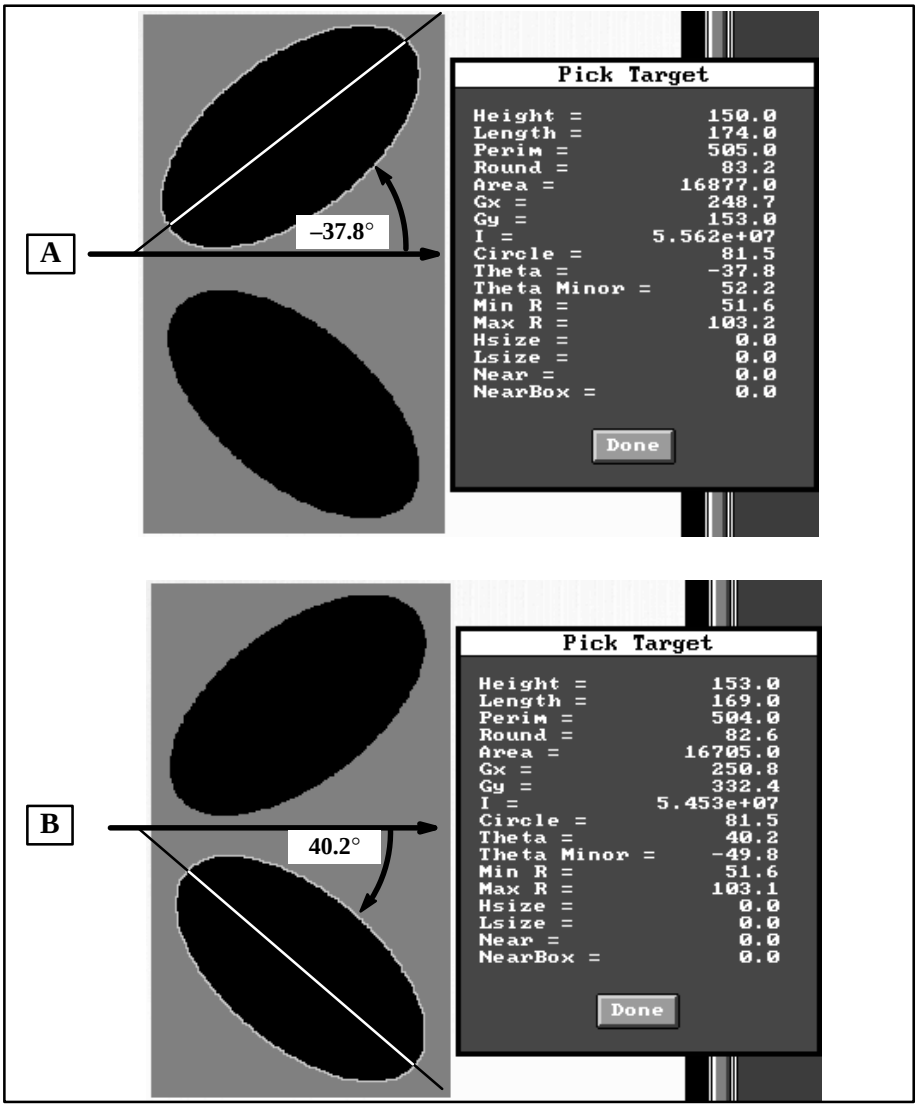
Figure 7.43 (page 7–49) illustrates the theta angle of two identical elliptical objects with different orientations in the image field. In this example, the major axis of object (**A**) is –37.8° (counterclockwise) from the X–axis, while object (**B**) is 40.2° (clockwise) from the X–axis.

Note that the maximum measurable angle in each direction is 90.0° (clockwise) and –90.0° (counterclockwise), since there is no provision for resolving the *direction* of the major axis. For example, if the object in Figure 7.43 (**A**) were to rotate counterclockwise past the –90.0° point, its theta would become *positive*.

NOTE: Although the angle values appear in the Pick Target panel with an apparent accuracy of one place to the right of the decimal, the actual values available to the math tool are stored with the full floating point accuracy.

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Figure 7.43 Example: Theta of Two Objects of Different Orientation

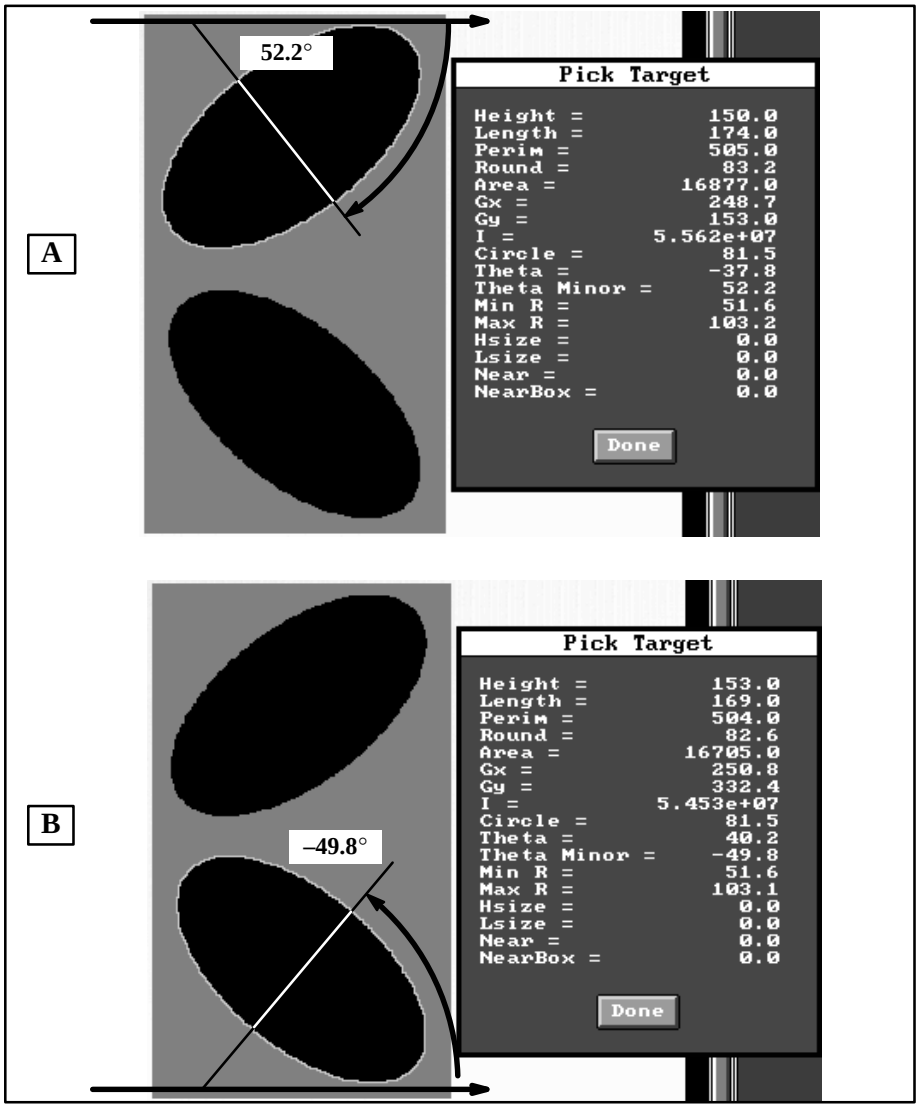


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Theta Minor — Theta minor measures the angle between the *minor* axis of an object and the X–axis of the image field (assuming 0° at the 3 o'clock position). Since a clearly definable minor axis is required for this measurement function to work properly, it cannot be used with circular objects.

Figure 7.44 illustrates the theta angle of two identical elliptical objects with different orientations in the image field. In this example, the minor axis of object (**A**) is.52.2° (clockwise) from the X–axis, while object (**B**) is –49.8° (counterclockwise) from the X–axis.

Figure 7.44 Example: Theta Minor of Two Objects of Different Orientation



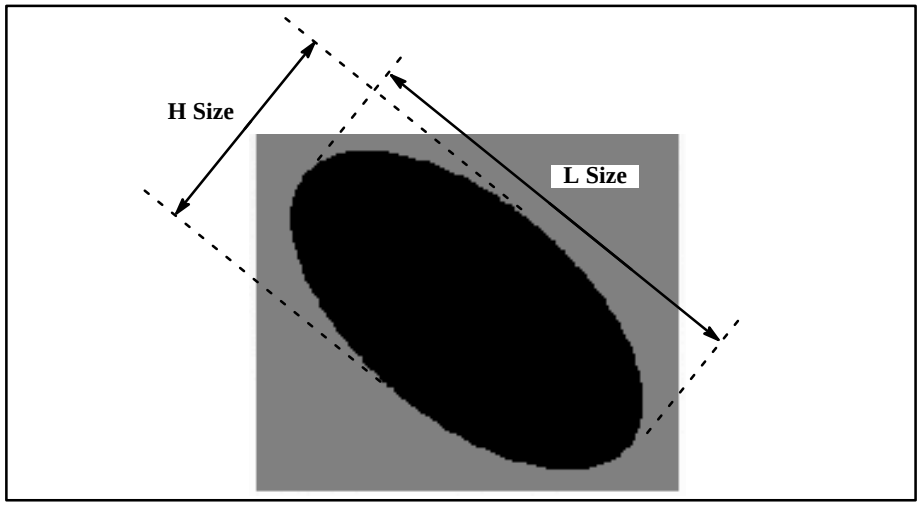
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Note that the maximum measurable angle in each direction is 90.0° (clockwise) and –90.0° (counterclockwise), since there is no provision for resolving the *direction* of the major axis. For example, if the object in Figure 7.43 (**A**) were to rotate counterclockwise past the –90.0° point, its theta would become *positive*.

NOTE: Although the angle values appear in the Pick Target panel with an apparent accuracy of one place to the right of the decimal, the actual values available to the math tool are stored with the full floating point accuracy.

H Size, L Size — The L Size contour measurement function returns the size, in pixels, of an object's *major axis*, while the H Size function returns the size of an object's *minor axis*, as illustrated in Figure 7.45.

Figure 7.45 Example: H Size and L Size Contour Measurement Functions



NOTE: These measurement functions are active only for Catalog No. 5370–CVIM2AC, which is a CVIM2 module equipped with an Advanced Contour Extractor (ACE) daughter board.

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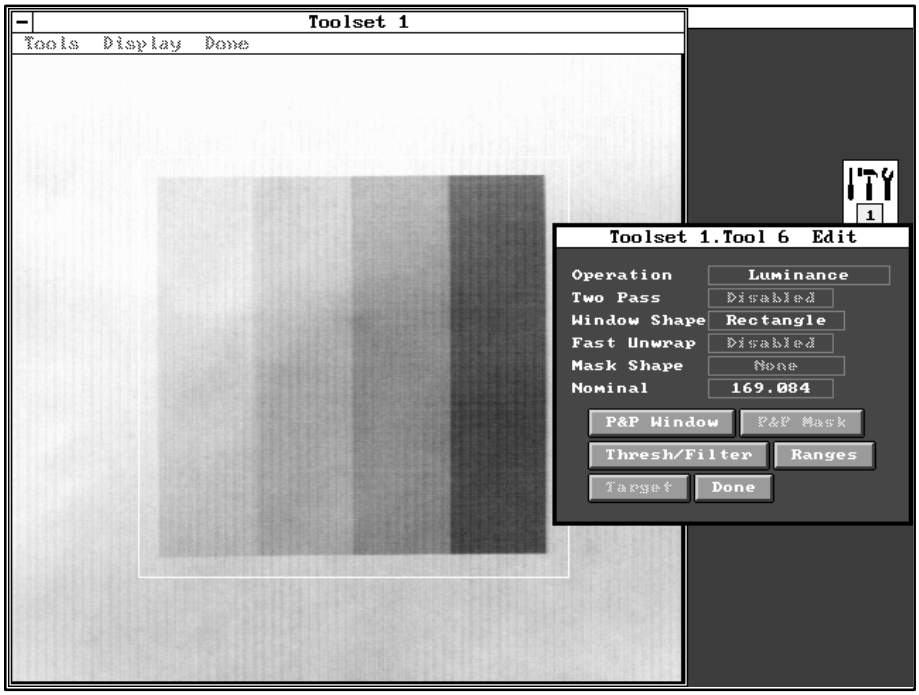
Luminance

The luminance window operation calculates the average luminance, or gray scale value, of all the pixels within the window. The average is based on gray scale values ranging from 0 to 255, where 0 is the darkest value, and 255 is the brightest value.

Refer to Table 7.2 (page 7–32) for shape restrictions when using the luminance operation.

Figure 7.46 illustrates the luminance operation. In this example, the "nominal" average luminance is 169.084.

Figure 7.46 Example: Using the Luminance Operation



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Two Pass

Some morphology functions can create artifacts along the border of the window. When two pass is used, the first pass actually processes additional pixels around the border of the window. The second pass runs within the border of the window to compute the result, which is unaffected by the border artifacts. Thus, two pass can provide more accurate results, but it runs slower.

Two Pass is *active* only when a destination buffer is assigned to a window in the toolset edit panel (such as "Proc1," as shown in Figure 7.24, page 7–27). The destination buffer stores the results of the first image processing pass, which the window then uses for the second image processing pass.

Figure 7.47 (page 7–54) provides an example that illustrates using Two Pass to eliminate a white ring of pixels inside the border of a circular window. This ring is the result of morphology operations performed in the first image processing pass.

The example shows a circular window using the white pixel counting operation and the two morphology stages (Morph 1 and Morph 2).

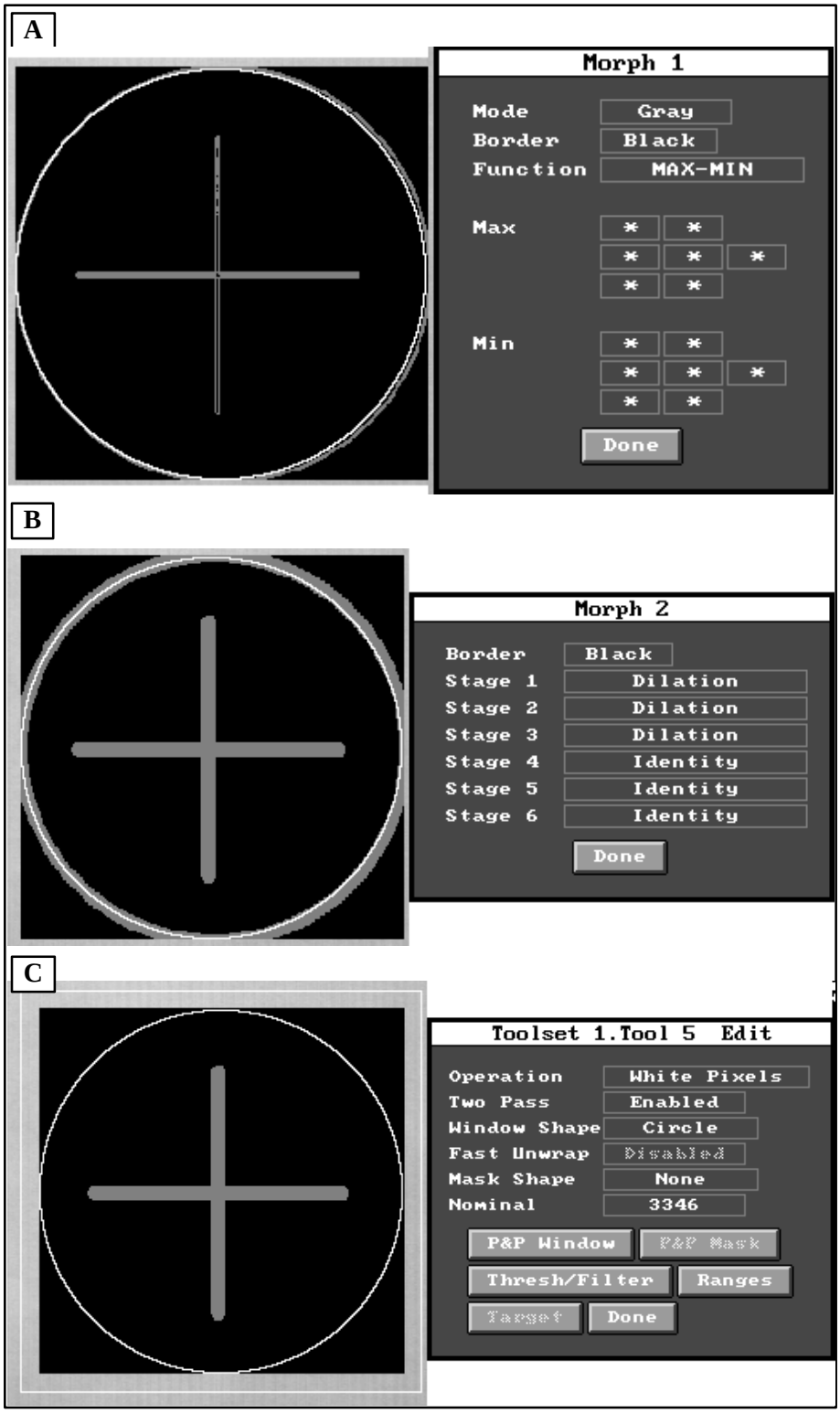
Figure 7.47 (**A**) and (**B**) illustrate the results of applying MAX–MIN, followed by binary dilations, to the image. The result of this morphology processing shows the edges of the cross *plus* a ring of white pixels around the edge of the window that are a side effect of the morphology processing.

If just *one* pass were used, the ring of pixels would remain inside the circular window, and the window would count them along with the pixels in the cross. The result would be, in this case, a "nominal" value of 10617 (not shown), which is the sum of the pixels in the ring and the cross. This is an inaccurate and unrepresentative pixel count for the purposes of the inspection.

By using Two Pass, however, a *second* pass will *exclude* the ring of pixels, as shown in Figure 7.47 (**C**), and count *only* the pixels in the cross. In this case, the "nominal" value is 3711 pixels, which represents the pixel count in the cross.

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Figure 7.47 Example: Using Two Pass to Remove Unwanted Pixels

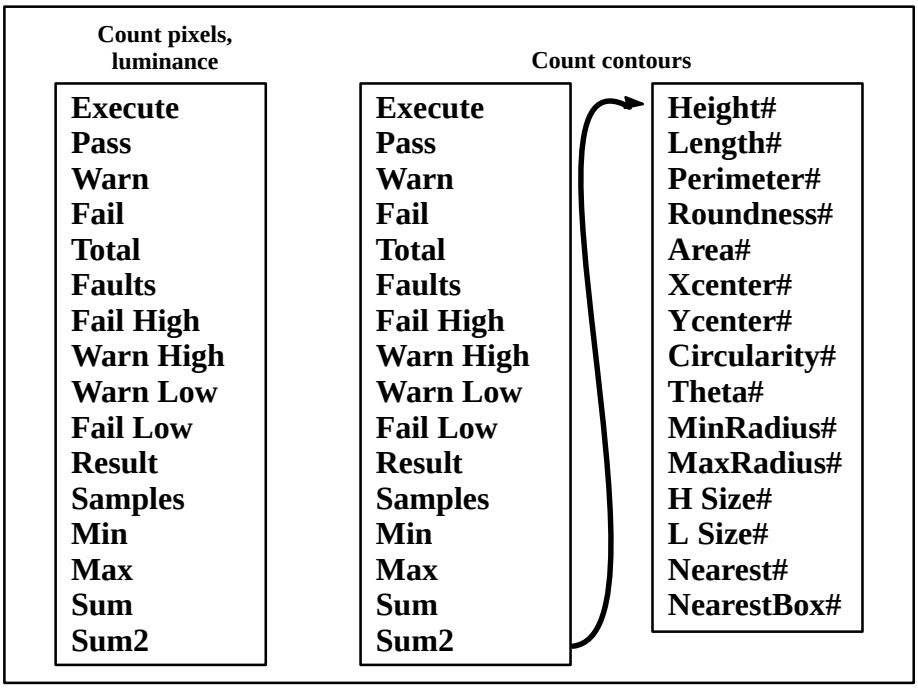


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Window Tool Inspection Results and Math Tool Formulas

This section discusses the expanded inspection results that are available to a math tool formula from a window tool. The specific set of expanded results depends on the specific window tool operation. As Figure 7.48 shows, the expanded inspection results that correspond to any particular window tool *operation* will appear in one of two scrolling lists.

Figure 7.48 Expanded Results Lists For Window Tools in Math Formulas



(Note that the two lists under “Count contours” in Figure 7.48 are really *one* scrolling list shown in two parts in order to display all of the results values that are available with contour operations when *all* measurement functions are enabled.)

Here is a brief definition and explanation of each of the expanded result types listed in Figure 7.48.

- **Execute** — This returns a 1.000 when the tool has *executed* its inspection task, and 0.000 for all other conditions.
- **Pass** — This returns a 1.000 when the tool has *passed* its inspection task, and 0.000 for all other conditions.
- **Warn** — This returns an “error code” when the tool is in a *warn* condition (and *not* in a *fail* condition) and 0.000 for all other conditions. The error code identifies a specific reason for the warning; for example, error code 1057.000 identifies “Low range warning” as the cause. The complete list of error codes and warn conditions appears in Appendix A of this manual.

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- **Fail** — This returns an "error code" when the tool is in a *fail* condition, and 0.000 for all other conditions. The error code identifies a specific reason for the failure; for example, error code 1045.000 identifies "High range fail" as the cause of the inspection failure. The complete list of error codes and fail conditions appears in Appendix A of this manual.
- **Total** — This returns the total number of inspections performed.
- **Faults** — This returns the total number of faults detected.
- **Fail High** — This returns a 1.000 when the inspection result from the tool has exceeded the *high* Fail limit and 0.000 when the result has *not* exceeded the *high* Fail limit.
- **Warn High** — This returns a 1.000 when the inspection result from the tool has exceeded the *high* Warn limit (and the tool is *not* in a *fail* condition) and 0.000 when the result has *not* exceeded the *high* Warn limit.
- **Warn Low** — This returns a 1.000 when the inspection result from the tool has exceeded the *low* Warn limit and 0.000 when the tool has *not* exceeded the *low* Warn limit.
- **Fail Low** — This returns a 1.000 when the inspection result from the tool has exceeded the *low* Fail limit and 0.000 when the result has *not* exceeded the *low* Fail limit.
- **Result** — This returns the actual value of the inspection result; that is, the count or other numeric result from the window tool. This value corresponds to the "learned" value that appears in the "Nominal" field of the window tool edit panel.
- ***Height#, Length#, etc.** — Each of these returns a *contour measurement* value, which is available *only* from a window tool configured for black or white contour operations. Figure 7.48 (page 7–55) shows how the list appears when *all* of the contour measurement functions are *enabled*.
- ****Samples** — This returns the current total number of inspection samples since the start of run operation.
- ****Min** — This returns the current *minimum* value of the inspection results since the start of the run operation.
- ****Max** — This returns the current *maximum* value of the inspection results since the start of the run operation.
- ****Sum** — This returns the current *sum* of all inspection results since the start of the setup or online run operation.
- ****Sum2** — This returns the current *sum* of the *squares* of all inspection results since the start of the setup or online run operation.

*Whenever one of these contour measurement functions is selected in a math tool formula, the "#" sign must be *replaced* with the appropriate *object number* when the "Single" operation is selected in the math tool edit panel.

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The object number that replaces the "#" sign must conform to these two requirements:

1. The object number must be a *constant* non–zero, positive integer.
2. The object number must be equal to, or less than, the *maximum* number appearing in the window.

When the "Multiple" operation is selected, the "#"sign must be *retained* in the formula (replacing or removing the "#" will cause incorrect results). For details about the Multiple operation mode, see the math tool example, *Example: Using a Single Math Tool to Generate Multiple Results*, on page 7–144.

Also, see the *Example: List Processing* section on page 7–141 for an additional example of using the "#" in a math formula.

**These expanded *statistical* results are available only when a tool is enabled for *statistics* operations, as indicated by a checked Statistics box in the tool's Options selection panel.

NOTE: Any formula that references an object (in the contour window) whose number is equal to or lower than the Max Results setting in the Target panel, but is *not found* in the window, will cause the math tool to *fail*. For example, if the Max Results setting is 10 and the contour window finds only five objects, the math tool will fail if the formula references objects 6 through 10.

Image Tool

An image tool performs processing operations on a portion of the image, using spatial (geometric) transformations, convolution, or image arithmetic, along with multiple stages of morphology. It temporarily stores the processed image in a *destination* image buffer, which can be accessed by tools that *follow* the image tool in the toolset edit panel.

Figure 7.49 (page 7–58) is an example that illustrates how an image tool could be set up, using source and destination images, to provide a processed image to a tool that follows it in the toolset edit panel.

In this example, the image tool (Tool 3) designates C1 (under the "S1" heading) as its image *source* and P1 (under the "Dest" heading) as its *destination* buffer. The following window tool (Tool 4) designates P1 — the processed image — as its image *source*. (Note that the gage tool (Tool 1) and the first window tool (Tool 2) *cannot* receive the image from the image tool, since they both *precede* the image tool in the toolset edit panel.)

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Figure 7.49 Example: Image Tool and Window in Toolset Edit Panel



Overview: Image Tool Operations

An image tool can be configured for one of three principal types of image enhancement operations; namely, *transform*, *convolve*, and *image arithmetic* operations.

Note that *morphology* filtering is available to all three image enhancement operations (see Chapter 8, *Threshold, Filters, And Morphology* for details about morphology filtering). Special look up tables (LUTs) are also available to the three image enhancement operations; however, they are not normally used with the *transform* operation.

Here is a brief description of each image enhancement operation:

Transform — A transform operation can perform spatial transformation ("warping") functions, which alter the *shape* of the image within an image tool, but do not alter the gray scale values of the pixels in the image. These functions are available *only* with the arc ring, quad, and perspective *shape* selections; they are *not* available with the convolve and image arithmetic operations. (The *Shape* section on page 7–87 of this manual provides details about spatial transformation operations.)

Convolve — A convolve operation can perform one of several spatial filtering functions, each of which provides *one* of the following *basic* results:

- Enhances *gradients* in the image that represent edges (or flaws) on inspected objects.
- Removes *noise* from the image.

Spatial filtering functions employ a "kernel" that performs "neighborhood operations" on all pixels within an image tool's "area of interest." The kernel is a matrix of coefficients that perform calculations on the gray scale values of a "neighborhood" of pixels, and the result of these calculations modifies the pixel that lies under the *center* of the matrix. This process continues throughout the image, moving from left to right and top to bottom.

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In the CVIM2 system, some spatial filtering functions (such as Sobel) have their kernel coefficients arrayed in specific pattern that, by convention, achieves a specific filtering effect. Others spatial filter functions have user–selectable coefficients.

NOTE: The user of *convolution* operations should have an understanding of the basic concepts of 3x3 and 5x5 "neighborhood operation" processes. For more information on this subject, here are some additional information sources:

- *Computer Imaging Recipes in C*, by H. R. Myler and A. R. Weeks, PTR Prentice Hall, 1993, ISBN 0–13–189879–5.
- *The Image Processing Handbook*, by J. C. Russ, CRC Press, 1992, ISBN 0–8493–4233–3.
- *Digital Image Processing: A Practical Primer*, by G. A. Baxes, Cascade Press, 1984, ISBN 0–945591–00–4.

Image Arithmetic — Arithmetic operations can perform subtraction or addition between images from two sources: a *primary* image source (S1), and one of three *secondary* image sources (S2, S1', or T). The S1 and S2 sources are either a camera (such as C1) or the output of an image processing tool (such as P1). The "S1'" image source is always the *current* image, while the "T" image source is a "feature" image stored from the current image or from an earlier one.

A typical application of image subtraction is to cancel *identical* features in two images and emphasize *different* features. A typical application of image addition is to combine features of two images into a single image for further analysis.

Image Tool Edit Panel

When "Image" is picked in the toolset edit panel, the image tool edit panel appears, as shown in Figure 7.50.

Figure 7.50 Example: Image Tool Edit Panel



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The image tool edit panel (named "Toolset 1.Tool 3 Edit" in Figure 7.50) contains several data fields and buttons. These are described briefly as follows:

- **Operation** — This field selects the type of operation that the image tool is to perform: image transformation, convolution, or arithmetic operations. The *default* operation is Transform.
- **Shape** — This field selects the image tool shape: rectangle, arc ring, quad, or perspective. The *default* shape is Rectangle.
- **Fast Unwrap** — This box is *active* only when the Transform operation is selected using the Arc Ring shape. When enabled, the "unwrap" function operates faster, but requires 1208 bytes more memory.
- **Kernel** — This field is active only when the Convolve operation is selected. It selects the "kernel" type and configuration to be used in the neighborhood operation. The *default* kernel is Sobel X.
- **Template** — This field is active only when an image arithmetic operation using an S1 – T or S1 + T function is selected. The Template field accesses the Image Manager panel, from which a portion of the current image can be stored and selected (or a *previously* stored image selected) as the *secondary* image source, T (the "template"), to be subtracted from or added to the *primary* image source, S1.
- **Direction** — This field is active only when an image arithmetic operation is selected. It enables selecting a scan direction for the *secondary* image (S2, S1', or T) that differs from the scan direction of the *primary* image (S1).
- **LUT** — This field selects a look–up table (LUT), which remaps the gray scale values of the image pixels following a transform, convolution, or image arithmetic operation. The *default* LUT is Identity, which has no effect on the pixels.
- **Morph Passes** — The field selects the number of times the image is passed through the morphology processors.
- ***P&P AOI 1** — The P&P AOI 1 button activates the pick and place function for AOI#1 (Area Of Interest #1), which is the *primary* area within the source image (S1) that is "of interest" for the inspection operation.
- ***P&P AOI 2** — The P&P AOI 2 button activates the pick and place function for AOI#2 (Area Of Interest #2), which is the *secondary* area within the source image (S2 or S1') that is "of interest" for the inspection operation. (This button in not active for S1 – T or S1 + T operations.)
- **P&P Dest** — The P&P Dest button activates the "destination" pick and place function. This button is active only for Transform operations using the arc ring, quad, or perspective shape, which send the processed image to a separate destination window. (For Convolve and image arithmetic operations, a "destination buffer," such as P1, must be specified in the toolset edit panel.)

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- **Thresh/Filter** — The Thresh/Filter button activates threshold and/or filter functions that are appropriate for the selected image tool operation.
- **Done** — When you pick the Done button, the system exits back to the toolset edit panel.

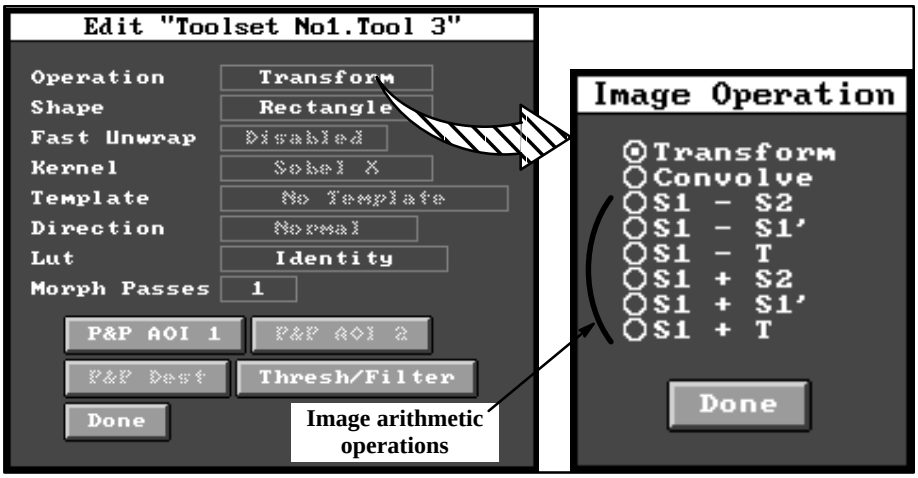
**Area of Interest* — The portion of a source image that an image tool processes is referred to as an *area of interest* (AOI), and it can be configured ("picked and placed") using the P&P AOI 1 and P&P AOI 2 buttons in the tool edit panel.

The functions of the data fields and buttons in the tool edit panel are described in the following discussions of the image tool operations and supporting functions.

Image Tool Operations: Selection

When the Operation field in the tool edit panel is picked, the Image Operation panel appears, as shown in Figure 7.51.

Figure 7.51 Image Operation Selection Panel



The Image Operation panel lists the three image tool operation *types* referred to earlier. Note that the last six operations are identified as *image arithmetic* operations.

You can select a specific image tool operation by picking the circle adjacent to the operation name, then picking the Done button. The tool edit panel returns with the selected operation name appearing in the Operation field.

The following sections discuss the image tool operations in detail.

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Image Tool Operations: Transform

The Transform operation is the appropriate choice under the following conditions:

- The required image processing can be performed adequately using morphology filters *alone*.
- An “unwrap” or “warp” spatial transformation function is required, and it can be performed by the arc ring, quad, or perspective shape.

In the first instance, refer to Chapter 8, *Thresholds, Filters, and Morphology*, in the *Area Tools: Threshold and Morphology Functions* section for morphology details. In the second instance, refer to the *Shape* section on page 7–87 of this chapter for details about the “unwrap” and “warp” spatial transformation functions.

Image Tool Operations: Convolve

The Convolve operation type is an appropriate choice when the Transform operation, using morphology filtering, cannot adequately process the image.

In addition to morphology filtering, the Convolve operation provides several spatial filtering functions, some using kernels with fixed coefficients, that can clarify or sharpen image features, or can smooth features and/or reduce noise in the image. Convolve also provides two kernels having user–configurable coefficients, for situations in which the fixed–coefficient kernels do not quite match the spatial filtering requirements. These kernels enable the user to experiment with other coefficient configurations in an attempt to improve the feature enhancement results.

This section discusses the details of the various spatial filter functions performed by the kernels listed in the Image Kernel selection panel (Figure 7.75, page 7–91) and illustrates their effects on image features. This section also provides a selection table that correlates the various kernels with the LUT(s) that are the most appropriate for the desired feature enhancement outcomes.

Sobel X, Sobel Y Kernels

The Sobel X and Sobel Y kernels perform *directional* spatial filtering functions that sharpen gradients lying along the Y–axis of the image (Sobel X) or the X–axis (Sobel Y). The kernels for these two functions use the same coefficient *values*, but these values are arrayed differently in each kernel.

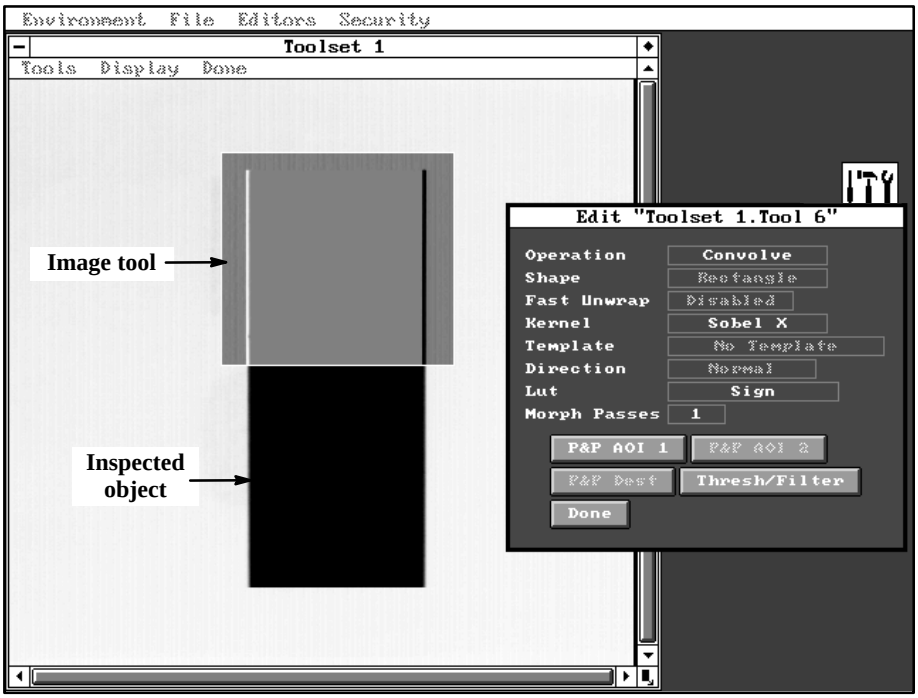
Sobel X Kernel — The coefficients in the Sobel X kernel are arrayed in a 3x3 matrix, as follows:

1	0	–1
2	0	–2
1	0	–1

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Figure 7.52 illustrates the effect of the Sobel X kernel on a dark object on a light background.

Figure 7.52 Example: Effect of Sobel X Kernel on Inspected Object



In Figure 7.52, the Sobel X kernel causes the gradient on the *left* side of the inspected object to appear as a thin vertical line of light pixels, and the *right* gradient to appear as a line of dark pixels. The pixels surrounding the two gradients were converted to medium gray.

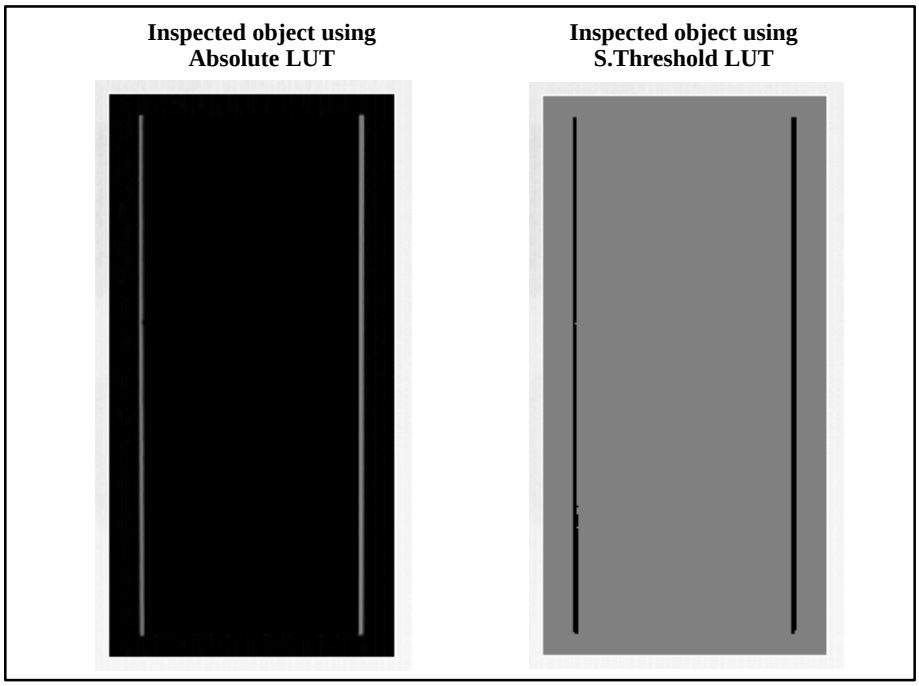
Note that the Sign LUT was selected for the example. Since the Sobel X kernel creates a *signed* image, which contains pixel values between –128 and +127, the Sign LUT removes negative values from the image by adding 128 to each value, thereby placing all pixel values in the 0 to 255 range that the inspection tools require to identify and evaluate features properly.

Note also that the Absolute, S.Threshold, or S.Clip LUT could be used, since they also remove negative values from the image. The choice of LUT depends on the specific requirements for the application.

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Figure 7.53 illustrates the effects on the inspected object that Absolute and S.Threshold LUTs have when using the Sobel X kernel.

Figure 7.53 Example: Effects of Absolute and S.Threshold LUTs With Sobel X Kernel



Sobel Y Kernel — The coefficients in the Sobel Y kernel are arrayed in a 3x3 matrix, as follows:

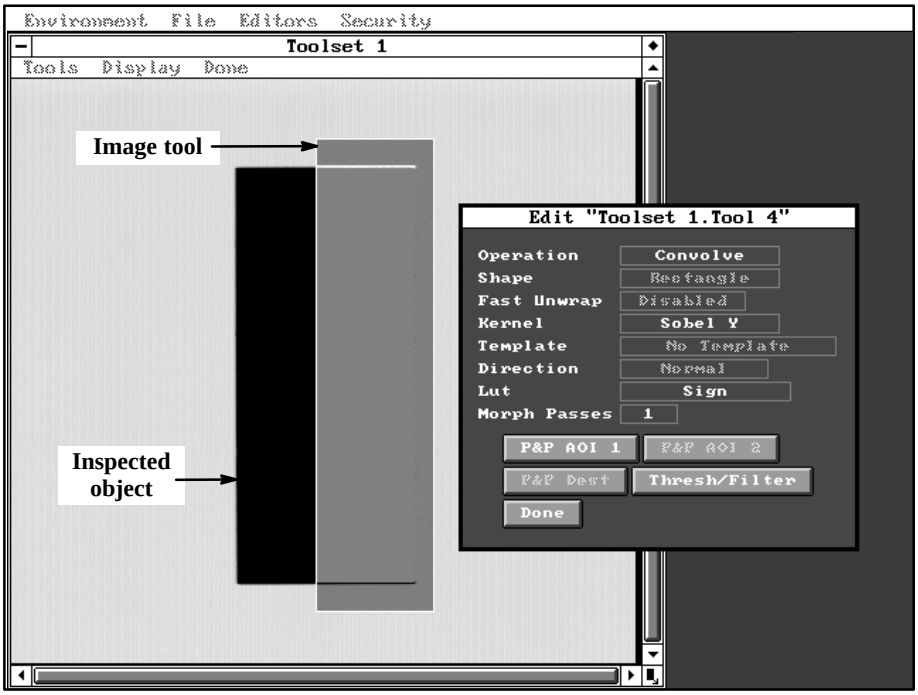
1	2	1
0	0	0
–1	–2	–1

Figure 7.54 (page 7–65) uses the inspected object shown in Figure 7.52 (page 7–63) to illustrate the effect of the Sobel Y kernel.

In Figure 7.54, the Sobel Y kernel causes the gradient on the *top* side of the inspected object to appear as a thin horizontal line of light pixels, and the *bottom* gradient to appear as a line of dark pixels. The pixels surrounding the two gradients were converted to medium gray.

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Figure 7.54 Example: Effect of Sobel Y Kernel on Inspected Object



Note that the Sign LUT was selected for the example. Since the Sobel Y kernel creates a *signed* image, which contains pixel values between –128 and +127, the Sign LUT removes negative values from the image by adding 128 to each value, thereby placing all pixel values in the 0 to 255 range that the inspection tools require to identify and evaluate features properly.

Note also that the Absolute, S.Threshold, or S.Clip LUT could be used, since they also remove negative values from the image. The choice of LUT depends on the specific requirements for the application.

The effects on the inspected object that the Absolute and S.Threshold LUTs have when using the Sobel Y kernel would be similar to the Sobel X examples in Figure 7.53 (page 7–64).

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Laplace Kernel

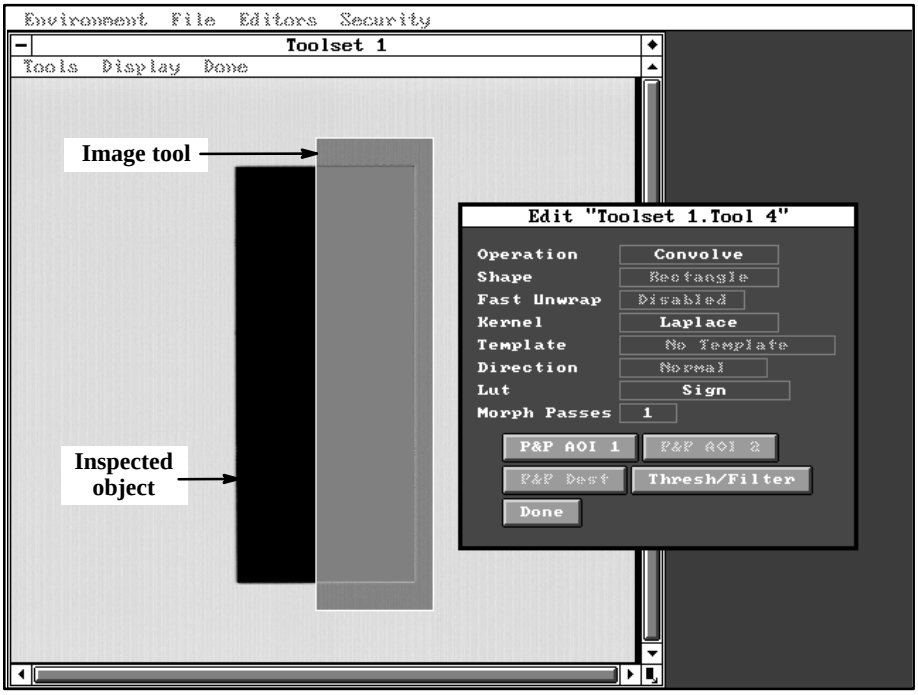
The Laplace kernel performs *nondirectional* spatial filtering functions that sharpen gradients lying along both the X–axis and the Y–axis of the image.

The coefficients in the Laplace kernel are arrayed in a 3x3 matrix, as follows:

0	–1	0
–1	4	–1
0	–1	0

Figure 7.55 illustrates the effect of the Laplace kernel on a dark inspected object on a light background.

Figure 7.55 Example: Effect of Laplace Kernel on Object in Image



In Figure 7.55, the Laplace kernel causes the gradients on the *all* sides of the inspected object to appear as a very thin line of light pixels, while the pixels surrounding the gradients were converted to medium gray.

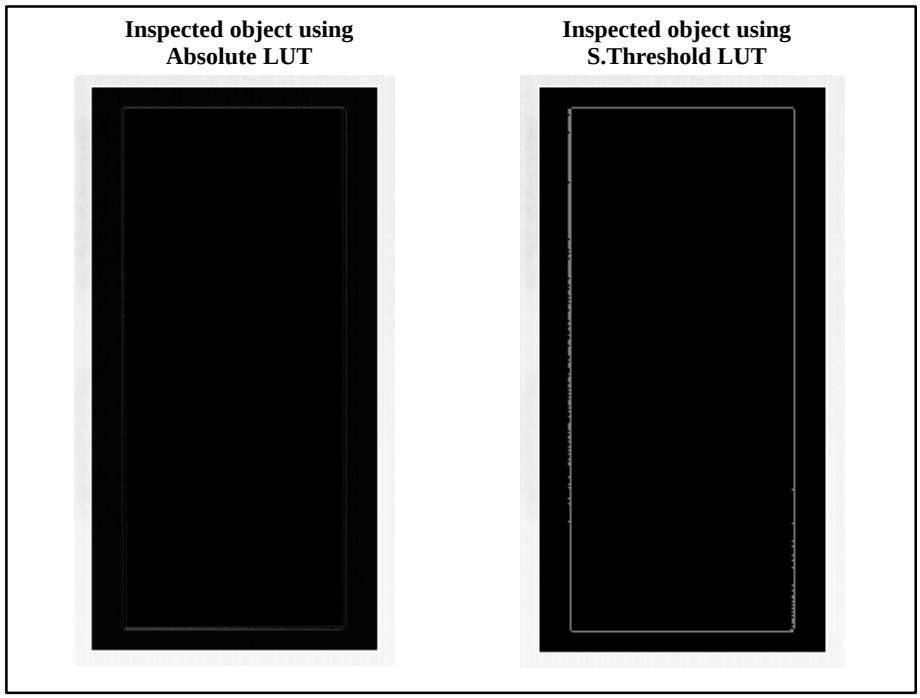
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Note that the Sign LUT was selected for the example. Since the Laplace kernel creates a *signed* image, which contains pixel values between –128 and +127, the Sign LUT removes negative values from the image by adding 128 to each value, thereby placing all pixel values in the 0 to 255 range that the inspection tools require to identify and evaluate features properly.

Note also that the Absolute, S.Threshold, or S.Clip LUT could be used, since they also remove negative values from the image. (When used with the Laplace kernel, however, the Absolute LUT yields a somewhat indistinct gradient compared to the S.Threshold LUT.) In any case, the choice of LUT depends on the specific requirements for the application.

Figure 7.56 illustrates the effects on the inspected object that Absolute and S.Threshold LUTs have when using the Laplace kernel.

Figure 7.56 Example: Effects of Absolute and S.Threshold LUTs With Laplace Kernel



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X Edge, Y Edge Kernels

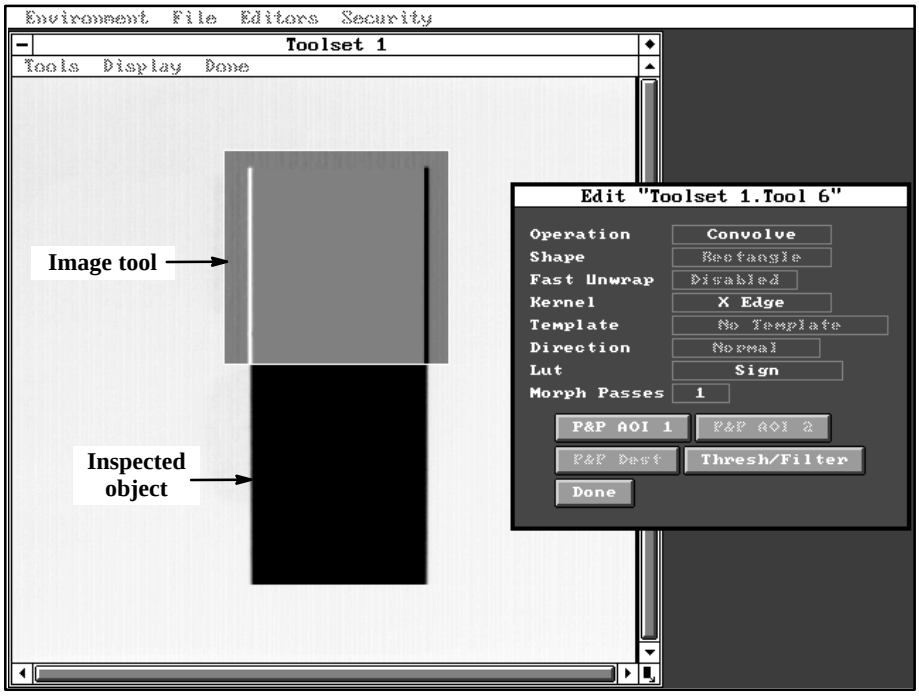
The X Edge and Y Edge kernels perform *directional* spatial filtering functions that sharpen gradients lying along the Y–axis of the image (X Edge) or the X–axis (Y Edge). (Note that the effect is similar to that of the Sobel kernels, except that the X Edge's 5x5 kernel produces a *wider gradient* than the Sobel X's 3x3 kernel.) The kernels for these two functions use the same coefficient *values*, but these values are arrayed differently in each kernel.

X Edge Kernel — The coefficients in the X Edge kernel are arrayed in a 5x5 matrix, as follows:

1	1	0	–1	–1
1	2	0	–2	–1
2	4	0	–4	–2
1	2	0	–2	–1
1	1	0	–1	–1

Figure 7.57 illustrates the effect of the X Edge kernel on a dark object on a light background.

Figure 7.57 Example: Effect of X Edge Kernel on Inspected Object



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In Figure 7.57, the X Edge kernel causes the gradient (edge) on the *left* side of the inspected object to appear as a vertical line of light pixels, and the *right* gradient (edge) to appear as a line of dark pixels. The pixels surrounding the two gradients were converted to medium gray. (Compare the results in this figure to the results of the Sobel X kernel in Figure 7.52 on page 7–63.)

Note that the Sign LUT was selected for the example. Since the X Edge kernel creates a *signed* image, which contains pixel values between –128 and +127, the Sign LUT removes negative values from the image by adding 128 to each value, thereby placing all pixel values in the 0 to 255 range that the inspection tools require to identify and evaluate features properly.

Note also that the Absolute, S.Threshold, or S.Clip LUT could be used, since they also remove negative values from the image. The choice of LUT depends on the specific requirements for the application.

The effects on the inspected object that the Absolute and S.Threshold LUTs have when using the X Edge kernel would be similar to the Sobel X examples in Figure 7.53 (page 7–64). The main difference is that the X Edge kernel produces a *wider* gradient.

Y Edge Kernel — The coefficients in the Y Edge kernel are arrayed as follows:

1	1	2	1	1
1	2	4	2	1
0	0	0	0	0
–1	–2	–4	–2	–1
–1	–1	–2	–1	–1

Figure 7.58 (page 7–70) uses the inspected object shown in Figure 7.57 (page 7–68) to illustrate the effect of the Y Edge kernel.

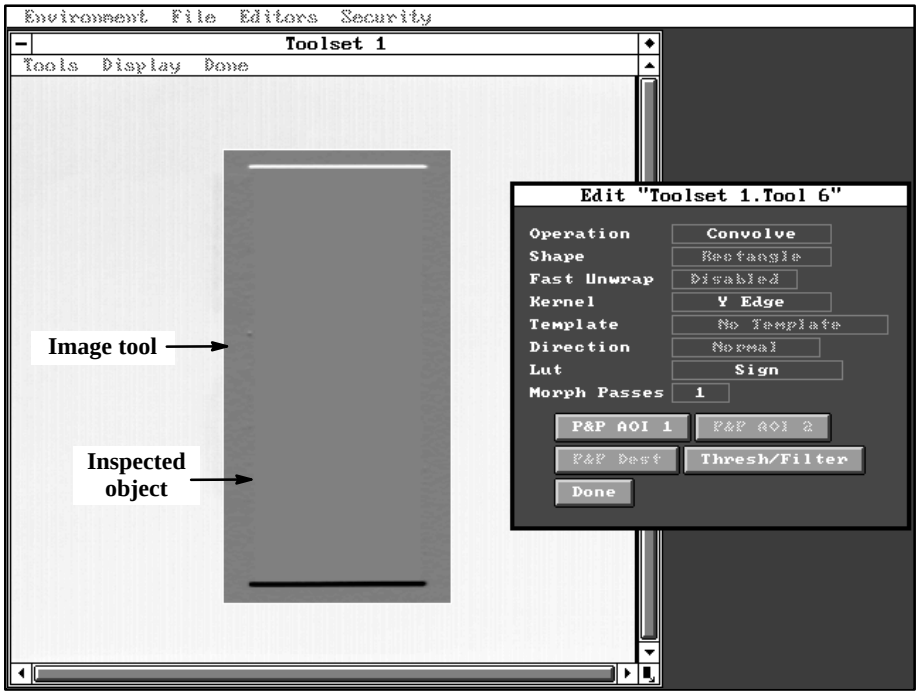
In Figure 7.58, the Y Edge kernel causes the gradient (edge) on the *top* side of the inspected object to appear as a horizontal line of light pixels, and the *bottom* gradient (edge) to appear as a line of dark pixels. The pixels surrounding the two gradients were converted to medium gray.

Note that the Sign LUT was selected for the example. Since the Y Edge kernel creates a *signed* image, which contains pixel values between –128 and +127, the Sign LUT removes negative values from the image by adding 128 to each value, thereby placing all pixel values in the 0 to 255 range that the inspection tools require to identify and evaluate features properly.

Note also that the Absolute, S.Threshold, or S.Clip LUT could be used, since they also remove negative values from the image. The choice of LUT depends on the specific requirements for the application.

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Figure 7.58 Example: Effect of Y Edge Kernel on Inspected Object



The effects on the inspected object that the Absolute and S.Threshold LUTs have when using the Y Edge kernel would be similar to the Sobel X examples in Figure 7.53 (page 7–64). The main difference is that the Y Edge kernel produces a *wider* gradient.

XY Edge Kernel

The XY Edge kernel is a Laplace–type kernel that performs *nondirectional* spatial filtering functions that sharpen gradients lying along both the X–axis and the Y–axis of the image. (Note that the effect is similar to that of the Laplace kernels, except that the XY Edge's 5x5 kernel produces a *wider gradient* than the Laplace's 3x3 kernel.)

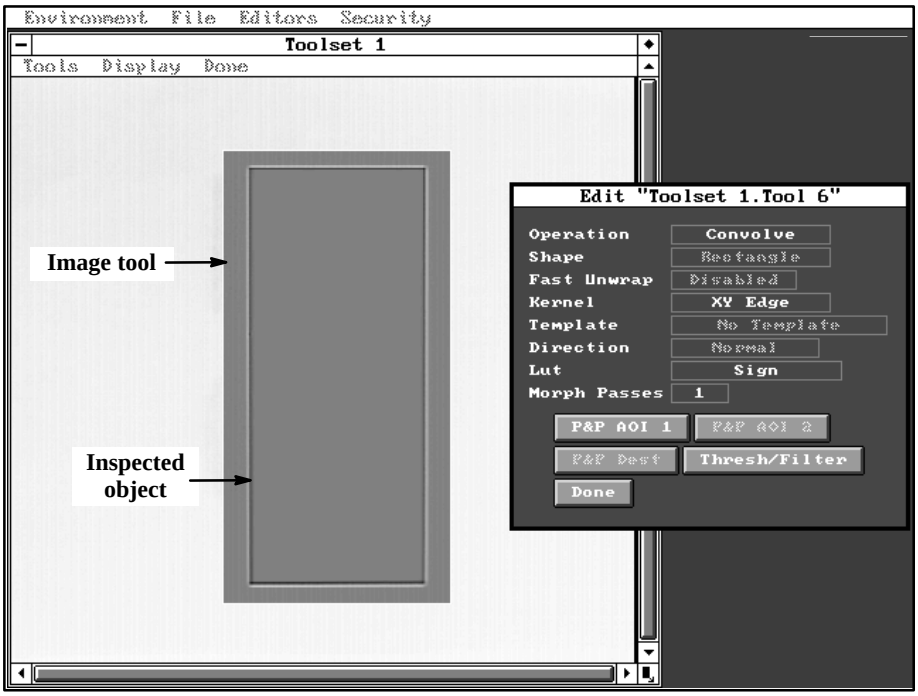
The coefficients in the XY Edge kernel are arrayed in a 5x5 matrix, as follows:

–1	–1	–1	–1	–1
–1	1	2	1	–1
–1	2	4	2	–1
–1	1	2	1	–1
–1	–1	–1	–1	–1

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Figure 7.59 illustrates the effect of the XY Edge kernel on a dark inspected object on a light background.

Figure 7.59 Example: Effect of XY Edge Kernel on Inspected Object



In Figure 7.59, the XY Edge kernel causes the gradients on the *all* sides of the inspected object to appear as a thin line of light pixels, while the pixels surrounding the gradients were converted to medium gray.

Note that the Sign LUT has been selected. This LUT removes negative values from the image by adding 128 to each value, thereby placing all values in the 0 to 255 range that the inspection tools require to identify and evaluate features properly.

Note also that the Absolute, S.Threshold, or S.Clip LUT could be used, since they also remove negative values from the image. (When used with the XY Edge kernel, however, the Absolute LUT yields a somewhat indistinct double gradient compared to the S.Threshold LUT.) In any case, the choice of LUT depends on the specific requirements for the application.

The effects on the inspected object that the Absolute and S.Threshold LUTs have when using the XY Edge kernel are similar to those shown in Figure 7.56 (page 7–67) for the Laplace kernel.

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Average 3x3, Average 5x5 Kernels

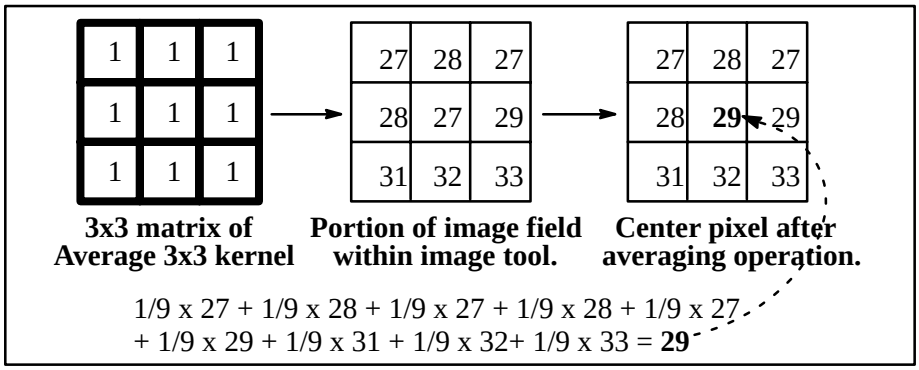
The Average 3x3 and Average 5x5 kernels calculate the average value of the pixels in a neighborhood, and then replace the center pixel in the neighborhood with that value. The general effect of the neighborhood operations by each of these kernels is to smooth gradients or discontinuities in the image. The main differences between these two kernels is that the 5x5 kernel has a greater smoothing effect than the 3x3 kernel, but it operates somewhat more slowly.

Average 3x3 Kernel — The coefficients values in the Average 3x3 kernel are all equal to 1, as follows:

1	1	1
1	1	1
1	1	1

Figure 7.60 illustrates the operation of the Average 3x3 kernel on a neighborhood of image pixels.

Figure 7.60 Example: Effect of Average 3x3 Kernel on Pixel Gray Scale Values

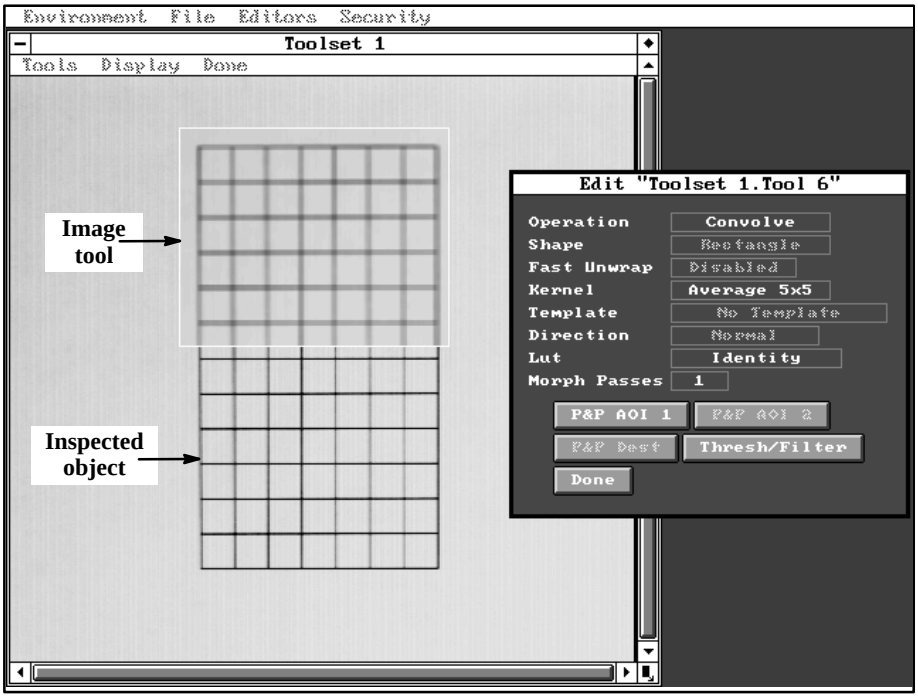


As the example in Figure 7.60 shows, the effect of the Average 3x3 operation is to multiply each gray scale value by 1/9, add the nine results, and replace the pixel value under the center of the matrix with the sum.

Figure 7.61 (page 7–73) illustrates the effect of the Average 3x3 kernel on a dark grid with a light background. Notice that the grid lines within the image tool are somewhat blurred when compared to the portion of the grid outside the tool. This indicates that the kernel has “smoothed” the sharp contrast between the dark grid lines and the light background.

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Figure 7.61 Example: Effect of Average 3x3 Kernel on Inspected Object



Average 5x5 Kernel — The coefficients values in the Average 5x5 kernel are all equal to 1, as follows:

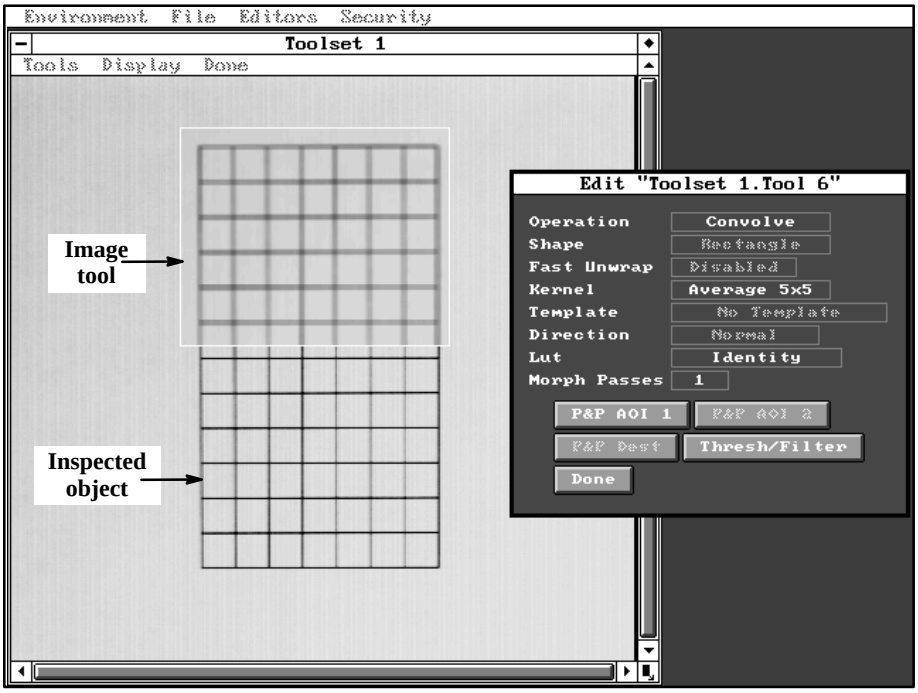
1	1	1	1	1
1	1	1	1	1
1	1	1	1	1
1	1	1	1	1
1	1	1	1	1

The operation of the Average 5x5 kernel is the same as the operation of the Average 3x3 kernel illustrated in Figure 7.60 (page 7–72). The difference is that the Average 5x5 kernel multiplies each of the 25 gray scale values by 1/25.

Figure 7.62 (page 7–74) illustrates the effect of the Average 5x5 kernel on the grid shown in Figure 7.61. Notice that the grid lines within the image tool are somewhat *more* blurred when compared to the grid in Figure 7.61. This demonstrates that the Average 5x5 kernel has a somewhat greater "smoothing" effect than the Average 3x3 kernel.

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Figure 7.62 Example: Effect of Average 5x5 Kernel on Inspected Object



User 3x3, User 5x5 Kernels

The User 3x3 and User 5x5 kernels can be configured with coefficient values that the user deems most appropriate for a specific inspection application. Initially, these kernels are configured in the “identity” mode; that is, the center coefficient is 1 and all other coefficients are 0, as shown below:

0	0	0
0	1	0
0	0	0

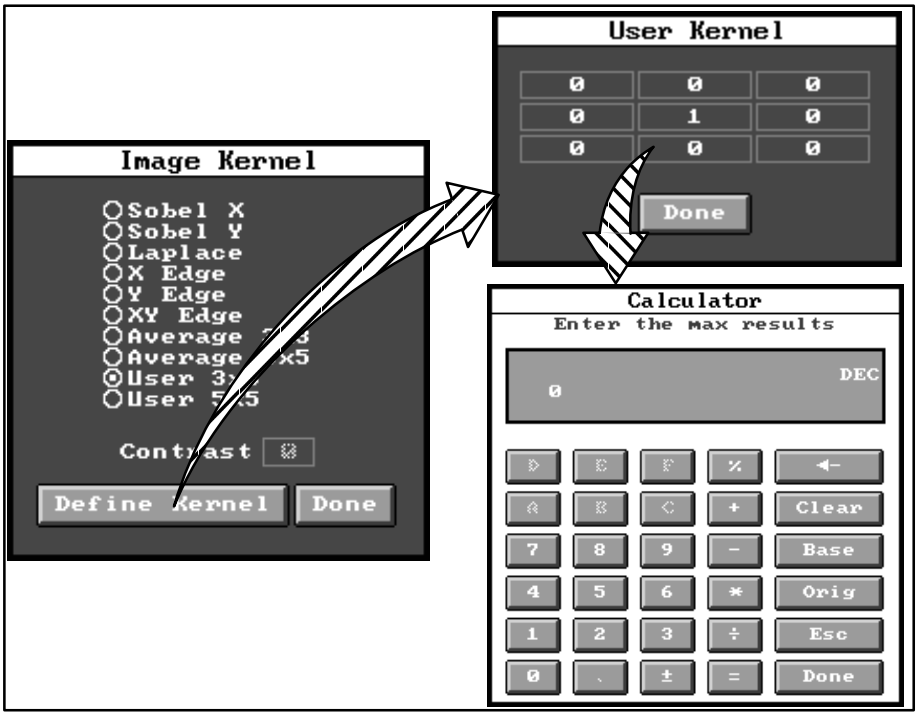
0	0	0	0	0
0	0	0	0	0
0	0	1	0	0
0	0	0	0	0
0	0	0	0	0

The result of these “identity” coefficients is that they have *no* effect on the pixels in the image.

When you pick User 3x3 or User 5x5 in the Image Kernel selection panel, the Define Kernel button becomes active, as shown in Figure 7.63 (page 7–75). When you then pick the Define Kernel button, the User Kernel setup panel appears, also shown in Figure 7.63.

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Figure 7.63 Selecting Coefficient for User 3x3 Kernel



As Figure 7.63 shows, when you pick any of the coefficient fields in the User Kernel setup panel, the calculator pad appears. To change a coefficient value, enter the new value in the calculator (range: –128 to 127) and pick the Done button. Repeat the process for all other coefficients that require new values.

Example: If you were to enter the coefficient values shown below . . .



. . . the kernel would operate exactly as the Sobel X kernel described earlier.

Kernel Contrast

The Image Kernel selection panel shown in Figure 7.63 contains a field labeled Contrast. The state of this field (*active* or *inactive*) depends on which kernel is selected. Thus, the Contrast field is *active* for all kernel selections; however, when User 3x3 or User 5x5 is selected, the state of the

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Contrast field depends on the placement of the user–selectable coefficients within the kernel.

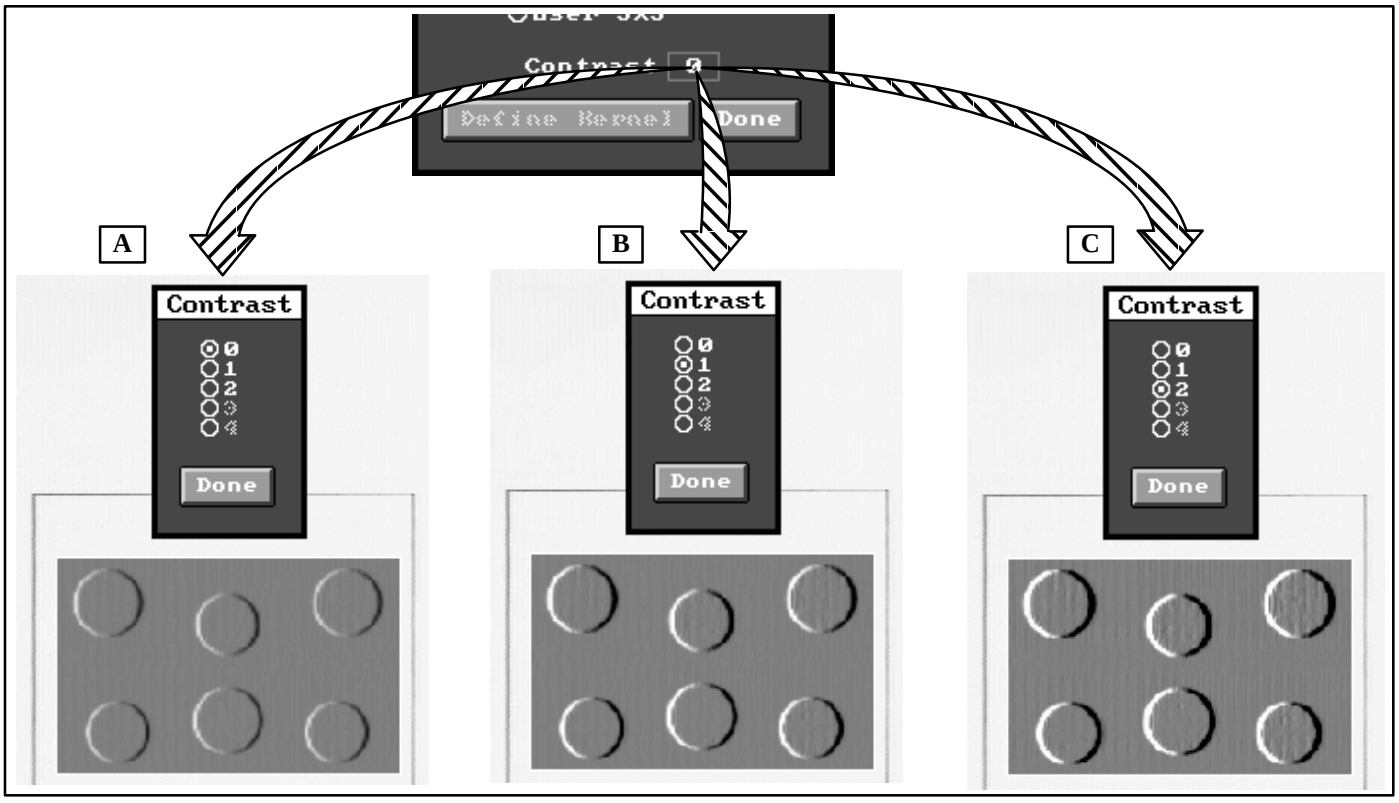
When active, the Contrast field enables you to select a contrast value of 1, 2, 3, or 4, according to the kernel selection. The contrast function has the effect of enhancing the gradients (edges).

In particular, a contrast setting of “1” will “double” the gray scale value of each pixel; a contrast setting of “2” will double the value again; and so on, with the following restrictions: Pixels in *unsigned* images whose “doubled” gray scale values *exceed* 255 are “clipped” to a *maximum* value of 255, while pixels in *signed* images whose doubled gray scale values exceed +127 are clipped to a maximum value of 127, and values below –128 are clipped to –128.

When you pick the Contrast field, the Contrast selection panel appears, as shown in Figure 7.64.

Figure 7.64 (**A**), (**B**), and (**C**) illustrate using a Sobel X kernel and the Sign LUT. In (**A**), the selected contrast value is 0 (default); in (**B**), the contrast value is 1; and in (**C**), the contrast value is 2.

Figure 7.64 Example: Effects of Contrast Adjustments



Notice that the vertical gradients on the round objects in the three images are more pronounced with each increase in the contrast value.

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The availability of the contrast function, and the maximum contrast values, are both related to the specific kernel selection. Table 7.3 identifies the kernel selections and their corresponding contrast functions and values.

Table 7.3 Summary Table of Kernels and Maximum Contrast Values

Kernel Selections	Contrast Function Enabled?	Max. Contrast Value
Sobel X	Yes	2
Sobel Y	Yes	2
Laplace	Yes	1
X Edge	Yes	3
Y Edge	Yes	3
Average 3x3	Yes	3
Average 5x5	Yes	4
User 3x3	①	①
User 5x5	①	①

① Depends on the kernel configuration.

Convolution Kernels and LUT Selections

Table 7.4 correlates the convolution kernels (except the two user–configurable kernels) with the LUTs (look–up tables). The table shows whether a kernel produces a *signed* image, which contains pixel values between –128 and +127, or an *unsigned* image, which contains pixel values between 0 and +255, and it indicates which LUTs are most appropriate for each kernel.

Table 7.4 Summary Table: Kernels and Appropriate LUTs

Convolution Kernel	Output Image: Signed or Unsigned	Appropriate LUTs							
		Ident.	Sign	Abs.	Inv.	Clip	S.Clip	Thres.	S.Thr.
Sobel X	Signed	No	Yes	Yes	No	No	①	No	Yes
Sobel Y	Signed	No	Yes	Yes	No	No	①	No	Yes
Laplace	Signed	No	Yes	Yes	No	No	①	No	Yes
X Edge	Signed	No	Yes	Yes	No	No	①	No	Yes
Y Edge	Signed	No	Yes	Yes	No	No	①	No	Yes
Average 3x3	Unsigned	Yes	No	No	Yes	Yes	No	Yes	No
Average 5x5	Unsigned	Yes	No	No	Yes	Yes	No	Yes	No

① May be useful if threshold is adjusted to remove negative values.

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Table 7.5 correlates the LUT with the signed/unsigned state of the input image from a convolution kernel, and indicates the characteristics of the resulting output image.

Table 7.5 Relation of LUT to Input and Output Images

Input Image from Kernel ①	LUT	Output Image	
		Signed or Unsigned	Gray Scale or Binary
Unsigned	Identity	Unsigned	Gray scale
Signed	Sign	Unsigned	Gray scale
Signed	Absolute	Unsigned	Gray scale
Unsigned	Inversion	Unsigned	Gray scale
Unsigned	Clip	Unsigned	Gray scale
Signed	S.Clip	Signed	Gray scale
Unsigned	Threshold	NA	Binary
Signed	S.Threshold	NA	Binary

① All input images have signed or unsigned gray scale values.

NOTE: The LUT assumes that the input image will be signed or unsigned as indicated in the table. (For example, the Sign and Absolute LUTs both "expect" a *signed* image from, say a Sobel X or Y Edge kernel; whereas, the Threshold LUT expects an *unsigned* image.)

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Image Tool Operations: Image Arithmetic

This section provides detailed information about the six arithmetic operations listed in the Image Operation selection panel (Figure 7.51, page 7–61) and illustrates the effects that these operations have on image features.

An image arithmetic operation is an appropriate choice when an arithmetic combination of two images is required in order to *extract* the relevant features of a workpiece, or *enhance* them, for inspection purposes.

Image arithmetic operations can be performed on a gray scale or binary image, or on a combination of gray scale and binary images. When two gray scale images are added or subtracted, the resulting image will be a gray scale image. Similarly, when two binary images are added or subtracted, the resulting image will be a binary image.

When one image is gray scale and the other is binary, however, the binary image is treated as a "mask," with the following consequences for both addition and subtraction:

S1	S2, S′, or T	Pn or Bn
Gray	Black	Gray
Gray	White	Black

The image arithmetic operations use the abbreviations S1 and S2, S1', or T to represent the specific image sources to be accessed in each operation. They are described briefly as follows:

- **S1** — This is the *primary* image source for *all* image arithmetic operations. It is specified in the toolset edit panel under the "S1" heading, and it can be an image from either a camera (C1 – C6) or from another image processing tool (P1 – P3 or B1 – B3).
- **S2** — This is the *secondary* image source for the S1 – S2 and S1 + S2 operations. It is specified in the toolset edit panel in the "S2" column, and it can be an image from either a camera (C1 – C6) or from another image processing tool (P1 – P3 or B1 – B3). (Note that S1 and S2 cannot specify the *same* image source for any one image tool. For example, C1 cannot be specified as both S1 *and* S2 for the same image tool.)
- **S1'** — This is the *secondary* image source for the S1 – S1' and S1 + S1' operations. It is always a part of the S1 image.
- **T** — This is the *secondary* image source for the S1 – T and S1 + T operations. It is always a "template" image that was saved from either the S1 image or from some other image.

During configuration, S1, S2, and S1' are each represented as an "area of interest" (AOI), and they are configured using the P&P AOI 1 and P&P AOI 2 buttons in the tool edit panel. The template image T is configured using the Image Manager panel.

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Image Subtraction: S1 – S2, S1 – S1', S1 – T

In an image subtraction operation, the image tool subtracts an AOI in the *secondary* image designated by S2 or S1' (or a "template" designated as T) from an AOI in the *primary* image designated by S1, and places the resulting image in the designated destination buffer. More specifically, the value of each pixel in the S2, S1', or T image is subtracted from the value of each *corresponding* pixel in the S1 image. This results in a *signed* image; that is, an image whose pixel values lie between –128 and 127.

If S1 and S2 (or S′ or T) are *binary* images, a logic XOR ("exclusive OR") function will be performed on the two images, as shown by the following table:

S1	S2, S′, or T	Pn or Bn
Black	Black	Black
Black	White	White
White	Black	White
White	White	Black

NOTE: Since image subtraction creates a *signed* image, the "Sign," "Absolute," "S.Threshold" or "S.Clip" LUT should be used in order to remove negative values from the image. The Sign, S.Threshold, and S.Clip LUTs add 128 to each pixel value, thereby placing all values in the 0 to 255 range that the inspection tools require to identify and evaluate features properly. The Absolute LUT changes all negative values to positive values.

Typically, image subtraction is used to cancel all features that are *common* to two images and leave only those features that are *different* between the two images.

The similarities and differences between the image subtraction operations are detailed in the following sections.

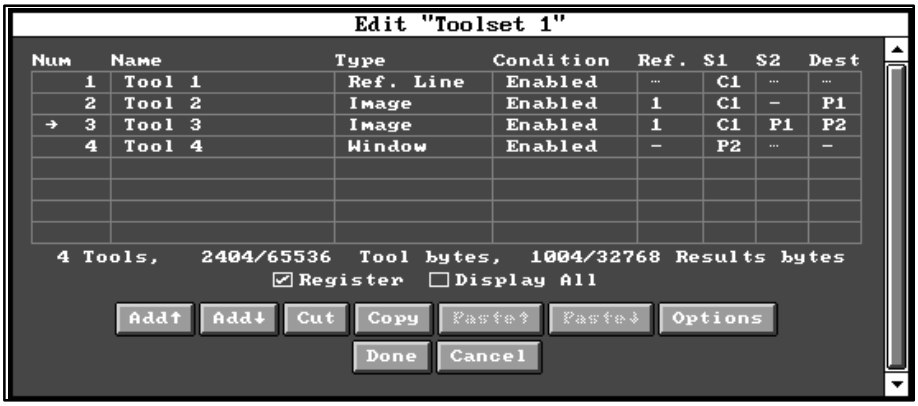
S1 – S2

The S1 – S2 image arithmetic operation subtracts an AOI within the S2 image from an AOI within the S1 image.

