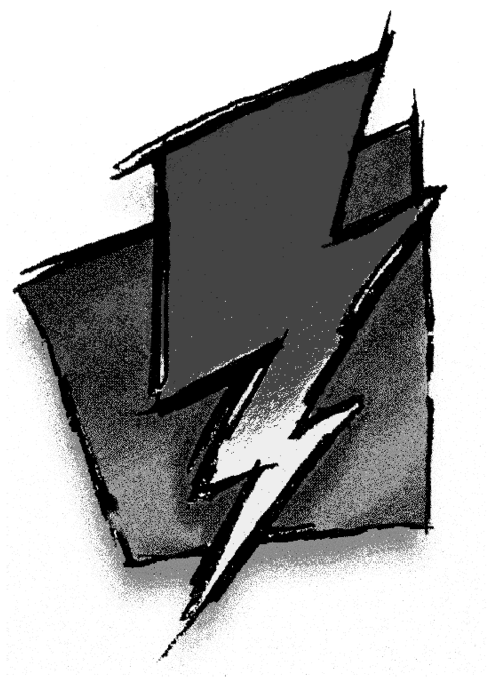
Watcom Debugger

User's Guide



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Introduction

1 Overview

1.1 Introduction

The Watcom Debugger is a powerful debugging tool that helps you analyse your programs and find out why they are not behaving as you expect. It allows you to single step through your code, set break points based on complex conditions, modify variables and memory, expand structures and classes and much more. With the debugger you can debug programs that run on the following platforms:

- DOS
- Tenberry Software DOS/4G Extender
- Phar Lap DOS Extender
- Windows 3.x
- Windows NT
- Windows 95
- 16 and 32-bit OS/2
- QNX
- Novell NetWare
- AutoCAD ADS

1.2 New Features

The latest version of the debugger contains many new features that you should know about.

1.2.1 User Interface

The debugger's user interface has been redesigned. There are GUI versions of the debugger that run under Windows 3.x, Windows NT, Windows 95, and 32-bit OS/2. There are also character mode versions that run under DOS, Windows 3.x, OS/2, and QNX. All versions share a common user interface incorporating powerful features like context sensitive menus, eliminating the need for command oriented debugging.

1.2.2 Reverse Execution

The debugger keeps a history of your interactions that modify the state of the program you are debugging. This includes the effects of statements in your program that you trace. The size of this history is limited only by available memory. Undo and Redo allow you to step backward and forward through this history. This allows you to reverse the effects of tracing over simple statements in your program. You can also reverse any accidental interactions that affect your program’s state. See "The Undo Menu" on page 63.

1.2.3 Replay

The debugger keeps a history of all interactions that affect the execution of your program such as setting break points and tracing. Replay allows you to restart the application and run the application back to a previous point. This is particularly useful when you accidentally trace over a call. This replay information may be saved to a file in order to resume a debugging session at a later date. See "The Replay Window" on page 65.

1.2.4 Stack Unwinding

You can navigate up and down the program’s call stack to see where the currently executing routine was called from. As you do this, all other windows in the debugger update automatically. Local variables in the calling routines will be displayed along with their correct values. See "The Undo Menu" on page 63.

1.2.5 Simplified Breakpoints

The debugger allows you to set breakpoints when code is executed or data is modified. These breakpoints may be conditional based on an expression or a countdown. Simple breakpoints are created with a keystroke or single mouse click. More complex breakpoints are entered using a dialog. See "The Breakpoint Dialog" on page 90.

1.2.6 Context Sensitive Menus

Context sensitive menus are present in each debugger window. To use them, you select an item from the the screen using the right mouse button. A menu containing a list of actions appropriate for that item is displayed. You can use this capability to perform actions such as displaying the value of an expression which you have selected from the source window.

1.2.7 Buttons

The debugger contains small buttons that appear on the left side of some windows. These buttons are shortcuts for the most common operations. For example, you can set and clear a breakpoint by clicking on the button to the left of a source line.

1.3 Common Menu Items

The debugger's context sensitive menus contain many useful menu items. Each of these items behave differently depending upon the selected item. A description of some of the commonly found menu items follows:

Inspect Inspect displays the selected item. The debugger determines how to best display the selected item based on its type. If you inspect a variable or an expression, the debugger opens a new window showing its value. If you inspect a function, the debugger positions the source code window at the function definition. If you inspect a hexadecimal address from the assembly window, a window showing memory at that address is opened, and so on. Experimenting with inspect will help you learn to use the debugger effectively.

Modify Modify lets you change the selected item. You will normally be prompted for a new value. For example, select the name of a variable from any window and choose Modify to change its value.

New New adds another item to a list of items displayed in a window. For example, choosing New in the Break Point window lets you create a new breakpoint.

Delete Delete removes the selected item from the window. For example, you can use Delete to remove a variable from the Watches window.

Source Source displays the source code associated with the selected item. The debugger will reposition the source code window at the appropriate line. Selecting a module name and choosing Source will display the module's source code.

Assembly Assembly positions the assembly code window at the code associated with the selected item.

Functions Functions shows a list of all functions associated with the selected item or window. For example, choose Functions in the source window to see a list of all functions defined in that module.

Watch	Watch adds the selected variable or expression to the Watches window. This allows you to watch its value change as the program runs. ***Note that this is not a watchpoint. Execution will not stop when the variable changes.*** See the chapter entitled "Breakpoints" on page 85 for information about setting watchpoints.
Break	Break sets a breakpoint based on the selected item. If a variable is selected, the program will stop when the variable is modified. If a function is selected, the program will stop when the function executes.
Globals	Globals shows a list of global variables associated with the selected item.
Show	Show will present a cascaded menu that let's you show things related to the selected item. For example, you can use ***Line*** from the ***Show*** menu in the source code window to see the line number of the selected line.
Type	Type will present a cascaded menu that allows you to change the display type of the window or selected item.

Preparing a Program to be Debugged

2 Preparing a Program to be Debugged

Before you can debug a program, you must put *debugging information* into the code.

There are three different formats of debugging information that can be put into the code — "Watcom", "Dwarf" or "Codeview". Starting with version 10.7, the default format is "Dwarf". In earlier releases, the default was "Watcom". Although the debugger supports all three formats, it is best if you allow the default format to be generated.

To produce an executable that has debugging information, you need to:

1. specify the correct compiler options when you compile, and
2. specify the correct linker options when you link.

During development, use the *d2* option of the compiler and use the *debug all* directive at the beginning of your linker command line or at the beginning of your linker directive file. This will ensure that maximum debugging information is available during your debugging session. Change to the *d1* option when you need to create a distribution version of your product. This is necessary since the *d2* option disables most compiler optimizations, whereas *d1* will not affect the quality of generated code. During production, you can use the linker's *symfile* option to put the *d1* debugging information into a separate file. This lets you distribute a production quality executable yet still have the luxury of source line debugging when bugs are reported.

2.1 Compiler Debugging Options

d0	The *d0* option will generate no debugging information. This is the default option.
d1	The *d1* option will generate debugging information for global symbols and line numbers.
d1+	The *d1+* option will generate debugging information for global symbols and line numbers, and typing information for local structs and arrays.
d2	The *d2* option will generate the most debugging information that is normally needed, including global information, line numbers, types, and local variables.

d2i	The *d2i* option is identical to *d2* but does not permit inlining of functions. This option can result in larger object and/or executable files (we are discussing both "code" and "file" size here).
d2t	The *d2t* option is identical to *d2* but does not include type name debugging information. This option can result in smaller object and/or executable files (we are discussing "file" size here).
d3	The *d3* option will generate all debugging information generated by *d2*. In addition, it will generate information about all types defined in a compilation unit, regardless of whether they are used in that compilation unit. ***This option will create very large objects and executable files. Do not use it unless you want to have access to types that have no variables associated with them.***

2.2 Linker Debugging Options

The linker is the tool that puts together a complete program and sets up the debugging information for all the modules in the executable file. There is a linker directive that tells the linker when it should include debugging information from the modules.

For "Dwarf" format debugging information, the directive is:

DEBUG DWARF

For "Watcom" format debugging information, there are two levels of debugging information that you should collect during the link. They are:

DEBUG WATCOM LINES global names, source line numbers

DEBUG WATCOM ALL global names, source line numbers, local variables, typing information

Linker DEBUG directives are position dependent so you must make sure that the directive *precedes* the object files and libraries that require debugging information.

For instance, if the file "mylink.lnk" contained:

```
#
# invoke with: wlink @mylink
#
file main
debug watcom lines
file input, output
debug watcom all
file process
```

then the files *input* and *output* will have global names and source line information available during debugging. All debugging information in the file *process* is available during debugging. No information is available for *main* except global names.

If you use a DEBUG directive anywhere, all files, including *main*, will have global name information.

2.3 Debugger Settings

You may encounter problems if the debugger does not know where to find the source code associated with your executable. The name of the source file included in the debugging information is the path and the original name from the compiler's command line. If the original filename is no longer valid (i.e., you have moved the source to another directory), you must tell the debugger where to find the source files by choosing ***Source Path*** from the ***File*** menu.

Starting the Debugger

3 Starting Up the Debugger

The following topics are discussed:

3.1 Watcom Debugger Command Line

There are several versions of the debugger.

binw\wd.exe	This is the DOS character-mode debugger.
binw\wdc.exe	This is the Windows 3.x character-mode debugger.
binw\wdw.exe	This is the Windows 3.x windowed (GUI) debugger.
binnt\wd.exe	This is the Windows NT/95 character-mode debugger.
binnt\wdw.exe	This is the Windows NT/95 windowed (GUI) debugger.
binp\wd.exe	This is the OS/2 character-mode debugger.
binp\wdw.exe	This is the OS/2 windowed (GUI) debugger.

wd This is the name of the debugger included with QNX.

See the sections entitled "Operating System Specifics" on page 129 and "Remote Debugging" on page 105 for information on which version to select for your situation.

On the debugger command line, you can specify options that you want to use during your debugging session. Acceptable option short forms are indicated in capital letters. For example, the */TRap* option may be shortened to */tr*.

3.2 Common Switches

The following switches are applicable to all operating systems.

/TRap=trap_file[;trap_parm]
specifies an executable helper program that the debugger uses to control the application being debugged, or to communicate across a remote link. It is called a "trap file" since the interrupts used for debugging are sometimes called "traps". The *trap* option selects the appropriate trap file to use. ***This option must be specified when remote debugging, debugging DOS extender applications, debugging OS/2 exception handlers, or debugging an AutoCAD ADS application.***

The remote trap files themselves have startup parameters. This is specified following the semi-colon. See "Remote Debugging" on page 105. Normally you do not have to specify a trap file. If you do not specify the *trap* option, the default trap file that supports local debugging is loaded. There are several exceptions.

1. To debug a Tenberry Software 32-bit DOS/4G(W) application, you must use */TRAP=RSI*.
2. To debug a Phar Lap 32-bit application, you must use */TRAP=PLS*.
3. To debug an OS/2 exception handler, you must use */TRAP=STD* 2 which tells the debugger to catch exceptions only on the second chance (normally it would be the debugger that traps the exception).
4. To debug an AutoCAD add on, you must use */TRAP=ADS*.
5. To debug an OS/2 16-bit application under Phar Lap’s RUN286 DOS extender, you must use */TRAP=STD16*.

/LInes=n controls the number of lines used by a character mode debugger. The number of lines available depends on the operating system and your video card. The values 25, 43 and 50 are often supported.

/COlumns=n
controls the number of columns used by a character mode debugger. The number of columns available depends on the operating system and your video card. If your system does not support the requested number of columns, this option is ignored

/Invoke=file may be used to specify an alternate name for the debugger configuration file which is to be used at start-up time. The default file name is "WD.DBG". Debugger configuration files are found in the current directory or one of the directories in your **PATH**.

/NOInvoke specifies that the default debugger configuration file is not to be invoked.

/NOMouse requests that the debugger ignore any attached mouse. ***This may be necessary if you are trying to debug mouse events received by your application.*** This option ensures that the debugger will not interfere with the mouse.

/DYnamic=number
specifies the amount of dynamic storage that the debugger is to set aside for its own use on startup. The default amount that is set aside is 500K bytes. The larger the amount, the less memory will be available for the application to be debugged. ***You only need to use this option if the debugger runs out of memory, or is causing your application to run out of memory.*** If you are using the remote debugging feature, the debugger will use as much available memory as available.

/NOExports specifies that no exports (system symbols) should be loaded. It helps to speed up load time when debugging remotely and marginally so when debugging locally.

/LOcalinfo=local_file
is used primarily in conjunction with the remote debugging capabilities of the debugger. It causes the debugger to use one or more local files as sources of debugging information if the right conditions are met. When the debugger observes that an executable file or Dynamic Link Library (DLL) is being loaded with the same name (i.e., the path and extension have been stripped) as one of the */localinfo* files, then the named local file is used as a source of debugging information. The named file can be an executable file, a DLL file (.dll), a symbolic information file (.sym), or any other file with debugging information attached.

Example:

```
    wd /local=c:\dlls\mydll.sym /local=c:\exes\myexe.exe /tr=par
    myexe
```

In the above example, the debugger would obtain debugging information for any executable or DLL called `myexe` or `mydll` from `C:\EXES\MYEXE.EXE` or `C:\DLLS\MYDLL.SYM` respectively. Note that no path searching is done for local files. The debugger tries to open the file exactly as specified in the *localinfo* option.

See the section entitled "Remote Debugging" on page 105 for an explanation of remote debugging.

/DOwnload specifies that executable file to be debugged is to be downloaded to the task machine from the debugger machine. The debugger searches for the executable file in the local path, and downloads it to the debug server's current working directory on the remote machine before starting to debug. Debugging information is not downloaded, but is obtained locally, as in the *localinfo* option. Note: Only the executable is downloaded; any required DLLs must be present on the remote machine. Downloading is relatively fast if you are using one of the TCP/IP (TCP) or Netware (NOV) remote links. Be sure to specify the file extension if it is not ".exe".

Example:

```
    wd /tr=nov;john /download sample.exe
    wd /tr=nov;john /download sample.nlm
```

The debugger does not erase the file when the debugging session ends. So if you debug the application again, it will check the timestamp, and if the file is up-to-date, it doesn't bother re-downloading it.

See the section entitled "Remote Debugging" on page 105 for an explanation of remote debugging.

/REMotefiles

is used in conjunction with the remote debugging capabilities of the debugger. It causes the debugger to look for all source files and debugger files on the remote machine. When *remotefiles* is specified, all debugger files (except "trap" files) and application source files are opened on the task machine rather than the debugger machine. The trap file must be located on the debugger machine.

The **PATH** environment variable on the task machine is always used in locating executable image files. When *remotefiles* is specified, the debugger also uses the task machine's **PATH** environment variable to locate debugger command files. See the section entitled "Remote Debugging" on page 105 for an explanation of remote debugging. See the section entitled "Specifying Files on Remote and Local Machines" on page 119 for an explanation of remote and local file names.

/NOFpu requests that the debugger ignore the presence of a math coprocessor.

/NOSymbols requests that the debugger omit all debugging information when loading an executable image. ***This option is useful if the debugger detects and tries to load debugging information which is not valid.***

/DIp=dipname
used to load a non-default Debug Information Processor (DIP). This option is generally not needed since the debugger loads all DIPs that it finds by default. See "The Images Window" on page 57.

3.3 DOS and Windows Options

The following switches apply to the DOS (binw\wd) and Windows 3.x character-mode (binw\wdc) debuggers. Refer to the sections called "DOS Specific Options" on page 20 and "Windows Specific Options" on page 21 for more switches relating to these environments.

/Monochrome
When two display devices are present in the system, this option indicates that the Monochrome display is to be used as the debugger's output device, leaving the Color display for the application to use. Use this option in conjunction with the *Two* option described below.

/Color, /Colour
When two display devices are present in the system, this option indicates that the Colour display is to be used as the debugger's output device. This option is used in conjunction with the *Two* option described below.

/Ega43 When an Enhanced Graphics Adapter (EGA) is present, 43 lines of output are displayed by a character mode debugger.

/Vga50 When a Video Graphics Array (VGA) is present, 50 lines of output are displayed by a character mode debugger.

/Overwrite specifies that the debugger's output can overwrite program output. In this mode, the application and the debugger are forced to share the same display area.

Do not use this option if you wish to debug a DOS graphics-mode application.

/Two specifies that a second monitor is connected to the system. If the monitor type *(Monochrome, Color, Colour, Ega43, Vga50)* is not specified then the monitor that is not currently being used is selected for the debugger's screen. If the monitor type is specified then the monitor corresponding to that type is used for the debugger's screen. ***This option may be used when debugging a DOS graphics-mode application on the same machine and a second monitor is available.***

3.4 DOS Specific Options

Use the following switches for the DOS debuggers. For more DOS options, refer to the section called "DOS and Windows Options" on page 19.

/Page specifies that page 0 of screen memory is to be used for the application's screen and that page 1 of screen memory should be used for the debugger's screen. This option may be selected when using a graphics adapter such as the CGA, EGA or VGA. Using the *Page* option results in faster switching between the application and debugger screens and makes use of the extra screen memory available with the adapter. This is the default display option. ***Do not use this option if you wish to debug a DOS graphics-mode application.***

/Swap specifies that the application's screen memory and the debugger's screen memory are to be swapped back and forth using a single page. The debugger allocates an area in its own data space for the inactive screen. This reduces the amount of memory available to the application. It also takes more time to switch between the application and debugger screens. ***This option MUST be used when debugging a DOS graphics-mode application and a second monitor is not available.***

The default display options are:

1. If you have a two display system, the debugger uses both displays with the program output appearing on the active monitor and the debugger output appearing on the alternate monitor. In other words, the *Two* option is selected by default.
2. If you have one of the CGA, EGA or VGA graphics adapters installed in your system then the debugger selects the *Page* option by default.
3. Under all other circumstances, the debugger selects the *Swap* option by default.

/CHecksize=number

specifies the minimum amount of storage, in kilobytes, that the debugger is to provide to DOS for the purpose of spawning a program while the debugger is active. ***This option is useful when the application that is being debugged uses up most or all of available storage, leaving insufficient memory to spawn secondary programs.*** In order to provide the requested amount of free memory to DOS, the debugger will checkpoint as much of the application as required.

Checkpointing involves temporarily storing a portion of the memory-resident application on disk and then reusing the part of memory that it occupied for the spawned program. When the spawned program terminates, the checkpointed part of the application is restored to memory.

The default amount is 0K bytes. In this case, the spawned program may or may not be run depending on how much free storage is available to DOS to run the program.

Warning: If the application being debugged installs one or more interrupt handlers, the use of this option could hang your system. Your system could lock up if the debugger checkpoints a portion of the application's code that contains an interrupt handler.

/NOCHarremap

turns off the character re-mapping that the DOS debugger uses for displaying dialogs and window frames. ***Use this option when trying to debug in an environment where character remapping is not available.*** Windowed DOS boxes under OS/2 do not support character re-mapping.

/NOGraphicsmouse

Turn off the graphics mouse emulation code that makes the mouse cursor look like an arrow instead of a block. ***Use this option if the mouse cursor appears as 4 line drawing characters instead of an arrow.***

3.5 Windows Specific Options

Use the following switches for the Windows character-mode debugger. Refer to the section called "DOS and Windows Options" on page 19 for more Windows options.

/Fastswap specifies that Windows 3.x screen memory and the debugger's screen memory are to be swapped back and forth using a technique that is faster than the default method of screen swapping but not guaranteed to work for all video adapters. This option applies to Windows 3.x only. By default, the Windows 3.x version of the debugger uses a more conservative (and slower) method that works with all video adapters.

3.6 QNX Options

You can use the following switch for the QNX debugger.

-Console=console_spec

specifies the virtual console to use for debugger windows. This may be a console number as in the following example.

Example:
```
    -console=2
```

You may also use a full device name.

Example:
```
    -console=//23/dev/ser1
```

In this case, the debugger will use that device for it's input and output. The debugger/application screen flipping features will be disabled.

You can also optionally follow the device name with a colon and a terminal type.

Example:
```
    -con=/dev/ttyp1:vt240
```

This will let the debugger know what kind of terminal it's talking to so it can initialize the user interface appropriately.

-COlumns=n

specifies the number of columns of the screen/window that the debugger should attempt to establish.

-XConfig=string

specifies a set of X Windows configuration options to pass to **xqsh.**

3.7 Environment Variables

You can use the **WD** environment variable to specify default options to be used by the debugger. Once you have defined the environment variable, those options are used each time you start the debugger.

3.7.1 WD Environment Variable

If the specification of an option involves the use of an "=" character, use the "#" character in its place. This is required by the syntax of the "SET" command. Options found in the environment variable are processed before options specified on the command line. The following example illustrates how to define default options for the debugger:

Example:
```
    C>set wd=/swap/lines#50
```

3.7.2 WD Environment Variable in QNX

The following example illustrates how to define default options for the debugger under QNX:

Example:
```
    $ export "WD=-nofpu -console=3"
```

Under QNX, care must be taken to specify the environment variable name entirely in uppercase letters.

Watcom Debugger Environment

4 The Watcom Debugger Environment

This chapter describes the interactions you need in order to use the debugger.

4.1 Debugger Windows

The debugger displays its information in windows. Both the character and the GUI-based debuggers use similar conventions for window manipulation.

4.1.1 Window Controls

Each window has the following controls

Minimize, Maximize, Restore
You can control the size of each window using the Minimize, Maximize, and Restore buttons. The buttons appear on the top right corner of the window. The Minimize button is the down arrow. When you click on the down arrow, the window becomes an icon at the bottom of the screen. The Maximize button is the up arrow. When you click on the up arrow, the window fills the whole screen. The Restore button appears only when the window is maximized. It is an up and down arrow. Click on the Restore button to put the window back to its original size.

Close Each window has a Close button in the top left corner. Double-click on this button to close the window.

System Menu
The ***System Menu*** contains menu items that operate on the window. It contains:

- ***Restore***
- ***Move***
- ***Size***
- ***Minimize***
- ***Maximize***

You can activate the System Menu of the main window by clicking once on the System Menu button (top, left-hand corner) or by typing ALT-Space. For Microsoft Windows, you can type ALT-Hyphen to activate a child window's System Menu.

Scroll Bars Windows that contain information that cannot fit in the window have scroll bars. Use the scroll bars to reposition the window so the information you want to see is visible. The small box in the scroll bar indicates the current scroll position in the window.

Title Each window is titled so that you know what information it contains. The title appears in the bar at the top of the window.

Buttons Many windows have small buttons on the left hand side. These buttons are short forms for performing the most common operations.

4.1.2 The Current Window

The current window is the one whose title bar is coloured. Press CTRL-TAB to move from window to window.

4.1.3 Controlling the Size and Location of Windows

The following window operations are possible.

- "Moving Windows"
- "Resizing Windows" on page 29
- "Zooming Windows" on page 29
- "Context Sensitive Pop-up Menus" on page 29
- "Text Selection" on page 29

4.1.3.1 Moving Windows

To move a window, click in the Title bar and drag it to a new location. You can also choose ***Move*** from the ***System Menu*** and use the cursor keys to reposition the window, pressing ENTER when the window is in the right spot.

4.1.3.2 Resizing Windows

In the GUI-based version of the debugger, you can resize a window’s width, height, or both. Refer to the system documentation for details.

In the character-based version of the debugger, you can only resize a window from the corners. Move the cursor to any corner of the window. Click and drag the mouse to resize the window.

You can also choose ***Size*** from the ***System Menu*** to change the size of a window. Use the cursor keys to resize the window, press ENTER when the window is the right size.

4.1.3.3 Zooming Windows

Choose ***Zoom*** from the ***Window*** menu to toggle a window between its maximized and normal sizes.

4.1.3.4 Context Sensitive Pop-up Menus

The debugger has context sensitive pop-up menus for each window in the application. ***You can access the menu either by pressing the right mouse button in the window or by typing the period (.) key.*** You can then choose a menu item by typing the highlighted character or by clicking the mouse on it.

If you have memorized the highlighted menu character, you can bypass the menu and activate the menu item directly by pressing the CTRL key in conjunction with that character. The items that appear in the menu depend on the current window. These menus are described in detail throughout this document.

Note The ***Action*** item in the main menu is identical to the the context sensitive pop-up menu for the current window and may be used instead of pop-up menus.

For more information on the choices presented in the pop-up menus, see the section entitled "Variable and Watch Windows" on page 71.

4.1.3.5 Text Selection

Some windows, such as the Source and Assembly windows, allow you to select text. For example, you might want to select a variable name or expression. Menu items will act on the selected item.

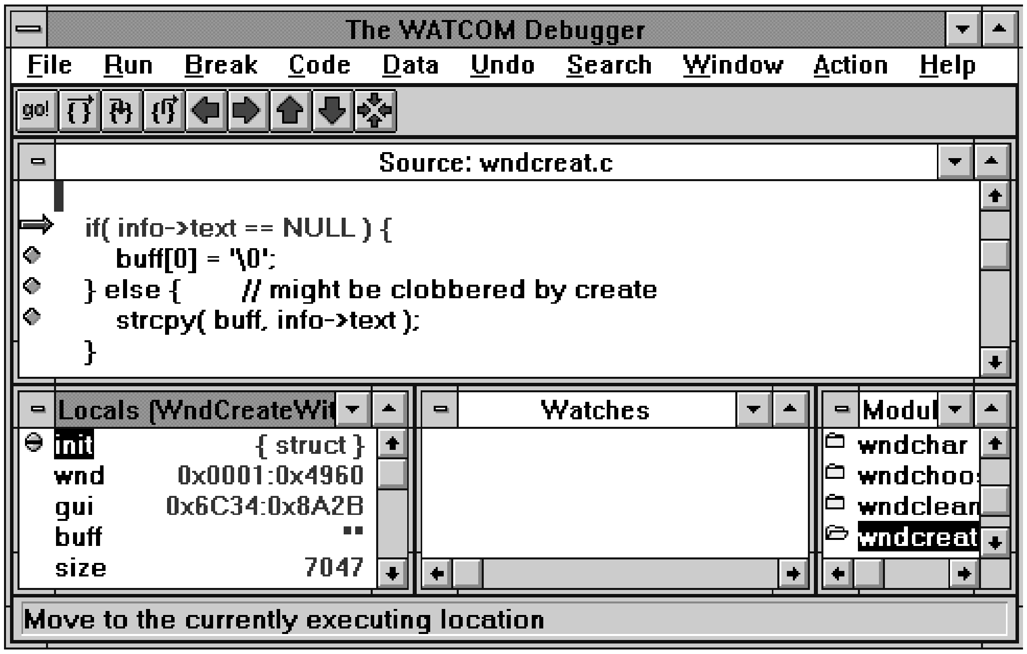
You can select text with either the left or right mouse button. If you use the right button, the pop-up menu appears when you release the button. With the keyboard, hold SHIFT while using the cursor keys. You can select a single character and the debugger will automatically extend the selection to include the entire surrounding word.

4.2 Menus

At the top of the debugger window are a number of menu items. You can select a menu item with the mouse or by pressing ALT and the highlighted character from the menu title.

Many menu items have accelerators or keyboard equivalents. They appear to the right of the menu item. As you learn the debugger, take time to learn the accelerators. They will help you to use the debugger more effectively.

4.3 The Toolbar



```
if( info->text == NULL ) {
    buff[0] = '\0';
} else {        // might be clobbered by create
    strcpy( buff, info->text );
}
```

```
init          { struct }
wnd       0x0001:0x4960
gui       0x6C34:0x8A2B
buff                 ""
size               7047
```

```
wndchar
wndchoo
wndclean
wndcreat
```

Move to the currently executing location

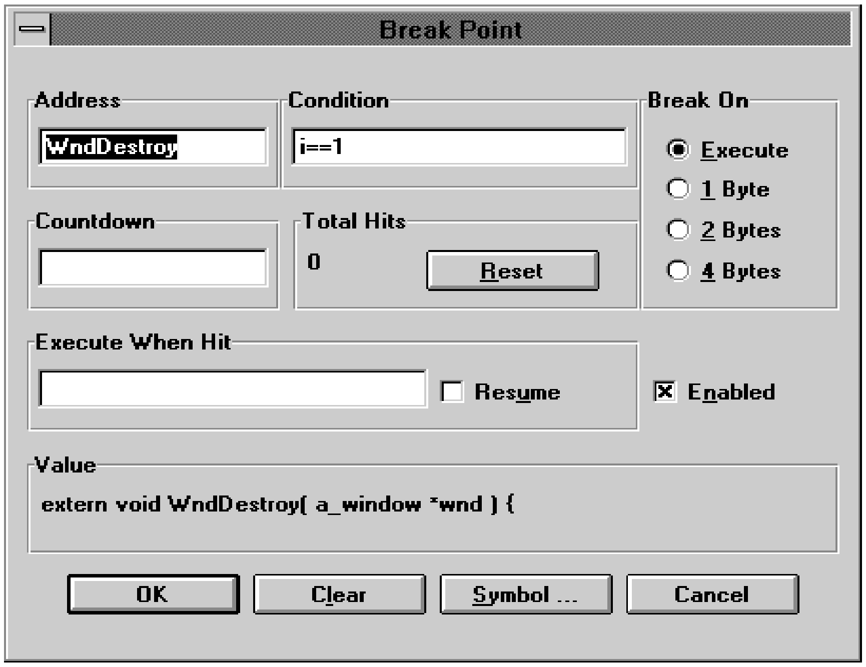
Figure 1. *The Debugger Window*

The Toolbar appears under the menu in the GUI-based debugger. The buttons in the Toolbar are equivalent to menu selections. There are eight buttons in the toolbar. Listed from left to right, they are:

- ***Go*** from the ***Run*** menu
- ***Step Over*** from the ***Run*** menu
- ***Trace Into*** from the ***Run*** menu
- ***Until Return*** from the ***Run*** menu
- ***Undo*** from the ***Undo*** menu
- ***Redo*** from the ***Undo*** menu
- ***Unwind Stack*** from the ***Undo*** menu
- ***Rewind Stack*** from the ***Undo*** menu
- ***Home*** from the ***Undo*** menu

See the sections entitled "The Run Menu" on page 61 and "The Undo Menu" on page 63 for details.

4.4 Dialogs



Break Point

Address: WndDestroy

Condition: i==1

Break On: [✓ Execute] 1 Byte 2 Bytes 4 Bytes

Countdown:

Total Hits: 0

Execute When Hit:

☐ Resume

☒ Enabled

Value: extern void WndDestroy(a_window *wnd) {

Figure 2. *A Typical Dialog*

Dialogs appear when you choose a menu item that does not perform an immediate action. They allow you to make choices and set options. The dialogs contain the following:

Edit fields These are fields in which you can type information.

Buttons You can click on buttons to perform actions.

Default button
The default button in a dialog is highlighted. You can select this button by pressing ENTER.

Cancel All dialogs contain a cancel button. Choose the Cancel button or press ESC to leave a dialog without saving or implementing changes you have made to the dialog.

Check Boxes
Check boxes are used to control settings in the debugger. Click on the field, or TAB to it and press SPACE to toggle the option between on and off.

Radio Buttons
Radio buttons present a set of mutually exclusive choices. Click on a radio button to turn it on or press TAB to move to the group of radio buttons and use the cursor keys to select a radio button. If this does not work, use the accelerator key to turn on the desired radio button. Only one radio button is on at all times. When you select a different radio button, the currently selected one is turned off.

List boxes A list box contains a list of applicable items.

Drop-down List boxes
A drop down list box is a list that does not appear on the screen until you click on the down arrow on the right of the box. You may then select from a list of options.

4.5 Accelerators

Accelerators are keys that you can press in place of selecting a menu item or typing commands. The debugger comes with a standard set of accelerators that you can view by choosing ***Accelerators*** from the ***Window*** menu.

If you are used to the CodeView debugger, you should be comfortable with the Watcom Debugger's default set of accelerators. If you are used to using Turbo Debugger, you can select accelerators which are similar to its accelerator definitions. To select Turbo accelerators, choose ***Accelerator*** from the ***Window*** menu then select ***TD Keys*** from the ***Action*** menu.

4.5.1 Default Accelerators

The default accelerators are:

/	Search/Find...
ALT-/	Search/Next
CTRL-\	Search/Next
?	add a new expression to the Watch window
F1	invoke help facility
F2	Data/Registers
F3	toggle between source level and assembly level debugging
F4	Window/Application
F5	Run/Go
F6	Window/Next
F8	Run/Trace Into
F9	Break/Toggle
F10	Run/Step Over
SHIFT-F9	add a new item to the Watch window
CTRL-F4	close the current window
CTRL-F5	restore the current window to its normal size
CTRL-F6	rotate the current window
CTRL-F9	minimize the current window
CTRL-F10	maximize the current window
ALT-F10	display the floating pop-up menu for the current window
CTRL-TAB	rotate the current window
CTRL-LEFT	Undo/Undo
CTRL-RIGHT	Undo/Redo
CTRL-UP	Undo/Unwind Stack
CTRL-DOWN	Undo/Rewind Stack
CTRL-BACKSPACE	Undo/Home
ALT-1	Data/Locals
ALT-2	Data/Watches
ALT-3	Code/Source
ALT-4	File/View...
ALT-5	Data/Memory at...
ALT-6	Data/Memory at...
ALT-7	Data/Registers
ALT-8	Data/80x87 FPU

ALT-9	File/Command...
CTRL-z	Window/Zoom
SPACE	Run/Step Over
.	display the floating pop-up menu for the current window
:	File/Command...
=	Search/Match
n	Search/Next
N	Search/Previous
u	Undo/Undo
U	Undo/Redo
b	Break/At Cursor
e	Data/Memory at...
g	Run/Execute to...
h	move cursor left one
i	Run/Trace Into
j	move cursor down one
k	move cursor up one
l	move cursor right one
t	Break/Toggle
x	Run/Next Sequential

4.5.2 Turbo Emulation Accelerators

The Turbo emulation accelerators are:

F2	Break/Toggle
F3	Code/Modules
F4	Run/Run to Cursor
F5	Window/Zoom
F6	Window/Next
F7	Run/Trace Into
F8	Run/Step Over
F9	Run/Go
ALT-F2	Break/New...
ALT-F3	close the current window
ALT-F4	Undo/Undo
ALT-F5	Window/Application
ALT-F7	trace one assembly instruction
ALT-F8	Run/Until Return
ALT-F9	Run/Execute to...
ALT-F10	activate the pop-up menu for the current window

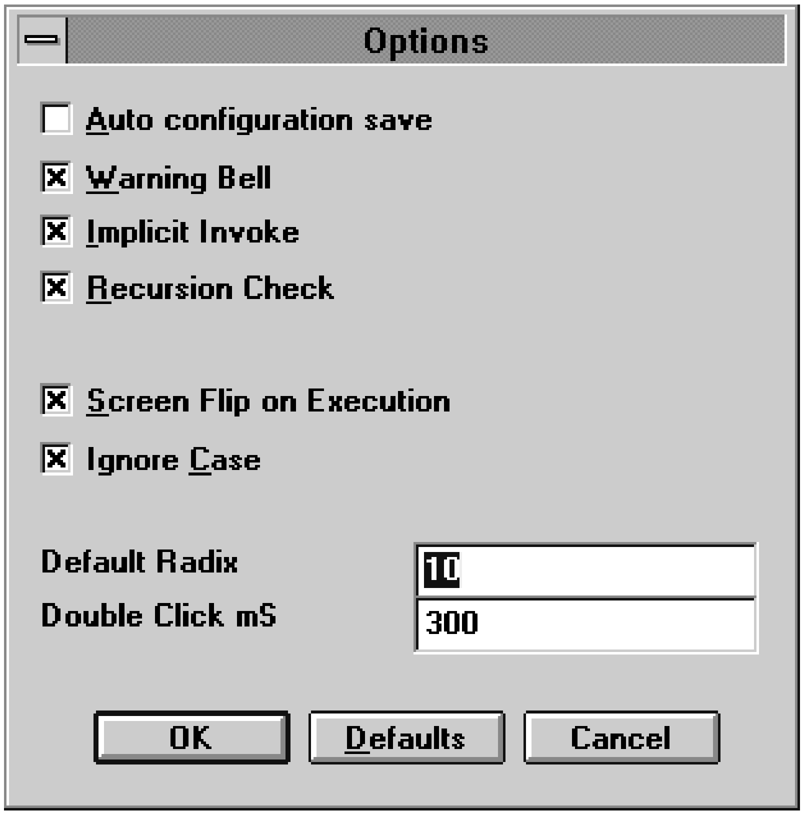
CTRL-F2	Run/Restart
CTRL-F4	open a new Watch window
CTRL-F7	add a new item to the Watch window

4.6 The File Menu

The ***File*** menu contains items that allow you to perform file operations, such as:

Open	Start debugging a new program, or to restart the current program with new arguments.
View	Display a file in a window.
Command	Enter a debugger command. For a description of debugger commands, refer to the section entitled "Debugger Commands" on page 175.
Options	Set the global debugging options. For a full description of these options, refer to the section entitled "The Options Dialog" on page 36.
Window Options	Set the options for the debugger's various windows. For a full description of these options, refer to the section entitled "The Window Options Dialog" on page 38.
Save Setup	Save the debugger's current configuration. This saves the positions and sizes of all windows as well as all options and settings. By default, this information is saved into the file `SETUP.DBG`, however, you can save this information into another file to create alternate debugger configurations.
Load Setup	Load a configuration previously saved using ***Save Setup.***
Source Path	Modify the list of directories which will be searched when the debugger is searching for source files.
System	The menu item appears only in the character-based version of the debugger. It spawns a new operating system shell.
Exit	Close the debugger.

4.6.1 The Options Dialog



[ ] Auto configuration save
[✓] Warning Bell
[✓] Implicit Invoke
[✓] Recursion Check
[✓] Screen Flip on Execution
[✓] Ignore Case

Default Radix: 10
Double Click mS: 300

Figure 3. *The Options Dialog*

The Options dialog allows you to change the following settings:

Auto configuration save When this option is on, the debugger automatically saves its configuration upon exit.

Warning Bell When this option is on, the debugger will beep when a warning or error is issued.

Implicit Invoke If this option is on, the debugger will treat an unknown command as the name of a command file and automatically try to invoke it. If this option is off, you must use the invoke command to invoke a command file.

Under QNX, a conflict is possible when Invoke is on. A path specified for a command file name is confused with the short form of the DO command (/). A similar problem occurs under DOS, OS/2, Windows 3.x, Windows NT, or Windows 95 when a drive specifier forms part of the file name.

Recursion Check Use this option to control the way tracing over recursive function calls is handled. When this option is on, and you trace over a function call, the debugger will not stop if the function executes recursively.

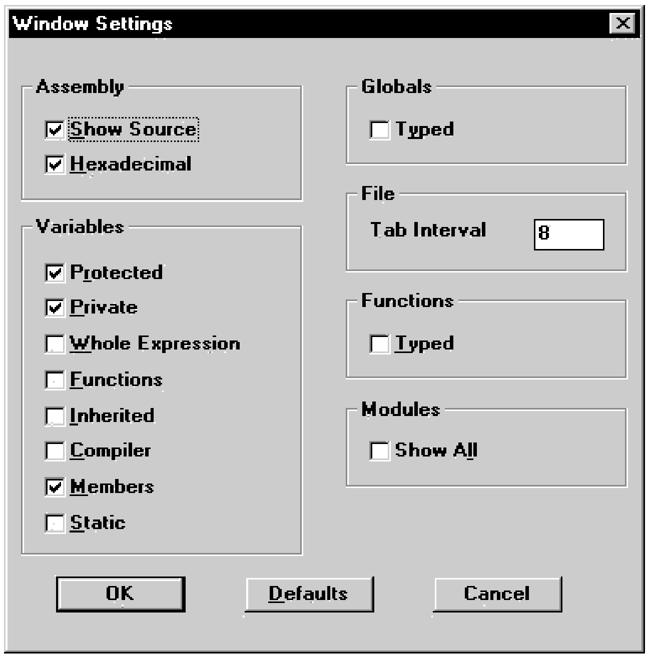
Screen flip on execution Use this option to control whether the debugger automatically flips the display to the application's screen upon execution. ***Leave this option on if you are using the character mode debugger to debug a Windows 3.x application.***

Ignore case This option controls whether or not case is ignored or respected when the debugger is searching for a string.

Default Radix Use this option to define the default radix used by the debugger. The debugger associates a radix with each action automatically. For example, if you are asked to enter an address, the debugger assumes base 16. If you double click on a decimal value, you will be prompted for a decimal replacement value but there are occasions when the debugger must use the default radix. If you add an arbitrary expression to the Watches window, the default radix is used when interpreting that expression. You can specify any radix between 2 and 36.

Double click mS This option sets the amount of time in milliseconds allowed between two clicks for the debugger to accept it as a double click. Enter a larger value if you are having trouble with double clicks.

4.6.2 The Window Options Dialog



Assembly
- ✓ Show Source
- ✓ Hexadecimal

Variables
- ✓ Protected
- ✓ Private
- ☐ Whole Expression
- ☐ Functions
- ☐ Inherited
- ☐ Compiler
- ✓ Members
- ☐ Static

Globals
- ☐ Typed

File
- Tab Interval: 8

Functions
- ☐ Typed

Modules
- ☐ Show All

Figure 4. *The Window Options Dialog*

Use the Window Options dialog to define options related to the debugger’s various windows. All of these options appear in a dialog when you choose ***Window Options*** from the ***File*** menu.

The Window Options dialog allows you to set options for the following windows:

- Source
- Modules
- Functions
- Assembly
- Watches
- Locals
- File Variables
- Globals
- Variable

4.6.2.1 The Assembly Options

The Assembly options allow you to define how your assembly code appears. You can set the following options:

Show Source
Turn on this option if you want source code intermixed with assembly code.

Hexadecimal
Turn on this option if you want immediate operands and values to be displayed in hexadecimal.

4.6.2.2 The Variables Options

Use the Variable options to set display options and to specify which members of a class you want displayed when a structure or class is expanded. You can set:

Protected Display protected members in expanded classes.

Private Display private members in expanded classes.

Whole Expression
Turn this option on to show the whole expression used to access fields and array elements instead of just the element number or field name itself.

Functions Display C++ member functions in expanded classes.

Inherited Display inherited members in expanded classes.

Compiler Display the compiler-generated members. You will usually not want this option turned on.

Members Display members of the ’this’ pointer as if they were local variables declared within the member function.

Static Display static members.

4.6.2.3 The File Options

You can set the display width of a tab in the File options section. This value defaults to 8 spaces.

4.6.2.4 The Functions and Globals Options

For both Functions and Global Variables windows, you can turn on the ***Typed Symbols*** option. This restricts the list of symbols to those that are defined in modules compiled with full debugging information (d2 option).

4.6.2.5 The Modules Options

You can turn on ***Show All*** to allow the Modules window to display all modules in your program, not just those which have been compiled with the d2 option.

4.7 The Code Menu

The ***Code*** menu allows you to display windows that show different information related to your code. It contains the following items:

Source	Open the Source window. It shows source code at the currently executing location. See "The Source Window" on page 51.
Modules	Display a sorted list of modules contained in the current program. See "The Modules Window" on page 53.
Functions	Open a sorted list of all functions in the program. See "The Functions Window" on page 56.
Calls	Open the Call History window. This window displays the program’s call stack. See "The Calls Window" on page 66.
Assembly	Open the Assembly window. It shows assembly code at the currently executing location. See "The Assembly Window" on page 98.
Threads	Open a list of all threads in your program and their current state. See "The Thread Window" on page 67.
Images	Open a list of the executable images which are related to the program being debugged. This includes a list of all loaded DLLs. See "The Images Window" on page 57.
Replay	Open the program execution Replay window. This window allows you to restart your application and replay your debugging session to any point. See "The Replay Window" on page 65.

4.8 The Data Menu

The ***Data*** menu contains a number of windows that you can open to view the state of your program's data. It contains the following items:

Watches Open a Watches window. You can add and delete variables from the Watches window and use it to evaluate complex expressions and perform typecasting. See "Variable and Watch Windows" on page 71.

Locals Open a Locals window. It displays the local variables of the currently executing function. See "Variable and Watch Windows" on page 71.

File Variables
Open a File Variables window. It contains a list of variables defined at file scope in the current module. See "Variable and Watch Windows" on page 71.

Globals Open a sorted sorted list of all global variables in your program. Values are not displayed since it would make this window very expensive to update, but you can select variables from this window and add them to a Watches window. See "The Globals Window" on page 55.

Registers Displays the CPU registers and their values. See "The CPU Register Window" on page 97.

FPU Registers
Displays the FPU registers and their values. See "The FPU Registers Window" on page 101.

MMX Registers
Displays the MMX (multi-media extension) registers and their values. See "The MMX Registers Window" on page 102.

Stack Displays memory at the stack pointer. See "The Memory and Stack Windows" on page 77.

I/O Ports Open a window that lets you manipulate the I/O address space of the machine. See "The I/O Ports Window" on page 100.

Memory at...
Display memory at a given address. See "The Memory and Stack Windows" on page 77.

Log	Displays debugger messages and the output from debugger commands. See "The Log Window" on page 44.

4.9 The Window Menu

The ***Window*** menu allows you to control and arrange the windows on your screen.

The ***Window*** menu contains the following items:

Application	Switch to the output screen of the application. Press any key to return to the debugger.
To Log	Save the current window’s contents to the log window. Open the Log window to see the contents.
To File	Save the contents of the current window to a file. You must enter a file name and choose the drive and directory to which you want to save the information. This is useful for comparing program state between debugging sessions.
Zoom	Change the size of the current window. Zoom toggles the current window between its normal and maximum sizes.
Next	Rotate through the windows, choosing a new current window.
Accelerator	Open the Accelerator window. This window allows you to inspect and modify the debugger’s keyboard shortcut keys.

4.10 The Action Menu

Most windows in the debugger have a context sensitive pop-up menu. The ***Action*** menu will contain the same menu items as the current window’s pop-up menu. It may be used as an alternative to the pop-up menus. As an alternative to selecting text with the right mouse button and using the pop-up menu, you can select text with the left mouse button or keyboard and use the ***Action*** menu. For more information on the choices presented in the pop-up menus, see the section entitled "Variable and Watch Windows" on page 71.

4.11 The Help Menu

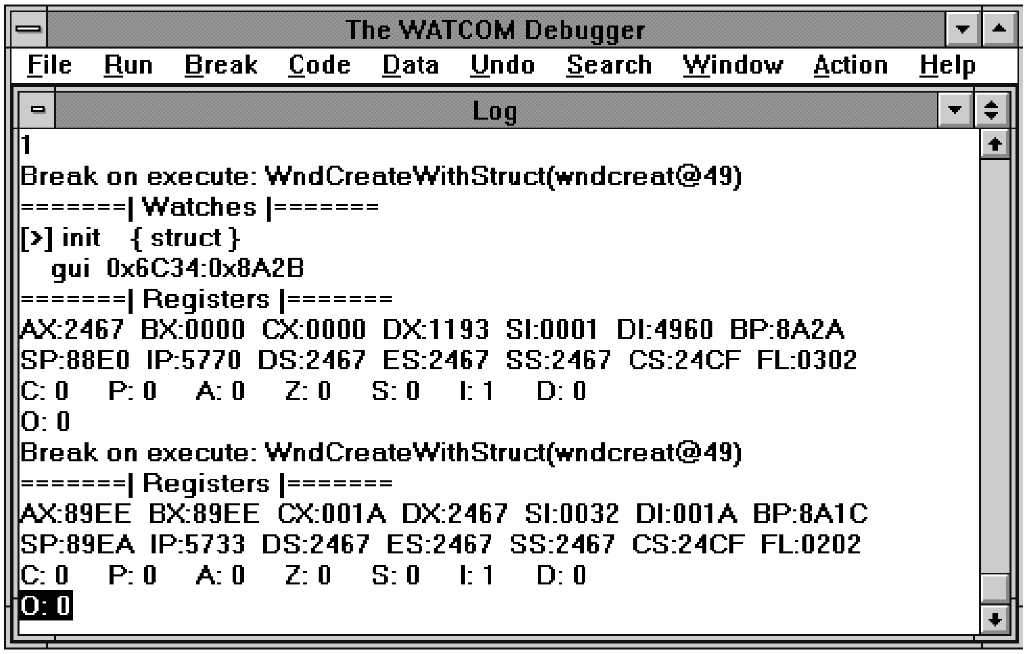
The ***Help*** menu contains items that let you use the on-line help facility. They are:

Contents	Show the main table of contents of the on-line help information. This is equivalent to pressing F1.
On Help	Display help about how to use the on-line help facility. This menu item is not available in character-mode versions of the debugger.
Search	Search the on-line help for a topic. This menu item is not available in character-mode versions of the debugger.
About	Display the "about box". It contains the copyright and version information of the debugger.

4.12 The Status Window

The Status window appears at the bottom of the debugger screen. As you drag the mouse over a menu item, descriptive text about that menu item appears in the toolbar. Messages about the current status of the program and debugger warning messages also appear in the Status window.