Figure 7.65 (page 7–81) is an example of how an S1 – S2 operation could be set up in the toolset edit panel.

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Figure 7.65 Example: Designating S2 Source for Image Tool Using S1 – S2



In this example, Tool 2 is an image tool that is configured to process an AOI within an image whose source is camera #1 (designated by "C1" in the "S1" column) and deliver the processed image to a destination image buffer (designated by "P1" in the "Dest" column).

Tool 3 is an image tool that is configured for the S1 – S2 image subtraction operation. Its *primary* image source is camera #1 (designated by "C1" in the "S1" column). Its *secondary* image source is the destination image buffer containing the processed image from Tool 2 (designated by "P1" in the "S2" column). The destination for Tool 3's processed image is a *different* destination image buffer (designated by "P2" in the "Dest" column).

Tool 4 is a window tool. Its primary (and only) image source is the destination image buffer (designated by "P2" in the "S1" column) that contains the results of the image subtraction operation performed by the preceding image tool, Tool 3.

When the S1 – S2 subtraction operation is selected for Tool 3, the P&P AOI 1 and P&P AOI 2 buttons both become active in the tool edit panel. The P&P AOI 1 button accesses the "pick and place" function for AOI#1, which relates to image source S1, while the P&P AOI 2 button accesses the "pick and place" function for AOI#2, which relates to image source S2.

Initially, AOI#1 appears in its *default* position in the upper–left part of the screen. The image content within AOI#1 *at this point* depends on whether any part of AOI#2 lies *outside* its source image (which is from the AOI in Tool 2, in this example). If *not*, the contents of AOI#1 will immediately display a processed image from the S1 – S2 subtraction; if *so*, the contents of AOI#1 will remain unchanged. (See the *Image Tool Operations: Warning Messages* section, on page 7–84, for a discussion of the automatic adjustments that the CVIM2 system performs on the AOI's under some circumstances, and the related "warning" messages.)

AOI#1 and AOI#2 can be resized and/or positioned at this time by picking their respective "P&P" buttons to access their pick and place functions.

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Either of the AOI's can be resized and/or positioned *first* — the *order* is not important.

In *general*, the size and position of each AOI is determined as follows:

- Each AOI will assume the *size* (height and width) of whichever AOI was resized *last*. Thus, AOI#1 will take the size of AOI#2, if AOI#2 was resized last; and vice versa.
- The position of the upper–left corner of *one* AOI will not be changed by the resizing/repositioning of the *other* AOI.

NOTE: The reference line tool (Tool 1) in Figure 7.65 is configured to supply shift and rotation compensation to the two image tools (Tool 2 and Tool 3). When the workpiece rotates during inspection operations, the output from Tool 1 causes Tool 2 and Tool 3 to rotate. The effect on Tool 3 is to rotate its S1 image source (C1, camera #1), but *not* its S2 image source (P1, from Tool 2). In this example, however, since Tool 2 is rotated from Tool 1, Tool 3's S2 image source will *also* be rotated.

S1 – S1'

The S1 – S1' image arithmetic operation subtracts *one* AOI within the S1 image from *another* AOI within the *same* S1 image.

S1 *and* S1' *both* represent the image source that is supplied to the current image tool and designated in the "S1" column. The image source can be either a camera (C1, C2, and so on) *or* an image buffer (P1, P2, or P3) containing an image processed by another image tool or a rotation finder tool. (Any source that may appear in the "S2" column will have no effect on the S1 – S1' subtraction operation.)

When the S1 – S1' subtraction operation is selected, the P&P AOI 2 and P&P AOI 1 buttons are both active. The P&P AOI 1 button relates to image source S1, while the P&P AOI 2 button relates to image source S1'.

Initially, the AOI #1 window is superimposed over the AOI #2 window in the upper–left part of the screen. The AOI #1 window should always be positioned *first*, using the P&P AOI 1 button to select its pick and place function.

After the AOI #1 window is positioned, and the pick and place function exited, the AOI #2 window can be positioned over the appropriate part of the image, using the P&P AOI 2 button to select the corresponding pick and place function. Note that the AOI#2 window *always* adopts the size of the AOI#1 window — its size *cannot* be altered independently.

The image in the AOI #2 window (S1') is subtracted from the image in the AOI #1 window (S1), and the result *always* appears in the AOI #1 window when neither window is being "picked and placed" *and* when the result of

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the subtraction is assigned to one of the image buffers (P1, P2, or P3) in the destination ("Dest") column of the toolset edit panel.

S1 – T

The S1 – T operation subtracts a stored template (T) from an AOI within the S1 image.

S1 represents the image source that is supplied to the current image tool and designated in the "S1" column. The image source can be either a camera (C1, C2, and so on) *or* an image buffer (P1, P2, or P3) containing an image processed by another image tool or a rotation finder tool. (Any source that may appear in the "S2" column will have no effect on the S1 – T subtraction operation.)

When the S1 – T subtraction operation is selected, the Template field becomes active and displays "No Template" initially.

When the Template field is picked, the Image Manager panel appears. This panel must be used to select an appropriate template image from the current image, or from another image, whichever is appropriate for the inspection application. For detail information about the Image Manager panel, refer to Chapter 4, *Inspection Configuration*, under the *Image Manager Panel* heading on page 4–40.

When the appropriate template image is selected, its name appears in the Template field. At the same time, the template image contents are automatically subtracted from the contents of the AOI #1 window, and the resulting image appears in the window (assuming that a destination buffer, such as P1, has been selected in the toolset edit panel). Also at the same time, the AOI #1 window is forced to adopt the size of the template image.

The AOI #1 window can then be positioned over the appropriate part of the image, using the P&P AOI 1 button to select its pick and place function. Note, however, that since the AOI#1 window *always* adopts the size of the template image, only its *position* can be altered once the template image has been selected.

Image Addition: S1 + S2, S1 + S1', S1 + T

Image addition operations (S1 + S2, S1 + S1', and S1 + T) can be used to emphasize features that are common to two images, or add different features on each image in order to create a composite image that contains all desired features. The abbreviations S1, S2, S1', and T represent the specific image sources to be used in the image addition operation.

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In an image addition operation, the image tool adds an AOI in the *secondary* image designated by S2 or S1' (or a "template" designated as T) to an AOI in the *primary* image designated by S1, and places the resulting *unsigned* image in the designated destination buffer. More specifically, the value of each pixel in the S2, S1', or T image is added to the value of each *corresponding* pixel in the S1 image, and the sum is divided by two. The resulting *average* of the two values is then placed the destination buffer.

If S1 and S2 (or S′ or T) are *binary* images, a logic AND function will be performed on the two images, as shown by the following table:

S1	S2, S′, or T	Pn or Bn
Black	Black	Black
Black	White	Black
White	Black	Black
White	White	White

The basic configuration details that apply to the image subtraction operations apply also the image addition operations. Refer to the corresponding section under the *Image Subtraction* heading, immediately preceding this section, for details.

Image Tool Operations: Warning Messages

As you configure an image tool, under some circumstances you will see two related warning messages on the display. These messages (which appear *sequentially*) are intended to alert you to certain adjustments that the CVIM2 system makes *automatically* during the image tool configuration.

The two messages are these:

- `The tool is outside of the image.`
- `The tool was modified to fit.`

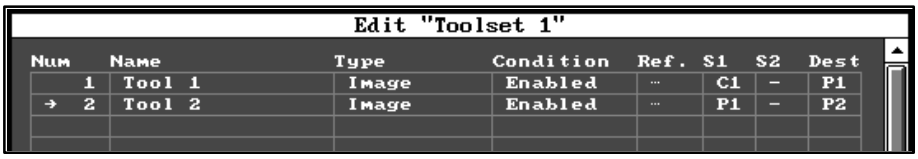
This section explains these two messages and the circumstances under which they occur.

Whenever you add a new image tool to the toolset edit panel, by *default* it will enter the lowest numbered camera (such as "C1") in the "S1" source column. If you then change S1 source to an image buffer (such as "P1") containing an image from an earlier image processing tool, that image will typically be significantly *smaller* than a full–size camera image and will always be positioned, by *default*, in the upper–left "corner" of the image buffer.

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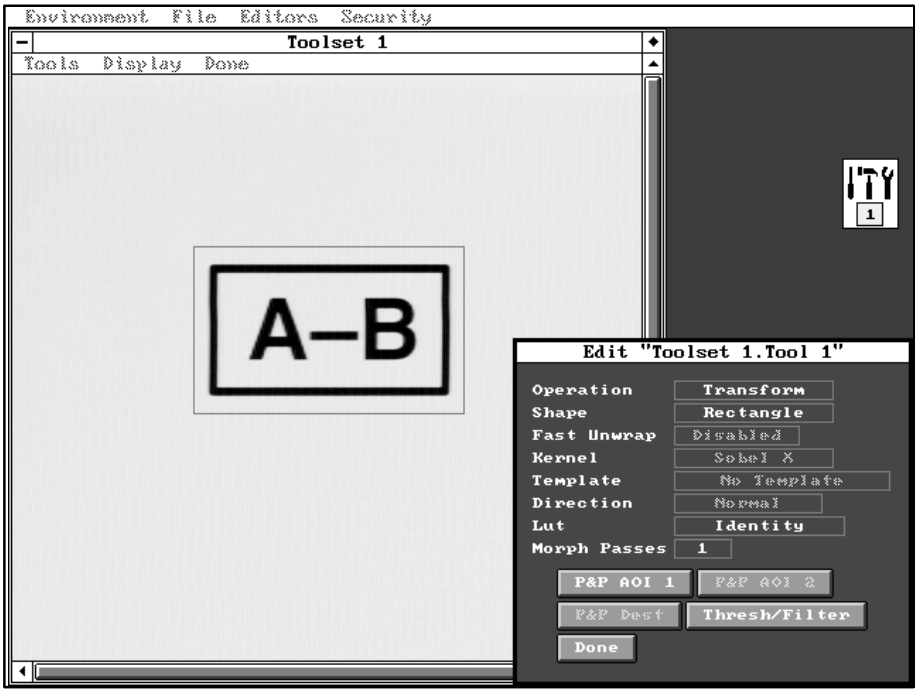
Figure 7.66 provides an example of a toolset edit panel with two image tools, where the *first* image tool (Tool 1) places its processed image in the P1 image buffer, as indicated by the "P1" entry in the "Dest" column, and the *second* image tool (Tool 2) uses the processed image from Tool 1 as its S1 source image.

Figure 7.66 Example: One Image Tool Using an Image From Another Image Tool



For the purposes of the example in Figure 7.66, assume that the AOI#1 window of Tool 1 is positioned over an object in the camera #1 image as illustrated in Figure 7.67.

Figure 7.67 Example: AOI #1 Window in Image Tool (Tool 1)

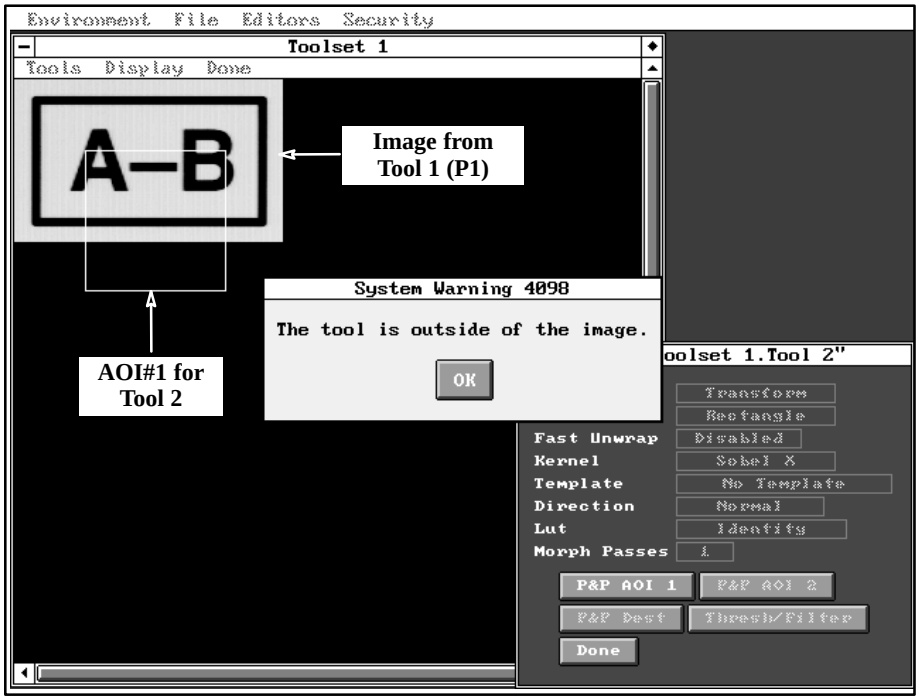


When you select the second image tool (Tool 2) from the toolset edit panel, the "tool outside" message appears, as shown in Figure 7.68 (page 7–86).

Note that the image from Tool 1 (that is, from image buffer P1) is positioned in the upper–left corner of the image display area, and the *default* "tool" (which in this case is the AOI#1 window of Tool 2) clearly extends *outside* the P1 image.

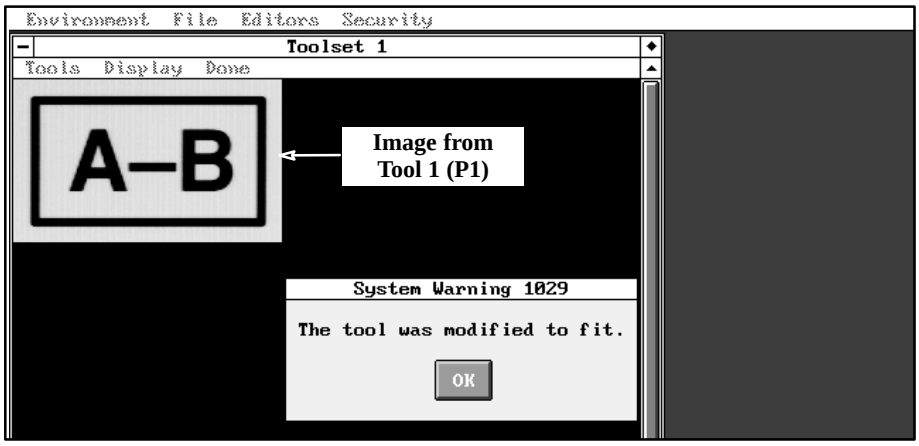
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Figure 7.68 Example: Occurrence of "Tool Outside" Message



When the "tool outside" message appears, continue by picking the OK button in the message box and the P&P AOI 1 button in the tool edit panel. When you do, the "tool modified" message appears, as shown in Figure 7.69.

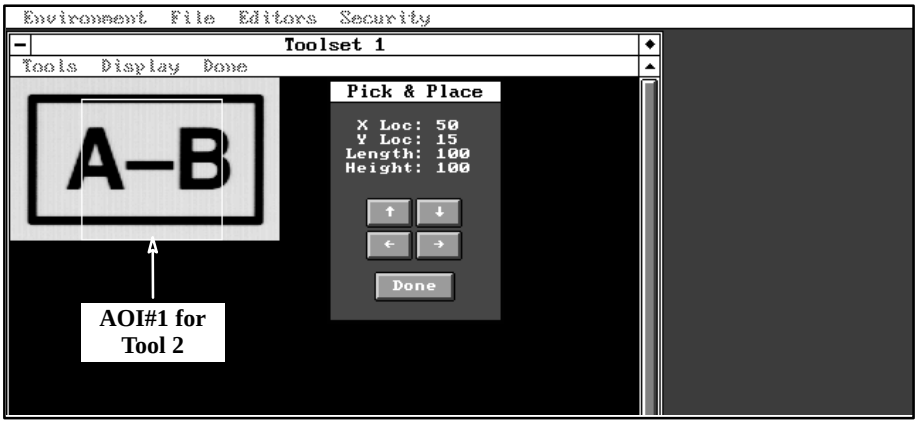
Figure 7.69 Example: Occurrence of "Tool Modified" Message



When the "tool modified" message appears, continue by picking the OK button in the message box. When you do, the AOI#1 window, now "modified to fit," appears *within* the image from Tool 1 (P1), as shown in Figure 7.70 (page 7–87), along with the Pick & Place panel for that window.

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Figure 7.70 Example: AOI Window "Modified to Fit" in Image



Note that the AOI window may not have the appropriate size or be in the appropriate position for your application at this point. If not, reposition and/or resize the window as needed.

Image Tool Shape

An image tool is available in four shapes: rectangle, arc ring, quad, and perspective. Note that the arc ring, quad, and perspective shapes are active only when the Transform image tool operation is selected.

NOTE: The rectangle shape must be selected before the Convolve operation or any of the image arithmetic operations can be selected.

Rectangle

The rectangle shape is used to create a new image by applying morphology (and thresholding if the binary mode is used), without any spatial transformation. It is the only shape allowed for the Convolve and image arithmetic operations.

Arc Ring

The arc ring "shape" image tool can perform an "unwrap" spatial transformation function, which can be used to examine circular features and, by "unwrapping" them, process them as though they were linear.

An arc ring window consists of a circular AOI and a rectangular "destination." The AOI consists of an outer arc and a concentrically positioned inner arc, with the two ends connected. The arc size (in degrees) can be increased to 380°, or decreased to a size (in degrees) that varies with the radius of the inner arc.

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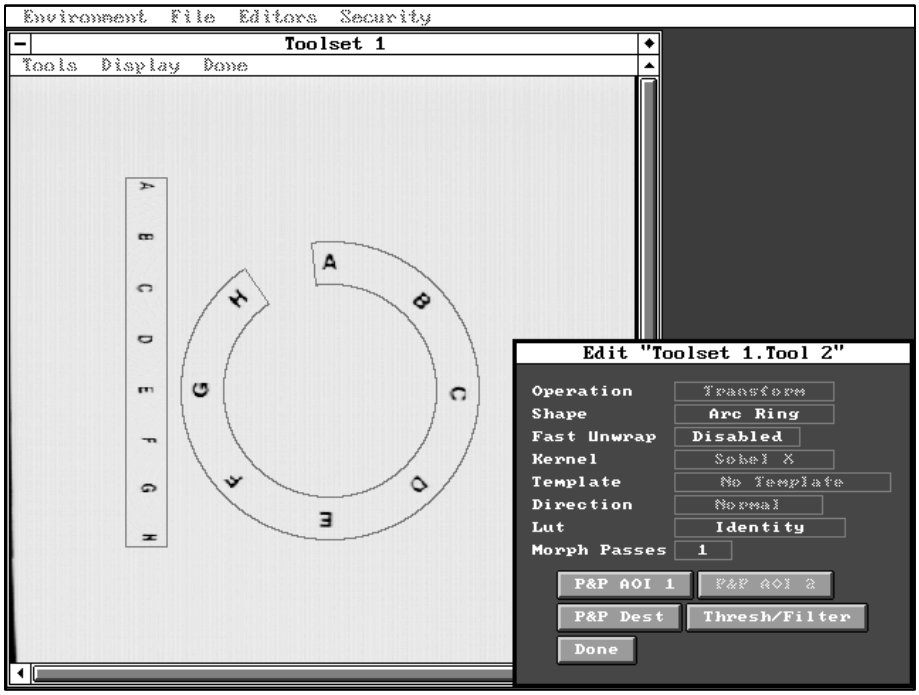
The pick and place procedure for the circular AOI is comparable to the procedure for circular gages, while the pick and place procedure for the destination is the same as for rectangular windows. For details, refer to Chapter 5, *Pick and Place Functions.*

NOTE: The destination should always be configured with the vertical axis *longer than* the horizontal axis, since the unwrapped image data is displayed *vertically.* The *aspect ratio* of the destination should be adjusted as needed to *optimize* the appearance of the part or item being inspected.

In operation, the arc ring image tool processes (and "unwraps") the image area lying between the inner and outer rings of the AOI, then displays the unwrapped and processed image *vertically* in the destination.

Figure 7.71 illustrates using a arc ring image tool to "unwrap" a circular array of alpha characters. Note that the image data is unwrapped, *always* starting at the end of the circular AOI shown in the figure, and displayed in the destination from the top down.

Figure 7.71 Example: Arc Ring Image Tool



In this example, the circular AOI is centered over a circular array of alpha characters, and the destination is positioned alongside. The result in the destination is a *linear* array of alpha characters, starting with letter "A."

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Quad

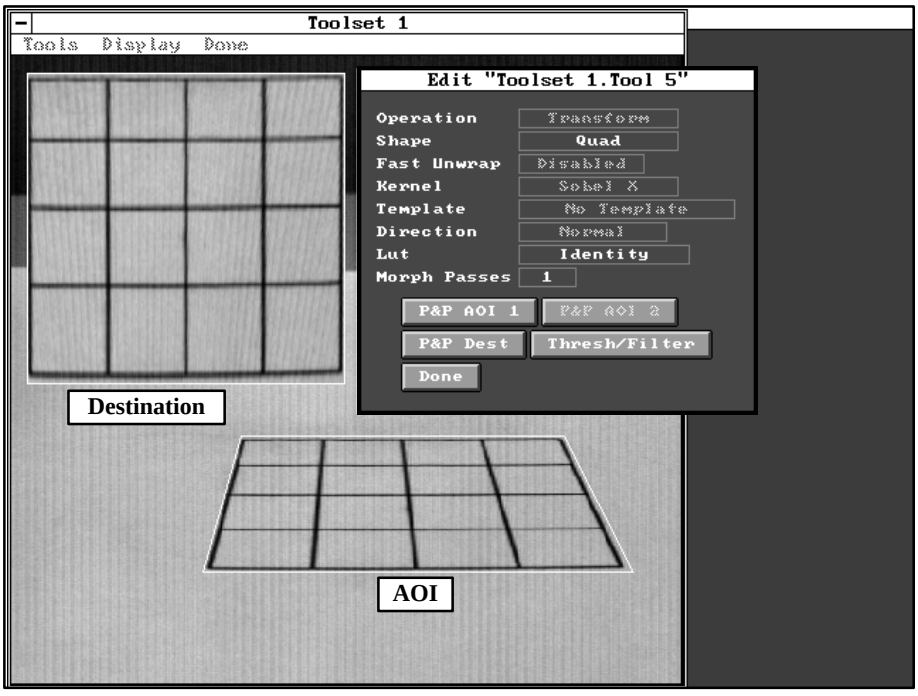
A quad “shape” image tool consists of two separate windows: a quadrilateral AOI, and a rectangular “destination.” The quad AOI provides a means of *reshaping* the contents of the original image.

The image appearing in the quadrilateral AOI is transformed according to the shape of the AOI and the aspect ratio of the destination. Each point in the AOI is “mapped” into a corresponding point in the destination. The quad image tool can be used to rotate an image, rescale an image (make larger or smaller), or change the aspect ratio.

Figure 7.72 illustrates this concept by using the image of a square grid where the image plane is *not perpendicular* to the camera. The resulting grid is trapezoidal, and the AOI is positioned around the grid.

The squared destination shows the resulting “quad” image.

Figure 7.72 Example: Image Tool With Quad “Shape”



The effect of the quad image tool, in this example, is to stretch the upper part of the original image *horizontally*, but not the bottom part. Note that the grid lines are essentially at right angles, but the bottom “squares” of the grid are slightly higher than the top squares because the quad shape does not compensate for perspective distortion.

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Perspective

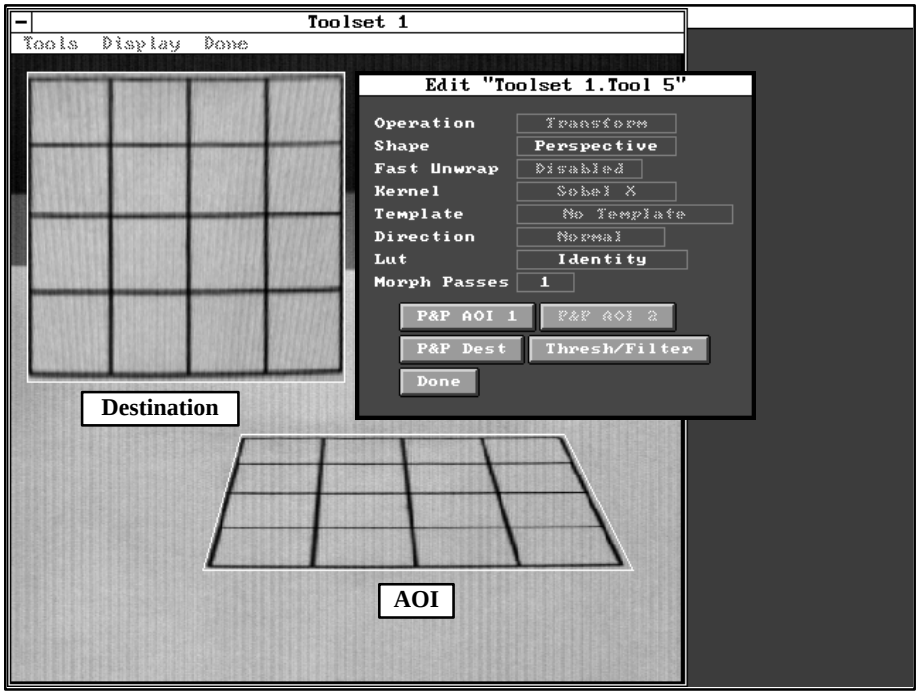
A perspective “shape” image tool consists of two separate windows: a perspective AOI, and a rectangular “destination.” It provides a means of *reshaping* the contents of the original image in cases where the original image is slightly distorted because the camera is not perpendicular to the image.

NOTE: The perspective image tool gives slightly better results than the quad image tool when used to correct for perspective distortion, but it runs more slowly.

The image appearing in the perspective AOI is transformed, according to the shape of both the AOI and the aspect ratio of the destination. Each point in the AOI is “mapped” into a corresponding point in the destination. The perspective image tool can be used to perform the same kinds of transformations as the quad image tool, with the added capability of correcting for perspective distortion.

Figure 7.73 illustrates this concept by using the image of a square grid where the image plane is *not perpendicular* to the camera. The resulting grid is thus a trapezoid, and the AOI is positioned around the grid.

Figure 7.73 Example: Image Tool With Perspective “Shape”



The squared destination shows the resulting “perspective” image.

The effect of the perspective image tool, in this example, is to stretch the upper part of the original image *horizontally* and *vertically*, but not the

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bottom part. Note that the grid lines are essentially at right angles. The bottom “squares” of the grid are nearly the same size as the top squares because the perspective shape compensates for perspective distortion.

Figure 7.74 compares the same destination image using quad and perspective shapes.

Figure 7.74 Example: Comparing Results From Quad and Perspective Shapes

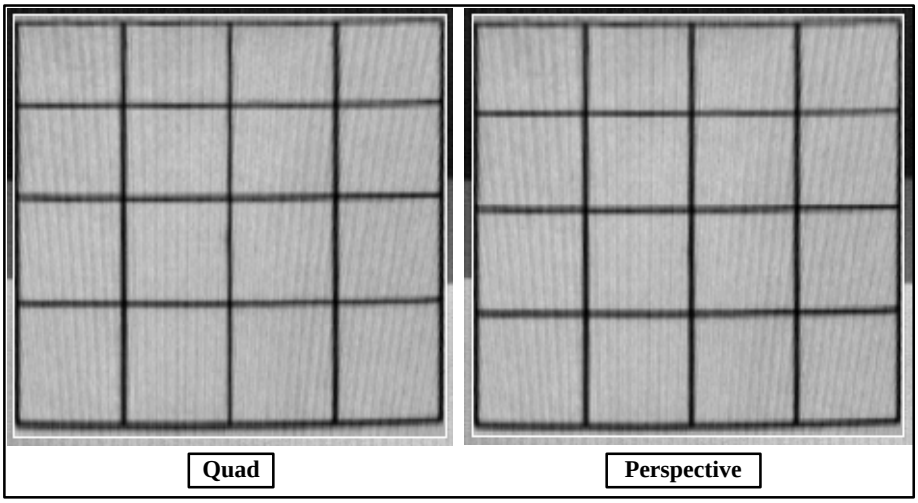
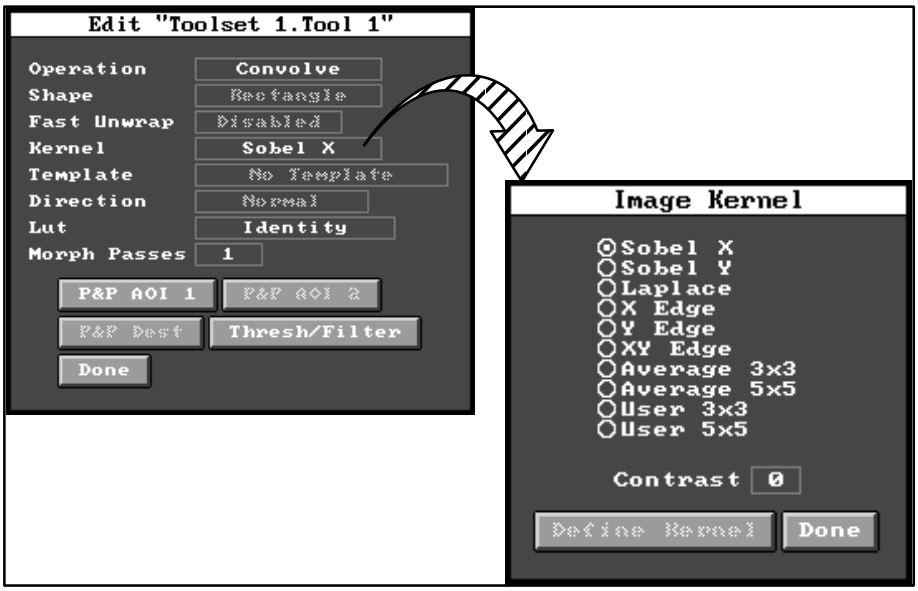


Image Tool Kernel

When you pick the Convolve image tool operation, the Kernel field in the tool edit panel becomes active, as shown in Figure 7.75. When you pick the Kernel field, the Image Kernel panel appears, also shown in Figure 7.75.

Figure 7.75 Selecting the Image Kernel Panel for the Convolve Operation



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From the Image Kernel panel you can select a spatial filtering function using a 3x3 or 5x5 kernel with either fixed or user–configurable coefficients, to perform neighborhood operations on the image tool pixels. The basic purpose of these operations is to either enhance the gradients that represent edges on image features, or to filter noise from the image.

Here is a brief description of each kernel in the Image Kernel panel:

- *Sobel X* — This is a 3x3 directional kernel that enhances the *vertical* gradients on an inspected object.
- *Sobel Y* — This is a 3x3 directional kernel that enhances the *horizontal* gradients on an inspected object.
- *Laplace* — This is a 3x3 non–directional kernel that enhances *vertical and horizontal* gradients on an inspected object.
- *X Edge* — This is a 5x5 directional kernel that enhances the *vertical* gradients on an inspected object.
- *Y Edge* — This is a 5x5 directional kernel that enhances the *horizontal* gradients on an inspected object.
- *XY Edge* — This is a 5x5 non–directional kernel that enhances the *vertical and horizontal* gradients on an inspected object.
- *Average 3x3* — This is a 3x3 kernel that performs an averaging function on each pixel in the image.
- *Average 5x5* — This is a 5x5 kernel that performs an averaging function on each pixel in the image.
- *User 3x3* — This is a 3x3 kernel in which the coefficient values are user–selectable.
- *User 5x5* — This is a 5x5 kernel in which the coefficient values are user–selectable.

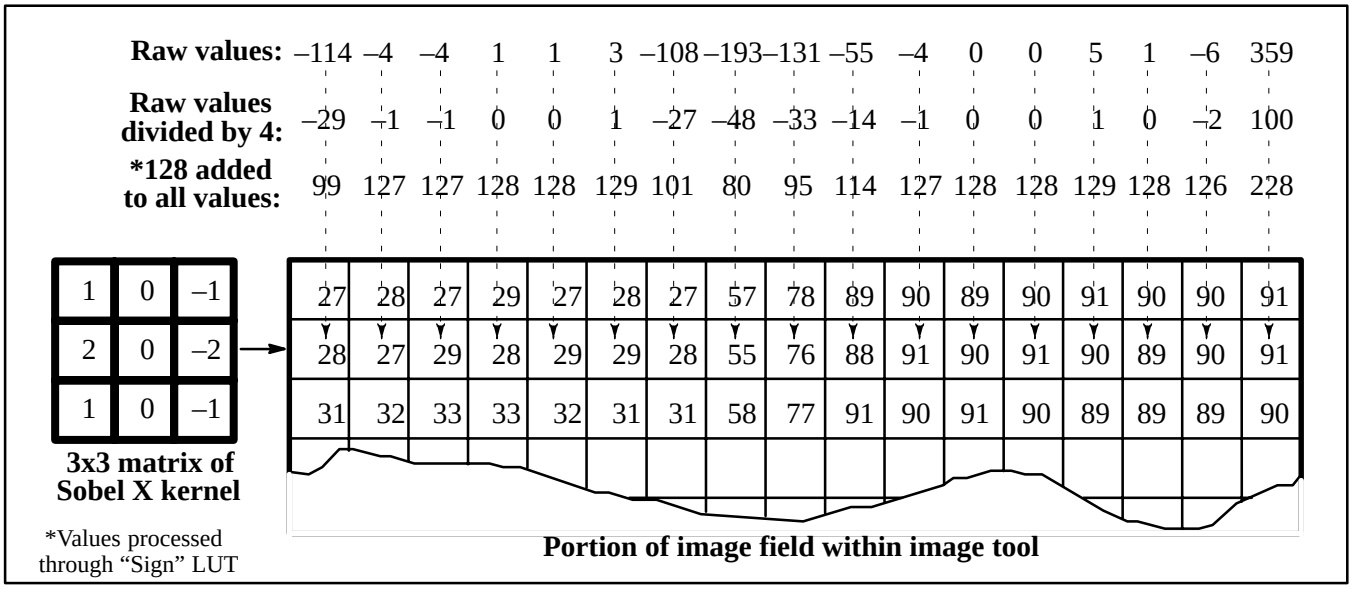
The kernel performs its neighborhood operation identically for *all* spatial filter functions. That is, the kernel “scans” the image tool left–to–right and top–to–bottom, and each coefficient in the 9 (or 25) matrix multiplies the gray scale value of the corresponding pixel in the underlying 3x3 (or 5x5) part of the image tool. These 9 (or 25) multiplications are then summed, and the total is placed in the image tool pixel directly under the *center* of the matrix. This process is repeated for each pixel in the image tool.

NOTE: All kernels except the “average” kernels produced *signed* images; that is, they may have *negative* values. The “average” kernels produce only *unsigned* images — their values are always *positive*.

Figure 7.76 (page 7–93) provides an example that illustrates the neighborhood operation of a kernel using, for this purpose, the coefficient array and values of a Sobel X filter. The example shows the result of the kernel’s neighborhood operations across the second row of pixels from the top of the image tool.

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Figure 7.76 Example: Neighborhood Operation in Image Tool



Note that the original gray scale values of the pixels in the second row are in the 20's and 30's on the *left* side of the image. In the middle of the image, these values increase abruptly to the 80's and 90's on the *right* side. This discontinuity is the location of a vertically aligned *gradient* in the image. (In this example, it is meant to represent a *vertical edge* on an inspected object.)

In the example, the Sobel X kernel moves left–to–right along the second row of pixels and calculates new *raw* values for each pixel along the way. Since these raw values could *potentially* range from –1020 to +1020, the CVIM2 system automatically *scales* them to the –128 to 127 range.

The CVIM2 system provides optional look–up table (LUT) mapping functions that can convert all of the values to *positive* values. Figure 7.76 shows the result of using the "sign" LUT (which adds 128 to each value). In the example, the result would be a displayed image in which the gradient (edge) would appear as a dark vertical stripe with areas of medium gray on both sides. Thus, the gradient values are 101, 80, 95, and 114, while the areas on both sides are nominally 128. (For more information about LUT mapping functions, see the *Image Tool Look–Up Table (LUT)* section on page 7–95 of this chapter.)

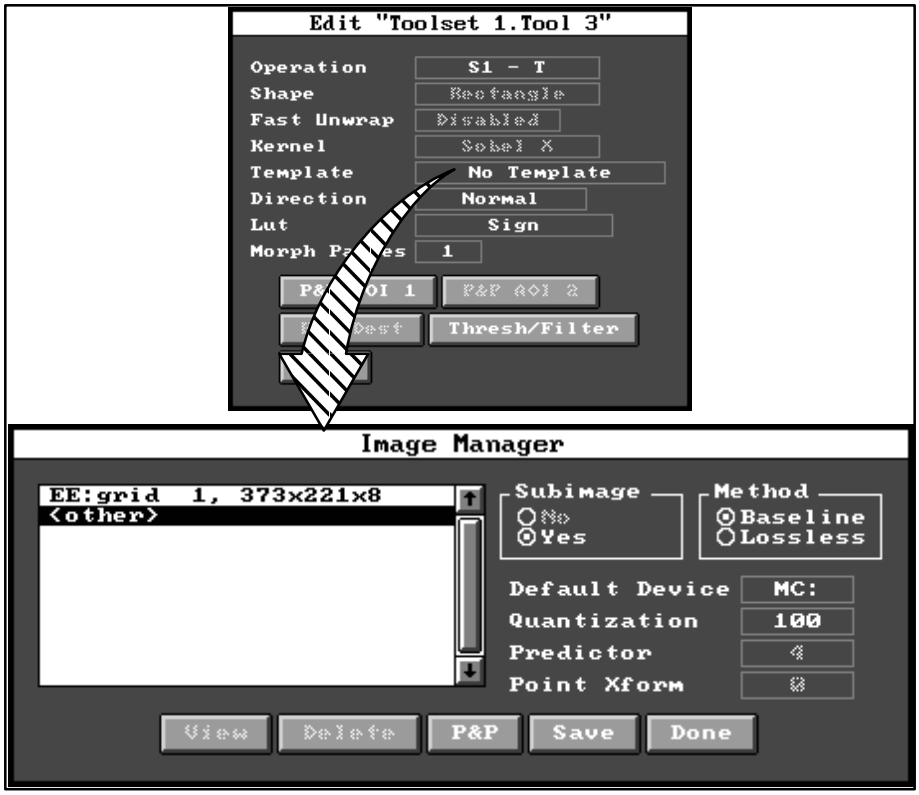
NOTE: In Figure 7.76, the values calculated for all of the *border* pixels differ from the non–border pixels because they are calculated with some of the kernel's coefficients "out of bounds." Those coefficients are set to zero, and the result is *raw* values of –114 and 359 for the leftmost and rightmost pixels in the second row (compared to the near–zero values elsewhere, away from the gradient). Therefore, when the image tool is used as an image source for a window tool, the window tool should be sized and positioned *away* from the image borders in order to avoid distorting effects that may arise from the inclusion of the image's *border* pixels.

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Image Tool Template

As noted earlier, the Template field in the tool edit panel is active when an S1 – T or S1 + T arithmetic operation is selected. When you pick the Template field, the Image Manager panel appears, as shown in Figure 7.77.

Figure 7.77 Accessing the Image Manager Panel to Select a Template Subimage



You can use the Image Manager panel to either create a *new* template "subimage" from a portion of the current image or select an *existing* template from the scrolling list in the panel, if appropriate. To create a *new* template, leave the highlight bar at the (other) entry in the list, then refer to Chapter 4, *Inspection Configuration*, under the *Image Manager Panel* heading on page 4–40 for details about configuring a new subimage.

To select an *existing* template, highlight the appropriate subimage file name in the scrolling list (such as the EE:grid 1, 373x221x8 file name), then pick the Done button to exit back to the tool edit panel. The highlighted file name should now appear in the Template field of the tool edit panel.

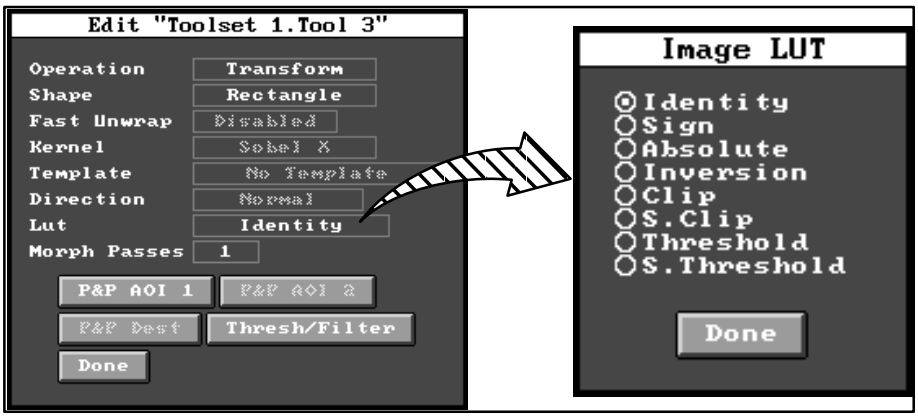
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Image Tool Look–Up Table (LUT)

The Lut field in the tool edit panel selects a look–up table (LUT), which, as noted earlier, remaps the gray scale values of the image pixels after all other operations (*except* a Morph 2 operation, if used) have been performed. Note that the *default* LUT is Identity, which has no effect on the pixels.

When you pick the Lut field in the image tool edit panel, the Image LUT selection panel appears as shown in Figure 7.78.

Figure 7.78 Accessing the Image LUT Selection Panel



The selections in the Image LUT panel are described briefly, as follows:

- **Identity** — This selection has no effect on the image tool pixels.
- **Sign** — This selection adds 128 to the gray value of each pixel, which converts a "signed" image (containing positive *and* negative gray values) to an "unsigned" image (containing only positive gray values). The range of values in the resulting image is 0 to 255.
- **Absolute** — This selection converts a "signed" image to an "unsigned" image by using the *absolute* value of each pixel. The range of values in the resulting image is 0 to 128.
- **Inversion** — This selection performs a "bit–wise" inversion of the gray value of each pixel. Thus, 255 becomes 0, 85 becomes 170, –105 becomes +22, and so on.
- **Clip** — This selection forces the gray values of all pixels in an "unsigned" image (maximum range: 0 to 255) to user–selectable high and low range limits. Thus, all pixels whose original gray values lie above (or below) the user–selected high (or low) threshold will be reset to a gray value equal to the high (or low) threshold.
- **S.Clip** — This selection forces the gray values of all pixels in a "signed" image (maximum range: –128 to 127) to user–selectable high and low range limits. Thus, all pixels whose original gray values lie above (or below) the user–selected high (or low) threshold will be reset to a gray value equal to the high (or low) threshold.

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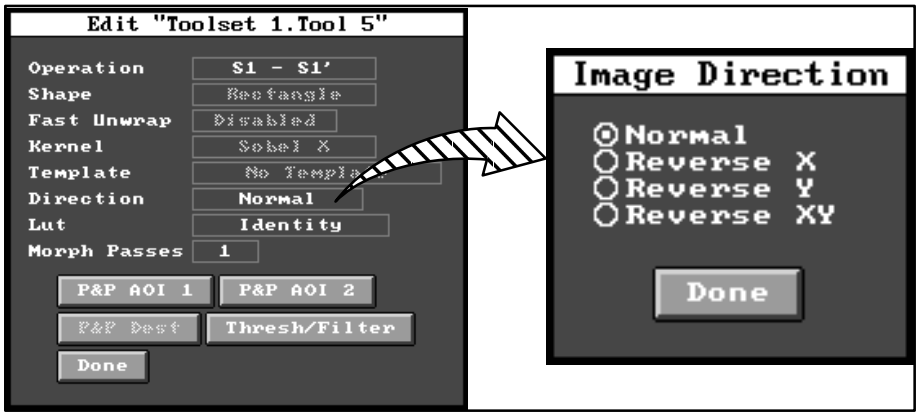
- **Threshold** — This selection converts an “unsigned” gray scale image to a *binary* image. All pixels whose gray values lie between the user–selectable thresholds become *white*, while all other pixels become *black*. Thresholds can be set to gray values ranging from 0 to 255.
- **S.Threshold** — This selection converts a “signed” image to a *binary* image. All pixels whose gray values lie between the user–selectable thresholds become *white*, while all other pixels become *black*. Thresholds can be set to gray values ranging from –128 to 127.

Image Tool Direction

The Direction field in the tool edit panel, as noted earlier, is active only when an *image arithmetic* operation is selected. This field accesses the Image Direction selection panel, which, enables you to select a different scan direction for the *secondary* image (S2, S1', or T). The scan direction for the *primary* image (S1) is *fixed*: left–to–right, and top–to–bottom.

When you pick the Direction field in the image tool edit panel, the Image Direction selection panel appears as shown in Figure 7.79.

Figure 7.79 Accessing the Image Direction Selection Panel



Note that the *default* scan direction is Normal, which indicates that the scan directions for the secondary and primary images are the same.

The selections in the Image Direction panel affect only the scan directions for the *secondary* image. They are described briefly as follows:

- **Normal** — This scan direction is left–to–right and top–to–bottom.
- **Reverse X** — This scan direction is right–to–left and top–to–bottom.
- **Reverse Y** — This scan direction is left–to–right and bottom–to–top.
- **Reverse XY** — This scan direction is right–to–left and bottom–to–top.

A typical application for the reverse scanning function is to inspect for symmetrical features.

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Image Tool Morph Passes

The Morph Passes parameter determines the number of times the image is passed through the image processing "pipeline"; that is, the number of times that the morphology processors are applied to the image.

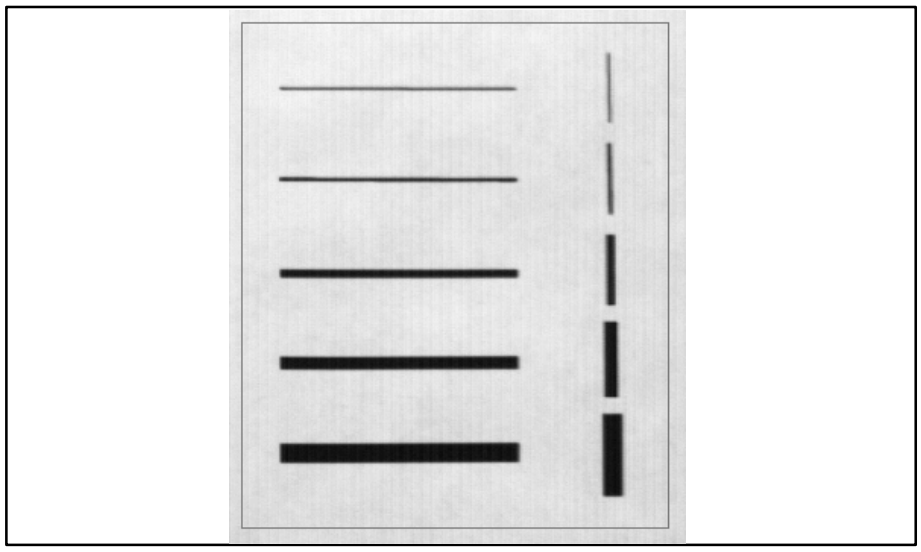
The following example (shown in Figure 7.80 through Figure 7.83) illustrates the use of gray scale morphology and multiple "morph passes" to eliminate progressively thicker horizontal (*unwanted*) features without significantly affecting vertical features. For the sake of simplicity, the example uses a transform operation and a rectangle shape.

Each "morph pass" in this example represents two stages of gray scale morphology processing. Both of these stages perform a "MAX" with the following morphology kernel:

–	*	
–	*	–
–	*	

In Figure 7.80, the lines appear in their *unprocessed* form in the image tool (both morphology functions are *disabled*).

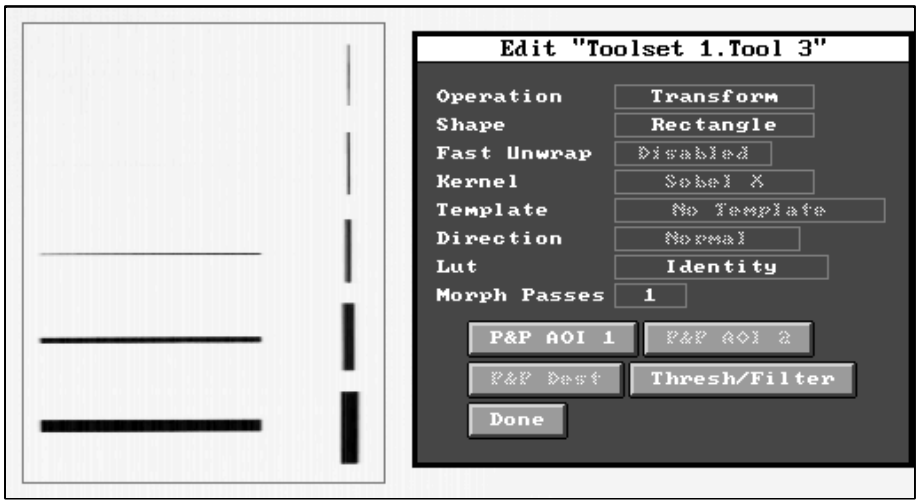
Figure 7.80 Example: Image Tool (Unprocessed Image)



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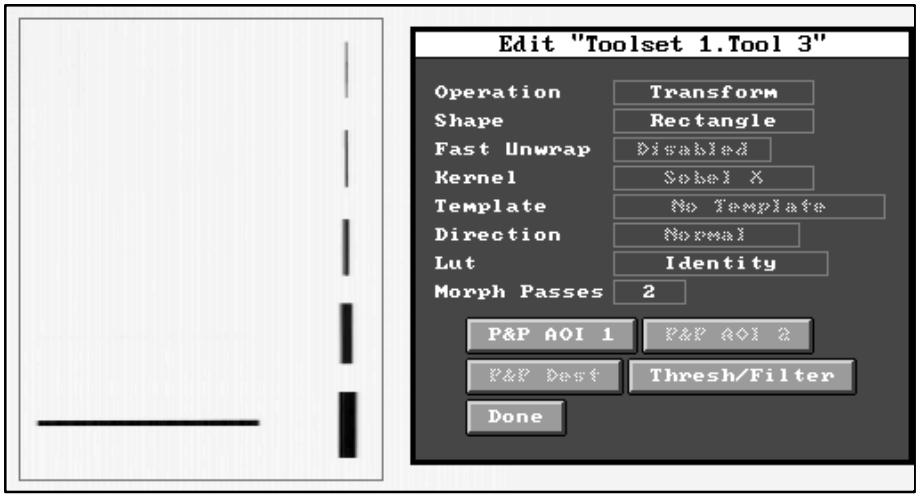
In Figure 7.81, one “morph pass” has occurred, with the result of eliminating the top two horizontal lines.

Figure 7.81 Example: Image Tool (One Morph Pass)



In Figure 7.82, two “morph passes” have occurred, with the result that all lines except the bottom line are *eliminated*. The bottom line is just barely visible.

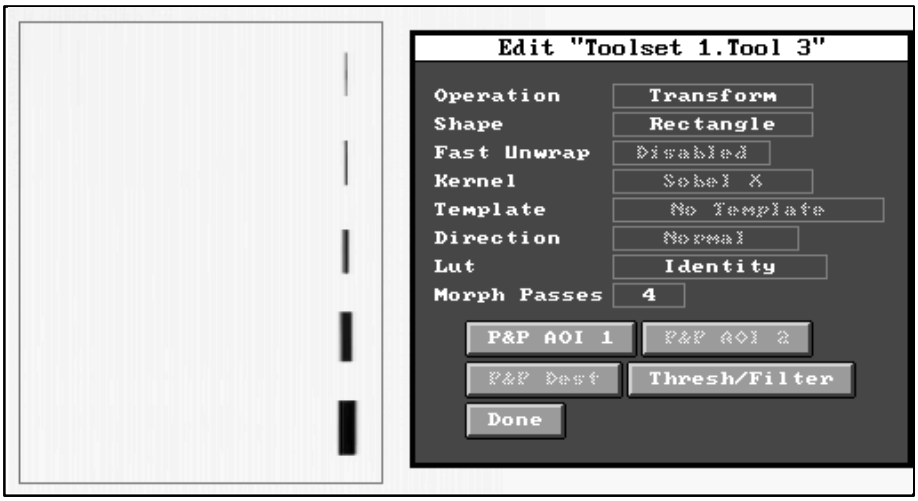
Figure 7.82 Example: Image Tool (Two Morph Passes)



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In Figure 7.83, four “morph passes” have occurred, with the result that all of the horizontal lines are *eliminated*.

Figure 7.83 Example: Image Tool (Four Morph Passes)

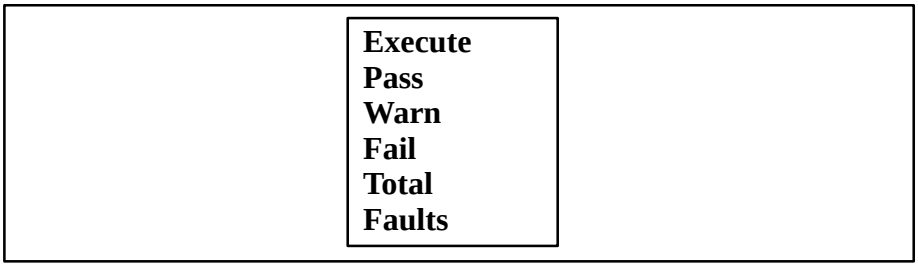


Note that the only effect on the *vertical* lines has been to shorten them.

Image Tool Inspection Results and Math Tool Formulas

This section discusses the expanded inspection results that are available to a math tool formula from an image tool. As Figure 7.84 shows, the expanded inspection results for an image tool appear in one list.

Figure 7.84 Expanded Results Lists For Image Tools in Math Formulas



Here is a brief definition and explanation of each of the expanded result types listed in Figure 7.84.

- **Execute** — This returns a 1.000 when the tool has *executed* its inspection task, and 0.000 for all other conditions.
- **Pass** — This returns a 1.000 when the tool has *passed* its inspection task, and 0.000 for all other conditions.
- **Warn** — This always returns a 0.000.

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- **Fail** — This returns an “error code” when the tool is in a *fail* condition and 0.000 for all other conditions. The error code identifies a specific reason for the failure; for example, error code 1031.000 identifies “No source image” as the cause of the inspection failure. The complete list of error codes and fail conditions appears in Appendix A of this manual.
- **Total** — This returns the total number of inspections performed.
- **Faults** — This returns the total number of faults detected.

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Feature Finder Tool

The feature finder tool is intended to perform object counting and object identification on the basis of gray scale template matching. Here are two of the inspection functions that it can perform:

- Count objects in the image when a window using the binary–based object counting operation cannot be used for any reason.
- Identify one object in the image on the basis of template matching.

Configuring a feature finder tool is nearly identical to configuring a reference window tool. Thus, this section concentrates on the information that is unique to the feature finder tool. For the remaining information, refer to the *Reference Window Tool* section in Chapter 6, *Reference Tools*.

Feature Finder Tool: Basic Elements

A feature finder tool consists of a number of basic *elements*, which are described briefly as follows:

Feature finder tool — This term refers to the whole feature finder tool; that is, each instance of "F. Finder " in the toolset edit panel.

Feature window — This window defines a small portion of the image that contains a unique workpiece feature. The "feature image" is stored in memory during configuration, and it is the "template" that the feature finder tool uses when it searches for a matching feature on a workpiece.

Search window — This window defines the portion of the image within which the smaller *feature window* searches for a particular workpiece feature.

Here is how a feature finder tool works during inspection operations: *The feature window, using a stored feature image as a template, searches the search window for a region that matches (or nearly matches) the stored template. When it finds a matching region, the "feature window" adds one to the feature count. It repeats this counting process for each object within the search window that matches the stored template.*

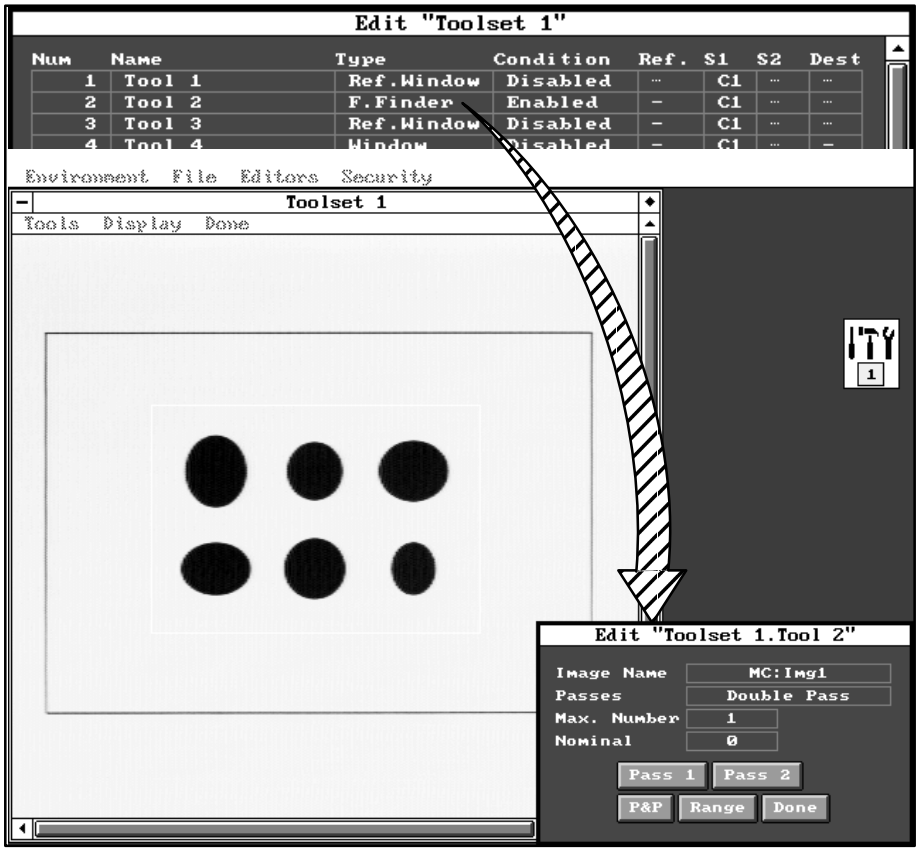
The user can set range limits according to the number of features that the inspection application is expected to find.

Feature Finder Tool Edit Panel

Once you have added a feature finder tool to the toolset edit panel, you can configure it for an inspection application by picking the F. Finder field in the panel. When you do, the feature finder tool edit panel appears, as shown by the example in Figure 7.85 (page 7–102).

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Figure 7.85 Example: Selecting the Feature Finder Tool Edit Panel



The feature finder edit panel (named "Toolset 1.Tool 2 Edit" in Figure 7.85) contains several fields and buttons, which are described briefly, as follows:

- **Image Name** — This field identifies the name of the currently selected feature image (or "No Image," if none is selected). When you pick this field, the Image Manager panel appears, which is used to save or select an image file for the feature window.
- **Passes** — This field selects either Single Pass or Double Pass, which is the number of passes the feature window makes through the search window. When you toggle this field, Single Pass toggles to Double Pass, or vice versa.
- **Max. Number** — This field selects the *maximum* number of features that the feature finder tool is enabled to recognize.
- **Nominal** — When you pick this field, the currently selected and configured feature finder tool counts the number of objects in the search window that match the stored template in the feature window.
- **Pass 1** — The Pass 1 button selects the First Pass panel, from which you can select the parameters that the feature window uses to scan the search window on the first (or only) pass.

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- **Pass 2** — The Pass 2 button selects the Second Pass panel, from which you can select the parameters that the feature uses to scan the search window on the second pass.
- **P&P** — The P&P button provides access to the "pick and place" function for the current search window.
- **Range** — The Ranges button provides access to the Ranges selection panel. For details, refer to the *Ranges* section on page 7–179 of Chapter 7, *Inspection Tools*.
- **Done** — The Done button saves the currently selected configuration settings for this feature, then exits the tool edit panel and returns to the toolset edit panel.

The remainder of the feature finder tool section discusses the configuration process from the perspective of the fields and buttons in the tool edit panel.

Overview: Feature Finder Tool Configuration

A feature finder tool can be selected when the toolset edit panel is on the screen. Starting from the main menu bar, the selection path to this panel is as follows: **Editors** → **Configuration** → **Setup** → **Tools**. This selection path is shown by the example in Chapter 7, *Inspection Tools*, Figure 7.1 (page 7–2).

Here is a summary of the basic selection and configuration steps for a feature finder tool, listed in their normal order of performance.

1. **Save feature image:**
   a. **"Pick and place"** — position the feature window over the appropriate feature on the workpiece image.
   b. **Select feature image compression parameters.**
   c. **Specify file name** — use the Image Manager to enter a device code and feature name, then store the feature image in a file on the selected device.
2. **Configure search window:**
   a. **"Pick and place"** — position the search window over the appropriate part of the workpiece image.
   b. **Select number of passes** — select the number of passes (one or two) that the feature window will make through the search window.
   c. **Select "pass" parameters** — select the appropriate masking, scaling, and other parameters for each "pass."
3. **Select maximum features** — select the maximum number of features that can be recognized and counted.
4. **Learn nominal values** — perform a "learn" operation to "learn" and store the "nominal" values — the data that indicate the workpiece's *initial* position.
5. **Select range limits** — select the upper and lower range limits for the number of features.

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Feature Finder Tool Configuration

This section discusses the configuration steps that are accessed from the fields and buttons in the feature finder tool edit panel shown in Figure 7.86. *Initially,* most of these fields and buttons are *inactive* (shaded). They become *active* when the appropriate points are reached in the configuration process.

Figure 7.86 Feature Finder Tool Edit Panel



Image Name: Feature Image Configuration

The feature image configuration procedure for the feature finder tool is identical to the same procedure for the reference window tool. Refer to the *Feature Image Configuration* section of Chapter 6, page 6–30, for details.

P&P: Search Window Configuration

The search window configuration procedure for the feature finder tool is identical to the same procedure for the reference window tool. Refer to the *Search Window Configuration* section of Chapter 6, page 6–33, for details.

Passes: First and Second Pass Configuration

Refer to the *Single Pass vs Double Pass* section of Chapter 6, page 6–34, for a discussion of the application considerations involved in choosing Single Pass or Double Pass.

First Pass Configuration

The first pass configuration procedure for the feature finder tool is identical to the same procedure for the reference window tool. Refer to the *First Pass Configuration* section of Chapter 6, page 6–34, for details.

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Second Pass Configuration

The second pass configuration procedure for the feature finder tool is identical to the same procedure for the reference window tool. Refer to the *Second Pass Configuration* section of Chapter 6, page 6–46, for details.

Max. Number: Limiting Feature Recognition

The Max. Number selection enables you to limit the number of features that the feature finder tool recognizes, thereby improving the tool's efficiency and conserving system memory.

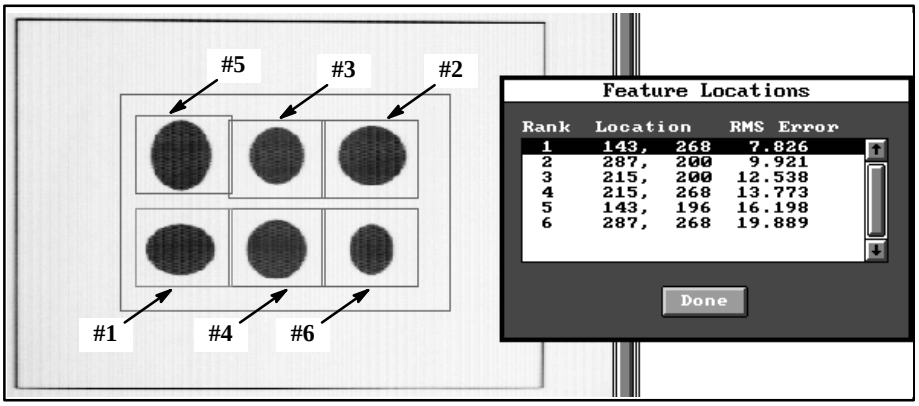
Nominal ("Learn") Function

The number appearing in the Nominal field after you pick it indicates the number of features that matched the stored template, within the limit imposed by the Max. Number setting in the tool edit panel. Thus, if six features *could* match the stored template, but Max. Number were set to 4, then the maximum "learn" number would be limited to 4.

When you pick the Nominal field, the Feature Locations panel appears in the display, as shown by the example in Figure 7.87. At the same time, the search window and one or more feature windows appear over the image. In this example, all six of the dark objects in the search window have been matched; thus, all six objects show feature windows.

Figure 7.87 illustrates the appearance of the Feature Locations panel and the windows when using the "Stop When First" parameter.

Figure 7.87 Example: Feature Locations Panel ("Stop When *First* Feature" Enabled)



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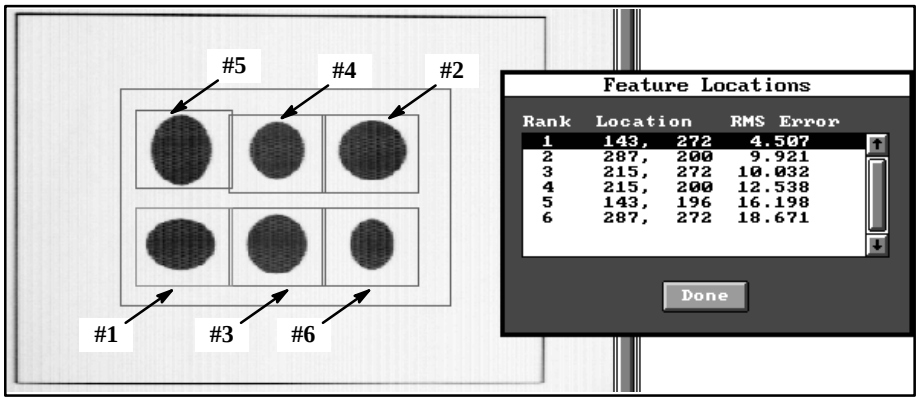
The data in the Feature Locations panel appears under three columns, which are defined as follows:

- **Rank** — This identifies the features in the list in *ascending* order of their RMS values. (The currently highlighted item in the panel corresponds to the *green* feature window in the image.)
- **Location** — This identifies the X– and Y–axis coordinates of the upper–left corner of each feature window.
- **RMS Error** — This displays the calculated RMS (root mean square) error for each feature (refer to the *Pixel Error Parameter Selections* section on page 6–43 for details about RMS error calculations).

Note that rank 1 in the Feature Locations panel is highlighted. The corresponding feature window, labeled #1 in the figure, appears in *green*. All the other feature windows appear in *red*. If ranks 2 through 6 are highlighted, one at a time, the corresponding feature windows will appear in green in the numerical order shown in the figure.

Figure 7.88 illustrates the appearance of the Feature Locations panel and the windows when using the "Stop When Best" parameter.

Figure 7.88 Example: Feature Locations Panel ("Stop When *Best* Feature" Enabled)



Note the slight differences in the coordinate and RMS values in the panel, and in the numerical order of the feature windows in the image. These differences arise because the "stop when best" parameter forces the feature window to scan the entire search window and record the *best* match at each object location.

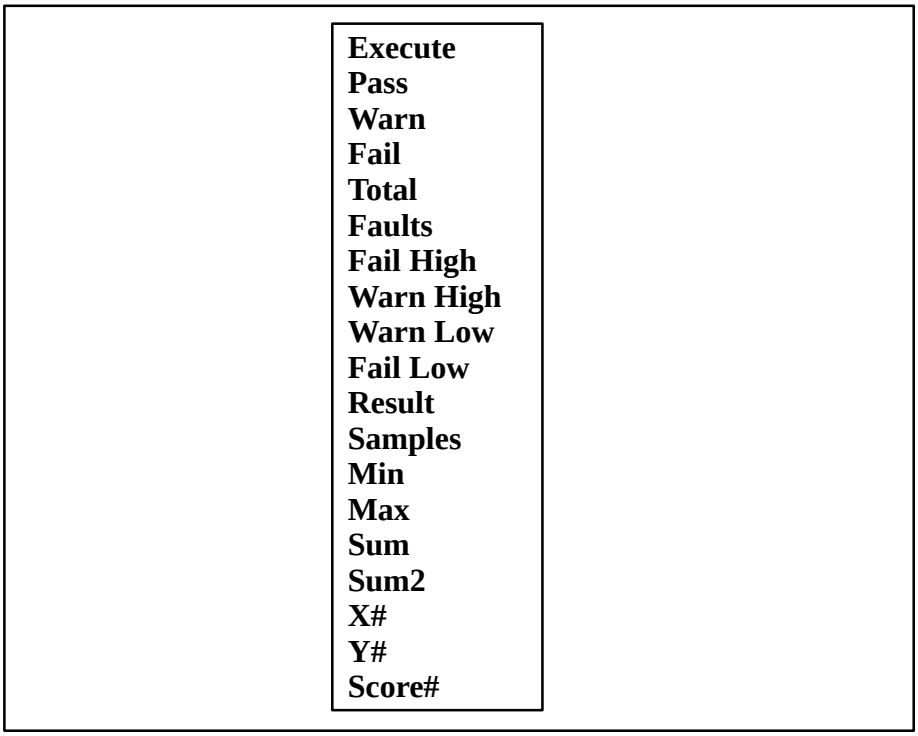
The "stop when first" parameter, however, causes the feature window to be satisfied when it matches the designated *number* of objects that match. The *first* match may or may *not* also be the *best* match in every case. For example, object #4 in the "stop when first" evaluation (X and Y = 215 and 268; RMS = 13.773) becomes object #3 (X and Y = 215 and 272; RMS = 10.032) in the "stop when best" evaluation.

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Feature Finder Tool Inspection Results and Math Tool Formulas

This section discusses the expanded inspection results that are available to a math tool formula from a feature finder tool. As Figure 7.89 shows, the expanded inspection results for a feature finder tool appear in one list.

Figure 7.89 Expanded Results Lists For Feature Finder Tools in Math Formulas



Here is a brief definition and explanation of each of the expanded result types listed in Figure 7.89.

- **Execute** — This returns a 1.000 when the tool has *executed* its inspection task, and 0.000 for all other conditions.
- **Pass** — This returns a 1.000 when the tool has *passed* its inspection task, and 0.000 for all other conditions.
- **Warn** — This returns an “error code” when the tool is in a *warn* condition (and *not* in a *fail* condition) and 0.000 for all other conditions. The error code identifies a specific reason for the warning; for example, error code 1057.000 identifies “Low range warning” as the cause. The complete list of error codes and warn conditions appears in Appendix A of this manual.
- **Fail** — This returns an “error code” when the tool is in a *fail* condition and 0.000 for all other conditions. The error code identifies a specific reason for the failure; for example, error code 1045.000 identifies “High range fail” as the cause of the inspection failure. The complete list of error codes appears in Appendix A of this manual.
- **Total** — This returns the total number of inspections performed.
- **Faults** — This returns the total number of faults detected.

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- **Fail High** — This returns a 1.000 when the inspection result from the tool has exceeded the *high* Fail limit and 0.000 when the result has *not* exceeded the *high* Fail limit.
- **Warn High** — This returns a 1.000 when the inspection result from the tool has exceeded the *high* Warn limit (and the tool is *not* in a *fail* condition) and 0.000 when the result has *not* exceeded the *high* Warn limit.
- **Warn Low** — This returns a 1.000 when the inspection result from the tool has exceeded the *low* Warn limit (and the tool is *not* in a *fail* condition) and 0.000 when the result has *not* exceeded the *low* Warn limit.
- **Fail Low** — This returns a 1.000 when the inspection result from the tool has exceeded the *low* Fail limit and 0.000 when the result has *not* exceeded the *low* Fail limit.
- **Result** — This returns the actual value of the inspection result; that is, the feature count from the feature finder tool. This value corresponds to the "learned" value that appears in the "Nominal" field of the feature finder tool edit panel.
- ***Samples** — This returns the current total number of inspection samples since the start of run operation.
- ***Min** — This returns the current *minimum* value of the inspection results since the start of the run operation.
- ***Max** — This returns the current *maximum* value of the inspection results since the start of the run operation.
- ***Sum** — This returns the current *sum* of all inspection results since the start of the setup or online run operation.
- ***Sum2** — This returns the current *sum* of the *squares* of all inspection results since the start of the setup or online run operation.
- ****X#** — This value pertains only to a feature finder tool. "X#" returns the X coordinate of the *center* of the feature window designated by the # sign, where # is the *number* of the feature.
- ****Y#** — This value pertains only to a feature finder tool. "Y#" returns the Y coordinate of the *center* of the feature window designated by the # sign, where # is the *number* of the feature.
- ****Score#** — This value pertains only to a feature finder tool." Score#" returns the "score" of the feature designated by the # sign, where # is the number of the feature. (The features are ranked according to their score values — the higher the score value, the higher the feature number).

*These expanded *statistical* results are available only when a tool is enabled for *statistics* operations, as indicated by a checked Statistics box in the tool's Options selection panel.

**Whenever X#, Y#, or Score# is selected in a math tool formula, the "#" sign must be replaced with the appropriate *feature* number when the "Single" operation is selected in the math tool edit panel.

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Also, the feature number that replaces the "#" sign must conform to these two requirements:

1. The feature number must be a *constant* non–zero, positive integer.
2. The feature number must be equal to, or less than, the *maximum* number of features appearing in the window.

When the "Multiple" operation is selected, the "#"sign must be *retained* in the formula (replacing or removing the "#" will cause incorrect results). For details about the Multiple operation mode, see the math tool example, *Example: Using a Single Math Tool to Generate Multiple Results*, on page 7–144.

Also, see the *Example: List Processing* section on page 7–141 for an additional example of using the "#" in a math formula.

NOTE: Any formula that references a feature (in the feature window) whose number is equal to or lower than the Max. Number setting in the feature finder tool edit panel, but is *not found* in the feature window, will cause the math tool to *fail*. For example, if the Max. Number setting is 10 and the feature finder finds only five features, the math tool will fail if the formula references features 6 through 10.

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Math Tool

The math tool enables the CVIM2 system to perform mathematical and/or logical operations, using formulas that you specify, on results data from any of the inspection or reference tools in the same toolset as the math tool (cameras must be combined in a single toolset to share results). Your inspection application can use results data from these operations instead of, or in addition to, results data from individual tools, according to your specific requirements.

This chapter provides detailed information about the math tool, the functions that it can perform in an inspection application, and its configuration. The functions and formula selections are defined on the pages listed in Table 7.6.

Table 7.6 Math Tool Functions: Page Locations

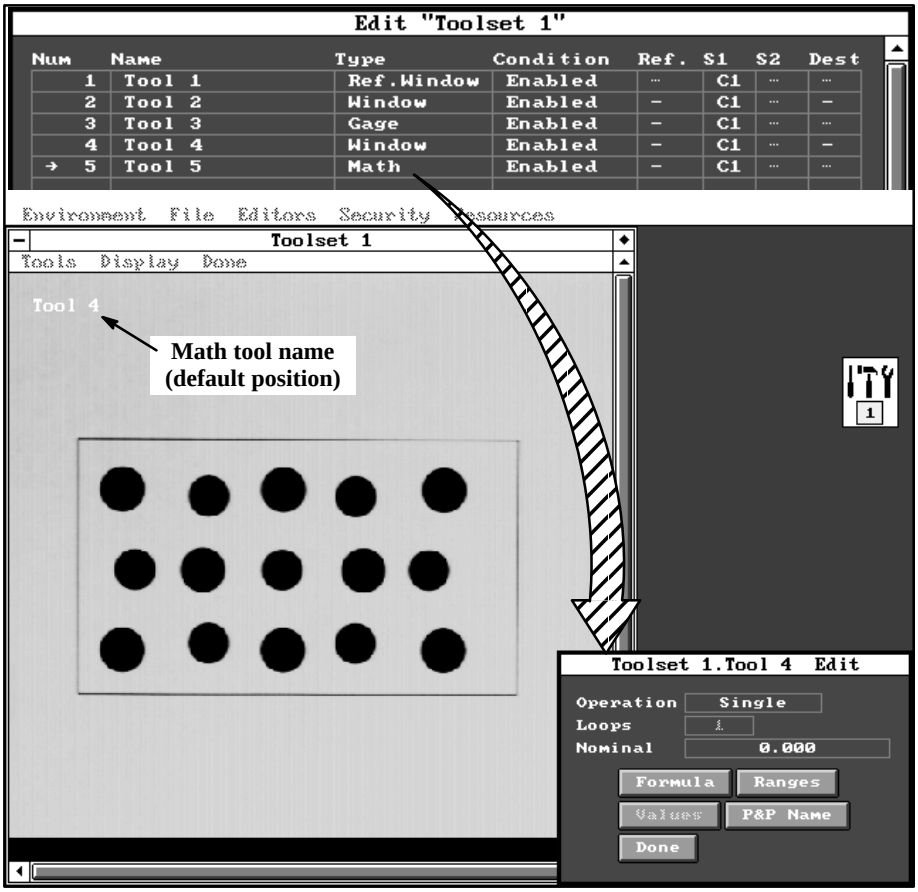
Function	Formula Selection	Page No.
Trigonometry	Sine	7–120
	Arc sine	7–121
	Cosine	7–121
	Arc cosine	7–121
	Tangent	7–121
	Arc tangent	7–122
	Arc tangent 2	7–122
	Degrees	7–123
	Radians	7–123
Logic	And	7–124
	Not	7–125
	Or	7–126
	Xor	7–126
	Test	7–127
	Range	7–127
Bit–logic	Bit and	7–128
	Bit not	7–128
	Bit or	7–129
	Bit xor	7–129
Statistics	Average	7–130
	Maximum	7–131
	Minimum	7–131
	Median	7–131
	Mode	7–131
	Standard deviation	7–131
	Variance	7–131
Miscellaneous	Absolute	7–133
	Distance	7–133
	Modulo	7–133
	Square	7–133
	Square root	7–134
	Sum	7–134
	Integer	7–134
	Fraction	7–134
	X scale	7–134
	Y scale	7–134

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Once you have selected a math tool as outlined in the *Overview: Inspection Tool Selection Process* section (page 7–1), you can configure a formula for that tool by picking the Math field in the toolset edit panel. (One math tool must be selected and configured for each formula required in a particular inspection application.)

When you pick the Math field, the math tool edit panel appears, as shown by the example in Figure 7.90.

Figure 7.90 Example: Selecting the Math Tool Edit Panel



Note in Figure 7.90 that the math tool name appears on the screen in its *default* name ("Tool n") and position.

The math tool edit panel (named "Toolset 1.Tool 4 Edit" in Figure 7.90) contains several data fields and buttons, which are described briefly as follows:

- **Operation** — This field selects either the Single operation mode, during which the math tool produces one result, or the Multiple operation mode, during which the math tool can produce multiple results when certain configuration requirements are met. (For details about the Multiple

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operation mode, see the math tool example, *Example: Using a Single Math Tool to Generate Multiple Results*, on page 7–144).

- **Loops** — This field enables you to set the number of results to produce when Multiple operation is selected.
- **Nominal** — When you pick this field, the currently selected and configured math tool performs a *test* operation, and the results data from the operation appear in this field. The type of results data depends on the formula and the selected operation (Single or Multiple). The *initial* value is 0.000.
- **Formula** — The Formula button accesses the math tool's formula entry keyboard, which is used to configure all formulas.
- **Ranges** — The Ranges button accesses the range–selection panel, which can be used to define range limits for formula results.
- **Values** — The Values button is active only when the Multiple operation is selected. When you pick this button, the Math Values panel appears and lists one or more results values from the formula.
- **P&P Name** — The P&P Name button accesses the Pick & Place panel, which enables you to reposition the math tool name within the image.
- **Done** — When you pick the Done button, the system exits back to the toolset edit panel.

NOTE: If an "illegal" name is entered (such as "tin" for the trig function "tan"), or an "illegal" math sequence used (such as "{Tool 1} +"), a "Bad formula." message box will appear on the screen.

Overview: Math Tool Configuration

A math tool can be selected when the toolset edit panel is on the screen. Starting from the main menu bar, the selection path to this panel is as follows: **Editors** → **Configuration** → **Setup** → **Tools**. This selection path is shown by the example in Figure 7.1 (page 7–2).