4.13 The Log Window



```
1
Break on execute: WndCreateWithStruct(wndcreat@49)
=======| Watches |=======
[>] init   { struct }
   gui  0x6C34:0x8A2B
=======| Registers |=======
AX:2467  BX:0000  CX:0000  DX:1193  SI:0001  DI:4960  BP:8A2A
SP:88E0  IP:5770  DS:2467  ES:2467  SS:2467  CS:24CF  FL:0302
C: 0    P: 0    A: 0    Z: 0    S: 0    I: 1    D: 0
O: 0
Break on execute: WndCreateWithStruct(wndcreat@49)
=======| Registers |=======
AX:89EE  BX:89EE  CX:001A  DX:2467  SI:0032  DI:001A  BP:8A1C
SP:89EA  IP:5733  DS:2467  ES:2467  SS:2467  CS:24CF  FL:0202
C: 0    P: 0    A: 0    Z: 0    S: 0    I: 1    D: 0
O: 0
```

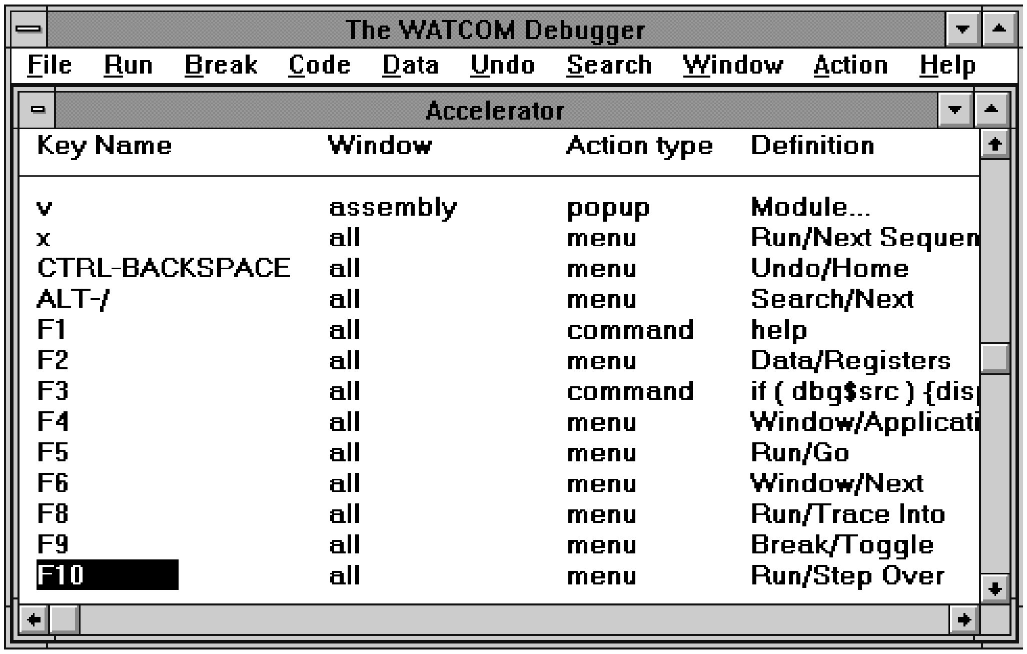
Figure 5. *The Log Window*

Choose ***Log*** from the ***Data*** menu to see the Log window. The Log window displays several different types of messages, including:

- status messages such as break point notification
- warning and error messages
- output from debugger commands

You can send the contents of any window to the Log window by selecting ***To Log*** from the ***Window*** menu. This allows you to save a window's contents and review it later.

4.14 The Accelerator Window



Key Name	Window	Action type	Definition
v	assembly	popup	Module...
x	all	menu	Run/Next Sequen
CTRL-BACKSPACE	all	menu	Undo/Home
ALT-/	all	menu	Search/Next
F1	all	command	help
F2	all	menu	Data/Registers
F3	all	command	if (dbg$src) {dis
F4	all	menu	Window/Applicati
F5	all	menu	Run/Go
F6	all	menu	Window/Next
F8	all	menu	Run/Trace Into
F9	all	menu	Break/Toggle
F10	all	menu	Run/Step Over

Figure 6. *The Accelerator Window*

The Accelerator window allows you to control the accelerators or keyboard equivalents used by the debugger. Choose ***Accelerator*** from the ***Window*** menu to open this window. The window displays 4 items relating to each accelerator definition. They are the key name, the window to which the accelerator applies, the type of action that the accelerator defines, and the specifics of that action.

Accelerators may either apply to all windows or to a specific window. You could define F2 to perform a different action depending upon which window is current. Accelerators which apply to all windows will have a window type of *all*.

An accelerator can define one of three action types. They are:

pop-up	Activate a pop-up menu item in the current window.
menu	Activate an item from the main menu.
command	Perform an arbitrary debugger command.

You can modify an element of an accelerator definition by double-clicking on it, or by cursoring to it and pressing ENTER. Press the right mouse button to access the following menu items:

Modify	Change the currently selected element of an accelerator assignment. If the key name is selected, the you will be prompted to type a new key. If the window name is selected, you will be presented with a list of possible window classes. If the action type or details are selected, you will be presented with a menu in order to pick the menu item which will be attached to the accelerator.
New	Add a new accelerator assignment. You will be prompted for all details.
Delete	Delete the selected accelerator.
TD Keys	Use an approximation of Borland Turbo Debugger’s accelerators.
WD Keys	Use the default set of accelerators. If you are familiar with CodeView, you will be comfortable with these key assignments.

Navigating Through a Program

5 Navigating Through a Program

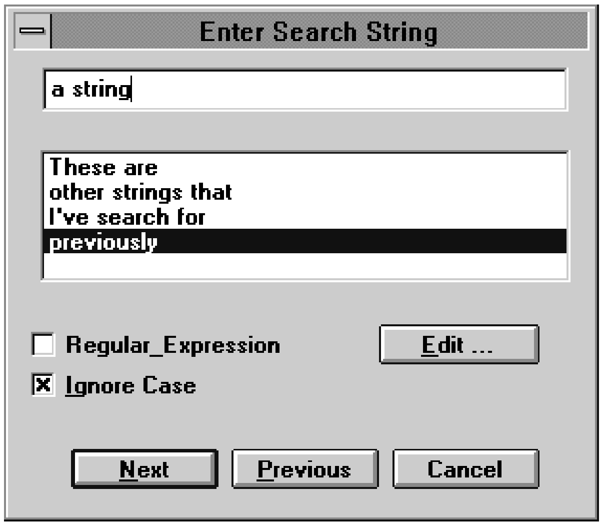
This section describes how to use the debugger to browse through your program.

5.1 The Search Menu

The ***Search*** menu allows you to search a window for a given string. It contains the following items:

Find	Search the current window for the first appearance of a given string. You will be prompted for the string. See "Entering Search Strings" on page 50.
Next	Find a subsequent occurrence of a search string.
Previous	Find a previous occurrence of a search string.
All Modules	This will search through the source code of all the modules contained in your program for a given string. See "Entering Search Strings" on page 50.
Match	Find a string in a sorted window by incremental matching. Once you select match, the text you type appears in the status window, and the window you are searching repositions itself as you type each character. Press ESC to leave this mode.

5.1.1 Entering Search Strings



a string

These are
other strings that
I've search for
previously

[ ] Regular_Expression
[✓] Ignore Case

Figure 7. *Entering a search string*

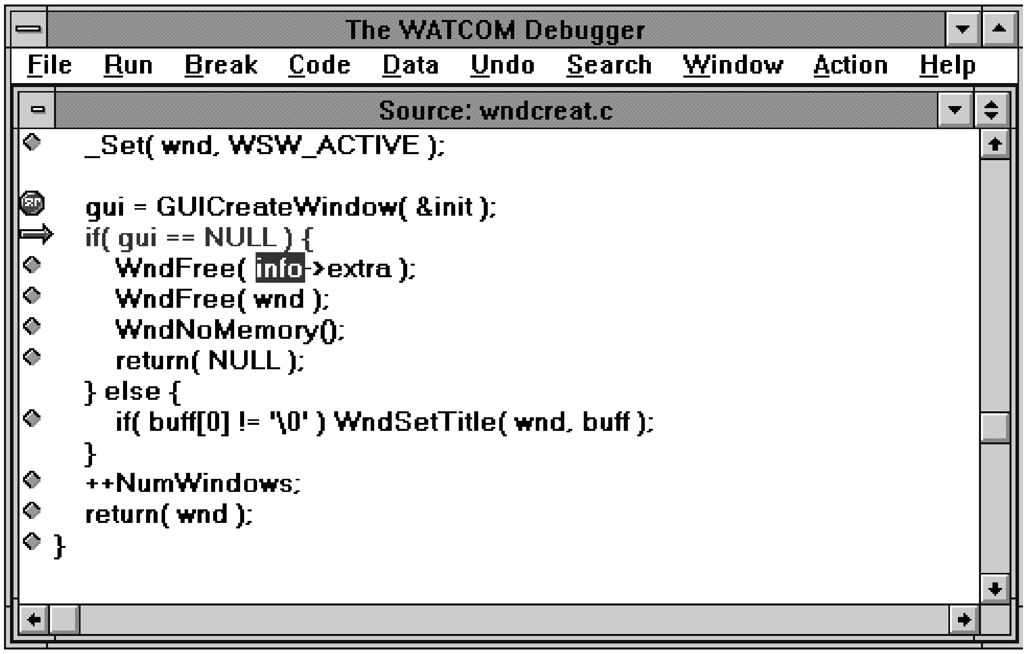
When you choose ***Find*** from the ***Search*** menu or ***All Modules*** from the ***Search*** menu, you must enter the search string that you are looking for and set the parameters for the search. The Search screen consists of the following items:

Enter Search String
Enter the string to be found in this edit box. The larger list below shows other strings that you have searched for during this debugging session. You can select these by clicking on them or by using the up and down arrow keys. The most recent search string appears at the top of the list.

Regular Expression
Check this box if the string is to be interpreted as a regular expression. You can click on the Edit button to edit the set of regular expression characters that will be used. For a description of regular expressions, see the Editor manual.

Ignore Case Check this box if you want the debugger to match the search string regardless of case.

5.2 The Source Window



```
    _Set( wnd, WSW_ACTIVE );

    gui = GUICreateWindow( &init );
    if( gui == NULL ) {
        WndFree( info->extra );
        WndFree( wnd );
        WndNoMemory();
        return( NULL );
    } else {
        if( buff[0] != '\0' ) WndSetTitle( wnd, buff );
    }
    ++NumWindows;
    return( wnd );
}
```

Figure 8. *The Source Window*

The Source window displays your program's source code. As you trace through your program, it repositions itself at the currently execution location. If you have an Assembly window open, the Source and Assembly windows will always be positioned at the same code. If you scroll in one, the other follows.

Source lines that have code associated with them have a button at the left of the screen. You can click on this button to set, disable and clear break points.

You can Inspect any item displayed in the source window by double-clicking on it, or by cursoring to it and pressing ENTER. Press the right mouse button to access the following pop-up menu items:

Inspect Inspect the selected item in an appropriate window. You can select function names, variable names, or any valid expression.

Run to Cursor
Resume program execution until the selected line is executed.

Break Add a breakpoint based on the selected text. If a variable is selected, the program will stop when its value changes. If a function name is selected the program will stop when that function is executed. ***This does not set a break at the current line.*** Use ***Toggle*** from the ***Break*** menu or ***At Cursor*** from the ***Break*** menu to set a breakpoint at the current line.

Enter Function
Resume program execution until the selected function is entered.

Watch Add the selected item to the Watches window for further inspection or modification.

Find Search for other occurrences of the selected string in the Source window.

Home Reposition the window to show the currently executing location. The cursor will move to the next line of the program to be executed.

Show/Assembly
Show the assembly code associated with the selected line.

Show/Functions
Show the list of all functions contained in the source file.

Show/Address
Reposition the window at a new address. You will be prompted for an expression. Normally you would type a function name but you can type any expression that resolves to a code address. For example, you might type the name of a variable that contains a pointer to a function. See "Watcom Debugger Expression Handling" on page 141.

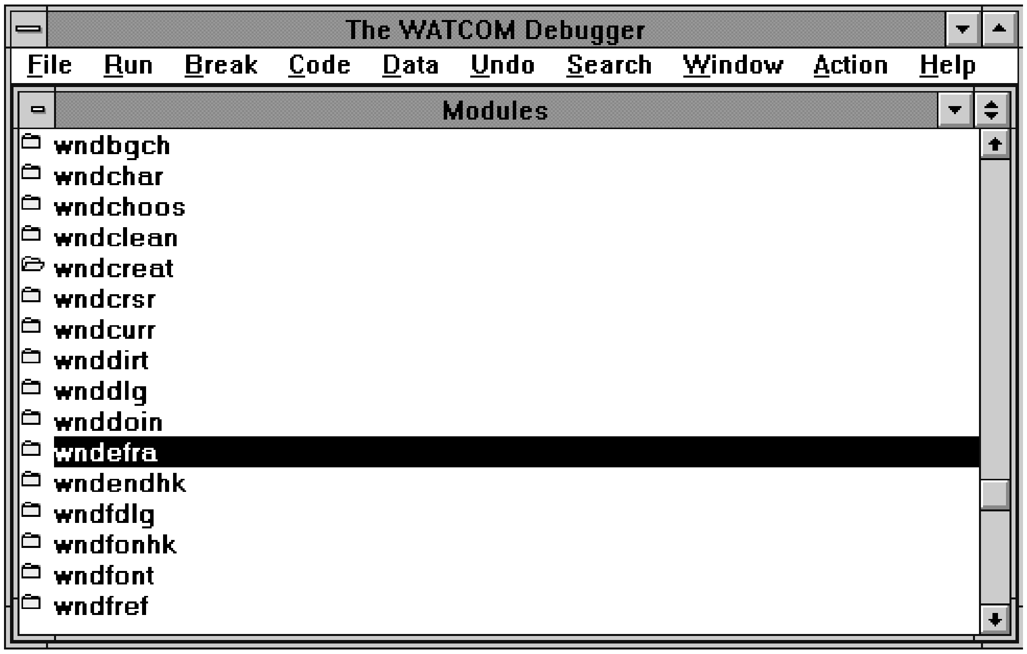
Show/Module
Show the code for a different module. You will be prompted for its name in a dialog. As a shortcut, you can type the beginning of a module name and click the Module... button. This will display a list of all modules that start with the text you typed.

Show/Line Move to a different source line. You can also find out what line you are looking at. The edit field will be initialized with the current line number.

5.3 The File Window

A File window is Similar to a source window except that it displays a file which is not part of the program being debugged. Menu items related to execution such as ***Break*** from the pop-up menu are not available.

5.4 The Modules Window



wndbgch
wndchar
wndchoos
wndclean
wndcreat
wndcrsr
wndcurr
wnddirt
wnddlg
wnddoin
wndefra
wndendhk
wndfdlg
wndfonhk
wndfont
wndfref

Figure 9. *The Modules Window*

The Modules window displays a list of the modules that make up the current program. To open the Modules window, choose ***Modules*** from the ***Code*** menu.

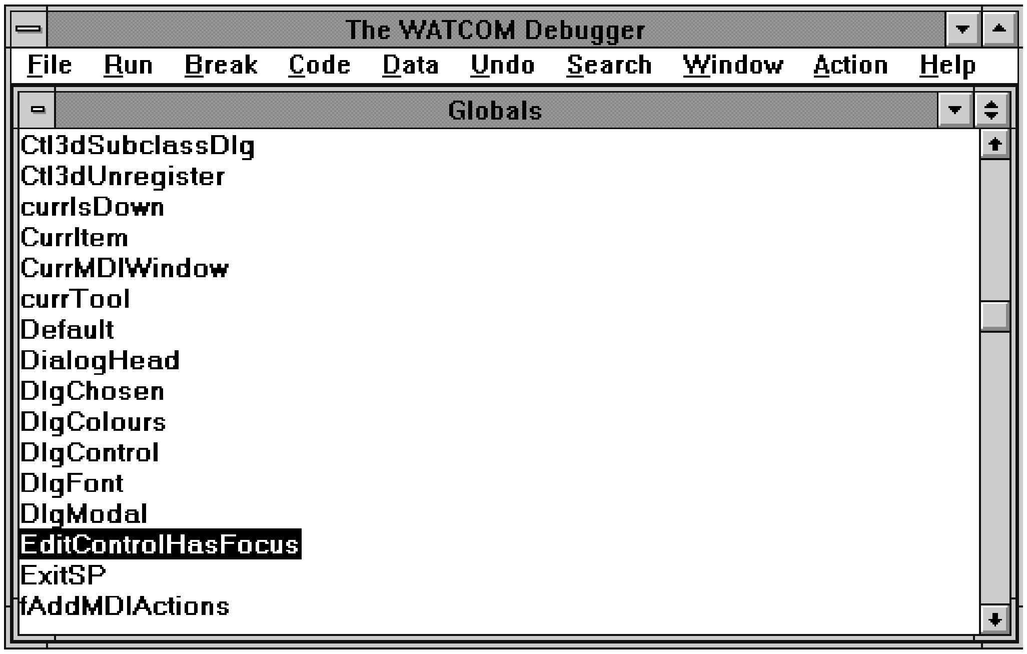
Three items are displayed for each module. At the left, there is a button. You can click the mouse on it to see the source or assembly associated with the module. This can also be accomplished by double-clicking on the module name or cursoring to it and pressing ENTER. Next is the module name. Third, if the module is contained in an executable image other than the one being debugged, is the name of that image.

Since this window is sorted ***Match*** from the ***Search*** menu can be used to find a module. Choose ***Match*** from the ***Search*** menu (or press =) and begin typing the name of the module.

Press the right mouse button to access the following pop-up menu items:

Source	Show the source code associated with the selected module.
Assembly	Show the assembly code associated with the selected module.
Functions	Show the list of all functions contained in this module.
Break All	Set a breakpoint at each function in this module.
Clear All	Delete all breakpoints which are set at addresses with this module. This does not affect break-on-write break points.
Show All	Toggle between showing all modules and just modules which were compiled with full debugging information (d2). This menu item sets options on a per-window basis, overriding the global settings. When you use the menu item to change these settings, they will not be saved between debugging sessions. To change an option permanently, see "The Window Options Dialog" on page 38.

5.5 The Globals Window



```
Ctl3dSubclassDlg
Ctl3dUnregister
currIsDown
CurrItem
CurrMDIWindow
currTool
Default
DialogHead
DlgChosen
DlgColours
DlgControl
DlgFont
DlgModal
EditControlHasFocus
ExitSP
fAddMDIActions
```

Figure 10. The Globals Window

You can open the Globals window by choosing ***Globals*** from the ***Data*** menu. This window displays the names of all global variables defined in the program. You can add a variable to the Watches window by double-clicking on it, or cursoring to it and pressing ENTER.

Press the right mouse button to access the following pop-up menu items:

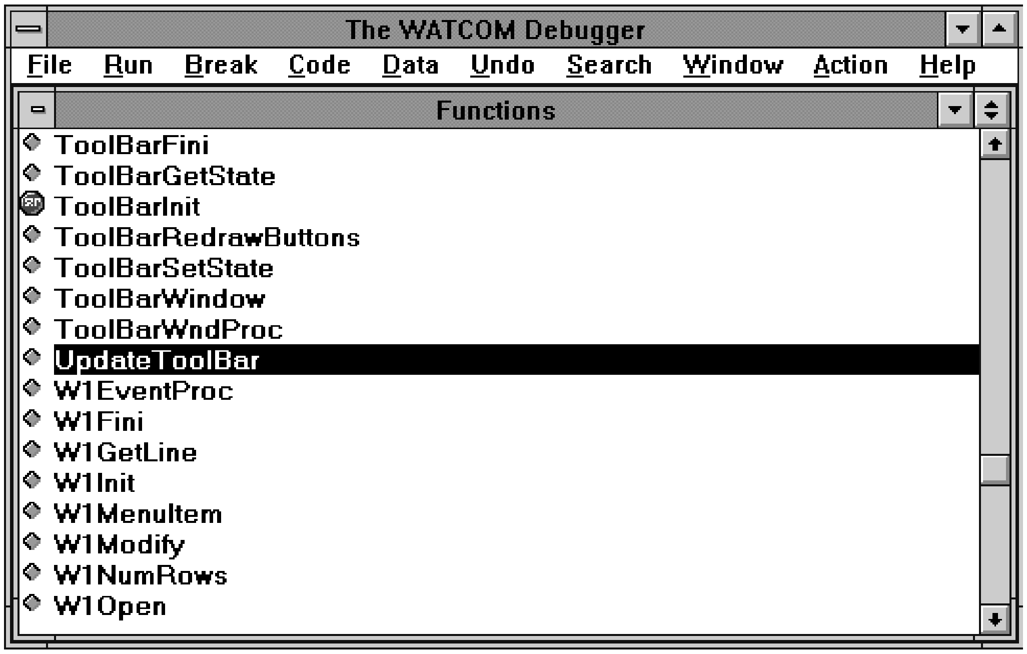
Watch Add the selected variable to the Watches window.

Raw Memory
Display the memory associated with the selected variable.

Typed Symbols
Toggle between showing all symbols and just those defined in modules compiled with the d2 option. Variables from the C/C++ library and assembly code are suppressed. This menu item sets options on a per-window basis, overriding the global settings. When you use the menu item to change these

settings, they will not be saved between debugging sessions. To change an option permanently, see "The Window Options Dialog" on page 38.

5.6 The Functions Window



ToolBarFini
ToolBarGetState
ToolBarInit
ToolBarRedrawButtons
ToolBarSetState
ToolBarWindow
ToolBarWndProc
UpdateToolBar
W1EventProc
W1Fini
W1GetLine
W1Init
W1MenuItem
W1Modify
W1NumRows
W1Open

Figure 11. *The Functions Window*

The Functions window can display a list of all functions contained in a module, executable image or program. To the left of each function name is a button. You can click on these buttons to set and clear breakpoints at the various functions. This can also be accomplished by double-clicking on the function name or cursoring to a function and pressing ENTER.

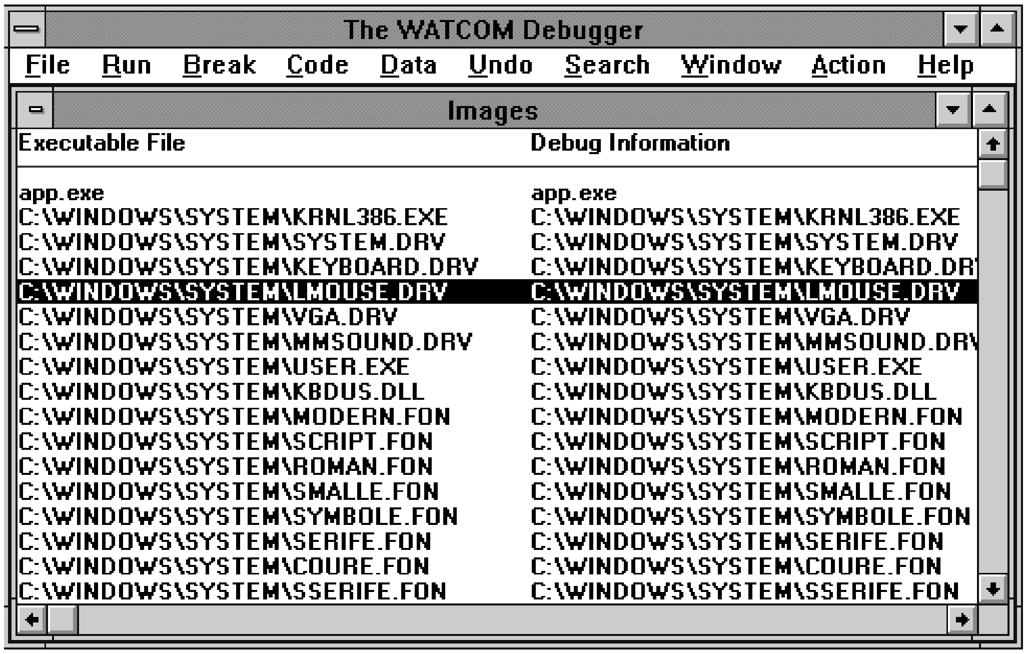
Press the right mouse button to access the following pop-up menu items:

Break	Set a breakpoint at the selected function. A dialog will appear so that you can fill in detailed breakpoint information. For more information, refer to the section entitled "The Breakpoint Dialog" on page 90.
Source	Show the source code for the selected function.

Assembly Show the assembly code associated with the selected function.

Typed Symbols
Toggle between showing all symbols and just those defined in modules compiled with the d2 option. Variables from the C/C++ library and assembly code are suppressed. This menu item sets options on a per-window basis, overriding the global settings. When you use the menu item to change these settings, they will not be saved between debugging sessions. To change an option permanently, see "The Window Options Dialog" on page 38.