Here is a summary list of the basic math tool configuration steps, listed in their normal order of performance:

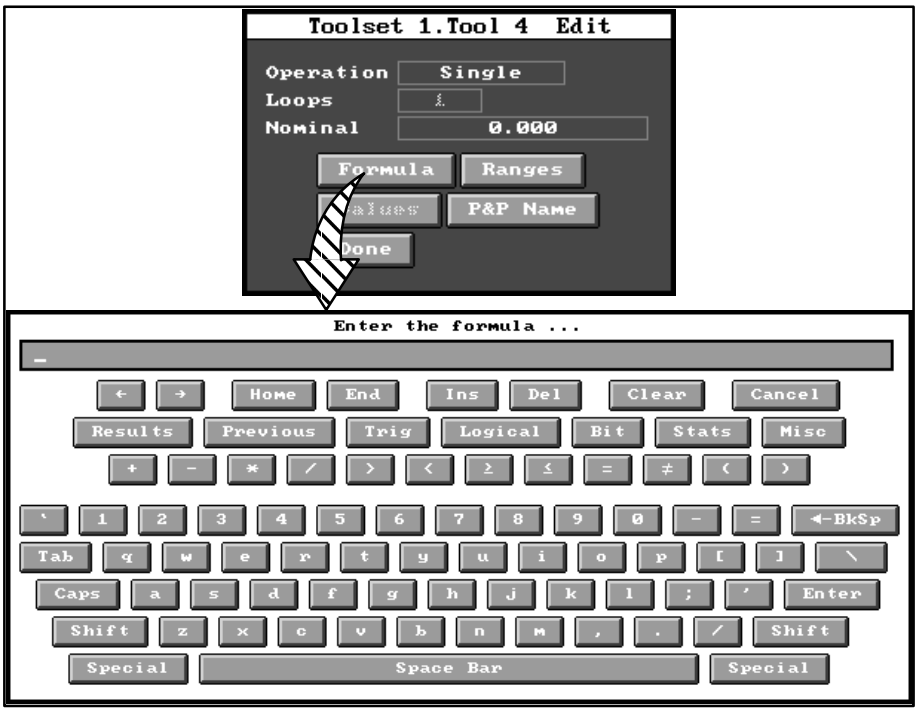
1. Select math tool operation mode.
2. Select number of loops (Multiple operation).
3. Select formula keyboard.
4. Configure formula.
5. Learn nominal value.
6. Check values (Multiple operation).
7. Select ranges.
8. "Pick and place" math tool name.

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Formula Components and Configuration

When you pick the Formula button on the math tool edit panel, the formula entry keyboard appears, as shown in Figure 7.91.

Figure 7.91 Selecting the Formula Entry Keyboard



Note that this keyboard is similar to other “typewriter” type keyboards used throughout the CVIM2 user interface, with the exception of the second and third rows of keys. These keys provide the gateway to the formula–building math operators and operands. The remaining keys provide the usual alpha and numeric entry and control functions, as described in Chapter 2, *CVIM2 System Configuration: An Overview*, on page 2–14.

NOTE: A formula cannot exceed 127 characters, since that is the length of the formula entry input buffer.

The *second row* keys operate as “macro” keys, in the sense that they enable you to enter formula components from lists in several panels, thus using fewer keystrokes. Here is a brief description of the second row keys:

- **Results key** — The Results key accesses the Results panel, which lists all of the tools that *precede* the math tool in the toolset edit panel. When you select one of these tools, it will supply to the formula its results from the *current* inspection.

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- **Previous key** — The Previous key accesses the Previous Results panel, which lists all of the tools in the toolset edit panel (including the math tool). When you select one of these tools, it will supply to the formula its results from the *previous* inspection.
- **Trig key** — The Trig key accesses the Trig Functions panel, which lists all of the trigonometry "operators" that are available to a formula.
- **Logical key** — The Logical key accesses the Logical Functions panel, which lists all of the logical "operators" that are available to a formula.
- **Bit key** — The Bit key accesses the Bit Functions panel, which lists all of the "bit–wise" logical "operators" that are available to a formula.
- **Stats key** — The Stats key accesses the Stats Functions panel, which lists all of the statistics "operators" that are available to a formula.
- **Misc key** — The Misc key accesses the Misc Functions panel, which lists several miscellaneous "operators" that are available to a formula.

NOTE: You can type a formula, or edit any part of one, using only the *character* keys on the keyboard. If you do, however, you must use exactly the *same format* (the same brackets, spacing, case, and so on) that appears when you select a formula function using the panels.

The *third row* keys enter math and logical operators directly into a formula. Here is a brief description of the third ro*w* keys:

- **Add key** — The + key enters an add (+) symbol in the formula, which causes the right operand to be added to the left operand.
- **Subtract key** — The - key enters a subtract (−) symbol in the formula, which causes the right operand to be subtracted from the left operand.
- **Multiply key** — The * key enters a multiply (✲) symbol in the formula, which causes the left operand to be multiplied by the right operand.
- **Divide key** — The / key enters a divide (/) symbol in the formula, which causes the left operand to be divided by the right operand.
- **Greater than key** — The > key is used to enter a "greater than" (>) symbol between two values in a formula. It produces a logic "1" result if the left operand is *greater than* the right operand; otherwise, it produces a logic "0" result.
- **Less than key** — The < key is used to enter a "less than" (<) symbol between two values in a formula. It produces a logic "1" result if the left operand is *less than* the right operand; otherwise, it produces a logic "0" result.

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- **Greater than or equal key** — The ≥ key is used to enter a “greater than or equal” (≥) symbol between two values in a formula, which produces a logic “1” result if the left operand is *greater than or equal to* the right operand; otherwise, it produces a logic “0” result.
- **Less than or equal key** — The ≤ key is used to enter a “less than or equal” (≤) symbol between two values in a formula. It produces a “1” result if the left operand is *less than or equal to* the right operand; otherwise, it produces a “0” result.
- **Equal key** — The = key is used to enter an equal (=) symbol between two values in a formula. It produces a “1” result if the left operand is *equal to* the right operand; otherwise, it produces a “0” result.
- **Not equal key** — The ≠ key is used to enter an equal (≠) symbol between two values in a formula. It produces a “1” result if the left operand is *not equal to* the right operand; otherwise, it produces a “0” result.
- **Open parenthesis key** — The (key is used to place an open parenthesis (() symbol at the beginning (left) of some group of values in formula. It is used to set the order of evaluation within a formula. Nesting of parentheses is limited by the length of the formula entry input buffer, which is 127 characters.
- **Close parenthesis key** — The) key is used to place a close parenthesis ()) symbol at the ending (right) of some group of values in formula. It is used to close an open parenthesis.

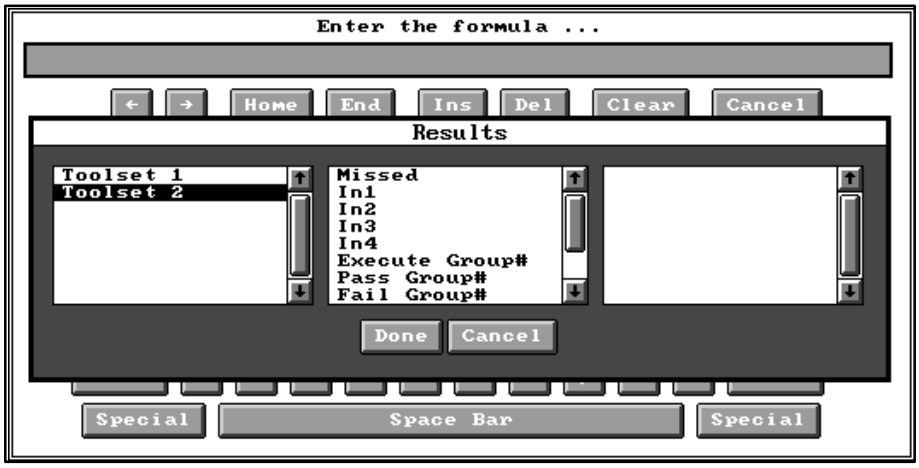
The following sections provide details, etc., of using the formula entry keys listed above.

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Results

When you pick the Results key, the Results panel appears, as shown by the example in Figure 7.92.

Figure 7.92 Example: Results Panel



The Results panel provides three scrolling lists, whose functions are described as follows:

- The *left* list contains all of the *toolsets* in the current configuration. The list illustrated in Figure 7.92 contains Toolset 1 and Toolset 2, which are the two toolsets in the current configuration. The function of the left list is to enable the user to select inspection results from *any* toolset within the current configuration.
- The *center* list contains the *basic results sources* from the *current* inspection cycle that are available to a math tool formula. The list illustrated in Figure 7.92 contains the basic results sources for Toolset 2, as follows:
  - — "Missed" refers to the missed trigger counter. When it is selected in a math formula, "Missed" returns the current missed trigger counter for the toolset.
  - — "In1 through In4" refers to discrete I/O inputs that must be configured in the Discrete I/O Editor panel before they can have any effect in a math tool formula. When one of these inputs is selected in a math formula, it returns the state of the corresponding input line as a logic "1" or logic "0."
  - — "Execute Group#" refers to the execution status of a group of tools that *precedes* the math tool in the toolset edit panel (see Figure 7.90 on page 7–111). The group number (1 to 32) is specified by the "#" sign. This result source returns a logic "1" if any *one* tool in the group *executes* during the inspection cycle, and a logic "0" if *no* tool in the group executes.

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— "Pass Group#" refers to the "pass" status of a group of tools that *precedes* the math tool in the toolset edit panel (see Figure 7.90 on page 7–111). The group number (1 to 32) is specified by the "#" sign. This result source returns a logic "1" if *all* tools in the group *pass* during the inspection cycle, and a logic "0" if any *one* tool in the group *fails*.

— "Fail Group#" refers to the "fail" status of a group of tools that *precedes* the math tool in the toolset edit panel (see Figure 7.90 on page 7–111). The group number (1 to 32) is specified by the "#" sign. This result source returns a logic "1" if any *one* tool in the group *fails* during the inspection cycle, and a logic "0" if *no* tool fails.

— "Tool 1 through Tool 4" refers to the four tools that *precede* the math tool in the toolset edit panel (see Figure 7.90 on page 7–111). During an inspection cycle, tools 1 through 4 are always processed *before* the math tool. Their results are stored in system memory, where they are available to a math tool formula during the *same* inspection cycle.

NOTE: Results from tools that *follow* a math tool in the toolset edit panel are *not* available to that math tool during the *same* inspection cycle.

- The *right* list contains *expanded tool results* that pertain to the tool highlighted in the center list. The list illustrated in Figure 7.92 is empty at this time. However, when one of the four tool (Tool 1 through Tool 4) is highlighted in the center (basic results) list, the corresponding expanded tool results will appear in this list.

The Results panel has two buttons, which are described briefly as follows:

- **Done** — When you pick the Done button, the system exits back to the formula entry keyboard and enters the highlighted results selection into the formula entry field in the keyboard.
- **Cancel** — When you pick the Cancel button, the exits back to the formula entry keyboard, but does *not* enter any highlighted results selection into the formula entry field.

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Basic Results Sources

When you highlight a tool in the center list of the Results panel and pick the Done button, the tool name appears in *braces* in the formula entry field of the keyboard . . .

{Tool 1}

. . . and the Results panel then exits from the screen.

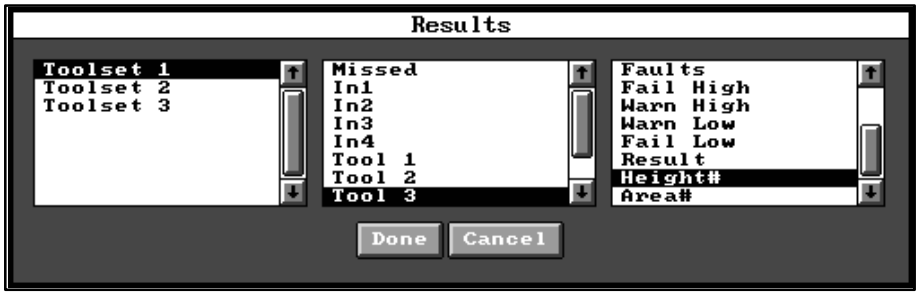
{Tool 1} *could* operate as a "formula" by itself, but more typically it would be a component of a larger formula. In either case, {Tool 1} returns the *basic results* from Tool 1 in the toolset edit panel.

The specific *content* of the basic results depends on the specific inspection tool *type* and the tool *operation* selected for it. Generally, the basic results corresponds to the "learned" value appearing in Nominal field of the tool edit panel. For example, if Tool 1 were a gage tool configured for linear measurement, the basic results data that {Tool 1} returns would be the *distance value* between Feature A and Feature B on the gage tool.

Expanded Tool Results

When you highlight a tool in the center (basic results) list, the *expanded* tool results for that tool appears in the right list, as shown by the example in Figure 7.93. The specific selections that appear in the expanded results list depend on the inspection tool *type* and the tool *operation* selected for it. The example in Figure 7.93 illustrates a partial list of expanded results for a window tool.

Figure 7.93 Example: Selecting Expanded Tool Results



When you highlight an entry in the right list and pick the Done button, the entry appears in *braces* in the formula entry field of the keyboard . . .

{Tool 3.Height#}

. . . and the Results panel then exits from the screen.

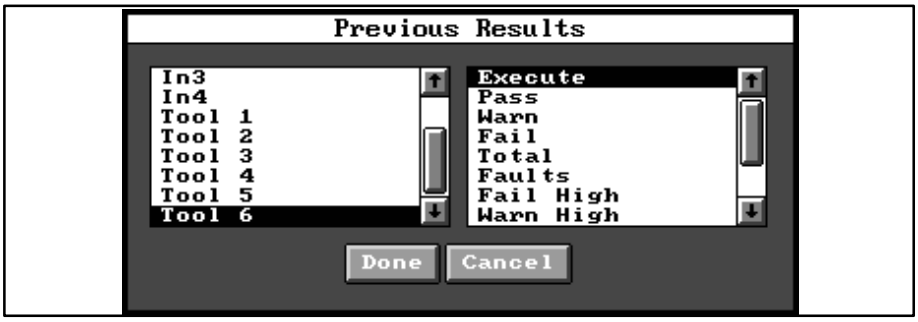
You will find detailed information about the expanded results selections that are available to each tool at the end of each tool section in this chapter and in Chapter 6, *Reference Tools*.

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Previous Results

When you pick the Previous key, the Previous Results panel appears, as shown by the example in Figure 7.94.

Figure 7.94 Example: The Previous Results Panel



The Previous Results panel provides two scrolling lists, whose functions are described as follows:

- The *left* list contains the *basic results sources* from the *previous* inspection cycle that are available to a math tool formula.
- The *right* list contains the *expanded tool results* that pertain to the tool highlighted in the left list.

(Note that unlike the Results panel, the Previous Results panel does not enable access to previous inspection results from *other* toolsets.)

Since these basic and expanded results are from the *previous* inspection cycle, not the *current* one, results from *all* tools in the toolset are available to a math tool formula, including the tools that *follow* the math tool in the toolset edit panel. Otherwise, these results are the same as those that are described in the *Basic Results Sources* and *Expanded Tool Results* sections on page 7–118.

NOTE: A math tool using a Previous Results formula will always fail the first inspection, since no "previous results" are available at that time.

When you highlight an entry in the right list (for example) and pick the Done button, the entry appears in *brackets* in the formula entry field of the keyboard . . .

[Tool 6.Execute]

. . . and the Previous Results panel then exits from the screen. (The brackets are used to differentiate *previous* results from *current* results.)

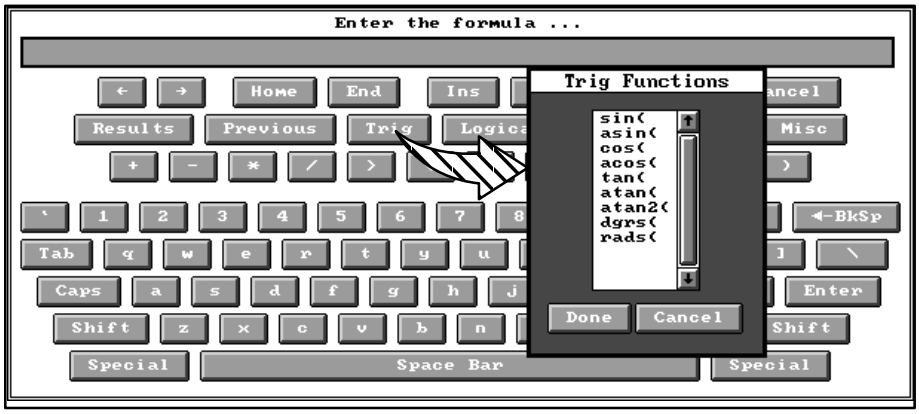
You will find detailed information about the expanded results selections that are available to each tool at the end of each tool section in this chapter and in Chapter 6, *Reference Tools*.

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Trig Functions

When you pick the Trig key, the Trig Functions panel appears, as shown by the example in Figure 7.95.

Figure 7.95 Example: Selecting the Trig Functions Panel



The Trig Functions panel lists all of the trigonometry functions that a math tool can perform.

When you highlight any one of these "trig" functions, and then pick the Done button, it appears in the formula entry field of the keyboard . . .

sin(

. . . and the Results panel then exits from the screen.

After selecting a trig function from the list, you must enter a value appropriate to the selected function, followed by a *closing parenthesis*. At that point, the entry *could* operate as a "formula" by itself; however, it would normally be used as one component of a longer formula.

Here is a brief description of each of the trig functions:

sin — The "sin" (sine) function calculates the sine of the angle that you enter after the opening parenthesis. Thus, if you enter sin(45) as a standalone formula, and then pick the Nominal field in the tool edit panel, 0.707 (the sine of 45°) will appear in the Nominal field.

Here are some examples that illustrate sine function results for other angles:

- sin(135) = 0.707
- sin(225) = –0.707
- sin(315) = –0.707

In a typical application, the sine function would likely be used to express the sine of an angle returned from a tool operation, such as this:

sin({Tool1.Theta})

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asin — The “asin” (arc sine) function calculates an arc sine (angle) on the basis of the sine value that you enter after the opening parenthesis. Thus, if you enter asin(.707) as a standalone formula, and then pick the Nominal field in the tool edit panel, 44.991 (the arc sine of 0.707) will appear in the Nominal field. Similarly, if you enter asin(–.707), –44.991 will appear.

Note that the acceptable range of arc sine values is 0.0 to ±1.0. If you enter a value greater than 1.0, the Nominal field will display an “Out of domain.” message box, which indicates that the value cannot be used.

cos — The “cos” (cosine) function calculates the cosine of the angle that you enter after the opening parenthesis. Thus, if you enter cos(60) as a standalone formula, and then pick the Nominal field in the tool edit panel, 0.500 (the cosine of 60°) will appear in the Nominal field.

Here are some examples that illustrate cosine function results for other angles:

- cos(120) = –0.500
- cos(240) = –0.500
- cos(300) = 0.500

In a typical application, the cosine function would likely be used to express the cosine of an angle returned from a tool operation, such as this:

cos({Tool1.Theta})

acos — The “acos” (arc cosine) function calculates the arc cosine (angle) on the basis of the cosine value that you enter after the opening parenthesis. Thus, if you enter acos(.5) as a standalone formula, and then pick the Nominal field in the tool edit panel, 60.000 (the arc cosine of 0.500) will appear in the Nominal field. Similarly, if you enter acos(–.5), 120.000 will appear.

Note that the acceptable range of arc cosine values is 0.0 to ±1.0. If you enter a value greater than 1.0, the Nominal field will display an “Out of domain.” message box, which indicates that the value cannot be used.

tan — The “tan” (tangent) function calculates the tangent of the angle that you enter after the opening parenthesis. Thus, if you enter tan(30) as a standalone formula, and then pick the Nominal field in the tool edit panel, 0.577 (the tangent of 30°) will appear in the Nominal field.

Here are some examples that illustrate tangent function results for other angles:

- tan(90) = 353013952228677
- tan(180) = –0.000

In a typical application, the tangent function would likely be used to express the tangent of an angle returned from a tool operation, such as this:

tan({Tool1.Theta})

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atan — The "atan" (arc tangent) function calculates the arc tangent (angle) on the basis of the tangent value that you enter after the opening parenthesis. Thus, if you enter atan(.5) as a standalone formula, and then pick the Nominal field in the tool edit panel, 26.565 (the arc tangent of 0.500) will appear in the Nominal field. Similarly, if you enter atan(–.5), –26.565 will appear.

Note that the acceptable range of arc tangent values is 0.0 to ∞.

atan2 — The "atan2" (arc tangent "2") function calculates the arc tangent (angle) on the basis of entering positive and negative Y–axis and X–axis values after the opening parenthesis. It takes the form "atan2(*y*,*x*)," where *y* is the Y–axis value and *x* is the X–axis value.

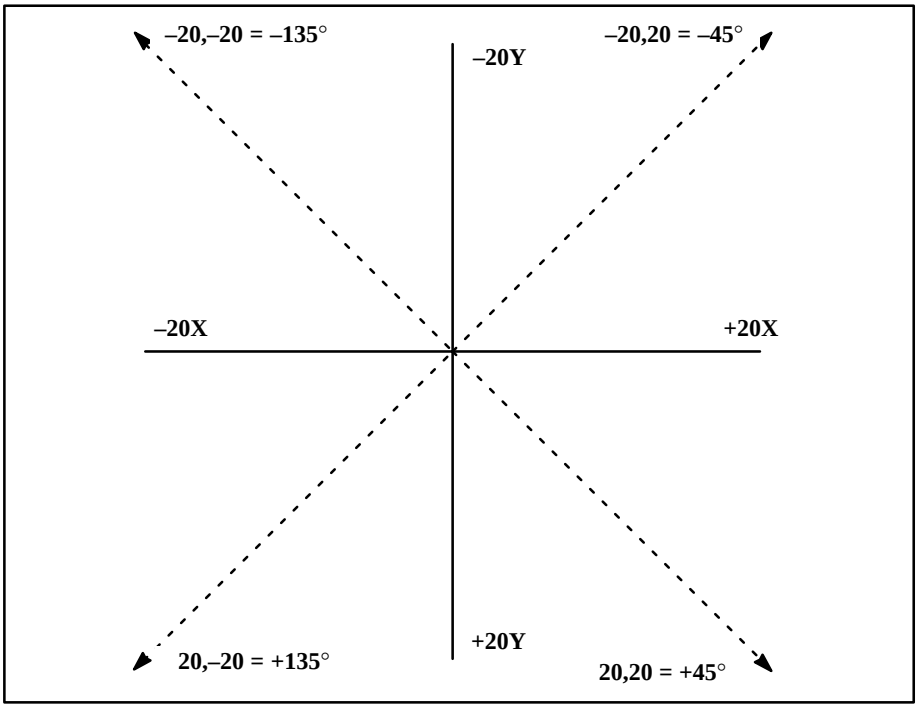
The unique aspect of the atan2 function is its ability to identify the *quadrant* in which an angle is located. It makes this distinction on the basis of the *signs* of the Y–axis and X–axis values. Thus, if you enter atan2(20,20) as a standalone formula, and then pick the Nominal field in the tool edit panel, 45.000° (the arc tangent of 20 ÷ 20 or 1.000) will appear in the Nominal field.

Similarly, atan2(–20,20) yields –45.000°, atan2(–20,–20) yields –135.000°, and atan2(20,–20) yields 135.000°. Thus, while each tangent value (that is, $y \div x$) in each of these examples is ± 1.000, the four possible combinations of the *signs* of *x* and *y* enables the atan2 function to determine the specific quadrant in which the angle is located.

In the CVIM2 image coordinate system, which is shown in Figure 7.96 (page 7–123), the angles are derived as indicated on the basis of the signs of *x* and *y*.

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Figure 7.96 CVIM2 image: X and Y Values and Corresponding Angles for atan2



For an example of using the atan2 function to find an angle in the image, refer to the *Math Tool Formula Examples* section on page 7–137.

dgrs — The "dgrs" (degrees) function converts radians to *degrees* on the basis of the radian value that you enter after the opening parenthesis. Thus, if you enter dgrs(3.14159) as a formula, and then pick the Nominal field in the tool edit panel,180.000 will appear in the Nominal field, indicating that 3.14159 *radians* was converted to 180.000 *degrees*.

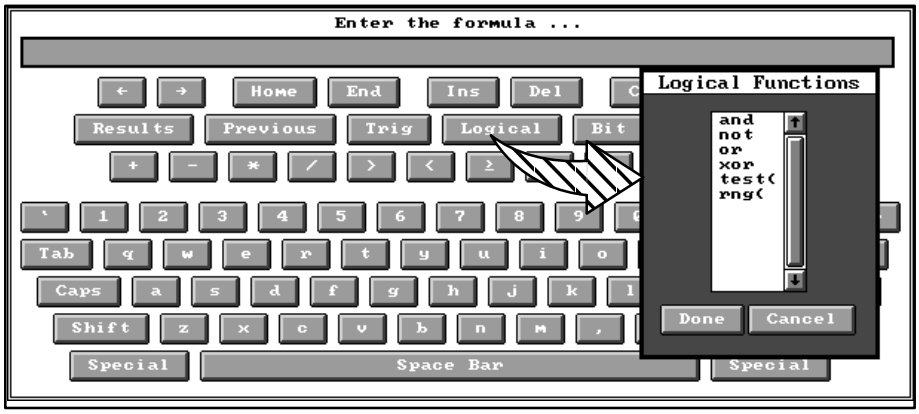
rads — The "rads" (radians) function converts degrees to *radians* on the basis of the degree value that you enter after the opening parenthesis. Thus, if you enter rads(180) as a formula, and then pick the Nominal field in the tool edit panel, 3.142 will appear in the Nominal field, indicating that 180 *degrees* was converted to 3.142 *radians*.

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Logical Functions

When you pick the Logical key, the Logical Functions panel appears, as shown by the example in Figure 7.97.

Figure 7.97 Example: Selecting the Logical Functions Panel



The Logical Functions panel lists all of the logic operators that are available to a math tool.

The "and," "or," and "xor" logic operators perform logical operations when placed between two values in a formula, whereas the "not" operator is placed ahead of an expression containing other logic operators. The "test" operator requires a *single* value to be placed immediately after the opening parenthesis (and must be followed by a closing parenthesis). The "rng" operator requires *three* values.

The value(s) used with a logic operator are usually inspection results of some kind. They are *always* either *zero* or *non–zero*, and can be thought of as "inputs" to a logic operator. Thus, if an input value is *zero*, it is considered to be "false," and if it is *non–zero*, it is considered to be "true." The result or "output" from all of these logic operators is either a logic "1" or a logic "0," according to whether or not the input logic condition is *satisfied* for the particular logic operator.

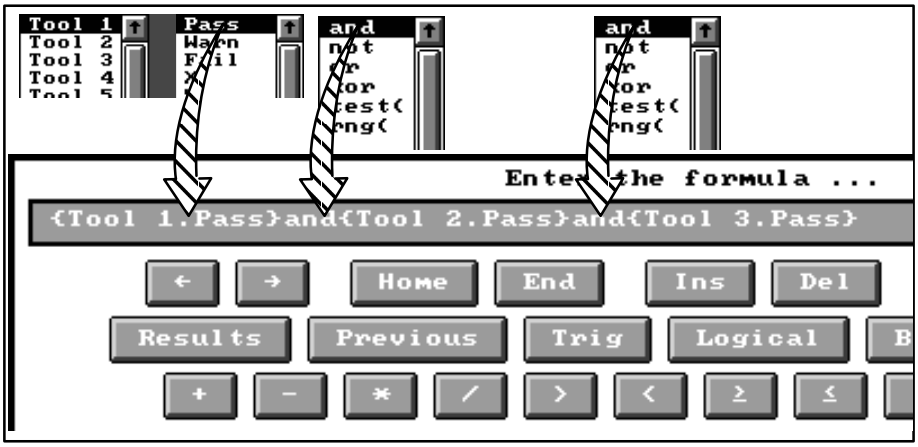
Here is a brief description of each logic operator and an example of its use:

and — The "and" logic operator is inserted between two or more expressions (such as inspection results values) in a formula. If the value of *each* expression ("input") is logic "1" *(*or *non–zero*), the result of the logic operation ("output") will be a logic "1." If *any* input is *zero*, however, the output of the formula will be a logic "0."

Figure 7.98 (page 7–125) uses a simple example of a formula to illustrate the relation of the "and" logic operation in a formula.

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Figure 7.98 Example: Using a Logical “and” Function



In this example, Tool 1.Pass, Tool 2.Pass, and Tool 3.Pass will each yield a logic “1” when the corresponding tool passes its inspection task. The *formula* will yield a logic “1” when *all three* tools pass (and each yields a logic “1”).

In another example, such as the following . . .

{Tool2}and{Tool3}

. . . Tool 2 could be an object–counting window tool returning a count of 8, and Tool 3 could be a gage tool returning a linear measurement of 312.000 pixels. Since both of these inputs are *non–zero*, the formula in this case will output a logic “1” result.

not — The “not” logic operator is used with expressions containing other logic operators, and its effect is to *invert* the normal logic result from such expressions. It must be inserted *ahead of* the expression that it modifies. Thus, if the “not” operator is appended to the example formula in Figure 7.98, it will appear as follows . . .

not({Tool1.Pass}and{Tool2.Pass}and{Tool3.Pass})

In this example formula, Tool 1.Pass, Tool 2.Pass, and Tool 3.Pass will each yield a logic “1” when the corresponding tool passes its inspection task. The *formula* would normally yield a logic “1” when *all three* tools pass (and each yields a logic “1”). The “not” operator, however, causes the normal logic “1” result from the formula to be *inverted* to logic “0.”

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or — The “or” logic operator is inserted between two or more expressions (such as inspection results values) in a formula. If the value of *any one* expression (“input”) is logic “1” (or *non–zero*), the result of the logic operation (“output”) will be a logic “1.” If *all* inputs are *zero*, however, the output of the formula will be a logic “0.”

In a simple example, the results from three tools are “ored” together in a formula as follows:

{Tool1.Fail High}or{Tool2.Fail Low}or{Tool3.Warn Low}

These tool results will each yield a logic “1” when the “fail” or “warn” range limit for the corresponding tool is exceeded. The *formula* will yield a logic “1” when *any one* of the three tools yields a logic “1.”

In another example, such as the following . . .

{Tool1}or{Tool2}

. . . Tool 1 could be an object–counting window tool returning a count of 0, and Tool 2 could be a gage tool returning an X–axis value of 156.000 pixels. Since at least *one* of these inputs is *non–zero*, the formula in this case will output a logic “1” result.

xor — The “xor” (exclusive “or”) logic operator is inserted between *two* expressions (such as inspection results values) in a formula. If the values of the expressions (“inputs”) on *both* sides of the “xor” operator are *non–zero*, the result (“output”) of the logic operation will be a logic “0.” If only *one* input is *non–zero*, the output will be a logic “1.” If *both* inputs are *zero*, the output will be a logic “0.”

In this example, if Tool 2 is an object–counting window tool returning a count of 8 and Tool 3 is a gage tool returning a linear measurement of 312.000 pixels, this “xor” formula will output a logic “0” result, since both of the inputs are *non–zero*.

In a simple example, the results from two tools are “xored” together in a formula as follows:

{Tool1.Fail High}xor{Tool2.Fail High}

These tool results will each yield a logic “1” when the “fail high” range limit for either tool is exceeded. The *formula* will yield a logic “1” when *one* of the two tools yields a logic “1.” If both tools yield logic “1” or “0,” the formula will yield a logic “0.”

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test — The “test” logic operator evaluates the expression following the parenthesis. If the value of the expression is *non–zero*, the output from the “test” operation will be a logic “1.” Conversely, if the value of the expression is *zero*, the output from the “test” operation will be a logic “0.”

In a simple example, the result from one tool is “tested” in a formula, as follows:

test({Tool3})

In this example, if the Tool 3 result is 12, the *formula* will output a logic “1,” since the tool result is *non–zero*.

rng — The “rng” (range) logic operator evaluates the expression following the parenthesis to determine whether a particular value lies within a specified range of values. If the value *does* satisfy the range test, the output from the “rng” operation will be a logic “1.” Conversely, if the value does *not* satisfy the range test, the output from the “rng” operation will be a logic “0.”

The value and range limits are entered from the keyboard immediately after the open parenthesis in this order: minimum range limit, value, maximum range limit. The entries must be separated by commas.

In a simple example, the result from one tool is range–checked in a formula, as follows:

rng(300,{Tool3},320)

In this example, the minimum range limit is 300, the value (Tool 3 result) is 312.000 pixels, and the maximum range limit is 320. Since the value, 312.000, *does* lie within the 300 to 320 range limits in this case, the *formula* will output a logic “1.” If the value were <300 or >320, the formula would output a logic “0.”

Bit Functions

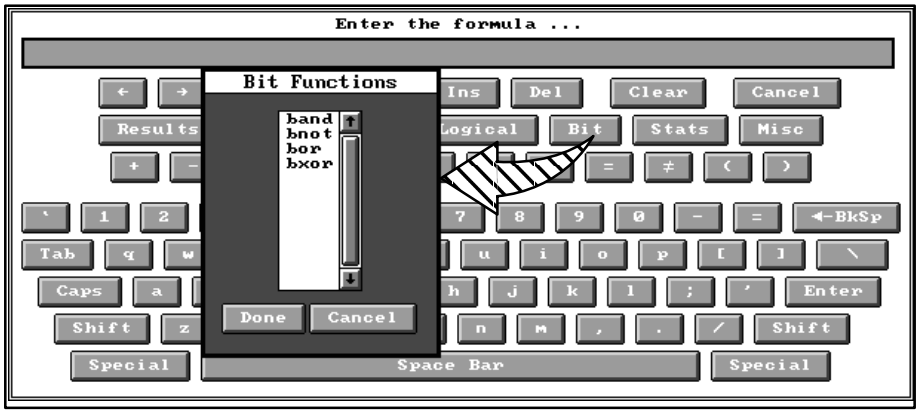
When you pick the Bit key, the Bit Functions panel appears, as shown by the example in Figure 7.99 (page 7–128).

The Bit Functions panel lists all of the bit–level logic operators that are available to a math tool.

The “band,” “bor,” and “bxor” logic operators perform logical operations when placed between two values in a formula, whereas the “bnot” operator is placed ahead of an expression containing other logic operators.

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Figure 7.99 Example: Selecting the Bit Functions Panel



The value(s) used with a bit–level logic operator are usually numeric inspection results of some kind. These values can be thought of as "inputs" to the logic operator, which converts them to binary equivalent values *first*, and then performs the selected bit–level logic operation.

The result or "output" from all of these bit–level logic operators is always a decimal *number*, not a logic "1" or "0."

band — The "band" (bit and) logic operator is inserted between *two* expressions (such as inspection results values) in a formula. The values of the expressions ("inputs") on both sides of the "band" operator are converted to binary equivalents and are "anded" at the binary level. The binary result of the logic operation ("output") is then converted back to decimal form.

In a simple example, two values are "bit–anded," as follows:

87band119

In this example, the ASCII value of the uppercase character "W" (87_{10}) is bit–anded with the ASCII value of the lowercase "w" (119_{10}). The effect is to convert the lowercase "w" to uppercase "W" by changing bit 5 to 0, as follows:

$$\begin{array}{l} 87_{10} = 1010111_2 \\ \underline{119_{10} = 1110111_2} \\ \qquad\quad 1010111_2 = 87_{10} \end{array} \Big) \text{ AND}$$

bnot — The "bnot" (bit not) logic operator is used with expressions containing other logic operators, and its effect is to *invert* the normal logic results from such expressions to their 32–bit "1's" complement. The "bnot" operator must be inserted *ahead of* the expression that it modifies.

Thus, if the "bnot" operator is appended to the "bxor" example formula above, it will appear as follows:

bnot87bxor119

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In this example formula, the decimal value 87_{10} is bit–xored with the decimal value $119_{10,}$ which produces a result of 32_{10}. The whole expression is then modified by the "bnot" operator, the effect of which is to invert all bit positions in a 32–bit version of the decimal 32_{10}, changing it to a 32–bit "1's" complement result, as follows:

```
                    87₁₀ = 1010111₂ ) XOR
                  119₁₀ = 1110111₂
                           0100000₂ = 32₁₀

0000 0000 0000 0000 0000 0000 0010 0000₂ =          32₁₀
                              BNOT↓
1111 1111 1111 1111 1111 1111 1101 1111₂ = 4294967263₁₀
```

However, since the 32–bit number resulting from the "bnot" operation is too large, because of internal restrictions, that number can be "masked" down to a more useful size by bit–anding it with an 8–bit mask of "1's" (that is, 255_{10}). The complete example formula would then appear as follows:

```
(bnot87bxor119)band255
```

This will yield a value of 223_{10}, as shown below:

```
1111 1111 1111 1111 1111 1111 1101 1111₂ = 4294967263₁₀
0000 0000 0000 0000 0000 0000 1111 1111₂ =         255₁₀
-----------------------------------------------------------
0000 0000 0000 0000 0000 0000 1101 1111₂ =         223₁₀
```

bor — The "bor" (bit or) logic operator is inserted between *two* expressions (such as inspection results values) in a formula. The values of the expressions ("inputs") on both sides of the "bor" operator are converted to binary equivalents and are "ored" at the binary level. The binary result of the logic operation ("output") is then converted back to decimal form.

In a simple example, two values are "bit–ored," as follows:

```
87bor119
```

In this example, the ASCII value of the uppercase character "W" (87_{10}) is bit–ored with the ASCII value of the lowercase "w" (119_{10}). The effect is to convert the uppercase "W" to lowercase "w" by changing bit 5 to 1, as follows:

```
  87₁₀ = 1010111₂ ) OR
119₁₀ = 1110111₂
         1110111₂ = 119₁₀
```

bxor — The "bxor" (bit "exclusive" or) logic operator is inserted between *two* expressions (such as inspection results values) in a formula. The values of the expressions ("inputs") on both sides of the "bxor" operator are converted to binary equivalents and are "xored" at the binary level. The

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1891879binary result of the logic operation (“output”) is then converted back to decimal form.

In a simple example, two values are “bit–xored,” as follows:

87bxor119

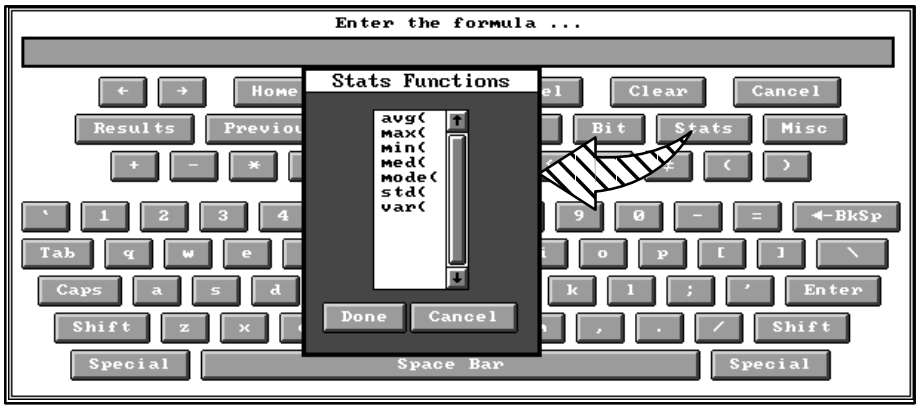
In this example, the decimal value 87_{10} is bit–xored with the decimal value 119_{10}. The effect is to convert all bit positions to 0 that have matching 1 bits or 0 bits (that is, 1 and 1 *become* 0; 0 and 0 *remain* 0), as follows:

$$\begin{array}{r} 87_{10} = 1010111_2 \\ \underline{119_{10} = 1110111_2} \\ 0100000_2 = 32_{10} \end{array} \quad \text{XOR}$$

Statistics Functions

When you pick the Stats key, the Stats Functions panel appears, as shown by the example in Figure 7.100.

Figure 7.100 Example: Selecting the Statistical Functions Panel



The Stats Functions panel lists all of the statistics functions that a math tool can perform.

After selecting a stats function, you must enter one or more values, as required for the selected function, that are separated by commas and followed by a *closing parenthesis*. At that point, the entry *could* operate as a “formula” by itself; however, it would normally be used as one component of a longer formula.

Here is a brief description of each of the “stats” functions:

***avg** — The “avg” (average) function calculates the average of a list of values.

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For example, the following formula calculates the average area of the four smallest contours in a window using a black or white contour operation:

avg([Win1.Area1],[Win1.Area2],[Win1.Area3],[Win1.Area4])

In this example, if Area1 = 907, Area2 = 1022, Area3 = 1202, and Area4 = 1302, the formula would calculate an average value of 1108.250.

***max** — The "max" (maximum) function finds the *largest* value in a list of values. The values must be separated from each other by commas.

For example, the formula "max(2,34,458,1,8977)" will return a result of 8977.000.

***min** — The "min" (minimum) function finds the *smallest* value in a list of values. The values must be separated from each other by commas.

For example, the formula "min(2,34,458,1,8977)" will return a result of 1.000.

***med** — The "med" (median) function sorts a list of values in ascending order, then returns the value of the *center* position for an *odd* number of values, or the *average* of the two center values for an *even* number of values. The values must be separated from each other by commas.

For example, in a formula containing an *odd* number of values, such as "med(82,3,86,2,43)," the formula first sorts the values in ascending order, (2,3,43,82,86), then returns the *center* value, 43.000.

In a formula containing an *even* number of values, such as "med(82,3,86,2,–15,8)," the formula first sorts the values in ascending order, (–15,2,3,8,82,86), then returns the *average value* of the two *center* values, 5.500.

***mode** — The mode function finds the one value in a list of values that appears *most often*. If no value appears any more often that any other value, the mode function returns the *lowest* value in the list. The values must be separated from each other by commas.

For example, the formula "mode(2,3,2,3,3)" will return the value 3.000, since that value occurs more often than 2.

***std** — The "std" (standard deviation) function calculates the standard deviation of a list of values. It calculates the standard deviation for the list of values.

For example, the formula "std(34,32,35,37,36,33)" will return 1.708, which is the standard deviation for this list of values.

***var** — The "var" (variance) function calculates the "variance" of a list of values. The sequence of calculations is this: Compute the *average* value of the values in the list; subtract the average value from each value in the list; compute the square of each of these differences; compute the average value of the squared differences.

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For example, the formula "var(5,8,10)" will be calculated as follows:

1. Compute the average value of the list:
   5 + 8 + 10 = 23
   23 ÷ 3 = 7.667
2. Subtract the average value from each value in the list:
   5 − 7.667 = −2.667
   8 − 7.667 = 0.333
   10 − 7.667 = 2.333
3. Square each of the differences:
   −2.667 × −2.667 = 7.113
   0.333 × 0.333 = 0.111
   2.333 × 2.333 = 5.443
4. Compute the average value of the squared differences:
   7.113 + 0.111 + 5.443 = 12.667
   12.667 ÷ 3 = 4.222

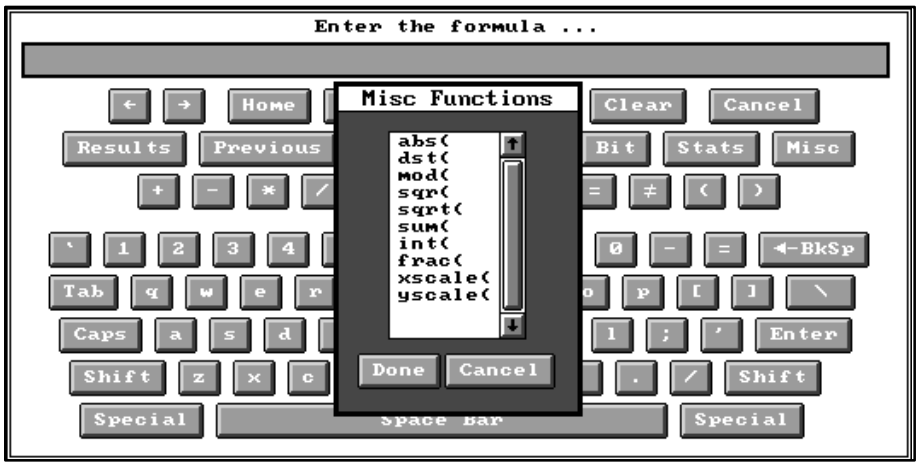
Thus, the *variance* in this example is 4.222.

*Each of the statistics functions can perform "list" processing on inspection tools that produce multiple results, such as a window tool performing a black contour operation. For details of the list processing function, refer to the *Example: List Processing* section on page 7–141.

Miscellaneous Functions

When you pick the Misc key, the Misc Functions panel appears, as shown by the example in Figure 7.101.

Figure 7.101 Example: Selecting the Misc Functions Panel



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The Misc Functions panel lists various additional functions that a math tool can perform.

After selecting a misc function, you must enter one or more values, as required for the selected function, followed by a *closing parenthesis*. At that point, the entry *could* operate as a "formula" by itself; however, it would normally be used as one component of a longer formula.

Here is a brief description of each of the miscellaneous functions:

abs — The "abs" (absolute) function converts a negative number to its absolute value. For example, the formula "abs(−45)" will convert −45 to 45.

dst — The "dst" (distance) function calculates the distance, in pixels, from one position in the image to another position. It performs this calculation on the basis of entering the X–axis and Y–axis coordinate values after the opening parenthesis (and separating them by commas). The dst function formula takes the form "dst(X_1,Y_1,X_2,Y_2)," where X_1 and Y_1 are the coordinates of one position, and X_2 and Y_2 are the coordinates of the other position.

The dst function performs the distance computation by using the Pythagorean theorem: *The square of the hypotenuse of a right angle triangle is equal to the sum of the squares of the two sides*.

Thus, to find the distance between two points in the image (the *hypotenuse* of a right angle triangle), the dst function squares the distance along the X–axis (*one side* of the triangle) and the Y–axis (the *other side* of the triangle), then computes the square root of the sum of the two squares.

For an example of using the dst function to measure a distance in the image, refer to the *Math Tool Formula Examples* section on page 7–137.

mod — The "mod" (modulo) function divides the *first* value entered after the opening parenthesis by the *second* value, and it returns the *remainder* or "modulo," if any, resulting from the division operation. The mod function formula takes the form "mod(X_1,X_2)," where X_1 is the dividend, and X_2 is the divisor.

For example, the formula "mod(45,11)" will divide 45 by 11 (which results in a quotient of 4 and a remainder of 1) and return a *modulo* value of 1.000.

sqr — The "sqr" (square) function calculates the square of the value entered after the opening parenthesis. Thus, the formula "sqr(25)" will return a value of 625.000.

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sqrt — The “sqrt” (square root) function calculates the square root of the value entered after the opening parenthesis. Thus, the formula “sqrt(25)” will return a value of 5.000.

***sum** — The “sum” function calculates the expression entered after the opening parenthesis. Thus, the formula “sum(1,2,3,4)” will return a value of 10.000, while the formula “sum(25/20)” will return a value of 1.250. Similarly, the formula “sum({Tool 1},{Tool 2})” will return a value of 190.000, where the Tool 1 result is 43.000 and the Tool 2 result is 147.000. Further, “sum({Tool 1.Area#})” will return the sum of the area values for tool 1.

*The sum function can perform “list” processing on inspection tools that produce multiple results, such as a window tool performing a black contour operation in a window tool. For details of the list processing function, refer to the *Example: List Processing* section on page 7–141.

int — The “int” (integer) function converts a floating point value to an integer. It performs the conversion by *truncating* the fractional portion of the value. Thus, the formula “int(56.034)” will return a value of 56.000 (“int(–56.034)” will return –56.000).

frac — The “frac” (fraction) function converts a floating point value to a fraction. It performs the conversion by *truncating* the integer portion of the value. Thus, the formula “frac(56.034)” will return a value of 0.034.

xscale — The “xscale” function returns the “X scale” parameter from the calibration data pertaining to a specific camera number, which is entered after the opening parenthesis. The xscale function formula takes the form “xscale(C1),” where C1 is a camera number (1 through 6).

The X scale parameter is the computed ratio of the measurement unit (such as inches) used in the calibration to a linear measurement, in pixels, along the X–axis. Thus, 311.656 pixels along the X–axis may represent a *calibrated* value of 3.000 inches for Camera 1. In this case, the scale factor would be 0.010 (rounded to three places). Therefore, the formula “xscale(1)” would return a value of 0.010.

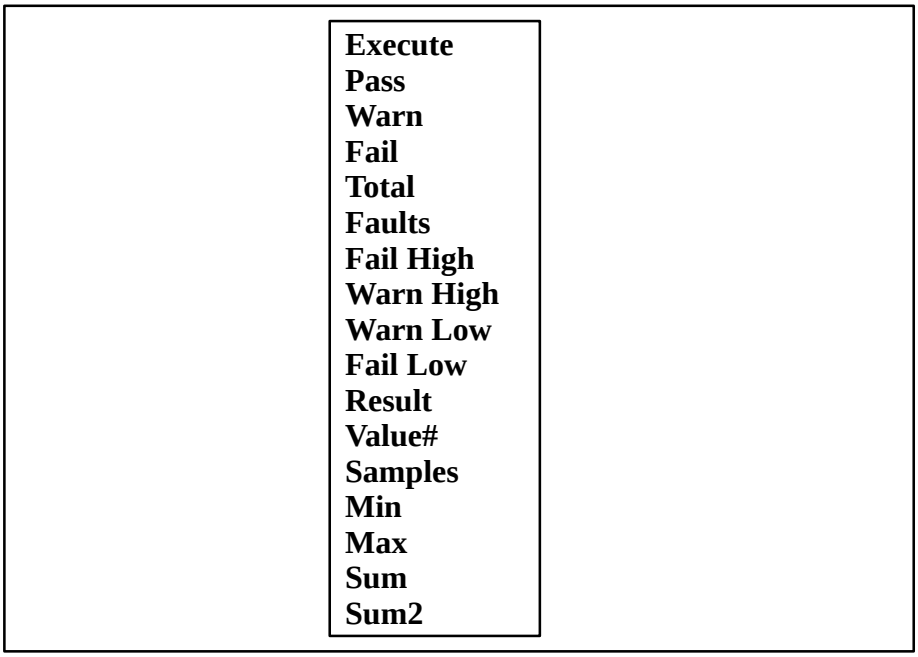
yscale — The “yscale” function performs the same function as the “xscale” function , except it returns the “Y scale” parameter.

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Math Tool Inspection Results and Math Tool Formulas

This section discusses the expanded inspection results that are available to a math tool formula from *another* math tool. As Figure 7.102 shows, the expanded inspection results for a math tool appear in one list.

Figure 7.102 Expanded Results List For Math Tools in Math Formulas



Here is a brief definition and explanation of each of the expanded result types listed in Figure 7.102.

- **Execute** — This returns a 1.000 when the tool has *executed* its inspection task, and 0.000 for all other conditions.
- **Pass** — This returns a 1.000 when the tool has *passed* its inspection task, and 0.000 for all other conditions.
- **Warn** — This returns an “error code” when the tool is in a *warn* condition (and *not* in a *fail* condition) and 0.000 for all other conditions. The error code identifies a specific reason for the warning; for example, error code 1057.000 identifies “Low range warning” as the cause. The complete list of error codes and warn conditions appears in Appendix A of this manual.
- **Fail** — This returns an “error code” when the tool is in a *fail* condition and 0.000 for all other conditions. The error code identifies a specific reason for the failure; for example, error code 1049.000 identifies “Could not access result” as the cause of the inspection failure. The complete list of error codes and fail conditions appears in Appendix A of this manual.
- **Total** — This returns the total number of inspections performed.
- **Faults** — This returns the total number of faults detected.

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- **Fail High** — This returns a 1.000 when the inspection result from the tool has exceeded the *high* Fail limit and 0.000 when the result has *not* exceeded the *high* Fail limit.
- **Warn High** — This returns a 1.000 when the inspection result from the tool has exceeded the *high* Warn limit (and the tool is *not* in a *fail* condition) and 0.000 when the result has *not* exceeded the *high* Warn limit.
- **Warn Low** — This returns a 1.000 when the inspection result from the tool has exceeded the *low* Warn limit (and the tool is *not* in a *fail* condition) and 0.000 when the result has *not* exceeded the *low* Warn limit.
- **Fail Low** — This returns a 1.000 when the inspection result from the tool has exceeded the *low* Fail limit and 0.000 when the result has *not* exceeded the *low* Fail limit.
- **Result** — This returns the actual value of the math tool result. This value corresponds to the "Nominal" value that is "learned" in the math tool setup panel.
- **Value#** — This pertains to a list of values that another math tool, configured for "Multiple" operation, has acquired from a tool that returns multiple results (for example, a window tool using the black contour operation.)
- ***Samples** — This returns the current total number of inspection samples since the start of run operation.
- ***Min** — This returns the current *minimum* value of the inspection results since the start of the run operation.
- ***Max** — This returns the current *maximum* value of the inspection results since the start of the run operation.
- ***Sum** — This returns the current *sum* of all inspection results since the start of the setup or online run operation.
- ***Sum2** — This returns the current *sum* of the *squares* of all inspection results since the start of the setup or online run operation.

*These expanded *statistical* results are available only when a tool is enabled for *statistics* operations, as indicated by Stats appearing in the Enabled column for the corresponding tool.

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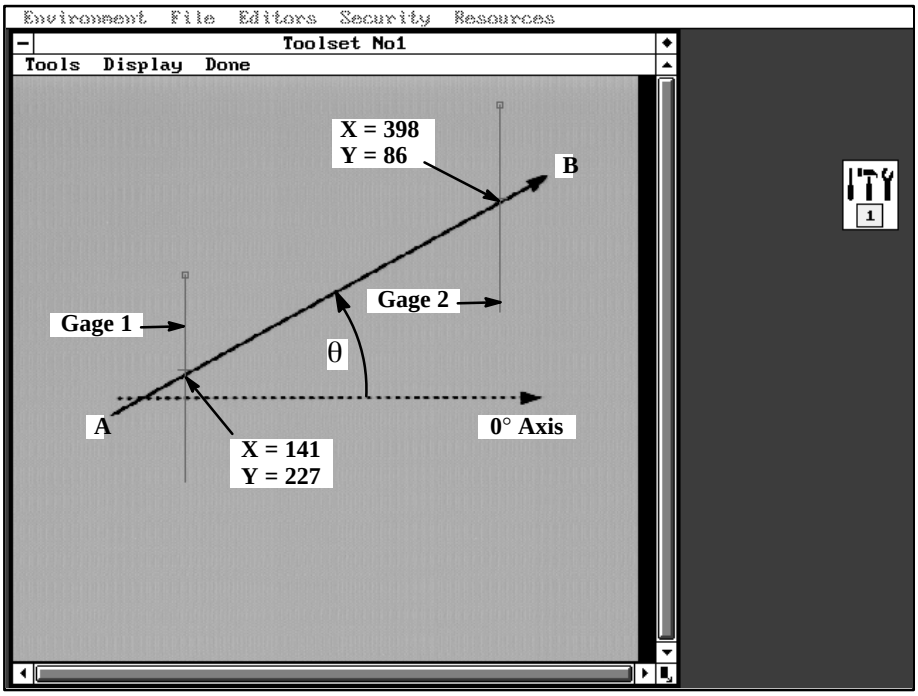
Math Tool Formula Examples

This section contains several examples that demonstrate some of the methods of using math tool formulas.

Example: ATN2 Function

Since the "atan2" (arc tangent "2") function returns an angle whose *value and sign* identifies the quadrant in which the angle is located, as shown in Figure 7.96 (page 7–123), it can be used to indicate the angle of rotation of a line in the image, where 0° is at the 3 o'clock position, as shown by the example in Figure 7.103.

Figure 7.103 Example: Two Gages Configured for Use in ATN2 Function



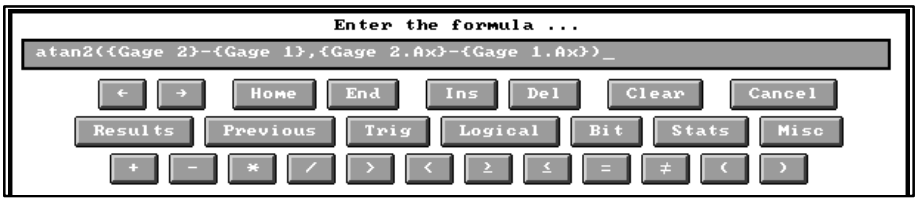
In the example, line A–B is rotated clockwise from the 0° axis of the image. Two gage tools are used to determine the X–axis and Y–axis coordinates of two points (edges) along line A–B. The coordinates of the Gage 1 edge are X = 141 and Y = 227, while the coordinates of the Gage 2 edge are X = 398 and Y = 86.

The atan2(Y,X) function uses positive or negative *values* along the Y–axis and X–axis in order to calculate an angle (and its quadrant). In the example above, these Y and X values are derived from the *changes* in the values of Y and X between Gage 1 and Gage 2; thus, the *change* in Y is from 227 (Gage 1) to 86 (Gage 2), or –141, while the *change* in X is from 141 (Gage 1) to 398 (Gage 2), or +257.

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The X and Y values are derived in a formula that is set up on the formula entry keyboard as shown in Figure 7.104.

Figure 7.104 Example: Using the ATN2 Function in a Math Tool Formula



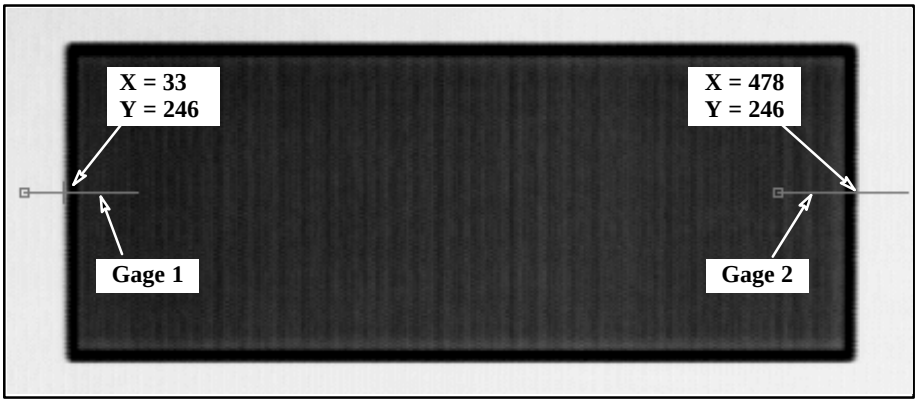
In this formula, inspection results from Gage 1 and Gage 2 are used. Since these gages are both configured for the Y Position operation, the *primary* results are the Y–axis coordinate values. Thus, {Gage 2}–{Gage 1} is evaluated as 86 – 227, which is –141. The *secondary* results are the X–axis coordinate values. Thus, {Gage 2.Ax}–{Gage 1.Ax} is evaluated as 398 – 141, which is +257. (In effect, this formula operates as though it were set up using the constants –141 and +257, as in atan2(–141,257), which calculates the angle as –28.751°.)

With the formula set up as shown in Figure 7.104, when you pick the Nominal field in the math tool edit panel, the system performs one "test" operation of the formula and returns an angle of –28.603°.

Example: DST Function

The "dst" (distance) function returns the distance, in pixels, from one point to another in the image, using the X– and Y–axis coordinates of each point to perform a calculation based on the Pythagorean theorem. Figure 7.105 provides an example that demonstrates its use in a formula.

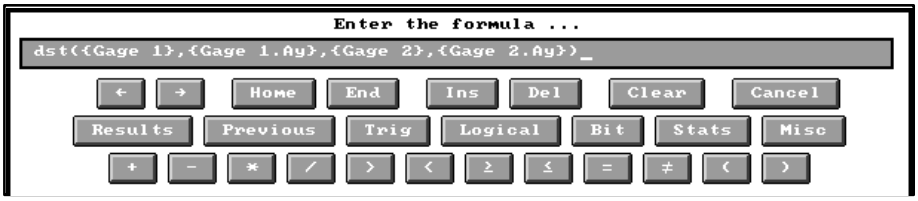
Figure 7.105 Example: Two Gages Configured for Use in DST Function



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In this example, two gages are used to find edge coordinate values on an object in the image. The X and Y values returned by these gages are incorporated into the formula that is set up on the formula entry keyboard as shown in Figure 7.106.

Figure 7.106 Example: Using the DST Function in a Math Tool Formula



In this formula, inspection results from Gage 1 and Gage 2 are used. Since these gages are both configured for the X Position operation, the *primary* results are the X–axis coordinate values, while the *secondary* results are the Y–axis values. Thus, {Gage 1},{Gage 1.Ay},{Gage 2},{Gage 2.Ay} is evaluated as 33, 246, 478, and 246. (In effect, this formula operates as though it were set up using the constants 33,246,478,and 246, as in dst(33,246,478,246), which calculates the distance as 445.000 pixels.)

With the formula set up as shown in Figure 7.106, when you pick the Nominal field in the math tool edit panel, the system performs one “test” operation of the formula and returns a distance of 444.997 (pixels).

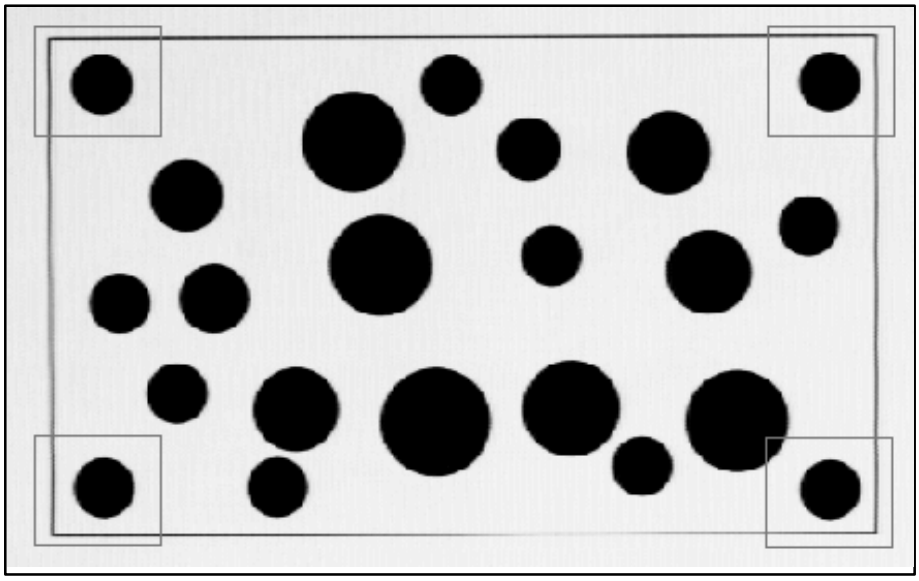
Example: Using Multiple Windows to Count Objects

In a situation where a single window tool cannot be used to count objects because of the difficulty or impossibility of masking unwanted objects within the window, multiple window can be used, along with a math tool formula, to count these objects. Figure 7.107 (page 7–140) illustrates a rectangular workpiece on which the inspection application looks for four rivets — one rivet at each corner of the workpiece.

In this case, the combination of a *single* window tool and a mask cannot remove all of the objects whose size is the same as the rivets. However, four window tools, each positioned over a single rivet and configured to count black objects, as shown in Figure 7.107, along with a math tool, configured to add the object counts from each window, can perform this application.

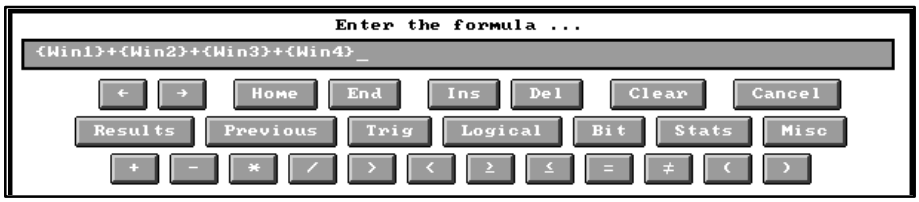
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Figure 7.107 Example: Four Window Tools Configured to Corner Objects



The formula is set up on the formula entry keyboard as shown in Figure 7.108.

Figure 7.108 Example: Formula Configured to Sum Results From Four Window Tools



With the formula set up as shown in Figure 7.108, when you pick the Nominal field in the math tool edit panel, the system performs one “test” operation of the formula and returns a total of 4.000.

By setting the window tools’ Fail High and Fail Low range limits to 1.000, each window tool will yield a “Pass” condition if it detects a single object, or a “Fail” result if it detects *no* object, or more than one object.

By setting the math tool’s Fail High and Fail Low range limits to 4.000, the math tool will yield a “Pass” condition if *all four* windows detect a single object, or a “Fail” result is any window fails.

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Example: List Processing

Some tool operations can produce, in addition to *basic* tool results, a variety of *multiple* results. In such cases, a math tool can be configured to access and process the multiple results either *individually*, or *collectively*, as a "list" of values. The latter case is called "list processing."

For instance, suppose that a window tool, using the "Black contours" operation, identifies ten black objects that meet previously specified *area* limits. A math tool formula can be configured to access and process each of the ten area values *individually*, one step at a time. Or, if appropriate, the formula can be configured to access all ten values (the "list") and process them in a single step using statistics functions (such as "avg") or other functions (such as "sum").

In Figure 7.109, an example window tool is shown using the Black contours operation. In this example, the *perimeter* and *area* parameters have been activated in the Target panel. As a consequence, the window, which contains 15 contours, has identified 12 of them as *objects* on the basis of their perimeter and area measurements. During an inspection cycle, the window tool calculates the perimeter and area values for each of the 12 objects.

Figure 7.109 Example: Window Tool Using Black Contours Operation

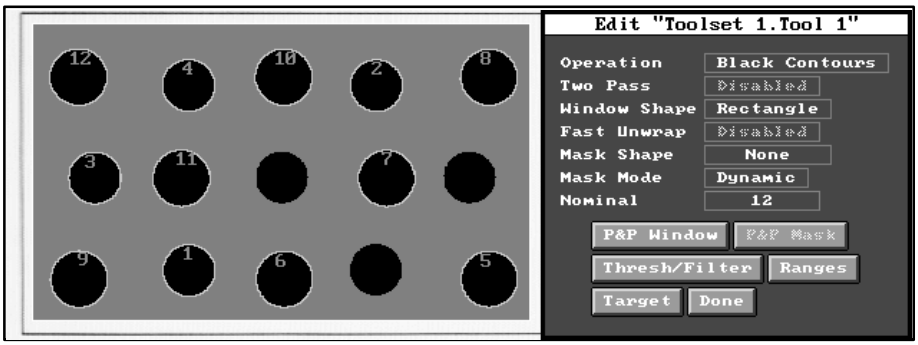
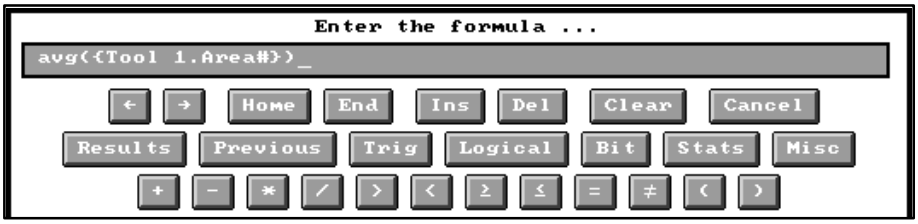


Figure 7.110 illustrates how a math tool formula could be set up for list processing. In this example, the formula performs an "avg" function on the area results from all 12 objects shown in Figure 7.109.

Figure 7.110 Example: Formula Configured For List Processing



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The first element in the formula is "avg(" from the Stats. Functions panel; the second element is "{Tool 1.Area#}" from the Results panel; and the third element is a closing parenthesis from the keyboard. Thus, the complete formula appears as follows:

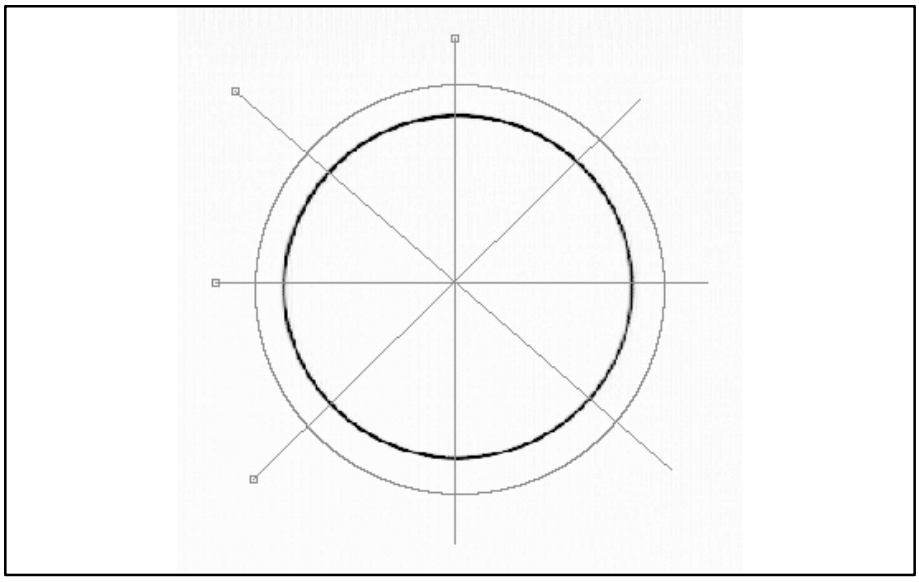
avg({Tool 1.Area#})

When the Nominal field in the math tool Edit panel is picked, it displays the average area of the 12 objects.

Example: Using Formulas to Perform Complex Inspections

Some inspection decisions require more than using only the results data from inspection tools as the *direct* basis for the decision. For some application situations, results data from multiple tools, and from a previous math tool, may be usefully employed in a second math tool. Figure 7.111 illustrates using four gages and window to measure a circular workpiece.

Figure 7.111 Example: Four Gage Tools and One Window Tool Configured to Measure Workpiece

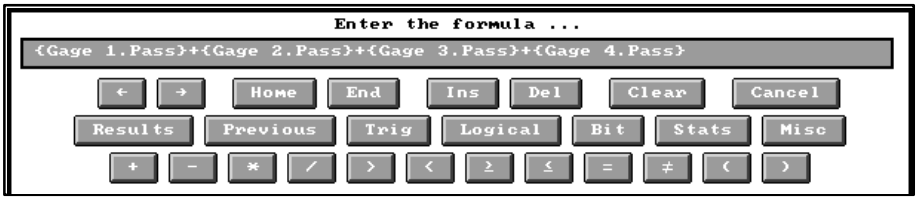


In this example, the four gages measure the diameter of the circular object, and the window measures its area. The gages all have their Fail High and Fail Low range limits set to 10.5 and 9.5, respectively.

The first formula evaluates the "pass" result of each gage (which yields a logic "1" for pass, and a logic "0" for fail), then adds the logic results. Thus, if all four gages *pass*, the math tool result is 4.000, the sum of the four logic "1" results. This formula is set up on the formula entry keyboard as shown in Figure 7.112 (page 7–143).

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Figure 7.112 Example: Formula Configured to Sum "Pass" Results From Four Gage Tools



NOTE: A math formula that sums a series of "tool fail" results, such as . . .

{Gage 1.Fail}+{Gage2.Fail}+{Gage3.Fail}+{Gage4.Fail}

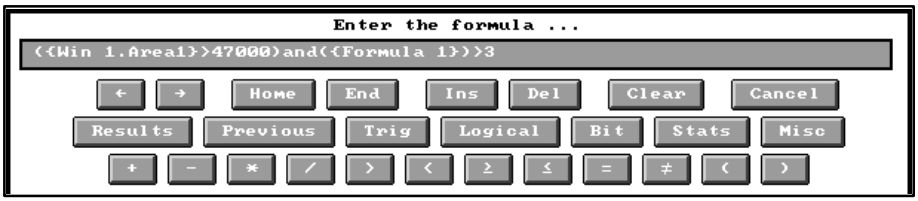
. . . would not work properly, since "tool fail" results are non–logic *error code* values when they are "true," and the sum would be unpredictable (see Appendix A for a list of error codes). However, by adding the "test" function, as follows . . .

test({Gage 1.Fail})+test({Gage 2.Fail})+ . . . test({Gage n.Fail})

. . . each *error code* would be converted to a logic "1," and the sum would thus become predictable.

The second formula evaluates the area returned by the window tool and performs a logical "and" operation with the results of the first math tool. Thus, if the window tool returns an area of 47000 or more pixels, and the first formula returns a result of 3 or greater (meaning that three of the four gages passed), then the second math tool returns a logic "1"; otherwise, it returns a logic "0." This formula is set up on the formula entry keyboard as shown in Figure 7.113.

Figure 7.113 Example: Formula Configured to AND Window Tool and First Math Tool Results



The second formula range limits could all be set to 1.000; thus, if the window tool returns a workpiece area of at least 47000 pixels AND at least three of the four gage tools *pass* their measurement inspections (that is, they return linear measurements between 9.5cm and 10.5cm), then the second math tool will *also* pass (that is, it will return a logic "1").

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Example: Using a Single Math Tool to Generate Multiple Results

This example illustrates the requirements for configuring a math tool to generate *multiple* results from a window tool using a *black contours* operation to generate multiple results. When configured for Multiple operation, a *single* math tool can thus generate the same number of results as an equivalent number of math tools using Single operation.

When you pick the Operation field in the math tool edit panel while "Single" is displayed, the field will toggle to "Multiple," as shown in Figure 7.114.

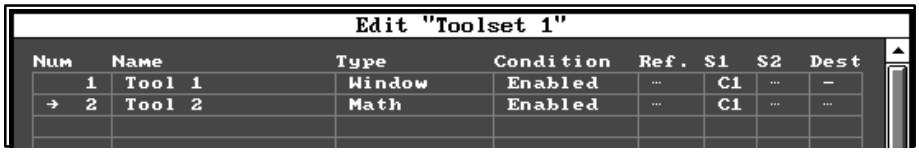
Figure 7.114 Math Tool Edit Panel After Selecting Multiple Operation



Note that the Loops field and the Values button become active when Multiple operation is selected.

In this example, it is assumed that the window tool and math tool are entered in the toolset edit panel as shown in Figure 7.115. It is also assumed that the window tool is configured to use the *black contours* operation to generate the "area" results values of a *maximum* of 15 objects (for details about window contours operations, see the *White Contours; Black Contours* section on page 7–40 of this chapter).

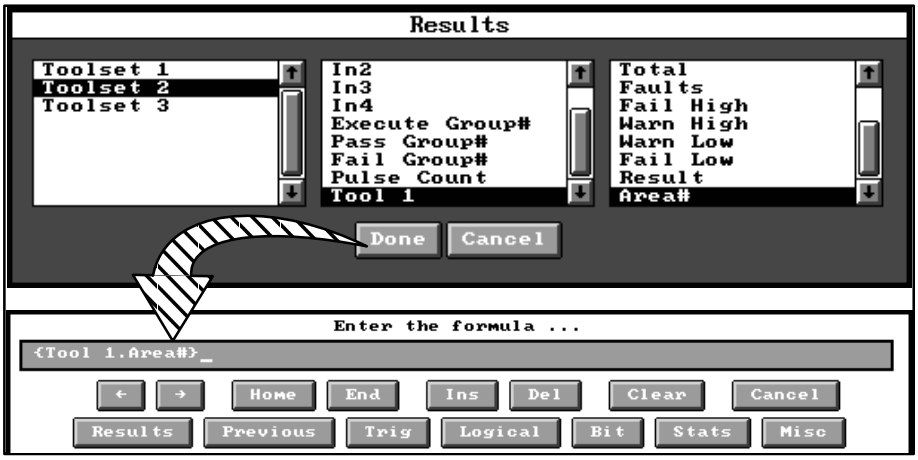
Figure 7.115 Toolset Edit Panel



After the Formula button has been picked to access the formula entry keyboard, the formula for acquiring the "area" results values is entered into the keyboard as shown in Figure 7.116 (page 7–145).

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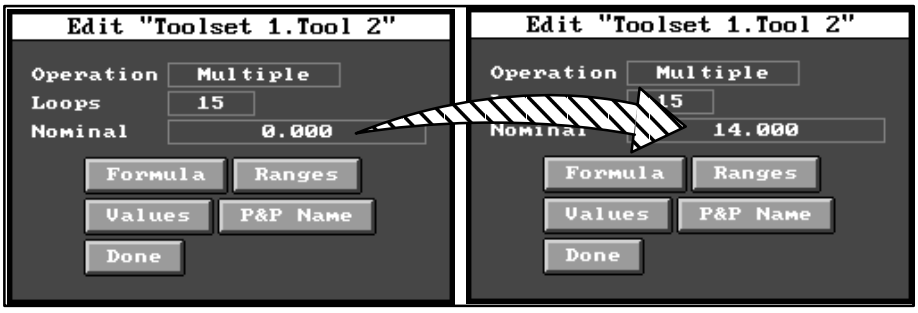
Figure 7.116 Example: Selecting "Area" Formula For Multiple Operation



After the Enter button is picked and the formula entry keyboard exited, the Loops field in the math tool edit panel must be set to 15 in order to "loop" through the formula *up to* 15 times.

When the Nominal field is picked, the math tool "learns" the number of objects whose area has been generated, and this value appears in the field, as shown in Figure 7.117. Note that in this example the number is 14, one *less* than the number *allowed* by the Loops setting of 15.

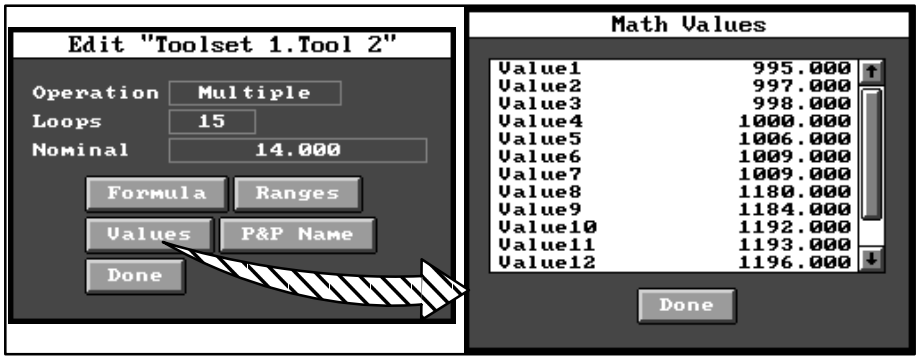
Figure 7.117 Example: "Learning" the Number of Objects



Next, when the Values button is picked, the Math Values panel appears, as shown in Figure 7.118 (page 7–146).

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Figure 7.118 Example: Displaying Area Values in Math Values Panel



The area values appearing in the “scrolling” list are in the same order in which they appear in the window tool. In this example, 14 area results values are listed. Note that only the first 12 values appear initially — the list would have to be “scrolled” to display the remaining values.

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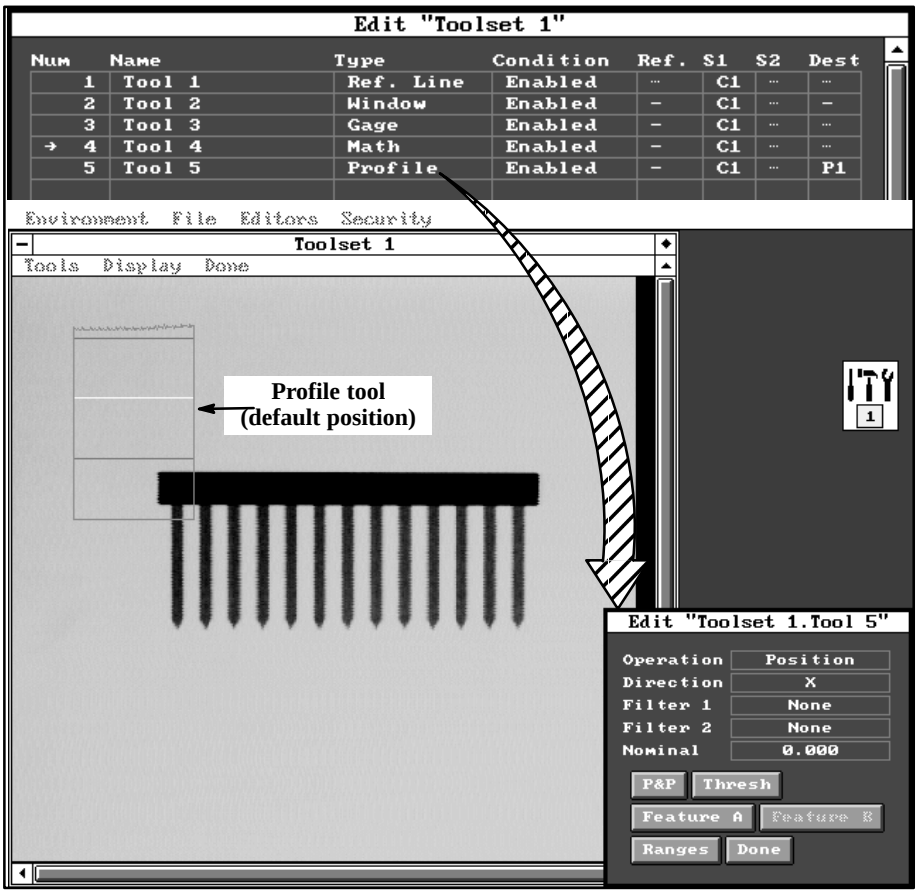
Profile Tool

This section discusses the profile tool and the inspection functions (“operations”) that it can perform.

The profile tool is an *area* tool that can be used to find edge locations and measure distances between edges on images whose edges are otherwise too indistinct for reliable gage tool operation. The profile tool creates a gray scale *profile* of an inspected object, and then identifies one or more features on the profile. These features are the basis for edge location, distance measurement, and object counting operations.

Once you have selected a profile tool as outlined in the *Overview: Inspection Tool Selection Process* section (page 7–1), you can configure it for an inspection application by picking the Profile field in the toolset edit panel. When you do, the profile tool edit panel appears, as shown by the example in Figure 7.119.

Figure 7.119 Example: Selecting the Profile Tool Edit Panel



When a profile tool is first selected, it appears in the upper–left corner of the image field, as shown in Figure 7.119.

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The profile tool edit panel (named "Toolset 1.Tool 5 Edit" in Figure 7.119) contains several parameter selection fields and buttons, which are described briefly as follows:

- **Operation** — This field provides access to the selection of one of the five profile tool "operations." The *default* profile tool operation is Position, which is a feature ("edge") location operation.
- **Direction** — Use this field to pick either the X or the Y direction. This selection determines the *axis* on which the profile tool will perform its measurements. The *default* selection is "X" (for the X axis).
- **Filter 1** — Use this field to pick any one of eight gray scale morphology filters (or "None") to be applied on the profile image, according to the requirements of your application. The *default* selection is None.
- **Filter 2** — This field has the same function as the Filter 1 field. When filters are selected in both fields, the Filter 2 filter will be processed *after* the Filter 1 filter.
- **Nominal** — When you pick this field, the currently selected and configured profile tool performs a *test* operation, and the resulting inspection results data appear in this field. The type of results data depends on the selected profile tool operation. The *initial* value is 0.000 or 0, according to the selected profile tool operation.
- **P&P** — The P&P button provides access to the "pick and place" function for the profile tool. For details about this function, see Chapter 5, *Pick and Place Functions*.
- **Thresh** — The Thresh button accesses the threshold adjustment function and the morphology filter selection panels. For details about the morphology filter functions, see Chapter 8, *Thresholds, Filters, and Morphology.*
- **Feature A, Feature B** — The Feature A and Feature B buttons access the "feature" selection panels for the "A" and "B" features on the profile. The Feature B button is active only when the "Distance" operation is selected for the profile tool.
- **Ranges** — The Ranges button accesses the range–selection panel, which defines limits for profile tool inspection results.
- **Done** — When you pick the Done button, the system exits back to the toolset edit panel.

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Profile Tool: Components and Initial Setup Process

This section defines the components of the profile tool and, using a simple example, illustrates the initial part of the profile tool setup process.

The four components of the profile tool are described briefly, as follows:

- **Profile window** — The *profile window* appears in *red* outline. It has the same function as a window tool or image tool, in the sense that it defines an "area of interest" (AOI), which is the portion of the image field that the profile tool processes in order to produce the *profile image*.
- **Profile image** — The *profile image* is a single line of "pixels," each of which represents the *average* gray scale value of a *column* or *row* of pixels in the *profile window*, according to the direction selection. (The profile image does *not* appear on the screen.)
- **Profile display** — The *profile display* appears in *green* outline. It is a graphic representation of the *profile image*.

  (The profile image, if it were displayed, would appear as a *single line* of gray scale pixels and would be difficult to use for inspection tool measurements. Instead, the gray scale data in the profile image is displayed *graphically* as the *profile display*.)
- **Threshold display** — The *threshold display* appears in *yellow* outline. It is a graphic representation of a gray scale value ranging from 0 to 255.

  The threshold display's function is similar to the threshold of a gage tool, in the sense that areas of the profile image "above" the threshold are considered to be "foreground objects," while areas "below" the threshold are considered to be "background objects." Points where the profile image *intersects* the threshold are considered to be "edges."

When you pick the P&P button, the *profile display* and *threshold display* components are turned off, and the *profile window* becomes visible (*red*) in its entirety. The window can then be repositioned to an appropriate location over the "pin connector" workpiece, as illustrated by the example in Figure 7.120 (page 7–150).

When you exit the pick and place function, the profile tool processes the new AOI, and the profile display (*green*) and threshold display (*yellow*) then reappear, as shown in Figure 7.121 (page 7–150).

In general, the profile display depicts "contours" of the image within the profile window; however, its appearance and orientation in each particular case are functions of the selections in the Direction, Filter 1, and Filter 2 fields in the tool edit panel. These fields, along with the threshold and feature buttons, are discussed in the remainder of the *Profile Tool* section.

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Figure 7.120 Example: Positioning the Profile Window Over Workpiece

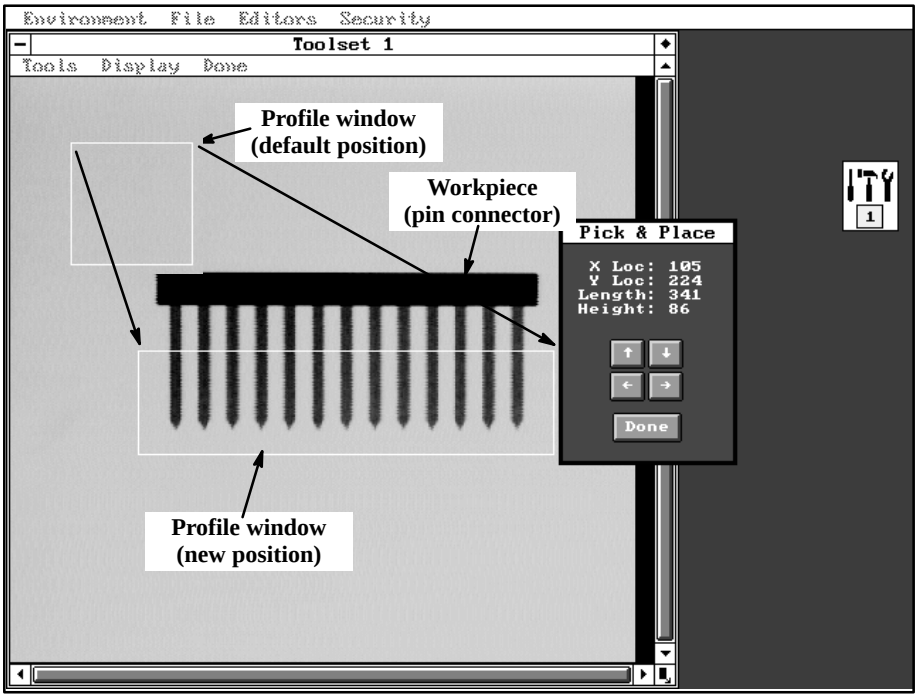
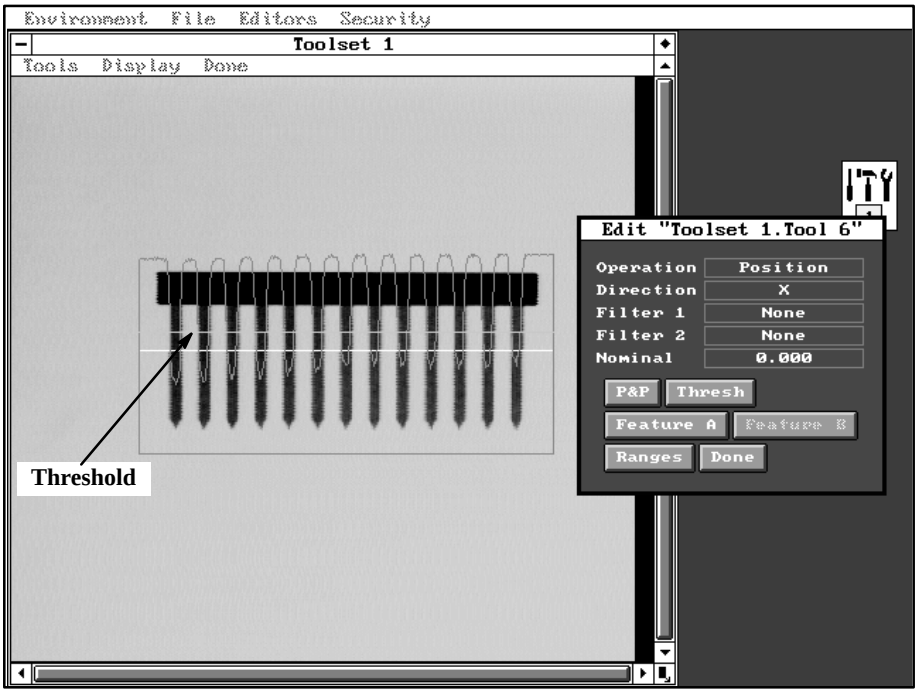


Figure 7.121 Example: Profile and Threshold After Pick and Place Operation



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Profile Window

As noted earlier, the *profile window* defines the portion of the image field to be processed for a particular application. The profile tool processes each row (or column) of pixels in the profile window on the basis of the "X" (or "Y") selection in the Direction field, as follows:

- When the "X" direction is selected, the profile tool calculates the average gray scale value of each *column* of pixels, and draws the profile display along the X axis.
- When the "Y" direction is selected, the profile tool calculates the average gray scale value of each *row* of pixels, and draws the profile display along the Y axis.

Profile Display

The *profile display* is a graphic depiction of the *profile image*, which is created by calculating the average gray scale value of each *column* of pixels (for the "X" direction) or *row* of pixels (for the "Y" direction) within the profile window, and it is superimposed over the corresponding parts of the image.

The profile display graphs the profile image's gray scale values (which can range from 0 to 255) and it provides a resolution of one pixel per gray scale value. Thus, the *potential* size of the profile display on the screen is 256 pixels *high* (for the "X" direction), or 256 pixels *wide* (for the "Y" direction). Accordingly, the profile display's actual size on the screen is affected by the camera resolution (it will appear larger when *lower* camera resolutions are selected). Also, its position on the screen is adjusted so that it can never extend *beyond* the screen.

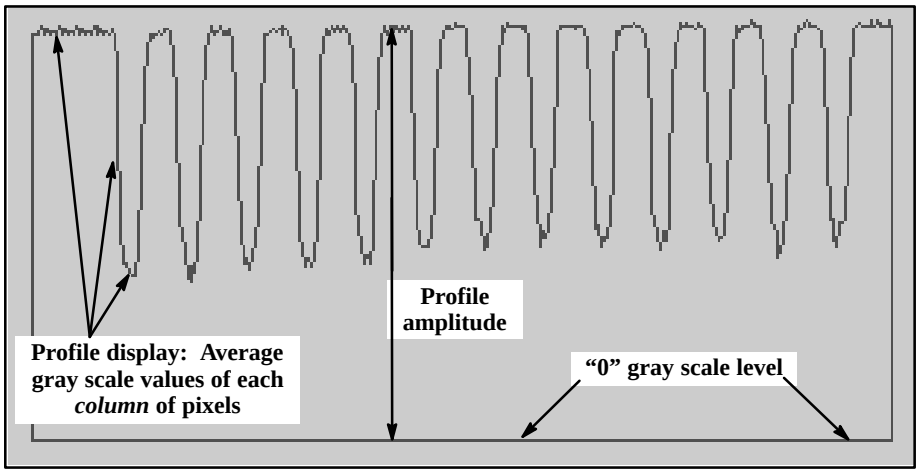
X Direction Profile Display

When the "X" direction is selected, the profile display is oriented with the variations in profile *amplitude* appearing along the X, or horizontal, axis of the image field. In this case, the bottom of the profile display represents the 0 (zero) reference point for gray scale levels ranging from 0 to 255, while the top of the display represents the average value for each *column* of the processed image (maximum value: 255).

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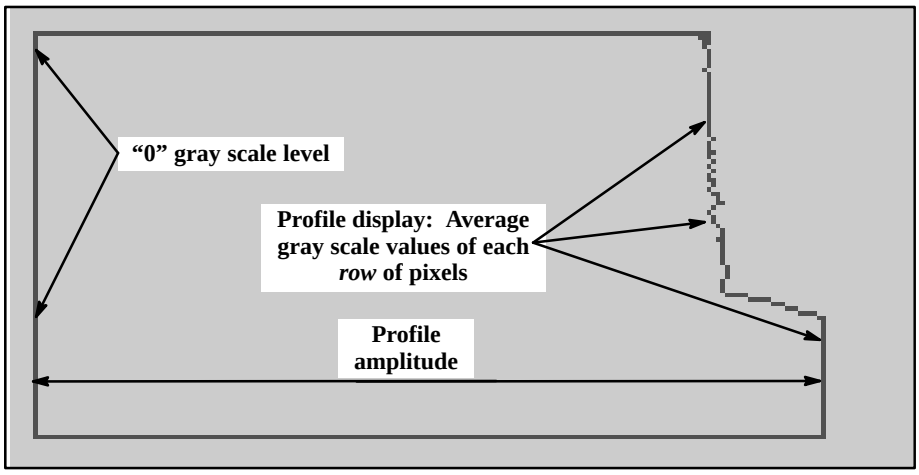
Figure 7.122 uses the “pin connector” workpiece in Figure 7.121 to illustrate an “X” direction profile display.

Figure 7.122 Example: “X” Direction Profile Display



Note that the “X” direction was selected for the pin connector in this example because it is the appropriate choice for “profiling” the connector pins, which are arrayed along the X axis. If the “Y” direction had been selected instead, the profile display would appear as illustrated in Figure 7.123.

Figure 7.123 Example: “Y” Direction Profile Display



In this case, since the *profile display* is a graphic depiction of the average gray scale value of each *row* of pixels within the profile window, it provides no useful basis for measuring *any* of the features on the pin connector.

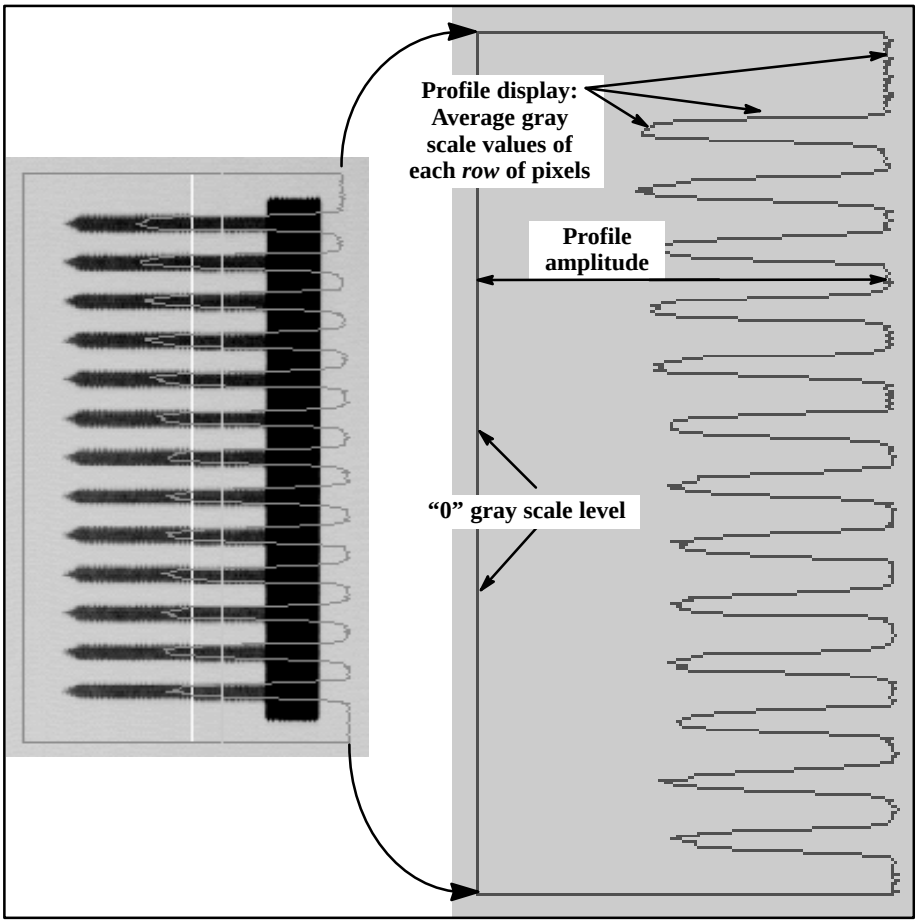
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Y Direction Profile Display

When the "Y" direction is selected, the variations in *amplitude* appear along the Y, or vertical, axis. In this case, the left side of the profile display represents the 0 (zero) reference point for gray scale level ranging from 0 to 255, while the right side of the display represents the average value for each *row* of the processed image (maximum value: 255).

Figure 7.124 uses the same workpiece shown in Figure 7.121, rotated 90° clockwise, to illustrate a "Y" direction profile display.

Figure 7.124 Example: "Y" Direction Profile Display

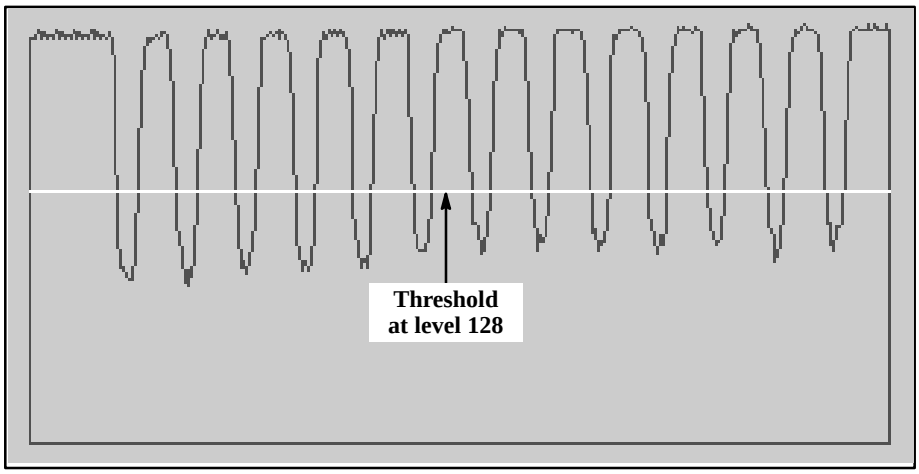


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Threshold Display

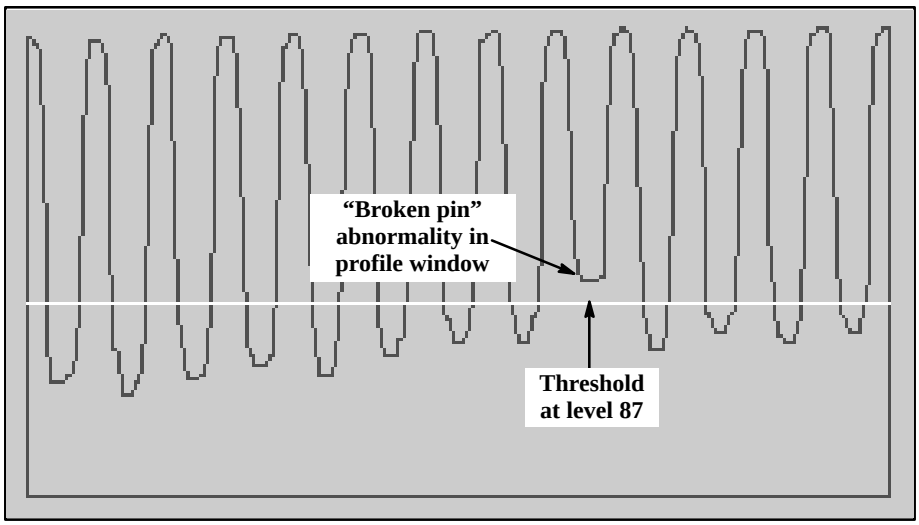
The *threshold display* is a graphic representation of the current threshold setting. It can be adjusted, using the threshold adjustment slide bar, within a range of 0 to 255 (see the *Threshold Adjustments and Mode Selection* section, on page 7–170, for details about the threshold adjustment procedure). Figure 7.125 shows the threshold display at a level of 128.

Figure 7.125 Example: Default Threshold Relative to Profile Display



Using the slide bar, you can adjust the threshold display to a level that is best suited for the application. Figure 7.126 shows the threshold display at a level of 87, which causes the profile tool to detect an abnormality. (In this example, the abnormality represents a “broken pin” on a connector. As a consequence, the profile tool will detect *two fewer edges* than when the pins are all intact.)

Figure 7.126 Example: Threshold Relative to Profile Display



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The threshold setting should be the one that optimizes the profile tool for its assigned inspection task of locating edges, counting edges, counting objects, or measuring distances between edges, according to the tool operation selected in the Operation field of the profile tool edit panel.

Overview: Profile Tool Configuration

A profile tool can be selected when the toolset edit panel is on the screen. Starting from the main menu bar, the selection path to this panel is as follows: **Editors** → **Configuration** → **Setup** → **Tools**. This selection path is shown by the example in Figure 7.1 (page 7–2).

Here is a summary list of the *basic* profile tool selection and configuration steps, listed in their normal order of performance:

1. Select the profile tool operation.
2. Select the profile direction.
3. "Pick and place" the profile tool.
4. Select morphology filter(s), if necessary. (For details, see Chapter 8, *Thresholds, Filters, and Morphology.*)
5. Set the profile threshold.
6. Select profile filters, if necessary.
7. Select the feature(s).
8. Learn the nominal value.
9. Select the ranges.

Profile Tool Operations

As noted earlier, there are five profile tool operations. When you pick the Operation field in the profile tool edit panel, the Operation selection panel appears, as shown in Figure 7.127.

Figure 7.127 Operation Selection Panel for Profile Tool



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Here is a brief description of each profile tool operation:

- **Position** — This operation identifies the location (the X or Y coordinate) of the selected feature in the image. The location result depends on the *direction* of the profile tool's operation; for example, when the selected Direction is "X," the location result will be the X coordinate of the feature. This is the *default* operation.
- **Distance** — This operation measures the *distance*, in pixels, between two points in the *profile image*, identified as "Feature A" and "Feature B" on the *profile display.*
- **FG Objects** — This operation counts the number of *foreground* objects, which are the areas in the *profile image* that are "above" the threshold setting.
- **BG Objects** — This operation counts the number of *background* objects, which are the areas in the *profile image* that are "below" the threshold setting.
- **Edges** — This operation counts the number of *edges* in the *profile image*. (Edges are located at points where the profile display intersects the threshold display.)

Position

This operation configures a profile tool to locate an object along either the X–axis or the Y–axis of the image, according to the selection in the Direction field. Position is the *default* operation.

The position operation is similar to the position operations for a gage tool, in the sense that they both return the X or Y coordinate of a selected feature or "edge" on an object. The main difference is that a gage tool identifies objects on the basis of a binary or gray scale threshold setting, while a profile tool identifies objects on the basis of where the profile image crosses the threshold.

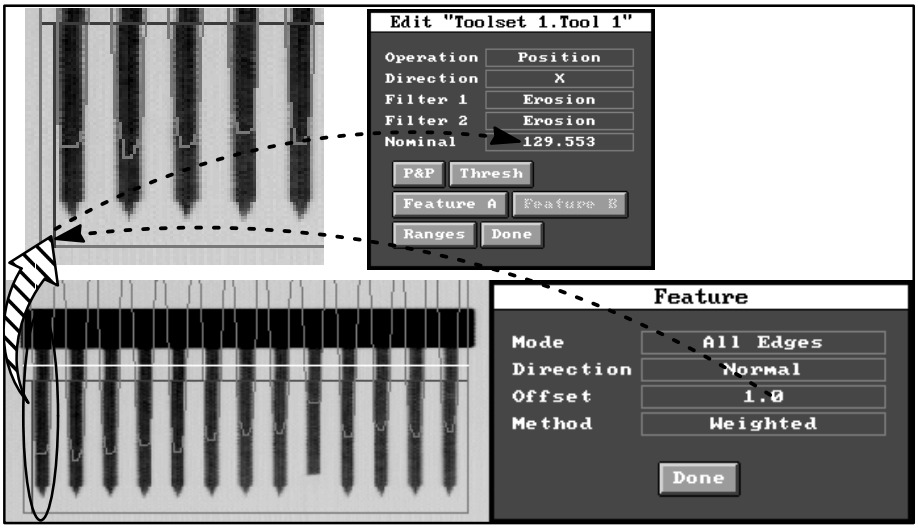
When the X direction is selected, the position operation returns the *absolute horizontal* position, in pixels, of a specified feature. The X position is reported in pixels, with the origin (0 coordinate) being the left boundary of the image.

Figure 7.128 (page 7–157) illustrates a profile tool using the position operation in the X direction.

In this example, the specified feature on the profile display corresponds to the left edge of a connector pin, and it is identified as "offset 1.0" in the Feature selection panel. In the tool edit panel, the X–axis position of this feature is shown to be 129.553 pixels from the left boundary of the image field. (Note: The Feature selection panel is described in detail in the *Feature Selection Functions* section on page 7–164.)

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Figure 7.128 Example: Reporting the X Coordinate of a Single Edge



When the workpiece is rotated 90°, and the Y direction selected, the position operation returns the *absolute vertical* (Y) position, in pixels, of a specified feature. In this case, the origin (0 coordinate) is the top boundary of the profile image.

Distance

This operation configures a profile tool to measure the distance between two features on an object. The measurement is performed along either the X–axis or the Y–axis of the image, according to the selection in the Direction field.

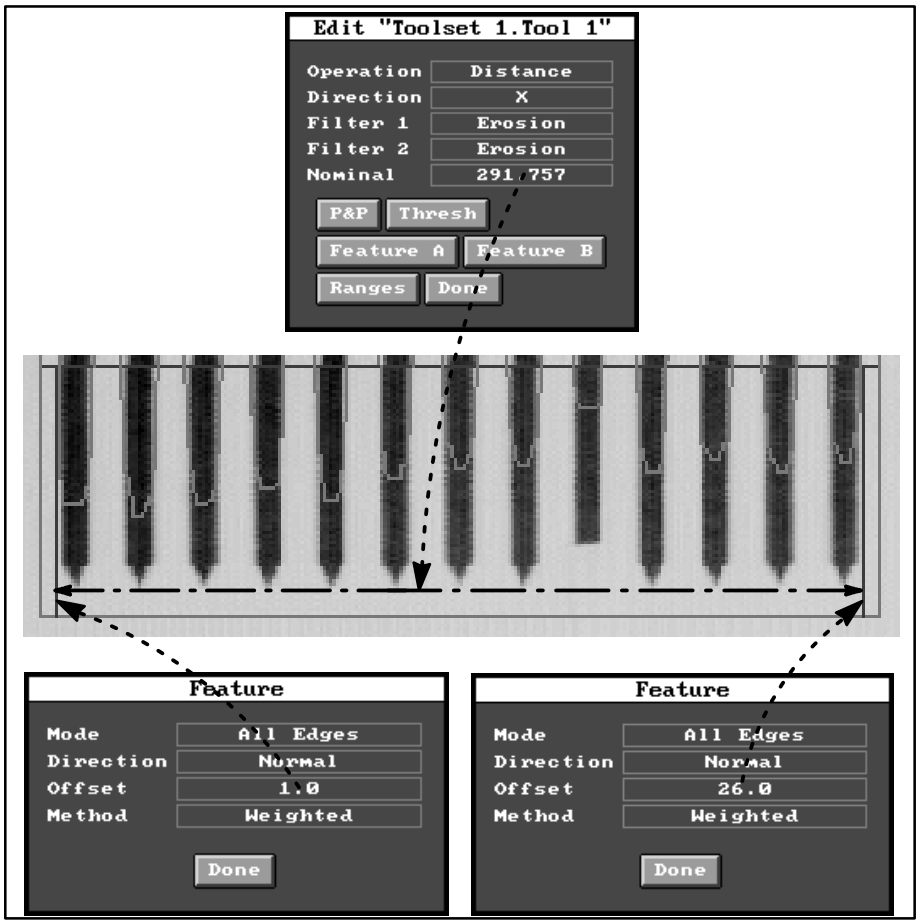
The distance operation is similar to the linear measure operation for a gage tool, in the sense that they both return the distance, in pixels, between two selected features or “edges” of objects. The main difference is that a gage tool identifies objects on the basis of a binary or gray scale threshold setting, while a profile tool identifies objects on the basis of where the profile image intersects the threshold setting.

When the X direction is selected, the distance operation measures the distance, in pixels, between two specified features along the X axis.

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Figure 7.129 illustrates a profile tool using the distance operation in the X direction.

Figure 7.129 Example: Reporting the Distance Between Two Edges Along X Axis



In this example, the specified features on the profile display correspond to the *left* edge of the *leftmost* connector pin and the *right* edge of the *rightmost* connector pin, both of which are identified as “offset 1.0” and “offset 26.0” in their respective Feature selection panels. In the tool edit panel, the distance between these features is shown to be 291.757 pixels. (Note: The Feature selection panel is described in detail in the *Feature Selection Functions* section on page 7–164.)

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Foreground Objects; Background Objects

These two operations configure a profile tool to count the number of "foreground" or "background" objects along the *display image*. The object counting is performed along either the X–axis or the Y–axis of the image field, according to the selection in the Direction field.

In the context of profile tool object counting operations, the terms "foreground object" and "background object" have specific meanings, as follows:

- *Foreground object* — An area in the profile image where the gray scale values of the "pixels" are "above" the threshold setting.

  Foreground objects appear as areas in the profile display that are *above* (in the X direction) or to the *right* (in the Y direction) of the threshold display.
- *Background object* — An area in the profile image where the gray scale values of the "pixels" are "below" the threshold setting.

  Background objects appear as areas in the profile display that are *below* (in the X direction) or to the *left* (in the Y direction) of the threshold display.

These object counting operations are similar to the *binary* object counting operations for a gage tool, in the sense that they both return the number of foreground or background objects. (See *Binary Gaging Mode: Foreground Objects* on page 7–8 and *Binary Gaging Mode: Background Objects* on page 7–9, for a comparison.)

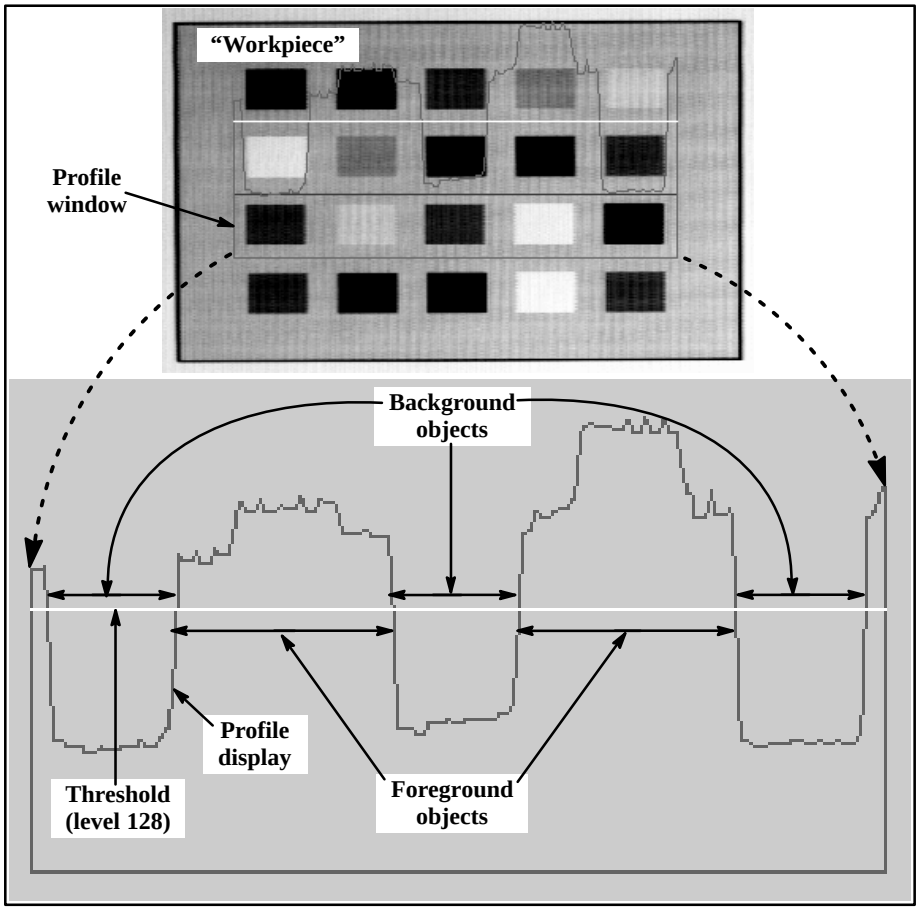
When the X direction is selected, the object counting operations count objects along the X axis, as is illustrated in Figure 7.130 (page 7–160).

The example in Figure 7.130 illustrates a *profile window* positioned over a row of rectangles on a "workpiece" and the resulting *profile display.* The *threshold display* is shown intersecting the profile display graphic at the default "gray scale" level (128).

In this example, the profile tool can identify either two *foreground* objects or three *background* objects, according to the selected tool operation. The two foreground objects correspond to the two lighter rectangles and the light spaces on both sides of them. (Note that the light areas at each end do *not* qualify as foreground objects, since they do *not* lie completely within the two ends of the profile window.) The three background objects correspond to the three darker rectangles.

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Figure 7.130 Example: Identifying Foreground and Background Objects



When the Y direction selected, the object counting operation will count objects along the Y axis.

Edges

This operation configures a profile tool to count the number of "edges" in the profile image. The edge counting is performed along either the X–axis or the Y–axis of the image field, according to the selection in the Direction field.

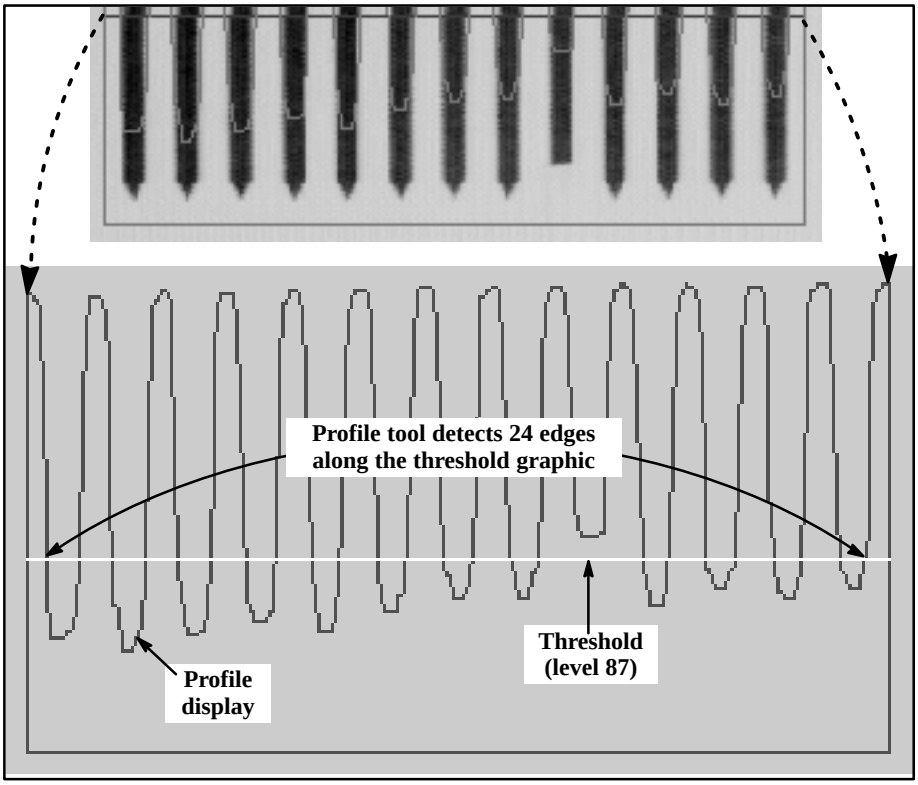
In the context of the profile tool's edge counting operations, the term "edge" refers to a point where the profile image intersects the threshold setting.

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The profile tool's edge counting operation is similar to the edge counting operations for a gage tool, in the sense that they both return the number of edges.

When the X direction is selected, the edge counting operation counts edges along the X axis, as illustrated in Figure 7.131.

Figure 7.131 Example: Identifying Edges



In Figure 7.131, the *profile window* is positioned over the pins on a 13–pin connector, and it produces the *profile display* as shown. In this example, the *threshold* has been set to gray scale level 87. At that level, the profile tool detects only 24 edges (instead of 26), since it misses the broken pin.

When the workpiece is rotated 90°, and the Y direction selected, the edge counting operation will count edges along the Y axis.

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Direction

The profile tool performs its operations along either the X–axis or the Y–axis, as determined by the selection in the Direction field of the tool edit panel.

When the "X" direction is selected, the profile tool calculates the average gray scale value of each *column* of pixels within the profile window and draws a graph or "profile" of the average values along the X–axis.

When the "Y" direction is selected, the profile tool calculates the average gray scale value of each *row* of pixels within the profile window and draws a graph or "profile" of the average values along the Y–axis.

For more information about direction, refer to the *Profile Display* section on page 7–151.

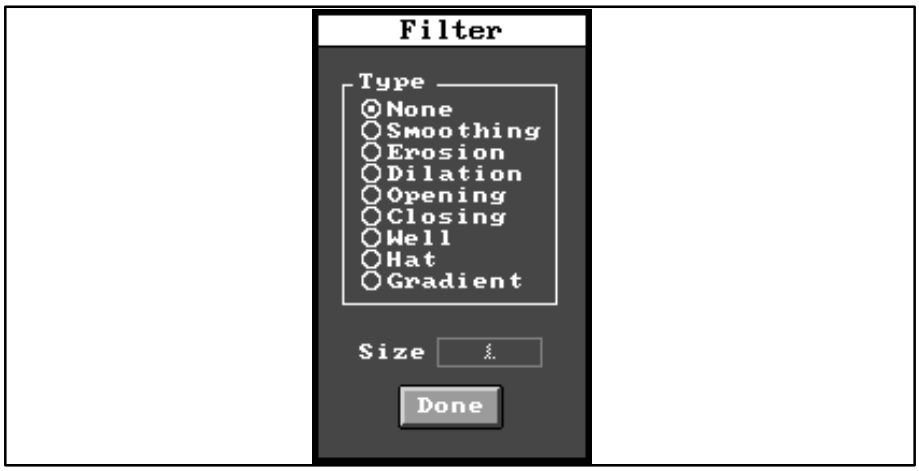
Filter 1 and Filter 2

The Filter 1 and Filter 2 fields provide access to several morphology filtering functions that affect the *profile image*. Each filter field provides access to a Filter selection panel, and each panel contains an identical list of morphology functions.

When filtering functions are selected from *both* filter fields, the effect on the profile display is *cumulative*, with the Filter 1 selection performing its morphology filter function *first*. (For additional information about morphology functions, refer to Chapter 8 of this manual under the following headings: *Morphology Function*, page 8–13; *Binary Morphology*, page 8–16; and *Gray Scale Morphology*, page 8–20.)

When you pick either filter field, the corresponding Filter selection panel appears, as shown by Figure 7.132.

Figure 7.132 Example: Filter Selection Panel



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The Filter selection panel lists eight morphology filtering functions and a "size" selection field. Morphology is an image processing technique that evaluates a neighborhood of pixels with the object of adjusting or changing an individual pixel's gray scale value on the basis of the gray scale values of its neighbors.

Here is a brief description of each morphology filter function:

- **None** — This selects *no* morphology filter function.
- **Smoothing** — This function "smoothes" edges and rounds sharp corners in the profile image without affecting the larger shapes or contours of the image. Its performance is similar to a gray scale average function.
- **Erosion** — This function "erodes" the *foreground* objects (and, conversely, expands the *background* objects). The result is that foreground objects in the profile image get *narrower*, while background objects get *wider*. Its performance is similar to a gray scale "Min" function.

  Erosion has the opposite effect of dilation.
- **Dilation** — This function "dilates" the *foreground* objects (and, conversely, shrinks the *background* objects). The result is that background objects in the profile image get *narrower*, while foreground objects get *wider*. Its performance is similar to a gray scale "max" function.

  Dilation has the opposite effect of erosion.
- **Opening** — This function operates as an *erosion* followed by a *dilation*. The result is that small foreground objects can be eliminated without affecting the size of background objects. Its performance is similar to a gray scale "min" followed by a "max."

  Opening has the opposite effect of closing.
- **Closing** — This function operates as a *dilation* followed by an *erosion*. The result is that small background objects can be eliminated without affecting the size of foreground objects. Its performance is similar to a gray scale "max" followed by a "min."

  Closing has the opposite effect of opening.
- **Well** — This function performs a closing, then subtracts the original profile image from the closed image. This allows the profile tool to filter out *large* background objects and retain only *small* background objects for analysis.

  Well has the opposite effect of hat.
- **Hat** — This function performs an opening, then subtracts the original profile image from the opened image. This allows the profile tool to filter out *large* foreground objects and retain only *small* foreground objects for analysis.

  Hat has the opposite effect of well.
- **Gradient** — This function subtracts the minimum gray scale value in the morphology neighborhood from the maximum gray scale value in the neighborhood. The result is a profile image with the "edges" enhanced.

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The Filter selection panel also has a "Size" field, which is used to select the size (or width) of the morphology filter to be applied to the profile image. The *default* size is 1.

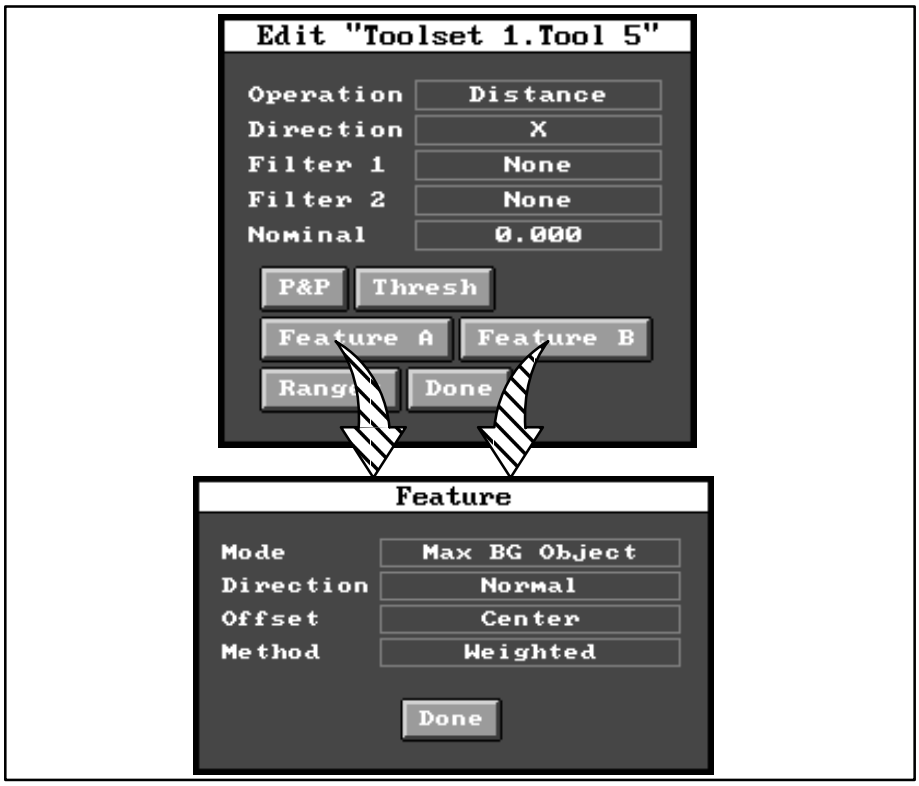
Feature Selection Functions

The "Position" and "Distance" profile tool operations employ "features" to identify the edges used to locate a position or measure a distance.

A profile tool can detect several edges, of which only one or two are required for the location or distance measurement. Thus, the edge selection functions enable you to select particular edges or other features related to the edges, and to determine other aspects of the search for these edges, including search direction and search mode. These subjects are discussed in detail in this section.

When you pick either of the Feature buttons on the profile tool edit panel, a Feature selection panel appears, as shown in Figure 7.133.

Figure 7.133 Example: Selecting the Feature Selection Panel



The threshold setting relative to the profile image determines which foreground–to–background transitions are detected as edges. The purpose of the *feature selection function* is to specify which of these edges (or midpoints between edges) are to be identified as "features," and used as the basis for the inspection operation. Each of these features is defined by an *offset*.

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Note that the Position operation needs to specify only *one* feature, while the Distance operation needs to specify *two* features. In the first case, only the Feature A button is *active*; in the second case, the Feature A button and the Feature B button are both *active*.

In addition to specifying the appropriate offsets, the feature selection process also specifies the edge search *direction* and the edge search *mode*.

Here is a brief description of the feature selection functions:

- **Mode** — The *mode* selects a particular group of edges that a profile tool evaluates when searching for a *specified feature*.
- **Direction** — The *direction* function selects the direction of the search for the *specified features* along the length of the profile image.
- **Offset** — The *offset* function enables you to identify *one* edge, or a midpoint between two edges, as the *specified* feature.
- **Method** — The *method* selection determines whether a midpoint offset is located exactly midway across an object, or is skewed toward the "center of gravity" of an object.

Mode

When you pick the Mode field in the Feature selection panel, the Feature Mode selection panel appears on the screen, as shown in Figure 7.134.

Figure 7.134 Feature Mode Selection Panel



The operation of the profile tool feature modes is described briefly as follows:

- **All Edges** — This feature mode causes the profile tool to include all detected "edges" in its search for a *specified feature* (this includes *edges* and *all midpoints* between each pair of consecutive edges, the *center* between the extreme edges, and the *starting* edge).

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- **FG Border** — This feature mode restricts the search for a *specified feature* on the basis that the *first* edge (offset 1.0) is the first point where the profile image is “below” the threshold setting.
- **BG Border** — This feature mode restricts the search for a *specified feature* on the basis that the *first* edge (offset 1.0) is the first point where the profile image is “above” the threshold setting.
- **Max Object** — This feature mode restricts the search for a *specified feature* to the leading edge and the midpoint of the *largest* identified “object” along the length of the threshold.
- **Max FG Object** — This feature mode restricts the search for a *specified feature* to the leading edge and the midpoint of the *largest* identified “foreground object” along the length of the threshold.
- **Max BG Object** — This feature mode restricts the search for a *specified feature* to the leading edge and the midpoint of the *largest* identified “background object” along the length of the threshold.
- **Middle FG Object** — This feature mode restricts the search for a *specified feature* to the leading edge and the midpoint of the “foreground object” lying closest to the center of the profile window.
- **Middle BG Object** — This feature mode restricts the search for a *specified feature* to the leading edge and the midpoint of the “background” object lying closest to the center of the profile window.

All Edges

The *all edges* feature mode enables you to specify an edge from among the following points along the length of the threshold:

- All *edges* detected as a result of the threshold/filter settings.
- Either end of the profile image, according to search direction.
- The *midpoints* between adjacent pairs of edges.
- The *center point* between the first edge and the last edge.

FG Border

The *foreground border* feature mode is identical to the *all edges* mode, except that offset 1.0 always coincides with a point where the profile image moves *below* the threshold level (in terms of its gray scale value).

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BG Border

The *background border* feature mode is identical to the *all edges* mode, except that offset 1.0 always coincides with a point where the profile image moves *above* the threshold level (in terms of its gray scale value).

Max Object

The *maximum object* feature mode enables you to specify an edge from among the following two points on the profile image:

- The first edge (offset 0.0) of the maximum–size object.
- The midpoint (Center) between the first edge and the last edge of the maximum–size object.

Max FG Object

The *maximum foreground object* feature mode enables you to specify an edge from among the following two points on the profile image:

- The first edge (offset 0.0) of the maximum–size *foreground* object.
- The midpoint (Center) between the first edge and the last edge of the maximum–size *foreground* object.

Max BG Object

The *maximum background object* feature mode enables you to specify an edge from among the following points along the length of the profile image:

- The first edge (offset 0.0) of the maximum–size *background* object.
- The midpoint (Center) between the first edge and the last edge of the maximum–size *background* object.

Middle FG Object

The *middle foreground object* feature mode enables you to specify an edge from among the following two points on the profile image:

- The first edge (offset 0.0) of the *foreground* object nearest the to middle of the profile window.
- The midpoint (Center) between the first edge and the last edge of the middle *foreground* object.

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Middle BG Object

The *middle background object* feature mode enables you to specify an edge from among the following points along the length of the profile image:

- The first edge (offset 0.0) of the *background* object nearest to the middle of the profile window.
- The midpoint (Center) between the first edge and the last edge of the middle *background* object.

Direction

The *search direction* is the direction used to search for an edge along the length of the profile image. The two available choices are these: Normal and Reverse.

When you pick the Direction field (Feature selection panel) successively, the selection toggles to the *opposite* direction. Thus, Normal changes to Reverse, and vice versa.

When Normal is selected, the edge search begins at the *left* side of the profile display (for the X direction) or the *top* side (for the Y direction). When Reverse is selected, the search begins at the *right* side or *bottom* side.

The choice of search direction should be based upon which one leads most *directly* to the specified edge. Normally, the *best* search direction is the one in which a *false* edge is least likely to be encountered.

Offset

The current *offset* location is identified on the screen by an *offset marker* (a red bar symbol) in the profile display. You can change the offset location by picking the Offset field successively.

When you pick the Offset field successively, the offset marker moves across the profile window in the selected *search direction*. The displayed offset will be one of these:

- **Fixed** — This refers to the end of the profile image at which the search *begins*.
- **Center** — This refers to the midpoint between the first edge and the last edge.
- **1.0, 2.0, etc.** — This refers to an edge specified by number.
- **1.5. 2.5, etc.** — This refers to a midpoint between two adjacent edges.

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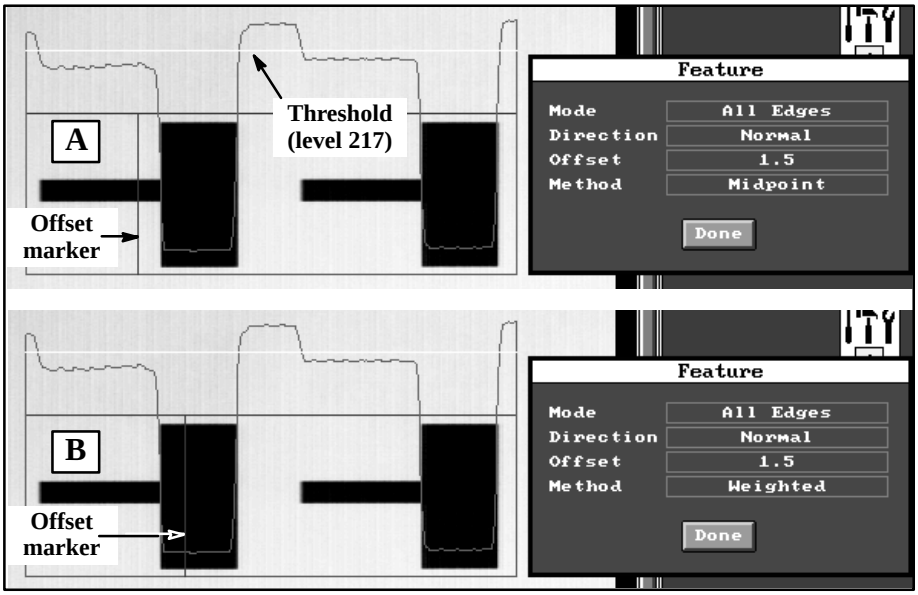
Method

The *method* selection determines the location of a *midpoint* offset. The two available choices are these: Midpoint and Weighted.

When you pick the Method field (Feature selection panel) successively, the selection toggles to the *opposite* method. Thus, Midpoint changes to Weighted, and vice versa.

Figure 7.135 compares the two methods. In this example, the profile window is positioned around two dark objects that are *asymmetrical*; thus, each objects' "center of gravity" is skewed toward its right side. The threshold is set near the top of the profile image so the profile tool can detect the extreme left edge of each object.

Figure 7.135 Example: Comparing the Midpoint and Weighted Methods



When Midpoint is selected, the midpoint offset will be located exactly *midway* between the edges of an object, as illustrated by Figure 7.135 (**A**). When Weighted is selected, the offset is skewed *rightward*, toward the center of gravity of the object, as illustrated by Figure 7.135 (**B**).

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Threshold Adjustments and Mode Selection

The threshold adjustments determine how the profile image is divided into foreground and background objects and where edges are detected by the profile tool. When you adjust the threshold setting, the position of the threshold display will move in relation to the profile display. The mode selection determines whether the threshold setting will be fixed or "dynamic" during run mode operations.

When you pick the Thresh button on the profile tool edit panel, the Threshold adjustment panel appears on the screen, as shown by Figure 7.136.

Figure 7.136 Initial Appearance of Threshold Adjustment Panel ("Fixed" Mode)

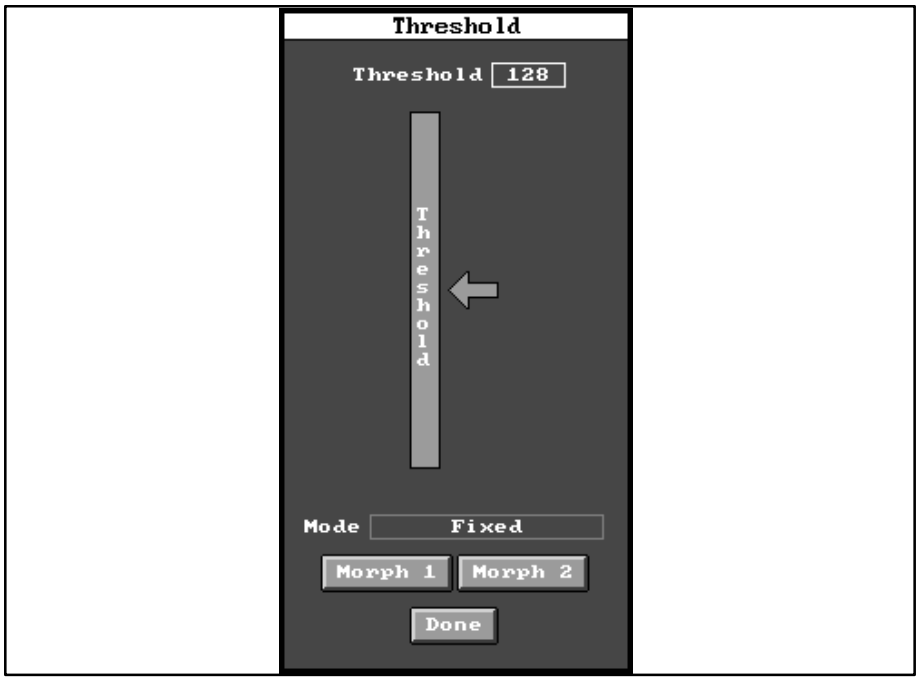


Figure 7.136 shows how the Threshold panel appears *initially*, in its *default* state (the "Fixed" threshold mode): It contains a Threshold slide bar with a single cursor, two fields, and three buttons. The appearance of this panel, as well as its function, will vary according to the "threshold mode" selection in the Mode field.

Slide Bar

When the Threshold panel is in the *initial* ("Fixed") mode, the "Threshold" slide bar provides a means by which you can quickly set the threshold in relation to the profile image. Picking the Threshold field accesses a calculator pad, which enables you to "fine tune" the threshold setting to a specific value.

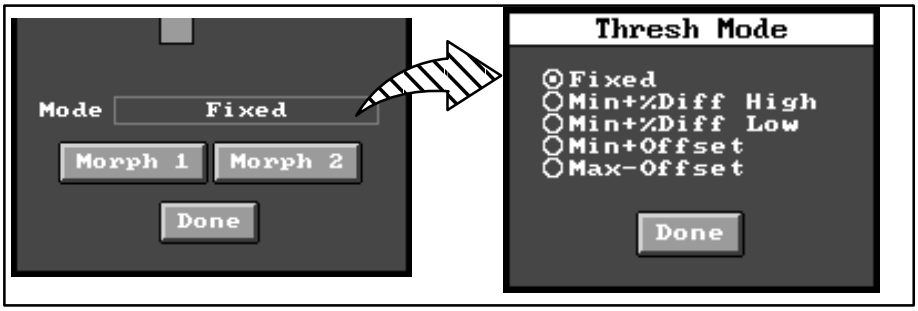
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When other threshold modes are selected, the slide bar assumes other functions, which are discussed next in the *Mode Selection* section.

Mode Selection

When you pick the Mode field in the Threshold panel, the Thresh Mode selection panel appears, as shown in Figure 7.137.

Figure 7.137 Selecting Thresh Mode Panel



The five threshold modes are described in the following sections.

Fixed Mode

This is the *default* threshold mode (see Figure 7.136, page 7–170), and it indicates that the threshold will remain *fixed* at the value to which it was last set by the Threshold slide bar or Threshold field entry. During the "Fixed" threshold mode, the slide bar and field have the following functions:

- *Threshold slide bar* — The Threshold slide bar uses a single cursor to set the threshold in relation to the profile image (and change the value in the Threshold field).
- *Threshold field* — The Threshold field accesses a "calculator," which can be used to select a *specific* threshold value. The *default* value is 128.

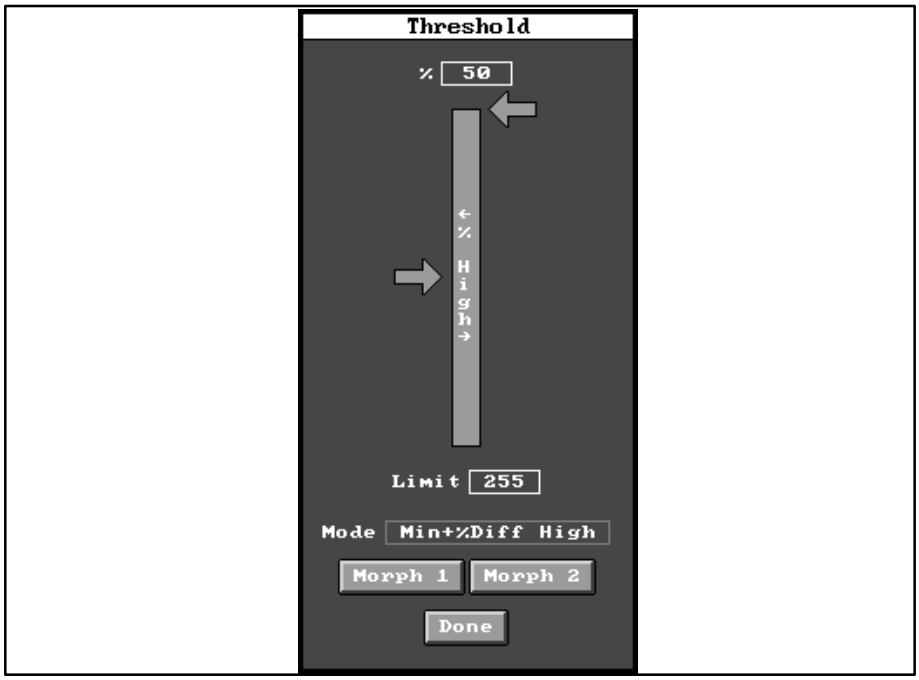
The Threshold slide bar, and/or the value entered into the Threshold field, affect the position of the threshold display as described in the *Threshold Display* section on page 7–154. In either case, the threshold can be set to any gray scale level within the range of 0 to 255 (which represents the lower and upper limits of the profile image). Figure 7.125 and Figure 7.126 (page 7–154) illustrate the threshold graphic at two different gray scale levels.

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Min+%Diff High Mode

When you pick Min+%Diff High in the Thresh Mode panel, the Threshold panel appears as shown in Figure 7.138.

Figure 7.138 Appearance of Threshold Adjustment Panel With Min+%Diff High Mode



In this mode, the slide bar has two cursors (the % and High cursors) and two corresponding fields (the % and Limit fields). The *default* value for the "%" field is 50, and the *default* value for the "Limit" field is 255.

The Min+%Diff High threshold mode enables you to set up a *dynamic* threshold, along with a *maximum* limit above which the threshold may not go during run mode operation.

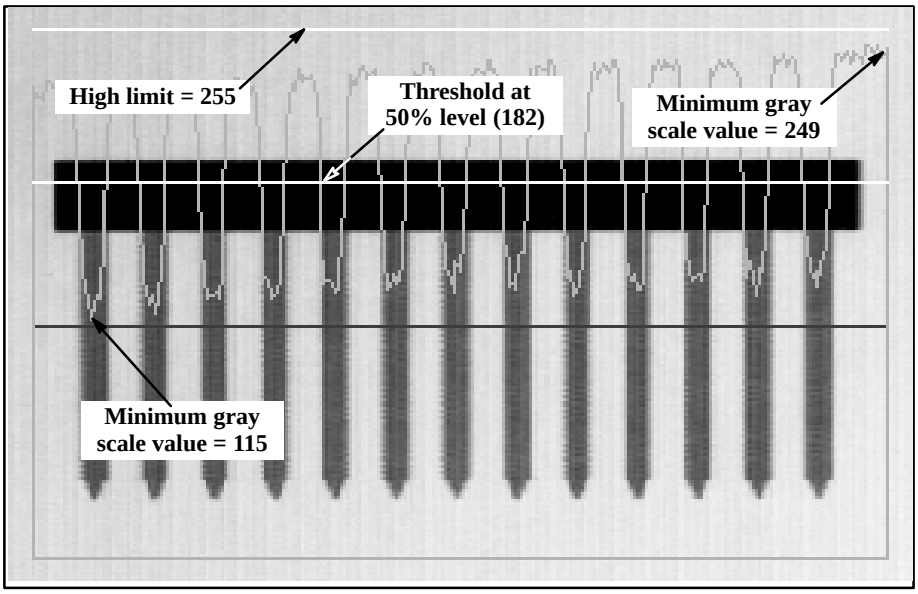
The concept of the Min+%Diff High threshold mode is this: The profile tool will find the *minimum* and *maximum* gray scale values on the profile display, and then place the threshold at a position that is equal to the *minimum* value plus 50% (*default* value) of the *difference* between the minimum and maximum values, not to exceed an upper limit of 255 (*default* value).

The practical effect is this: During run mode operation, the threshold will *automatically* readjust itself whenever lighting and other external circumstances change, but it will not exceed the high limit value.

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Figure 7.139 illustrates the Min+%Diff High threshold mode, using the *default* values for the "%" and "Limit" settings.

Figure 7.139 Example: "Min+%Diff High" Threshold Mode



In this example, the profile tool finds the minimum gray scale value at 115 and the maximum value at 249. It calculates the difference, then places the threshold at the minimum plus % difference, or 115 + (50% x (249 – 115), which is 182.

Min+%Diff Low Mode

When you pick Min+%Diff Low in the Thresh Mode panel, the Threshold panel appears as shown in Figure 7.140 (page 7–174).

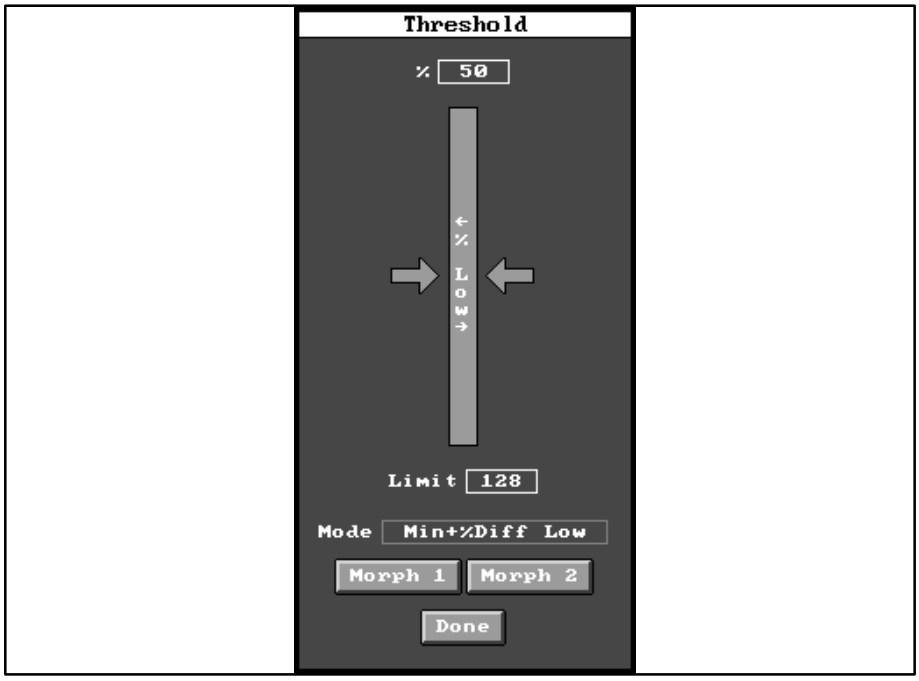
In this mode, the slide bar has two cursors (the % and Low cursors) and two corresponding fields (the % and Limit fields). The *default* value for the "%" field is 50, and the *default* value for the "Limit" field is 128.

The Min+%Diff Low threshold mode enables you to set up a *dynamic* threshold, along with a *minimum* limit below which the threshold may not go during run mode operation.

The concept of the Min+%Diff Low threshold mode is identical to the concept of the Min+%Diff High threshold mode, except that the threshold has a *low* limit instead of a *high* limit.

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Figure 7.140 Appearance of Threshold Adjustment Panel With Min+%Diff Low Mode



Min+Offset Mode

When you pick Min+Offset in the Thresh Mode panel, the Threshold panel appears as shown in Figure 7.141 (page 7–175).

In this mode, the slide bar has two cursors (the Δ and High cursors) and two corresponding fields (the Offset and Limit fields). The *default* value for the "Offset" field is 128, and the *default* value for the "Limit" field is 255.

The Min+Offset threshold mode enables you to set up a *dynamic* threshold, along with a *maximum* limit above which the threshold may not go during run mode operation.

The concept of the Min+Offset threshold mode is this: The profile tool will find the *minimum* gray scale values in the profile image, and then place the threshold at a position that is equal to the minimum value plus the *offset* value.

The practical effect is this: During run mode operations, the threshold will *automatically* readjust itself whenever lighting and other external circumstances change, but it will not exceed the high limit value.

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Figure 7.141 Appearance of Threshold Adjustment Panel With Min+Offset Mode

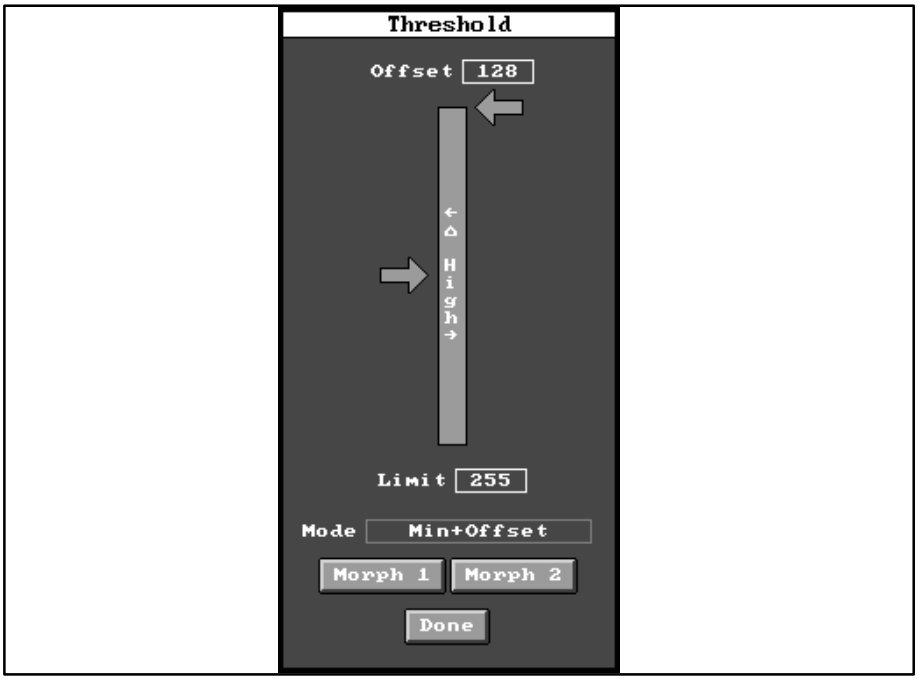
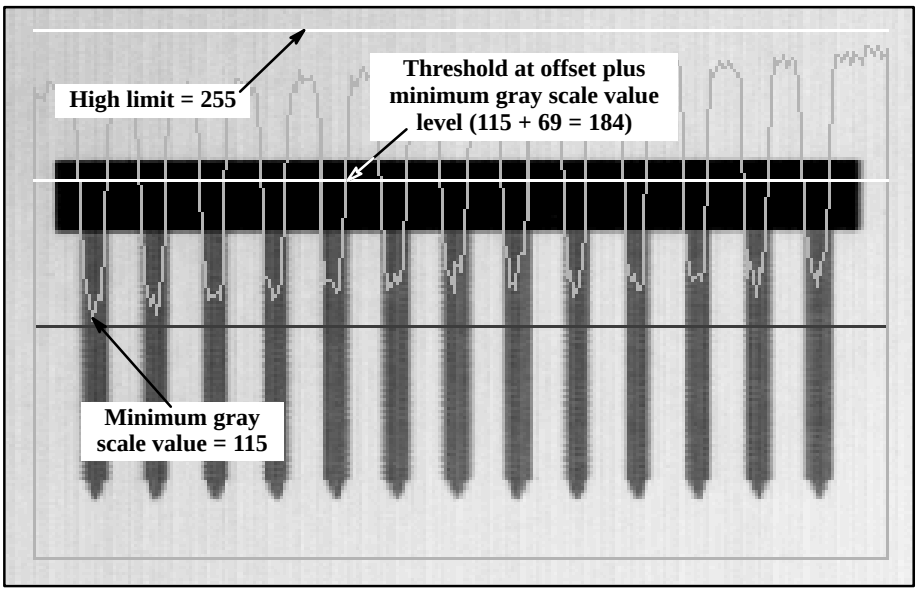


Figure 7.142 illustrates the Min+Offset threshold mode, using 69 for the "Offset" setting and 255 for the "Limit" setting.

Figure 7.142 Example: "Min+Offset" Threshold Mode



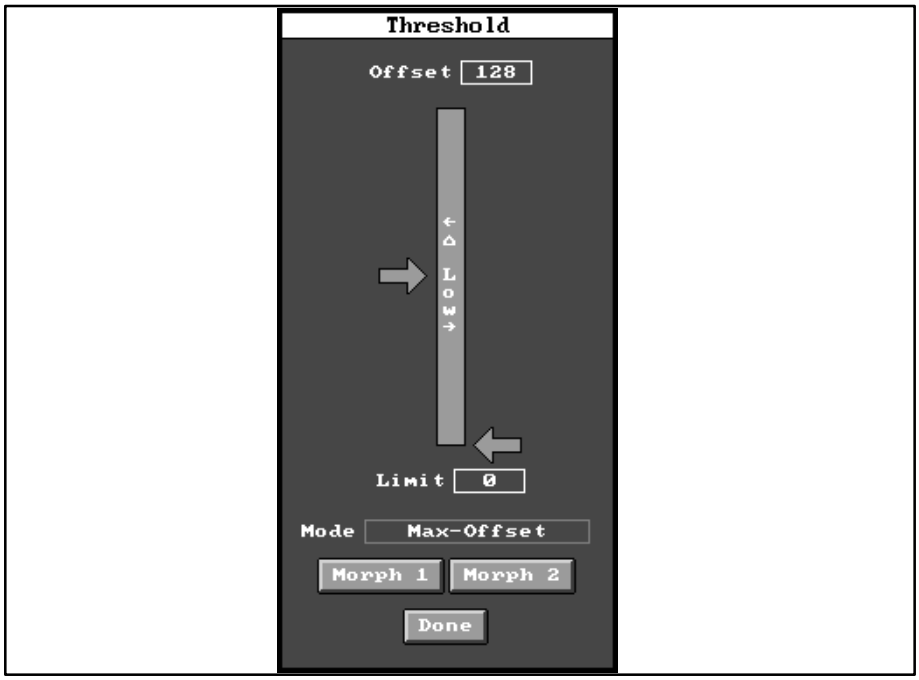
In this example, the profile tool finds the minimum gray scale value at 115. It then adds offset value 69 to minimum value 115 and places the threshold at the 184 gray scale level (69 + 115 = 184).

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Max–Offset Mode

When you pick Max–Offset in the Thresh Mode panel, the Threshold panel appears as shown in Figure 7.143.

Figure 7.143 Appearance of Threshold Adjustment Panel With Max–Offset Mode



In this mode, the slide bar has two cursors (the Δ and Low cursors) and two corresponding fields (the Offset and Limit fields). The *default* value for the "Offset" field is 128, and the *default* value for the "Limit" field is 0.

The Max–Offset threshold mode enables you to set up a *dynamic* threshold, along with a *minimum* limit below which the threshold may not go during the run mode operation.

The concept of the Max–Offset threshold mode is identical to the concept of the Min+Offset threshold mode, except that the threshold has a *low* limit instead of a *high* limit.

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Morphology Filter Selection

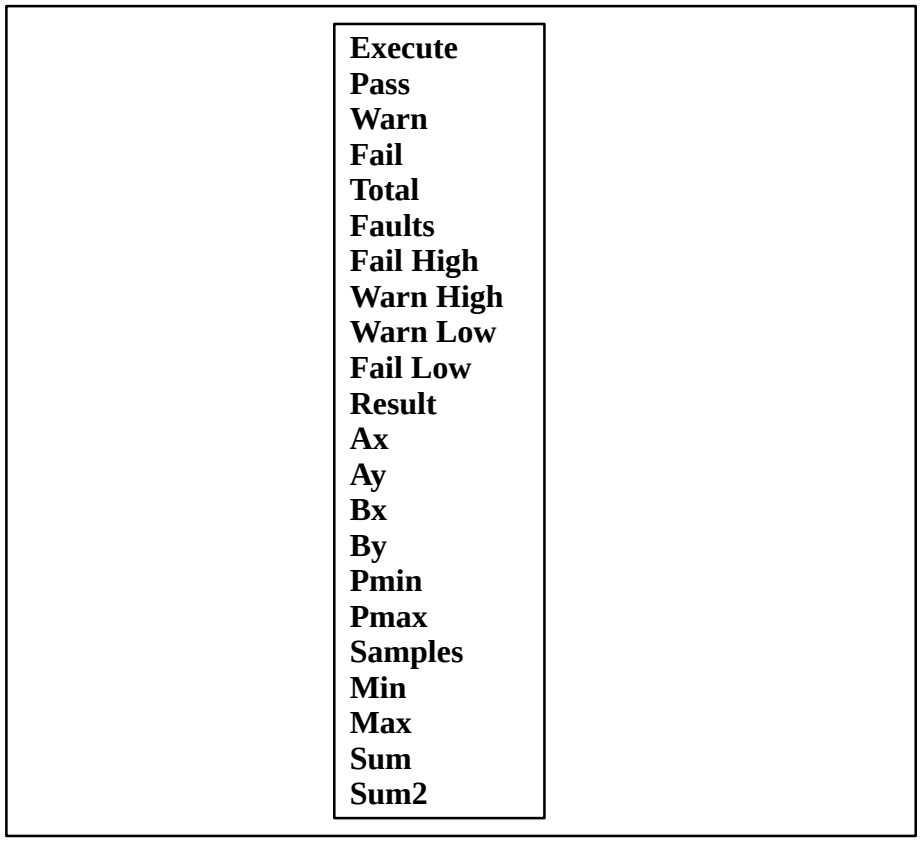
The Morph 1 and Morph 2 buttons under the slide bar provide access to identical morphology selection panels (see Figure 8.13 on page 8–15), from which you can select gray scale morphology filtering operations. The two morphology buttons, and the Done button, are effective for *all* threshold mode selections in the Mode field.

These morphology filter functions are applied to the gray scale image within the profile window *before* the profile tool generates the profile image. (For detailed information about morphology functions, refer to Chapter 8 of this manual under the following headings: *Morphology Function*, page 8–13; *Binary Morphology*, page 8–16; and *Gray Scale Morphology*, page 8–20.)

Profile Tool Inspection Results and Math Tool Formulas

This section discusses the expanded inspection results that are available to a math tool formula from a profile tool. As Figure 7.144 shows, the expanded inspection results for a profile tool appear in one list.

Figure 7.144 Expanded Results Lists For Profile Tools in Math Formulas



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Here is a brief definition and explanation of each of the expanded result types listed in Figure 7.144.

- **Execute** — This returns a 1.000 when the tool has *executed* its inspection task, and 0.000 for all other conditions.
- **Pass** — This returns a 1.000 when the tool has *passed* its inspection task, and 0.000 for all other conditions.
- **Warn** — This returns an "error code" when the tool is in a *warn* condition (and *not* in a *fail* condition) and 0.000 for all other conditions. The error code identifies a specific reason for the warning; for example, error code 1057.000 identifies "Low range warning" as the cause. The complete list of error codes and warn conditions appears in Appendix A of this manual.
- **Fail** — This returns an "error code" when the tool is in a *fail* condition and 0.000 for all other conditions. The error code identifies a specific reason for the failure; for example, error code 1045.000 identifies "High range fail" as the cause of the inspection failure. The complete list of error codes appears in Appendix A of this manual.
- **Total** — This returns the total number of inspections performed.
- **Faults** — This returns the total number of faults detected.
- **Fail High** — This returns a 1.000 when the inspection result from the tool has exceeded the *high* Fail limit and 0.000 when the result has *not* exceeded the *high* Fail limit.
- **Warn High** — This returns a 1.000 when the inspection result from the tool has exceeded the *high* Warn limit (and the tool is *not* in a *fail* condition) and 0.000 when the result has *not* exceeded the *high* Warn limit.
- **Warn Low** — This returns a 1.000 when the inspection result from the tool has exceeded the *low* Warn limit (and the tool is *not* in a *fail* condition) and 0.000 when the result has *not* exceeded the *low* Warn limit.
- **Fail Low** — This returns a 1.000 when the inspection result from the tool has exceeded the *low* Fail limit and 0.000 when the result has *not* exceeded the *low* Fail limit.
- **Result** — This returns the actual value of the inspection result; that is, the measurement, count, or other numeric result from the profile tool. This value corresponds to the "learned" value that appears in the "Nominal" field of the profile tool edit panel.
- **Ax, Ay** — These values pertain *only* to a profile tool configured for distance or position operations. "Ax" returns the X coordinate of the Feature A offset, while "Ay" returns the Y coordinate of the Feature A offset.

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- **Bx, By** — These values pertain *only* to a profile tool configured for distance or position operations. "Bx" returns the X coordinate of the Feature B offset, while "By" returns the Y coordinate of the Feature B offset.
- **Pmin** — This returns the *minimum* gray scale value in the profile image.
- **Pmax** — This returns the *maximum* gray scale value in the profile image.
- ***Samples** — This returns the current total number of inspection samples since the start of run operation.
- ***Min** — This returns the current *minimum* value of the inspection results since the start of the run operation.
- ***Max** — This returns the current *maximum* value of the inspection results since the start of the run operation.
- ***Sum** — This returns the current *sum* of all inspection results since the start of the setup or online run operation.
- ***Sum2** — This returns the current *sum* of the *squares* of all inspection results since the start of the setup or online run operation.

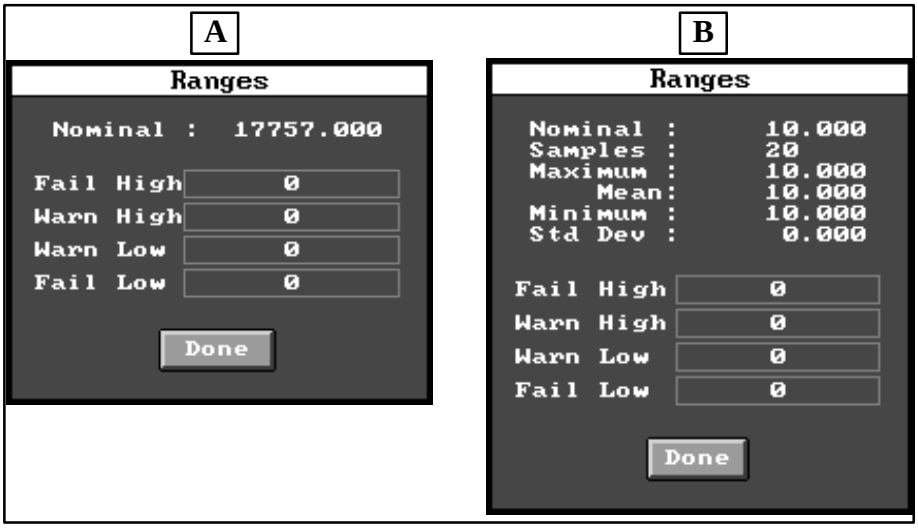
*These expanded *statistical* results are available only when a tool is enabled for *statistics* operations, as indicated by a checked Statistics box in the tool's Options selection panel.

Ranges

Ranges provide a quantitative measure against which the results from each inspection tool are compared. There are "fail" limits "warning" limits, and each has an upper and lower value that you can set as is appropriate for the tools in your particular inspection application. Not all tool types have ranges.

When you pick the Ranges button, the Ranges selection panel appears on the screen as illustrated in Figure 7.145.