5.7 The Images Window



```
Executable File                         Debug Information

app.exe                                 app.exe
C:\WINDOWS\SYSTEM\KRNL386.EXE           C:\WINDOWS\SYSTEM\KRNL386.EXE
C:\WINDOWS\SYSTEM\SYSTEM.DRV            C:\WINDOWS\SYSTEM\SYSTEM.DRV
C:\WINDOWS\SYSTEM\KEYBOARD.DRV          C:\WINDOWS\SYSTEM\KEYBOARD.DR
C:\WINDOWS\SYSTEM\LMOUSE.DRV            C:\WINDOWS\SYSTEM\LMOUSE.DRV
C:\WINDOWS\SYSTEM\VGA.DRV               C:\WINDOWS\SYSTEM\VGA.DRV
C:\WINDOWS\SYSTEM\MMSOUND.DRV           C:\WINDOWS\SYSTEM\MMSOUND.DR
C:\WINDOWS\SYSTEM\USER.EXE              C:\WINDOWS\SYSTEM\USER.EXE
C:\WINDOWS\SYSTEM\KBDUS.DLL             C:\WINDOWS\SYSTEM\KBDUS.DLL
C:\WINDOWS\SYSTEM\MODERN.FON            C:\WINDOWS\SYSTEM\MODERN.FON
C:\WINDOWS\SYSTEM\SCRIPT.FON            C:\WINDOWS\SYSTEM\SCRIPT.FON
C:\WINDOWS\SYSTEM\ROMAN.FON             C:\WINDOWS\SYSTEM\ROMAN.FON
C:\WINDOWS\SYSTEM\SMALLE.FON            C:\WINDOWS\SYSTEM\SMALLE.FON
C:\WINDOWS\SYSTEM\SYMBOLE.FON           C:\WINDOWS\SYSTEM\SYMBOLE.FON
C:\WINDOWS\SYSTEM\SERIFE.FON            C:\WINDOWS\SYSTEM\SERIFE.FON
C:\WINDOWS\SYSTEM\COURE.FON             C:\WINDOWS\SYSTEM\COURE.FON
C:\WINDOWS\SYSTEM\SSERIFE.FON           C:\WINDOWS\SYSTEM\SSERIFE.FON
```

Figure 12. *The Images Window*

Choose ***Images*** from the ***Code*** menu to open the Images window. It displays a list of executable images associated with the program that you are currently debugging. Executable images include the program executable, DLLs (Windows, OS/2 and Windows NT), and NLMs (NetWare). This window displays the name of the executable image, the name of the symbolic debugging information file (if available), and the debugging information type.

Different debugging information types are generated by different compilers.

Valid information types are:

WATCOM This information is generated by the WATCOM compilers.

DWARF This information is optionally generated by the WATCOM compilers.

CodeView Several other compilers, including Microsoft, generate CodeView style information.

EXPORTS This information is contained in the executable file itself, and is used by the operating system. Under OS/2, Windows and Windows NT, DLLs have export tables which define the names and addresses of entry points. Exports information lets you see the names of system entry points and APIs. Novell NLMs also have entry point tables. In addition, they may have Novell style debugging information, created with Novell’s linker (NLMLINK) or using the WATCOM Linker’s "debug novell" option. This information is made available to the debugger.

You can add new debugging information to an image by double-clicking on the image name or cursoring to it and pressing ENTER.

Press the right mouse button to access the following pop-up menu items:

New Symbols
Add symbolic debugging information for the selected image. This is useful if you know that a separate debug information file contains the appropriate debugging information that was not found by the debugger.

Delete Symbols
Delete any symbolic debugging information associated with the selected image.

Modules Show a list of modules contained in the selected image.

Functions Show a list of functions contained in the selected image.

Globals Show a list of all global variables contained in the selected image.

Controlling Program Execution

6 Controlling Program Execution

This section describes how you can control the execution of your program as you debug it.

6.1 The Run Menu

The ***Run*** menu controls how your program executes. It contains the following items.

Go Start or resume program execution. Execution resumes at the current location and will not stop until a breakpoint is encountered, an error occurs, or your program terminates.

Run to Cursor
Resume program execution until it executes the location of the cursor in the Source or Assembly window. Execution will stop before the cursor position if a breakpoint is encountered or an error occurs.

Execute to Resume program execution until it executes a specified address. You will be prompted to enter an address. It can be the name of a function or an expression that resolves to a code address. See "Watcom Debugger Expression Handling" on page 141. In the dialog, you can click the Symbols... button as a shortcut. You can type a partial symbol name like `foo` and the Symbol button will show you a list of symbols that start with `foo.` You can then choose one of these symbols by clicking on it or hitting ENTER. Note that the first time you use the Symbols... in a debugging session, it will take a while as the debugger sorts the symbol table for the program.

If your program encounters a breakpoint or an error occurs before the specified address is executed, your request to stop at the given address is ignored.

Step Over Trace a single source or assembly line depending on whether the source or assembly window is current. Step Over will not step into any function calls.

Trace Into This is similar to ***Step Over*** except that it will step into any function calls.

Next Sequential
Run until the program executes the next sequential source line or assembly

instruction. This is useful if the program is executing the last statement in a loop and you wish to execute until the loop terminates. When using this command, be sure that the execution path will eventually execute the next statement or instruction. If execution fails to reach this point then the program may continue to execute until completion. This situation is like setting a breakpoint at a statement or assembly instruction which will never be executed and then issuing a GO command. In this situation, the application would execute until an error occurred or another breakpoint was encountered.

Until Return
Resume program execution until the currently executing function returns. Execution terminates prior to this if an error occurs or a breakpoint is encountered.

Skip to Cursor
Reposition the instruction pointer at the cursor position, "skipping" all instructions in between. When you continue execution, the program continues from this point. This is useful if you want to skip an offending line or re-execute something. ***Use this menu item with caution. If you skip to an instruction which is not in the current function or skip to code that expects a different program state, your program could crash.***

Restart Restart your program from the beginning. All breakpoints in your program will be preserved. Breakpoints in DLLs will not be preserved.

Debug Startup
Restart your program from the beginning but stop before system initialization. Normally the debugger puts you at the main (fmain, winmain, etc.) entry point in your application. This option will allow you to break much earlier in the initialization process. This feature is useful for debugging run-time startup code, initializers, and constructors for static C++ objects.

For DOS, Windows 3.x and Netware, the debugger will put you at the assembly entry point of your application (i.e., it doesn't run the "progstart" hook).

Windows 3.x runs each DLL's startup code as it loads it, and the static DLLs are really loaded by the run-time startup code, so, to debug the startup code for a statically linked Windows 3.x DLL, you need to do the following.

1. Select ***Debug Startup*** from the ***Run*** menu.

2. Select ***On Image Load*** from the ***Break*** menu. Type the name of the DLL in which you are interested.

3. Select ***Go*** from the ***Run*** menu

For OS/2 and Windows NT, the debugger will put you at a point after all DLLs have been loaded, but before any DLL initialization routines are called. This enables you to set breakpoints in your statically referenced DLL’s startup code.

If you have hard-coded int3 instructions in your DLL startup, the debugger will skip them, unless you use ***Debug Startup*** from the ***Run*** menu.

All breakpoints in your program will be preserved. Breakpoints in DLLs will not be preserved.

Save Save the current debugging session to a file. The file contains commands that will allow the debugger to play your debugging session back to its current point in a later session. See "The Replay Window" on page 65.

Restore Restore a saved debugging session. If you run the program with different input or if the program is a multi-threaded application, this option may not work properly since external factors may have affected program execution. See "The Replay Window" on page 65.

6.2 The Undo Menu

The debugger keeps an execution history as you debug your program. This history is accessible using the ***Undo*** menu. The effect of program statements as you single step through your program are recorded. All interactions that allow you to modify the state of your program including modifying variable values, changing memory and registers are also recorded. Undo and Redo let you browse backward and forward through this execution history. As you use these menu items, all recorded effects are undone or redone, and each of the debugger’s windows are updated accordingly.

You can resume program execution at any previous point in the history. The program history has no size restrictions aside from the amount of memory available to the debugger, so theoretically you could single step through your entire program and then execute it in reverse. There are several practical problems that get in the way of this. When you single step over a call or interrupt instruction, or let the program run normally, the debugger has no way of knowing what kind of side effects occurred. No attempt is made to discover and record these side effects, but the fact that you did step over a call is recorded. If you try to resume program execution from a point prior to a side effect, the debugger will give you a the option to continue or back out of the operation. Use caution if you choose to continue. If an important side effect is duplicated, you program could crash. Of course reversing execution over functions with no side effects is harmless, and can be a useful debugging technique. If you have accidentally stepped over a call that does have a side effect, you can use ***Replay*** to restore your program state.

Unwind and Rewind move the debugger's state up and down the call stack. Like Undo, all windows are updated as you browse up and down the stack, and you can resume execution from a point up the call stack. A warning will be issued if you try resuming from a point up the call stack since the debugger cannot completely undo the effects of the call.

Unwind is particularly useful when your program crashes in a routine that does not contain debugging information. strcpy() is a good example of this. You can use Unwind to find the call site and inspect the parameters that caused the problem.

The runtime library detects certain classes of errors and diagnoses them as fatal runtime errors. If this occurs when you are debugging, the debugger will be activated and the error message will be displayed. For example, throwing an exception in C++ without having a catch in place is a fatal runtime error. In C, the abort() and assert() functions are fatal errors. When this happens, you will be positioned in an internal C library call. You can use Unwind to find the point in your source code that initiated the error condition.

When Unwind and Undo are used in conjunction, Undo is the primary operation and Unwind is secondary. You can Undo to a previous point in the history and then Unwind the stack. If you Unwind the stack first and then use Undo, the Unwind has no effect.

If you modify the machine state in any way when you are browsing backward through the execution history, all forward information from that point is discarded. If you have browsed backward over a side effect the debugger will give you the option of canceling any such operation.

The Undo menu contains the following items.

Undo Browse backwards through the program execution history.

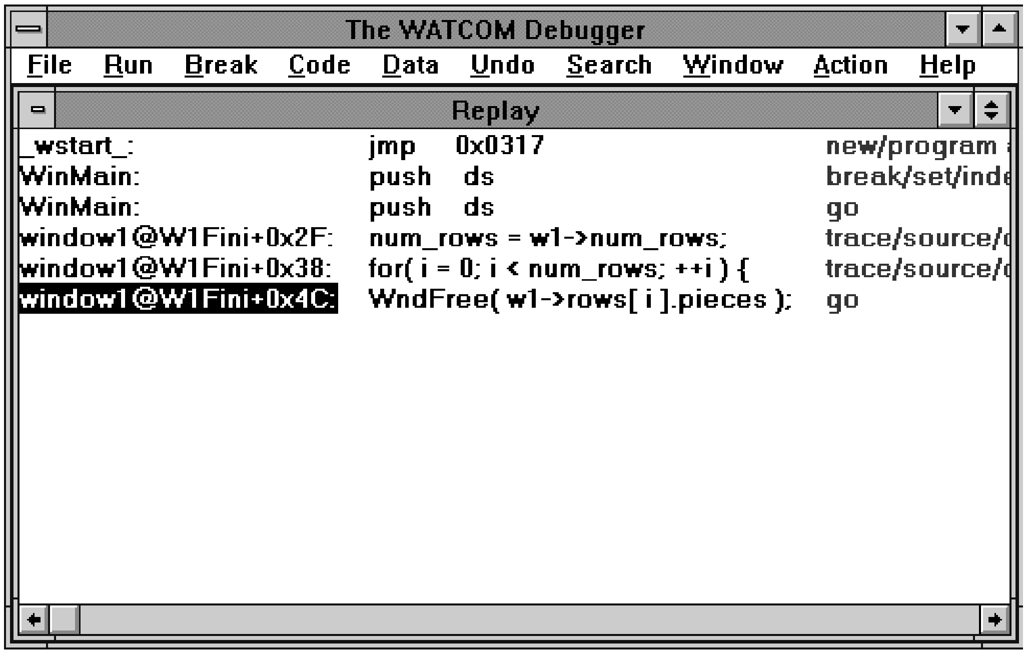
Redo Browse forward through the program execution history.

Unwind Stack
Move up the call stack one level.

Rewind Stack
Move down the call stack one level.

Home Return to the currently executing location, reversing the effects of all Undo and Unwind operations.

6.3 The Replay Window



```
_wstart_:                 jmp    0x0317                     new/program
WinMain:                  push   ds                         break/set/inde
WinMain:                  push   ds                         go
window1@W1Fini+0x2F:      num_rows = w1->num_rows;          trace/source/
window1@W1Fini+0x38:      for( i = 0; i < num_rows; ++i ) { trace/source/
window1@W1Fini+0x4C:      WndFree( w1->rows[ i ].pieces );  go
```

Figure 13. *The Replay Window*

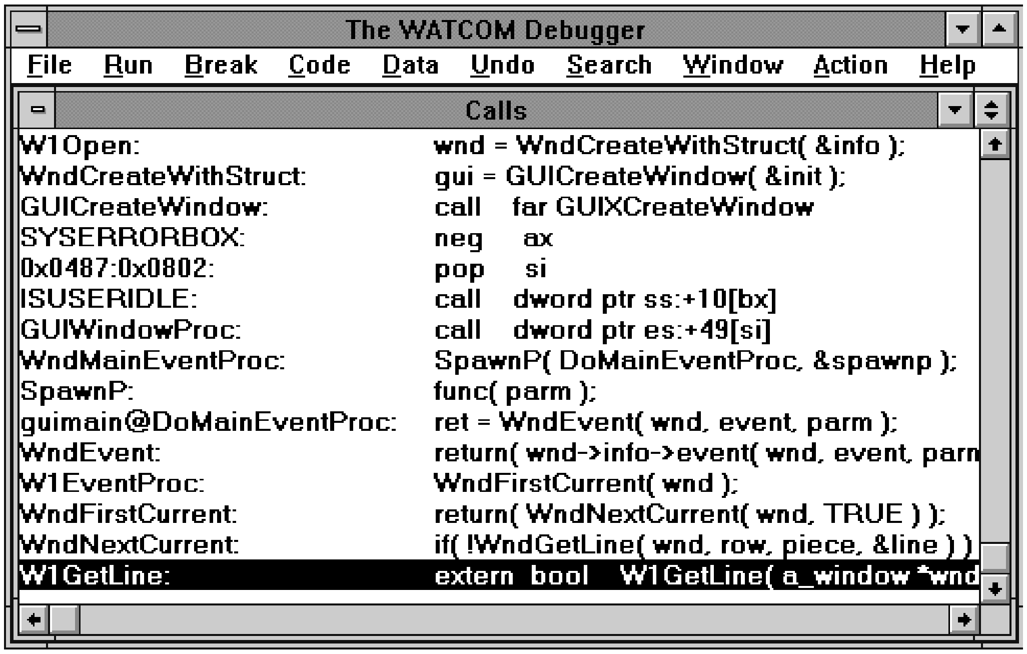
Choose ***Replay*** from the ***Code*** menu to open the Replay window. This window displays each of the steps that you have performed during this debugging session that might have affected program flow. There are three items displayed in the replay window. First is the address the program was executing when you took some action that could affect the program. These actions include setting break points, tracing and modifying memory. Second is the source or assembly code found at that address. Third is a command in the debugger’s command language that will duplicate the action you took. The most common use for Replay is when you accidentally step over a function call, or the program unexpectedly runs to completion. If this happens, you can open the replay window, and replay you debugging session up to any point prior to the last action you took.

There are special cases where replay will not perform as expected. Since replay is essentially the same as playing your keystrokes and mouse interactions back to the debugger, your program must behave identically on a subsequent run. Any keyboard or mouse interaction that your program expects must be entered the same way. If your program expects an input file, you must run it on the same data set. Your program should not behave randomly or handle asynchronous events. Finally, your program should not be multi-threaded. If you have just been tracing one thread, your program will replay correctly, but multiple threads may not be scheduled the same way on a subsequent run.

You can replay program execution to any point by double clicking on that line or by cursoring to it and pressing ENTER. Select any line and press the right mouse button to see the following pop-up menu items:

Goto	Replay the program until it returns to the selected level in the replay history.
Source	Position the source window at the selected line.
Assembly	Show the assembly code for the selected line.

6.4 The Calls Window



```
W1Open:                      wnd = WndCreateWithStruct( &info );
WndCreateWithStruct:         gui = GUICreateWindow( &init );
GUICreateWindow:             call   far GUIXCreateWindow
SYSERRORBOX:                 neg    ax
0x0487:0x0802:               pop    si
ISUSERIDLE:                  call   dword ptr ss:+10[bx]
GUIWindowProc:               call   dword ptr es:+49[si]
WndMainEventProc:            SpawnP( DoMainEventProc, &spawnp );
SpawnP:                      func( parm );
guimain@DoMainEventProc:     ret = WndEvent( wnd, event, parm );
WndEvent:                    return( wnd->info->event( wnd, event, parm
W1EventProc:                 WndFirstCurrent( wnd );
WndFirstCurrent:             return( WndNextCurrent( wnd, TRUE ) );
WndNextCurrent:              if( !WndGetLine( wnd, row, piece, &line ) )
W1GetLine:                   extern  bool   W1GetLine( a_window *wnd
```

Figure 14. *The Calls Window*

Choose ***Calls*** from the ***Code*** menu menu to display the Calls window. This window displays the program's call stack. Each line contains the name of the function that was executing, and the source or assembly code at the call site. You can use Unwind and Rewind to obtain this information, but the calls windows will show you the entire call stack.

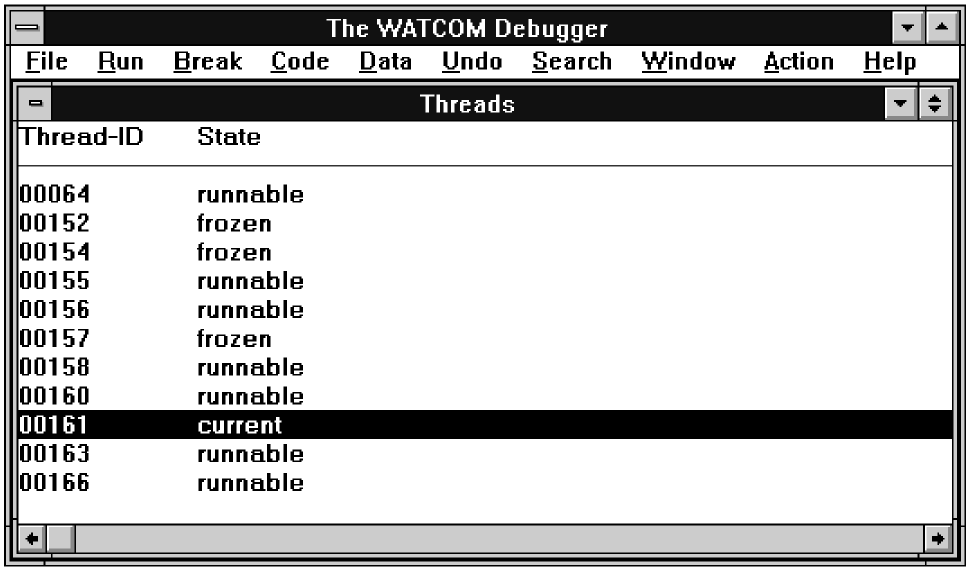
You can Unwind to any point in the call stack by double-clicking on a line, or by cursoring to it and pressing ENTER. Select a line and press the right mouse button to access the following pop-up menu items:

Unwind Unwind the stack to the level of the selected code. This is equivalent to using ***Unwind*** from the ***Undo*** menu or ***Rewind*** from the ***Undo*** menu.

Break Set a breakpoint at the return from the selected call.

Goto Execute until the program returns from the selected call.

6.5 The Thread Window



```
Thread-ID    State

00064        runnable
00152        frozen
00154        frozen
00155        runnable
00156        runnable
00157        frozen
00158        runnable
00160        runnable
00161        current
00163        runnable
00166        runnable
```

Figure 15. *The Thread Window*

Choose ***Thread*** from the ***Code*** menu to display Thread window. This window displays the system ID of each thread, the state of the thread, and under some operating systems, system specific information about the thread including its name and scheduling priority. The state of each thread can be:

current	This is the thread that was running when the debugger was entered. It is the thread that hit a break point or error. When you trace through the application, ***only the current thread is allowed to run.***
runnable	This thread will be allowed to run whenever you let your program run, but will not run when you trace the program.
frozen	This thread will not be allowed to run when you resume your program.
dead	Under some operating systems, threads that have been terminated still show up in the list of threads. A dead thread will never execute again.

You can make any thread current by double clicking on it or cursoring to it and pressing ENTER. All other debugger windows update accordingly. Press the right mouse button to access the following pop-up menu items:

Switch to	Make the selected thread current.
Freeze	Change the state of the selected thread to be ***frozen***. You cannot freeze the current thread.
Thaw	Change the state of the selected thread to be ***runnable.***. The current thread is always runnable.

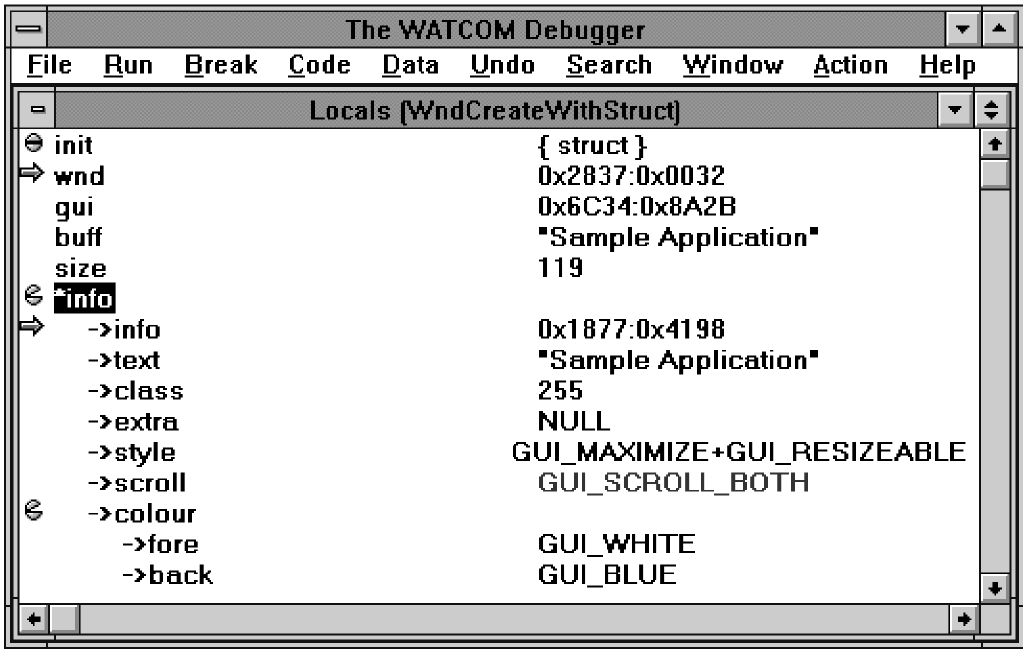
Examining and Modifying the Program State

7 Examining and Modifying the Program State

The following topics are discussed:

- "Variable and Watch Windows"
- "The Memory and Stack Windows" on page 77

7.1 Variable and Watch Windows


The WATCOM Debugger
File Run Break Code Data Undo Search Window Action Help
Locals (WndCreateWithStruct)

```
init                        { struct }
wnd                         0x2837:0x0032
gui                         0x6C34:0x8A2B
buff                        "Sample Application"
size                        119
*info
  ->info                    0x1877:0x4198
  ->text                    "Sample Application"
  ->class                   255
  ->extra                   NULL
  ->style                   GUI_MAXIMIZE+GUI_RESIZEABLE
  ->scroll                  GUI_SCROLL_BOTH
  ->colour
    ->fore                  GUI_WHITE
    ->back                  GUI_BLUE
```

Figure 16. The Watch and Variable Window

Windows that display variables come in several different varieties. They are:

- Locals
- File Variables
- Watches
- Variable

They are collectively called variable windows. You use the same interactions in all variable windows to display, modify and browse your variables and data structures. The only difference between these windows are the variables that they display. The values in each window are updated as you trace through your program. The windows display the following information:

Locals Contains the list of variables which are local to the current routine. Choose ***Locals*** from the ***Data*** menu to open this window.

File Variables Contains a list of all variables which are defined at file scope in the current module. This includes external and static symbols. Choose ***File Variables*** from the ***Data*** menu to open this window.

Watches The Watches windows allows you to add and delete variables and expressions. In other windows you can choose ***Watch*** from the pop-up menu. This will open the watches window add the text which is selected in another window to the watches window. You can use ***New*** from the pop-up menu to add any expression to the Watches window. Once entered, you can choose ***Edit*** from the pop-up menu to edit the expressions or typecast the variables.

Variable This is another instance of a Watches window. A variable window is created when you select a variable or expression in a window and use ***Inspect*** from the pop-up menu.