Figure 7.145 Example: Ranges Selection Panel



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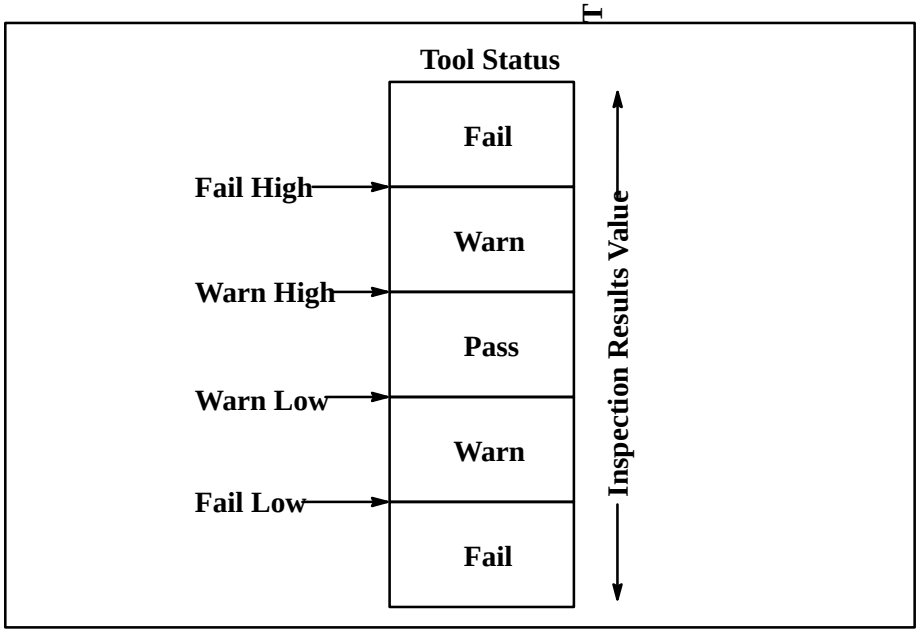
Figure 7.145 (**A**) appears when the "Statistics" option has not been selected for the corresponding tool, while (**B**) appears when the "Statistics" option has been selected (and inspection data has been acquired). Note that (**B**) applies only to tools for which this option is available.

The Ranges selection panel contains a number of fields, which are described briefly as follows:

- **Nominal** — The reading in this field is the "nominal" or learned value that results when you pick the Nominal field in the Tool Edit panel. It is included in this panel as a convenience for setting the range limits.
- **Fail High** — Use this field to set the upper "fail" limit.
- **Warn High** — Use this field to set the upper "warning" limit.
- **Warn Low** — Use this field to set the lower "warning" limit.
- **Fail Low** — Use this field to set the lower "fail" limit.

For tools with ranges, the CVIM2 system compares the inspection results value to the range limits selected for that tool. The tool status is a function of where an inspection results value lies in relation to the range limits, as illustrated in Figure 7.146.

Figure 7.146 Relation of Ranges to Tool Status



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As Figure 7.146 shows, the CVIM2 system provides *two* sets of range limits: *Warning range* limits, and *fail range* limits. Warning range limits must always lie *within* fail range limits or must be *equal* to them, as shown below:

Fail Low <= Warn Low <= Warn High <= Fail High

NOTE: A tool can also "fail" if it is unable to perform its inspection. For example, a gage will fail if its operation is Linear Measure and it finds no edges.

Here is an example of ranges:

- The **Fail Low** limit is set to 14.6.
- The **Warn Low** limit is set to 14.8.
- The **Warn High** limit is set to 15.2.
- The **Fail High** limit is set to 15.4.

With the range limits set as shown above, if an inspection result is outside either *warning* limit (above 15.2 or below 14.8), the CVIM2 system will generate a warning signal *only.* If an inspection result is outside either *fail* limit (above 15.4 or below 14.6), the CVIM2 system will generate a fail signal *only.*

In a practical application, the warning range limits could be used to indicate a *deteriorating* condition, such as a part that is *very close* to a tolerance limit because of wear in a cutting tool or die. The fail range limits could be used to indicate a *failure* condition, such as a part that has *exceeded* a tolerance limit because of a broken cutting tool or die.

Here are some methods for determining the appropriate warning and fail range limits:

- For measurements or counting operations using pixels, use the Nominal function to determine the pixel values of workpieces at the upper and lower tolerance limits. Use the nominal value as the basis for determining the appropriate fail and warning limits.
- For any measurements, run a series of trial inspections, using a representative sample of workpieces, in order to accumulate a *statistical* basis for setting the appropriate fail and warning limits.

After you determine the appropriate range limits for your application, you can enter them in the Ranges selection panel (see Figure 7.145, page 7–179).

To enter each of the range limits, as may be required for your application, pick the field alongside the limit. When you do, the calculator pad appears on the screen. Enter the value for each limit as required for your application.

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Here is a summary of the conditions under which tool *fail* and tool *warn* conditions can occur.

A tool *fail* condition arises from the following situations:

- A tool result that is *greater than* the Fail High limit (FH $<$ R).
- A tool result that is *less than* the Fail Low limit (FL $>$ R).
- Any other situation in which the tool cannot operate properly, such as a reference line being unable to find a specified feature.

A tool *warn* condition arises from the following situations:

- A tool result that is *greater than* the Warn High limit and *less than* or *equal to* the Fail High limit (WH $<$ R $\leqq$ FH), and is *not* a tool *fail* condition.
- A tool result that is *less than* the Warn Low limit and *greater than* or *equal to* the Fail Low limit (WL $>$ R $\geqq$ FL), and is *not* a tool *fail* condition.

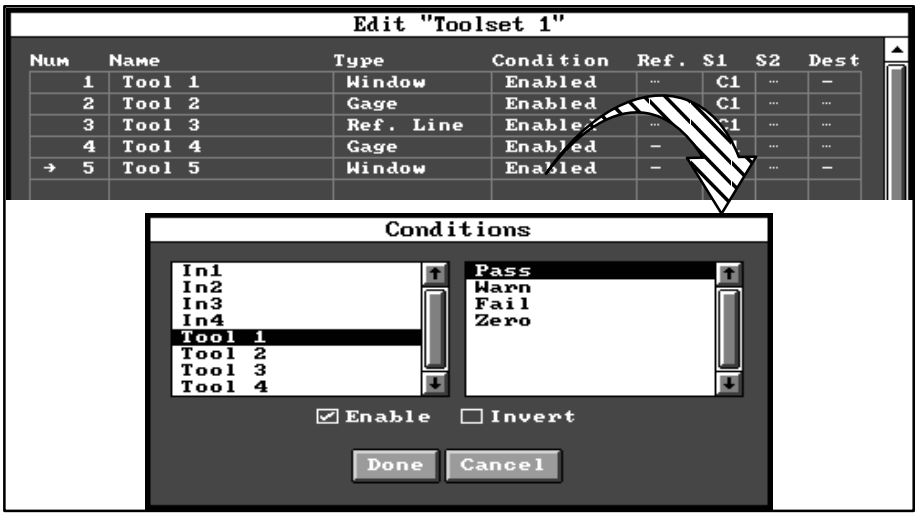
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Conditional Processing

This section discusses “conditional processing,” which, when selected for a specific inspection tool, permits that tool to execute *only* when a specific “condition” (such as an active input signal, or a “pass” tool result) is satisfied. The main effect of conditional processing is this: When the specified condition is satisfied, the tool executes; when the condition is *not* satisfied, the tool does *not* execute.

Conditions are selected from the Conditions panel, which can be accessed from the toolset edit panel by picking the Condition field for a specific tool, as illustrated by the example in Figure 7.147.

Figure 7.147 Example: Accessing Conditions Panel



The Conditions panel in Figure 7.147 illustrates the basic condition selections, which are described briefly, as follows:

- **In1 – In4** — The status of these inputs (that is, logic “0” or logic “1”) can be used to determine whether or not the corresponding “conditional” tool will execute. (Note that when any of these inputs are selected for conditional use, they must also be defined in the Discrete I/O panel. Refer to the *In1 – In4 Input Selection* section, on page 9–6 of Chapter 9, for more information.)
- **Tool n** — This indicates the name of a specific tool, whose status determines whether or not the corresponding “conditional” tool will execute. (The Tool n selections must always include a selection from the second list.)
- **Pass, Warn, Fail, Zero** — These selections specify the status of Tool n that will determine whether or not the corresponding “conditional” tool executes. (Note that the “Zero” selection is not available for all tools; for example, the reference line tool and the image tool.)

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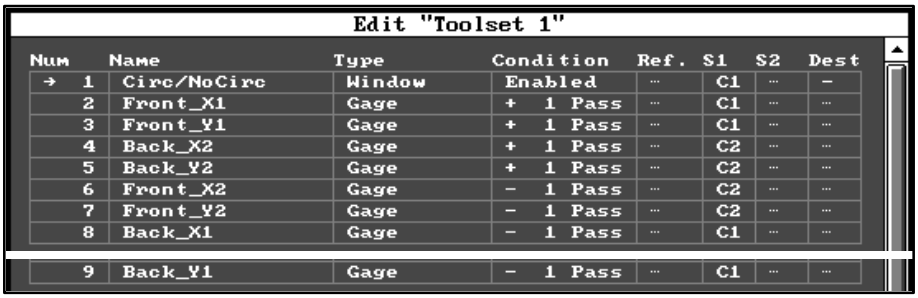
The Conditions panel also contains two checkboxes and two buttons, which are described briefly, as follows:

- **Enable** — The Enable checkbox is used to enable or disable the corresponding inspection tool. The tool is *enabled* when a check mark (√) appears in the checkbox, and is *disabled* when the box is empty. The selection can be changed to its *opposite* state by picking the box alternately.
- **Invert** — The Invert checkbox is used to enable or disable the *invert* function for the selected condition (input or tool result). The invert function is *enabled* when a check mark (√) appears in the checkbox, and is *disabled* when the box is empty. The function can be changed to its *opposite* state by picking the box alternately.

  When the invert function is enabled, the "condition" will be satisfied when its *opposite* state is asserted; thus, if Tool 1 – Pass is the selected condition, as shown in Figure 7.147 (page 7–183), and Invert is enabled, the condition will be satisfied when the opposite state (that is, Fail) is present. Similarly, if input In1 is the selected condition and Invert is enabled, the condition is satisfied when In1 is *inactive*. Further, if Zero is the selected condition with Invert enabled, the condition is satisfied when a *non–zero* condition occurs.
- **Done** — Use the Done button to save the highlighted condition and exit the Conditions panel.
- **Cancel** — Use the Cancel button to exit the Conditions panel *without* saving any newly selected conditions.

Figure 7.148 and Figure 7.149 provide an example inspection that illustrates the *concept* of conditional processing. Figure 7.148 shows a toolset edit panel containing one window tool and eight gage tools. The window tool and four of the gage tools receive their image from C1 (camera #1), while the other four gage tools receive their image from C2 (camera #2).

Figure 7.148 Tool Setup For Conditional Processing Example



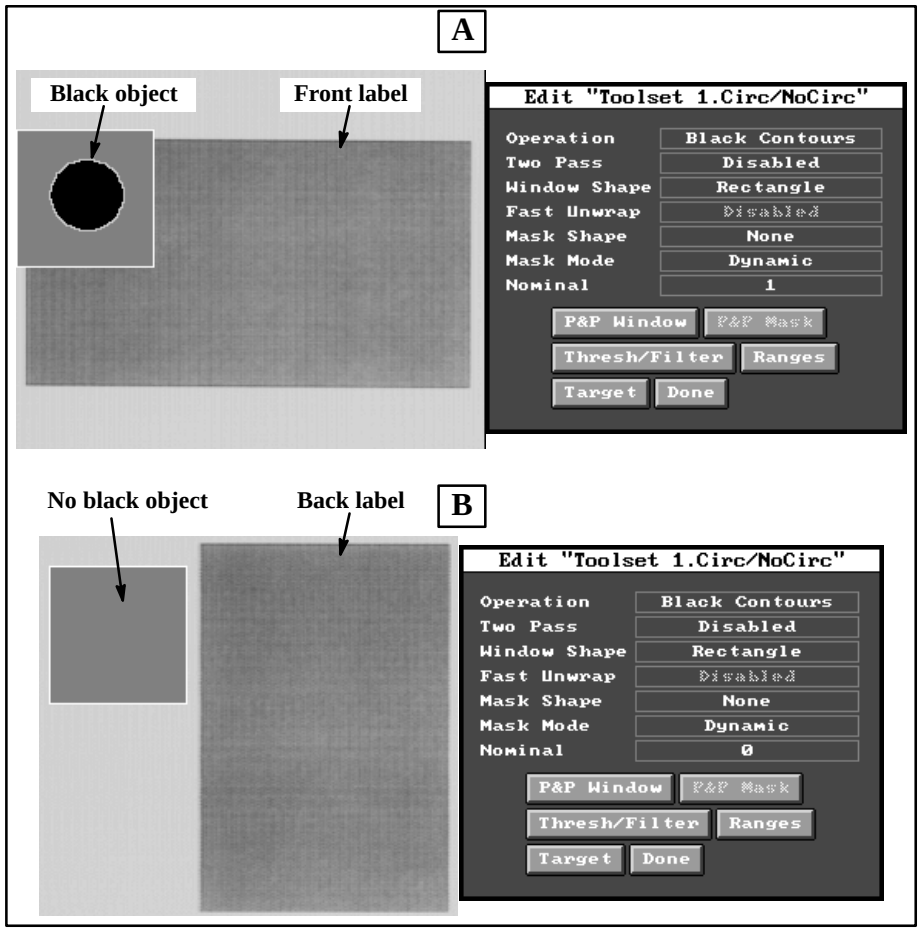
(Note that a toolset edit panel can display only *eight* tools at one time; thus, the *ninth* tool in this example is shown separately, below the first eight tools.)

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In this example, the object of the inspection is to inspect the front and back labels of a package for correct positioning, using two cameras. The assumption is that the inspected package can be oriented with *either* label facing *either* camera; thus, the inspection must correctly identify the front and back labels, and then apply the correct set of measurement tools to those labels, regardless of the package's orientation.

The window tool, "Circ/NoCirc," acquires its image from C1 (camera #1). It is configured for the Black Contours operation and looks for a black contour that is present *only* on the front label. If it finds the black contour, as shown by (**A**) in Figure 7.149, the window tool "passes" its inspection and, in effect, "detects" the *front* label.

Figure 7.149 Example: Detection of Front and Back Labels



If it does *not* find the black contour, as shown by (**B**) in Figure 7.149, the window tool "fails" its inspection and, in effect, "detects" the *back* label.

Note that in this example, the "pass" and "fail" conditions for the "Circ/NoCirc" window tool are based on its high *and* low range limits *both* being set to "1." Thus, if the result is "1," the window tool "passes"; if the result is "0," the window tool "fails."

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The first four gages in Figure 7.148 are configured to locate the left edge and top edge positions of the front and back labels. The gage tools "Front_X1" and "Front_Y1" receive their images from camera 1, while "Back_X2" and "Back_Y2" receive their images from camera 2. If the "Circ/NoCirc" window tool passes its inspection (that is, it detects the *front* label), these four gage tools will execute, since they are configured to execute on condition that the window tool *passes* (+ 1 Pass). The second four gage tools will not execute, in this case.

The second four gage tools perform the same functions as the first four gage tools. The gage tools "Front_X2" and "Front_Y2" receive their image from camera 2, while "Back_X1" and "Back_Y1" receive their image from camera 1. If the "Circ/NoCirc" window tool fails its inspection (that is, it does *not* detect the front label), these four gage tools will execute, since they are configured to execute on condition that the window tool *fails* (– 1 Pass). The first four gage tools will not execute, in this case.

The net result is that, regardless of the front/back orientation of the package in this example inspection, the conditional processing function causes the *correct* set of tools to execute.

NOTE: The example could also be based on the "Zero" condition selection. In this case, the *first* four gages would use the "– 1 Zero" selection, which is, in effect, a *non–zero* indicator. This would be appropriate when the inspection results from the "Circ/NoCirc" window tool are "1," indicating that it has detected the black contour on the front label. Conversely, the *second* four gages would use the "+1 Zero" selection, which would be appropriate when the inspection result from the window tool is "0," indicating that it has *not* detected the contour on the front label.

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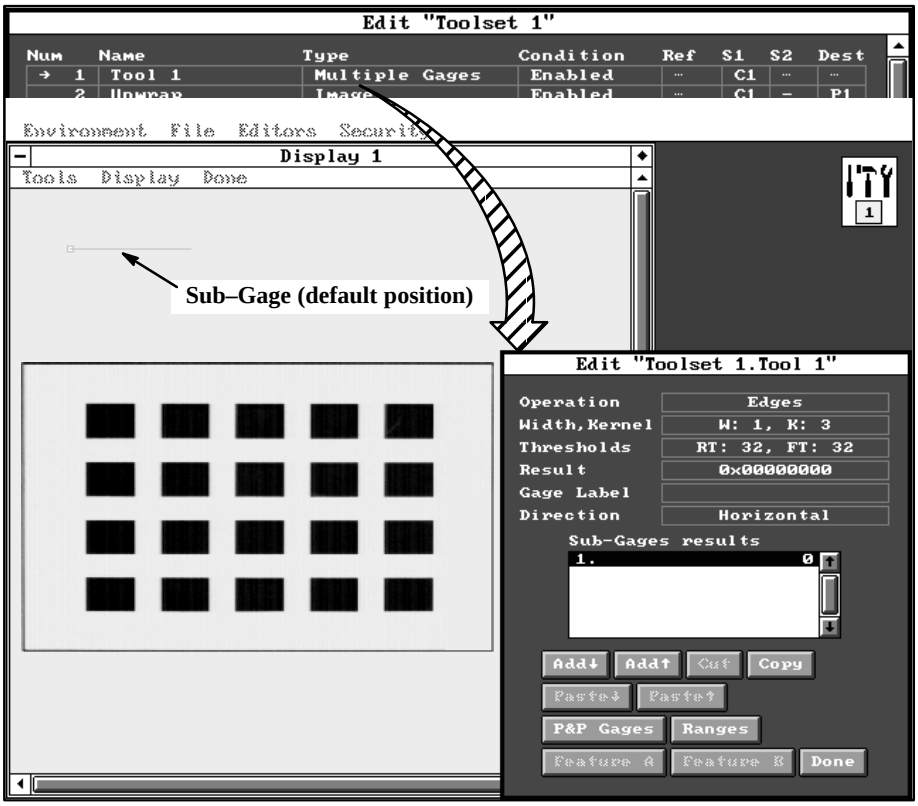
Multiple Gages Tool

This section discusses the multiple gages tool and the inspection functions ("operations") that it can perform.

Once you have selected a multiple gages tool as outlined in the *Overview: Inspection Tool Selection Process* section (page 7–1), you can configure it for an inspection application by picking the Multiple Gages field in the toolset edit panel. When you do, the multiple gages tool edit panel appears, as shown by the example in Figure 7.150.

Note that in Figure 7.150 a single "sub–gage" is shown in its *default* position and orientation on the screen.

Figure 7.150 Example: Selecting the Multiple Gage Tool Edit Panel



The multiple gages tool edit panel (named Edit "Toolset 1.Tool 1" in Figure 7.150) contains several data fields, buttons, and a "sub–gage results" box, which are used to create and configure each sub–gage. Their functions are described briefly as follows:

- **Operation** — This field provides access to the selection of one of the sub–gage "operations." The *default* sub–gage operation is Edges — an edge–counting operation.

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- **Width, Kernel** — This field provides access to the selection of the Gage Width & Kernel panel, which sets the sub–gage width (in pixels) and the "kernel" size.
- **Thresholds** — This field provides access to the Gage Threshold panel, which sets the change in gray scale values that are required to detect the "rising" and "falling" edges of an object in the image.
- **Result** — This field displays an eight–digit hexadecimal number. Each of the 32 bit positions represents the pass/fail status of the corresponding sub–gage. (A "0" bit indicates that the sub–gage has *passed*; a "1" bit indicates that it has *failed*.) For example, the hex number 0x00000021 indicates that sub–gages 1 and 6 have failed (bit positions 1 and 6 are set to "1"), while sub–gages 2 – 5 (and any sub–gages above 6) have passed (bit positions 2 – 5 and 7 – 32 are all set to "0").

  This hexadecimal "result" value is *not* range checked by the multiple gages tool; instead, it is made available to math tools, and to host systems through the communication ports.
- **Gage Label** — This field enables you to select an appropriate name tag for each sub–gage. When the sub–gage is repositioned, the name tag moves with it.
- **Direction** — This field sets the sub–gage orientation to either Horizontal or Vertical. Toggling this field successively alternates between these two orientations. No other orientations are available.
- **Sub–Gages results** — This is a *list box* that contains from 1 to 32 sub–gages and their current results values. By *default*, it contains one sub–gage initially. (Additional sub–gages are created with the "Add" and "Copy and Paste" functions, which are described below.)

Here is a brief description of each *button* in the toolset edit panel:

- **Add**↑ — Use the Add↑ button to select a new sub–gage and insert it *before* (above) the highlighted sub–gage in the list box.
- **Add**↓ — Use the Add↓ button to select a new sub–gage and insert it *after* (below) the highlighted sub–gage in the list box.
- **Cut** — Use the Cut button to delete (and save in a "clipboard") the highlighted sub–gage in the list box.
- **Copy** — Use the Copy button to copy into a "clipboard" the highlighted sub–gage in the list box. After copying, the next step is pasting the copied sub–gage (see the **Paste**↑ and **Paste**↓ button descriptions below).
- **Paste**↑ — Use the Paste↑ button to "paste" a copied sub–gage from the "clipboard" and insert it *before* (above) the highlighted sub–gage.
- **Paste**↓ — Use the Paste↓ button to "paste" a copied sub–gage from the "clipboard" and insert it *after* (below) the highlighted sub–gage.

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- **P&P Gages** — The P&P Gage button activates the pick and place function for the highlighted sub–gage. Each time a sub–gage is ”picked and placed,” its results value in the list box is automatically recalculated.

  For details about this function, see Chapter 5, *Pick and Place Functions*.
- **Ranges** — The Ranges button accesses the range–selection panel, which defines inspection result limits for the *highlighted* sub–gage.

  NOTE: Range limits set for *one* sub–gage are *independent* of range limits set for any *other* sub–gage. Also, range limits do *not* apply to the Multiple Gages tool itself — *only* to the sub–gages.
- **Feature A, Feature B** — The Feature buttons accesses the “feature,” or edge selection panels for the respective features of the highlighted sub–gage. This function is accessible only for the X Position, Y Position, and Linear Measure operations.
- **Done** — When you pick the Done button, the system exits back to the toolset edit panel.

Overview: Multiple Gages Tool Configuration

A multiple gages tool can be selected when the toolset edit panel is on the screen. Starting from the main menu bar, the selection path to this panel is as follows: **Editors** → **Configuration** → **Setup** → **Tools**. This selection path is shown by the example in Figure 7.1 (page 7–2).

Here is a summary list of the basic selection and configuration steps for each *sub–gage* in a multiple gages tool, listed in their normal order of performance:

1. Create (”Add”) a new sub–gage or “Copy” and “Paste” an existing one in the Sub–Gage results list box.
2. Highlight the sub–gage to be configured.
3. Select the sub–gage operation.
4. Select the sub–gage direction.
5. “Pick and place” the sub–gage.
6. Adjust the edge detection parameters.
7. Learn the result value.
8. Select the appropriate result limit ranges.
9. Select a sub–gage label (optional).

NOTE: The following functional restrictions apply to sub–gages:

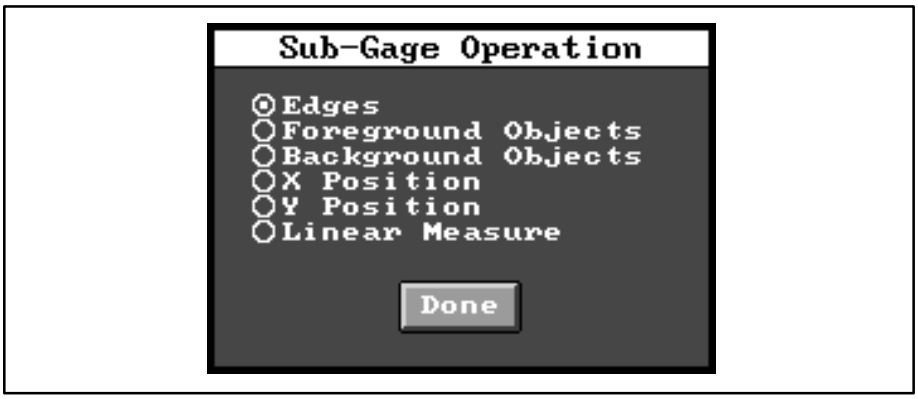
- Since they can operate *only* in the gray scale gaging mode, they cannot perform the White Pixels and Black Pixels operations.
- Their shape can *only* be linear, and their orientation can *only* be horizontal (pointing *right*) or vertical (pointing *down*).
- They cannot use a *rotational* reference tool (if one is assigned, a “clip fail” error will occur, and the “Results” value will be all zeros.

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Sub–Gage Operations

When you pick the Operation field in the multiple gages tool edit panel, the Sub–Gage Operation selection panel appears, as shown in Figure 7.151.

Figure 7.151 Sub–Gage Operation Selection Panel

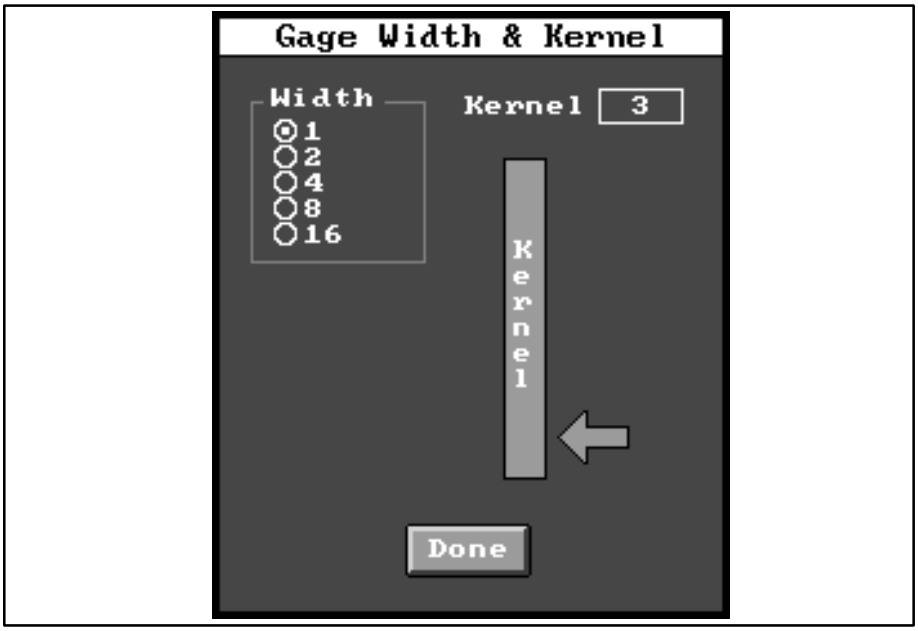


These sub–gage operations are identical to those for single gages. For details about these operations, refer to pages 7–8 to 7–16. (Note: Since all sub–gage operations use the *gray scale* gaging mode, ignore all references to the binary gaging mode.)

Width and Kernel Functions

When you pick the Width, Kernel field in the multiple gages tool edit panel, the Gage Width & Kernel panel appears, as shown in Figure 7.152.

Figure 7.152 Gage Width & Kernel Panel



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The Width box enables the selection of one of several sub–gage widths. The *default* width setting is 1 pixel, but a wider setting may be necessary if a particular edge is somewhat uneven. In that case, a wider setting has the effect of *smoothing* an uneven edge by calculating its *average* location across the width of the gage.

The *kernel* setting determines the number of consecutive pixels over which the brightness change is evaluated. At a given point, the brightness change is evaluated over a distance equal to two times the kernel setting, plus one.

The kernel setting is 3 by *default*. This means that an edge will be detected whenever a “rising” or “falling” brightness change occurs (as determined by the Thresholds settings) within *three consecutive pixels* along the length of the gage. A higher setting may be necessary to detect an edge where the brightness change is more *gradual*.

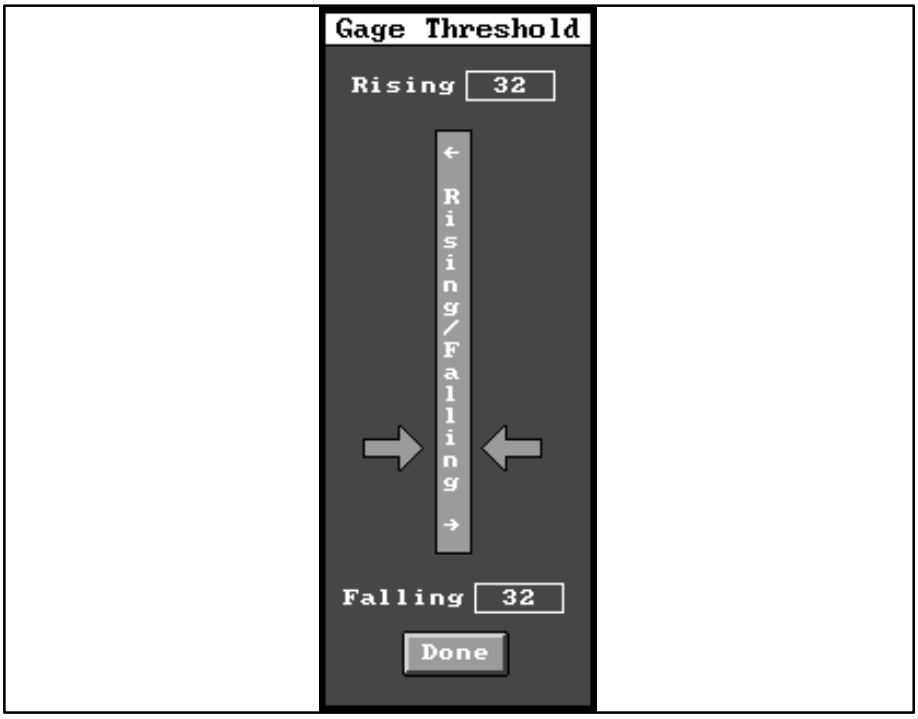
The kernel value can be adjusted by sliding the cursor up or down, or by clicking the “box” containing the kernel value. In that case, the calculator pad will appear, and a value between 1 and 16 can be entered.

For more detailed information about kernels, refer to the *Threshold and Kernel Settings* section on page 8–6.

Threshold Functions

When you pick the Threshold field in the multiple gages tool edit panel, the Gage Threshold panel appears, as shown in Figure 7.153.

Figure 7.153 Gage Threshold Panel



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The Gage Threshold panel contains a separate adjustment for the “rising” and “falling” edges of an object in the image field. The *rising* edge is a transition from a dark to a light area; the *falling* edge is a transition from a light to a dark area.

The threshold settings are both 32 by *default*. This means that an edge will be detected wherever the gray scale value changes by at least 32 (within the number of pixels specified by the Kernel setting). For a rising edge, the gray scale value must *increase* by 32 or more; for a falling edge the value must *decrease* by that amount.

A threshold value can be adjusted by sliding the appropriate cursor up or down, or by clicking the “box” containing the threshold value. In that case, the calculator pad will appear, and a value between 0 and 127 can be entered.

For more detailed information about thresholds, refer to the *Threshold and Kernel Settings* section on page 8–6.

Gage Label Function

When you pick the Gage Label field in the multiple gages tool edit panel, the keyboard panel appears, as shown in Figure 7.154.

Figure 7.154 Gage Label Keyboard Panel



You can use the keyboard to enter an appropriate name or “label” for the selected sub–gage. The label can contain up to eight characters. When you click the Enter key to enter the label, the label will appear in the Sub–Gages result list box and adjacent to the sub–gage. Whenever you move (“pick and place”) the sub–gage, the label will move with it.

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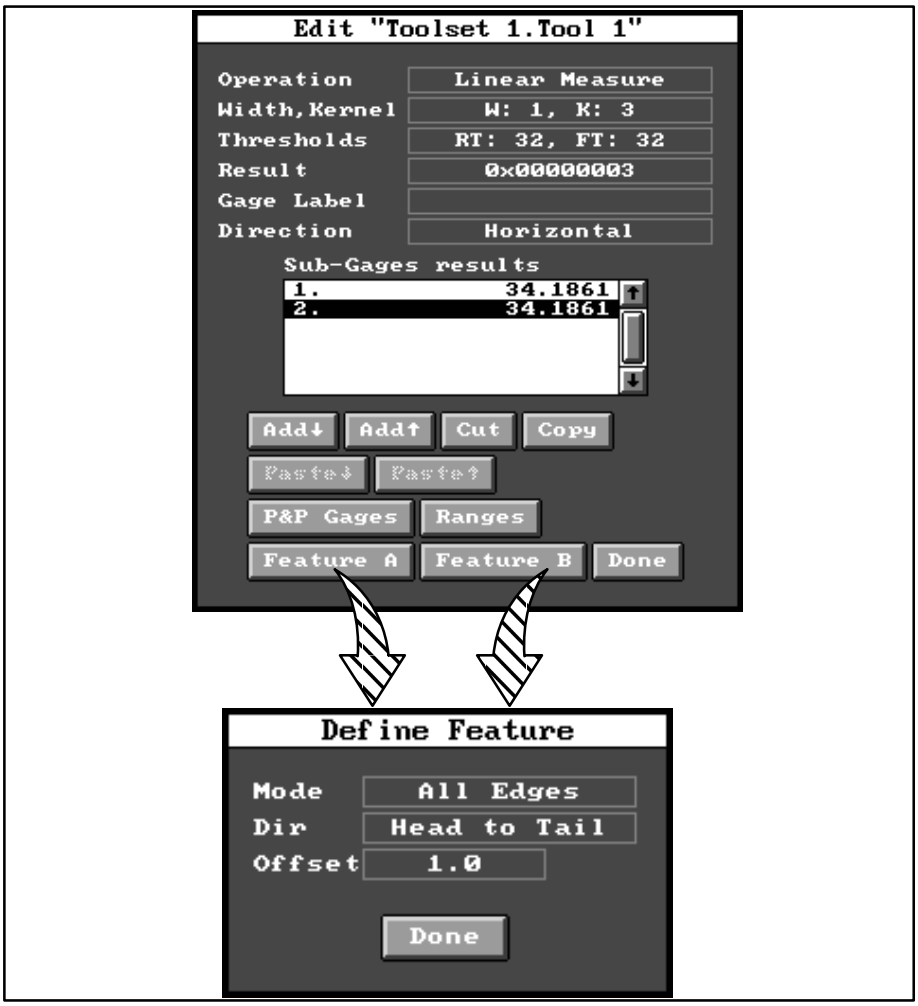
Feature Selection Functions

The following three gage operations employ “features” to identify the edges used for a measurement: X position, Y position, and linear measure.

A sub–gage can detect several edges, of which only one or two are required for the measurement. Thus, the edge selection functions enable you to select particular edges, or other features related to the edges, and determine other aspects of the search for these edges, including search direction and search mode.

When you pick either of the Feature buttons on the tool edit panel, a Define Feature selection panel appears, as shown in Figure 7.155.

Figure 7.155 Example: Selecting the Define Feature Selection Panel



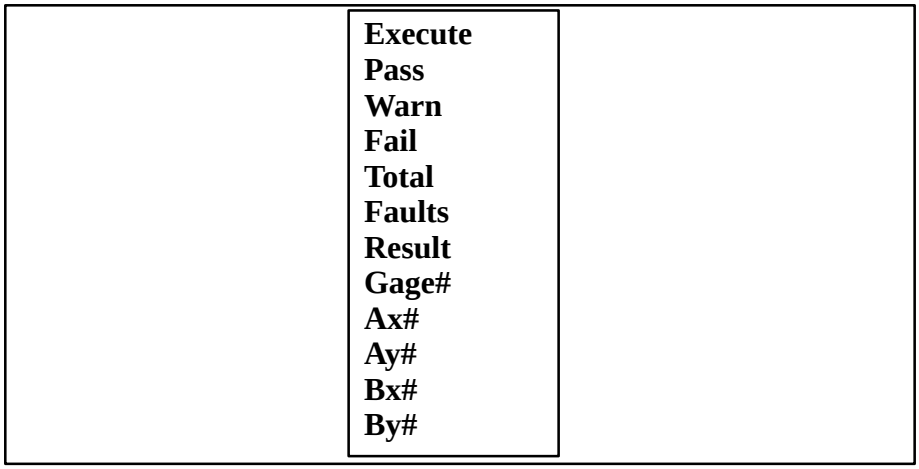
The width, kernel, and threshold settings determine which light/dark transitions along a sub–gage are detected as edges. The purpose of the *feature selection function* is to specify which of these edges (or midpoints between edges) are to be identified as “features,” used as the basis for the inspection operation. For complete details, refer to pages 7–18 to 7–23.

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Multiple Gages Tool Inspection Results and Math Tool Formulas

This section discusses the expanded inspection results that are available to a math tool formula from a multiple gages tool. As Figure 7.156 shows, the expanded inspection results for *all* tool operations appear in a single scrolling list.

Figure 7.156 Expanded Results List For Multiple Gages Tools in Math Formulas



Here is a brief definition and explanation of each of the gage result types listed in Figure 7.156:

- **Execute** — This returns a 1.000 when the tool has *executed* its inspection task, and 0.000 for all other conditions.
- **Pass** — This returns a 1.000 when the tool has *passed* its inspection task, and 0.000 for all other conditions.
- **Warn** — This returns an "error code" when the tool is in a *warn* condition (and *not* in a *fail* condition) and 0.000 for all other conditions. The error code identifies a specific reason for the warning; for example, error code 1057.000 identifies "Low range warning" as the cause. The complete list of error codes appears in Appendix A of this manual.
- **Fail** — This returns an "error code" when the tool is in a *fail* condition and 0.000 for all other conditions. The error code identifies a specific reason for the failure; for example, error code 1045.000 identifies "High range fail" as the cause of the inspection failure. The complete list of error codes and fail conditions appears in Appendix A of this manual.
- **Total** — This returns the total number of inspections performed.
- **Faults** — This returns the total number of faults detected.
- **Result** — This returns the decimal equivalent of a bit–mapped hexadecimal value that represents the pass/fail status of up to 32 sub–gages. Thus, the low–order bit represents sub–gage 1, while the high–order bit represents sub–gage 32.

  For example, a hex value of 2A would indicate that sub–gages 2, 4, and 6 had failed. In this example, the decimal equivalent for hex 2A, which is 42, would appear as the result value in a math formula.

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- **Gage#** — This returns the results value from a specific sub–gage (for *single* math operations) or the results values from several sub–gages (for *multiple* math operations).

  For *single* math operations, the pound sign should be replaced with the number of a specific sub–gage.

  For *multiple* math operations, the pound sign should not be replaced.

- **Ax#** — This value pertains *only* to a sub–gage tool configured for linear measurement or X or Y position operations. “Ax” returns the value of the X coordinate of Feature A.

  For *single* math operations, the pound sign should be replaced with the number of a sub–gage that is configured for linear measure or X or Y position operation.

  For *multiple* math operations, the pound sign should not be replaced.

- **Ay#** — This value pertains *only* to a sub–gage tool configured for linear measurement or X or Y position operations. “Ay” returns the value of the Y coordinate of Feature A.

  For *single* math operations, the pound sign should be replaced with the number of a sub–gage that is configured for linear measure or X or Y position operation.

  For *multiple* math operations, the pound sign should not be replaced.

- **Bx#** — This value pertains *only* to a sub–gage tool configured for linear measurement operations. “Bx” returns the value of the X coordinate of Feature B.

  For *single* math operations, the pound sign should be replaced with the number of a sub–gage that is configured for linear measure.

  For *multiple* math operations, the pound sign should not be replaced.

- **By#** — This value pertains *only* to a gage tool configured for linear measurement operations. “By” returns the value of the Y coordinate of Feature B.

  For *single* math operations, the pound sign should be replaced with the number of a sub–gage that is configured for linear measure.

  For *multiple* math operations, the pound sign should not be replaced.

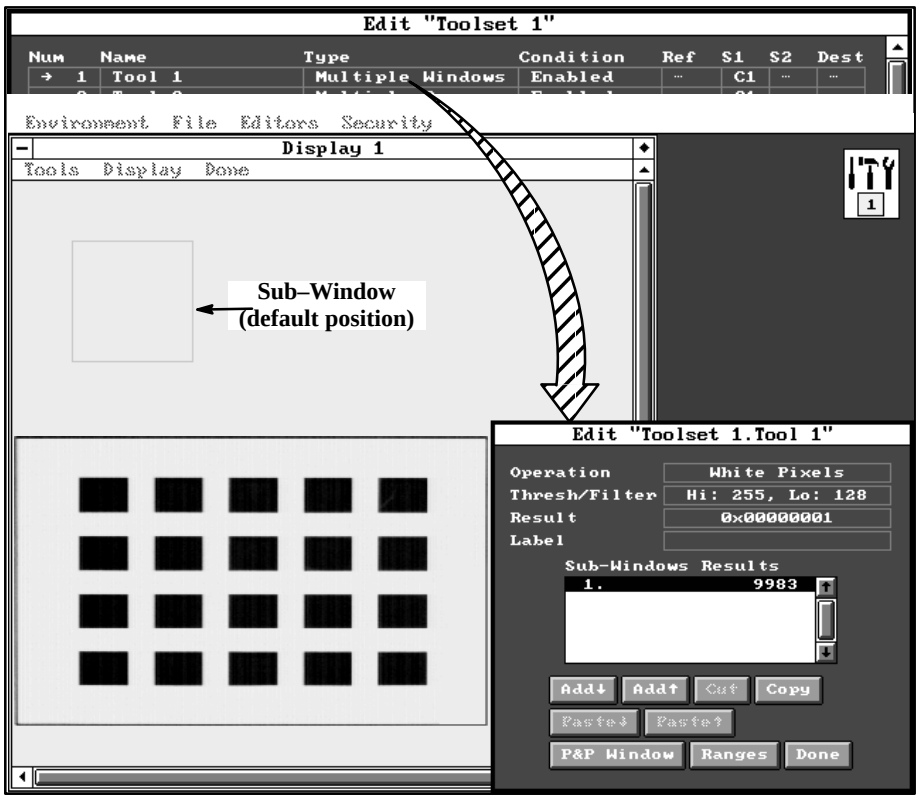
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Multiple Windows Tool

This section discusses the multiple windows tool and the inspection functions (“operations”) that it can perform.

Once you have selected a multiple windows tool as outlined in the *Overview: Inspection Tool Selection Process* section (page 7–1), you can configure it for an inspection application by picking the Multiple Windows field in the toolset edit panel. When you do, the multiple window tool edit panel appears, as shown by the example in Figure 7.157.

Figure 7.157 Example: Selecting the Multiple Windows Tool Edit Panel



Note that in Figure 7.157 a single “sub–window” is shown in its *default* position on the screen.

The multiple windows tool edit panel (named Edit “Toolset 1.Tool 1 Edit”) in Figure 7.157) contains several data fields, buttons, and a “sub–windows results” box, which are used to configure each sub–window. Their functions are described briefly as follows:

- **Operation** — This field provides access to the selection of one of the sub–window “operations.” The *default* sub–window operation is White Pixels, which is a pixel–counting operation.
- **Thresh/Filter** — This field provides access to the threshold and/or morphology filter selection panels. For details about this function, refer to page 8–9 in Chapter 8, *Thresholds, Filters, and Morphology.*

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- **Result** — This field displays an eight–digit hexadecimal number. Each of the 32 bit positions represents the pass/fail status of the corresponding sub–window. (A “0” bit indicates that the sub–window has *passed*; a “1” bit indicates that it has *failed*.) For example, the hex number 0x00000021 indicates that sub–windows 1 and 6 have failed (bit positions 1 and 6 are set to “1”), while sub–windows 2 – 5 (and any sub–windows above 6) have passed (bit positions 2 – 5 and 7 – 32 are all set to “0”).

  This hexadecimal “result” value is *not* range checked by the multiple windows tool; instead, it is made available to math tools, and to host systems through the communication ports.
- **Label** — This field enables you to select an appropriate name tag for each sub–window. When the sub–window is repositioned, the name tag moves with it.

Here is a brief description of each *button* in the toolset edit panel:

- **Add**↑ — Use the Add↑ button to select a new sub–window and insert it *before* (above) the highlighted sub–window in the list box.
- **Add**↓ — Use the Add↓ button to select a new sub–window and insert it *after* (below) the highlighted sub–window in the list box.
- **Cut** — Use the Cut button to delete (and save in a “clipboard”) the highlighted sub–window in the list box.
- **Copy** — Use the Copy button to copy into a “clipboard” the highlighted sub–window in the list box. After copying, the next step is pasting the copied sub–window (see the **Paste**↑ and **Paste**↓ button descriptions below).
- **Paste**↑ — Use the Paste↑ button to “paste” a copied sub–window from the “clipboard” and insert it *before* (above) the highlighted sub–window.
- **Paste**↓ — Use the Paste↓ button to “paste” a copied sub–window from the “clipboard” and insert it *after* (below) the highlighted sub–window.
- **P&P Window** — The P&P Window button activates the window pick and place function. For details about this function, see Chapter 5, *Pick and Place Functions*.
- **Ranges** — The Ranges button accesses the range–selection panel, which defines inspection result limits for the *highlighted* sub–window.

  NOTE: Range limits set for *one* sub–window are *independent* of range limits set for any *other* sub–window. Also, range limits do *not* apply to the Multiple Windows tool itself — *only* to the sub–windows.
- **Done** — When you pick the Done button, the system exits back to the toolset edit panel.

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Overview: Multiple Windows Tool Configuration

A window can be selected when the toolset edit panel is on the screen. Starting from the main menu bar, the selection path to this panel is as follows: **Editors → Configuration → Setup → Tools**. This selection path is shown by the example in Figure 7.1 (page 7–2).

Here is a summary list of the basic selection and configuration steps for each *sub–window* in a multiple windows tool, listed in their normal order of performance:

1. Create (”Add”) a new sub–window or “Copy” and “Paste” an existing one in the Sub–Window results list box.
2. Highlight the sub–window to be configured.
3. Select the sub–window operation.
4. “Pick and place” the sub–window.
5. Select the appropriate result limit ranges.
6. Select a sub–window label (optional).

NOTE: The following functional restrictions apply to sub–windows:

- They can perform *only* the White and Black Pixels, and Luminance operations.
- Their shape can *only* be rectangular, and they cannot use a mask.
- They cannot use a *rotational* reference tool (if one is assigned, a “clip fail” error will occur, and the “Results” and “Sub–Windows Results” values will be all zeros).

Sub–Window Operations

When you pick the Operation field in the multiple windows tool edit panel, the Sub–Window Operation selection panel appears, as shown in Figure 7.158.

Figure 7.158 Sub–Window Operation Selection Panel



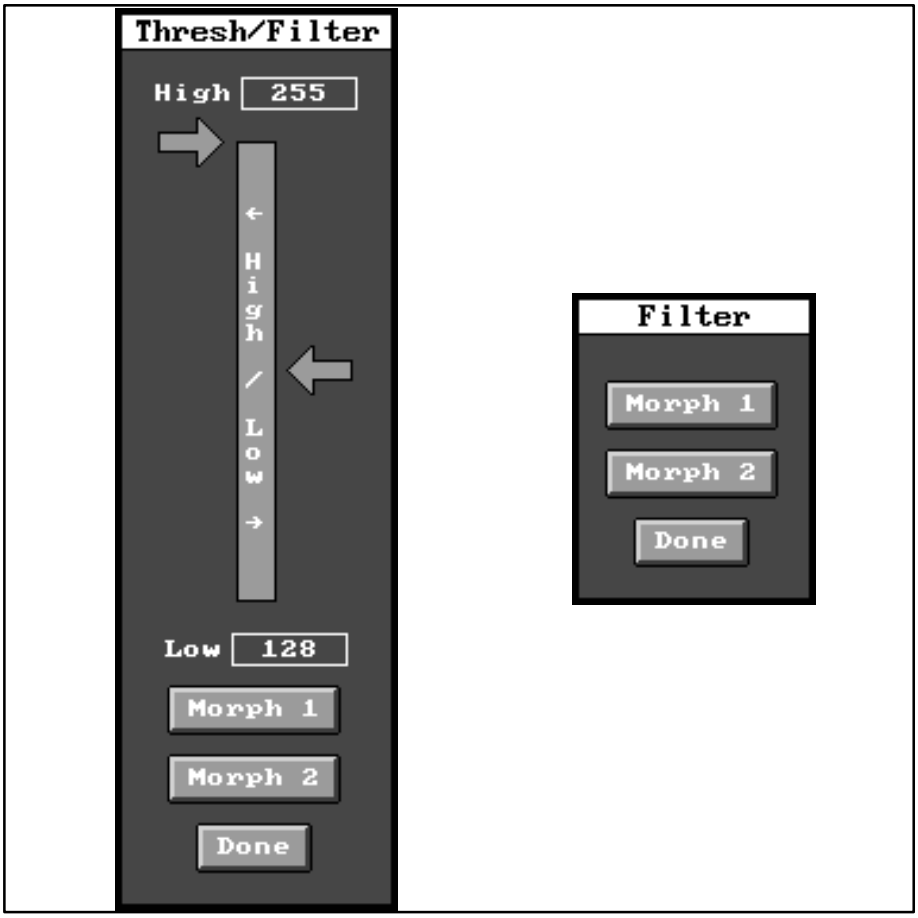
These sub–window operations are identical to those for single windows. For details about these operations, refer to the *Window Operations* section, pages 7–32 and 7–52.

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Threshold/Filter Functions

When you pick the Thresh/Filter field in the multiple windows tool edit panel, the Thresh/Filter panel appears when a pixel counting operation has been selected, while the Filter panel appears when the luminance operation has been selected, as shown in Figure 7.159.

Figure 7.159 Thresh/Filter and Filter Panels



For pixel counting operations, the two cursors adjust the “high” and “low” binary thresholds. In addition, the Morph1 and Morph2 buttons provide access to binary and gray scale morphology filters.

For luminance operations, only the Morph1 and Morph2 buttons are available.

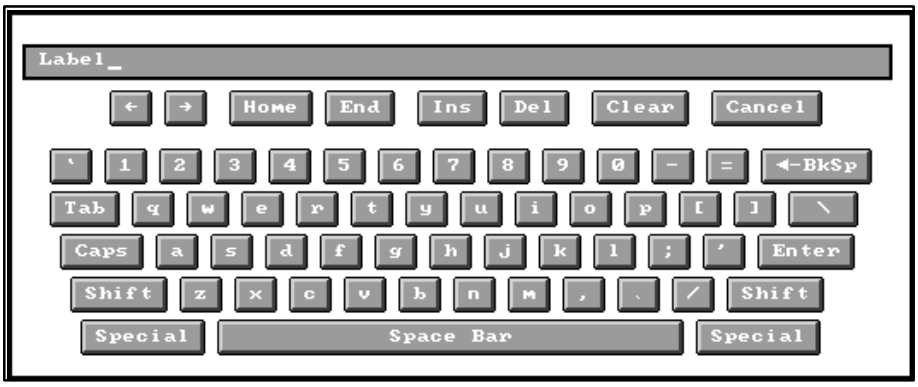
For detailed information about thresholds and morphology, refer to the *Area Tools: Threshold and Morphology Functions* section on page 8–9.

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Label Function

When you pick the Label field in the multiple windows tool edit panel, the keyboard panel appears, as shown in Figure 7.160.

Figure 7.160 Keyboard Panel

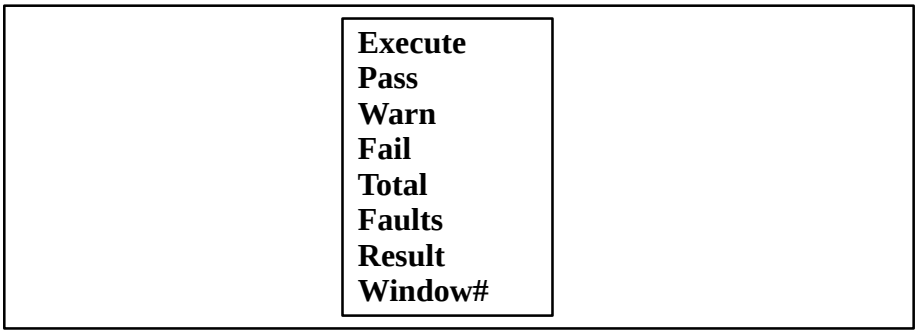


You can use the keyboard to enter an appropriate name or “label” for the selected sub–window. The label can contain up to eight characters. When you click the Enter key to enter the label, the label will appear in the Sub–Windows Results list box and adjacent to the sub–window. Whenever you move (“pick and place”) the sub–window, the label will move with it.

Multiple Windows Tool Inspection Results and Math Tool Formulas

This section discusses the expanded inspection results that are available to a math tool formula from a multiple windows tool. As Figure 7.161 shows, the expanded inspection results for *all* tool operations appear in a single scrolling list.

Figure 7.161 Expanded Results List For Multiple Window Tools in Math Formulas



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Here is a brief definition and explanation of each of the expanded result types listed in Figure 7.161.

- **Execute** — This returns a 1.000 when the tool has *executed* its inspection task, and 0.000 for all other conditions.
- **Pass** — This returns a 1.000 when the tool has *passed* its inspection task, and 0.000 for all other conditions.
- **Warn** — This returns an "error code" when the tool is in a *warn* condition (and *not* in a *fail* condition) and 0.000 for all other conditions. The error code identifies a specific reason for the warning; for example, error code 1057.000 identifies "Low range warning" as the cause. The complete list of error codes and warn conditions appears in Appendix A of this manual.
- **Fail** — This returns an "error code" when the tool is in a *fail* condition, and 0.000 for all other conditions. The error code identifies a specific reason for the failure; for example, error code 1045.000 identifies "High range fail" as the cause of the inspection failure. The complete list of error codes and fail conditions appears in Appendix A of this manual.
- **Total** — This returns the total number of inspections performed.
- **Faults** — This returns the total number of faults detected.
- **Result** — This returns the decimal equivalent of a bit–mapped hexadecimal value that represents the pass/fail status of up to 32 sub–windows. Thus, the low–order bit represents sub–window 1, while the high–order bit represents sub–window 32.

  For example, a hex value of 2A would indicate that sub–windows 2, 4, and 6 had failed. In this example, the decimal equivalent for hex 2A, which is 42, would appear as the result value in a math formula.
- **Window#** — This returns the results value from a specific sub–window (for *single* math operations) or the results values from several sub–windows (for *multiple* math operations).

  For *single* math operations, the pound sign should be replaced with the number of a specific sub–window.

  For *multiple* math operations, the pound sign should not be replaced

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Chapter 8

Thresholds, Filters, and Morphology

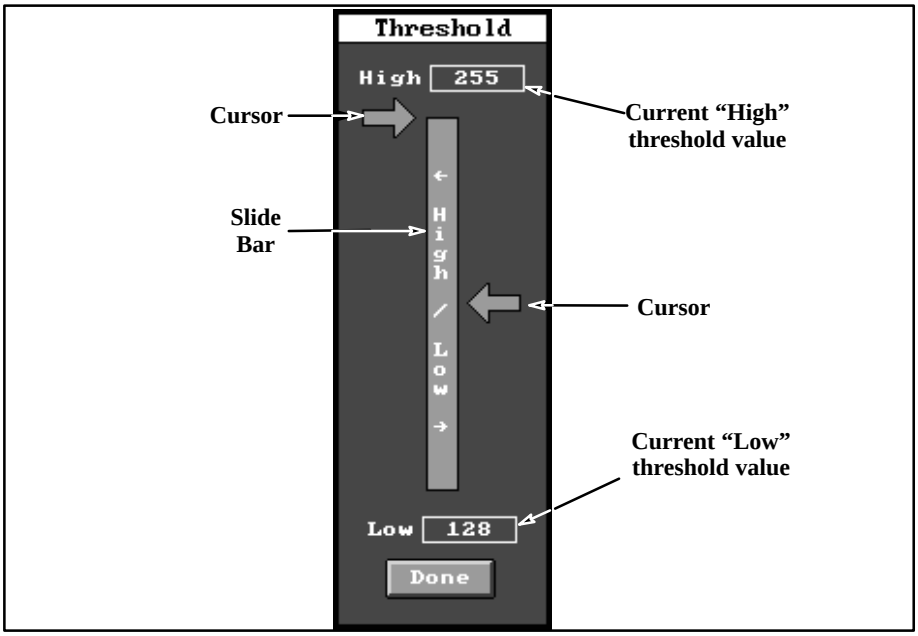
This chapter discusses the various threshold and filter settings for the inspection tools, as follows:

- **Binary thresholds: Gaging tools** — These settings adjust the edge detection parameters of gaging tools (gages and reference lines) operating in the binary gaging mode.
- **Binary filter: Gaging tools** — This function provides several degrees of filtering that can remove or reduce "noise" from the image for gaging tools that are operating in the *binary* gaging mode.
- **Kernel and threshold** — These settings adjust the edge detection parameters of gaging tools operating in the gray scale gaging mode.
- **Thresholds and Morphology: Area tools** — Threshold settings define the separation between black and white in windows that are configured for any of the binary area tool (window and image tool) operations.

  Morphology is an image processing function that provides refinement of the raw camera image. It can be used to enhance both binary and gray scale images.

Numerical parameters such as thresholds are adjusted by a "slide bar." Settings are indicated by the visual positions of one or two cursor symbols, and by numbers appearing in boxes near the cursors. The *specific* function of each cursor depends on the specific parameter it represents. Figure 8.1 shows how two cursors and their associated "slide bar" typically appear on the display.

Figure 8.1 Typical Threshold–Setting Cursors and Slide Bar



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Settings can be changed by “dragging” the cursors up and down, or by picking the screen above or below a cursor. Alternatively, the settings can be changed by picking the box containing the current value and entering a specific value on the calculator pad, for gaging tools, or on a formula–entry keyboard for area tools using binary thresholding. In the latter case, the keyboard can be used to enter either a constant, for *static* thresholding, or a math formula, for *dynamic* thresholding (refer to the *Dynamic Threshold Function* section on page 8–11 of this chapter for details).

Gaging Tools: Binary Threshold Procedures

Your main objective in setting the binary threshold is to *define the most stable edges* along the gage where the gage crosses the proposed reference points on the workpiece image.

The binary threshold setting affects *only* the part of the workpiece image lying within a small box that surrounds the gage. Within that box, the workpiece image is *binarized* — that is, its features appear as either black or white. The reason for displaying the binarized image is to provide a visual aid for setting the binary threshold.

Threshold Settings: Left and Right Cursors

The two thresholds *interact* to affect the appearance of the binarized workpiece image within the binarized image box. Individually, the two threshold settings have the following effects:

- **High threshold (left cursor)** — This setting determines the *high threshold value* for the binarized image. Any part of that image whose original gray–scale brightness value is *higher* than the high threshold value will appear *black* in the binarized image.

  For example, if the high threshold setting is 190, any part of the binarized image whose brightness value is *higher* than 190 will appear *black*.

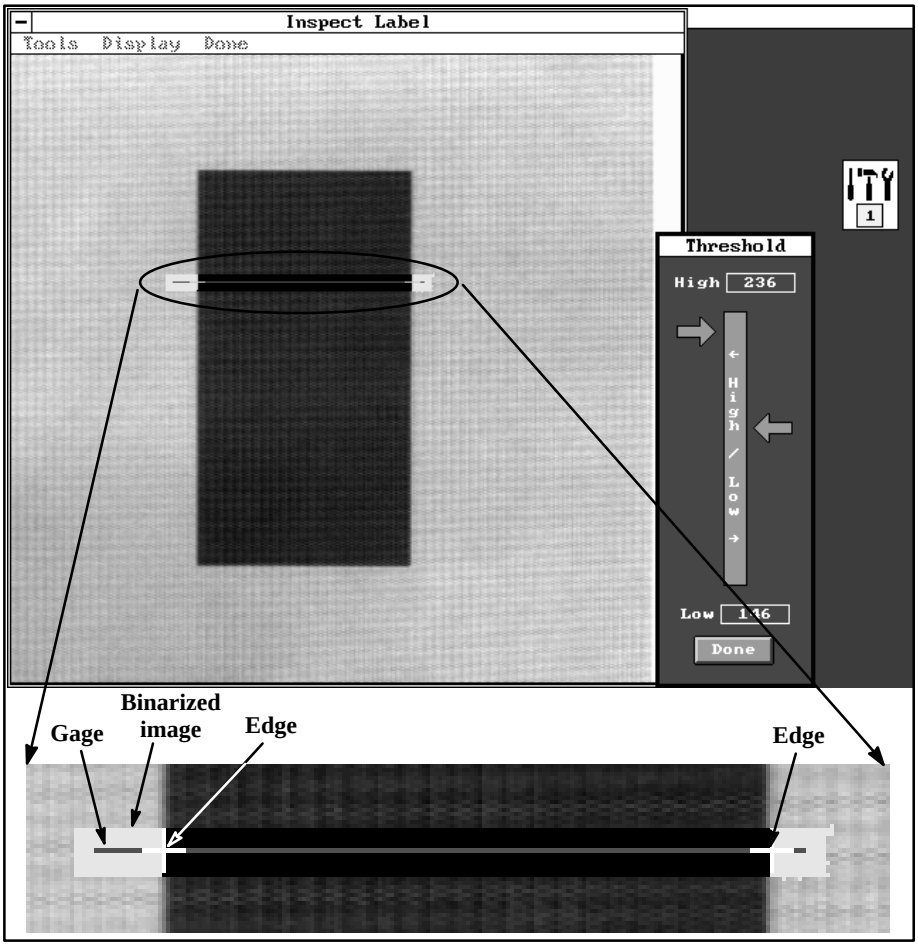
- **Low threshold (right cursor)** — This setting determines the *low threshold value* for the binarized image. Any part of that image whose original gray–scale brightness value is *lower* than the low threshold value will appear *black* in the binarized image.

  For example, if the low threshold setting is 40, any part of the image whose brightness value is *lower* than 40 will appear *black*.

The *interactive result* of the two threshold settings is this: Any part of the image (in the binarized image box) whose original brightness value is *between* the high and low threshold values will appear *white* in the box. (In the examples above, this applies to brightness values from 40 to 190.) Figure 8.2 (page 8–3) illustrates a binarized image with optimized thresholds.

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Figure 8.2 Example: Optimizing the Threshold Settings (Binary Gaging Mode)



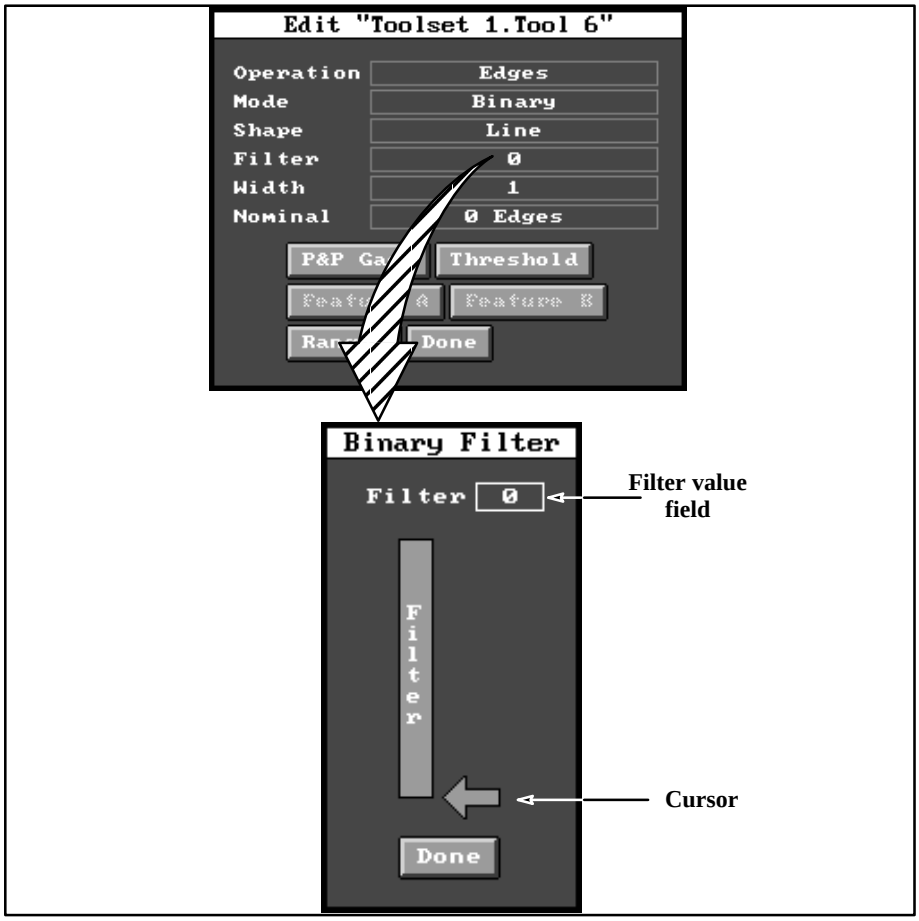
If “noise” persists in the binarized image, however, and superfluous “+” edge markers appear on the gage, see the *Binary Filter* section for information about “filtering” this noise.

Binary Filter

The binary filter enables you to remove small white or black noise along the gage. This filtering function can be useful if noise prevents you from getting stable edges, and/or you want to reduce or eliminate unwanted edges. If so, you can pick the field next to “Filter” in the tool edit panel. When you do, the Binary Filter panel appears, as shown in Figure 8.3 (page 8–4).

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Figure 8.3 Selecting Binary Filter Panel for Gage



From the Binary Filter panel you can select the number (from 0 to 10) of consecutive black or white noise pixels to be masked (filtered) from the workpiece image and background, in the area around the gage, *before* the gage looks for edges. The *default* filter value is 0, as shown in Figure 8.3.

Thus, the *effect* of the filtering function is to mask out the noise so that it does not create false or unwanted edges on the gage. (The noise will remain visible in the binary box, however.)

This is how the filter function works: If the filter value were set to 3, for example, and the gage encountered three (or fewer) consecutive white pixels in a stream of black pixels, these white pixels would be regarded as noise and "filtered" out; thus, the gage would not detect any edges at that point. Conversely, if the gage encountered a group of four (or more) consecutive white pixels, the gage *would* detect *two* edges — a *leading* edge and a *trailing* edge.

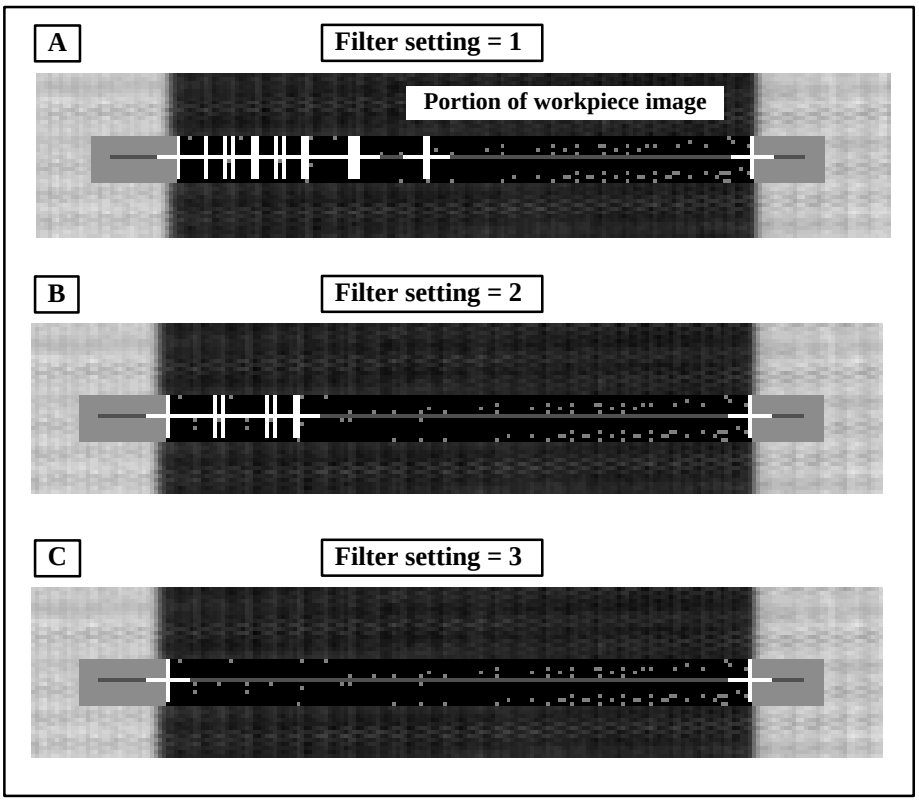
To use the filter function, you can pick the cursor and drag it upward to increase the filtering value; or, you can pick the filter value field and select a new filter value using the calculator pad. The *objective* is to set the filter to a

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value that results in consistent edges being detected at the desired reference points on the workpiece image.

Figure 8.4 provides an example of setting the filter value so that the superfluous “edges” are masked or filtered out. This example shows three stages of setting the filter value for a linear gage that lies across a portion of a workpiece image.

Figure 8.4 Example: Filtering the White “Noise” in a Workpiece Image



With the filter value currently set to “1,” numerous unwanted “edges” (“+” symbols) appear along the gage, as shown in part A of Figure 8.4. In part **B**, the filter is set to “2,” and fewer unwanted edges are detected. In part **C**, the filter is set to “3,” and only the desired edges are detected.

Exit the Binary Filter panel by picking the Done button.

Gaging Tools: Gray Scale Edge Detection

Your main objective in setting the gray scale threshold is to define the most stable edges along the gage where the gaging tool crosses the proposed reference points on the workpiece.

Gray scale edge detection uses two parameters to analyze the image and detect edges. These parameters are called *threshold* and *kernel*.

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Threshold specifies the relative brightness change between neighboring pixels, while *kernel* specifies the number of consecutive pixels over which the brightness change is evaluated. The settings of threshold and kernel interact to determine whether an edge will be detected in any one instance.

Threshold and Kernel Settings

The *threshold* setting (value) determines the relative brightness change between neighboring pixels; thus, high threshold values require a large brightness change between pixels in order to detect an edge. Conversely, low threshold values enable edge detection with smaller brightness changes, and are used to detect edges when *low contrast* exists between the desired feature and the background.

The *kernel* setting (value) determines the number of consecutive pixels (the size of the neighborhood of pixels) that the gaging tool examines to determine whether an edge exists. Small kernel values require the brightness change specified by the threshold value to occur over a small distance (1–3 pixels) in order for the gaging tool to detect an edge. Conversely, larger kernel values require the brightness change to occur over a larger distance (8–10 pixels, or more), and are useful for reducing the number of superfluous edges that result from noise in the image.

NOTE: Increasing the kernel size will generally increase the analysis time slightly. In some applications, however, it may actually decrease the time by eliminating some edges. If analysis time is critical to your application, you should be careful to note any changes to the analysis time when the kernel size is changed.

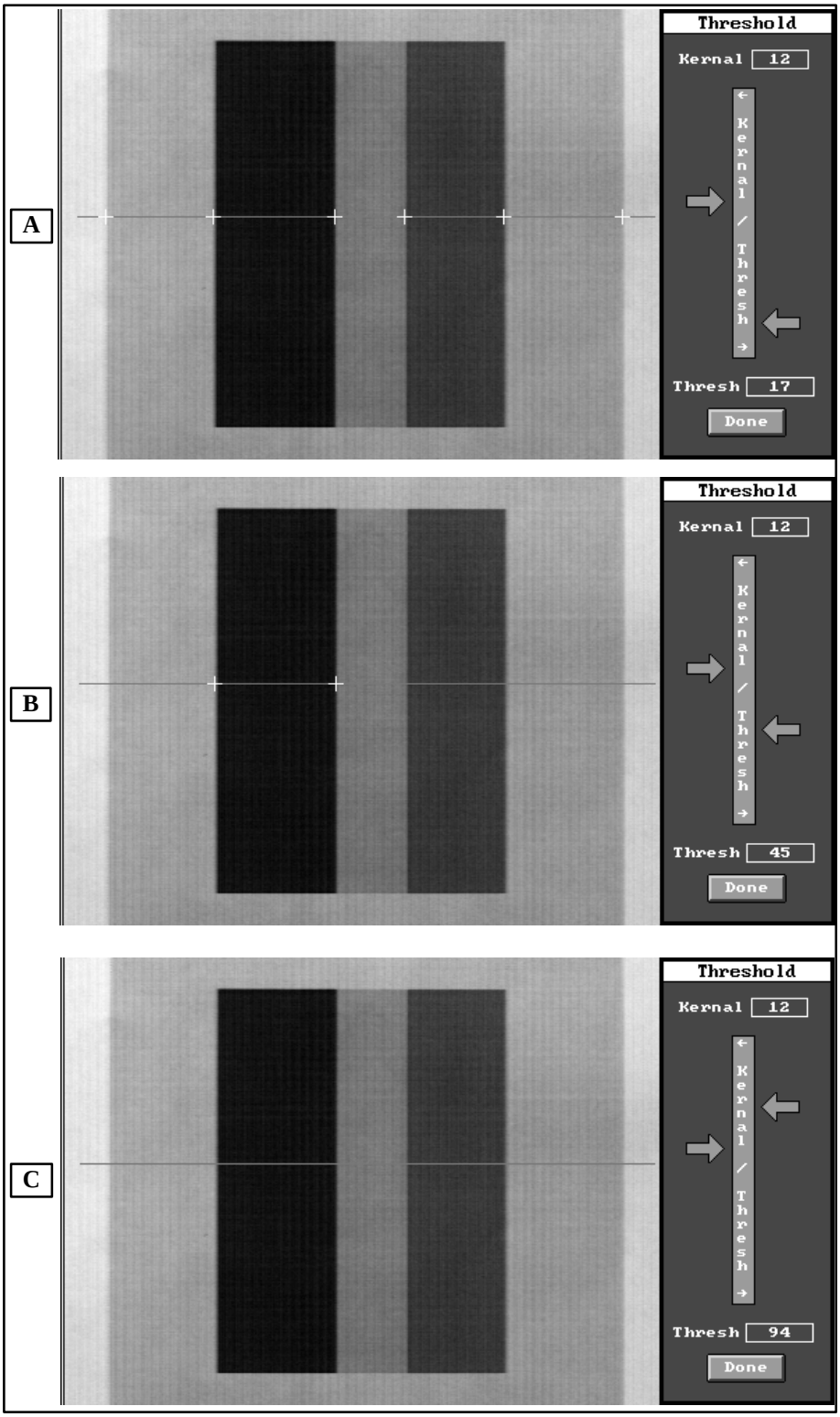
The *interactive result* of the two settings is to match the kernel and threshold characteristics of the proposed edges as closely as possible and, at the same time, *exclude* as many of the superfluous, unwanted “edges” as possible.

Figure 8.5 (page 8–7) illustrate(s) the effects of different threshold values when the kernel value is held constant. This example shows how increasing the threshold value *reduces* the number of detected edges by requiring greater and greater relative brightness changes (that is, contrast) between neighboring pixels to detect edges. Thus, (**A**) shows six edges, (**B**) shows two edges, and (**C**) shows *no* edges.

Figure 8.6 (page 8–8) illustrates the effects of different kernel values when the threshold value is held constant. Thus, (**A**) shows a small kernel value resulting in edges being detected at locations having a high contrast over a small distance; (**B**) shows a larger kernel value adding two edges to (**A**) by detecting edges over a larger distance; and, (**C**) shows a large kernel value *removing* two of the previous edges because the contrast *was not sustained* over a large enough distance (they are, in effect, filtered out).

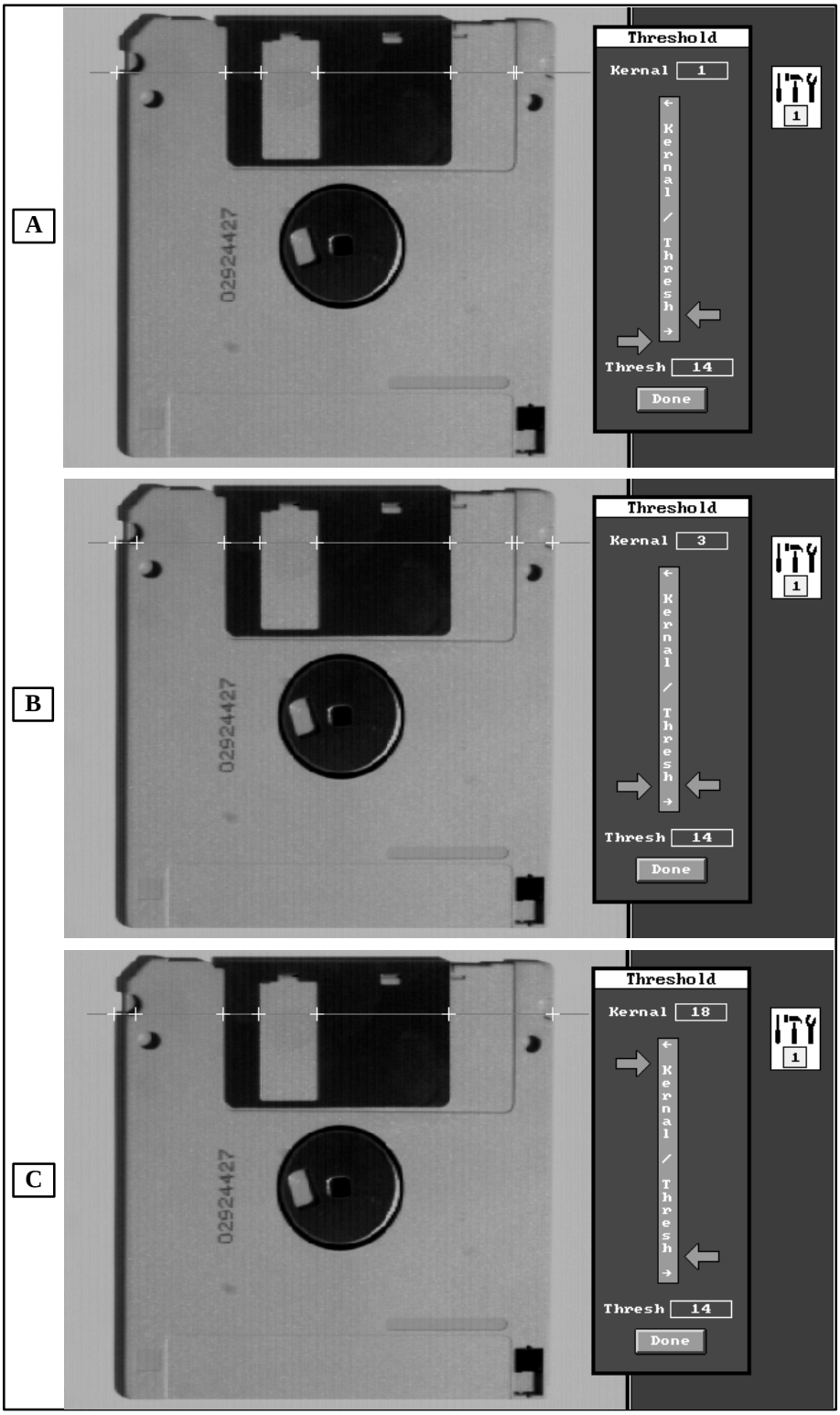
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Figure 8.5 Example: Effects of Changing Threshold Values (Constant Kernel)



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Figure 8.6 Example: Effects of Changing Kernel Values (Constant Threshold)



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Area Tools: Threshold and Morphology Functions

There are two methods by which you can alter the processed image within a window: setting binary thresholds, and setting morphology parameters.

Binary Threshold Function

Your main objective in setting the binary thresholds is to optimize the binarized workpiece image within the window in order to produce the most accurate and repeatable pixel count or object count. If optimizing these binary thresholds does *not* yield an acceptable workpiece image for your application, you can use the powerful morphology function to further "fine tune" the workpiece image.

NOTE: The binary thresholding function for the *black pixel–counting window operation* works in the *opposite sense* from the way it works for the other binary window operations. Its operation is described separately.

High threshold — Any part of that image whose gray–scale brightness value is *higher* than the high threshold value will appear *black* in the window. For example, if the high threshold is 190, any part of the image whose brightness value is *higher* than 190 will appear *black* in the window.