Each line of a variable window has three elements. On the left is a button. The button changes depending on the type of the variable or expression. it changes based on the type of the item:

structs (classes) (unions) Structures may be opened and closed by clicking on the button at the left. When you open a structure or class, one line is added to the window for each field of the structure. These new lines are indented. If you click on the button again, the structure is closed and the window is returned to its original state.

arrays Like structs, arrays may be opened and closed. When you open an array, one line is added to the window for each element of the array. The debugger will display at most 1000 elements of an array. If it contains more you can use ***Type/Array...*** to open different ranges. Multi dimensional arrays are treated like an array of arrays. When you open the first dimension, the lines that are added will also be arrays which you can open.

pointers When the variable is a pointer, you can click on the button and the debugger will follow the pointer and change the line to represent the item which is the result of the pointer reference. For example, if you have a pointer to an integer and click on the button, the integer value will be displayed. The button then changes to indicate so that you can undo the operation by clicking on it again.

In the case of pointers to pointers, clicking on the button will follow the pointers one level each time you click on the button until a non-pointer value is reached. Clicking on the button at this point will undo take you back to the original state. When the pointer points to a struct, the structure will automatically be opened when you click on the button. If a pointer is really an array, you can use ***Type/Array...*** from the pop-up menu to open it as an array.

Next comes the name of the variable, field or array element being displayed. Finally, the value is displayed. If the item being displayed is not a scalar item, the value displayed is an indication that it is a complex data type. If the value changes when you run your program, it will be highlighted. If a variable goes out of scope, or a pointer value becomes invalid, the value will be displayed as question marks.

You can modify a variable's value by double clicking on the value field, or by cursoring to it and pressing enter. Double clicking or pressing enter on the name field is equivalent to clicking on the button. Press the right mouse button to access the following pop-up menu items:

Modify... Modify the value of the selected item.

Break Set a breakpoint so that execution stops when the selected item's value changes. This is the same as setting a breakpoint on the object. See "Breakpoints" on page 85.

Inspect Open a new Variable window containing the selected item. If the item is a compound object (array, class, or structure), it will be opened automatically.

Watch Add the selected item to the Watch window.

Show/Raw Memory
Display raw memory at the address of this variable. This lets you examine the actual binary representation of a variable.

Show/Pointer Memory
Display the memory that the item points to. This is useful when you have a pointer to a block of memory that does not have a type associated with it.

Show/Pointer Code
Display the code that the variable points to. If the item being displayed is a pointer to function, you can use this menu item to see the definition of that function.

Show/Type Display the type of the variable in an information message box. Select "OK" to dismiss the information box and resume debugging.

Edit Open a dialog box in which you can edit an expression in the Watch window. This is useful for typecasting variables or evaluating expressions. See "Watcom Debugger Expression Handling" on page 141.

New Add a new variable or expression to the window. You will be prompted for the expression to add.

Delete Delete the selected item from the window.

FieldOnTop Display the value of this member at the top of the structure/class. You can selectively add or remove items from the list that is displayed "on top". For example, say you have a `struct Point` displayed as:

```
[-] point
  x      10
  y      30
  other  "asdf"
```

If you toggle ***FieldOnTop*** for both `x` and `y` then `point` would be displayed like this:

```
[-] point { 10, 30 }
  x      10
  y      30
  other  "asdf"
```

Furthermore, if you closed the struct (or pointer to struct) then you would see:

```
[+] point { 10, 30 }
```

This carries to structs containing structs (and so on) as shown in the following struct containing two `Point` structures.

```
[-] rect { { 10, 10 }, { 30, 30 } }
  top_left { 10, 10 }
  bot_right { 30, 30 }
```

If you close it, then you will see:

```
[+] rect { { 10, 10 }, { 30, 30 } }
```

Class/Show Functions
Display function members of this object. If this option is not selected, no functions are displayed. This option works in conjunction with other ***Class*** selections to display "Inherited", "Generated", "Private" and "Protected" functions.

Class/Show Inherited
Display inherited members of this object. To see inherited functions, you must also select ***Class/Show Functions.***

Class/Show Generated
Display compiled-generated members of this object. To see generated functions, you must also select ***Class/Show Functions.***

Class/Show Private
Display private members of this object. To see private functions, you must also select ***Class/Show Functions.***

Class/Show Protected
Display protected members of this object. To see protected functions, you must also select ***Class/Show Functions.***

Class/Show Static
Display static members of this object.

Type/Hex Change the value to be displayed in hexadecimal.

Type/Decimal
Change the value to be displayed in decimal.

Type/Character
Change the value to be displayed as a single character constant. This useful

when you have a one byte variable that really contains a character. The debugger will often display it as an integer by default.

Type/String The debugger automatically detects pointers to strings in the variable windows and displays the string rather than the raw pointer value. In the string is not null terminated, contains non-printable characters, or is not typed as a pointer to ’char’, this mechanism will not work. ***Type/String*** overrides the automatic string detecting and displays the pointer as a string regardless of its type.

Type/Pointer

This will undo the effects of ***Type/String*** or ***Type/Array***. It will also let you see the raw pointer value when the debugger has automatically displayed a pointer to char as a string.

Type/Array...

Use this menu item to display a pointer as if it were an array, or to display ranges of an array’s elements. You will be prompted for the first and last element to display.

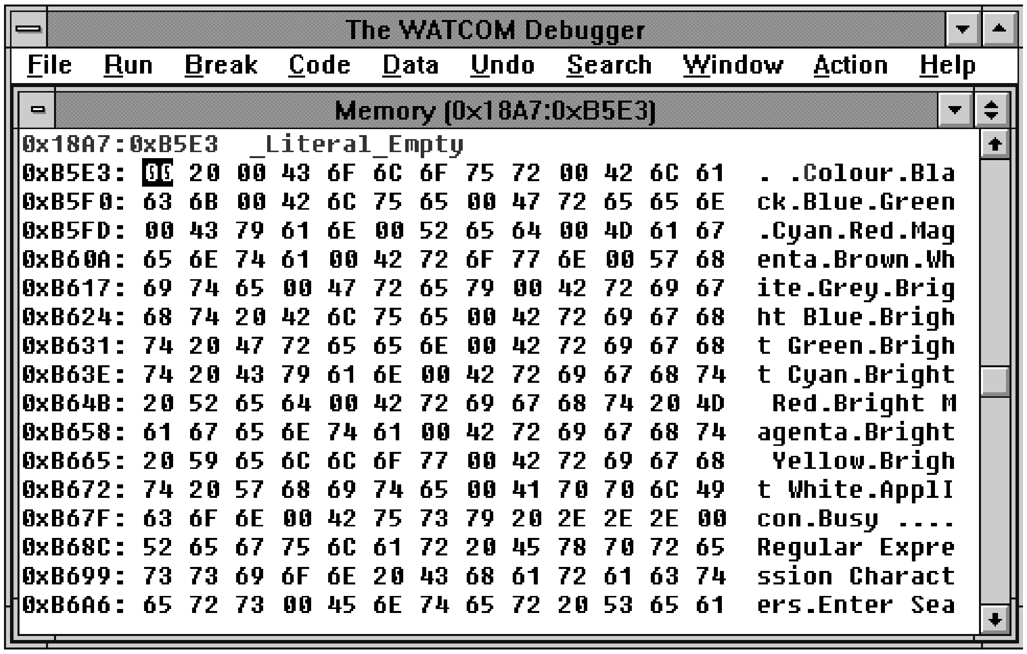
Options/Whole Expression

Select this option to show the whole expression used to access fields and array elements instead of just the element number or field name itself.

Options/Expand ’this’

Do not display members of the ’this’ pointer as if they were local variables declared within the member function.

7.2 The Memory and Stack Windows



```
0x18A7:0xB5E3   _Literal_Empty
0xB5E3: 00 20 00 43 6F 6C 6F 75 72 00 42 6C 61  . .Colour.Bla
0xB5F0: 63 6B 00 42 6C 75 65 00 47 72 65 65 6E  ck.Blue.Green
0xB5FD: 00 43 79 61 6E 00 52 65 64 00 4D 61 67  .Cyan.Red.Mag
0xB60A: 65 6E 74 61 00 42 72 6F 77 6E 00 57 68  enta.Brown.Wh
0xB617: 69 74 65 00 47 72 65 79 00 42 72 69 67  ite.Grey.Brig
0xB624: 68 74 20 42 6C 75 65 00 42 72 69 67 68  ht Blue.Brigh
0xB631: 74 20 47 72 65 65 6E 00 42 72 69 67 68  t Green.Brigh
0xB63E: 74 20 43 79 61 6E 00 42 72 69 67 68 74  t Cyan.Bright
0xB64B: 20 52 65 64 00 42 72 69 67 68 74 20 4D   Red.Bright M
0xB658: 61 67 65 6E 74 61 00 42 72 69 67 68 74  agenta.Bright
0xB665: 20 59 65 6C 6C 6F 77 00 42 72 69 67 68   Yellow.Brigh
0xB672: 74 20 57 68 69 74 65 00 41 70 70 6C 49  t White.ApplI
0xB67F: 63 6F 6E 00 42 75 73 79 20 2E 2E 2E 00  con.Busy ....
0xB68C: 52 65 67 75 6C 61 72 20 45 78 70 72 65  Regular Expre
0xB699: 73 73 69 6F 6E 20 43 68 61 72 61 63 74  ssion Charact
0xB6A6: 65 72 73 00 45 6E 74 65 72 20 53 65 61  ers.Enter Sea
```

Figure 17. *The Memory Window*

Use the Memory window or the Stack window to examine memory in raw form. To open a Memory window, choose ***Memory At*** from the ***Data*** menu. The *Enter Memory Address* dialog appears. Enter the memory address and press Return to see the Memory window. You can also use one of the Show/Pointer Memory or Show/Raw Memory items in a variable window to display the memory associated with a variable.

The Stack Window always shows the memory at the stack pointer. It is moved as your program executes to track the top of the stack. The stack pointer location will be at the top of the window. The location of the BP or EBP register will also be indicated. Choose ***Stack*** from the ***Data*** menu to open the Stack window.

You can modify memory by double-clicking on a value in the Memory or Stack window, or by cursoring to it and pressing enter. You will be prompted for a new value.

Memory windows allow you to follow data structures in the absence of debugging information. The ***Follow*** menu items will reposition the memory window to the address that is found under the cursor. The ***Repeat*** and ***Previous*** items will let you repeat a follow action.

This makes it simple to follow linked lists. Press the right mouse button to access the following pop-up menu items:

Modify Modify the value at the selected address. You will be prompted for a new value. You should enter the value in the same radix as the window is currently displaying. You are not limited to typing constants values. You can enter an arbitrary expression to be used for the new value.

Break on Write
Set a breakpoint to stop execution when the selected value changes. See "Breakpoints" on page 85.

Near Follow
Displays the memory that the selected memory points to, treating it as a near pointer. The new offset to be displayed will be xxxx where xxxx is the word under the cursor. DGROUP will be used as the segment if it can be located. The program's initial stack segment will be used otherwise. When you are debugging a 16-bit or 32-bit application, the appropriate word size is used.

Far Follow Displays the memory that the selected memory points to, treating it as a far pointer. The new address to be displayed will be the the segment and offset found at the cursor location. Note that pointers are stored in memory with the offset value first and the segment value second.

Segment Follow
Display the segment that the selected memory points to, treating it as a segment selector. The new address to be displayed will be xxxx:0 where xxxx is the two byte word under the cursor.

Cursor Follow
Make the selected position the new starting address in the window. This means that the first byte in the memory window will become the byte that the cursor was pointing to. This is useful for navigating through an array when no debugging information is available.

Repeat Repeat the previous Follow operation. The new address that will be used is at the same offset relative to the beginning of the window as it was in the original Follow operation. Repeating a pointer or segment follow is a linked list traversal. Repeating a Cursor Follow operation advances to the next element in an array.

Previous	Back out of a Follow or Repeat operation. This will display the memory window you were previously viewing. Essentially, this undoes a Follow operation. You can back all the way out to the first memory location you were examining.
Home	Undo all Follow and Repeat operations. This will take you back to the very first location window you were examining. It is equivalent to using Previous repeatedly.

Left	Scroll the window backward through memory by the size of the displayed memory items.
Right	Scroll the window forward through memory by the size of the displayed memory items.

Address	Position the window at a new address. You will be prompted to type in a new address. You can type an arbitrary expression. See "Watcom Debugger Expression Handling" on page 141. If you type the name of a variable, the *address* of that variable is used. If the expression you type does not contain a segment value DGROUP will be used as the segment if it can be located. The program's initial stack segment will be used otherwise.
Assembly	Position the assembly window to the address of the memory under the cursor. This is useful if you have incorrectly displayed a pointer as data and wish to look at the code instead.
Type/Byte	Display as hexadecimal bytes.
Type/Word	Display as hexadecimal 16-bit words.
Type/Dword	Display as hexadecimal 32-bit words.
Type/Qword	Display as hexadecimal 64-bit words.
Type/Char	Display as signed 8-bit integers.
Type/Short	Display as signed 16-bit integers.
Type/Long	Display as signed 32-bit integers.

Type/__int64
Display as signed 64-bit integers.

Type/Unsigned Char
Display as unsigned 8-bit integers.

Type/Unsigned Short
Display as unsigned 16-bit integers.

Type/Unsigned Long
Display as unsigned 32-bit integers.

Type/Unsigned __int64
Display as unsigned 64-bit integers.

Type/0:16 Pointer
Display as 16-bit near pointers (16-bit offset).

Type/16:16 Pointer
Display as 32-bit far pointers (16-bit segment, 16-bit offset).

Type/0:32 Pointer
Display as 32-bit near pointers (32-bit offset).

Type/16:32 Pointer
Display as 48-bit far pointers (16-bit segment, 32-bit offset).

Type/Float Display as 32-bit floating-point values.

Type/Double
Display as 64-bit floating-point values.

Type/Extended Float
Display as 80-bit floating-point values.

7.2.1 Following Linked Lists

Use the memory window to display the memory address of the first node of your linked list. Move to the "next" field of your structure and use the Near (or Far) Follow command. The next node of your linked list will be displayed. Now by using the Repeat command you can traverse the linked list.

7.2.2 Traversing Arrays

Display the memory address of your array. Select the first byte of the second element of your array then use the Cursor Follow command to move the second element of your array to the beginning of the memory window. By using the Repeat command you can traverse your array.

Breakpoints

8 Breakpoints

The Watcom Debugger uses the single term breakpoint to refer to the group of functions that other debuggers often call breakpoints, watchpoints, and tracepoints.

A breakpoint is traditionally defined as a place in your program where you want execution to stop so that you can examine program variables and data structures. A watchpoint causes your program to be executed one instruction or source line at a time, watching for the value of an expression to become true. Do not confuse a watchpoint with the watch window. A tracepoint causes your program to be executed one instruction or source line at a time, watching for the value of certain program variables or memory-referencing expressions to change.

In the Watcom Debugger:

- Break-on-execute refers to the traditional breakpoint
- Break-on-write refers to the traditional tracepoint
- A traditional watchpoint is a break-on-execute or break-on-write that is coupled with a condition

The Watcom Debugger unifies these three concepts by defining three parts to a breakpoint:

- the location in the program where the breakpoint occurs
- the condition under which the breakpoint is triggered
- the action that takes place when the breakpoint triggers

You can specify a countdown, which means that a condition must be true a designated number of times before the breakpoint is triggered.

When a breakpoint is triggered, several things can happen:

- program execution is stopped (a breakpoint)
- an expression is executed (code splice)
- a group of breakpoints is enabled or disabled

In this chapter, you will learn about the breakpoint including how to set simple breakpoints, conditional breakpoints, and how to set breakpoints that watch for the exact moment when a program variable, expression, or data object changes value.

8.1 How to Use Breakpoints during a Debugging Session

The following topics are discussed:

- "Setting Simple Breakpoints"
- "Clearing, Disabling, and Enabling Breakpoints" on page 87

8.1.1 Setting Simple Breakpoints

When debugging, you will often want to set a few simple breakpoints to make your program pause execution when it executes certain code. You can set or clear a breakpoint at any location in your program by placing the cursor on the source code line and selecting ***Toggle*** from the ***Break*** menu or by clicking on the button to the left of the source line. You can set breakpoints in the assembly window in a similar fashion. Setting a break-on-write breakpoint is equally simple. Select the variable with the right mouse button and choose ***Break*** from the pop-up menu.

Break points have three states. They are:

- enabled
- disabled
- cleared (non-existent)

The button for an enabled break point is a stop sign or [!]. The button for a disabled break point is a grey stop sign or [.]. A green diamond or [ ] appears when no breakpoint exists at the given line. The same buttons also appear in the Assembly window and the Break window to indicate the status of a break point.

Note: Some lines in your program do not contain any machine code to execute and therefore, you cannot set a breakpoint on them. The compiler does not generate machine code for comments and some C constructs. All lines of code in your program that can have a breakpoint on them have a button to the left of the source line. You can click on them to change their current status.

8.1.2 Clearing, Disabling, and Enabling Breakpoints

Choosing ***Toggle*** from the ***Break*** menu (F9) toggles between the three different breakpoint states:

• enabled
• disabled
• cleared (non-existent)

8.2 The Break Menu

You can use the ***Break*** menu to control your breakpoints. Operations including creating new breakpoints, changing a breakpoint's status, and viewing a list of all break points.

Toggle Change the status of the breakpoint at the current line in the source or assembly window. The status alternates between enabled, disabled and cleared. The button on the source or assembly line will be updated to reflect the status of the breakpoint.

Note: Disabled and cleared breakpoints are not the same. If you disable a breakpoint, you can re-enable it and retain the information about the breakpoint (i.e., conditions, countdown, and actions). When you clear a breakpoint, you lose all information about the breakpoint. If you disable a breakpoint, and press F9 twice to enable, you will lose the information about the breakpoint because you cleared it before you re-enabled it. To enable a disabled breakpoint without losing the breakpoint information, use the Breakpoint Option dialog or the Breakpoint window.

At Cursor Set a breakpoint at the current line in the source or assembly window. If the current line does not contain any executable code, the breakpoint is set on the closest preceding line of code that does contain executable code. When you choose ***At Cursor***, the Breakpoint dialog appears.

New This allows you to create any type of breakpoint using a dialog. You must specify the address in the dialog.

On Image Load...
Cause program execution to stop when an executable image (DLL) is dynamically loaded. The menu item is only available when debugging an Win32 or OS/2 executable. A dialogue will appear allowing you to add and delete image names from the list. You only need to type a substring of the

actual image name. You can identify the file "C:\PATH\IMAGE.DLL" with any substring, for example "IMAGE", "IMAGE.DLL" or "ATH\IMAGE.DLL". Case is ignored in the image names.

On Debug Message
When checked, cause program execution to stop whenever Windows 3.1, Windows NT, or Windows 95 prints a debug string. A debug string is printed whenever the application or debug Kernel calls the ***OutputDebugString*** function. This option is toggled each time it is selected from the ***Break*** menu.

View All Open the breakpoint window. This window will show a list of all breakpoints. You can use the window to create, delete and modify breakpoints.

Clear All Clear all breakpoints.

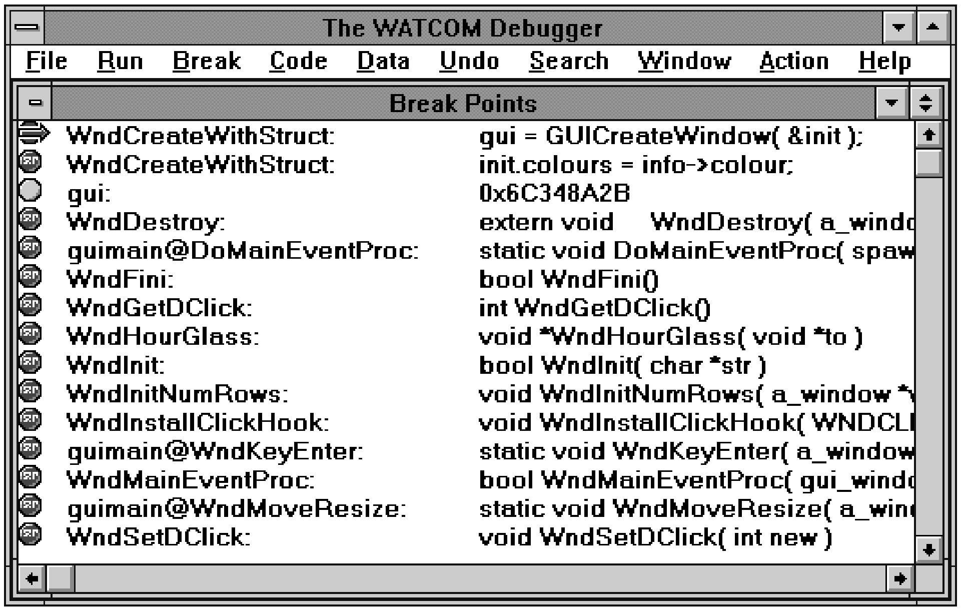
Disable All Disable all breakpoints, but do not delete them.

Enable All Enable all breakpoints that are disabled.

Save Save all breakpoint information to a file. This is useful when you are creating complicated breakpoints. You can save and restore them in a later debugging session.

Restore Restore a set of breakpoints that were saved by using ***Save*** from the ***Break*** menu.

8.3 The Break Window



```
WndCreateWithStruct:          gui = GUICreateWindow( &init );
WndCreateWithStruct:          init.colours = info->colour;
gui:                          0x6C348A2B
WndDestroy:                   extern void    WndDestroy( a_windo
guimain@DoMainEventProc:      static void DoMainEventProc( spaw
WndFini:                      bool WndFini()
WndGetDClick:                 int WndGetDClick()
WndHourGlass:                 void *WndHourGlass( void *to )
WndInit:                      bool WndInit( char *str )
WndInitNumRows:               void WndInitNumRows( a_window *
WndInstallClickHook:          void WndInstallClickHook( WNDCLI
guimain@WndKeyEnter:          static void WndKeyEnter( a_window
WndMainEventProc:             bool WndMainEventProc( gui_windo
guimain@WndMoveResize:        static void WndMoveResize( a_win
WndSetDClick:                 void WndSetDClick( int new )
```

Figure 18. *The Break Window*

The Break window displays each breakpoint and its status. It appears when you select the ***View All*** from the ***Break*** menu A breakpoint button appears at the left of each line. You can click on this button to enable and disable a breakpoint. Unlike the source and assembly windows, the button will not clear the breakpoint. Next appears the address of the breakpoint. Finally, for break-on-execute breakpoints, the source or assembly code at the break point location is displayed. For break-on-write breakpoints, the current value of the location is displayed in hex.

You can modify any break point by double clicking on it, or by cursoring to it and pressing enter. The Breakpoint Options dialog will appear to allow you to modify the break point. Press the right mouse button to access the following pop-up menu items:

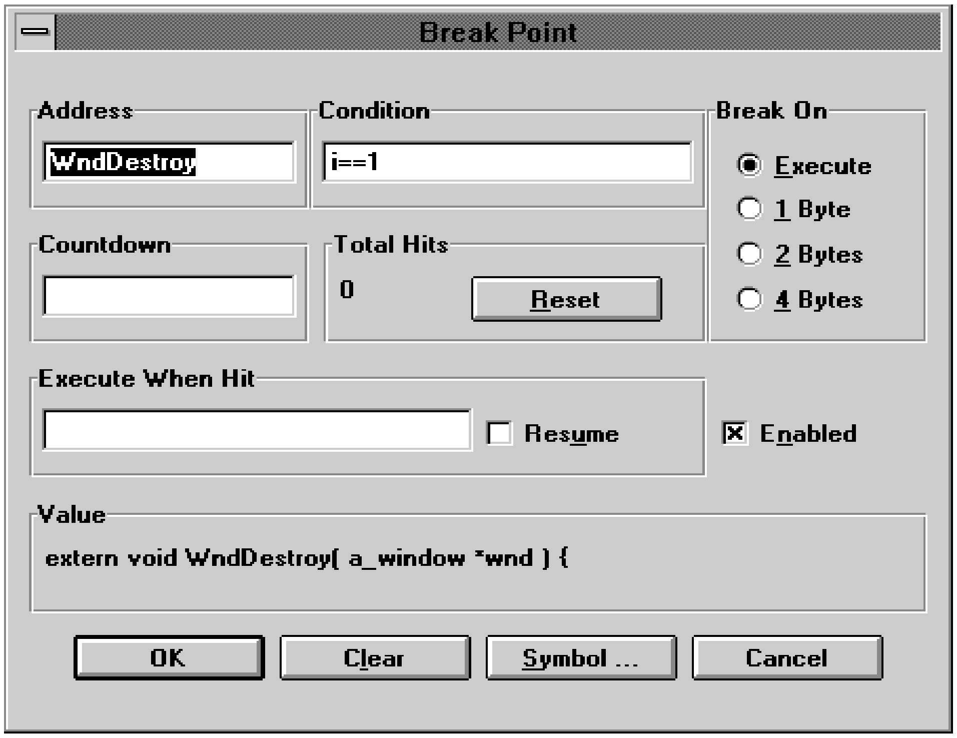
Modify Change the definition of the selected breakpoint. The Breakpoint dialog will appear.