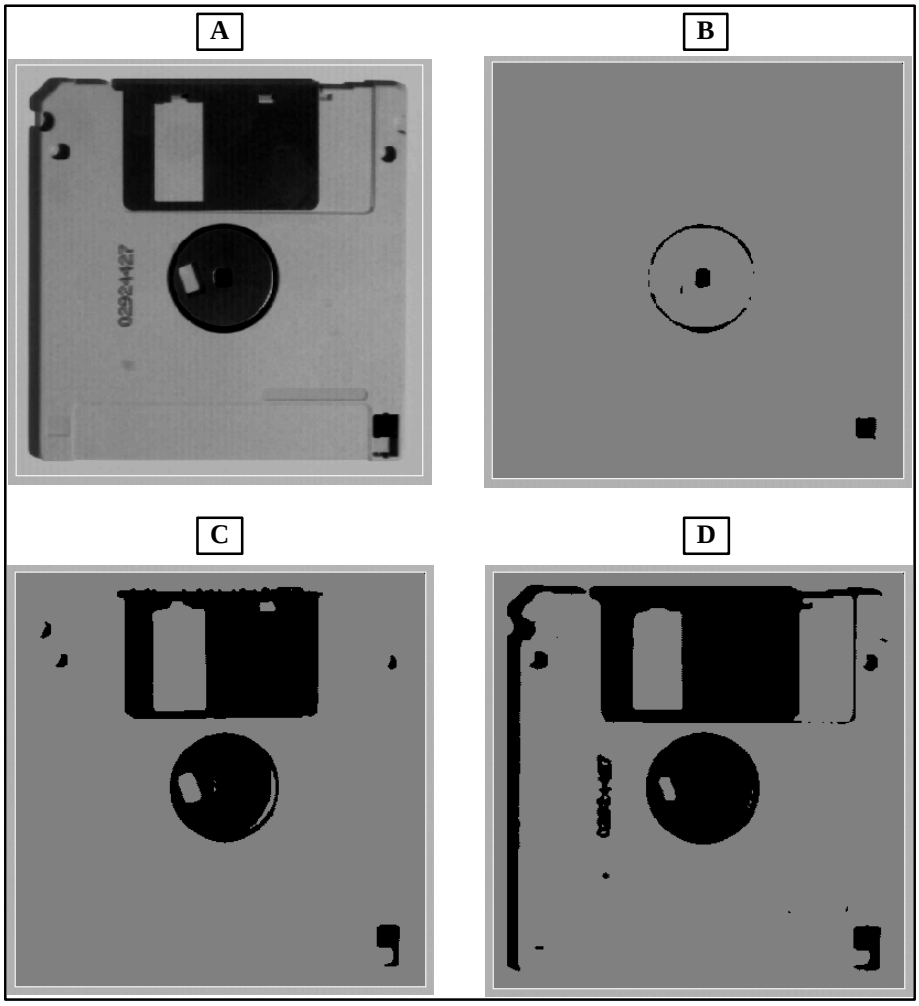
Low threshold — Any part of that image whose gray–scale brightness value is *lower* than the low threshold value will appear *black* in the window. For example, if the low threshold is 140, any part of the image whose brightness value is *lower* than 140 will appear *black* in the window.

The *interactive result* of the two threshold settings is this: Any part of the window image whose brightness value is *between* the high and low threshold values will appear *white* in the window. (In the examples above, this would apply to brightness values from 140 to 190.)

For most applications, set the high threshold at 255. Figure 8.7 (page 8–10) illustrates the effects of changing the low threshold. Thus, (**A**) shows the unprocessed gray scale image; (**B**) shows a low threshold value of 3; (**C**) shows a low threshold value of 30; and, (**D**) shows a low threshold value of 124.

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Figure 8.7 Example: Effects of Changing Low Threshold (Constant High Threshold)



Binary Threshold Function (Count Black Pixels Operation *Only*)

When you use the *black pixel–counting* window operation, the thresholds work in the *opposite sense* from that of the other binary window operations.

This means that workpiece features that are dark on a light background in the raw, gray–scale camera image are inverted so that they appear *white* on a *black background* in the window's binarized image. The pixels that appear white are the pixels that will be counted.

High threshold — Any part of that image whose gray–scale brightness value is *higher* than the high threshold value will appear *white* in the window. For example, if the high threshold is 190, any part of the image whose brightness value is *higher* than 190 will appear *white* in the window.

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Low threshold — Any part of that image whose gray–scale brightness value is *lower* than the low threshold value will appear *white* in the window. For example, if the low threshold is 140, any part of the image whose brightness value is *lower* than 140 will appear *white* in the window.

The *interactive result* of the two threshold settings is this: Any part of the window image whose brightness value is *between* the high and low threshold values will appear *black* in the window. (In the examples above, this would apply to brightness values from 140 to 190.)

Dynamic Threshold Function

The dynamic threshold function can provide real–time threshold adjustments to window tools and image tools that are configured for binary image processing operations. This function involves using the results from a math formula to adjust the high and/or low threshold values *dynamically*, during run operations.

Specifically, when the "High" (or "Low") box in the Thresh/Filter panel is picked, as shown in Figure 8.8, a formula–entry keyboard appears, and the appropriate formula can be entered at that point (by *default*, the *current* value in the box will appear initially in the formula–entry field).

Figure 8.8 Example: Formula Entry Keyboard For Dynamic Threshold Function

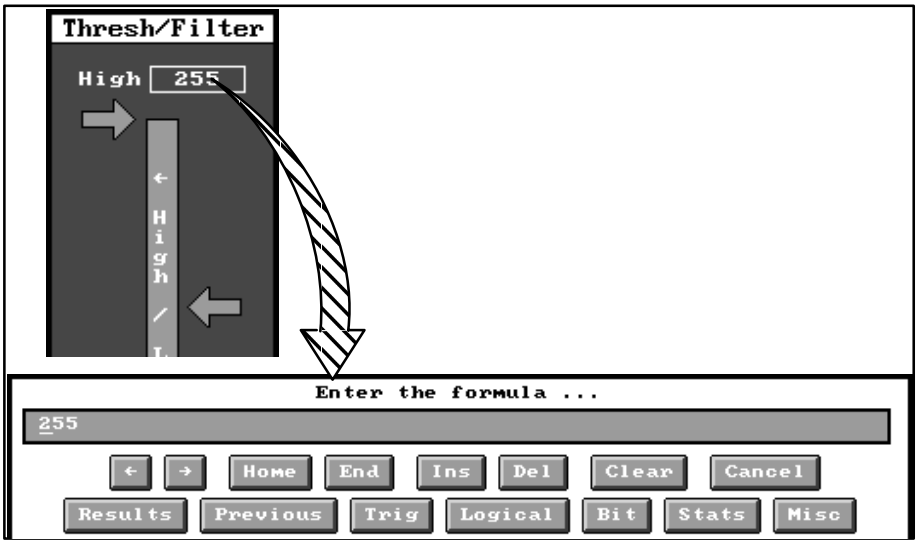
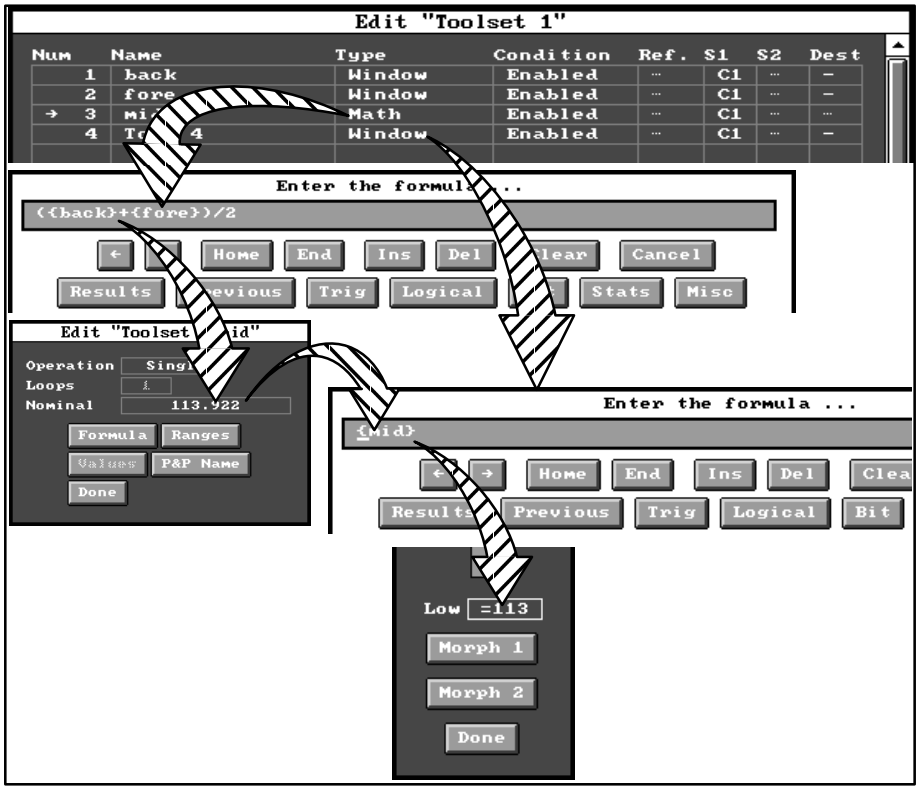


Figure 8.9 (page 8–12) illustrates using the dynamic threshold function to maintain the "Low" threshold setting, under varying light conditions, for a window tool that is configured to count pixels.

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Figure 8.9 Example: Using the Dynamic Threshold Function



In this example, the toolset contains, in order, the following tools: two window tools, a math tool, and another window tool. The first two windows are configured for luminance operations; one acquires the *background* luminance value of the image field, while the other acquires the *foreground* luminance value.

The math tool formula is configured to *average* the two luminance values, and the third window, configured to count pixels, uses the math tool result in its "Low" threshold setting to *dynamically* alter the low threshold value when the light level changes. The math tool formula uses the window tools' names to represent the luminance values from them, and, as shown in Figure 8.9, it takes the following form:

({back}+{fore})/2

Since the math tool's name is "mid," the math formula for the third window's "Low" threshold can use that name to acquire the results from the math tool. In the Figure 8.9 example, the current average value from the math tool's calculation is "113.922" (see the "Nominal" field in the math tool's edit panel). The third window, using "{mid}" in the "Low" threshold's math formula, acquires the math tool result, and that value (rounded off) appears as "=113" in the "Low" threshold box. During run operations, this value will vary according to changes in the external light levels, and it will thereby maintain the correct "Low" threshold setting for the window.

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NOTE 1: In this example, the formula, ({back}+{fore})/2, could have been entered *directly* as the third window's "Low" dynamic threshold math formula, in order to save space. If, however, the formula will be used by other windows, placing the formula in an intermediate math tool, as shown by the example, is useful.

NOTE 2: Maximum size of a dynamic threshold formula is 32 characters. If more characters are needed, use an intermediate math tool, which can hold up to 128 characters.

NOTE 3: If the formula used to compute the dynamic threshold *fails* (for example, it cannot access the specified inspection result), then the tool using the dynamic thresholding will fail. The tool will also fail if the dynamic thresholding formula produces an *invalid* threshold setting (for example, a *negative* value, or a value above 255).

Morphology Function

Morphology is a technique for performing image enhancements such as edge detection, noise removal, and smoothing.

The CVIM2 system has two morphology processors, each of which can operate in either gray scale or binary mode, as follows:

- In gray scale mode, the morphology processor receives gray scale image data as input. It processes this data and produces a *new* gray scale image as its output.
- In binary mode, the morphology processor receives binary image data as input. It processes this data, using up to six operation, and produces a *new* binary image as its output.

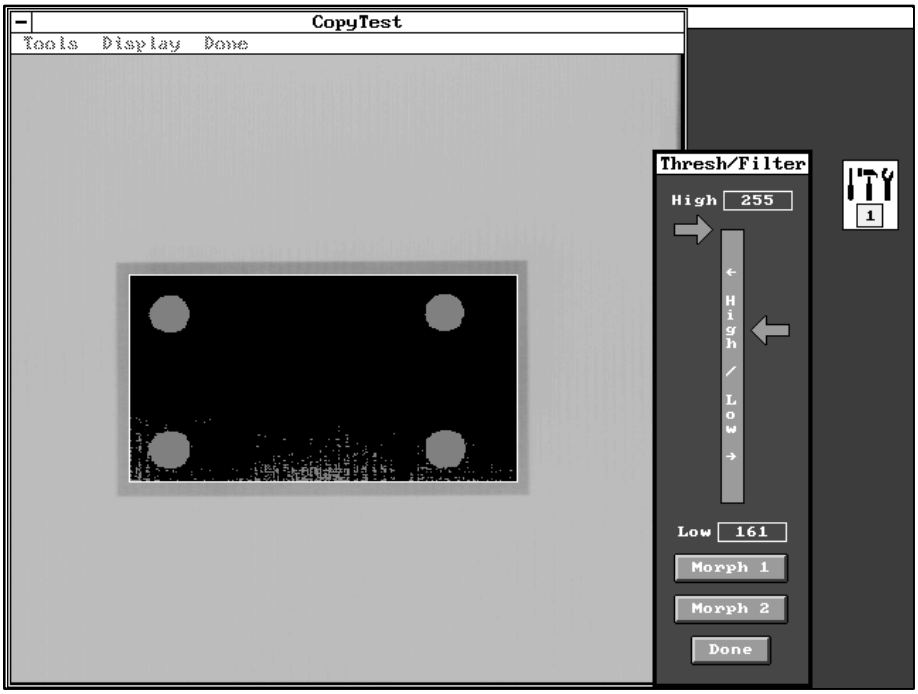
One example of the utility of morphology is where low contrast exists between the workpiece features and the thresholded image contains white or black "noise."

When you optimize the threshold settings for solid white features, for example, the black background may show white "noise," which would interfere with the counting of the white pixels in the features. In such a case, you may be able to eliminate the white noise from the black background by using morphology.

Figure 8.10 (page 8–14) shows a window placed over a workpiece. In this example, white noise appears in the black background.

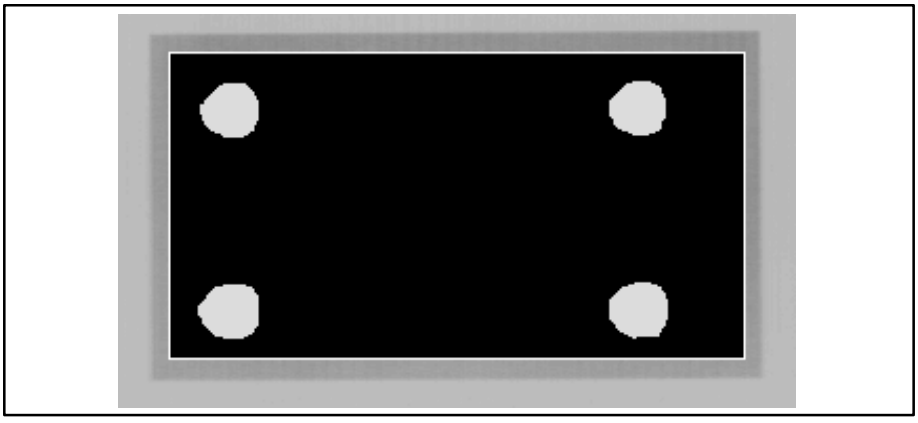
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Figure 8.10 Example: Workpiece Image With White Noise in Background



If left in the window, the unwanted white noise pixels would increase the total pixel count, and would thus interfere with the accuracy of the inspection result. By using morphology, however, you can remove or "filter" this noise from the window, as shown in Figure 8.11.

Figure 8.11 Example: Workpiece Image With White Noise Filtered



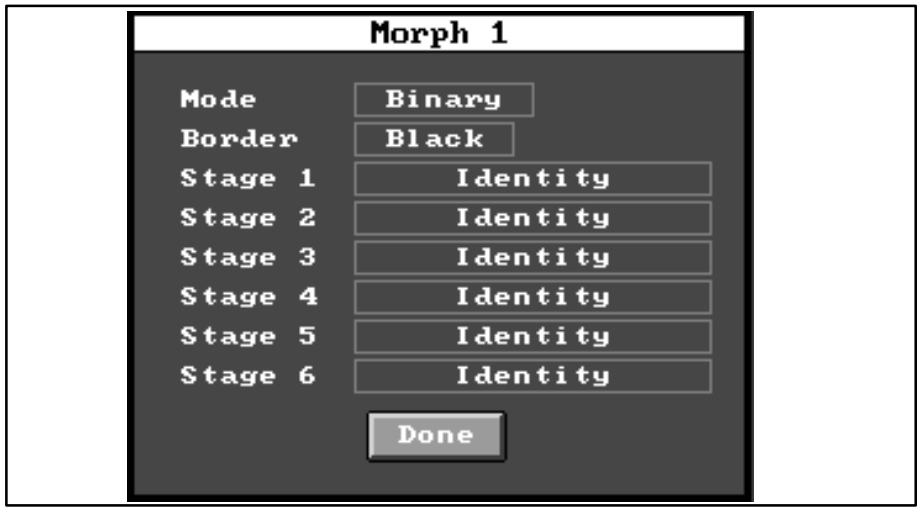
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Morphology Selection Panels

Note the Morph 1 and Morph 2 buttons under the cursors and slide bar in Figure 8.10 (page 8–14). Each button selects a morphology selection panel from which you can select the various types of morphology filtering operations, binary or gray scale.

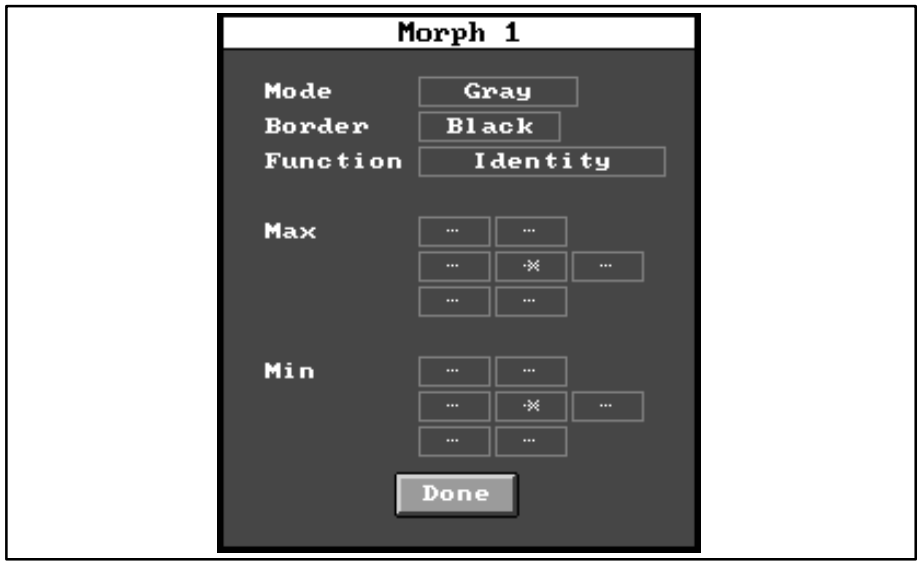
When you pick the Morph 1 button, the Morph 1 selection panel may appear initially as shown in Figure 8.12.

Figure 8.12 Example: Morph 1 Binary Selection Panel



When you pick the Mode box (which currently displays "Binary") the *gray scale* Morph 1 selection panel appears, as shown in Figure 8.13.

Figure 8.13 Example: Morph 1 Gray Scale Selection Panel



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When you pick the Morph 2 button (see Figure 8.10, page 8–14), the Morph 2 selection panel appears.

In general, the Morph 1 and Morph 2 filters can each be used in either binary or gray scale mode; however, specific inspection tools may restrict either or both filters to a particular mode.

The remainder of this section discusses the details of the binary and gray scale morphology functions.

Binary Morphology

As shown in Figure 8.12 (page 8–15), the binary selection panel contains several boxes and a Done button.

The boxes in the binary panel, and the method of selecting the parameters that they represent, are described briefly as follows:

- **Mode** — This box indicates whether the binary or the gray scale morphology function is selected.

  When you pick this box, Binary toggles to Gray, or vice versa.
- **Border** — This box indicates whether pixels outside the processing area are considered white or black. Black is the *default* border selection.

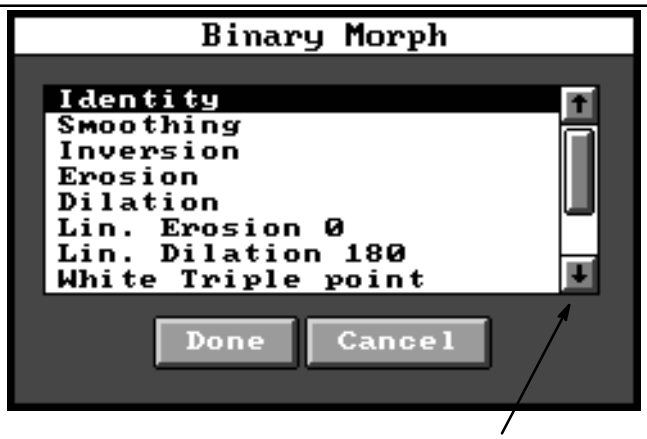
  When you pick this box, Black toggles to White, or vice versa.
- **Stage 1** through **Stage 6** — Each of these boxes enables you to select one of the binary morphology operations for each stage of the morphology processor. "Identity" is the *default* selection for each stage.
- **Done** — Use the Done button to save the entries in the binary Morph 1 selection panel entries and exit to the Thresh/Filter panel.

Note the six stages of binary morphology filtering shown in Figure 8.12. These stages operate sequentially; that is, stage 1 performs the first operation, then stage 2, and so on. In general, you should set the binary threshold to achieve the best possible image *first*, then, if necessary, set up the morphology functions.

When you pick any of the six "stage" boxes, the Binary Morph function selection panel appears, as shown in Figure 8.14 (page 8–17).

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Figure 8.14 Binary Morph Function Selection Panel



Here are the binary morphology filter functions available in the Binary Morph selection menu, along with a brief description of each:

- **Identity** — This function performs *no* filtering effect on the binary image. It is equivalent to making the stage inactive. Thus, when all six menu boxes are set to Identity, the binary image is unaffected by the morphology processor.
- **Smoothing** — This function performs a filtering operation that removes ”noise” pixels from the image. Noise pixels are isolated single or double black pixels on a white background or white pixels on a black background. “Smoothing” also smoothes edges on an object, rounds sharp corners, and removes small features from the object and image field. It does this without affecting the area of large objects.
- **Inversion** — This function changes all white pixels to black pixels, and vice versa; thus, it inverts the image.
- **Erosion** — This function erodes the edges of white objects (and, conversely, dilates the edges of black objects). Thus, white objects in the image field get smaller, while black objects get larger. Successive stages of erosion can be used to achieve the desired effect. If it is necessary to remove white noise from within a black object without changing the size of the black object, the stages of erosion must be followed by an equal number of stages of dilation.

  Another effect of erosion is to ”weld” together small black objects that are otherwise separated in the original image.

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- **Dilation** — This function dilates the edges of white objects (and, conversely, erodes the edges of black objects). Thus, white objects in the image field get larger, while black objects get smaller. Successive stages of dilation can be used to achieve the desired effect. If it is necessary to remove black noise from within a white object without changing the size of the white object, the stages of dilation must be followed by an equal number of stages of erosion.

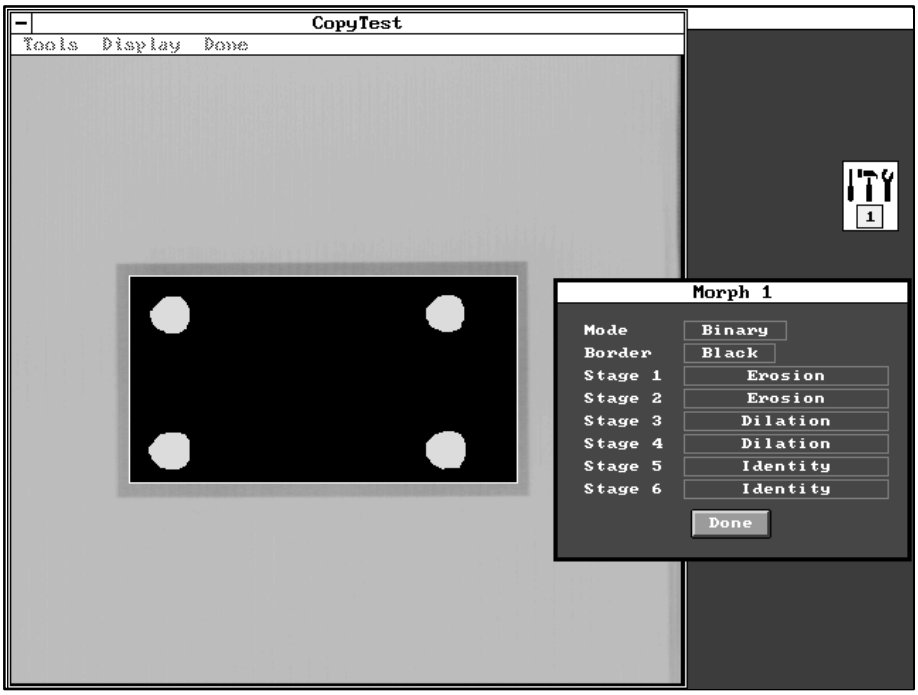
  Another effect of dilation is to ”weld” together small white objects that are otherwise separated in the original image.
- **Lin. Erosion 0** — This function erodes white objects horizontally from left to right. It erodes only on the left side of an object, and its effect, in successive stages, is to *eliminate* thin white vertical objects (such as lines), or, conversely, *thicken* thin black vertical objects, without affecting thin horizontal objects.
- **Lin. Dilation 180** — This function dilates white objects horizontally from right to left. It dilates only on the right side of an object, and its effect, in successive stages, is to *thicken* thin white vertical objects (such as lines), or, conversely, *eliminate* thin black vertical objects, without affecting thin horizontal objects.
- **White Triple Point** — This function can eliminate small white objects from within black objects without affecting the size of the black objects.
- **Black Triple Point** — This function can eliminate small black objects from the image without affecting the size of the white objects.
- **Erosion Top Triangle** — This function has an effect that is similar to the effect of the erosion function, but not as pronounced. Thus, erosion top triangle could be used where a smaller erosion effect is desired in one stage. It can be used with the dilation bottom triangle function in balanced numbers of stages, such as is described above for the erosion and dilation functions.
- **Dilation Bottom Triangle** — This function has an effect that is similar to the effect of the dilation function, but not as pronounced. Thus, dilation top triangle could be used where a smaller dilation effect is desired in one stage. It can be used with the erosion top triangle function in balanced numbers of stages, such as is described above for the erosion and dilation functions.

Look at the white features and black background in Figure 8.10 (page 8–14). Notice that the black background contains white noise. The morphology filtering function can be used, in this case, to remove the noise from the background.

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Figure 8.15 shows how the workpiece image in Figure 8.10 would appear after being filtered by an appropriate choice of morphology operations.

Figure 8.15 Example: Workpiece Image With White Noise Filtered



Note that the Binary Morph panel selections shown in the example include, from the top down, these filtering functions:

The first and second operations (Erosion) each remove some white noise from the black background, but at the same time, decrease the white features' size. The second and third operations (Dilation) each restore the white features' size *without* restoring the white noise in the black background.

Thus, the net *cumulative* effect of the four morphology filtering operations is to remove the noise from the black background without affecting the size of the white features.

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Gray Scale Morphology

As shown in Figure 8.13 (page 8–15), the gray scale selection panel contains several boxes and a Done button.

The boxes in the gray scale selection panel, and the method of selecting the parameters that they represent, are described briefly as follows:

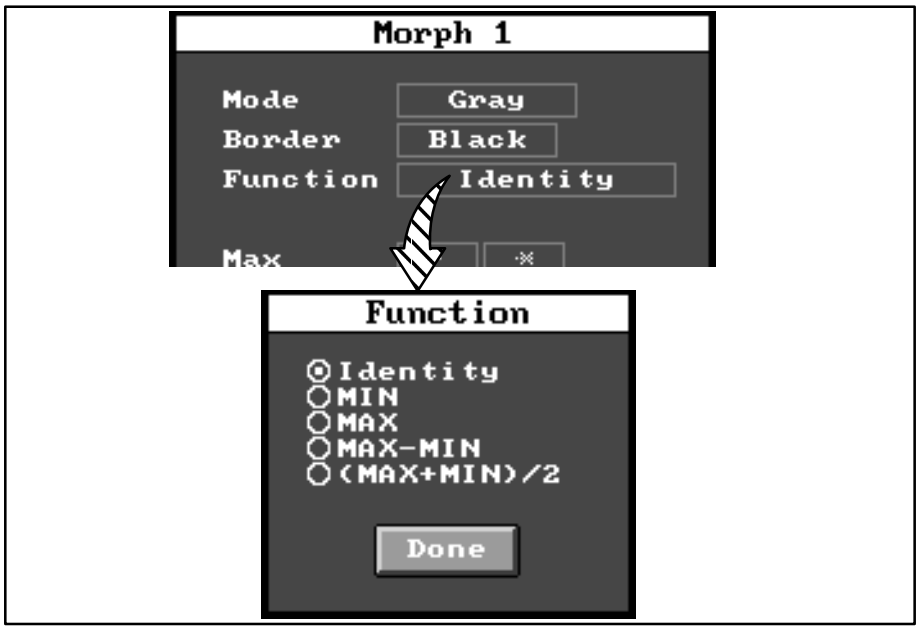
- **Mode** — Use this box to select either the binary or the gray scale morphology function for Morph 1. Binary is the *default* mode selection.

  When you pick this box, Binary toggles to Gray, or vice versa.
- **Border** — Use this box to select either a black or white inside border for the window. Black is the *default* border selection.

  When you pick this box, Black toggles to White, or vice versa.
- **Function** — Use this to select a gray scale function.
- **Max, Min** — Use either or both of these two groups of seven boxes to configure the gray scale "kernel" structure, which determines, along with the selected function, the effect of the gray scale morphology processing.
- **Done** — Use the Done button to save the entries in the gray scale Morph 1 selection panel entries and exit to the Thresh/Filter panel.

When you pick the Function box, the gray scale Function selection panel appears, as shown in Figure 8.16.

Figure 8.16 Example: Selecting Gray Scale Function Panel



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Here are the gray scale morphology functions shown in the Function selection panel, along with a brief description of each:

- **Identity** — This operation performs *no* filtering effect on the image. It is equivalent to making the gray scale morphology inactive.
- **MIN** — This function uses only the selections in the Min boxes. The result is the minimum of the neighbors enabled in the MIN kernel.

  When the Min kernel is fully configured with asterisks, the Min function is analogous to the binary *erosion* function, in the sense that it makes bright objects smaller (and dark objects larger).
- **MAX** — This function uses only the selections in the Max boxes. The result is the *maximum* of the neighbors enabled in the MAX kernel.

  When the Max kernel is fully configured with asterisks, the Max function is analogous to the binary *dilation* function, in the sense that it makes bright objects larger (and dark objects smaller).
- **MAX – MIN** — This function uses the selections in both the Min and the Max boxes. It is used to detect edges, and it smoothes the image slightly.
- **(MAX + MIN) / 2** — This function uses the selections in both the Min and the Max boxes. The result value is the average of the Max and Min selections.

Gray scale morphology processing uses a “kernel” structure to examine each pixel in the image. The “kernel” structure is represented by a group of seven boxes, as shown in the gray scale selection panel in Figure 8.13 (page 8–15). This structure comprises a “neighborhood” of seven pixels.

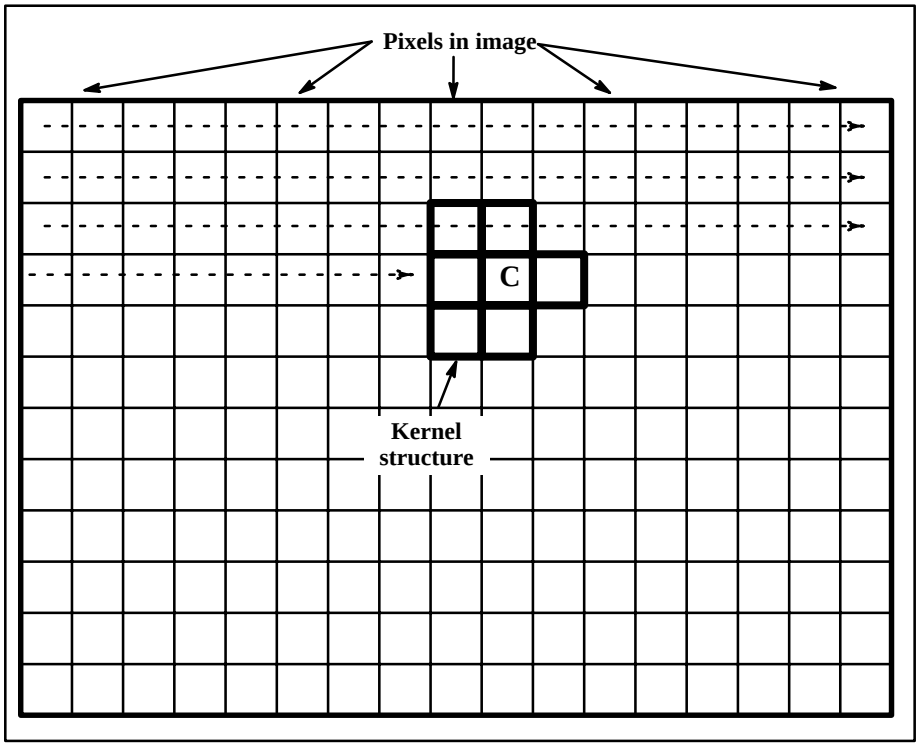
Each box can contain either an asterisk (*) or a minus sign (–). An asterisk designates the neighborhood pixels that the morphology processor will evaluate; a minus sign designates the neighborhood pixels that the processor will *not* evaluate.

Figure 8.17 (page 8–22) illustrates the relation of the kernel structure to the matrix of pixels in the image. The pixel being examined currently is the one under the “**C**” (center) box in the kernel structure. (The arrows indicate the path of the kernel through the image matrix.)

As noted above, the morphology processor evaluates only the neighborhood pixels under the boxes containing asterisks. It determines (and replaces the *center* pixel with) the *largest* gray scale value of these pixels in the MAX kernel. Similarly, it determines (and replaces the *center* pixel with) the *smallest* gray scale value of these neighborhood pixels in the MIN kernel.

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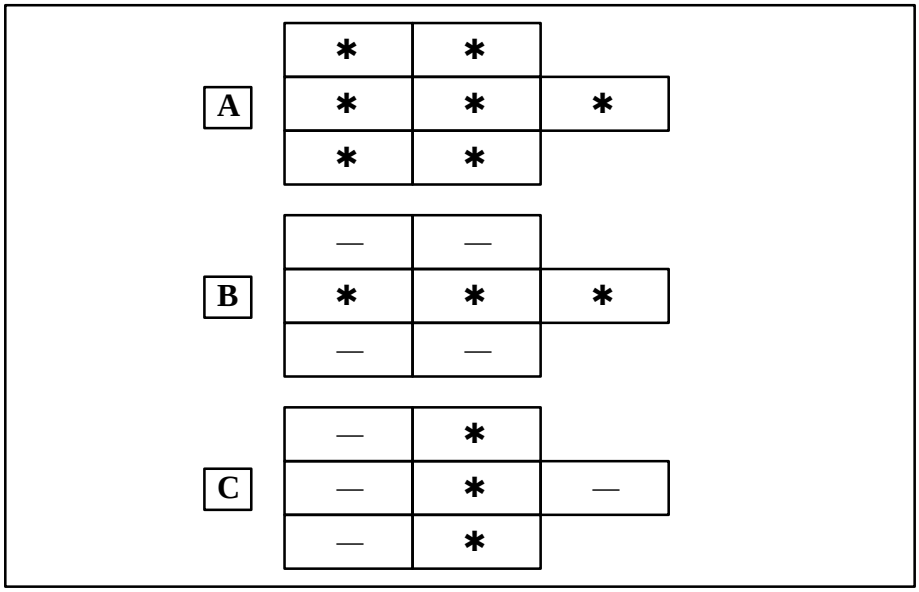
Figure 8.17 Example: Kernel Structure and Neighborhood of Image Pixels



The resulting output pixel value depends on the selected function.

NOTE: Of special significance is the Max – Min function when *both* kernels are configured in one of the following three forms as shown in Figure 8.18.

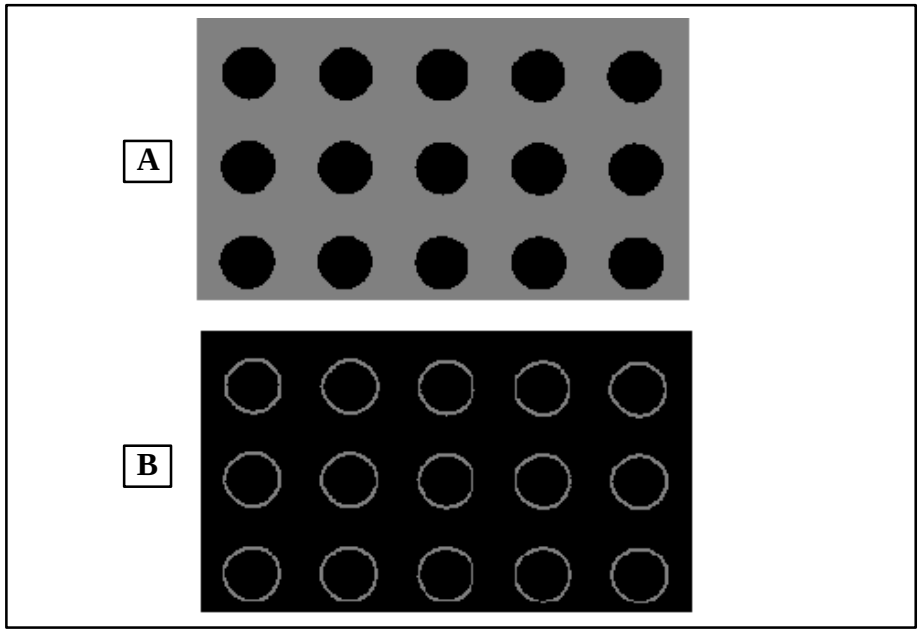
Figure 8.18 Examples of Three Kernel Configurations for Max – Min Function



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When configured as shown in (**A**) of Figure 8.18, where *all* of the kernel's seven boxes have asterisks (for both Max and Min), the effect of the Max – Min function is to detect *all* edges around objects within the inspection window. Thus, the circular black objects shown in (**A**) of Figure 8.19 are shown with their edges "detected" (highlighted) all around in (**B**) of Figure 8.19.

Figure 8.19 Example: Filtering Effect of Max – Min Function With All Asterisks Set



When configured as shown in (**B**) of Figure 8.18, where just the three adjacent horizontal boxes have asterisks (they must be the *same* three horizontal boxes for both Max and Min), the effect of the Max – Min function is to "detect" only the *vertical* edges on objects within the inspection window. Thus, the rectangular black objects shown in (**A**) of Figure 8.20 (page 8–24) are shown with their vertical edges "detected" (highlighted) in (**B**) of Figure 8.20.

When configured as shown in (**C**) of Figure 8.18, where just three adjacent vertical boxes have asterisks (they must be the *same* three vertical boxes for both Max and Min), the effect of the Max – Min function is to "detect" only the *horizontal* edges on objects within the inspection window. Thus, the rectangular black objects shown in (**A**) of Figure 8.21 (page 8–24) are shown with their horizontal edges "detected" (highlighted) in (**B**) of Figure 8.21.

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Figure 8.20 Example: Filtering Effect of Max – Min Function With Three Horizontal Asterisks Set

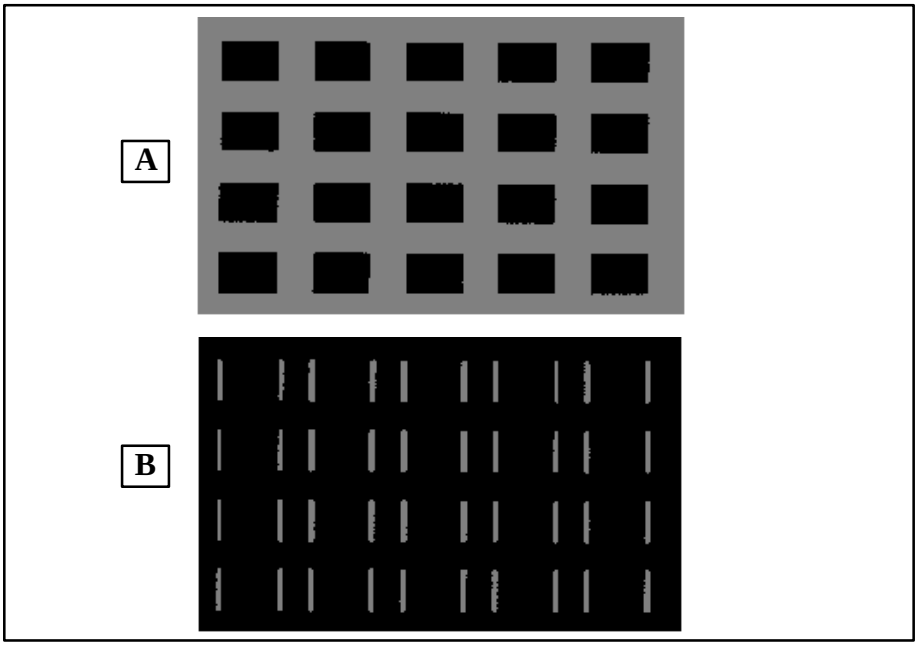
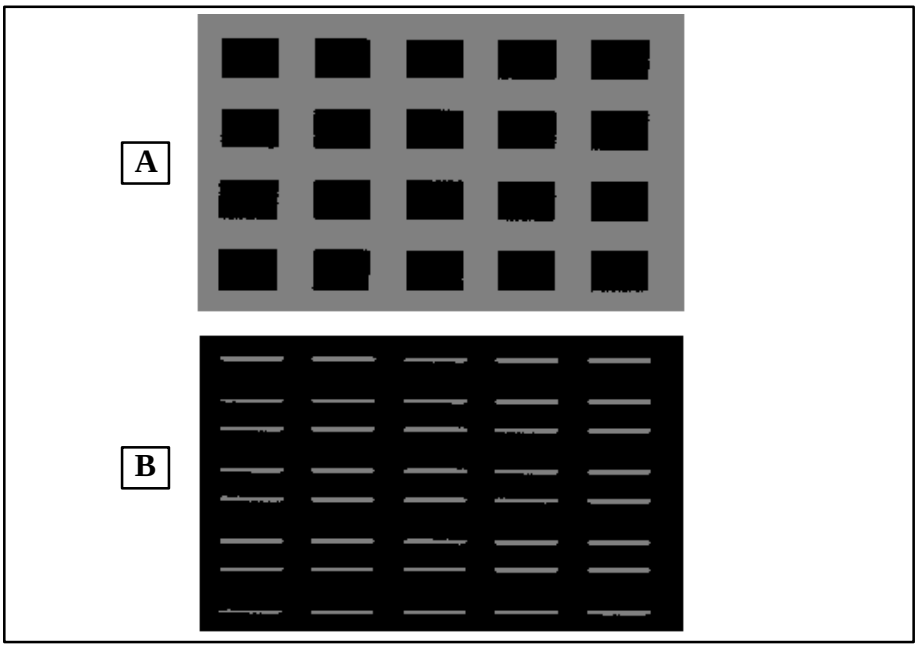


Figure 8.21 Example: Filtering Effect of Max – Min Function With Three Vertical Asterisks Set



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Chapter 9

Discrete I/O Assignments

This chapter provides detailed information about the discrete inputs and outputs that connect the CVIM2 system to the user's process control equipment through the Module I/O, System I/O, and Remote I/O ports on the CVIM2 module front panel. This chapter also includes the procedures for assigning signals to the discrete inputs and outputs, the front panel LEDs and the remote I/O inputs and outputs.

The Module I/O port contains two input and 14 output lines, while the System I/O port contains 16 discrete lines that the user can select as inputs *or* outputs. The front panel contains two user–assignable status LEDs. The Remote I/O port provides 120 inputs to the CVIM2 from a PLC™, and 128 outputs to a PLC (the CVIM2 appears to a PLC as a full 8–slot rack on the remote I/O line).

Discrete I/O Editor Panel: General Information

The discrete I/O assignments are performed in the Discrete I/O Editor panel. When you pick Discrete I/O in the Editors menu of the main menu bar, the Discrete I/O Editor panel appears, as shown in Figure 9.1.

Figure 9.1 Selecting the Discrete I/O Editor Panel (VGA Monitor)



NOTE: You can access this panel from various places within the Configuration and Acquisition editors, and there are differences in the types of signal functions that you can assign, accordingly. These differences are pointed out later in this chapter.

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Panel Layout and Functions

The Discrete I/O Editor panel shown in Figure 9.1 (page 9–1) is arranged as a table containing 16 rows and five columns. Each row designates one of the 16 input or output locations, such as "In 1" and "Out 6." (When an RS–170 monitor is used, the Discrete I/O Editor panel appears in two "pages," each with eight rows.

Just above the top row are the column headings, which are described briefly as follows:

- **In/Out** — This column indicates whether a row pertains to a discrete *input* or a discrete *output*.
- **Signal Name** — This column identifies the names of the signals assigned to each input and output.
- **Time** — Time applies to input and output signals. Use this field to change parameters for the corresponding input *or* output signal.

  For input signals, the *default* time is "5." This means that a trigger input signal must occur *at least* 5 milliseconds after the previous trigger signal in order to be recognized.

  For output signals, the *default* time is "25." This means that an output signal will be *active* for 25 milliseconds, after which it will return to its *inactive* state.
- +/– — This field applies to the polarity of input and output signals. Use this field to change parameters for the corresponding input *or* output signal. Picking this field toggles it from "Pos" to "Neg," or vice versa.

  For inputs, the *default* edge polarity is "Pos" (positive). This means that the CVIM2 system will respond to the positive–going edge of a trigger signal.

  For outputs, the *default* output signal state is "Pos" (non–inverted). This means that the signal will be active *high* and inactive *low.*
- **Force** — Use this field to alter the state of the outputs. The *default* state is "No." In this state, the outputs follow the signals that are assigned to them (such as "fail," "warn," "ACK," and so on).

  However, you can *force* an output to a continuously *active* state, or to a continuously *inactive* state. Thus, "On" causes the output to be continuously *active*, while "Off" causes the output to be continuously *inactive*.
- **Delay** — Use this field (in conjunction with the pulse *input* signal and an inspection results *output* signal) to select the number of input pulses that the CVIM2 system must count before making the inspection results available to the user's process equipment for "parts tracking" purposes.

At the bottom of the panel in Figure 9.1 are four buttons, whose functions are described briefly as follows:

- **Done** — The Done button saves the currently selected discrete I/O selections for this panel, then exits the I/O panel and returns to the main menu bar or other origin.

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- **Cancel** — Use the Cancel button to exit to the main menu bar without saving any of the additions or changes in the I/O panel.
- **Module I/O** — Use the Module I/O button to select the I/O Device panel, from which you can select the *other* I/O panels: the System I/O panel, the LED Outputs panel, and the Remote I/O panel. The current selection appears in this button.
- **Goto** — Use the Goto button to access the second half (rows 8 through 15) of the Module I/O or System I/O panels when you are using an Allen–Bradley Catalog No. 2801–N8 color monitor, or equivalent RS–170 monitor in the panel.

  When you are using a VGA monitor, the button is active *only* when the Remote I/O panel is selected. In this case, the Goto button selects the keyboard, which you can use to access a specific remote I/O address.

Note that the Discrete I/O Editor panel appears in four formats, according to the selection that you make in the I/O Device panel: Module I/O, System I/O, LED Outputs and Remote I/O. The differences between these four panels are described in the remaining sections of this chapter.

Relation of Discrete I/O Assignments to Configuration File

Discrete I/O assignments are described in files whose *file type* name is "Discrete I/O" in the EE or other filer. The Discrete I/O files are created (named) in the Config Files panel, using the same methods that are used to create the configuration, message, and acquisition configuration files, and described in Chapter 4, *Inspection Configuration* under the *Configuration Process* heading on page 4–2.

Multiple files can be named under the "Discrete I/O" file type name; however, only *one* can be selected for a particular configuration file and "saved" as part of that file. The effect is that when an existing configuration file name is selected, the associated discrete I/O file is automatically accessed.

Discrete Inputs: Interrupt Processing vs Poll Processing

The CVIM2 system uses two methods to process input signals: interrupt, and polling. The main difference is that the *interrupt* method is faster than the polling method; thus, this method is preferable for inputs that generally require immediate response, such as triggers. The *polling* method is adequate for inputs that are less time–critical, such as bank switching.

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Hardware Interrupt

When a trigger is assigned to either input line on the Module I/O panel, or to any of lines 0 through 3 on the System I/O panel, the CVIM2 system will automatically process triggers using hardware interrupts. When a trigger occurs, the CVIM2 system *hardware* responds immediately and diverts the *software* operation to starting an inspection cycle. The system response time to a hardware interrupt is in the microsecond range.

Note that triggers *can* be assigned to lines 4 through 15 on the System I/O panel; however, the system will use the *polling* method to process triggers on those lines. Since polling has a resolution in the *millisecond* range, it may be too slow to process triggers; and, when trigger pulses are of short duration, the system may miss some of those triggers.

Polling

When an input *other than* a trigger is assigned to *any* of the input lines, the CVIM2 system will use polling to process the input, *regardless* of whether the line is capable of performing hardware interrupt processing. When using polling, the system *software* checks the state of the input line periodically (at approximately 25ms intervals), and performs the appropriate operations when is detects a change of state on the input line.

Module I/O Functions

When the Module I/O format is on the monitor screen (see Figure 9.1, page 9–1), the top two rows of the table are dedicated to discrete input signal assignments, while the 14 remaining rows are dedicated to discrete output signal assignments. The inputs and outputs assigned in this panel are routed to the Module I/O connector on the CVIM2 front panel.

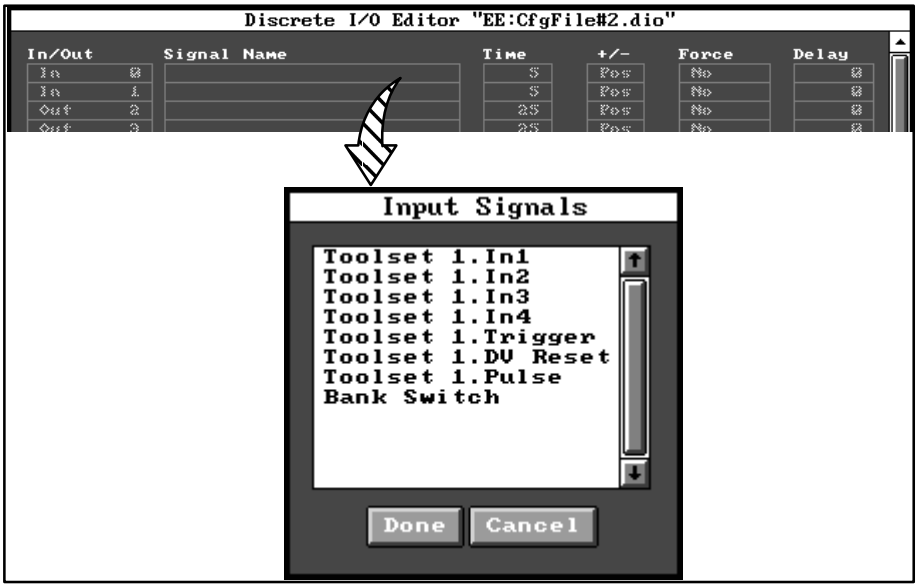
Trigger Input Selections

As noted above, the first two discrete I/O locations are reserved for inputs *only.* To assign a trigger source to *either* input, pick the corresponding box under the Signal Name heading. When you do, the Input Signals menu appears, as shown in the example in Figure 9.2 (page 9–5).

Note that *only* the trigger names that are defined in the *currently selected configuration file* will appear in the Input Signals menu at this time. Since most inspection applications must be synchronized with *external* events, such as a sensor activated by parts or assemblies moving down a conveyor belt, a trigger signal will normally be routed from such an external source.

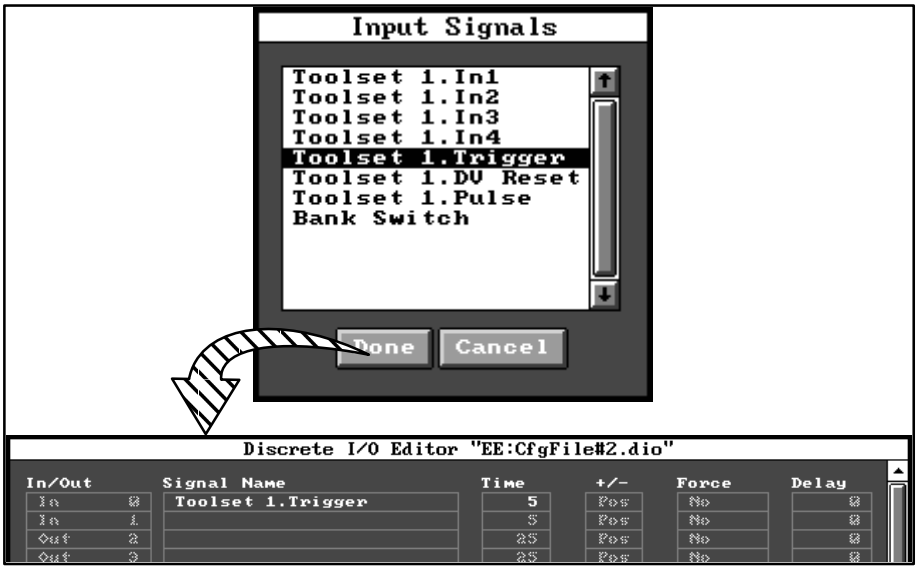
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Figure 9.2 Example: Selecting the Input Signals Menu



To select a trigger input signal from the Input Signals list, highlight the signal name, then pick the Done button. When you do, that name will appear in the Discrete I/O Editor panel, as shown in Figure 9.3.

Figure 9.3 Example: Selecting a Trigger Input Signal (Module I/O Layout)



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You can assign more than one input signal from the Input Signals list to a single discrete I/O input. For example, you could assign *both* Toolset 1.Trigger and Toolset 2.Trigger in Figure 9.3 (page Figure 9.3) to discrete input "In 0" in the Module I/O editor.

You can assign a trigger input signal to only *one* discrete I/O input. For example, if you assign Toolset 1.Trigger to discrete input "In 0," as shown in Figure 9.3, and then assign that same input signal to *another* discrete I/O input, it will be *removed* from "In0."

To *remove* a trigger input signal from the discrete I/O editor, pick its name in the Inputs Signals list, then pick the Done button.

Bank Switch Input Selection

The Bank Switch input function is used to activate either cameras 1, 2, and 3 or cameras 4, 5, and 6. (Normally, this function should be assigned *only* to the System I/O panel, as an *input*, on one of lines 4 through 15. Lines 0 through 3 on the System I/O panel, and lines 0 and 1 on the Module I/O panel should be reserved for trigger inputs. See *Discrete Inputs: Interrupt Processing vs Poll Processing* on page 9–3 for details.)

DV Reset Input Selection

The DV Reset (data valid reset) input function is intended for operations in which the CVIM2 system is connected to an Allen–Bradley PLC™ through the Remote I/O front panel connection.

The DV Reset function is assigned as an *output* from the PLC in the Remote I/O panel (an *input* to the CVIM2 system). It is one of the "handshaking" signals used between the two systems. For details about its use, refer to the *CVIM2 Communications Reference Manual*.

In1 – In8 Input Selections

Input selections In1 through In4 (or In1 through In8 if the "tsin" environment variable is set to 08) can be configured as general purpose input signals that can be used in math tool formulas and "Condition" selections in the toolset edit panel. In a math tool formula, these inputs return a logic "1" when active, and a logic "0" when inactive. In a Condition selection, these inputs, when active, enable the corresponding tool to execute, and when inactive, prevent a tool from executing.

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Pulse Input Selection: Parts Tracking Function

The pulse input signal enables the CVIM2 system to be synchronized with the user's process equipment in order to track parts *beyond* the physical point at which the inspections take place — that is, beyond the camera station.

The pulse input is selected by highlighting "Toolset n.Pulse" for the appropriate toolset (n) in the Input Signals panel (refer to Figure 9.3 on page 9–5). As is the case with trigger signals, you can assign a pulse input signal to only *one* discrete I/O input. For example, if you assign Toolset 1.Pulse to discrete input "In 0," and then assign that same input signal to *another* discrete I/O input, it will be *removed* from "In0."

In effect, this is a "parts tracking" function that *delays* the CVIM2 system's delivery of "pass/fail" (or other) inspection results to the user's process equipment, thereby allowing that equipment to take the appropriate "accept/reject" action on the inspected parts at a *user specified distance* downstream from the camera station.

Since each pulse represents a known *distance* along a conveyor system, or a known number of cycles of an indexed machine, the user can specify the number of pulses that most accurately places the inspected parts within the accept/reject station. When the CVIM2 system has received the user–designated number of pulses, it issues the pass/fail results from the corresponding inspection, and the process equipment can then respond accordingly at the accept/reject station.

The pulses *may originate* from a separate encoder device mounted on a conveyor system. On an indexed machine, the pulse signal may come from the same trigger signal source that initiated the inspection cycle. The pulse count parameter (that is, the number of pulses to be counted) can be selected in the Delay column of the Discrete I/O Editor panel, after selecting an appropriate *output* signal, as illustrated by the examples in Figure 9.6 (**A**) and (**B**) on page 9–11.

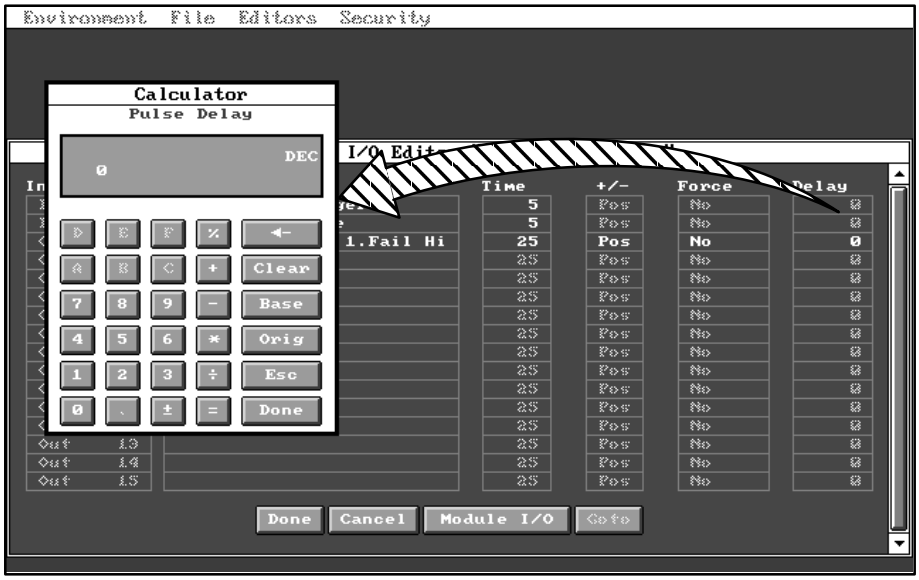
To select the pulse count parameter, pick the appropriate box in the Delay column. When you do, the "calculator pad" appears, as indicated in Figure 9.4 on page 9–8.

Using the known distance between the camera station and the accept/reject station, and also the distance that a part travels between successive pulses, select a pulse count that will ensure the CVIM2 system issues the inspection results when the inspected parts reach the accept/reject station. For example, if the distance from the camera station to the accept/reject station were 12 feet (144 inches), and each pulse represented 3 inches, you would need to select 144 ÷ 3 = 48 pulses.

NOTE: If the trigger signal source is to be used also as the *pulse* source, the trigger signal will count as the first pulse count. Thus, if an output is to be set on the *second* pulse after the one that initiated the inspection, the pulse delay count must be set to 3, not 2.

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Figure 9.4 Example: Using the Calculator Pad to Select Delay Parameter

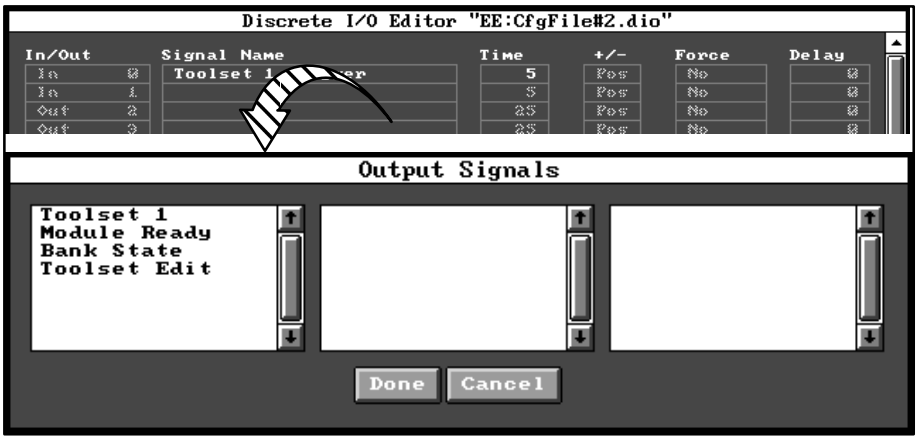


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Output Selections

As noted earlier, the lower 14 discrete I/O locations in the Module I/O layout are reserved for output signals *only*. To assign an output signal, pick one of the corresponding boxes under the Signal Name heading. When you do, the Output Signals panel appears, as illustrated by the example in Figure 9.5.

Figure 9.5 Example: Selecting the Output Signals Panel



Note that this panel contains three scrolling lists. The *left* list contains signal names that relate to the toolsets in the *currently selected configuration file*, and to the configuration generally. The *center* list contains signal names that pertain to results from specific *toolsets*. The *right* list contains signal names that pertain to results from specific *tools* within a specific *toolset*. (Note that the center and right panels are empty, initially.)

The signal names appearing in the *left* scrolling list are described briefly as follows:

- **Toolset n** — This is the generic name for a toolset. It cannot be selected *alone*; it is always selected in conjunction with a toolset–related selection in the center panel, or with a toolset selection *and* a tool–related selection in the right panel.
- **Module Ready** — This signal is active *continuously* when the CVIM2 system is *online* and is able to process inspections; otherwise, it is inactive.
- **Bank State** — This signal indicates whether cameras 1, 2, and 3 are active, or cameras 4, 5, and 6.
- **Toolset Edit** — This signal indicates that the system is online and ready for inspections, and the toolset edit panel is open.

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The signal names appearing in the *center* scrolling list are described briefly as follows:

- **Pass** — This signal occurs when the system has processed all tools and has found that all have passed their inspection tasks.
- **Fail** — This signal occurs when the system has processed all tools and has found at least one tool that failed its inspection task for any reason.
- **Tool n** — This is the generic name for an inspection tool. When you highlight "Tool n," a list of tool results selections appears in the *right* scrolling list (the selections are detailed below).
- **Strobe** — This signal, when assigned to an output, delivers a strobe–firing pulse after receiving and processing a trigger signal.
- **Trigger ACK** — This signal occurs after the CVIM2 system has detected a trigger signal. It indicates that the inspection will be processed.
- **Trigger NAK** — This signal occurs after the CVIM2 system has detected a trigger signal. It indicates that the inspection will *not* be processed.
- **Data Valid** — This signal occurs after the inspection is complete and the outputs have a valid state.
- **DV Overrun** — This signal is generally assigned in the Remote I/O panel as an output to an Allen–Bradley PLC™. It indicates that the CVIM2 system did not receive a Data Valid Reset signal from the PLC before a new set of inspection results became available; thus, the new set of inspection results has overrun the previous set.

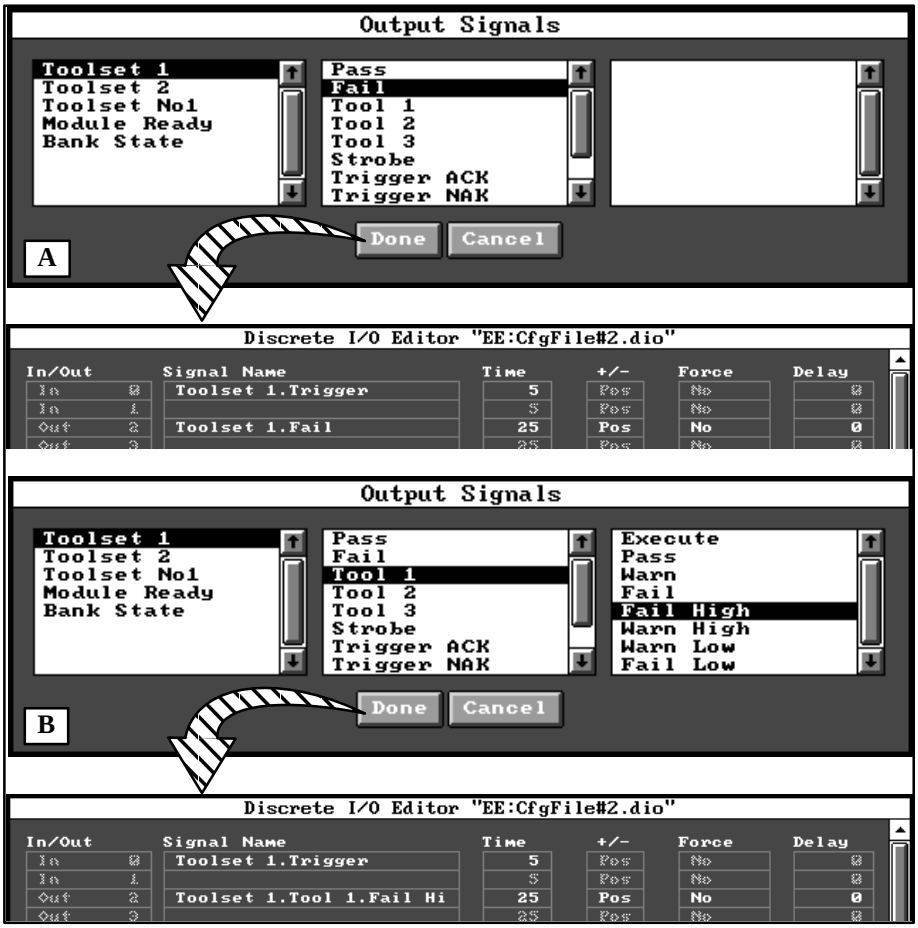
The signal names appearing in the *right* scrolling list pertain to inspection results from the tool selected in the center panel. The specific set of names appearing in this list depends on the specific tool *type* (such as gage or window) depicted by the Tool n selection in the *center* panel. Execute, Pass, Fail, and Fail High are among those names typically appearing in the right panel (refer to the various "*Tool Inspection Results and Math Tool Formulas*" sections in Chapter 6 and Chapter 7 for explanations of these names within the context of the specific inspection tool types).

To select an output signal, highlight a signal name in the *left* scrolling list. If you highlight either Module Ready or Bank State, *no* additional names will appear in the *center* list; thus, you can pick the Done button at this time.

If you highlight one of the *toolset* names in the left list, however, additional names will appear in the center list. At this point, you must highlight a signal name in that list. If you highlight any name *except* a *tool* name, *no* additional names will appear in the *right* list; thus, you can pick the Done button at this time. When you do, the highlighted signal name will appear in the Discrete I/O Editor panel, as shown in Figure 9.6 (**A**) on page 9–11.

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Figure 9.6 Example: Selecting an Output Signal (Module I/O Layout)



If you highlight one of the *tool* names in the center list, however, additional names will appear in the right list. At this point, you must highlight a signal name in that list, and then pick the Done button. When you do, the highlighted signal name will appear in the Discrete I/O Editor panel, as shown in Figure 9.6 (**B**).

The output signals are examined in more detail in the timing charts later in this chapter.

Time Selections

As indicated earlier, the "Time" field designates parameters for the corresponding input *or* output signal:

For *input* signals, the Time parameter designates the *minimum* time separation between the leading edge of successive trigger signals. The purpose of this setting is to "debounce" inputs from mechanical devices.

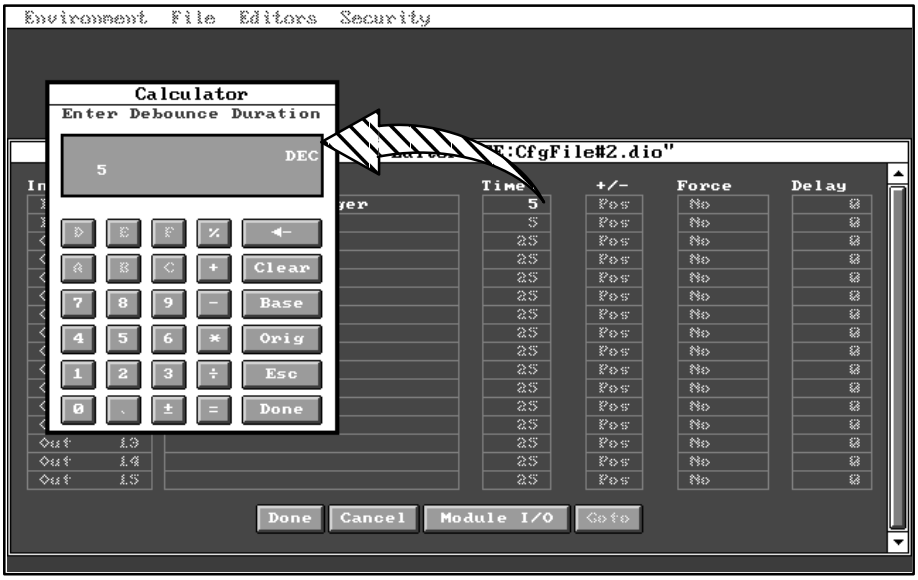
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The *default* Time setting for inputs is 5ms. In this case, the CVIM2 system will not recognize a trigger signal whose leading edge occurs *earlier than* 5ms after the leading edge of the previous trigger signal.

For *output* signals, the Time parameter designates the *minimum* duration that an output signal remains active. The *default* Time setting for outputs is 25ms.

To change the input *or* output setting, pick the appropriate box in the Time column. When you do, the "calculator" pad appears, as shown in Figure 9.7.

Figure 9.7 Example: Using the Calculator Pad to Change Time Settings



To change a time setting using the calculator, pick the Clr button, then enter any new number from 1 to 9999. After entering the number, pick the Done button. When you do, the new number will appear in the Time box, and the calculator will disappear.

NOTE: Setting an output pulse duration of 0ms has a special effect; namely, it results in a *non–pulsed* output, which means that an output will *remain* at the *level* to which it was set by the results of the *last inspection cycle*. The output will change to the *opposite* level only when a subsequent inspection result changes. For example, an output assigned to a tool "fail" function will remain *active* after receiving a tool "fail" signal, and it will go *inactive* only after the corresponding tool passes an inspection.

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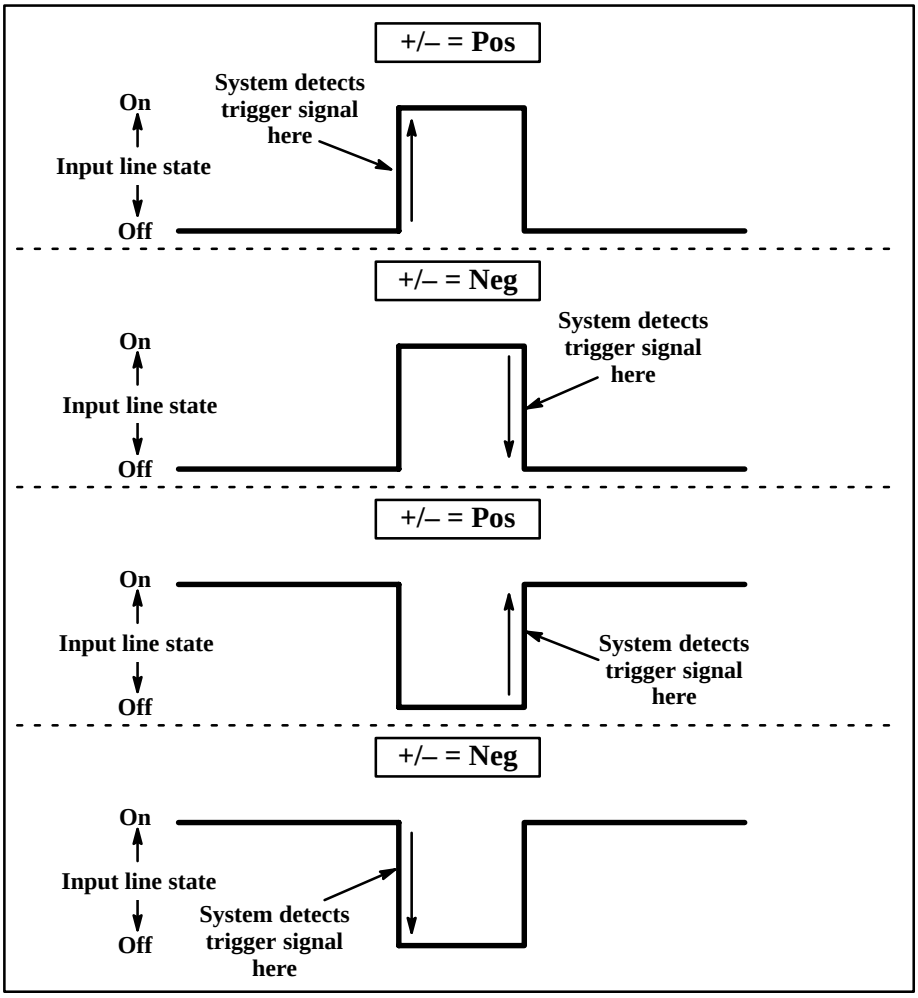
+/– Selections

As described earlier, the +/– field selects additional parameters for the discrete inputs and outputs, as follows:

For *inputs* signals (System I/O *only*), the +/– parameter determines (when the CVIM2 system is *online*) whether the system will respond to an off–to–on change in the trigger input line (Pos), or to an on–to–off change in the input line (Neg). Pick the appropriate box under the +/– heading to toggle "Pos" to "Neg," or vice versa, for a particular input signal.

If an I/O interface board is being used, you can determine the input line state by looking at the corresponding LED on the JMB board: Thus, the input line state is *on* when the corresponding LED on the JMB board is *on*, and vice versa. Figure 9.8 shows these relationships.

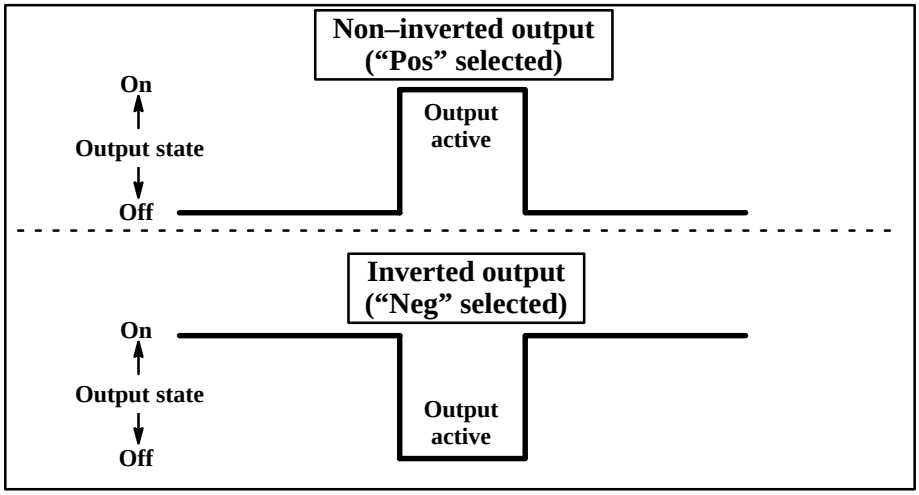
Figure 9.8 Example: Effects of +/– Settings on Trigger Signal Detection



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For *output* signals, the +/– parameter determines whether an output will be inverted. If "Pos" is selected (the *default* selection), the output is *not* inverted, and its active state is *on*. If "Neg" is selected, the output is inverted and its active state is *off*. Figure 9.9 illustrates this relationship. Pick the appropriate box under the +/– heading to toggle "Pos" to "Neg," or vice versa, for a particular output signal.

Figure 9.9 Example: Effects of Non–inverted and Inverted Output Selections



Force Selections

As described earlier, the Force parameter can alter the state of an output *when the system is online*, according to which of the three choices is selected: No, On, or Off. These are described briefly as follows:

No — This is the *default* selection, and it causes the selected output to follow the variations in the signal function that is assigned to it.

On — This forces the selected output to go *active* and *remain active* as long as the system is *online*.

Off — This forces the selected output to go *inactive* and *remain inactive* as long as the system is *online*. (Note that *all* outputs, except the strobe output, are deactivated when the system goes *offline*.)

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Output Status from Various +/– and Force Selections

Table 9.1 shows the output status (*activated* or *deactivated*) for each combination of inspection results (*true* and *false*) and corresponding settings of "+/–" (Pos and Neg) and "Force" (No, On, and Off).

Table 9.1 Output States from Various Inv and Force Selections

Inspection Results	+/– Selection	Force Selections	*Output Status
Any	Pos	Off	Deactivated
Any	Pos	On	Activated
Any	Neg	Off	Activated
Any	Neg	On	Deactivated
False	Pos	No	Deactivated
True	Pos	No	Activated
False	Neg	No	Activated
True	Neg	No	Deactivated

*When the CVIM2 system is *offline*, all outputs (except the strobe output) are deactivated.

System I/O Functions

System I/O is the second of the four Discrete I/O devices. You can select it as shown in Figure 9.10 (page 9–16).

When the System I/O format is on the monitor screen, all 16 rows of the table are available for input *or* output signal assignments. The inputs and outputs assigned in this panel are routed to the System I/O connector on the CVIM2 front panel.

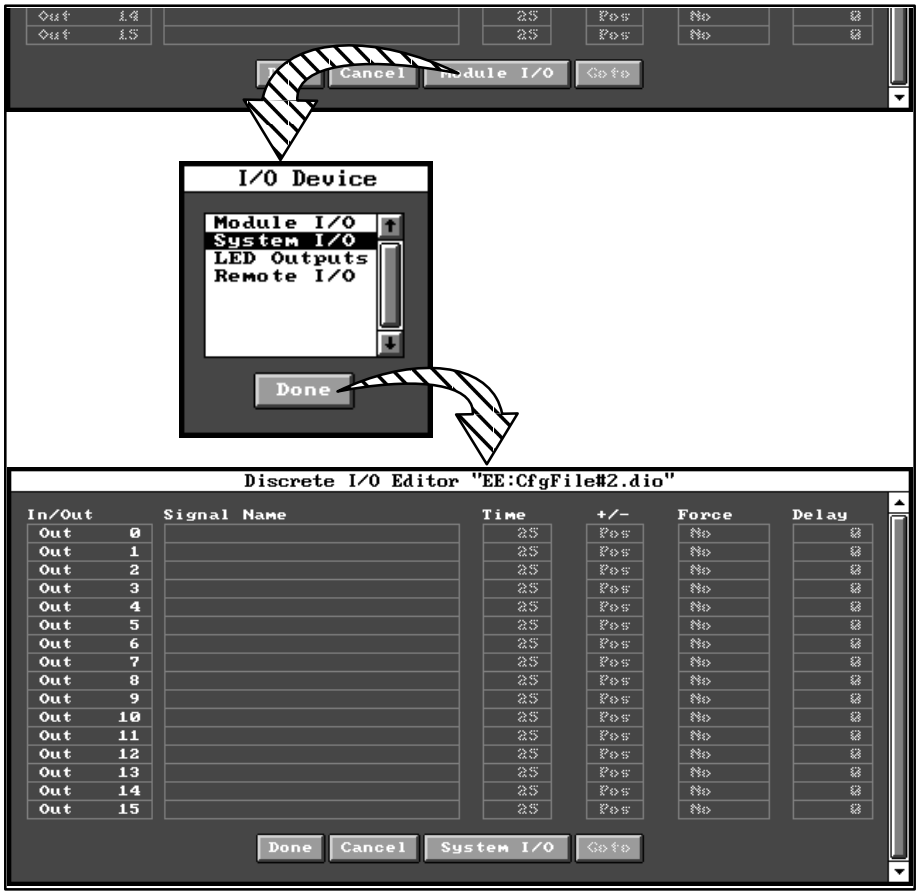
Note that *initially* all of the rows are designated as outputs, "Out 0" to "Out15." To change any row to an input signal, just pick one of the "out" boxes. When you do, the "out" box toggles to become an "in" box. Thus, "Out 0" toggles to "In 0," for example.

NOTE: Triggers should be assigned *only* to inputs 0 and 1 on the Module I/O panel and inputs 0 to 3 on the System I/O panel. Other inputs should *not* normally be assigned to these inputs. (See *Discrete Inputs: Interrupt Processing vs Poll Processing* on page 9–3 for details.)

For information about selecting input and output signals, refer to the *Module I/O Functions* section on page 9–4.