New Add a new breakpoint. An empty Breakpoint dialog will appear. You must specify the address of the new Breakpoint. Refer to the section entitled "The

Breakpoint Dialog" for a description of the items in the which appear in the dialog.

Delete	Delete the selected breakpoint.
Enable	Enable the selected breakpoint.
Disable	Disable the selected breakpoint.
Source	Display the source code associated with the break point. This operation only makes sense for break-on-execute breakpoints.
Assembly	Display the assembly code associated with the selected line. This operation only makes sense for break-on-execute breakpoints.

8.4 The Breakpoint Dialog


Break Point

Address: WndDestroy

Condition: i==1

Break On: [✓ Execute] 1 Byte 2 Bytes 4 Bytes

Countdown:

Total Hits: 0

Execute When Hit:

Resume: ☐

Enabled: ☒

Value: extern void WndDestroy(a_window *wnd) {

Figure 19. *The Breakpoint Dialog*

The breakpoint dialog appears when you select ***At Cursor*** from the ***Break*** menu or ***New*** from the ***Break*** menu and whenever you attempt to modify a break point. It allows you to define the breakpoint and set all of its conditions. A description of the items in the dialog follows.

Address This edit field displays the address tag associated with the selected breakpoint.

When you choose ***At Cursor*** this field already contains an address that describes the line of code that the cursor is on. The format of the address tag is `symbol+offset` where `symbol` is the name of the nearest function and `offset` is distance in bytes past that symbol where the break point is defined. It is normally best NOT to edit this field. To change the line of source code, leave the dialog, move the cursor to where you want the breakpoint, and use the ***At Cursor*** command again.

When you choose ***New***, this field is empty. You can type any valid address expression in this field. It can be the name of a function, global variable. Refer to the section entitled "Watcom Debugger Expression Handling" on page 141 for more information about address expressions. In the dialog, you can click the Symbols... button as a shortcut. You can type a partial symbol name like `foo` and the Symbol button will show you a list of symbols that start with `foo.` You can then choose one of these symbols by clicking on it or hitting ENTER. Note that the first time you use the Symbols... in a debugging session, it will take a while as the debugger sorts the symbol table for the program.

Note: Be careful when using local (stack) variables for a break-on-write breakpoint. As soon as execution leaves the scope of the variable, the memory will change at random since the variable does not really exist any more and the memory will be used for other variables. Also, if execution enters that variable's scope again, the variable may not have the same memory address.

Condition Use this field to enter a conditions that must be met before a breakpoint will trigger. The condition can be an arbitrary debugger expression. These include statements in the language you are debugging. A valid example for the C language is `i == 1.`

Break on Execute
Check this field to create a break-on-execute breakpoints. If you choose Execute, be sure that the address field contains a code address (function name or code line number) and not a variable address. Variable are never executed. If the address field names a variable, the breakpoint will never trigger.

Break on 1 Byte/2 Bytes/4 Bytes...
Check one of these fields to create break-on-write breakpoints. If you choose

one of these options, be sure that the Address field contains a variable address and not a code address. A code address will never be written to, so the breakpoint will never trigger. The size of the memory location is defined by the checkbox you use as follows:

1 Byte	The breakpoint will trigger only when the first byte of the memory address is written to.
2 Bytes	The breakpoint will trigger when either of the first two bytes at the memory address are written to.
4 Bytes	The breakpoint will trigger if any of the first four bytes of the memory address are written to.
etc.	The breakpoint will trigger if any of the first "n" bytes of the memory address are written to.

Countdown Use this field to enter the number of times an address must be hit before the breakpoint triggers. Every time the breakpoint conditions are met, the countdown decreases by one. The breakpoint will trigger only after the countdown is at zero. Once the countdown reaches zero, the breakpoint will trigger each time the conditions are met. If you have also set a condition, the countdown will only decrease by one when the condition is true.

Total Hits This field displays the total number of times an address has been hit. This includes the times the breakpoint does not trigger because a condition failed or the countdown has not yet hit zero.

Reset Click on this button to reset the Total Hits field to zero.

Execute when Hit
Use this field to enter a debugger command. When the breakpoint is triggered, the debugger will execute this command. You can use this field to execute arbitrary C statements, change a variable or register, or even set other breakpoints. For a more detailed description of commands that can be entered in this field, refer to the section called "Debugger Commands" on page 175. If you want to use this field to execute a statement in the language you are debugging, you need to use a DO command in front of the statement. For example, you could enter `DO i = 10` to have the value of 10 assigned to i each time the breakpoint triggered.

Resume Check this field if you want the program to resume execution after the *Execute when Hit* command has been completed. This capability can be used to patch your code.

Enabled This field displays the current status of the breakpoint. If it is checked, the breakpoint is enabled. If it is unchecked, the breakpoint is disabled.

Value	For Break-on-Execute breakpoints this field displays the source line or the assembly line at which the break point is defined. For Break-on-Write breakpoints, this field displays the memory contents.
Clear	Click on the clear button to clear the breakpoint and close the dialog.

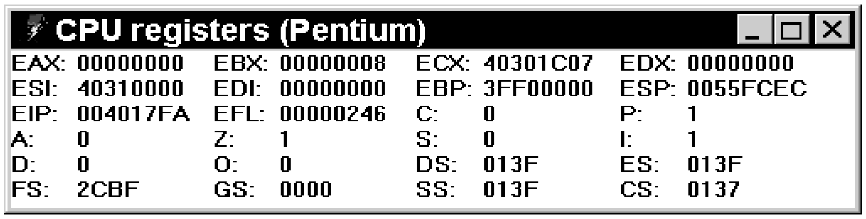
Assembly Level Debugging

9 Assembly Level Debugging

This chapter addresses the following assembly language level debugging features:

- "The CPU Register Window"
- "The Assembly Window" on page 98
- "The I/O Ports Window" on page 100
- "The FPU Registers Window" on page 101
- "The MMX Registers Window" on page 102

9.1 The CPU Register Window



```
EAX: 00000000   EBX: 00000008   ECX: 40301C07   EDX: 00000000
ESI: 40310000   EDI: 00000000   EBP: 3FF00000   ESP: 0055FCEC
EIP: 004017FA   EFL: 00000246   C:   0          P:   1
A:   0          Z:   1          S:   0          I:   1
D:   0          O:   0          DS:  013F       ES:  013F
FS:  2CBF       GS:  0000       SS:  013F       CS:  0137
```

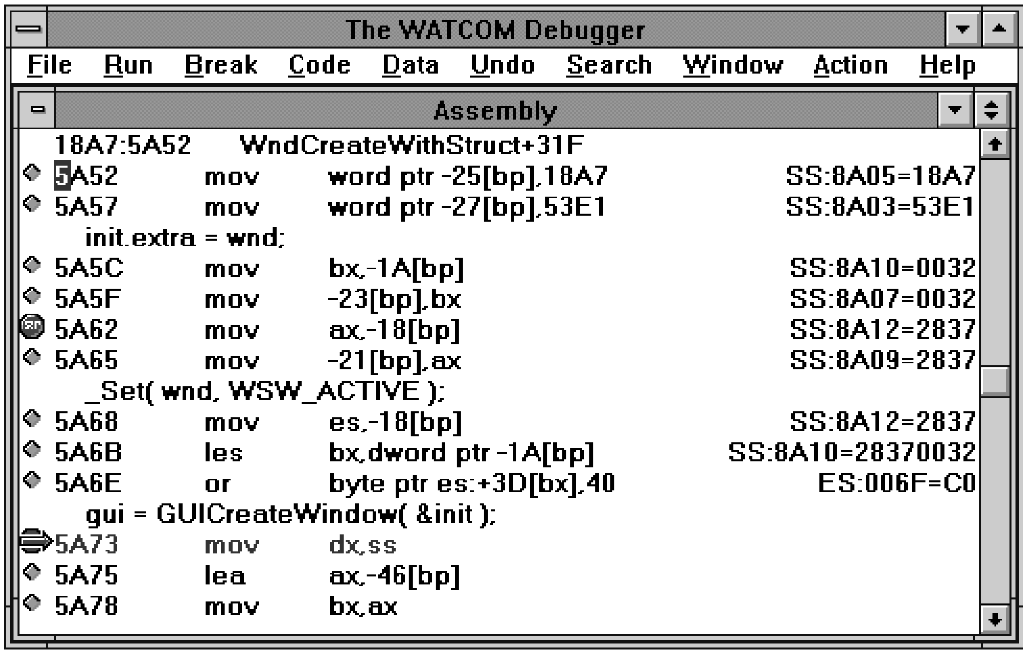
Figure 20. *The CPU Register Window*

You can open the CPU Register window by choosing ***Register*** from the ***Data*** menu. The register names and values are displayed in this window. As you execute your program, registers that have changed since the last trace or breakpoint will be highlighted.

You can modify a register value by double clicking on the value, or by cursoring to it and pressing ENTER. Press the right mouse button to access the following pop-up menu items:

Modify	Change the value of the selected register.
Inspect	Open a Memory window displaying the memory contents of the address specified by the register. If a segment register is selected, memory at offset 0 in the segment will be displayed.
Hex	Toggles the register window display format between hexadecimal and decimal.
Extended	Displays the Extended 386 register set. This menu item sets options on a per-window basis, overriding the global settings. When you use the menu item to change these settings, they will not be saved between debugging sessions. To change an option permanently, see "The Window Options Dialog" on page 38.

9.2 The Assembly Window



```
18A7:5A52     WndCreateWithStruct+31F
5A52     mov     word ptr -25[bp],18A7          SS:8A05=18A7
5A57     mov     word ptr -27[bp],53E1          SS:8A03=53E1
  init.extra = wnd;
5A5C     mov     bx,-1A[bp]                     SS:8A10=0032
5A5F     mov     -23[bp],bx                     SS:8A07=0032
5A62     mov     ax,-18[bp]                     SS:8A12=2837
5A65     mov     -21[bp],ax                     SS:8A09=2837
  _Set( wnd, WSW_ACTIVE );
5A68     mov     es,-18[bp]                     SS:8A12=2837
5A6B     les     bx,dword ptr -1A[bp]       SS:8A10=28370032
5A6E     or      byte ptr es:+3D[bx],40         ES:006F=C0
  gui = GUICreateWindow( &init );
5A73     mov     dx,ss
5A75     lea     ax,-46[bp]
5A78     mov     bx,ax
```

Figure 21. *The Assembly Window*

You can open the Assembly window by choosing ***Assembly*** from the ***Code*** menu. You can Inspect an item in by double-clicking on it, or by cursoring to it and pressing ENTER. Press the right mouse button to access the following pop-up menu items:

Inspect When you selecting a memory address, register or operand and use Inspect, the debugger opens a Memory Window displaying the selected memory address.

Break If a code address is selected this command will set a break-on-execute breakpoint at the selected code address. If a variable address is selected, this command will set a break-on-write breakpoint on the selected address. ***this does not set a break at the current line.*** Use ***Toggle*** from the ***Break*** menu or ***At Cursor*** from the ***Break*** menu to set a breakpoint at the current line.

Enter Function
Resume program execution until the selected function is executed.

Show/Source
Display the source code associated with the selected assembly line.

Show/Functions
Show the list of all functions defined in the current module.

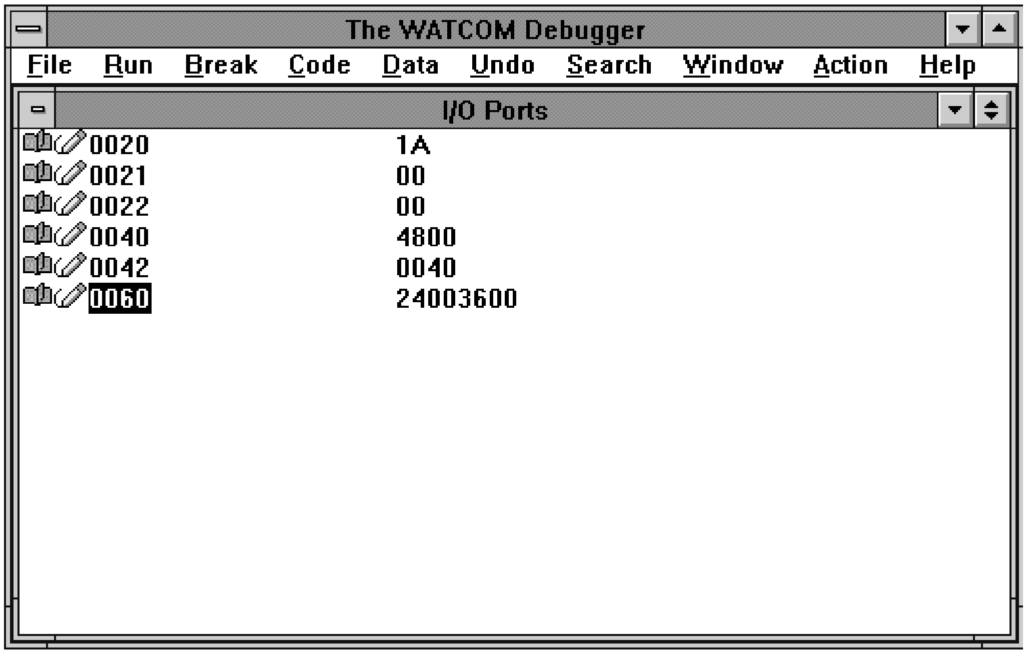
Show/Address
Reposition the window at a new address. You will be prompted for an expression. Normally you would type a function name but you can type any expression that resolves to a code address. For example, you might type the name of a variable that contains a pointer to a function. See "Watcom Debugger Expression Handling" on page 141.

Show/Module...
Show a different module. You will be prompted for its name in a dialog. As a shortcut, you can type the beginning of a module name and click the Module... button. This will display a list of all modules that start with the text you typed.

Home Reposition the window to the currently executing location. The cursor will move to the next line of the program to be executed.

Hex Toggle the Assembly window display between hexadecimal and decimal. This menu item sets options on a per-window basis, overriding the global settings. When you use the menu item to change these settings, they will not be saved between debugging sessions. To change an option permanently, see "The Window Options Dialog" on page 38.

9.3 The I/O Ports Window



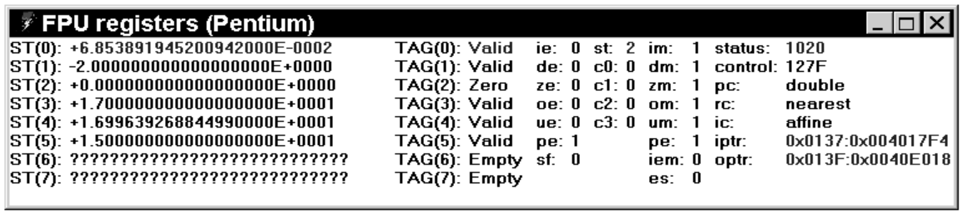
```
0020    1A
0021    00
0022    00
0040    4800
0042    0040
0060    24003600
```

Figure 22. *The I/O Window*

Use the I/O window to manipulate I/O ports. This is only supported when the operating system allows application software to use **IN** and **OUT** instructions. I/O ports can be added to the window, and typed as a byte, word (2 bytes) or dword (4 bytes). Use ***New*** from the pop-up menu to add a new port to the window. Once you have done this, four items will appear on the line. First appears the read button which appears as an open book, or [r]. Second appears the write button. It is a pencil or [w]. Third appears the port address, and finally the value. When you first enter a port address the value appears as question marks. The debugger does not automatically read or write the value since this can have side effects. In order to read the displayed value from the port, click on the read button. To write the displayed value back, click on the write button. You can change the value by double clicking on it, or by cursoring to it and pressing ENTER. Press the right mouse button to access the following pop-up menu items:

Modify	Change the selected item. You can change either the value field or the address field. ***This does not write the value back to the port.*** You must choose ***Write*** to write to the port.
New	Add a new line to the window. You can have several I/O ports displayed at once.
Delete	Delete the selected line from the window.
Read	Read the displayed value from the port.
Write	Write the displayed value to the port.
Type	Change the display type of the value. The size of this type determines how much is read from or written to the I/O port.

9.4 The FPU Registers Window



FPU registers (Pentium)

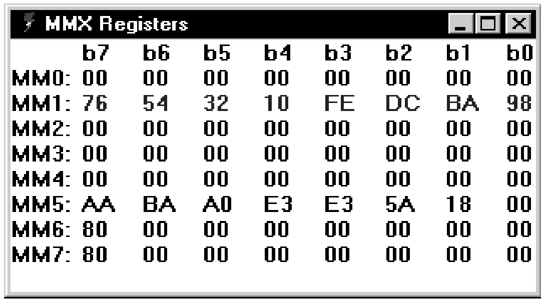
```
ST(0): +6.853891945200942000E-0002     TAG(0): Valid  ie: 0  st: 2  im:  1  status:  1020
ST(1): -2.000000000000000000E+0000     TAG(1): Valid  de: 0  c0: 0  dm:  1  control: 127F
ST(2): +0.000000000000000000E+0000     TAG(2): Zero   ze: 0  c1: 0  zm:  1  pc:      double
ST(3): +1.700000000000000000E+0001     TAG(3): Valid  oe: 0  c2: 0  om:  1  rc:      nearest
ST(4): +1.699639268844990000E+0001     TAG(4): Valid  ue: 0  c3: 0  um:  1  ic:      affine
ST(5): +1.500000000000000000E+0001     TAG(5): Valid  pe: 1         pe:  1  iptr:    0x0137:0x004017F4
ST(6): ????????????????????????????    TAG(6): Empty  sf: 0         iem: 0  optr:    0x013F:0x0040E018
ST(7): ????????????????????????????    TAG(7): Empty                es:  0
```

Figure 23. *The FPU Registers Window*

Choose ***FPU Registers*** from the ***Data*** menu to open the FPU window. This window displays the current value and status of all the FPU registers. If you are debugging a program that uses Intel 8087 emulation, this window display the contents of the emulator’s data area. You can change a value by double-clicking on, it or by cursoring to it and pressing ENTER. Press the right mouse button to access the following pop-up menu items:

Modify	Change the value of the selected register, or bit. You will be prompted for a new value, unless you are modifying a bit. A bit will toggle between 0 and 1.
Hex	Toggle the FPU window display between hexadecimal and floating point display. This menu item sets options on a per-window basis, overriding the global settings. When you use the menu item to change these settings, they will not be saved between debugging sessions. To change an option permanently, see "The Window Options Dialog" on page 38.

9.5 The MMX Registers Window



```
      b7  b6  b5  b4  b3  b2  b1  b0
MM0:  00  00  00  00  00  00  00  00
MM1:  76  54  32  10  FE  DC  BA  98
MM2:  00  00  00  00  00  00  00  00
MM3:  00  00  00  00  00  00  00  00
MM4:  00  00  00  00  00  00  00  00
MM5:  AA  BA  A0  E3  E3  5A  18  00
MM6:  80  00  00  00  00  00  00  00
MM7:  80  00  00  00  00  00  00  00
```

Figure 24. *The MMX Registers Window*

Choose ***MMX Registers*** from the ***Data*** menu to open the MMX window. This window displays the current values and status of all the MMX registers. You can change a value by double-clicking on, it or by cursoring to it and pressing ENTER. Press the right mouse button to access the following pop-up menu items:

Modify	Change the value of the selected register component. You will be prompted for a new value. The same action can be performed by pressing ENTER or double-clicking as described above.
Inspect	This item has no function in the MMX register window.
Hex	Toggle the MMX register window display between hexadecimal and floating point display. This menu item sets options on a per-window basis, overriding the global settings. When you use the menu item to change these settings, they will not be saved between debugging sessions. To change an option permanently, see "The Window Options Dialog" on page 38.
Signed	Toggle the display of the contents of the MMX registers as signed or unsigned quantities. When "signed" is enabled, each byte, word or double-word is displayed as a signed quantity. When "signed" is disabled, each byte, word or double-word is displayed as an unsigned quantity.
Byte	Display the contents of the MMX registers as a series of 8 bytes.
Word	Display the contents of the MMX registers as a series of 4 words.
DWord	Display the contents of the MMX registers as a series of 2 double-words.

Remote Debugging

10 Remote Debugging

10.1 Overview

Remote debugging allows you to run the debugger on one side of a communication link and the application being debugged on the other. Remote debugging is required when there is not enough memory to run both the debugger and the application on the same machine.

The DOS debugger runs in protected mode (above the 1M mark), with a small memory footprint in the first 640k. Newer operating systems such as OS/2 and Windows NT/95 have eliminated the 640k barrier, so there is little need for remote debugging. Remote debugging is also required to debug Novell NetWare applications.

There are many different communication links supported. Some communicate between two machines. In this case an external communication medium is used. Some links communicate between two operating systems shells on the same machine. In either case, the concepts are the same.

While remote debugging, you may want to reference a file that is found on one machine or the other. See the section entitled "Specifying Files on Remote and Local Machines" on page 119 for details about remote and local file names.

The debugger is broken down into 4 parts.

The Debugger This is the portion of the debugger that contains the user interface. It is the largest part of the debugger. Its name is either WD.EXE, WDW.EXE or WDC.EXE

The Debug Kernel The debugger interprets your requests and sends low level requests to the debug kernel. It is a small executable that is dynamically loaded by the debugger or a remote debug server and used to control your application. It can be called STD.TRP, STD.DLL, RSI.TRP, ADS.TRP or PLS.TRP

Remote Trap Files— These are versions of the debug kernel file that take requests and send them across a communications link to a remote debug server. You choose a trap file using the debugger’s "trap" option. See "Common Switches" on page 16. Trap files have a 3 letter file name that represents the name of the communications layer being used. The file extension is TRP or DLL.

Remote Debug Servers— These executable files receive requests from a communications link and pass them to a debug kernel. Remote debug server names all start with ???SERV. The first 3 letters represent the communication layer being used and correspond to the trap file that is used on the other side of the link.

In the following examples,

```
A>cmd1
B>cmd2
```

indicates that `cmd1` is to be run on one machine and `cmd2` is to be run on the other.

A normal non-remote debugging session just uses the user interface and the debug kernel. All components run on the same machine. This simple debugging session would be started with the command:

```
A>wd app

+-----------+ +----------+     +----------+
|  WD.EXE   | | STD.TRP  |     | APP.EXE  |
|          / /           |     |          |
|          \ \           |     |          |
|           | |          |     |          |
+-----------+ +----------+     +----------+
```

Debugging a Tenberry Software DOS/4GW (32-bit extended DOS) application is the same except you must use a different trap file to control the application.

```
A>wd /trap=rsi app

+-----------+ +----------+     +----------+
|  WD.EXE   | | RSI.TRP  |     | APP.EXE  |
|          / /           |     |          |
|          \ \           |     |          |
|           | |          |     |          |
+-----------+ +----------+     +----------+
```

A remote debugging session adds a remote debug server and a remote trap file as well. For example, using the parallel port to debug between two machines would be accomplished using the following components:

```
A>parserv
B>wd /tr=par app

+-----------+ +----------+
|  WD.EXE   | | PAR.TRP  |
|          / /           |
|          \ \           |
|           | |          |
+-----------+ +----------+
                  |
   +-- parallel --+
   |   cable
   |
+-----------+ +----------+     +----------+
|  PARSERV  | | STD.TRP  |     | APP.EXE  |
|  .EXE    / /           |     |          |
|          \ \           |     |          |
|           | |          |     |          |
+-----------+ +----------+     +----------+
```

In order to start the above remote debugging session, you must follow these steps.

1. Connect the two machines with a parallel cable. See "Wiring For Remote Debugging" on page 209.
2. Start the remote debug server (PARSERV) on one machine.
3. Start the debugger with the option "/trap=PAR" on the other machine. This causes the debugger to load the remote trap file (PAR). This will communicate across the remote link to PARSERV.EXE, which will in turn communicate with the debug kernel (STD) in order to debug the application.

The rest of the debugger command line is identical to the command you would type if you were debugging the application locally.

You must start the remote debug server first. If you do not, the remote trap file will not be able to establish a communication link and the debugger will refuse to start.

It is important to realize that the application to be debugged must reside on the debug server machine. It must be possible for the debug server to locate the application to be debugged. It can be in the current working directory of the debugger server machine, or in the **PATH,** or a path to locate the application on the debug server machine can be specified on the debugger command line. Alternatively, you can ask the debugger to download the application to the debug server machine if the application resides on the debugger machine.

```
A>parserv
B>wd /down /tr=par app
```

See the description of the "download" option in the section entitled "Common Switches" on page 16.

If you are remote debugging a 32-bit application, you must ***use the correct trap file on the remote debug server side*** of the link. The trap file specification must come first before any other arguments on the command line.

```
A>serserv /tr=rsi
B>wd /tr=ser app

+-----------+ +----------+
|  WD.EXE   | | SER.TRP  |
|          / /           |
|          \ \           |
|           | |          |
+-----------+ +----------+
                   |
   +--- serial ---+
   |    cable
   |
+-----------+ +----------+     +----------+
|  SERSERV  | | RSI.TRP  |     | APP.EXE  |
|  .EXE    / /           |     |          |
|          \ \           |     |          |
|           | |          |     |          |
+-----------+ +----------+     +----------+
```

Following is an example of an internal remote link. This example shows you how to use the OS/2 version of the debugger to debug a DOS application.

```
+-----------+ +----------+
|  WD.EXE   | | NMP.DLL  |
|          / /           |
|          \ \           |
|           | |          |
+-----------+ +----------+
                      |
   +-- OS/2 NP API --+
   |
+-----------+ +----------+     +----------+
|  NMPSERV  | | STD.DLL  |     | APP.EXE  |
|  .EXE    / /           |     |          |
|          \ \           |     |          |
|           | |          |     |          |
+-----------+ +----------+     +----------+
```

The communication medium employed in this case is OS/2 Named Pipes.

The debugger provides the following remote link capabilities:

NOV	This link uses Novell's SPX layer for communication. Supported under DOS, OS/2, Windows 3.x, Windows NT and NetWare.
NET	This link uses NetBIOS to communicate. If your network software supports NetBIOS, you can use this link. Supported under DOS, OS/2, Windows 3.x, and NetWare.
PAR	This link supports communication using the parallel or printer port. Several different cable configurations are supported. See "Wiring For Remote Debugging" on page 209. Supported under DOS, OS/2, Windows 3.x, NetWare and QNX.
SER	This link uses a serial port to communicate. Rates of up to 115K BAUD are supported. See "Wiring For Remote Debugging" on page 209. Supported under DOS, OS/2 and QNX.
WIN	This link will communicate between two Windows DOS boxes. Supported under Windows 3.x and Windows 95 (for DOS applications only).
NMP	This link will use Named Pipes to communicate internally between OS/2 sessions. OS/2, DOS and Win-OS/2 sessions are supported. If your network supports Named Pipes, and you have at least one OS/2 machine on the network, you can communicate between OS/2, DOS and Windows 3.x machines on the network. Supported under OS/2 (DOS, OS/2 and Windows 3.x applications).
VDM	This link is a subset of the NMP link. It is supported under OS/2 and Windows NT. The application being debugged must be a DOS or seamless Win-OS/2 application. Supported under OS/2 and Windows NT (DOS, OS/2 and Windows 3.x applications).
TCP	This link will use TCP/IP to communicate internally or over a network between sessions. Supported under OS/2, Windows NT, Windows 95 and QNX.

Communication parameters may be passed to the remote trap file and the remote server. They are passed to the remote trap file by following the name of the trap file with a semi-colon and the parameter. For example:

```
A>serserv 2.4800
```

passes the parameter 2.4800 to the remote debug server. To pass the same parameter to the remote trap file, use:

```
    B>wd /tr=ser;2.4800 app
```

These link parameters are specific to each remote link and are described in the following section.

Each of the debug servers can accept an optional "Once" parameter. The "Once" parameter is used by the Watcom Integrated Development Environment. Usually, a server stays running until terminated by the user. If the "Once" option is specified, the remote server will terminate itself as soon as the debugger disconnects from it.

10.2 Link Descriptions

The following communication links are described:

- "NOV (Novell SPX)"
- "NET (NetBIOS)" on page 111
- "PAR (Parallel)" on page 111
- "SER (Serial)" on page 112
- "WIN (Windows 3.x/95 Virtual DOS Machine)" on page 114
- "NMP (Named Pipes)" on page 115
- "VDM (Virtual DOS Machine)" on page 116
- "TCP/IP (Internet Packets)" on page 117

10.2.1 NOV (Novell SPX)

This link communicates over a Novell Network. In order to use this link, you must have a NetWare requester installed on both machines. Be sure that it is configured to include the SPX option. Consult your NetWare documentation for details.

The parameter to this link is an arbitrary name to be used for the connection. This allows multiple network users users to remote debug simultaneously. The default name is NovLink. If the remote server will not start, try specifying a different name for the link. The following example shows how to use the default link parameters:

```
A>novserv
B>wd /tr=nov app
```

The following example shows how to name "john" as a link parameter:

```
A>novserv john
B>wd /tr=nov;john app
```

10.2.2 NET (NetBIOS)

This link communicates over NetBIOS. In order to use this link, you must have NetBIOS installed on both machines. Consult your network documentation for details.

The parameter to this link is an arbitrary name to be used for the connection. This allows multiple network users users to remote debug simultaneously. The default name is NetLink. The following example shows how to use the default link parameters.

```
A>netserv
B>wd /tr=net app
```

The following example shows how to use the name "tammy" as a link parameter.

```
A>netserv tammy
B>wd /tr=net;tammy app
```

10.2.3 PAR (Parallel)

This link communicates over the parallel port. Three different cable types may be used. They are called the LapLink, Flying Dutchman, and WATCOM cables. Although the WATCOM cable will communicate considerably faster than the other two, we have found it to be unreliable on some printer cards. See "Wiring For Remote Debugging" on page 209.

The parameter to this link is a number from 1 to 3 or the letter "p" followed by a hexadecimal printer I/O port address. This tells the software which parallel port the cable is connected to (LPT1, LPT2, LPT3). The default is 1. The parameter used on each side of the link depends on which printer port the cable is plugged into on that machine. It need not be the same on both sides. The following example shows how to debug across a parallel cable plugged into printer port 3 on one machine and port 2 on the other.

```
A>parserv 3
B>wd /tr=par;2 app
```

As an alternative, you can specify a port address to use. It is less convenient than specifying a port number but will work on systems like OS/2 where the actual I/O port address cannot be obtained from the system. The following example shows how to debug across a parallel cable plugged into I/O port 0x378 on one machine and port 2 on the other.

```
A>parserv p378
B>wd /tr=par;2 app
```

If you are going to debug a DOS extender application, then you must also specify a trap file to the server program. The trap file must be specified before the port number. The following example shows how to debug a 32-bit DOS/4GW application across a parallel cable plugged into printer port 2 on one machine and port 3 on the other.

```
A>parserv /tr=rsi 2
B>wd /tr=par;3 app
```

The "RSI" trap file is specified for DOS/4G(W) applications. You can specify other trap files for the other DOS extenders (e.g., "PLS" for Phar Lap). Do not forget to include other required files in the path.

RSI	Both "DOS4GW.EXE" and the loader help file "RSIHELP.EXP" must also be located in one of the directories listed in the DOS **PATH** environment variable. See the section entitled "Debugging DOS/4G(W) 32-bit DOS Extender Applications" on page 130 for more information on debugging applications that use the DOS/4GW DOS extender.
PLS	One or more of "RUN386.EXE" (or "TNT.EXE"), "DBGLIB.REX", "PLSHELP.EXP", and "PEDHELP.EXP" must be located in one of the directories listed in the DOS **PATH** environment variable. See the section entitled "Debugging Phar Lap 32-bit DOS Extender Applications" on page 130 for more information on debugging applications that use the Phar Lap DOS extender.
ADS	See the section entitled "Debugging AutoCAD Applications" on page 131 for more information on debugging AutoCAD applications.

10.2.4 SER (Serial)

This link communicates over the serial port. See the appendix entitled "Wiring For Remote Debugging" on page 209 for wiring details. The debugger and server will automatically synchronize on a communications speed. They may communicate at rates as high as 115kB. The DOS and OS/2 "mode" command or the QNX "stty" commands need not be used.

The parameter to this link takes the form

```
port_number.baud_rate
```

`port_number` is a number from 1 to 3 indicating which serial port the cable is connected to. The default is 1.

`baud_rate` is the maximum BAUD rate at which to communicate. If you already know the maximum BAUD rate at which the two machines will communicate, this parameter will speed up the connection time by eliminating some of the synchronization protocol.

`baud_rate` may be any of 115200, 57600, 38400, 19200, 9600, 4800, 2400, or 1200. It may be shortened to the first 2 digits.

A special BAUD rate of 0 is also allowed. This should be used if the serial port has been pre-assigned using the "mode" or "stty" commands. The pre-assigned BAUD rate is used and the BAUD rate negotiation is avoided. This will allow you to debug over a modem.

The following example shows how to debug across a serial cable using default settings:

```
A>serserv
B>wd /tr=ser app
```

The following example shows how to debug across a serial cable using serial port 2 on each machine setting the maximum BAUD rate to 9600:

```
A>serserv 2.9600
B>wd /tr=ser;2.9600 app
```

QNX Note: Under QNX, a node id may be specified followed by a comma if the serial port is not located on the current node. The command "serserv 3,1.9600" would use the device //3/dev/ser1 at a BAUD rate of 9600. Alternatively, you can specify a device such as /dev/foobar. To specify the maximum line speed, you can specify something like /dev/foobar.56. Of course, you can also include a node id such as //5/dev/foobar.

```
A>serserv //3/dev/ser2.9600
B>wd /tr=ser;//5/dev/ser2.9600 app
```

If you are going to debug a DOS extender application, then you must also specify a trap file to the server program. The trap file must be specified before the port number and BAUD rate. The following example shows how to debug a 32-bit DOS/4GW application across a serial cable using serial port 1 on one machine and serial port 2 on the other machine setting the maximum BAUD rate to 9600 for each:

```
A>serserv /tr=rsi 1.9600
B>wd /tr=ser;2.9600 app
```

The "RSI" trap file is specified for DOS/4G(W) applications. You can specify other trap files for the other DOS extenders (e.g., "PLS" for Phar Lap). Do not forget to include other required files in the path.

RSI Both "DOS4GW.EXE" and the loader help file "RSIHELP.EXP" must also be located in one of the directories listed in the DOS **PATH** environment variable. See the section entitled "Debugging DOS/4G(W) 32-bit DOS Extender Applications" on page 130 for more information on debugging applications that use the DOS/4GW DOS extender.

PLS One or more of "RUN386.EXE" (or "TNT.EXE"), "DBGLIB.REX", "PLSHELP.EXP", and "PEDHELP.EXP" must be located in one of the directories listed in the DOS **PATH** environment variable. See the section entitled "Debugging Phar Lap 32-bit DOS Extender Applications" on page 130 for more information on debugging applications that use the Phar Lap DOS extender.

ADS See the section entitled "Debugging AutoCAD Applications" on page 131 for more information on debugging AutoCAD applications.

10.2.5 WIN (Windows 3.x/95 Virtual DOS Machine)

This link communicates between 2 Windows DOS boxes. In order to use this link, you must have Windows 3.x or Windows 95 installed on your machine. You must run Windows 3.x in enhanced mode. You must also include the "device" specification listed below in the [386Enh] section of your "SYSTEM.INI" file (this line is usually added during the Watcom software installation process).

```
DEVICE=C:\WATCOM\BINW\WDEBUG.386
```

In order for this link to work properly, you must ensure that this link runs in a DOS box that has background execution enabled.

The parameter to this link is an arbitrary name to be used for the connection. This allows you to have multiple remote debug sessions active simultaneously. The default name is WinLink. The following examples show how to use the default name or specify a link name using the Windows 3.x/95 VDM link.

```
A>winserv
B>wd /tr=win app

A>winserv whats_in_a_name
B>wd /tr=win;whats_in_a_name app
```

The following examples show how to debug a 32-bit extended DOS application using the Windows 3.x/95 VDM link.

```
A>winserv /tr=rsi
B>wd /tr=win app

A>winserv /tr=rsi whats_in_a_name
B>wd /tr=win;whats_in_a_name app
```

The "RSI" trap file is specified for DOS/4G(W) applications. You can specify other trap files for the other DOS extenders (e.g., "PLS" for Phar Lap). Do not forget to include other required files in the path.

RSI Both "DOS4GW.EXE" and the loader help file "RSIHELP.EXP" must also be located in one of the directories listed in the DOS **PATH** environment variable. See the section entitled "Debugging DOS/4G(W) 32-bit DOS Extender Applications" on page 130 for more information on debugging applications that use the DOS/4GW DOS extender.

PLS One or more of "RUN386.EXE" (or "TNT.EXE"), "DBGLIB.REX", "PLSHELP.EXP", and "PEDHELP.EXP" must be located in one of the directories listed in the DOS **PATH** environment variable. See the section entitled "Debugging Phar Lap 32-bit DOS Extender Applications" on page 130 for more information on debugging applications that use the Phar Lap DOS extender.

10.2.6 NMP (Named Pipes)

The named pipes link allows you to communicate between any two sessions on an OS/2 machine. You can also debug remotely between DOS, Windows 3.x and OS/2 machines if you have installed remote named pipe support on these machines. See your network documentation for details on remote named pipes.

In order to use named pipes, you must first run the NMPBIND program. This may run any OS/2 machine on the network. It can be run detached, by putting the following line into your OS/2 CONFIG.SYS.

```
RUN=C:\WATCOM\BINP\NMPBIND.EXE
```

If you run NMPSERVW under Win-OS/2, it must be run as a seamless Windows session. This is due to the fact that full screen Win-OS/2 sessions may not get any processor time when they are not in the foreground.

The parameter to this link can take the following forms:

```
name
name@machine
```

`name` is an arbitrary name to be used for the connection. This allows you to have multiple remote debug sessions active simultaneously. The default name is NMPLink.

`machine` is the name of the machine on which the NMPBIND program is running. This allows you to use remote named pipes.

The following example shows you how to use the named pipe link between two sessions on the same OS/2 machine.

```
A>nmpserv
B>wd /tr=nmp app
```

The following example assumes that there is a machine named HAL with a remote named pipe server on the network which is running NMPBIND.

```
A>nmpserv mylink@hal
B>wd /tr=nmp;mylink@hal app
```

10.2.7 VDM (Virtual DOS Machine)

VDM is actually a limited version of named pipes that does not require the NMPBIND program to be running. It has several restrictions however.

1. It does not support network debugging.
2. Under OS/2, the debugger (user interface) must run in an OS/2 (not a DOS) session. The debugger may also be started under Windows NT but not Windows 95 since it does not support named pipes.
3. Under OS/2, the remote debug server must run in a seamless Win-OS/2 or a DOS session.
4. Under Windows NT, the remote debug server will be run in a Windows NT Virtual DOS Machine.

5. Under Windows 95, the remote debug server can be started but since Windows 95 does not support named pipes it will not work properly. See the section entitled "WIN (Windows 3.x/95 Virtual DOS Machine)" on page 114 for an alternative.
6. If you are running VDMSERVW under Win-OS/2, it must be run as a seamless Windows session. This is due to the fact that full screen Win-OS/2 sessions may not get any processor time when they are not in the foreground.

The parameter to this link is an arbitrary name to be used for the connection. This allows you to have multiple VDM debug sessions active simultaneously. The default name is VDMLink. The following example shows how to use the VDM link:

```
A>vdmserv
B>wd /tr=vdm app
```

The following example shows how to use the VDM link specifying "brian" as the link name.

```
A>vdmserv brian
B>wd /tr=vdm;brian app
```

10.2.8 TCP/IP (Internet Packets)

The TCP/IP link allows you to communicate between any two sessions using TCP/IP if you have installed TCP/IP support. You can also debug remotely between OS/2 and Windows NT/95 machines if you have installed TCP/IP support on these machines. See your network documentation for details on installing TCP/IP support.

In order to use TCP/IP to remotely debug a program, you must start the TCPSERV server program first.

Example:

```
A>tcpserv
Socket port number: 3563
WATCOM TCP/IP Debug Server
Version 11.0
Copyright by WATCOM International ...
Press ’q’ to exit
```

The server program displays an available socket port number on the screen.

You may specify a TCP/IP "service" as an argument on the command line. TCPSERV will check the TCP/IP services list to find a matching service. If no argument is specified on the command line, TCPSERV uses "tcplink" as the service name. If no matching service name is found, TCPSERV attempts to convert the argument to a numeric port number and use that. If the argument can not be converted to a number, port number 3563 is used.

The TCP/IP services list is stored in different places depending on the operating system.

OS/2 `d:\TCPIP\ETC\SERVICES` depending on the drive where TCP/IP is installed

QNX `/etc/services`

Windows 95 `d:\windows\SERVICES` depending on the drive and directory where Windows 95 is installed

Windows NT `d:\WINNT35\SYSTEM32\DRIVERS\ETC\SERVICES` depending on the drive where Windows NT is installed

You will also need to know the Internet Protocol (IP) address of the machine running the TCPSERV program. This can be in alphanumeric or numeric form (e.g., jdoe.watcom.on.ca or 172.31.0.99). With the alphanumeric form, it is not necessary to specify the domain name portion if the two machines are in the same domain.

To use the remote TCP/IP server, you must specify the TCP/IP trap file name to the debugger along with an argument consisting of your IP address, optionally followed by a ":" and the service name or socket port number used by TCPSERV. You must also include the name of the application you wish to run and debug on the remote machine.

Example1:
```
    A>tcpserv
    B>wd /tr=tcp;jdoe app
            or
    B>wd /tr=tcp;172.31.0.99 app
```

Example2:
```
    A>tcpserv 1024
    B>wd /tr=tcp;jdoe:1024 app
            or
    B>wd /tr=tcp;jdoe.watcom.on.ca:1024 app
            or
    B>wd /tr=tcp;172.31.0.99:1024 app
```

Example3:
```
    A>tcpserv dbgservice
    B>wd /tr=tcp;jdoe:dbgservice app
            or
    B>wd /tr=tcp;jdoe.watcom.on.ca:dbgservice app
            or
    B>wd /tr=tcp;172.31.0.99:dbgservice app
```

The TCP/IP remote debug service permits debugging of applications anywhere on the Internet. However, response will vary with the distances involved.

10.3 Specifying Files on Remote and Local Machines

In order to identify files on either the local or remote machine, two special prefixes are supported.

@L The "@L" prefix is used to indicate that the file resides on the local machine (the one on which the debugger is running).

```
@L[d:][path]filename[.ext]
```

When "[path]" is not specified, the current directory of the specified drive of the local machine is assumed. When "[d:]" is not specified, the current drive of the local machine is assumed.

Example:

```
@LOUTPUT.LOG
@LD:\CMDS
@LD:\CMDS\DATA.TMP
```

@R The "@R" prefix is used to indicate that the file resides on the remote machine.

```
@R[d:][path]filename[.ext]
```

When "[path]" is not specified, the current directory of the specified drive of the remote machine is assumed. When "[d:]" is not specified, the current drive of the remote machine is assumed.

Example:

```
@RMYAPPL.DAT
@RD:\PROGRAMS\EXE\MYAPPL.LNK
@R\PROGRAMS\SRC
@R\PROGRAMS\SRC\UILIB.C
```

Thus a file may be identified in three different ways.

```
[d:][path]filename[.ext]
@L[d:][path]filename[.ext]
@R[d:][path]filename[.ext]
```

A file of the first form resides on either the local or remote machine depending on whether the current drive is a local or remote drive. A file of the second form always resides on the local machine. A file of the third form always resides on the remote machine.

Notes:

1. In the each form, the omission of "[d:]" indicates the current drive.

   ```
   [path]filename[.ext]
   @L[path]filename[.ext]
   @R[path]filename[.ext]
   ```

2. In the each form, the omission of "[path]" indicates the current path of the specified drive.

   ```
   [d:]filename[.ext]
   @L[d:]filename[.ext]
   @R[d:]filename[.ext]
   ```

   Observe that if "[d:]" is omitted also then the following forms are obtained:

   ```
   filename[.ext]
   @Lfilename[.ext]
   @Rfilename[.ext]
   ```

3. The special drive prefixes "@L" and "@R" cannot be used in your own application to reference files on two different machines. These prefixes are recognized by the Watcom Debugger only. Should the situation arise where one of your filenames begins with the same prefix ("@L", "@l", "@R" or "@r") then "@@" can be used. For example, if your wish to refer to the file on disk called "@link@" then you could specify "@@link@". Note that ".\@link@" would also suffice.

Interrupting A Running Program

11 Interrupting a Running Program

11.1 Overview

It is not unusual for your code to contain an endless loop that results in the program getting stuck in one spot. You then want to interrupt the program so that you can see where it's getting stuck. The process to give control back to the debugger is different for each operating system.

11.2 DOS

Press the Print Screen key. This will work if the program is stuck in a loop. If it has misbehaved in some other way, Print Screen may have no effect since a misbehaved application may overwrite code, data, the debugger, or operating system code.

11.3 Windows 3.x

Press CTRL-ALT-F. Windows must be running in enhanced mode and the device WDEBUG.386 must be installed the [386Enh] section of SYSTEM.INI for this to work. You cannot interrupt a running program under Win-OS/2.

11.4 Windows NT, Windows 95

If you are using the non-GUI version of the debugger, switch focus to the debugger screen and press CTRL-BREAK.

If you are using the GUI-based version of the debugger or one of the remote debug servers, switch focus to the debugger or debug server screen and click anywhere. When you switch to the debugger screen, you will see a pop-up stating that:

```
The debugger cannot be used while the application is
running.  Do you want to interrupt the application?
```

If you select "Yes", the debugger will attempt to interrupt the application. If you select "No", the debugger will resume waiting for the application to hit a breakpoint or terminate.

If you select "Yes" and the debugger cannot interrupt the application, you can click on the debugger again and it will display a pop-up asking:

```
The debugger could not sucessfully interrupt your
application.  Do you want to terminate the application?
```

If you select "Yes", the debugger will terminate your application. If you select "No", the debugger will resume waiting for the program to hit a breakpoint or terminate.

Note: Under Windows 95, it is very difficult to interrupt a program that is in an infinite loop or spending most of its time in system API's. Under Windows 95, you can only interrupt a program that is responding to messages (or looping in its own thread code). If your program is an infinite loop, interrupting the program will likely fail. The only option in this case is to terminate the program.

This is not an issue under Windows NT which has a superior debug API.

If you press CTRL-BREAK when the application has focus, you will terminate the application being debugged rather than interrupting it.

11.5 OS/2

Use the program manager to switch focus to the debugger screen then press CTRL-BREAK. If you press CTRL-BREAK when the application has focus, you will terminate the application being debugged rather than interrupting it.

11.6 NetWare

On the NetWare file server console, press ALT-ESCAPE while holding down both SHIFT keys. In some instances, this may cause the system debugger to become active instead of the Watcom Debugger.

11.7 QNX

Switch focus to the debugger console and press CTRL-BREAK. Alternatively, you may send any unhandled signal to the application being debugged. Consult your QNX system documentation for details.

Operating System specifics

12 Operating System Specifics

This section discusses the following topics:

DOS Extender debugging
See the section entitled "Debugging 32-bit DOS Extender Applications".

AutoCAD debugging
See the section entitled "Debugging AutoCAD Applications" on page 131.

NLM debugging
See the section entitled "Debugging a Novell NLM" on page 132.

Graphics programs
See the section entitled "Debugging Graphics Applications" on page 133.

Windows 3.x debugging
See the section entitled "Debugging Windows 3.x Applications" on page 133.

DLL debugging
See the section entitled "Debugging Dynamic Link Libraries" on page 134.

Disabling 386/486 debug registers
See the section entitled "Disabling Use of 386/486 Debug Registers" on page 135.

QNX debugging
See the section entitled "Debugging Under QNX" on page 135.

12.1 Debugging 32-bit DOS Extender Applications

The Watcom Debugger supports debugging of 32-bit applications developed with Watcom C/C++^{32}, Watcom FORTRAN 77^{32}, and assembly language. A DOS extender must be used to run the application. The following DOS extenders are supported.

DOS/4GW a DOS extender from Tenberry Software, Inc. DOS/4GW is a subset of Tenberry Software's DOS/4G product. DOS/4GW is customized for use with Watcom C/C++^{32} and Watcom FORTRAN 77^{32} and is included in these packages.

386|DOS-Extender
(version 2.2d or later) a DOS extender from Phar Lap Software, Inc.

12.1.1 Debugging DOS/4G(W) 32-bit DOS Extender Applications

When using the Tenberry Software DOS extender, the "DOS4GW.EXE" or "DOS4G.EXE" file must be located in one of the directories listed in the DOS **PATH** environment variable. The "DOS4GW.EXE" file will usually be stored in the "BINW" directory of the WATCOM compiler package. You must also use the *TRap=RSI* option. The "RSI.TRP" file will usually be stored in the "BINW" directory of the WATCOM compiler package. You should ensure that this "BINW" directory is included in the DOS **PATH** environment variable. Otherwise, you must specify the full path name for the trap file.

The help file "RSIHELP.EXP" must also be located in one of the directories listed in the DOS **PATH** environment variable. It will usually be stored in the "BINW" directory of the WATCOM compiler package.