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Figure 9.10 Selecting the System I/O Editor Panel

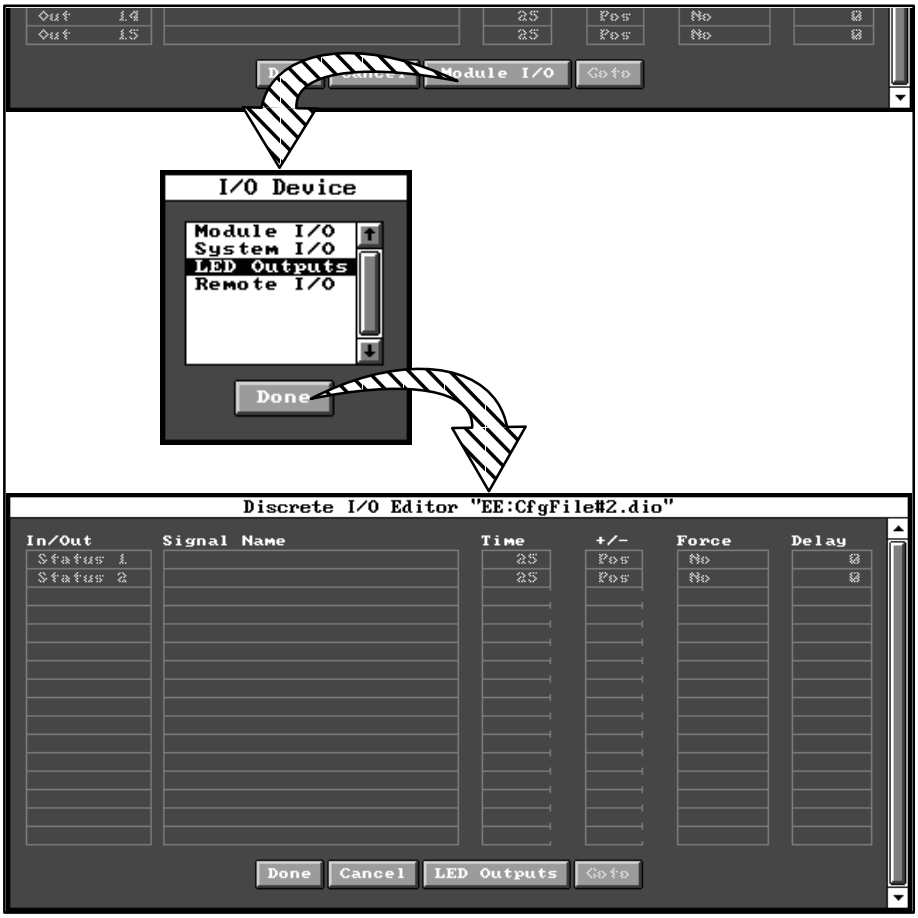


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LED Outputs

LED Outputs is the third of the four Discrete I/O devices. You can select it as shown in Figure 9.11.

Figure 9.11 Selecting the LED Outputs Panel



When the LED Outputs format is on the monitor screen, only the top two rows of the table are available for status LED assignments. The LED outputs assigned in this panel are routed to the Status 1 and Status 2 indicator LEDs on the CVIM2 front panel.

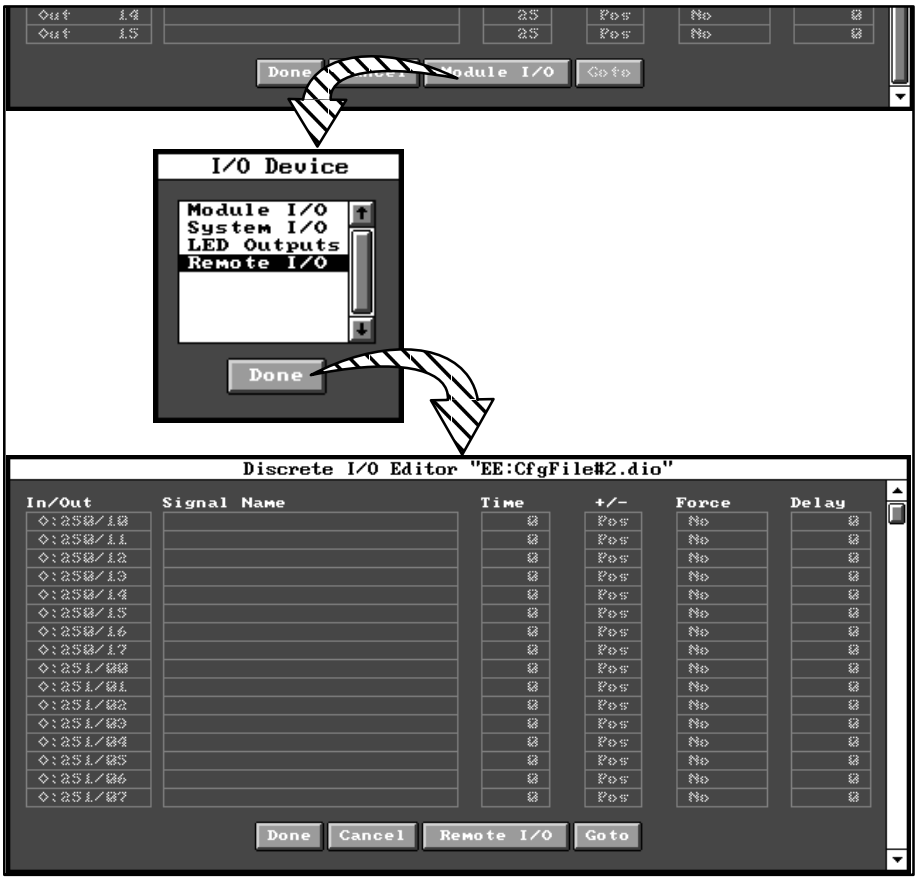
For information about assigning outputs to the two status LEDs, refer to the *Output Selections* section on page 9–9. You can select output signals from the same Output Signals menu shown in Figure 9.5 (page 9–9).

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Remote I/O Functions

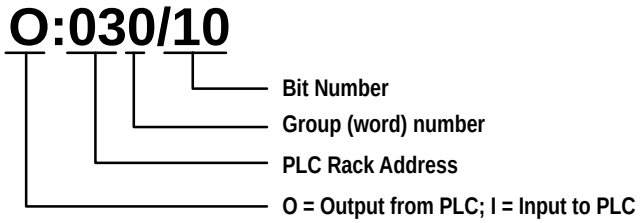
Remote I/O is the fourth of the four Discrete I/O devices. You can select it as shown in Figure 9.12.

Figure 9.12 Selecting the Remote I/O Editor Panel



When the Remote I/O format first appears on the monitor screen, the 16 rows in the editor panel pertain to the first 16 of 248 composite addresses for an Allen–Bradley PLC™ (programmable logic controller).

The PLC addresses appear under the In/Out heading in the Remote I/O editor panel, and they have the following basic format:



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Note that "O" and "I" indicate *output* and *input* from the PLC *perspective*. The "rack address" is the one that you set in the Remote I/O Configuration panel, which you can access from Environment in the main menu bar (refer to Chapter 10, *Environment Menu Selections* for details).

Note also that the composite addresses (as well as the parameters under the Time, +/–, and Force headings) are *shaded*, and thus you cannot alter them in the Remote I/O panel.

The first 120 rows are all PLC *outputs* (CVIM2 *inputs*), while the remaining 128 rows are all PLC *inputs* (CVIM2 *outputs*). You can access all 248 rows by picking the Goto button and entering a specific address in a keyboard, or by picking the scroll bar, scroll bar arrows, or scroll bar slider at the right side of the editor panel. In all cases, the proper selection of these composite addresses is dependent upon knowledge of the PLC and how it is programmed to interface to the CVIM2 through the remote I/O port.

For information about selecting input and output signals, refer to the *Module I/O Functions* section on page 9–4 of this manual. For details about remote I/O communications, refer to the *CVIM2 Communications Reference Manual*.

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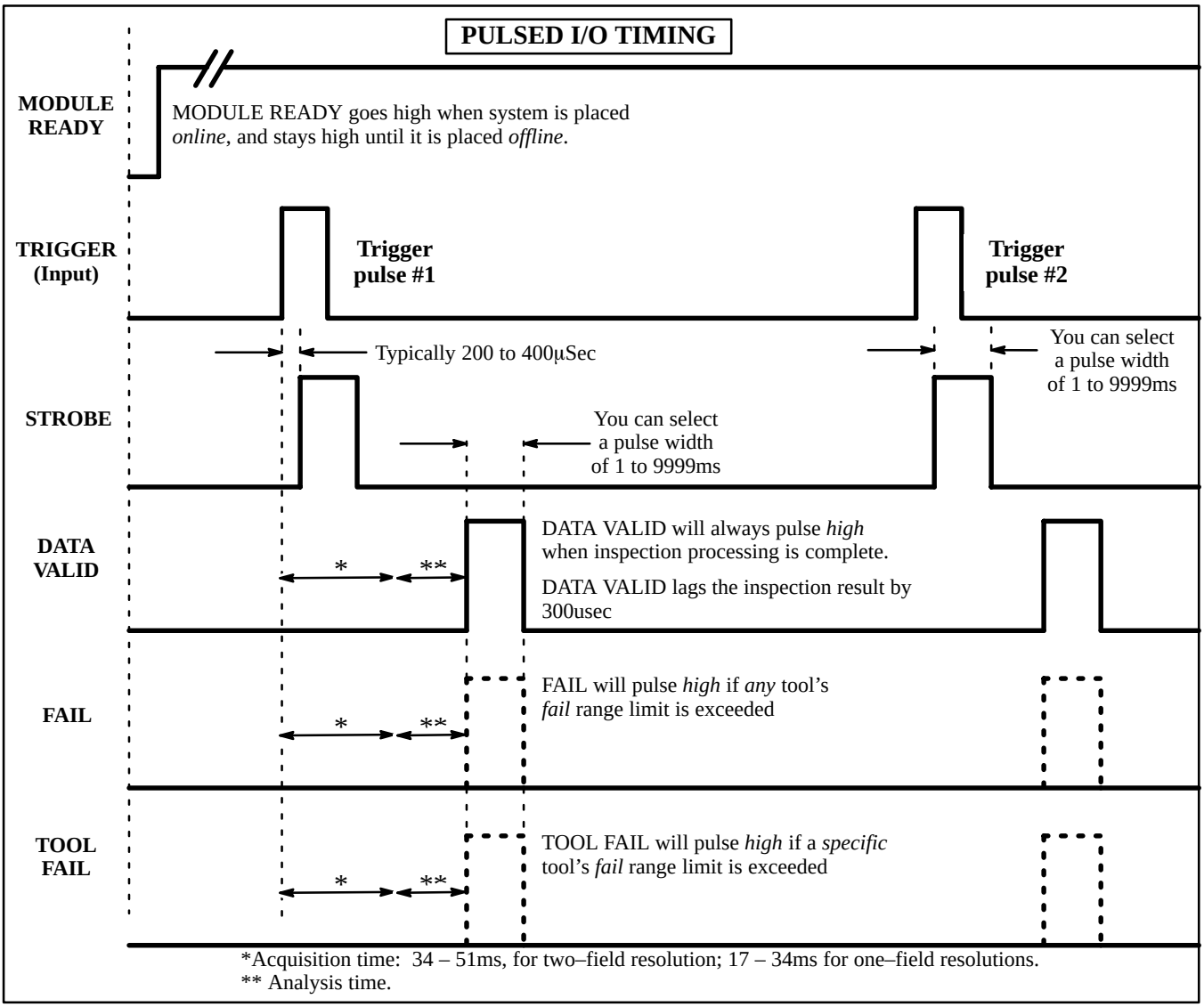
Discrete I/O Signal Timing Data

To make proper use of the output signals, you must first understand the timing relationships that exist between the trigger *input* signal (which *starts* each inspection cycle) and the *output* signals.

Knowing these signal timing relationships enables you to accurately *synchronize* the CVIM2 system's inspection cycles with your process equipment. The timing charts in Figure 9.13, Figure 9.14 (page 9–21), and Figure 9.15 (page 9–22) contain examples of these signal timing relationships in various circumstances.

Figure 9.13 shows the relationship between the trigger leading edge and the strobe, data valid, fail, and tool fail signals, where the last three appear as *pulses* whose duration you determine in the appropriate Time box in the Discrete I/O Edit panel.

Figure 9.13 Example: Timing Relationships for Pulsed Outputs

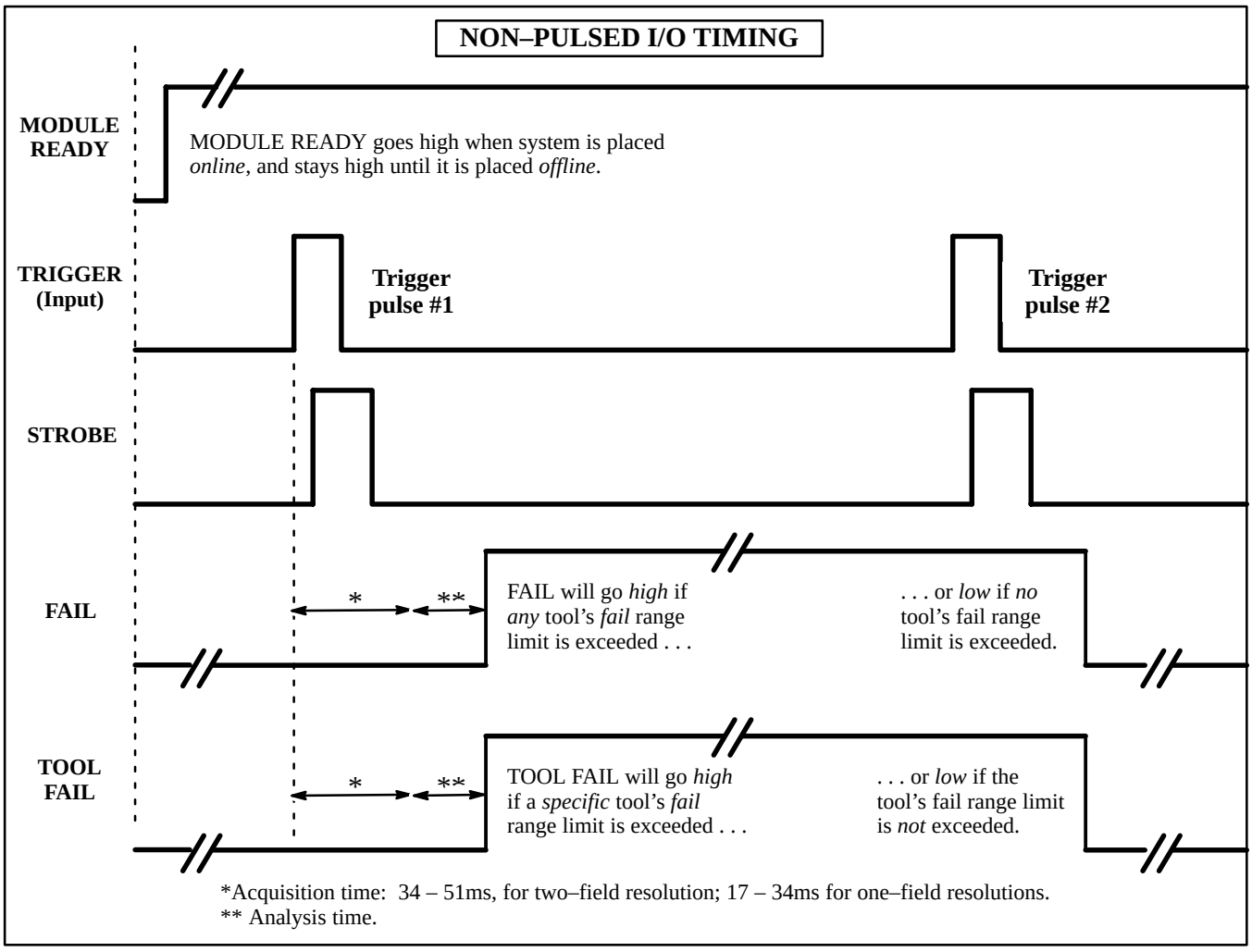


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Note that Module Ready is *high* only when the system is *online*.

Figure 9.14 also shows the relationship between the trigger leading edge and the strobe, data valid, tool fail, and fail signals, when the output duration has been set to 0ms and thereby selects *non–pulsed* output. In this case, the last three appear as *changes in signal levels*. This will occur if you select 0 msec in the appropriate Time boxes in the Discrete I/O Edit panel.

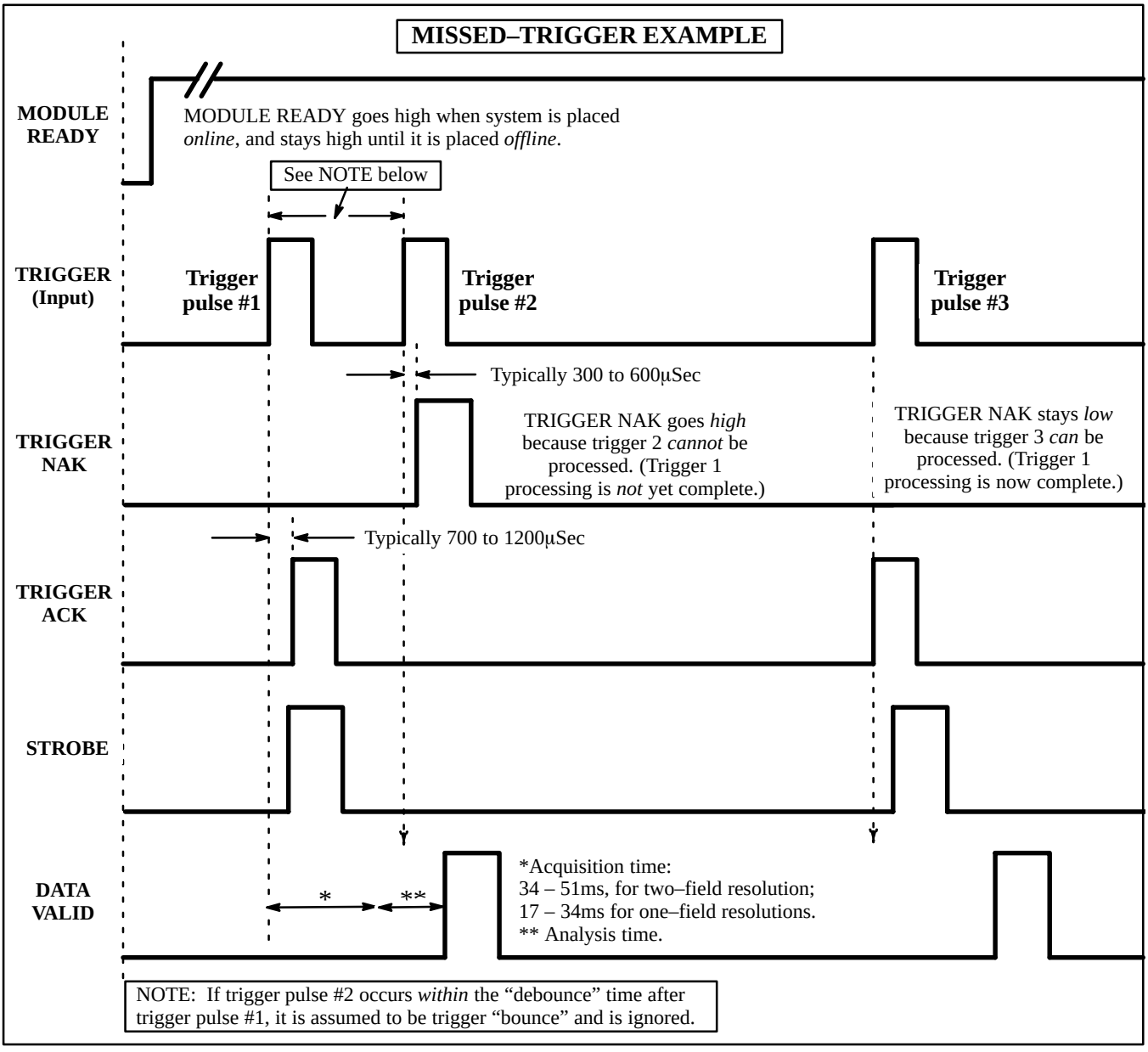
Figure 9.14 Example: Timing Relationships for Non–Pulsed Outputs



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Figure 9.15 is an example of a missed–trigger situation, in which a *second* trigger signal arrives before the system is ready to process another trigger. When this occurs, the system sets the Trigger NAK signal.

Figure 9.15 Example: Timing Relationships for Missed Trigger



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The system will *not* process a trigger signal in the following situations:

- Whenever a second trigger signal occurs within the “debounce” time of the first signal. (In this case, there is *no* Trigger NAK signal, and no “missed trigger” is counted.)
- When the “Overlap Acq/Insp” function is *disabled*, and a *second* trigger signal occurs before the system has finished the *inspection* cycle started by the *first* trigger signal. In this case, the trigger NAK signal occurs.
- When the “Overlap Acq/Insp” function is *enabled*, and a *second* trigger signal occurs before the system has finished the *image acquisition* cycle started by the *first* trigger signal. In this case, the trigger NAK signal occurs.

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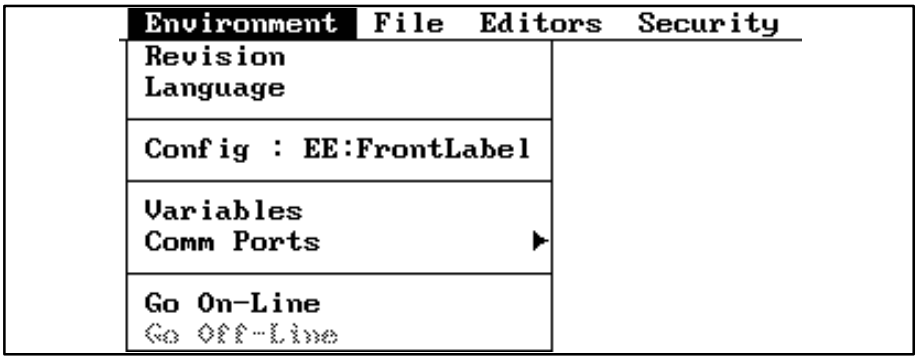
Chapter 10

Environment Menu Selections

This chapter provides detailed information about the functions that you can select in the Environment menu in the main menu bar.

The Environment menu appears when you pick Environment in the main menu bar, as shown by the example in Figure 10.1.

Figure 10.1 Example: Selecting the Environment Menu



The Environment menu contains six items. The functions of these menu items are described briefly, as follows:

- **Revision** — When you pick this menu item, the CVIM2 Revision information box appears on the screen. It contains the CVIM2 banner information, along with the series, revision, and firmware revision levels of your CVIM2 module, and any option package installed.
- **Language** — When you pick this item, the Language selection panel appears on the screen. Using this panel, you can select the appropriate language for the CVIM2 module user interface.

  NOTE: To use a language other than English, you must purchase a language card (such as Catalog No. 5370–FRE2 or 5370–GER2) that contains foreign language dictionaries.
- **Config : xx:<filename>** — This item displays the currently *active* configuration file. The system executes this file when you pick Go On–Line. You can pick Config : xx:<filename> to select a different configuration file from the Config Files panel.
- **Variables** — When you pick this item, the environment variables editor panel appears on the screen. Using this panel, you can modify or delete various system variables, or add new variables in some cases.
- **Comm Ports** — When you pick this item, the Comm Ports selection menu appears on the screen. From that menu, you can select the configuration panel for each of the four RS–232 serial ports: Module I/O Port A, Module I/O Port B, System I/O Port A, and System I/O Port B.

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- **Go On–Line** — When you pick this item, the CVIM2 system goes *online*, and is enabled to perform inspections using the configuration file identified in the Config : xx:<filename> line. (If the system is *already* online, the type is shaded.)
- **Go Off–Line** — When you pick this item, the *online* CVIM2 system goes *offline*, and terminates inspections using the configuration file identified in the Config : xx:<filename> line. (If the system is *already* offline, the type is shaded.)

The remainder of this chapter describes the functions listed above.

Revision Data

When you pick the Revision item in the Environment menu, a CVIM2 Revision box appears, similar to the one illustrated in Figure 10.2.

Figure 10.2 Selecting the CVIM2 Revision Information Box



The Series and Revision levels pertain to the CVIM2 hardware, while the Firmware Revision level pertains to the basic operating system software. If an option package is installed, its name and revision level also appears in this box.

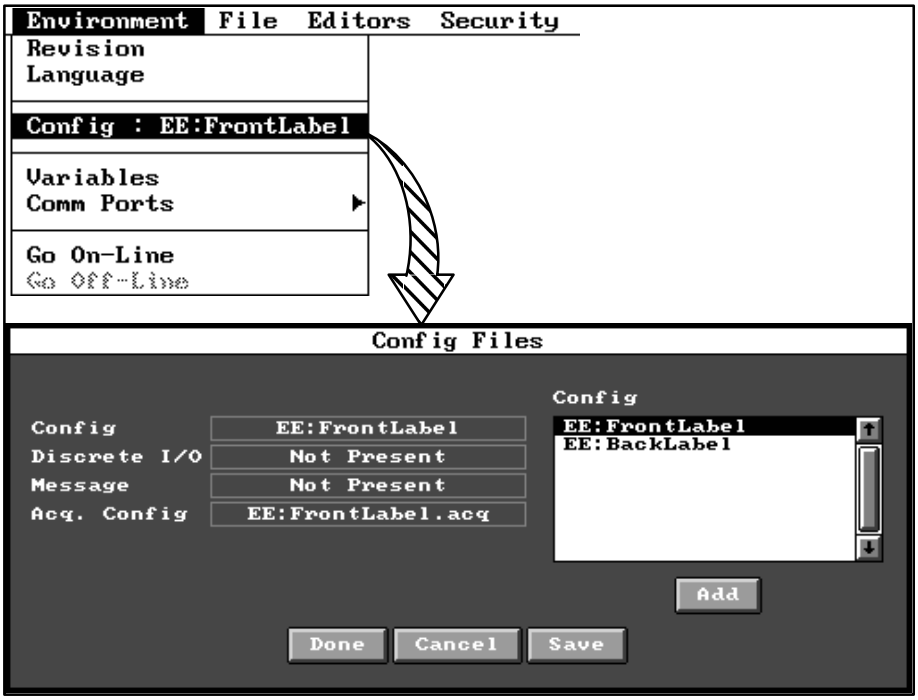
Configuration File Selection

The configuration *process*, which creates all of the configuration files that are required for an application, is discussed in detail in Chapter 4, *Inspection Configuration*, starting on page 4–2. After completing that process, when you then pick the Config : xx:<filename> item in the Environment menu, the Config Files menu reappears, as illustrated by the example in Figure 10.3 (page 10–3).

Initially, the Config Files menu highlights the currently selected configuration file (EE:FrontLabel in the example). To select a *different* configuration file, pick (highlight) the appropriate configuration file name. When you do, the new name appears in the Config field (along with the corresponding Acq. Config, Discrete I/O, and Message file names). After highlighting the other configuration file name, pick the Done button to exit to the main menu bar.

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Figure 10.3 Example: Selecting the Configuration File Selection Menu

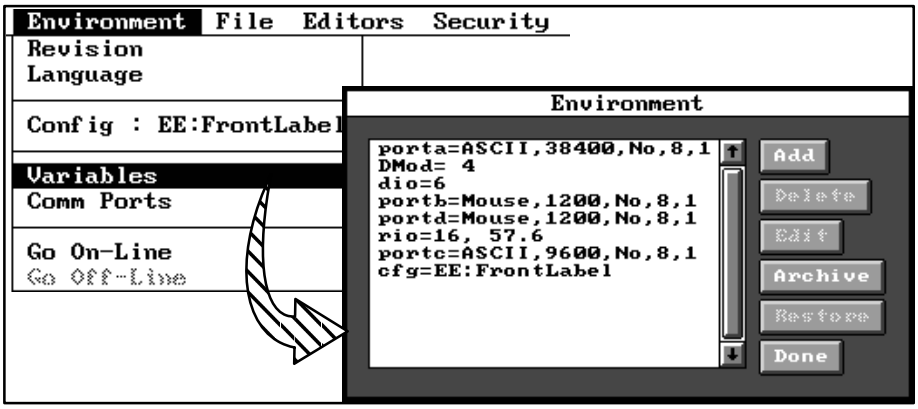


If you pick the Environment menu again, you will see the newly selected device and configuration file in the Config : xx:<filename> line. This configuration file will used when you place the CVIM2 system *online*.

Variables

When you pick the Variables item in the Environment menu, the Environment panel appears, as shown in Figure 10.4. Note that the Variables item is available only for security level 8 users, by *default*.

Figure 10.4 Example: Selecting the Environment Panel



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Note that the Environment panel contains several “buttons.” Here is a brief description of their functions:

- **Add** — Use the Add button to add new variables.
- **Delete** — Use the Delete button to delete the highlighted variables file.
- **Edit** — Use the Edit button to edit the highlighted variables file.
- **Archive** — Use the Archive button to archive the highlighted variables file in a specified device.
- **Restore** — Use the Restore button to restore a previously archived variables file.
- **Done** — Use the Done button to exit to the main menu bar.

The example in Figure 10.4 illustrates a list of *system* variables, whose settings and parameters affect the overall operation of the CVIM2 system.

Some variables can be set by utilities outside this menu. In particular, the “porta=x . . .” items show the parameters set under the RS–232 serial port panels (see *RS–232 Serial Port Setup* following this section); and, the “cfg=xx:<filename>” item is the configuration file selected in the Config Files panel (see *Configuration File Selection*, page 10–2). For a complete list of user–selectable environment variables, refer to Appendix B.

Editing Variables

NOTE: It is normally not necessary to edit the variables in the Environment panel.

The general procedure for editing a variable is to pick (highlight) the variable, then pick the Edit button. When you do, the keyboard appears, as shown in Figure 10.5.

Figure 10.5 Example: Editing a Variable



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Note that all variable names are *case–sensitive*. Enter the appropriate changes to the variable, then pick the Enter button. When you do, the keyboard disappears and the changed variable appears in the Environment panel.

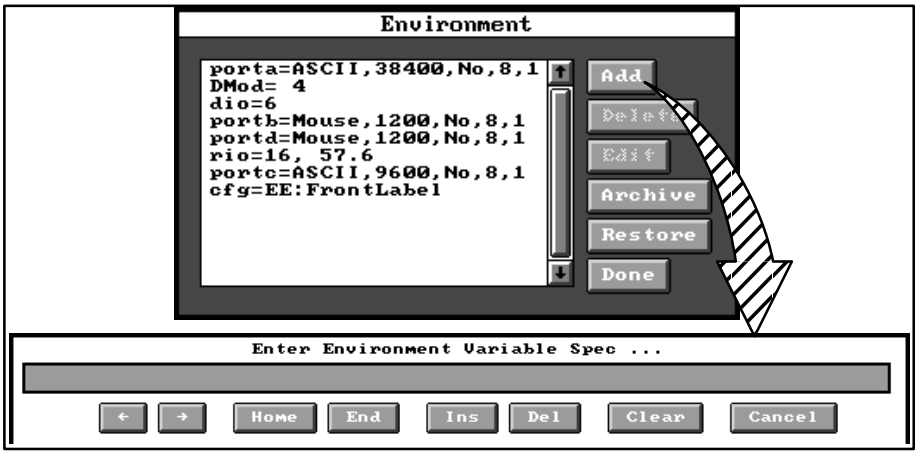
NOTE: An edited variable *may not* become effective immediately; usually, you must cycle the power to the CVIM2 module in order to activate the changed value.

Adding Variables

The Add function enables you to add variables that can alter or "customize" the CVIM2 system's performance in important and useful ways. Refer to Appendix B for a complete list and description of the user configurable environment variables.

To add a variable, the *first* step is to pick the Add button in the Environment panel. When you do, the keyboard appears, as illustrated by Figure 10.6 (Part 1).

Figure 10.6 Example: Adding a Variable (Part 1)



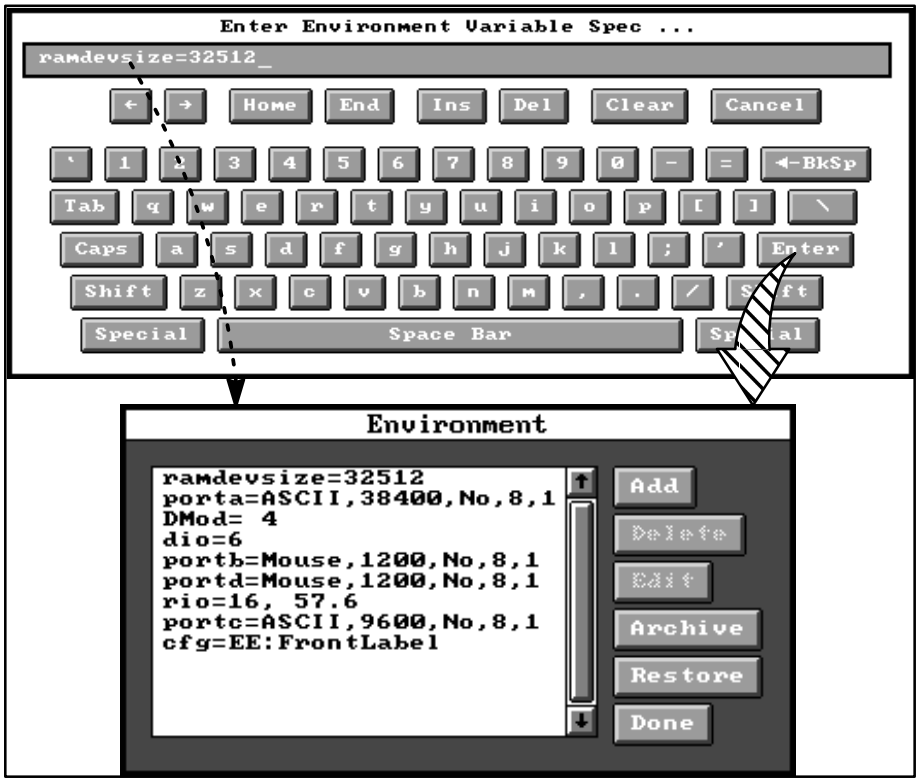
The *second* step is to enter the environment variable name, the equal sign (=), and the parameter(s) on the keyboard, then pick the Enter key. When you do, the keyboard disappears and the new variable appears in the Environment panel, as illustrated by Figure 10.7 (Part 2).

Figure 10.7 uses the "ramdevsize" variable as an example of a user configurable environment variable. This variable can be used to change the size of the RM: device for *temporary* storage of files. (Since the RM: device is *volatile*, files stored there will be lost whenever the CVIM2 module is powered down.)

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The *default* size of the RM: device is 4048 bytes; however, you can increase it to a maximum of 32,512 bytes by adding "ramdevsize=32512" to the environment variables panel and cycling power to the CVIM2 module.

Figure 10.7 Example: Adding a Variable (Part 2)



NOTE: An added variable *may not* become effective immediately; usually, you must cycle the power to the CVIM2 module in order to activate the variable.

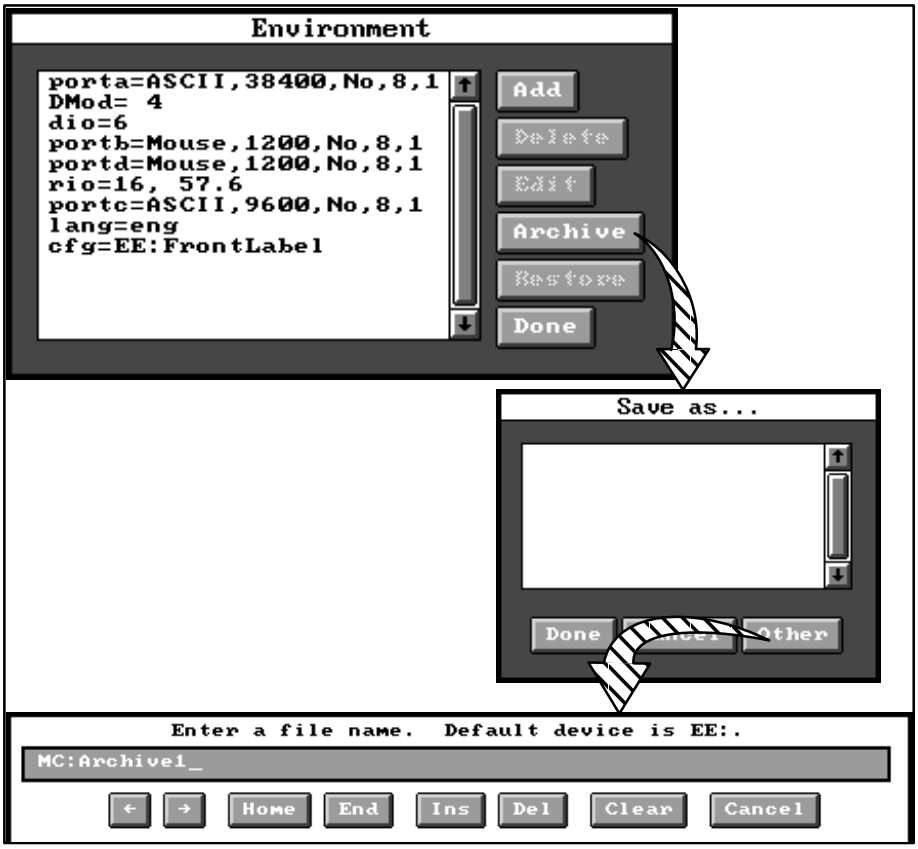
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Archiving Variables

The Archive function enables you to save the entire list of variables in the Environment panel to a separate file for the purpose of transferring the environment to another CVIM2 system (or for use as backup in case of hardware failure).

When you pick the Archive button, the "Save as . . ." panel appears, as shown in Figure 10.8. Initially, the panel is empty, as shown.

Figure 10.8 Example: Selecting Archive File Name



To archive the current list of environment variables, pick the Other button. When you do, a keyboard appears. Enter an appropriate name for the archive file, (such as MC:Archive1 in Figure 10.8). (Note the message in the keyboard title bar indicating that the default device is EE:. If you want to change the device, enter the new device name ahead of the archive file name.)

After entering the archive file name, pick the Enter key on the keyboard. When you do, the keyboard disappears and the "Save as . . ." panel returns with the archive file name listed, as shown in Figure 10.9 (page 10–8).

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Figure 10.9 Example: Archive File Name in "Save As . . ." Panel



To exit the "Save as . . ." panel, pick the Done button. At that point, the Environment panel will reappear. (Note that the Restore button is now active, indicating the presence of one or more "Env. Arch." files.) To exit the Environment panel, pick the Done button.

After exiting the Environment panel, if you pick File in the main menu bar and access the device in which you stored the archive file ("MC:" in the current example), you should see that file listed as "Env. Arch." under the File Type heading, with the name that you selected (Archive 1) appearing under the File Name heading, as illustrated in Figure 10.10.

Figure 10.10 Example: Archive File Name in "MC:" Device



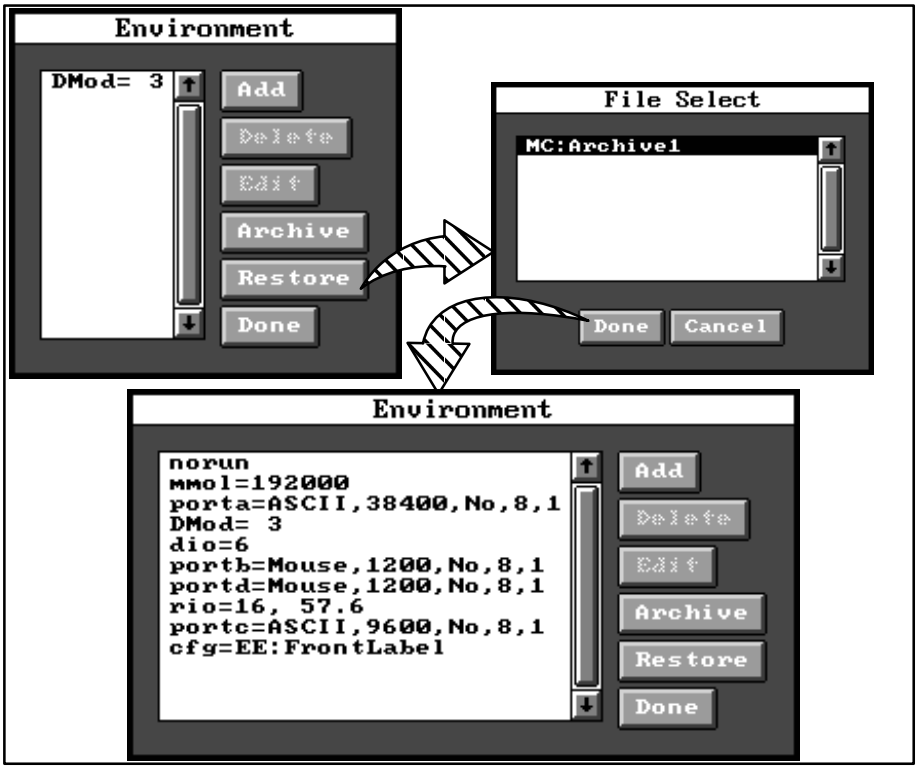
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Restoring Archived Variables

The Restore function enables you to restore any previously archived list of environment variables. If the environment variables are lost for any reason, you can restore them by picking the Restore button.

When you pick the Restore button, the File Select panel appears, as shown in Figure 10.11. As the example shows, all of the variables in the Environment panel have been lost (the DMod=n variable appears after powerup). To restore an archived list of environment variables, highlight the appropriate archive filename (if more than one is listed) and pick the Done button. When you do, the Environment panel reappears with the archived variables. At this point, you should cycle the power to the CVIM2 module to ensure that the restored variables become effective.

Figure 10.11 Example: Restoring Archived File



Alternatively, you can also restore the archived variables by accessing the File panel and copying the saved archive file. To perform the copy operation, highlight the "Env. Arch." file in the appropriate device and pick the Copy button. When the keyboard appears, enter the following device and name *exactly* as shown:

EE:Environment

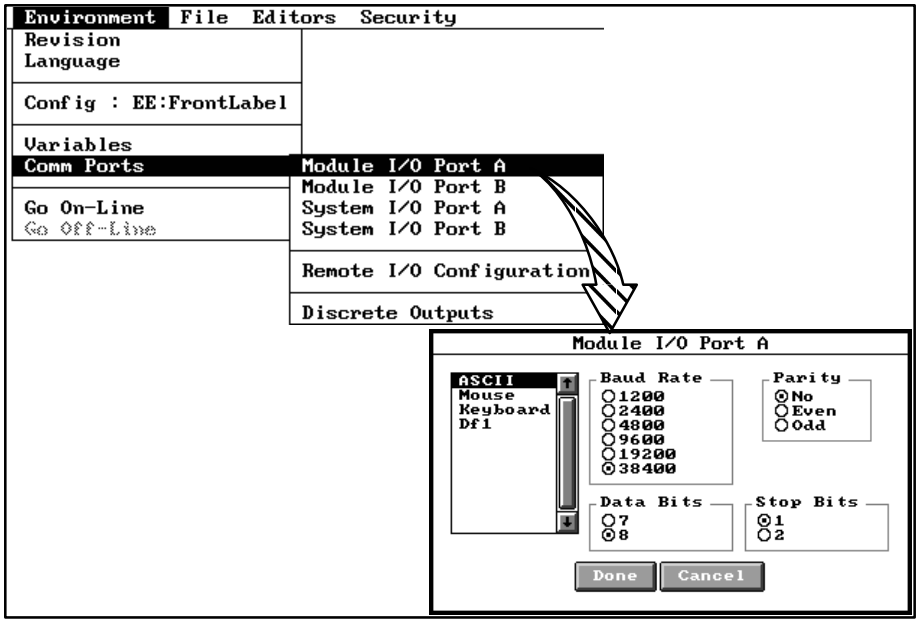
You can also perform the copy operation using the "fcopy" operation through one of the communication ports. (Refer to the *CVIM2 Communications Reference Manual* for use of the fcopy command.)

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RS–232 Serial Port Setup

When you pick Comm Ports in the Environment menu, the Comm Ports selection menu appears, as shown in Figure 10.12. When you then pick one of the four RS–232 port items, the corresponding I/O port configuration panel appears as shown in the figure.

Figure 10.12 Example: Selecting an RS–232 Port Configuration Panel



The CVIM2 system has four RS–232 serial ports, which are listed as follows in the setup panel: Module I/O Port A, Module I/O Port B, System I/O Port A, and System I/O Port B. All of these ports are accessed through the physical Module I/O and System I/O ports on the CVIM2 front panel.

The example in Figure 10.12 illustrates selecting one of the port setup panels, in this case, the Module I/O Port A setup panel. To configure this serial port, first select its intended use (ASCII, Mouse, Keyboard, or DF1) by picking (highlighting) one. Here is a brief description of the applicability of each of the four selections:

- **ASCII** — Select ASCII when using the RS–232 port to transfer data to and from devices using the ASCII protocol.
- **Mouse** — Select Mouse when the port is dedicated to a serial mouse.
- **Keyboard** — Select Keyboard when connecting an external RS–232 keyboard to the port. This can be used to input data when the graphical keyboard or calculator is on the screen.
- **DF1** — Select DF1 when using the RS–232 port to transfer data to and from devices using Allen–Bradley's DF1 communication protocol.

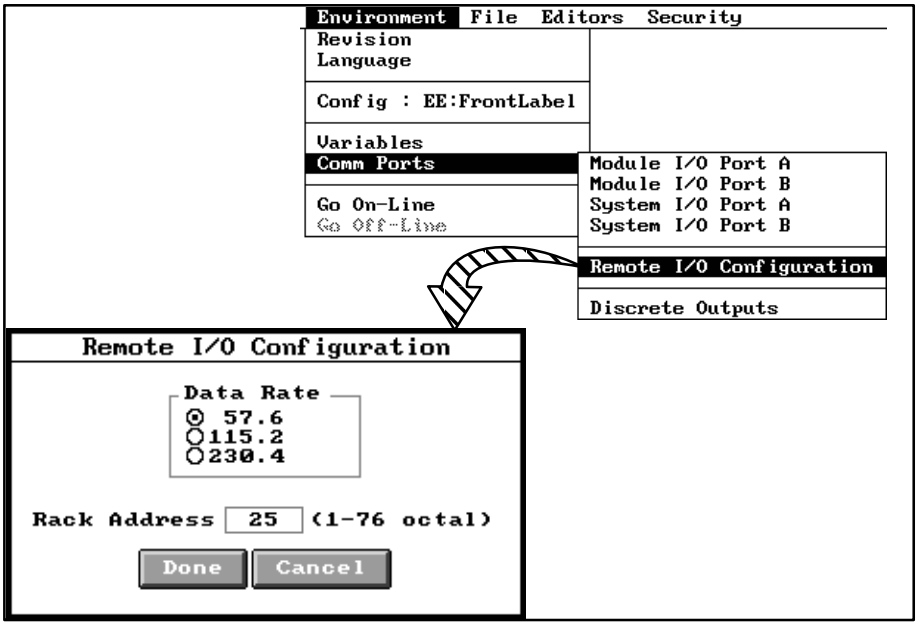
Then, choose the appropriate values from the selections alongside each of the four parameters (baud rate, number of data bits, parity, and number of stop bits), according to the requirements of the equipment to which the port is connected.

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Remote I/O Serial Port Setup

When you pick Comm Ports in the Environment menu, the Comm Ports selection menu appears, as shown in Figure 10.13. When you then pick Remote I/O Configuration, the remote I/O port configuration panel appears as shown in the figure.

Figure 10.13 Example: Selecting the Remote I/O Port Configuration Panel



The CVIM2 system has one physical Remote I/O port on the front panel, and it is used for data communications with Allen–Bradley PLC™ processors or 6008SI interface cards.

To configure the remote I/O port, select the appropriate data rate and rack address, then pick the Done button. When you do, the panel disappears and the main menu bar is once again active.

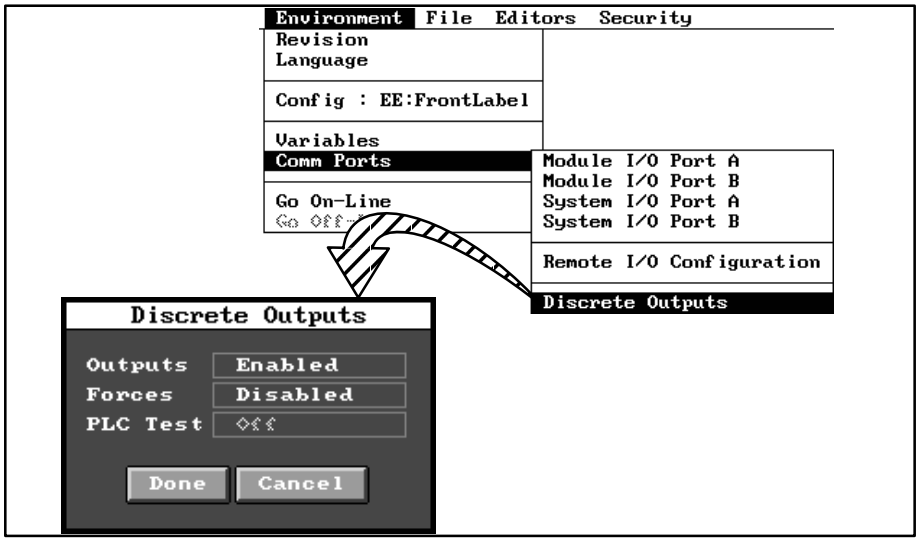
Enable/Disable Discrete Outputs

When you pick Comm Ports in the Environment menu, the Comm Ports selection menu appears, as shown in Figure 10.14 (page 10–12). When you then pick Discrete Outputs, the Discrete Outputs configuration panel appears as shown in the figure.

The top two fields in this panel enable you to control the state of the discrete *outputs* during *online* operations. The bottom field displays the test/runmode status of the programmable logic controller connected to the remote I/O port.

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Figure 10.14 Example: Selecting the Discrete Outputs Configuration Panel



Here is a brief description of the three fields in the Discrete Outputs panel:

- **Outputs** — The two selections in this field are Enabled and Disabled. "Enabled" allows the discrete outputs to become *active* during *online* operations, and to reflect the results of inspections. "Disabled" causes all outputs (except the designated Strobe outputs) to remain *inactive* during *online* operations.
- **Forces** — The two selections in this field are Enabled and Disabled. "Enabled" allows all discrete outputs that are configured with a "Force" selection of "On" or "Off" to reflect the Force selection during *online* operations. "Disabled" prevents the Force selections from operating.

  Note that if "Disabled" is selected in the Outputs field, the selection in the Forces field has no effect.
- **PLC Test** — The two status conditions displayed in this field are On and Off. When the "On" status is displayed, all discrete outputs are *disabled* (except the designated Strobe outputs) *regardless* of the selection in the Outputs field. When the "Off" status is displayed, the outputs are subject to the selections in the Outputs and Forces fields.

  The "On" status will appear *only* when an Allen–Bradley programmable logic controller (PLC™) is connected to the Remote I/O port *and* the PLC is set to the "test" or "program" mode.

  NOTE: The "Off" status can be restored *only* when the PLC reports that its has returned to the "run" mode. If communications with the PLC are disrupted after the PLC has set the "On" status, the "Off" status can be restored *only* by cycling the power to the CVIM2 module.

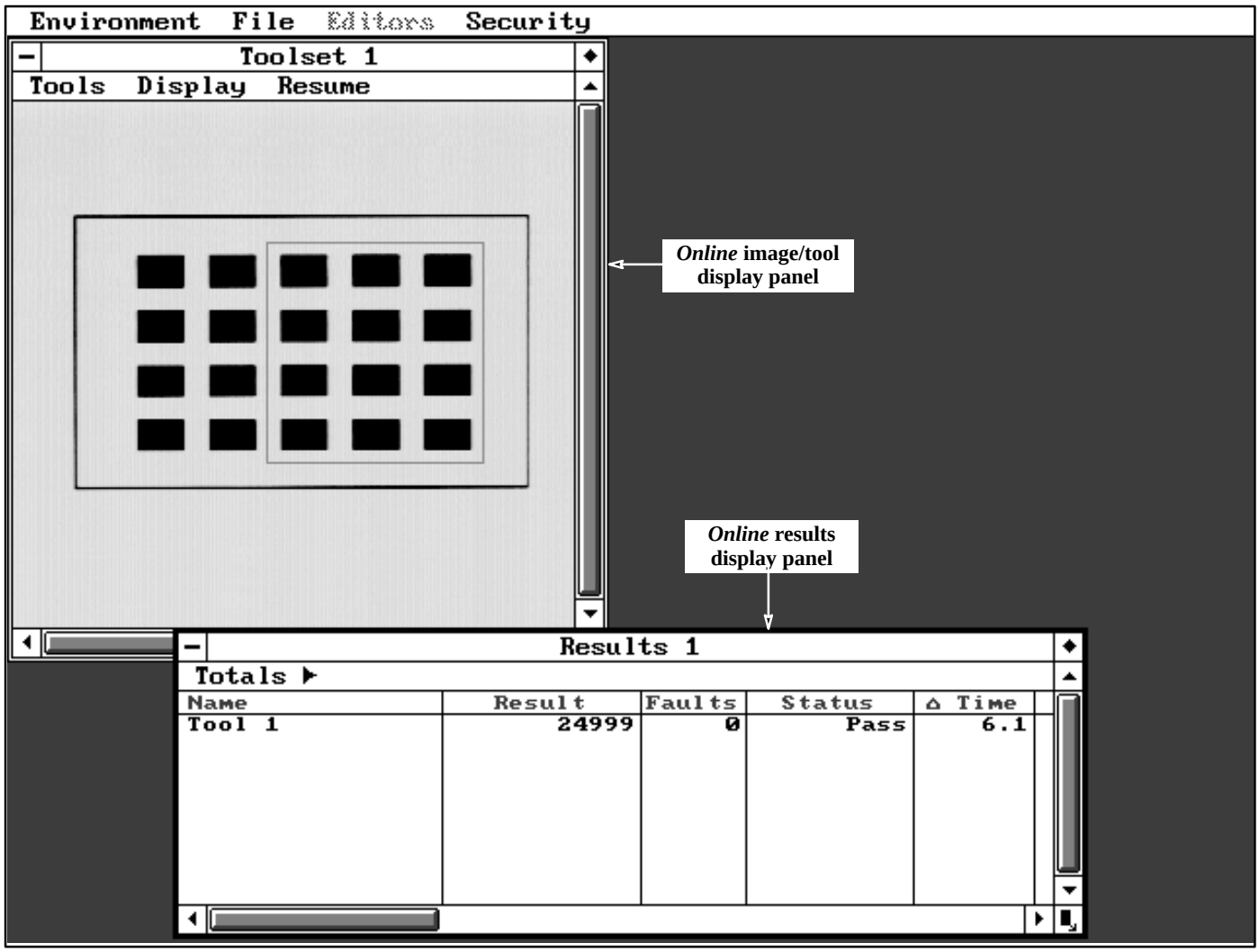
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Online Operations

The Go On–Line item in the Environment menu is the gateway to *online* operations, during which the CVIM2 system is *enabled* to perform inspections.

When you pick Go On–Line, the system is activated for *online* operations, and at least one image/tool display panel and one results display panel appears on the screen, as shown by the example in Figure 10.15.

Figure 10.15 CVIM2 Activated for *Online* Operations



In this example, the image display is at the top of the screen, while the results display is at the bottom. The positions of these panels, as well as their size, can be configured using the Display configuration panel, as described on page 4–23 of Chapter 4, *Inspection Configuration*.

This section describes these panels and their functions.

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Online Image/Tool Display Panel

The *online* image/tool display (Figure 10.15, page 10–13) conforms to the parameters set up in the Display panel (which is discussed in the *Selecting Display Parameters* section of Chapter 4, on page 4–16).

One such *online* image/tool display panel appears on the screen for each tool set defined in the Configuration Editor panel (see Figure 4.7 on page 4–9, in the *Inspection Names and Archive Names* section of Chapter 4). Thus, if three tool sets are defined, three image/tool display panels will appear on the screen.

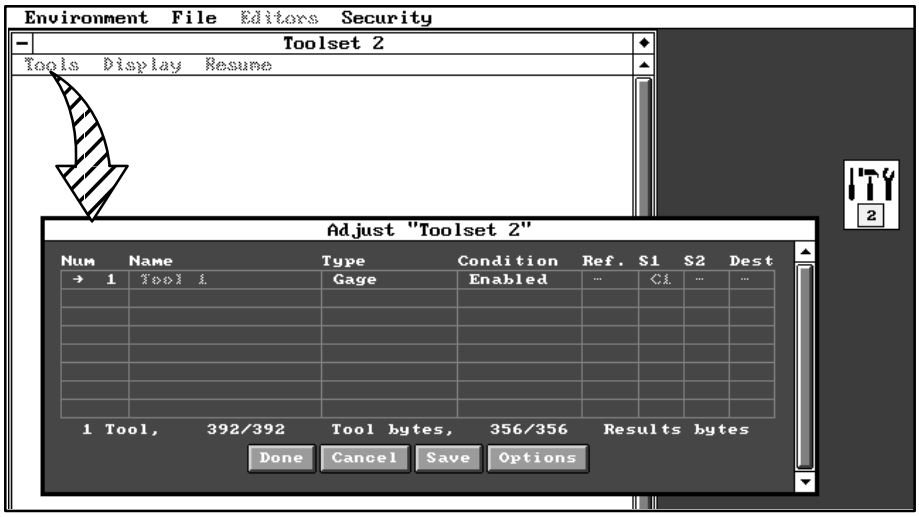
Note that the image/tool display panel has a menu bar containing three functions, which are described briefly, as follows:

- **Tools** — When you pick this item, the toolset Adjust panel appears, which enables you to make *some* tool adjustments such as tool position and size, range limits, and so on.
- **Display** — When you pick this item, a display selection menu appears. The selections in this menu determine the content of the image/tool display panel, as well as the image–freeze mode, during *online* operations.
- **Resume** — When you pick this item after an image freeze has occurred, the frozen image is released and the image updates resume.

Tools

When you pick Tools in the menu bar, the *toolset* Adjust panel appears, as shown in Figure 10.16.

Figure 10.16 Example: Selecting the Toolset Adjust Panel



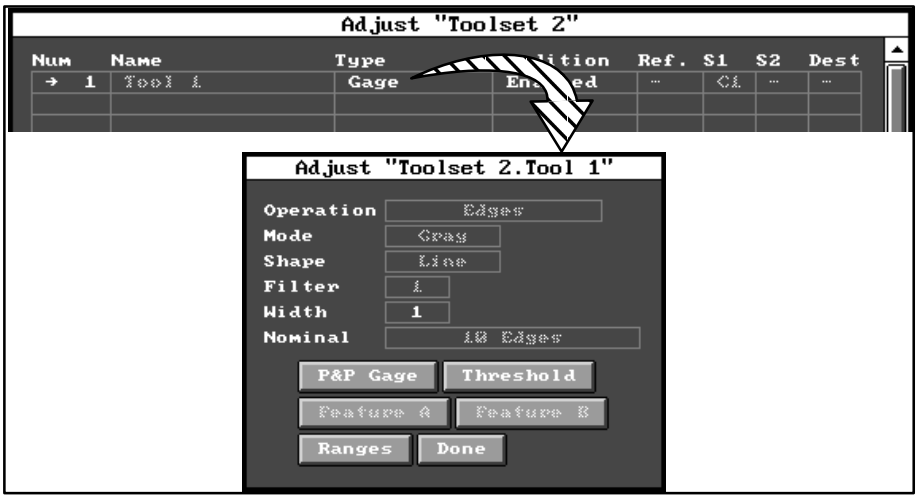
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The toolset Adjust panel is similar to the Toolset Edit panel described in Chapter 4, *Inspection Configuration*, under the *Setting Up Inspection Tools* heading (page 4–20). Note that some of the functions in the Toolset Edit panel are unavailable or inactive in the toolset Adjust panel; for example, the tool name is *inactive* (shaded type), which signifies that you cannot change the name in this panel.

The main function of the toolset Adjust panel is to enable you to adjust *some* tool parameters *while the system remains online and continues to perform inspections with no loss in speed*.

When you pick a tool *type* field in the toolset Adjust panel (such as "Gage"), the *tool* Adjust panel for that tool appears, as shown in Figure 10.17.

Figure 10.17 Example: Selecting a Tool Adjust Panel for the Gage Tool



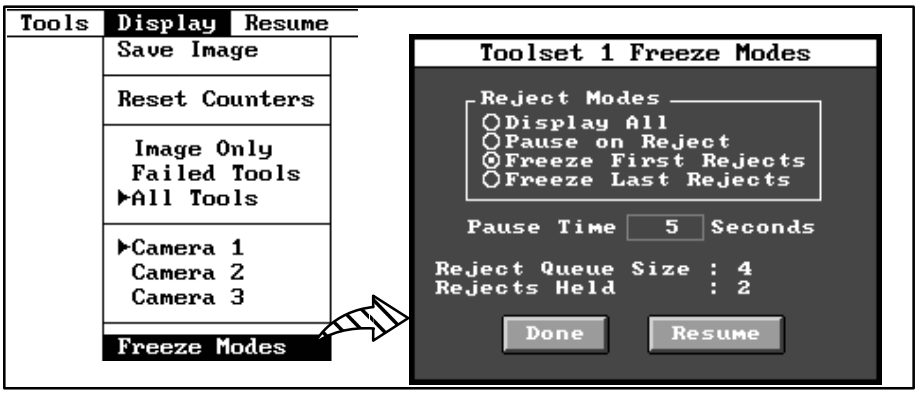
Note that the gage tool parameters that are adjustable at this time are indicated by the *active fields and buttons* — the remaining parameters are adjustable only while the system is in the *setup* mode.

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Display

When you pick Display in the menu bar, the Display menu appears, as shown in Figure 10.18.

Figure 10.18 Example: Selecting the Freeze Mode Panel



Note that the save image, reset counters, tool, and camera selections for the *online* Display panel are the same as in the *setup mode* Display panel (which is described in Chapter 4, *Inspection Configuration*, on page 4–23). The difference is that the *online* Display panel does *not* contain a Load Image field, and *does* contain a Freeze Modes field.

When you pick the Freeze Modes field, the Freeze Modes panel appears, as shown in Figure 10.18. The selections in this panel cause the system to "freeze" an image when a tool failure occurs, thus enabling you to inspect the image and possibly determine the cause of the tool failure.

Note that in the Reject Modes section of the panel you can select *one* of the following four reject display conditions:

- **Display All** — This selection causes the system to update the display continuously regardless of reject conditions.
- **Pause on Reject** — This selection causes the system to "pause" for the time specified in the Pause Time field; that is, the image is "frozen" when a reject occurs, for the specified pause time (1 to 30 seconds). After that, screen updates resume, and they continue until the next reject occurs. Inspection operations are *not* halted.
- **Freeze First Rejects, Freeze Last Rejects** — These selections cause the system to store the image associated with a reject condition. Inspection operations are *not* halted.

  When Freeze First Rejects is selected, the first rejected image will be held on the display. While the image is frozen, subsequent rejected images will be stored in the reject queue. Once the queue is full, additional rejected images will be discarded. When you select Resume, the CVIM2 will continue to update the image display if the reject queue is empty; otherwise, the next image in the queue will be removed from the queue and displayed.

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When Freeze Last Rejects is selected, the first rejected image will be held on the display. While the image is frozen, subsequent rejected images will be stored in the reject queue. Once the queue is full, the *oldest* rejected image in the queue will be removed from the queue and placed on display (in effect, an automatic *resume* when the queue is full). When you select Resume, the CVIM2 will resume the normal image display if the reject queue is empty; otherwise, the next image in the queue will be removed from the queue and displayed.

Resume

When you pick Resume in the image display menu bar, or pick the Resume button in the Freeze Modes panel, a “frozen” image is released, and the image updates *resume*.

Reject Queue Size

This field reflects the reject queue size that was selected in the Display panel, as indicated in Chapter 4, *Inspection Configuration*, on page 4–17.

Rejects Held

This field reflects the current number of reject images held in the CVIM2 system. This number, in some instances, may be one greater than the queue size.

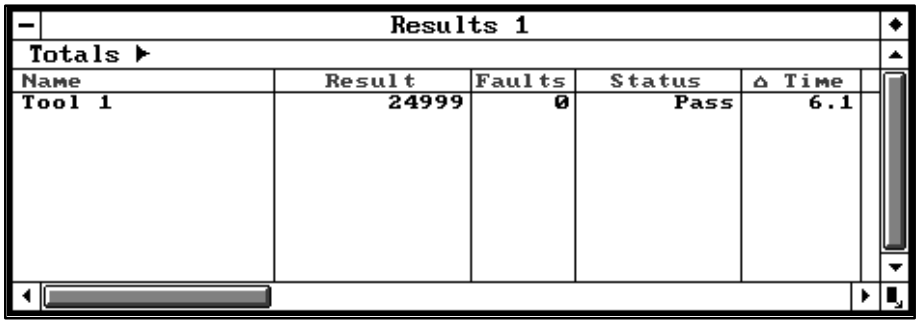
Inspection Results Display Panel

The main purpose of the inspection results panel is to display the results of each inspection cycle for each tool in the associated tool set. The panel displays the tool’s name, the pass/fail status of the previous inspection, the cumulative total of failed inspections, and the results values of the previous inspection. (Note: This panel is the same for both *online* and *offline* (“setup”) operations.)

The basic display data are illustrated by the example Results panel shown in Figure 10.19 (page 10–18).

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Figure 10.19 Example: Inspection Results Display Panel



The Results panel contains several columns having the following functions:

- **Name** — This is the name of the tool as listed in the toolset edit panel.
- **Result** — This shows the basic result value from each active tool. It is updated following each inspection.
- **Faults** — This indicates the number of faults (inspection failures) accumulated for each active tool during the current *online* session.
- **Status** — This indicates the "pass," "fail," or other status for each tool following the last inspection cycle.
- **Δ Time** — This indicates the inspection cycle time for each tool.
- **Type** — This indicates the inspection tool *type* (such as a gage or window).
- **Operation** — This indicates the *inspection operation* for which the tool has been configured.
- **Reference** — This indicates the tool number of the reference tool providing shift and/or rotation compensation. "None" indicates that no reference tool has been assigned.

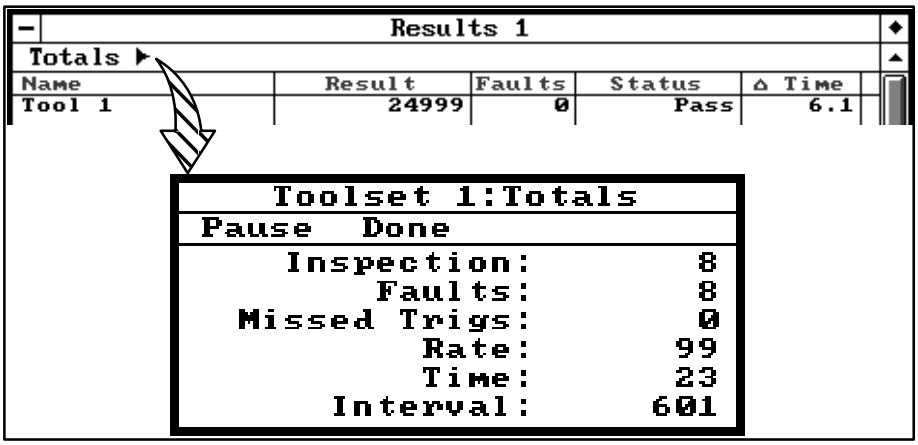
The Results panel has two other display functions: The Totals detail panel, and the Tool Results graphic detail panel. These two panels are described in the following sections.

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Totals Detail Panel

When you pick Totals in the Results panel menu bar, the Totals detail panel appears, as shown in Figure 10.20.

Figure 10.20 Example: Totals Detail Panel



The items in this panel are described briefly as follows:

- **Inspection** — This shows the cumulative total of inspections since the system was placed *online*.
- **Faults** — This shows the cumulative total of faults for the associated tool set since the start of inspection operations.
- **Missed Trigs** — This shows the cumulative total of trigger signals that the system detected, but could not process, since the start of inspection operations.
- **Rate** — This shows the current rate of inspection cycles, in parts per minute, based on the interval value.
- **Time** — This shows the time, in milliseconds, of the most recent inspection cycle.
- **Interval** — This shows the time interval, in milliseconds, between the start of the most recent inspection and the start of the previous inspection.

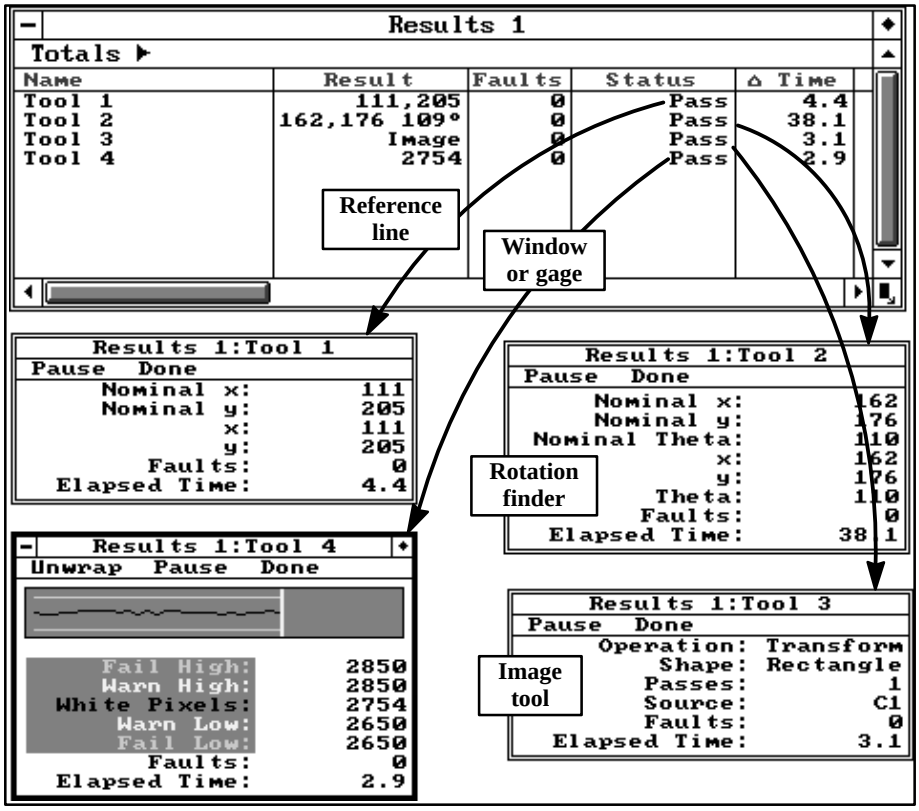
To *pause* the display updates, pick Pause in the menu bar; to *exit* the display, pick Done.

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Tool Results Detail Panel

When you “pick” anywhere along a tool results line in the Results panel under the Result, Faults, Status, or other column headings, a Results detail panel appears. Figure 10.21 provides an example of four different detail panels.

Figure 10.21 Example: Selecting Tool Results Detail Panels



Note in Figure 10.21 that the example detail panels for Tool 1, Tool 2, and Tool 3 contain only *text* data, while the panel for Tool 4 contains both text and *graphic* data. As the figure shows, the *specific* text data that appears in any detail panel varies with the tool type and tool operation, and with the inspection results.

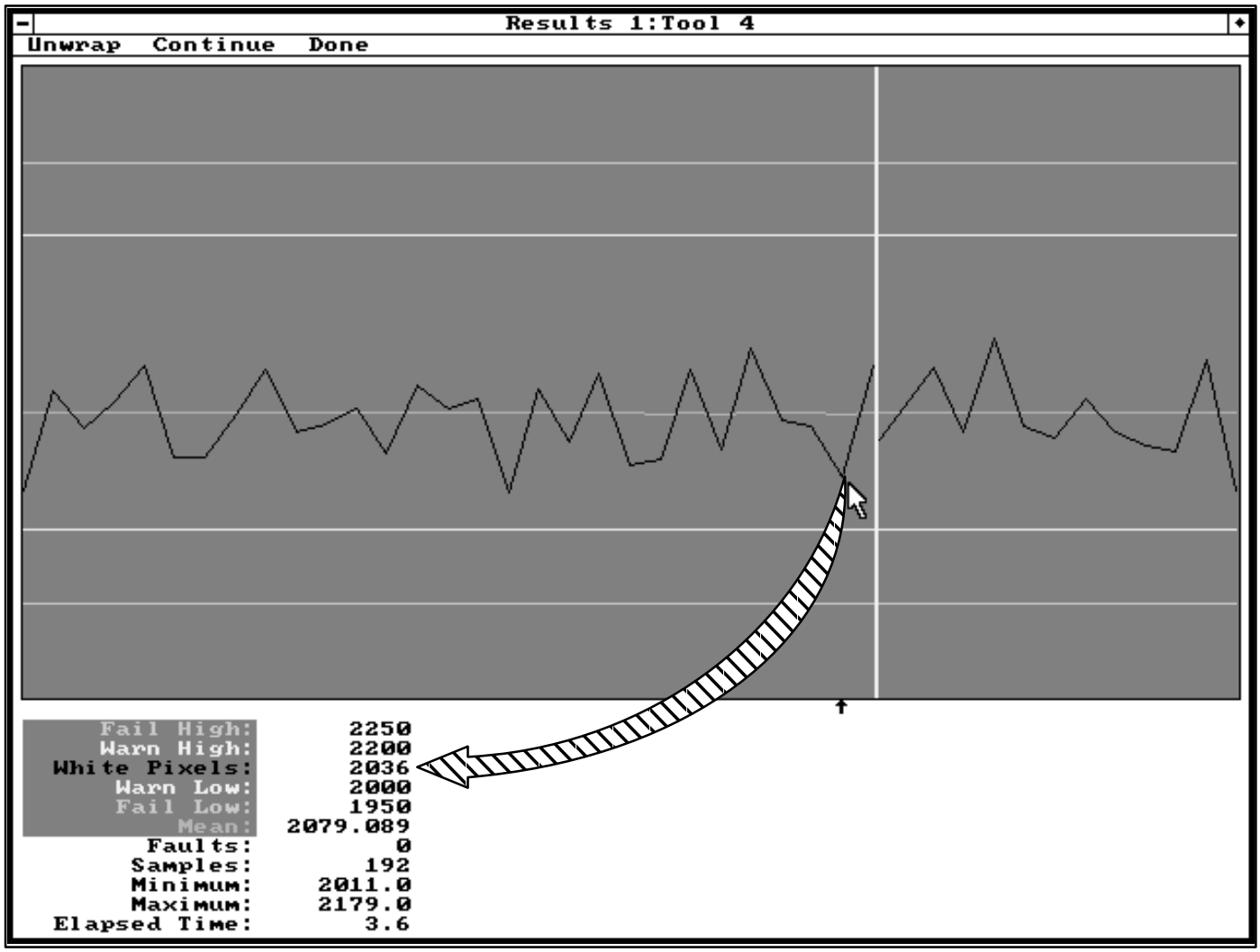
You can expand a detail panel containing *graphic* data to a larger size by picking the diamond (◆) symbol in the upper–right corner of the panel. When you pick this symbol, the detail panel expands to occupy the entire screen, with the graphic display using most of the screen space.

By picking the diamond symbol again, you can return the detail panel to the smaller size.

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Figure 10.22 illustrates an expanded detail panel. In this case, it presents results data from a window tool.

Figure 10.22 Example: Tool Results Graphic Display Panel (Maximized)



The *graphic data* elements appearing in this example panel are typical for all graphic displays, and are described briefly as follows:

- **Dynamic horizontal line (black)** — This line records the results value of each inspection cycle.
- **Dynamic vertical line (yellow)** — The line moves left to right, and shows the point of the current inspection result. Note that the inspection results on the black line just to the left of the yellow vertical line are the *newest*, while the results just to the right are the *oldest*.

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- **Dynamic horizontal line (green)** — This line shows the *relative* level of the current “mean” value.
- **Static horizontal lines (red)** — These two lines show the *relative* level of the current “fail high” value (upper line) and “fail low” value (lower line).
- **Static horizontal lines (yellow)** — These two lines show the *relative* level of the current “warning high” value (upper line) and “warning low” value (lower line).

The vertical tracking line moves from left to right. When it reaches the rightmost position of the display, it moves to the leftmost position at the end of the next inspection cycle.

To *restart* the vertical tracking line at the leftmost position on the graphic display, pick Unwrap in the menu bar; to *pause* the display updates, pick Pause in the menu bar; to *exit* the display, pick Done.

Figure 10.22 (page 10–21) illustrates how you can identify specific *results values* along the black “results” line in a graphic display. It works like this: When you position the cursor at any point on the black line and pick the line, the results value closest to the “pick” point will appear in the data table as shown in Figure 10.22. Also, a caret (∧) symbol will appear along the bottom of the graphics area, just below the pick point.

The *text data* appearing in the example (Figure 10.22) reflects the tool type (window), tool operation (white pixels), and current and statistical results data for the tool in this example. (Note that The Stat function must be selected in the Toolset Editor panel for a particular tool in order for *statistical* data to appear in the data table.)

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Chapter 11

File Functions

This chapter provides detailed information about the file–manipulation functions that you can perform in the File panel, which appears when you select the File menu in the main menu bar. Essentially, these functions enable you to examine and, in varying degrees, manipulate the files in the various internal (or external) memory elements that the CVIM2 system uses. These memory elements are called “devices” in the File panel.

File Panel: Description and Use

The File panel is like a file *directory* in the sense that it lists all files residing in the currently selected device. For most devices, the file panel can be used to manipulate files by deleting them from the device, copying them to the same device or to another device, or renaming them.

The File panel appears when you pick File in the main menu bar, as shown by the example in Figure 11.1.

Figure 11.1 Example: Selecting the File Menu



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File List Column Headings

The File panel contains a scrolling list that displays the files in the currently selected device. The column headings for the file list are described briefly as follows:

- **File Type** — This heading shows the name of the file *type* for each listed file (see the *File Types* section on page 11–4, for details).
- **Size** — This heading shows the size, in bytes, of each file in the list.
- **Name** — This heading shows the name of each file.

Devices and Device Status

To the right of the file list in Figure 11.1 (page 11–1) is the device list (see the *Devices: Definitions and Descriptions* section on page 11–6, for details). Below the file list are the status messages pertaining to the currently selected device.

You can change to a different device by simply highlighting it in the device list. At that point, the file list displays the files in the newly selected device, and the device status fields are updated to reflect the status details for that device.

The status messages shown for the EE: device in Figure 11.1 are typical of the status messages for the V1:, V2; and RM: devices; that is, these messages all indicate the status of the selected device, the memory available and memory used.

When you highlight the MC: device, however, one of the following two types of status messages will appear, as shown in Figure 11.2:

Figure 11.2 Memory Card Status Messages



In the *first* instance, the memory card is *not* installed in the front panel slot of the CVIM2 module; thus, the file list is blank, and the Battery button is shaded.

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In the *second* instance, the memory card *is* installed in the front panel; thus, the file list displays the files on the card, the Battery button is active, and the memory available/used/free message appears in the status message field. Also appearing in the message field are the following special data and status information:

- **Type** — This indicates whether or not the card is formatted for CVIM2 data.
- **Size** — This indicate the total capacity, in Kbytes, of the memory card.
- **Write Protect** — This indicate whether the write protect switch on the memory card is ON (write protected) or OFF (*not* write protected).
- **Battery** — This indicates the battery condition: OK, or Low.

File Panel Buttons

Note that a File panel contains several buttons and one data entry field. Here is a brief description of the buttons appearing at the bottom of the panel:

- **View** — When you highlight *one* file in the file list, and then pick the View button, the "Viewing file" panel appears and displays the contents of that file (see the *View* section on page 11–6, for details).
- **Copy** — The Copy button remains shaded type until you pick (highlight) one or more of the listed files. You can then pick the button to copy the highlighted file or files (see the *Copy* section on page 11–7, for details).
- **XCopy** — The XCopy button remains shaded until you pick (highlight) one or more of the listed files. You can then pick this button to copy the highlighted file or files to a different device (see the *XCopy* section on page 11–9, for details).
- **Rename** — The Rename button remains shaded until you pick (highlight) one or more of the listed files. You can then pick this button to change the name of the highlighted file or files.
- **Delete** — The Delete button remains shaded until you pick (highlight) one or more of the listed files. You can then pick this button to delete the highlighted file or files (see the *Delete* section on page 11–9, for details).
- **Done** — When you pick the Done button, the File panel disappears.

Here is a brief description of the buttons and data entry field appearing at the right side of the File panel:

- **Format** — When you highlight any device (*except* FL: and V1:) in the device list, and then pick the Format button, the format "Yes or No" decision panel appears on the screen for those devices that can be formatted (see the *Format Function* section on page 11–11, for details).
- **Recycle** — When you highlight the V1 or V2 device, the Recycle button is active. This enables you to reclaim memory occupied by deleted files (see the *Recycle Function* section on page 11–12, for details).

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- **Battery** — When you highlight the MC device, the Battery button is active. This enables you to change the memory card battery with the card in the front panel (see the *Battery Change* section on page 11–10, for details).
- **Filter field** — This data entry field enables you to list *selected* files by using the "wildcard" symbol "*" as appropriate (see the *Filter* section on page 11–5, for details).

File Types

The main file types appearing in the file list are described briefly as follows:

- **Acq. Config** — This identifies an acquisition configuration file, which contains the acquisition parameters selected for a configuration.
- **Config** — This identifies a configuration file, which contains all of the parameters associated with a particular configuration.
- **Discrete I/O** — This identifies a discrete I/O configuration file, which contains the discrete I/O parameters selected for a particular configuration.
- **Image** — This identifies an image file that was created in the image manager panel.
- **Infc. Scr.** — This identifies an interface script file, which contains a list of instructions that controls how a display panel is created and operates.
- **Insp. Scr.** — This identifies an inspection script file, which contains a list of instructions that controls how an inspection is run; that is, where to get the tools and where to place the inspection results.
- **Message** — This identifies a message file, which contains the message definitions of a particular configuration.
- **Password** — This identifies a password file, which contains user names, passwords, and user levels.
- **Priv. Dict.** — This identifies a privilege dictionary, which contains changes to default security privilege settings.
- **Reserved** — This applies to files that are generated for internal use and are not accessible to the user.
- **Str. Dict.** — This identifies a string dictionary file, which contains strings pertaining to buttons, menu boxes, error codes, and so on.
- **Tools** — This identifies an inspection tool file, which contains the parameters pertaining to each tool in a set of tools (such as gages and windows).
- **Unknown** — This applies to any file type that the system cannot recognize, such as a file downloaded from an external system or host that did not contain a file type description.

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Filter

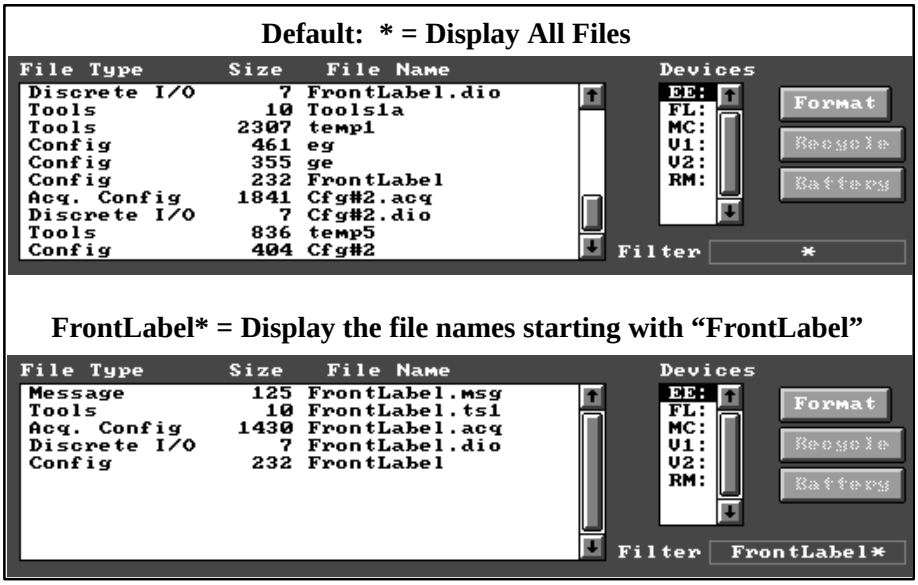
The entry in the Filter data field determines which files (if any) will appear in the file list. The Filter data field in Figure 11.1 (page 11–1) shows a single asterisk (*), which is the *default* entry in this field. It is used as a "wildcard" symbol, which means that it can be used as a substitute for all, or part, of a file *name* (not file *type*). When used alone, the asterisk causes *all* files to be listed.

The question mark (?) can be used as a wildcard symbol for any *single* character in a file name. Multiple question marks can be used, if needed.

To change the current entry in the Filter field, pick the Filter field. When you do, the keyboard appears, asking "Enter Filter." After entering a new file filter, press the Enter button on the keyboard. At that point, the file list will be amended according to the new filter.

Figure 11.3 illustrates using the (*) wildcard to amend the file list.

Figure 11.3 Examples: Different Filter Field Entries and Results



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Devices: Definitions and Descriptions

The term “device” refers to one of the six memory elements used by the CVIM2 system. The mnemonic name for each memory “device” appears in the device list, as shown in Figure 11.1 on page 11–1.

The six devices are described briefly as follows:

- **EE** — This is a 64K–byte internal EEPROM, an electrically erasable, programmable, read–only memory. It is typically used to store configuration files, the password file, tool configurations, and acquisition configurations.
- **FL** — This is an internal “flash” memory. It is used to store files that are used by the CVIM2 system software, and you cannot alter or delete these files.
- **MC** — This is an external memory card, which is a battery–backed memory that inserts into a slot in the CVIM2 front panel. It is typically used to store configuration files; however, it *can* be used to store any file from any other device. The file size is limited only by the amount of free space available on the card. Memory cards are available in sizes from 64K to 512K bytes.
- **V1** — This is an internal “flash” memory. The CVIM2 system uses it to store “help” files, string files, dictionary files, and files created by external packages.

  NOTE: You should not use the V1 device as a backup storage device for your files, since those files will be deleted when new revisions of the CVIM2 firmware are loaded.
- **V2** — This is an internal “flash” memory. It is used to store foreign language dictionary files. You may use V2 as a backup storage device for tool files, configuration files, and image files.
- **RM** — This is a portion of the internal random access memory (RAM), up to 32K bytes in size, which is intended to be used for temporary file storage. Its contents are lost when power is removed.

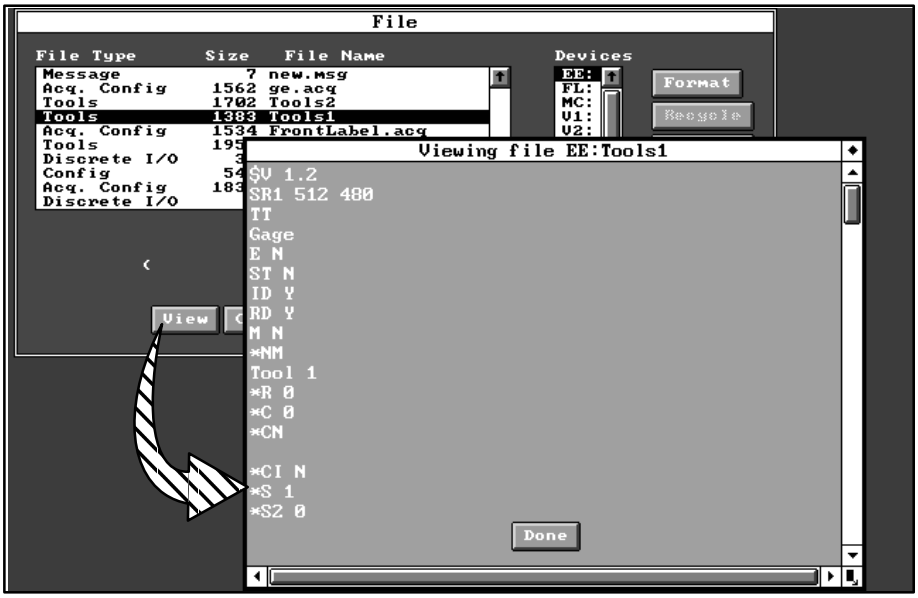
View

The view function enables you to view the contents of one of the files listed in the panel. When you pick the View button after highlighting one of the files in the file list, the “Viewing file” panel appears, as shown in Figure 11.4 (page 11–7).

This function is intended for viewing characters and strings that are in “printable” ASCII text form, such as the abbreviations and codes that represent the inspection tool configuration in the “Tools1” file in Figure 11.4. (If an image or dictionary file were viewed, the “Viewing file” would display the file in both hexadecimal and ASCII form.)

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Figure 11.4 Examples: Accessing "Viewing File" Panel



Copy

The copy function enables you to copy a file to the same device under a *different* name (a device *cannot* have two files with the *same* name). Also, you can copy a file with either the same name or a different name to a *different* device (except the FL device), provided that device has sufficient room for the copied file.

If no files are highlighted, the Copy button will be shaded. When you highlight one or more files, the Copy button becomes *active*. When you then pick the Copy button, the keyboard appears, asking you to "Copy from "xx:filename" to what file."

To copy a highlighted file to the *same* device, enter a *different* file name. To copy *multiple* files, highlight the files, and use a new name for each file.

To copy a highlighted file to a *different* device, enter a device identifier, such as "MC:" (use uppercase letters) *ahead of* the file name. You can use the same file name, or a different one, in this case.

When you pick the Enter button on the keyboard, the copy operation occurs, and the copied files enter the appropriate device under the selected file names.

Figure 11.5 and Figure 11.6 (page 11–8) provide an example of the copy operation.

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Figure 11.5 Example: Starting the File Copy Operation

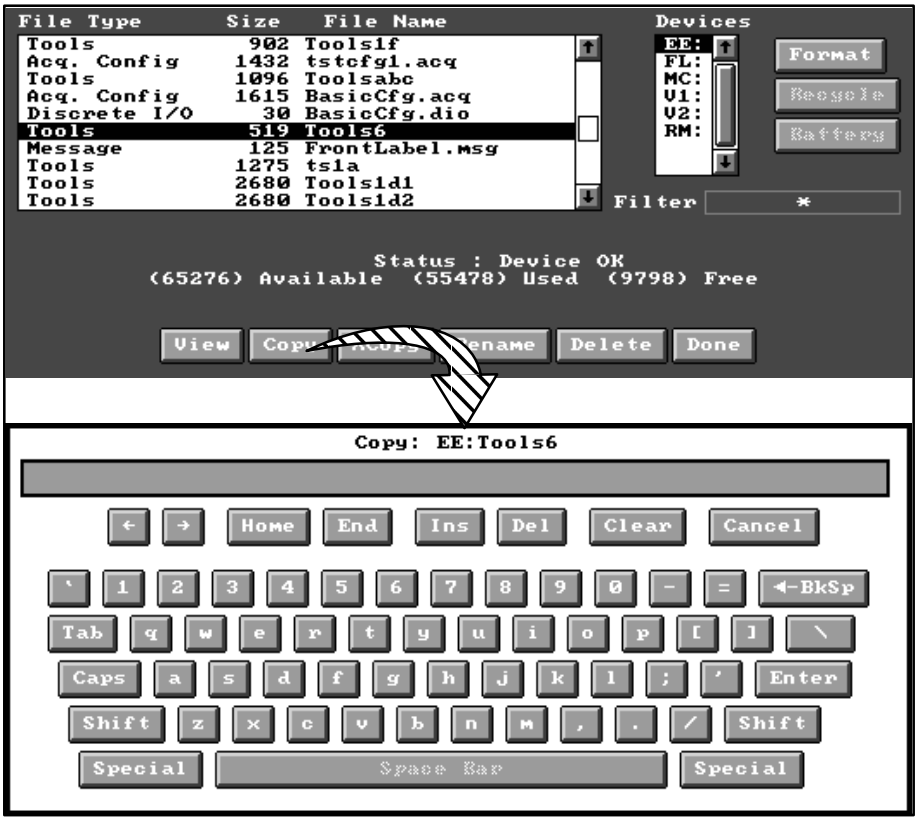
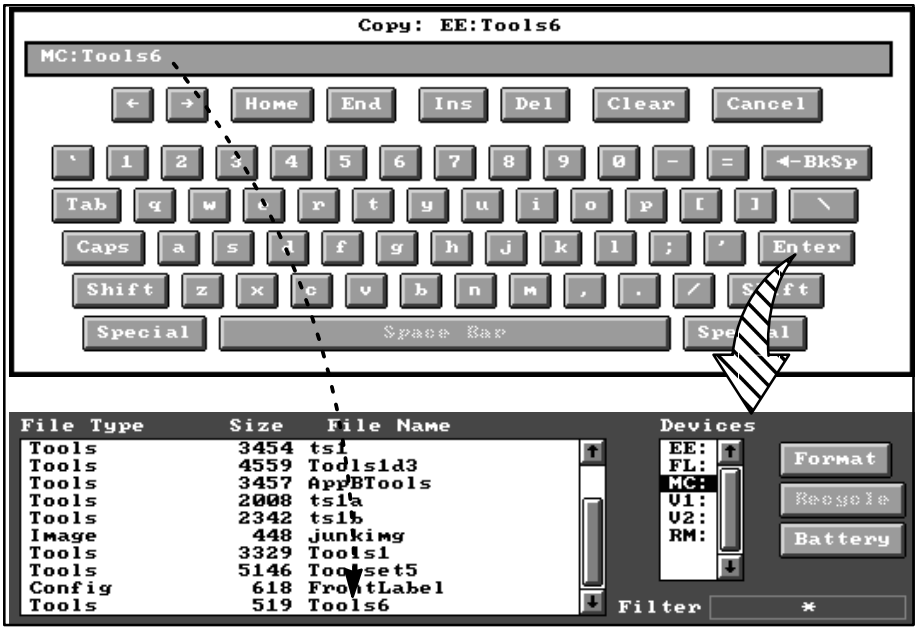


Figure 11.6 Example: Completing the File Copy Operation



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XCopy

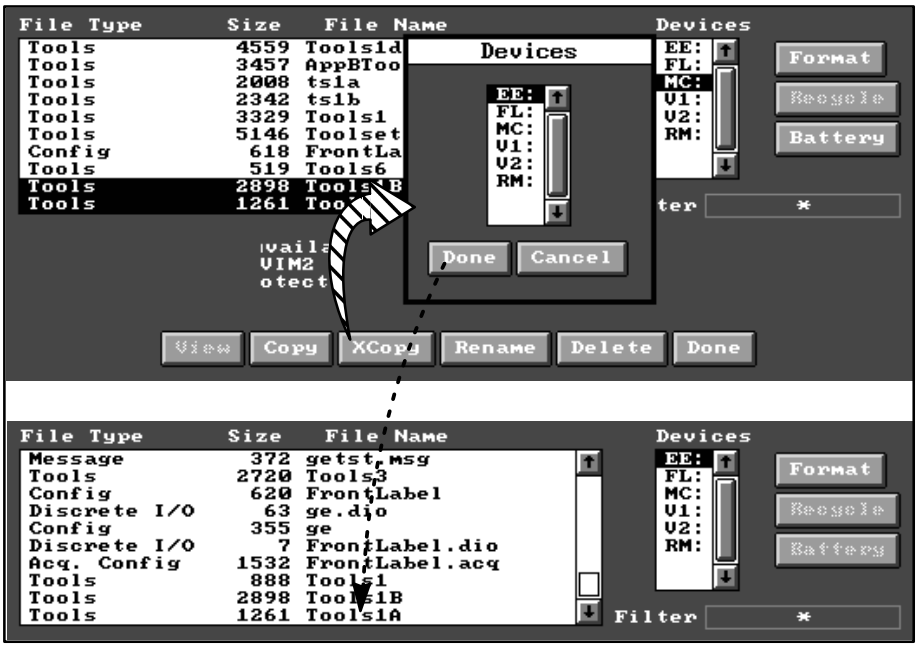
The external copy function enables you to copy one or more files in one device to a *different* device (except the FL device), provided that device has sufficient room for the copied file(s). The file name(s) remains the same.

If no files are highlighted, the XCopy button will be shaded. When you highlight one or more files, the XCopy button becomes *active*. Then, when you pick the XCopy button, the Devices selection panel appears over the File panel, as shown in the example in Figure 11.7 (page 11–9).

At this point, highlight a *different* device name in the device list as a destination for the highlighted file or files. When you then pick the Done button in the Devices panel, the external copy operation occurs.

If you examine the file listings for the EE: device, you will find the copied files there. Figure 11.7 illustrates how the transferred files might appear in the EE: device file listings.

Figure 11.7 Example: Performing the File XCopy Operation



Delete

The delete function enables you to delete one or more files in a device.

If no files are highlighted, the Delete button will be shaded. When you highlight one or more files, the Delete button becomes *active*. Then, when you pick the Delete button, a warning message box appears on the screen as shown by the example in Figure 11.8 (page 11–10).

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Figure 11.8 Example: Delete Warning Message Box



If you intend to perform the delete function, pick the Yes button; if not, pick the No button to exit the delete function.

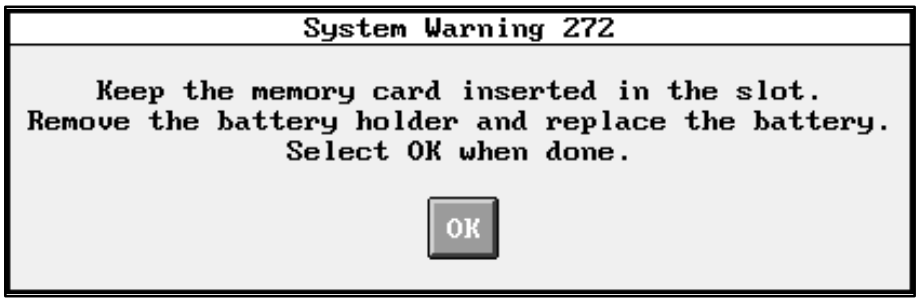
If you pick the Yes button, the file whose name appears in the warning message box will be deleted. If two or more files were highlighted in the file listing, a warning message will appear for each highlighted file. Thus, a "Yes" or "No" decision must be made for each of these files.

Battery Change

The battery change function enables you to change the battery in a memory card while the card is inserted in the CVIM2 module front panel slot. The battery should be changed whenever the battery status message (on the File panel) indicates that the battery is low, or every two years, as a preventive measure.

The Battery button becomes *active* when you highlight "MC" in the device list. When you pick the Battery button, the CVIM2 module applies power to the memory card and turns on the Memory Active LED, which indicates that you can remove the battery without losing data. Also, a warning message box appears on the screen, as shown in Figure 11.9.

Figure 11.9 Example: Battery Warning Message Box



To perform the battery change function, follow the instructions in the message box, then pick the OK button when the change is completed.

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Format Function

The format function can be used to erase all data from the external memory card and from some of the internal memory devices. When you pick Format in the File menu, a warning message box appears on the screen as shown in Figure 11.10.

NOTE 1: If the Format item in the File menu appears in shaded type, the format function for the selected device is *not* available or applicable.

Figure 11.10 Format Warning Message Box



If you intend to perform the format function, pick the Yes button; if not, pick the No button to exit the format function.

If you pick the Yes button, two messages will appear on the screen, usually in rapid succession: Format in Progress, and Format Complete.

NOTE 2: When formatting is under way for the V1: or V2: device, the Pass/Fail LED on the CVIM2 front panel alternates between orange and green until formatting is completed.

NOTE 3: When the files ".passwd, "Except.lvl," and "Except.str" are stored in the EE: device, they are *not* destroyed by a format operation on the EE: device. These files are copied to the RM: device before the format operation begins, and they are restored to the EE: device when the format is complete. (If the RM: device has insufficient space for the copy operation, the files will be copied instead to the V2: device; however, if *neither* device has sufficient space, the format operation will be *aborted*.)

Note that a *tilde* (~) is added to each filename before being copied to the RM: or V2: device. Thus, the file "Except.lvl" would be copied to the RM: or V2: device as "~Except.lvl", thereby preventing it from overwriting a file that was previously stored there under the "Except.lvl" filename. The tilde is removed from the filename when the copied file is restored to the EE: device.

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Recycle Function

The recycle function applies *only* to the V1: and V2: devices, and then *only* when you need to update the appropriate device after *deleting* one or more files in the device's file list (see the *File Panel: Description and Use* section, page 11–1, for information about the File panel).

The V1: and V2: devices are *flash memory* elements. When you copy a file from another device (such as an external memory card) to the V2: device, for example, that file will appear in the V2: device file list, *and* it will be stored in an unused portion of V2: device (assuming that sufficient space exists).

If, however, you then *delete* that same file from V2, the file will disappear from the V2: device file list, but it will continue to occupy space in the V2: device — and that space will *not* be available to files *subsequently* copied to the V2: device.

The recycle function *regains the memory space occupied by deleted files*. Thus, after deleting a file from the V2: device file list, you must pick Recycle in order to make the memory space that the deleted files occupied available to other files.

When you pick Recycle in the File menu, the recycle operation begins, and two messages appear on the screen in succession: Recycle Operation in Progress, and Recycle Operation Complete.

NOTE 1: When recycling is under way for the V1: or V2: device, the Pass/Fail LED on the CVIM2 front panel alternates between orange and green until recycling is completed.

NOTE 2: When you edit a file (such as a "Tools" file), the old version of the file will be deleted and replaced by the new version of the file after you complete your modifications. Repeatedly editing a file that is stored on the V2: device (such as a "V2:FrontLabel" tools file) can quickly fill the V2: device with *old* versions of that file, and it may increase the frequency with which you must *recycle* the V2 device. Thus, during the time that you are *actively editing* a file, you should store it on the EE: or MC: device.

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Chapter 12

System Security

This chapter provides detailed information about the system security provided in the CVIM2 system. Briefly, the system provides eight security levels, where Level 1 is the lowest level and Level 8 is the highest (system administrator) level. At each level, a user must have a user name and, optionally, a password to gain access at the authorized level.

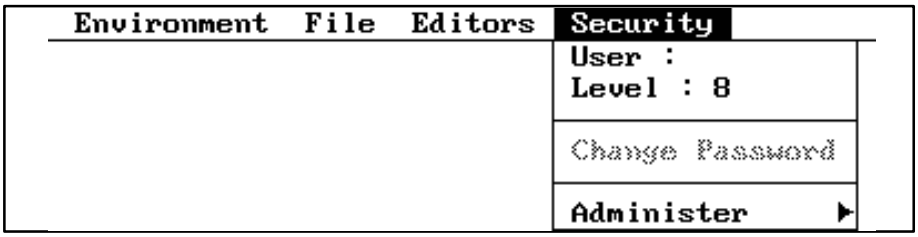
The security levels enable authorized users to access various functions within the CVIM2 system, including, for the system administrator only, altering or customizing some of the text fields in menus and "buttons," and changing "privilege" levels that enable access to various parts of the system.

The CVIM2 system provides *default* levels for access to these functions. Initially, some functions require a Level 8 for access, while others require a Level 1. The system administrator can change many of these default levels as required for a particular installation.

Security Levels

The security assignments are performed in the Security menu, which appears when you pick Security in the main menu bar. Initially, the menu bar and Security menu appear as shown in Figure 12.1.

Figure 12.1 Initial Appearance of Main Menu Bar and Security Menu



The security levels are described briefly, as follows:

- **Levels 1 through 7** — These levels are all assignable; that is, the system administrator can enable and disable access to various system functions (*except* system administration functions) as required by designated users at each level.
- **Level 8** — This level enables the system administrator to have access to *all* system and security setup functions.

NOTE 1: Initially, the *default* user is "no user," and the security level is Level 8. Security is *not established* until a password file is created.

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NOTE 2: The *first* user level created should be Level 8, since after a password file has been created, the CVIM2 system *always* defaults to the Level 1 user following powerup. If Level 8 is *not* the first user level created, the system will *automatically* create a *default* Level 8 user. Thus, when the system power is subsequently cycled, the user can obtain access to Level 8 functions by entering the following user name and password:

User name: superuser

Password: key

When the *default* Level 8 user has been created, it should be *replaced* as soon as possible with a *permanent* Level 8 user name and password, in order to avert unauthorized entry to system administrator–only functions.

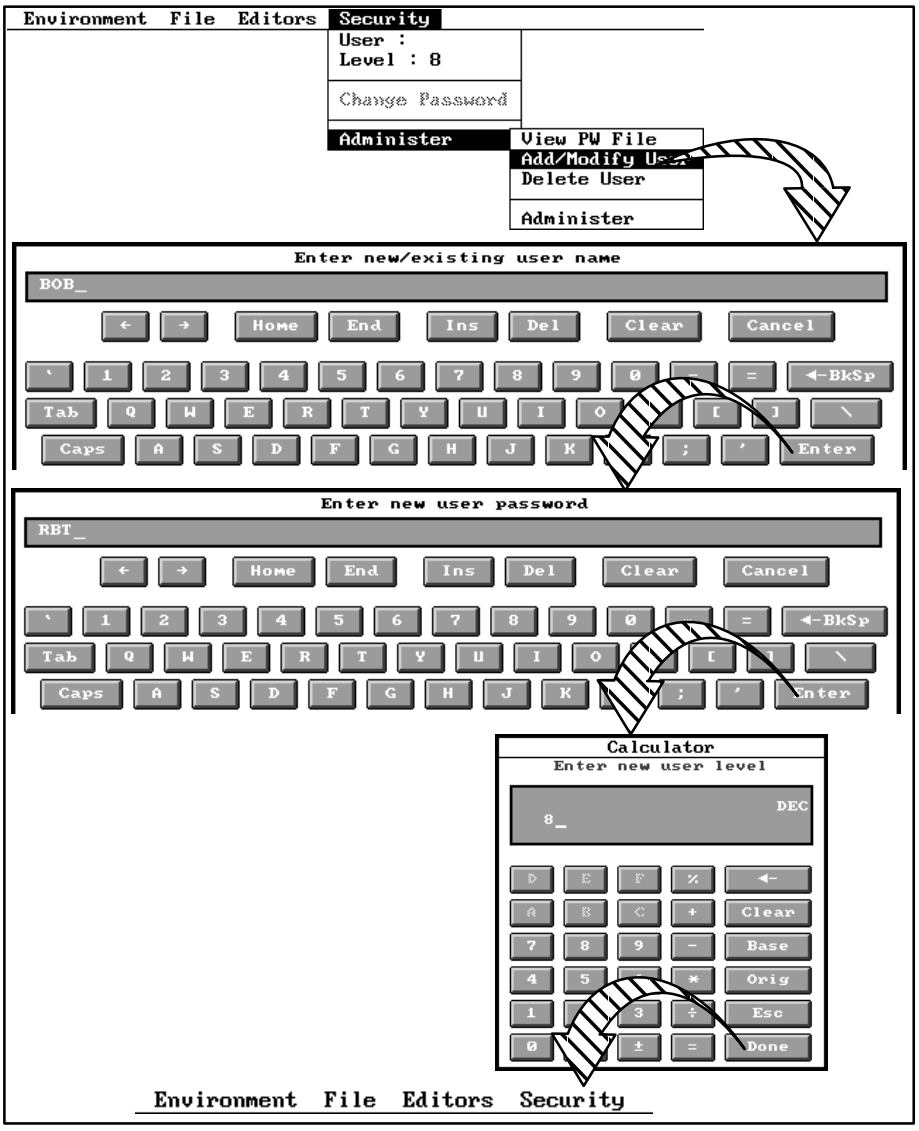
NOTE 3: The password file, which appears in the EE: filer as file type "Password" and file name ".passwd," can be sent to a host system; however, the user name and password data are encrypted for security.

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Initial Level 8 Security Setup

Since the system initially has no password file, the system security level defaults to Level 8, and *any* user can access *all system functions*. Thus, in order to restrict access, the system administrator should first establish a *user name* and *optional password* for Level 8 — for administration access only. This process is illustrated in Figure 12.2.

Figure 12.2 Example: Initial Security Setup –– Level 8

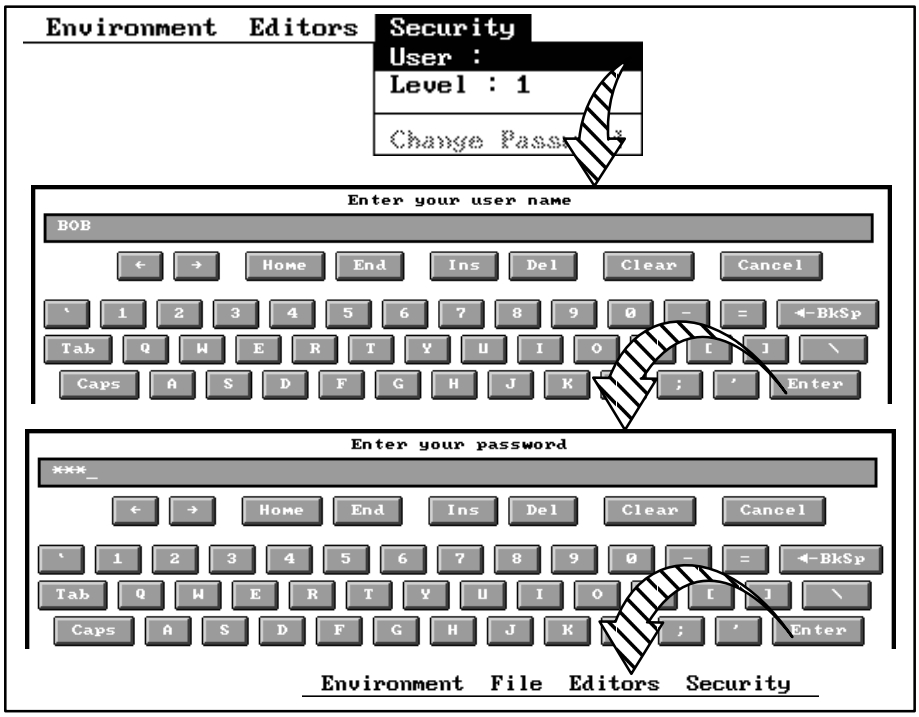


Once the system administrator's Level 8 user name/password is entered, the CVIM2 system will default to Level 1 on all subsequent power up operations. Thereafter, the administrator *must* enter the Level 8 user name/password correctly, using the appropriate uppercase and lowercase characters, in order to gain access to Level 8 functions.

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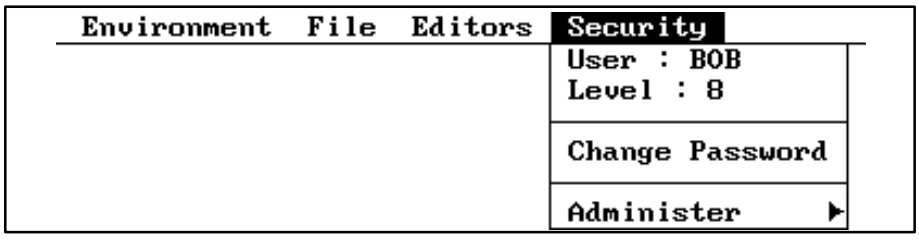
This is illustrated by the example in Figure 12.3. Upon powerup, the main menu bar will reflect the Level 1 condition; that is, "File" is missing, and Level : 1 appears in the Security menu. In this example, when the user name "BOB" and password "RBT" are entered (the password appears as "***" in the keyboard), the main menu bar returns to its previous Level 8 appearance.

Figure 12.3 Example: Entering Level 8 User Name and Password



When Security is then picked, the Security menu will show User : BOB and Level : 8, as shown in Figure 12.4.

Figure 12.4 Example: Security Menu With Level 8 User Entered



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Password Changes

This section illustrates the procedure for changing a user's password. When you pick Change Password, a keyboard appears, as shown in Figure 12.5.

Figure 12.5 Example: Changing Password



The title line above the keyboard asks "Enter your password." This means that you must enter your *current* password (not the new one). Note that as you enter the password, an asterisk (*) appears in place of each character of the password. When you complete the password entry, press the Enter button.

After pressing the Enter button (and assuming that you entered the *correct* password) the keyboard reappears with the title line now asking "Enter your new password." Again, an asterisk (*) appears in place of each character of the new password as you enter it. When you complete the new password entry, press the Enter button.

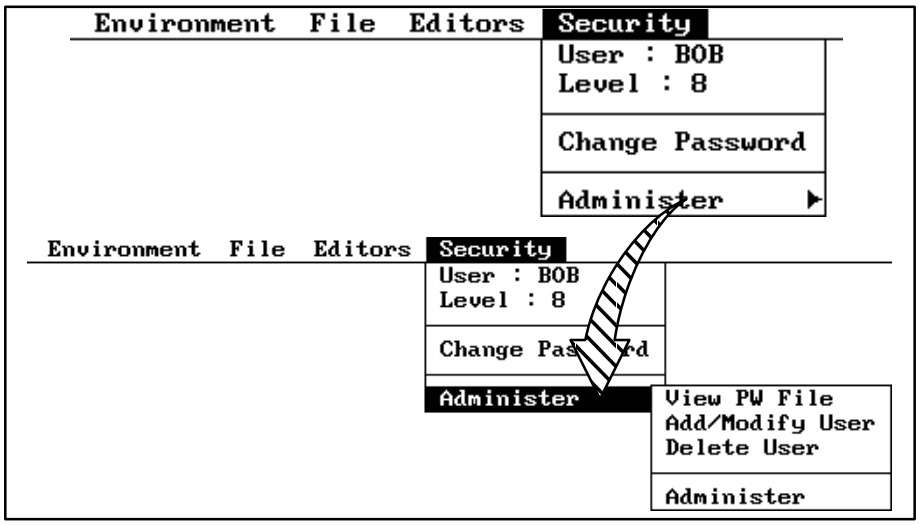
After you press the Enter button, the keyboard reappears, this time with the title line asking "Verify the new password." When you finish reentering the new password, press the Enter button. If you reentered the changed password correctly, the keyboard will disappear, indicating that the password change was successful.

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Security Administration

This section discusses the security functions that are accessible *only* to the Level 8 user (the "administrator"). When you pick Administer in the Security menu, the Administer menu appears, as shown in Figure 12.6.

Figure 12.6 Selecting the Administer Menu (Level 8 Only)



The Administer menu contains three items that enable the administrator to inspect the password file, add new users, modify the password of any existing user, or delete any user from the security system. In addition, it contains an Administer function, which enables the administrator to change the text in selected menu fields and buttons.

View Password File

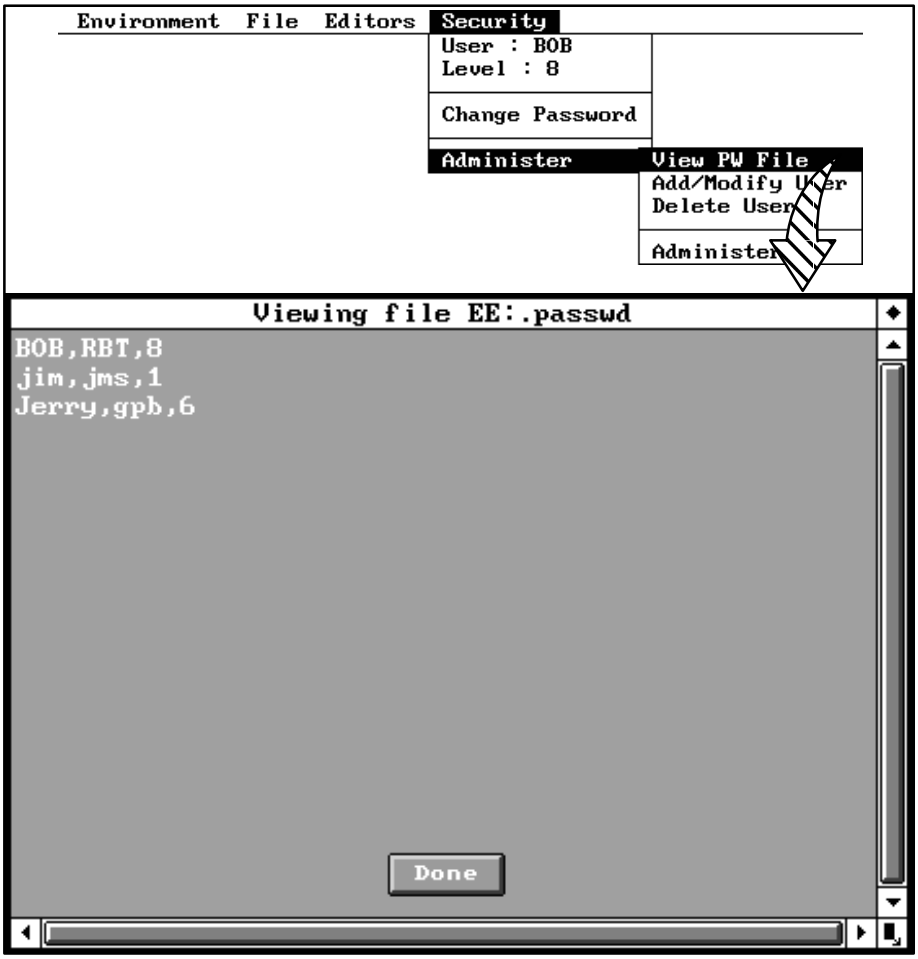
When you pick View PW File, the "Viewing file <filename>" panel appears, an example of which is shown in Figure 12.7 (page 12–7). This panel contains the contents of the "EE: .passwd" file.

From left to right, each line entry in this panel shows the user name, the password, and the security level. For example, the topmost entry in Figure 12.7 shows that the user's name is "BOB," the user's password is "RBT," and the user's level is "8." Thus, in this case, the top entry is also the system administrator, while the remaining entries have lower security levels.

Note that the top–down order in the "Viewing file" list indicates only the *order* in which the entries were made, *not* the hierarchy of security levels (the Level 8 user could just as well have been the *last* in the list).

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Figure 12.7 Example: Selecting the Password File Viewing Panel



Note also that you can only *view* the entries in this panel; you cannot change them at this point. To do that, you must pick the "Add/Modify User" or "Delete User" items in the Administer menu. These are described in the following sections.

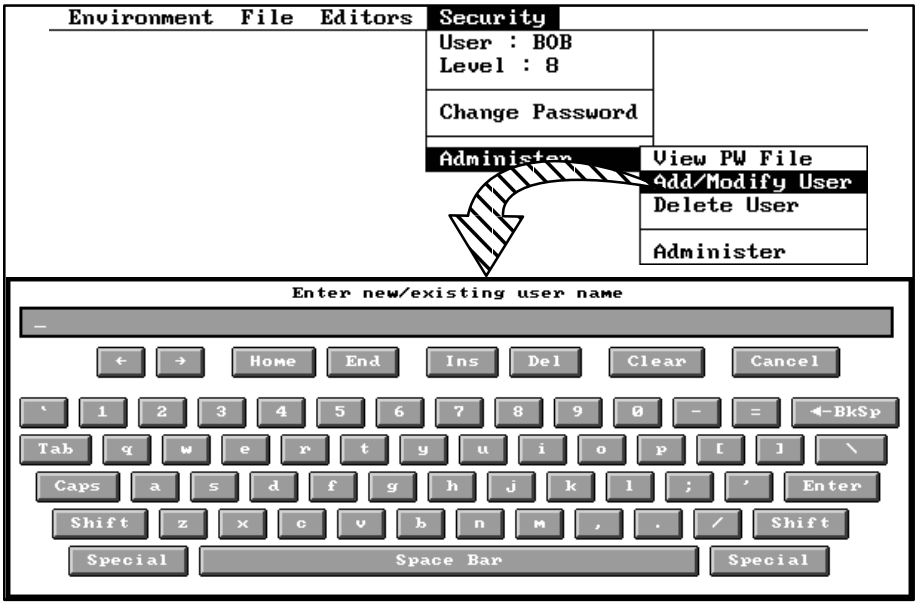
When you are finished viewing the password file, pick the Done button to exit the file and return to the main menu bar.

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Add a New User or Modify an Existing User

When you pick Add/Modify User, the keyboard appears, as shown in Figure 12.8.

Figure 12.8 Example: Selecting Add/Modify User



The title line above the keyboard asks "Enter new/existing user name." This means that you must enter a *new* name to *add* a user, or enter an *existing* name to *modify* that user's password or security level.

Adding a New User

With the keyboard displayed as shown in Figure 12.8, above, use the following steps to enter a *new* user.

Enter a new user name on the keyboard. After entering the name, press the Enter button. When you do, the keyboard reappears with the title line now asking "Enter new user password."

Enter the new user password on the keyboard. After entering the password, press the Enter button. When you do, the keyboard reappears, this time with the title line asking "Enter new user level."

After entering the user level, press the Enter button. When you do, the keyboard will disappear, indicating that the new user was entered successfully and is stored in the password file.

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Modifying an Existing User

With the keyboard displayed as shown in Figure 12.8 (page 12–8) use the following steps to modify an existing user's password and/or level.

Enter the existing user name on the keyboard. After entering the name, press the Enter button. When you do, the keyboard reappears with the title line now asking "Modify existing user password."

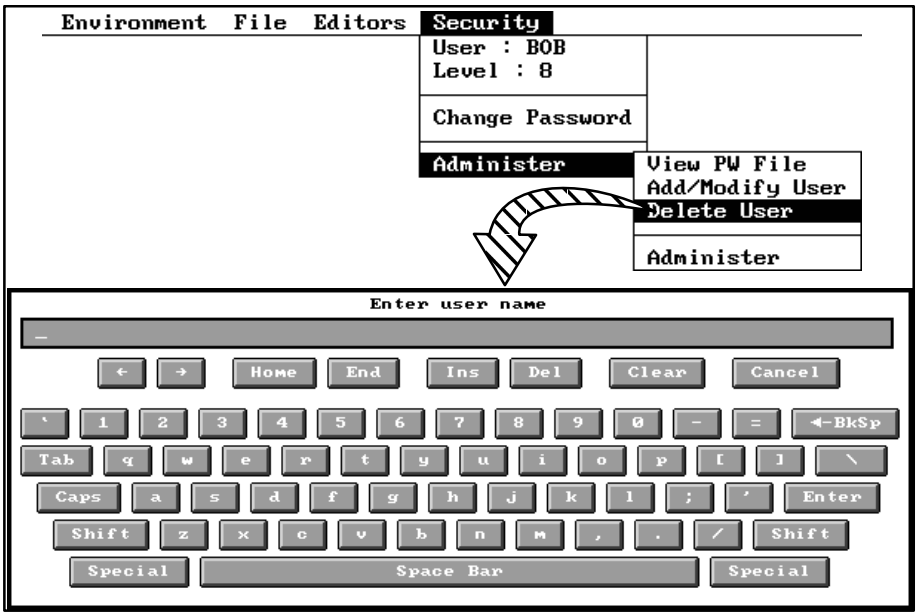
If appropriate, press the Clear button to clear the previous password, then enter a *new* user password on the keyboard. After entering the new password, press the Enter button. When you do, the keyboard reappears, this time with the title line asking "Modify existing user level."

If appropriate, enter a different user level number. After entering the new user level number, press the Enter button. When you do, the keyboard will disappear, indicating that the existing user's password and/or user level was entered successfully and is stored in the password file.

Delete a User

When you pick Delete User, the keyboard appears, as shown in Figure 12.9.

Figure 12.9 Example: Selecting Delete User



The title line above the keyboard asks "Enter user name." This means that you must enter an *existing* name to *delete* that user from the password file.

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With the keyboard displayed as shown in Figure 12.9 (page 12–9), use the following steps to delete an existing user from the password file:

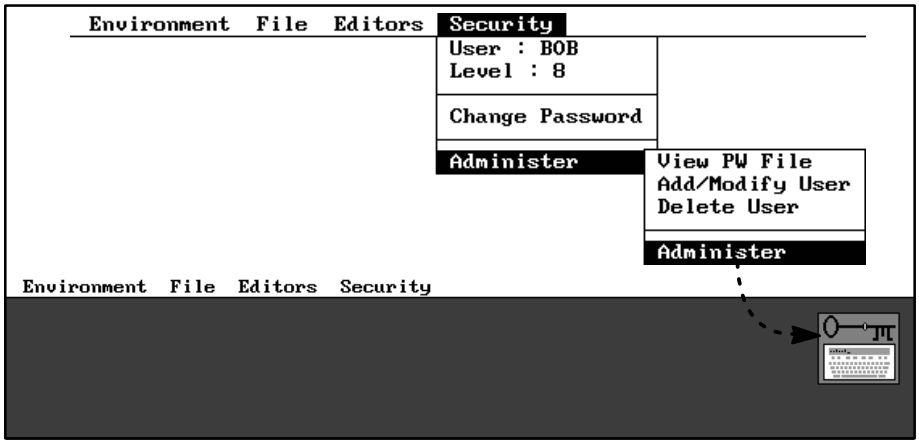
Enter the existing user name on the keyboard. After entering the name, press the Enter button. When you do, the keyboard will disappear, indicating that the existing user was deleted successfully and is *no longer* stored in the password file.

Administer Function

The "administer" function enables the system administrator to customize certain text fields in menus and buttons, and to change the "privilege" levels for some of these menu and button items from their default access privilege settings of Level 8 or Level 1.

When you pick Administer in the Administer menu, the Administer icon appears under the Help icon, as shown in Figure 12.10, indicating that the administer function is enabled.

Figure 12.10 Example: Selecting Administer Function



When you pick the Administer icon, the icon disappears and the following message appears . . .

```
Select the item to be changed.
```

. . . and, after a few seconds, the message also disappears. At this point the system is fully enabled for modifying text and/or privilege levels and is waiting for you to pick an item to be changed.

NOTE: You must have the item to be changed already appearing on the screen *before* picking the Administer icon.

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Changing Text: Menu Field

After enabling the system for text/privilege changes, as described in the preceding section, you must pick the item that is to be changed. An example of this process is illustrated in Figure 12.11 (page 12–12). In this example, the "File" text field in the main menu is changed to "File Storage."

When you pick File in the main menu, the Change Menu Option panel appears, as shown in Figure 12.11. Note that the *current* name, "File," appears in the Menu Option field. When you pick this field, the keyboard appears with the current name in the entry field.

At this point, you would type in "File Storage" and pick the Enter key to exit the keyboard. When you do, the new name "File Storage" appears in the Menu Option field of the Change Menu Option panel. When you pick the Done button, the main menu appears with the new name File Storage in place of the previous name.

Changing Text: Button Field

The process for changing text in a button is basically the same as for changing text in a menu field, described above. The first step is to make sure the button appears on the display *before* picking the Administer icon. Then, pick the button to access the change panel (titled Push Button Change in this case).

NOTE: If you pick a button that the system does not allow to be changed, the message . . .

```
This item cannot be changed.
```

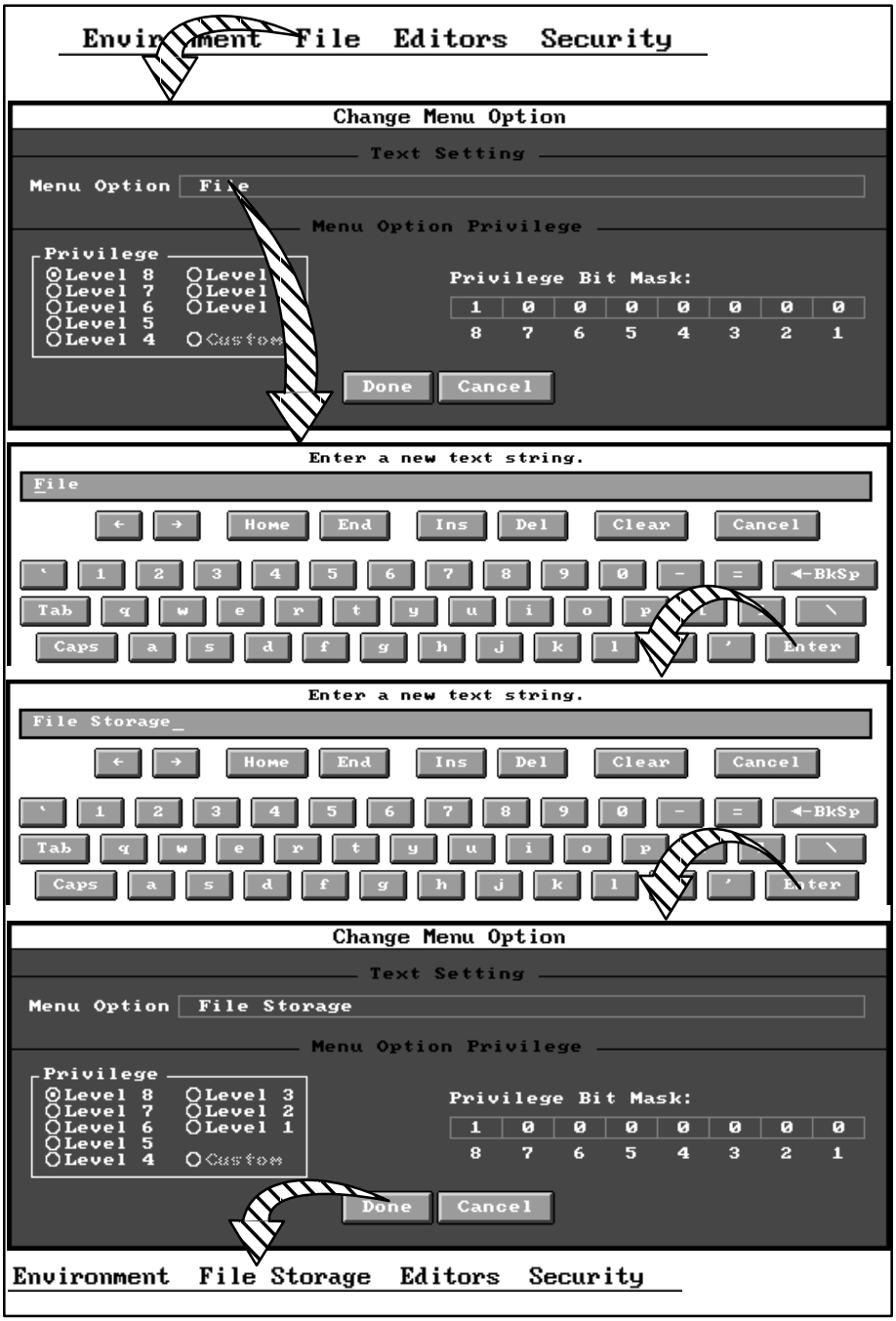
. . . will appear on the screen.

As an example of changing button text, if you wanted to change the Ranges button in a tool edit panel to "HiLo Limits," you would first pick the Administer icon to *enable* the change operation. You would then pick the Ranges button to access the Push Button Change panel, enter "HiLo Limits" in the Menu Option field, and pick the Done button. The new name "HiLo Limits" would then appear in button instead of "Ranges."

Note that in the Ranges button example, the full change panel appeared, which allows both text modifications and access privilege level changes (described later). If, however, you pick the Done button, the *abbreviated* version of the change panel would appear. The difference is that this panel provides for text changes *only*. The system does not allow privilege level changes for this button.

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Figure 12.11 Example: Changing “File” to “File Storage” in Main Menu Bar

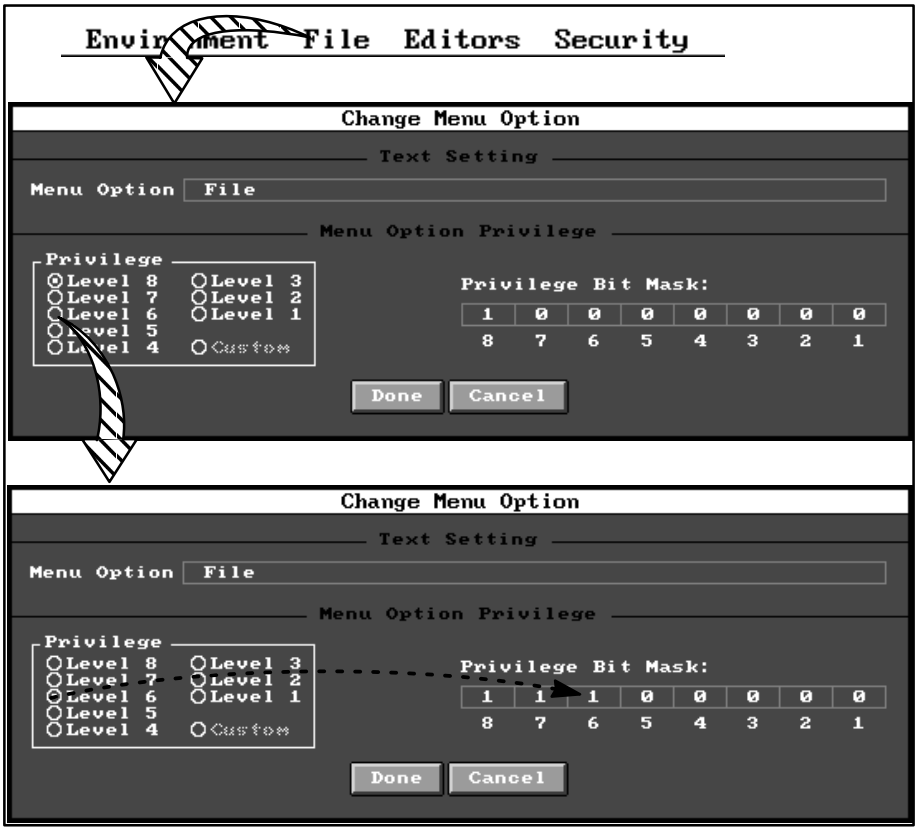


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Changing Access Privilege Levels

The process for setting up a privilege change is the same as for changing menu and button text fields. Thus, if the privilege level for "File" (see Figure 12.11, page 12–12) is to be changed to include Level 6, the Level 6 selector must be picked as shown by the example in Figure 12.12.

Figure 12.12 Example: Changing Privilege Level



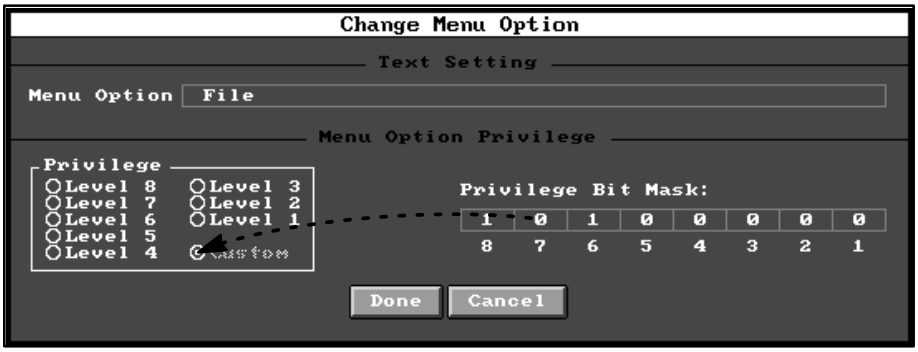
Note that *initially* Level 8 is selected in the Privilege box, while in the Privilege Bit Mask section, only Bit 8 is a "1." Together, these indicate that by *default* only a person with a Level 8 access (the system administrator) has access to "File" from the main menu bar.

When you pick the Level 6 selector, Bit 8, Bit 7, and Bit 6 are all "1." By *default*, whenever you select a level *below* Level 8 in the Privilege box, the levels *above* will become (or remain) "1," which means that the selected level *and all higher users* will have Level 8 access (to "File" in the main menu bar, in this case).

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When you then pick Security, the Security menu will appear as shown in Figure 12.14 (page 12–14). You can then access the filer containing the existing password file and view the Level 8 user name and/or password, or, if a Level 8 user name/password was never entered, enter a *new* one. If, for some reason, you want only Level 8 and Level 6 users to have access to "File," you can pick the "1" box above "7" in the Privilege Bit Mask to toggle it to "0," as shown by the example in Figure 12.13.

Figure 12.13 Example: Customizing Privilege Level



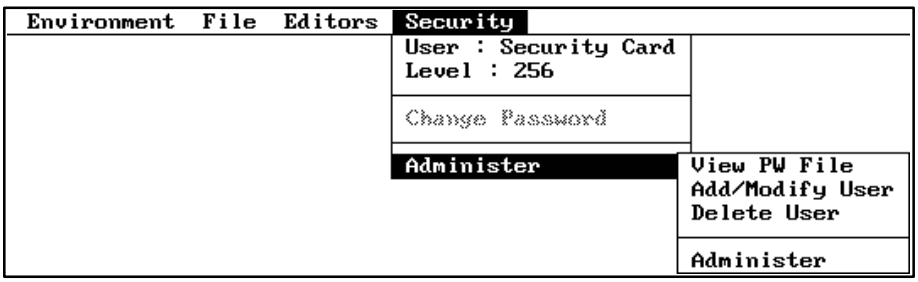
This *disables* access to "File" for Level 7 users. Note in the selection in the Privilege box has changed from Level 6 to Custom, since this is a *custom* privilege configuration.

Security Card

A "security" memory card must be used for Level 8 access to the CVIM2 system whenever the Level 8 user name (other than the system–created "Superuser") and/or password has been misplaced or forgotten, and the current security level is Level 7 or lower.

To regain Level 8 access, you must insert the security card into the Archive Memory slot on the front panel of the CVIM2 module. In a second or two, the *full* main menu bar will appear. When you pick Security in the main menu, the Security menu appears as shown in Figure 12.14.

Figure 12.14 Security Menu With Security Card Inserted



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You should then pick the "Administer" field in the Security menu to access the Administer menu, as shown in Figure 12.14.

At this point, you can either pick View PW File to view an existing password file and record (if appropriate) the *existing* Level 8 user name/password, or, if a Level 8 user name/password was never entered, pick the Add/Modify User field and enter a *new* Level 8 user name/password as described in the *Add a New User* or *Modify an Existing User* section of this chapter.

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Appendix A

Warning and Error Messages

This appendix tabulates all of the CVIM2 system warning and error messages, which are listed in ascending numerical order. Each message appears in a message box on the monitor screen. The text of each message is shown under the “Message Text” heading in the table. A brief statement of the “reason” for each message is shown under the “Conditions” heading.

Warning/Error Code	Message Text	Conditions
256	Too many open files	Open file limit exceeded.
257	File not found	Requested file does not exist.
258	File exists	Requested file exists and should not for the current operation.
259	No such device	Requested device is not in the device list.
260	No space left on device	There is insufficient space on the requested device for the operation.
261	Invalid access mode	The device does not support the requested access.
262	I/O error	An error exists on the device.
263	Write access denied	The device is read only or write protected.
264	Illegal seek	Requested seek is out of bounds for the file.
265	Device has no directory	The device does not support a directory.
266	Too many open directories	Open directory limit exceeded.
267	CRC on file failed	The data in the file is corrupted.
268	Error deleting file *name*	The specified file should not be deleted.
269	Error renaming file *name*	The specified file should not be renamed.
270	Error copying file *name*	The specified file should not be copied.
271	Error reading file *name*	The specified file should not be read.
272	Keep the memory card inserted in the slot	Memory card change battery operation in progress.
273	Too many files on device	The maximum number of files for the device (200) has been exceeded.
274	EEPROM is corrupted and has been formatted.	Power loss occurred during a file write operation.

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Warning/Error Code	Message Text	Conditions
275	Language could not be installed.	Insufficient memory on the device for language files.
276	Help file could not be installed.	Insufficient memory on the device for language files.
512	Can't initialize device manager	Device Manager initialization fault. (1)
513	Too many devices installed	Device limit exceeded.
768	Default ISR executed	An unknown or unserviceable interrupt has occurred. (1)
769	Software watchdog triggered	Software watchdog task has been idle for too long a period. (1)
770	Hardware watchdog triggered	Hardware error. (1)
771	Out of memory	None. (1)
772	Out of memory	Insufficient memory for the current operation.
773	Memory tracking – Block missing	None. (1)
774	Memory tracking – Bad address from mm_malloc()	None. (1)
775	Memory tracking – Memory block corrupted	None. (1)
776	System state transition failure	A system state transition is unsuccessful.
777	Bad memory block passed to free	An attempt is made to free up a memory block with an invalid address.
778	Environment variable cannot be set or deleted.	A command is received to set or delete an environment variable which does not exist.
779	Environment is empty or bad.	The EE area reserved for archiving environment variables has been corrupted.
780	Package functions will not be installed	Package load aborted during powerup.
781	Online memory exceeded	Configuration is too large, or memory has become fragmented.
782	Package initialization error.	None. (1)

Note (1). There is no condition in the CVIM2 Default System where this error would be expected to occur. Packages may use the operating system in such a way as to cause this error.

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Warning/Error Code	Message Text	Conditions
783	Run–time error. System has been taken off–line. Toolset <n> has delayed messages or outputs but no pulse input.	A message or output signal of the specified toolset has a nonzero pulse delay, but the toolset has no Pulse input assigned. The error is not detected until the message or output signal is actually generated in run mode.
	Run–time error. System has been taken off–line. Part tracking requirements have exceeded available memory.	Messages or output signals accumulate in the tracking queue until memory is exhausted.
	Run–time error. System has been taken off–line. Unable to build a message with an input event.	A message is generated by an interrupt input bit and interrupts come in faster than the corresponding messages can be built.
	Run–time error. System has been taken off–line. Toolset <n> inspection time exceeded tracking pulse delay.	A toolset has a delayed output or message whose pulse delay expires before the inspection is complete.
1024	Can’t get results set version in inspection	A required results set version does not exist. (1)
1025	Formula initialization error	Formula manager initialization fault. (1)
1026	System mode is incorrect for this request	A command is issued which is not serviceable under the current system mode.
1027	Bad status in buffer manager.	None. (1)
1028	System state is incorrect for this request	A command is issued which is not serviceable under the current system state.
1029	The tool was modified to fit.	A tool’s position and/or size is modified to fit a specific source image.
1030	The tool failed	Inspection operation failed.
1031	No source image	Source image not available for inspection processing.

Note (1). There is no condition in the CVIM2 Default System where this error would be expected to occur. Packages may use the operating system in such a way as to cause this error.

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Warning/Error Code	Message Text	Conditions
1032	The tool reference failed	The tool's associated reference tool failed, or the registration operation moved the tool off of the image.
1033	The tool is outside of the image	Tool coordinates are outside of the image.
1034	Too many edges	Image is too noisy, or there is insufficient scratch memory to analyze the current image.
1035	No edge memory	Scratch memory size is 0.
1036	Incorrect tool shape	Tool file is corrupt.
1037	Unknown tool operation	Tool file is corrupt.
1038	One or more features could not be found	An edge or feature could not be located in the current image.
1039	Range failure	Inspection tool failed the range specified limit.
1040	Too many contours	Image is too noisy, or there is insufficient contour memory to analyze the current image.
1041	Too many start points	Image is too noisy, or there is insufficient contour memory to analyze the current image.
1042	Too many contour points	Image is too noisy, or there is insufficient contour memory to analyze the current image.
1043	Not enough scratch memory	Image is too noisy, or there is insufficient scratch memory to analyze the current image.
1044	Data type error	Tool file is corrupt.
1045	High range fail	Inspection result is greater than the high fail limit.
1046	Low range fail	Inspection result is less than the low fail limit.
1047	No destination image	Inspection tool requires a destination image.
1048	Bad formula	Invalid tool name, operand, or string in the formula.
1049	Could not access result	Specified inspection result does not exist.
1050	Division by zero	Formula divisor is zero.
1051	Out of domain	Formula result is an imaginary number (e.g., $\sqrt{-9}$).

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Warning/Error Code	Message Text	Conditions
1052	Formula too big	Formula size limit has been exceeded (128 bytes for Math tool, 64 bytes for Build Ref. tool).
1053	Parentheses mismatch	Incorrect number or sequence of parentheses in formula.
1054	Wrong number of parameters	Incorrect number of operators for the specified formula operand.
1055	A timeout occurred	None. (1)
1056	High range warning	Inspection result is greater than the high warning limit, but less than the high fail limit.
1057	Low range warning	Inspection result is less than the low warning limit, but greater than the low fail limit.
1058	Size exceeds buffer length	Tool adjust (tooladj) command is too long to process.
1059	Binary source image not supported	Profile tool cannot inspect binary images.
1280	User name *name* not found	Specified name is not in the password file.
1281	Incorrect password	Specified password is incorrect.
1282	Verification of password failed	Password entered for verification does not match previously entered password.
1283	Invalid user name *name* (commas not allowed)	Invalid character in a user name.
1284	Invalid password *password* (commas not allowed)	Invalid character in a password.
1285	Invalid domain *name*	Invalid domain specification.
1286	Password file is corrupt – Delete it	Password file has been corrupted.
1536	Start of image marker not found	Invalid JPEG file.
1537	Unsupported compression type	Unsupported JPEG mode.
1538	End of file found	Invalid JPEG file.
1539	Unknown marker found	Invalid JPEG file.
1540	Bad sample size	Invalid JPEG file.
1541	Bad segment length	Invalid JPEG file.

Note (1). There is no condition in the CVIM2 Default System where this error would be expected to occur. Packages may use the operating system in such a way as to cause this error.

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Warning/Error Code	Message Text	Conditions
1542	Bad number of components in a scan	Invalid JPEG file.
1543	Bad spectral start	Invalid JPEG file.
1544	Bad restart marker found	Invalid JPEG file.
1545	Not enough memory for allocation request	Insufficient memory for the operation.
1546	Invalid table identifier	Invalid JPEG file.
1547	Invalid quantization table precision	Invalid JPEG file.
1548	Unexpected DNL marker found	Invalid JPEG file.
1549	Unexpected marker found	Invalid JPEG file.
1550	File error detected	Invalid JPEG file.
1551	Unknown huffman code found	Invalid JPEG file.
1552	The huffman table specified in scan not defined	Invalid JPEG file.
1553	The quantization table specified in scan not defined	Invalid JPEG file.
1554	Invalid component ID found	Invalid JPEG file.
1555	Decoding was aborted due to request for information only	Request was for file information only.
1792	Discrete I/O initialization error	None. (1)
1793	Backplane I/O initialization error	None. (1)
1794	Remote I/O initialization error	None. (1)
1795	Can't start communications task	None. (1)
1796	CVIM2 not in module list	CVIM2 module not found in the PI module list. (1)
1797	CVIM2 rejected by controller	CVIM2 module has been rejected by the rack controller. (1)
1798	Powerup out of phase	Rack powerup sequence is out of phase. (1)
1799	Bad bit number	Invalid discrete I/O bit specified. (1)
2048	Panel Manager Error	None. (1)

Note (1). There is no condition in the CVIM2 Default System where this error would be expected to occur. Packages may use the operating system in such a way as to cause this error.

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Warning/Error Code	Message Text	Conditions
2049	Panel Manager Help System Error	Invalid help file(s).
2050	Dialogue Box Manager Error	Memory allocation error. An expected ‘gadget’ (i.e. selector) cannot be found in the list of ‘gadgets.’
2051	*name* cannot be blank	An empty string is entered when changing the text of a dialogue box item.
2052	Error initializing the String Dictionary:	A string exception dictionary file is not valid.
2053	Error initializing the Privilege Dictionary:	A level exception dictionary file is not valid.
2304	Can’t allocate a new panel	There is insufficient memory to allocate a new results/detail panel.
2560	Incompatible code extension	The code in the main flash and that in the video flash are not from the same build.
2816	(VRTX) Error in task create	Task exists, insufficient memory, or insufficient tasks.
2817	(VRTX) Error in task delete	None. (1)
2818	(VRTX) Error in task suspend	None. (1)
2819	(VRTX) Error in task resume	None. (1)
2820	(VRTX) Error in task priority	None. (1)
2821	(VRTX) Error in task inquiry	None. (1)
2822	(VRTX) Error in get memory block	None. (1)
2823	(VRTX) Error in release memory block	None. (1)
2824	(VRTX) Error in message post	None. (1)
2825	(VRTX) Error in message pend	None. (1)
2826	(VRTX) Error in get time	None. (1)
2827	(VRTX) Error in set time	None. (1)
2828	(VRTX) Error in delay	None. (1)
2829	(VRTX) Error in getc	None. (1)

Note (1). There is no condition in the CVIM2 Default System where this error would be expected to occur. Packages may use the operating system in such a way as to cause this error.

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Warning/Error Code	Message Text	Conditions
2830	(VRTX) Error in putc	None. (1)
2831	(VRTX) Error in waitc	None. (1)
2837	(VRTX) Error in enable time slice	None. (1)
2839	(VRTX) Error in event flag create	Insufficient control blocks.
2840	(VRTX) Error in event flag delete	None. (1)
2841	(VRTX) Error in event flag pend	None. (1)
2842	(VRTX) Error in event flag post	None. (1)
2843	(VRTX) Error in event flag clear	None. (1)
2844	(VRTX) Error in event flag inquiry	None. (1)
2846	(VRTX) Error in queue jam	None. (1)
2847	(VRTX) Error in queue create	Insufficient queues or queue elements.
2848	(VRTX) Error in lock	None. (1)
2849	(VRTX) Error in unlock	None. (1)
2850	(VRTX) Error in memory partition create	None. (1)
2851	(VRTX) Error in memory partition extend	None. (1)
2853	(VRTX) Error in message accept	None. (1)
2854	(VRTX) Error in queue post	None. (1)
2855	(VRTX) Error in queue pend	None. (1)
2856	(VRTX) Error in queue accept	None. (1)
2857	(VRTX) Error in queue create	Insufficient queues or queue elements.
2858	(VRTX) Error in queue inquiry	None. (1)
2859	(VRTX) Error in semaphore create	Insufficient control blocks.
2860	(VRTX) Error in semaphore delete	None. (1)

Note (1). There is no condition in the CVIM2 Default System where this error would be expected to occur. Packages may use the operating system in such a way as to cause this error.

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Warning/Error Code	Message Text	Conditions
2861	(VRTX) Error in semaphore pend	None. (1)
2862	(VRTX) Error in semaphore post	None. (1)
2863	(VRTX) Error in semaphore inquiry	None. (1)
3072	Timed out waiting for trigger	An external trigger needed by acquisition is not present.
3073	Duplicate name entered	Name of trigger or camera type specification exists during a copy.
3074	Channel acquires 1 field, continue?	None (2)
3075	Memory allocation error, Acquisition Manager.	None. (1)
3076	Online memory allocation error, Acquisition Manager.	There is insufficient online memory available.
3077	Acquisition item *name* not found.	An acquisition item (camera, camera type, ...) which had been in the list of active items could not be found in the list.
3078	Acquisition item *name* not found.	An acquisition item expected to be found in the active list could not be found.
3079	Acq. Configuration *name* revision error.	The acquisition config. file has a revision other than that expected.
3080	Acq. Configuration *name* doesn't exist.	The acquisition config. file required for the current configuration does not exist.
3081	Acq. Configuration *name* read error.	An error has occurred reading an acquisition config. file.
3082	Acq. Configuration *name* validation error.	An acquisition config. is invalid.
3083	Error locking on to an external reference.	The system cannot lock onto an external horizontal reference.
3084	External reference unlock.	When online and using an external horizontal reference, the reference becomes unlocked.
3085	Calibration error.	A camera cannot be calibrated.

Note (1). There is no condition in the CVIM2 Default System where this error would be expected to occur. Packages may use the operating system in such a way as to cause this error.

Note (2) There is no reference to this error.

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Warning/Error Code	Message Text	Conditions
3086	OK to calibrate ?	The calibration action is selected before either gage is Picked and Placed.
3087	Trigger request failed.	An acquisition trigger request can't be processed.
3088	H.Timing parameters will be updated.	The horizontal scanning mode for a camera type has been toggled double speed <–> normal speed.
3089	V.Timing parameters will be updated.	the vertical scanning mode for a camera type has been toggled interlaced <–> non–interlaced.
3328	Command not found	ASCII protocol command not recognized.
3329	Too many arguments	Incorrect argument list for the command.
3330	Too few arguments	Incorrect argument list for the command.
3331	Invalid character detected	Bad character.
3332	Last byte in non zero	
3333	UART receive queue overflow	UART error.
3334	UART echo queue overflow	UART error.
3335	UART receive semaphore error	UART error.
3336	UART transmit semaphore error	UART error.
3337	UART overrun error	UART error.
3338	UART parity error	UART error.
3339	UART framing error	UART error.
3340	UART break received	UART error.
3341	Invalid data format	None
3342	Invalid block size	None
3343	Unknown protocol request	None
3344	Invalid command.	None
3345	Message not found	None
3346	Message not available	None
3347	Message *name* Signal *name*	None
3348	Invalid message destination format.	None
3349	Invalid message cell format.	None
3350	Message token out of order.	None

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Warning/Error Code	Message Text	Conditions
3351	Message unknown token found.	None
3352	Message file name unknown.	None
3353	DF1 Command aborted.	None
3354	DF1 Communications failed.	None
3355	DF1 Bad packet type.	None
3356	DF1 Bad DLE sequence.	None
3357	DF1 Invalid packet checksum.	None
3358	DF1 packet is too long.	None
3359	DF1 Timed out.	None
3360	DF1 Input overrun.	None
3361	Panel not found for specified name.	None
3362	Unsupported port id.	None
3363	Port specification required.	None
3584	An unsupported section type was found.	Invalid package file.
3585	The object file is not for the 68020 processor.	Invalid package file.
3586	A seek on the output file failed.	Invalid output device for the executable package file, or error on the device.
3587	An invalid object record was encountered.	Invalid package file.
3588	There is insufficient RAM to perform the load.	Insufficient RAM to perform the load.
3589	There is insufficient file space to store the output code.	No space to store the executable package file.
3590	Unexpected EOF	Invalid package file.
3591	The object file contains a data section. This is not supported.	Invalid package file.
3592	Object file contains an unknown symbol.	Invalid package file.
3840	No inspections defined.	None.
3841	No elements to preview.	There are no elements to preview for a message.
3842	No inspection signals defined.	A message is keyed on an inspection event, but there are no current inspection signals.

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Warning/Error Code	Message Text	Conditions
3843	File name is too long.	A file name entered contained more than the maximum number of characters.
3844	Invalid device specified.	A device name entered as part of a file name specified an unknown device.
3845	File already exists.	A duplicate file name is entered, Configuration Manager.
3846	Error creating file.	A file system error occurs when creating a default Config or associated file.
3847	Error saving configuration.	A file system error occurs while saving the Config file.
3848	Error adding config. participant.	A participant could not be added to the configuration manager panel. Memory allocation fault.
3849	File type *name* is required.	An attempt is made to save a Config file which is missing a required file type.
3850	Displayed setup has not been saved. Save it?	Done is selected in the Config. Manager panel and the displayed setup has not been saved. (2)
3851	File *name* does not exist.	A Config file is opened which references a non–existent file.
3852	A *name* file is not included in the current configuration.	An attempt is made to edit a configuration which is not included in the current Config file.
3853	Pick & Place Error.	Pick & place can't be exited with the shape having its current position and/or size.
3854	Feature is too large for the source image.	A feature selected from the image manager panel is too large for the source image on which it is to be applied.
3855	File already exists. Overwrite?	A name entered via the image manager panel is a duplicate of an existing file.
3856	Invalid bit specification	An invalid Remote I/O bit address is entered.
3857	Config file revision error.	A Config file has an incompatible revision.
3858	You must define an event for the message before editing it.	A message was created, but the Edit key was picked before any event was assigned to the message.

Note (2) There is no reference to this error.

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Warning/Error Code	Message Text	Conditions
4096	The window border may affect the result	Morphology processing around a window border can create unwanted black or white pixels.
4097	Not enough memory to add the tool.	An inspection tool database storage requirements is greater than that remaining in the toolset database.
4098	Registration could not be reproduced.	A registered source image for a tool can't be reproduced.
4099	Illegal tool name.	An invalid name is entered for an inspection tool.
4100	Processed image could not be reproduced.	An inspection tool is setup on a processed image which can't be reproduced.
4101	Not enough memory to resize the tool.	A tool requires more memory than is available for resizing.
4102	Too many tools.	The maximum number of tools for a single toolset is exceeded.
4103	File already exists.	A duplicate archive name for a toolset is entered.
4104	Tools file not loaded.	A tool file referenced in the Config file does not exist.
4105	Image buffers exceeded.	The acquisition and inspection buffer requirements is too great.
4106	File could not be saved.	An error occurred saving an inspection tools file.
4107	Referenced tools are now fixed.	A reference tool which is providing registration to at least 1 other tool is deleted.
4108	Illegal neighborhood.	Either the Min or Max morphology neighborhood is empty.
4109	Toolset not found.	None
4110	Pass 1 scale reduced to accommodate image size.	A selected feature is too small for the current Pass 1 x and/or y scale.
4111	Tool could not be adjusted.	None
4112	Camera resolution has changed.	The resolution of a camera has been modified requiring tool coordinate verification.
4113	Image file *name* not found.	An image file required by a tool could not be found.

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Warning/Error Code	Message Text	Conditions
4114	Image file *name* not loaded.	An image file required by a tool could not be loaded into an image buffer. (1)
4115	Conditions have been reset	A tool which is providing a condition to at least one other tool is deleted.
4116	Tool condition has not been met	

Note (1). There is no condition in the CVIM2 Default System where this error would be expected to occur. Packages may use the operating system in such a way as to cause this error.

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Appendix **B**

Environment Variables

Table B.1 in this appendix contains a list of environment variables for the CVIM2 system. The table includes the default, minimum, and maximum values for each variable, along with a recommended value, in some cases.

Environment variables are case sensitive and must be entered exactly as shown in the "**Name**" column of Table B.1 and in the "**Usage**" examples. After adding an environment variable to the list in the Environment panel, you must cycle power, since environment variables are read only during the system initialization phase immediately following powerup. (Refer to the *Adding Variables* section of Chapter 10, page 10–5, for more information.)

NOTE: When an environment variable is not present in the Environment panel list, a *default* value is assigned to that variable.

Table B.1 Environment Variables

Name	Default	Minimum	Maximum	Usage
cfg	n/a	n/a	n/a	Specifies the name of the active configuration file. THIS VARIABLE SHOULD BE SET USING THE CONFIG MENU UNDER ENVIRONMENT OR BY USING THE "sconfig" COMMUNICATION COMMAND. IT SHOULD NOT BE MODIFIED!
csize	32K bytes	2K bytes	128K bytes	Specifies the amount of memory reserved for contour processing each toolset. For most applications, the default size is recommended. **Usage: csize=32768**
ctime	500ms	50ms	5000ms	Specifies the contour processing timeout period. This is used to instruct the CVIM2 system to abort contour processing when the image is excessively noisy. For most applications, the default value is recommended. **Usage: ctime=500**
dio	n/a	n/a	n/a	Specifies the number of discrete I/O connections. THIS VARIABLE IS SET BY THE DIO EDITOR. IT SHOULD NOT BE MODIFIED!
DMod	Depends on Monitor type	n/a	n/a	Indicates the type of monitor connected to the CVIM2 system. For most applications, the CVIM2 module will detect the type of monitor that is connected and set the value for DMod Values are: 1 – RS–170 (e.g. 2801–N8) 2 – CCIR (Do Not Set!) 3 – VGA (composite sync) 4 – VGA (separate H & V sync) **Usage: DMod=3**

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Name	Default	Minimum	Maximum	Usage
Lang	Eng	n/a	n/a	Specifies the current language for the CVIM2 menus. THIS VARIABLE SHOULD BE CONFIGURED USING THE LANGUAGE MENU OPTION UNDER ENVIRONMENT. IT SHOULD NOT BE MODIFIED!
golm	350000 bytes	32K bytes	400K bytes	Specifies the amount of graphics memory available for configuration. DO NOT USE WITHOUT CONSULTING AN ALLEN–BRADLEY REPRESENTATIVE! **Usage: golm=350000**
mmol	N/A	N/A	N/A	Not used in firmware revision B03 and higher.
olm	280000 bytes	32K bytes	280K bytes	Specifies the amount of memory available for contour, configuration and results data. DO NOT USE WITHOUT CONSULTING AN ALLEN–BRADLEY REPRESENTATIVE! **Usage: olm=280000**
norun	n/a	n/a	n/a	If present, the CVIM2 system will not automatically enter run–mode after power–up initialization. **Usage: norun**
oldpipe	n/a	n/a	n/a	If present, the CVIM2 system may interrupt image processing to display an image in its entirety. When not present, the CVIM2 will interrupt image displays to perform inspections which may cause the image display to appear in phases. DO NOT USE WITHOUT CONSULTING AN ALLEN–BRADLEY REPRESENTATIVE! **Usage: oldpipe**
porta portb portc portd	n/a	n/a	n/a	Specifies the configuration of the four serial ports. Ports C and D refer to the System I/O port. THESE VARIABLES SHOULD BE CONFIGURED USING THE SERIAL PORT CONFIGURATION MENU. THEY SHOULD NOT BE MODIFIED!
ramdev-size	4K bytes	4K bytes	128K bytes	Specifies the amount of system RAM to reserve for the RM: device. This memory device is volatile and should not be used for permanent file storage. It is used by some optional CVIM2 software packages and for temporary file storage when processing ”toolcfg” communication commands. The size should only be increases when the ”toolcfg” command needs additional space to store temporary files. **Usage: ramdevsize=4096**
Resources	n/a	n/a	n/a	If present, the Main Menu will contain a menu option to access the system Resources panel. This includes memory usage, and CPU/ Pipe utilization meter. **Usage: Resources**

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Name	Default	Minimum	Maximum	Usage
rint	16	0	128	Specifies the number of Remote I/O bits that are examined each time the Remote I/O network interrupts the CVIM2 module. Increasing this value will require additional CPU processing time which may impact the CVIM2 module's ability to process other interrupts and perform inspections. **Usage: rint=16**
rio	n/a	n/a	n/a	Specifies the configuration of the Remote I/O port. THIS VARIABLE SHOULD BE CONFIGURED USING THE REMOTE I/O PORT CONFIGURATION MENU. IT SHOULD NOT BE MODIFIED!
rsize	32K bytes	1K bytes	64K bytes	Specifies the maximum size for the results data for each toolset. For most applications, the default size is recommended. **Usage: rsize=32768**
rtg	n/a	n/a	n/a	If present, the CVIM2 system will use Graphics memory instead of main memory for parts tracking operations. This causes the system to run slightly slower, but it allows more memory for tracking purposes. **Usage: rtg**
ssize	5K bytes	1K bytes	64K bytes	Specifies the amount of memory reserved for intermediate inspection tool calculations for each toolset. For most applications, the default size is recommended. **Usage: ssize=5120**
tser	0	0	6	Specifies the number of extra results data to allocate when the system goes online. DO NOT USE WITHOUT CONSULTING AN ALLEN–BRADLEY REPRESENTATIVE! **Usage: tser=0**
tsin	4	0	8	Specifies the number of discrete inputs (e.g. "Toolset 1.In1" allowed per toolset. These inputs are typically used for conditional processing and for evaluation by Math Tools. **Usage: tsin=4**
tsize	64K bytes	2K bytes	128K bytes	Specifies the maximum size (memory usage, not file size) of each toolset. For most applications, the default size is recommended. **Usage: tsize=65535**
tsng	n/a	n/a	n/a	If present, the CVIM2 system will not use Graphics memory to store toolset configuration. DO NOT USE WITHOUT CONSULTING AN ALLEN–BRADLEY REPRESENTATIVE! **Usage: tsng**

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