Example:
```
C>wd /trap=rsi hello
  or
C>set wd=/trap#rsi
C>wd hello
```

12.1.2 Debugging Phar Lap 32-bit DOS Extender Applications

When using the Phar Lap Software, Inc. DOS extender, the "RUN386.EXE" (or "TNT.EXE"), "DBGLIB.REX", "PLSHELP.EXP", and "PEDHELP.EXP" files must be located in one of the directories listed in the DOS **PATH** environment variable. You must also use the *TRap=PLS* option. The "PLS.TRP", "PLSHELP.EXP" and "PEDHELP.EXP" files will usually be stored in the "BINW" directory of the WATCOM compiler package. You should ensure that this "BINW" directory is included in the DOS **PATH** environment variable. Otherwise, you must specify the full path name for the trap file.

Parameters are passed to the "RUN386" or "TNT" DOS extender using the *TRap* option. The entire parameter must be placed within braces. The following example illustrates how to debug a Phar Lap application passing the -maxreal switch to RUN386.EXE or TNT.EXE.

Example:
```
    C>wd /trap=pls;{-maxreal 512} hello
      or
    C>set wd=/trap#pls;{-maxreal 512}
    C>wd hello
```

12.2 Debugging AutoCAD Applications

The Watcom Debugger can be used to debug AutoCAD Development System (ADS) and AutoCAD Device Interface (ADI) applications. Before running the debugger, add a line similar to the following to your "ACAD.ADS" file. This line specifies the path to the "ADSHELP.EXP" file.

```
    C:\WATCOM\BINW\ADSHELP.EXP
```

The file "ACAD.ADS" contains a list of AutoCAD applications that are loaded by AutoCAD when AutoCAD is started. "ADSHELP.EXP" is an AutoCAD application that is required by the debugger for debugging AutoCAD applications.

To debug an ADS application, a special trap file "ADS.TRP" must be used.

WD /TRap=ADS

If you do not have a two-monitor setup, you should also specify the *Swap* option.

WD /TRap=ADS /Swap

Note that we did not specify the AutoCAD executable file; the trap file, "ADS.TRP", will load AutoCAD automatically. You should now be in the debugger. At this point, choose ***Command*** from the ***File*** menu and enter the following debugger command specifying the name of the file containing your AutoCAD application (e.g., foo.exp).

Example:
```
DBG>ads foo.exp
```

The file "ADS.DBG" contains a sequence of debugger commands that starts AutoCAD, loads the debugging information from the executable file you specify, and relocates address information based on the code and data selector values for your application.

You should now be in AutoCAD. When you load your AutoCAD application from AutoLISP, the debugger will be entered and source for your program should be displayed in the source window.

Example:
```
xload "foo.exp"
```

You are now ready to debug your AutoCAD application.

12.3 Debugging a Novell NLM

Novell NLM's may only be debugged remotely. You must use either the serial, parallel, or Novell SPX link. There are 5 NLM's distributed in the WATCOM package. The following table describes their use:

	NetWare 3.11/3.12	NetWare 4.01
Serial		serserv4.nlm
Parallel	parserv3.nlm	parserv4.nlm
SPX	novserv3.nlm	novserv4.nlm

To start remote debugging, you load one of the above NLMs at the NetWare file server console. The debugger is then invoked as in any remote debugging session. See the chapter entitled "Remote Debugging" on page 105 for parameter details. See the appendix entitled "Wiring For Remote Debugging" on page 209 for parallel/serial cable details.

For example, on a NetWare 4.01 server type: `load novserv4`

On a workstation, type: `WD /tr=nov mynlm`

Debugging information for every running NLM is available. You can debug any NLM in the system as if it were part of your application, as long as you created it with debug information. If the NLM does not have WATCOM style debugging information, the debugger will attempt to use any debugging information created by Novell's linker (NLMLINK).

12.4 Debugging Graphics Applications

When debugging a graphics application, there are a number of Watcom Debugger command line options that could be specified depending on your situation.

1. If you only have one monitor attached to your system, use the *Swap* option. The *Swap* option specifies that the application’s screen memory and the debugger’s screen memory are to be swapped back and forth using a single page.

2. If you have two monitors attached to your system then the *Two* and *Monochrome* options should be used. The *Two* option specifies that a second monitor is connected to the system. Note that if the monitor type (*Monochrome, Color, Colour, Ega43, Vga50*) is not specified then the monitor that is not currently being used is selected for the debugger’s screen. If you specify *Monochrome* then the monochrome monitor will be used for the debugger’s screen.

3. If you are debugging the graphics application using a second personal computer and the remote debugging feature of the Watcom Debugger then the choice of display and operation mode for the Watcom Debugger is irrelevant. If one system is equipped with a graphics display and the other with a monochrome display then you will undoubtedly use the system equipped with the monochrome display to run the Watcom Debugger.

12.5 Debugging Windows 3.x Applications

Both a character mode and a GUI debugger are supplied that run in the Windows environment. You must choose which of these debuggers you are going to use. They both have advantages and disadvantages. When your application is suspended, the GUI and character mode debuggers behave differently. The GUI debugger allows other applications to continue running. The character mode debugger does not. Although the GUI debugger has a much nicer looking user interface, you should not use it under some circumstances. You can always use the character mode debugger. You should be aware of the following restrictions:

1. If you are trying to debug an applications that uses DDE you should ***not*** use the GUI debugger.
2. Do ***not*** try to use the GUI debugger to debug system modal dialogs.
3. If you hit a break-point in a dialog callback procedure or in your window procedure when it is receiving certain events (e.g., WM_MENUSELECT), the GUI debugger will lock input to itself. When this happens, you will not be able to switch away from the debugger, and no other application will repaint themselves. When this

happens, pop-up menus will not draw correctly and you will have to use the ***Action*** menu instead. You should not try to quit the debugger when it is in this state.

4. Do ***not*** try to use either of the Windows debuggers in a seamless Win-OS/2 session.

If you find that the Windows debugger starts too slowly, try using the *DIp=WATCOM* option. This prevents the debugger from searching each DLL in the system for debugging information. It will start up faster, but you will not be able to see the name of the Windows API calls.

To start the Watcom Debugger, select the program group in which you have installed the Watcom Debugger. One of the icons presented is used to start the debugger. Double-click on the Watcom Debugger icon.

You can make special versions of the Watcom Debugger icon using ***Properties*** from the ***File*** menu of the Windows "Program Manager". For example, you can add any options you wish to the "Command Line" field of the "Properties" window. When you click on the newly created icon, the options specified in the "Command Line" field are the defaults. As long as no executable file name was specified in the "Command Line" field, the Watcom Debugger will present its prompt window. In the prompt window, you can specify an executable file name and arguments.

If you are debugging the same program over and over again, you might wish to create an icon that includes the name of the file you wish to debug in the "Command Line" field. Each time you click on that icon, the Watcom Debugger is started and it automatically loads the program you wish to debug.

12.6 Debugging Dynamic Link Libraries

The debugger automatically detects all DLLs that your application references when it loads the application. When your program loads a DLL dynamically, the debugger detects this as well. If you have created your DLL with debugging information, you can debug it just as if it were part of your application. Even if it does not have debugging information, the debugger will process system information to make the DLL entry point names visible. There are a few limitations:

1. You cannot debug your DLL initialization code. This is the first routine that the operating system runs when it loads the DLL. This is not normally a problem, since most DLLs do not do much in the way of initialization.
2. When a DLL is loaded dynamically, its debugging information may not be available immediately. Try tracing a few instructions and it will appear.

3. If you restart an application, you will lose any break points that you had set in dynamically loaded DLLs. You need to trace back over the call to LoadModule or DOSLoadModule and re-set these break points.

12.7 Disabling Use of 386/486 Debug Registers

It may be necessary to prevent the Watcom Debugger from using the 386/486 Debug Registers (a hardware feature used to assist debugging). This situation arises with certain DOS control programs that do not properly manage Debug Registers. If the Watcom Debugger fails upon startup on a 386/486 system, it is a good indication that use of the Debug Registers must be disabled. With "STD.TRP", the trap file parameter "d" may be specified to disable the use of Debug Registers. The following example illustrates the specification of the "d" trap file parameter.

Example:
```
    C>wd /trap=std;d calendar
```

12.8 Debugging Under QNX

When the debugger starts up, it will attempt to open the initialization file `.wdrc` provided that you have not specified the *Invoke* command line option. It looks for this file in all the usual places (**CWD, WD_PATH,** `/usr/watcom/<ver>/wd, /usr/watcom/wd`). This file normally contains your customization commands. If it is found, it is processed as the default configuration file. You would normally place this file in your home directory.

If the file does not exist, the debugger then looks for the `wd.dbg` file.

If you do not want the debugger to use the `.wdrc` file then you can do one of two things — make sure that it cannot be located (e.g., delete it) or use the *Invoke* command line option (you could specify the `wd.dbg` file as the target).

The supplied version of the `wd.dbg` file contains an "invoke" command referencing the file `setup..dbg` This file, in turn, contains a "configfile" command and "invoke" commands referencing other command files. The "configfile" command marks `setup.dbg` as the default file name to use when the debugger writes out the current configuration.

The following section entitled "Debugging Under QNX Using the Postmortem Dump Facility" on page 136 describes the use of the debugger with the Postmortem dump facility. The following section entitled "Search Order for Watcom Debugger Support Files under QNX" on page 138 describes the search order for debugger files under QNX.

12.8.1 Debugging Under QNX Using the Postmortem Dump Facility

A limited form of debugging of an application that has terminated and produced a postmortem dump can be done under QNX. In order to use this feature, you must start the QNX "dumper" program.

dumper [-d path] [-p pid] &

dumper	is the program name for the QNX postmortem dump program.
-d path	The name of the directory in which postmortem dumps are written. If not specified, the default is the user's home directory.
-p pid	Save a dump file for this process if it terminates for any reason. Do not save a dump file for any other process.
&	must be specified so that the shell is rejoined.

Example:
```
    $ dumper &
    $ dumper -d /usr/fred/dump_area &
```

Whenever a program terminates abnormally, a dump of the current state of the program in memory is written to disk. The dump file name is the same as the program name with a **.dmp** extension. For example, if the program name is **a.out** then the dump will be written to the **/home/userid/a.out.dmp** file.

You can use the *-d* option of the dumper program to force all dumps into a single directory rather than into the invoking user's home directory.

The *-p* option lets you monitor a particular process. You can run multiple copies of the dumper program, each monitoring a different process.

If the Watcom Debugger was being used to debug the program at the time that it abnormally terminated then the dump is written to the user's home directory provided that the *-d* option was not used.

To examine the contents of the postmortem dump, the Watcom Debugger may be used. The interface between the Watcom Debugger and the postmortem dump is contained in a special "trap" file. The trap file is specified to the Watcom Debugger using the *TRap* option.

wd -TRap=pmd[;i] [:sym_file] file_spec

wd is the program name for the Watcom Debugger.

-TRap=pmd[i] must be specified when debugging an application that has terminated and produced a postmortem dump. The optional ";i" is specified when the modification date of the original program file does not match the information contained in the dumper file. It indicates that the symbolic debugging information in the program file may be out-of-date. It instructs the Watcom Debugger to ignore the date mismatch. Depending on the shell that you are using, it may be necessary to place the option specification in quotation marks if you include the optional ";i".

Example:

```
    $ wd "-trap=pmd;i" myapp
```

sym_file is an optional symbolic information file specification. The specification must be preceded by a colon (":"). When specifying a symbol file name, a path such as "//5/etc/" may be included. For QNX, the default file suffix of the symbol file is ".sym".

file_spec is the file name of the dumper file to be loaded into memory. When specifying a file name, a path such as "//5/etc/" may be included. If a path is omitted, the Watcom Debugger will first attempt to locate the file in the current directory and, if not successful, attempt to locate the file in the default dumper directory: **/usr/dumps.**

Basically, the Watcom Debugger is fully functional when a postmortem dump is examined. However, there are some operations which are not allowed. Among these are:

1. Task execution cannot be restarted using ***Go*** from the ***Run*** menu.
2. A register can be modified for the purposes of expression evaluation. You can choose ***Go*** from the ***Run*** menu to restore the register contents to their original postmortem state.
3. Memory cannot be modified.
4. Memory outside of regions owned by the program cannot always be examined.
5. I/O ports cannot be examined.

12.8.2 Search Order for Watcom Debugger Support Files under QNX

There are several supporting files provided with the Watcom Debugger. These files fall into five categories.

1. Watcom Debugger command files (files with the ".dbg" suffix).
2. Watcom Debugger trap files (files with the ".trp" suffix).
3. Watcom Debugger parser files (files with the ".prs" suffix).
4. Watcom Debugger help files (files with the ".hlp" suffix).
5. Watcom Debugger symbolic debugging information files (files with the ".sym" suffix).

The search order for Watcom Debugger support files is as follows:

1. the current directory,
2. the paths listed in the **WD_PATH** environment variable,
3. the path listed in the **HOME** environment variable, and, finally,
4. the "/usr/watcom/wd" directory.

You should note the following when using the remote debugging feature of the Watcom Debugger. When the *REMotefiles* option is specified, the debugger also attempts to locate the Watcom Debugger's support files (command files, trap files, etc.) on the task machine.

Expressions

13 Watcom Debugger Expression Handling

13.1 Introduction

The Watcom Debugger is capable of handling a wide variety of expressions. An expression is a combination of operators and operands selected from application variables and names, debugger variables, and constants. Expressions can be used in a large number of debugger commands and dialogs. For example, the evaluated result of an expression may be displayed by choosing ***New*** from the pop-up menu in the Watches window or by using the print command.

The appropriate syntax of an expression, i.e., the valid sequence of operators and operands, depends on the grammar of the language that is currently established. The Watcom Debugger supports the grammars of the C, C++, and FORTRAN 77 languages. A grammar is selected automatically by the debugger when tracing the execution of modules in an application. For example, part of an application may be written in C, another part in C++, and another part in FORTRAN 77. The modules must have been compiled by one of the WATCOM C, C++ or FORTRAN 77 compilers. When tracing into a module written in one of these languages, the debugger will automatically select the appropriate grammar. In addition to this automatic selection, a particular grammar may be selected using the debugger ***Set LAnguage*** command. The language currently selected can be determined using the ***SHow Set LAnguage*** command.

13.2 General Rules of Expression Handling

The debugger handles two types of expressions. The difference between the two types of expressions is quite subtle. One is called an "expression" and things operate as you would normally expect. This type of expression is used for all "higher" level operations such as adding items to the Watches window. The other type is called an "address expression". It is used whenever the debugger prompts for an address and in lower level commands such ***Examine*** and ***Modify.*** If the notation for a particular command argument is <address>, it is an address expression. If it ends in just "expr" then it is a normal expression. The difference between the two forms lies in how they treat symbol names. In a normal expression the value of a symbol is its *rvalue,* or contents. In an address expression, the value of a symbol is (sometimes) its *lvalue,* or address.

Consider the following case. You have a symbol `sam` at offset 100 and the word at that location contains the value 15. If you enter `sam` into the watches window you expect the value 15 to be printed and since the Watches window takes a normal expression that is what you get. Now let us try it with the Breakpoint dialog. Enter `sam` in the address field. The Breakpoint dialog uses the result of its expression as the address at which to set a breakpoint. The Breakpoint dialog takes an address expression, and an implicit unary "&" operator is placed in front of symbols. The debugger has a set of heuristics that it applies to determine whether it should use the rvalue or lvalue of a symbol.

13.3 Language Independent Variables and Constants

The following sections describe conventions used in the debugger for identifying modules, variables, line numbers, registers, etc.

13.3.1 Symbol Names

Regardless of the programming language that was used to code the modules of an application, the names of variables and routines will be available to the debugger (provided that the appropriate symbolic debugging information has been included with the application's execution module). The debugger does not restrict the way in which names are used in expressions. A name could represent a variable but it could also represent the entry point into a routine.

The syntax of a symbol name reference is quite complicated.

[[[image]@][module]@][routine_name.]symbol_name

Generally, an application will consist of many modules which were compiled separately. The current image is the one containing the module which is currently executing. The current module is the one containing the source lines currently under examination in the Source or Assembly window. By default, the Source window's title line contains the current module name. The current routine is the one containing the source line at which execution is currently paused.

The following are examples of references to symbol names.

Example:
```
symbol_name
main
WinMain
FMAIN
printf
LIB$G_OPEN
stdin
```

If the symbol does not exist in the current scope then it must be qualified with its routine name. Generally, these are variables that are local to a particular routine.

Example:
```
routine_name.symbol_name
main.curr_time
main.tyme
SUB1.X
SUB2.X
```

If the symbol is not externally defined and it does not exist in the current module then it may be qualified with its module name. In the C and C++ programming languages, we can define a variable that is global to a module but known only to that module ("static" storage class).

Example:
```
static char *NarrowTitle = { "Su Mo Tu We Th Fr Sa" };
```

In the above example, "NarrowTitle" is global to the module "calendar". If the current module is not "calendar" then the module name can be used to qualify the symbol as shown in the following example.

Example:
```
calendar@NarrowTitle
```

If the symbol is local to a routine that is not in the current module then it must be qualified with its module name and routine name.

Example:
```
module_name@routine_name.symbol_name
calendar@main.curr_time
calendar@main.tyme
subs@SUB1.X
subs@SUB2.X
```

If the symbol is local to an image that is not in the current executable then it must be fully qualified with the image name.

Example:
```
    prog_name@@routine_name
    prog_name@module_name@routine_name
    prog_name@module_name@routine_name.symbol_name
    dll_name@calendar@main.curr_time
    dll_name@calendar@main.tyme
    program@subs@SUB1.X
    program@subs@SUB2.X
```

There is a special case for the primary executable image. This is the name of the program you specified when you started the debugger. You can reference it by omitting the image name. The following examples all refer to symbols in the primary executable image:

Example:
```
    @@WinMain
    @module@WinMain
    @@routine.symbol
```

In the FORTRAN 77 programming language, all variables (arguments, local variables, COMMON block variables) are available to the subprogram in which they are defined or referenced. The same symbol name can be used in more than one subprogram. If it is a local variable, it represents a different variable in each subprogram. If it is an argument, it may represent a different variable in each subprogram. If it is a variable in a COMMON block, it represents the same variable in each subprogram where the COMMON block is defined.

Example:
```
    SUBROUTINE SUB1( X )
    REAL Y
    COMMON /BLK/ Z
        .
        .
        .
    END
    SUBROUTINE SUB2( X )
    REAL Y
    COMMON /BLK/ Z
        .
        .
        .
    END
```

In the above example, "X" is an argument and need not refer to the same variable in the calling subprogram.

Example:
```
    CALL SUB1( A )
    CALL SUB2( B )
```

The variable "Y" is a different variable in each of "SUB1" and "SUB2". The COMMON block variable "Z" refers to the same variable in each of "SUB1" and "SUB2" (different names for "Z" could have been used). To refer to "X", "Y", or "Z" in the subprogram "SUB2", you would specify "SUB2.X", "SUB2.Y", or "SUB2.Z". If "SUB2" was in the module "MOD" and it is not the current module, you would specify "MOD@SUB2.X", "MOD@SUB2.Y", or "MOD@SUB2.Z".

Note: Global and local symbol name debugging information is included in an executable image if you request it of the linker. However, local symbol information must be present in your object files. The WATCOM C, C++ and FORTRAN 77 compilers can include local symbol debugging information in object files by specifying the appropriate compiler option. See "Preparing a Program to be Debugged" on page 9.

13.3.2 Line Numbers

Regardless of the programming language that was used to code the modules of an application, line number information identifying the start of executable statements will be available to the debugger (provided that the appropriate symbolic debugging information has been included with the application's execution module). The debugger does not restrict the way in which line number references are used in expressions. A line number represents the code address of an executable statement in a routine. Not all line numbers represent executable statements; thus some line numbers may not be valid in an expression. For example, source lines consisting of comments do not represent executable statements.

The general format for a line number reference is:

[[image]@] [module_name] @ decimal_digits

The following are examples of references to executable statements.

Example:
```
@36
@@45
@51
@125
hello@9
@hello@9
prog@hello@9
otherprg@goodbye@9
puzzle@50
calendar@20
SUB1@30
```

If the line number does not exist in the current module, it must be qualified with its module name. If it does not exist in the current image, it must be qualified with the image name. Line numbers are not necessarily unique. For example, an executable statement could occur at line number 20 in several modules. The module name can always be used to uniquely identify the line 20 in which we are interested. In the above examples, we explicitly refer to line 20 in the module "calendar". When the module name is omitted, the current module is assumed.

Note: Line number debugging information is included in an executable image if you request it of the linker. However, line number information must be present in your object files. The WATCOM C, C++ and FORTRAN 77 compilers can include line number debugging information in object files by specifying the appropriate compiler option. See "Preparing a Program to be Debugged" on page 9. You can request line number debugging information when assembling assembly language source files using Microsoft’s MASM Version 5. The "Zd" option must be specified on the command line.

13.3.3 Constants

A *constant* can be arithmetic or character. Each constant has a data type associated with it. Arithmetic constants consist of those constants whose data type is one of integer, real, or complex (FORTRAN only). C treats character constants like arithmetic constants so they can be used in arithmetic expressions. FORTRAN treats character constants as constants of type CHARACTER so they cannot be used in arithmetic expressions.

13.3.3.1 Integer Constants

An *integer constant* is formed by a non-empty string of digits preceded by an optional radix specifier. The digits are taken from the set of digits valid for the current radix. If the current radix is 10 then the digits are ’0’ through ’9’. If the current radix is 16 then the digits are ’0’ through ’9’ and ’A’ through ’F’ or ’a’ through ’f’. See "The Options Dialog" on page 36.

The following are examples of integer constants.

Example:
```
123
57DE
1423
345
34565788
```

Radix specifiers may be defined by the user, but two are predefined by the debugger. *0x* may be defined to be a radix specifier for hexadecimal (base 16) numbers. *0n* may be defined to be a radix specifier for decimal (base 10) numbers

Example:
```
0x1234      hexadecimal
0n1234      decimal
255         decimal
0xff        hexadecimal
0x1ADB      hexadecimal
0n200       decimal
0x12fc0     hexadecimal
```

13.3.3.2 Real Constants

We first define a *simple real constant* as follows: an optional sign followed by an integer part followed by a decimal point followed by a fractional part. The integer and fractional parts are non-empty strings of digits. The fractional part can be omitted.

A *real constant* has one of the following forms.

(1) A simple real constant.

(2) A simple real constant followed by an `E` or `e` followed by an optionally signed integer constant.

The optionally signed integer constant that follows the `E` is called the *exponent.* The value of a real constant that contains an exponent is the value of the constant preceding the `E` multiplied by the power of ten determined by the exponent.

The following are examples of real constants.

```
    123.764
    0.4352344
    1423.34E12
    +345.E-4
    -0.4565788E3
    2.E6
    1234.
```

Note: The accepted forms of floating-point constants are a subset of that supported by the FORTRAN 77 programming language. The debugger does not support floating-point constants that begin with a decimal point (e.g., .4352344) or have no decimal point (e.g., 2E6). However, both forms would be acceptable to a FORTRAN compiler. Also, the debugger does not support double precision floating-point constants where "D" is used instead of "E" for the exponent part (e.g., 2D6, 2.4352344D6). All floating-point constants are stored internally by the debugger in double precision format.

13.3.3.3 Complex Constant (FORTRAN Only)

A *complex constant* consists of a left parenthesis, followed by a real or integer constant representing the real part of the complex constant, followed by a comma, followed by a real or integer constant representing the imaginary part of the complex constant, followed by a right parenthesis.

The following are examples of complex constants.

```
    ( 1423.34E12, 3 )
    ( +345, 4 )
```

Complex constants will be accepted when the debugger’s currently established language is FORTRAN. The language currently selected can be determined using the ***SHow Set LAnguage*** command.

13.3.3.4 Character Constant (C Only)

In the C and C++ programming languages, a *character constant* consists of an apostrophe followed by a single character followed by an apostrophe. The apostrophes are not part of the datum. An apostrophe in a character datum represents one character, namely the apostrophe. A character constant must have length 1.

The following are examples of character constants.

```
'A'
'e'
'''
```

The C/C++ form of a character constant will be accepted when the debugger's currently established language is C or C++. The language currently selected can be determined using the ***SHow Set LAnguage*** command.

13.3.3.5 Character String Constant (FORTRAN Only)

In the FORTRAN 77 programming language, a *character constant* consists of an apostrophe followed by any string of characters followed by an apostrophe. The apostrophes are not part of the datum. If an apostrophe is to appear as part of the datum it must be followed immediately by another apostrophe. Note that blanks are significant. The length of the character constant is the number of characters appearing between the delimiting apostrophes. Consecutive apostrophes in a character datum represent one character, namely the apostrophe. A character constant must not have length 0.

The following are examples of character constants.

```
'ABCDEFG1234567'
'There''s always tomorrow'
```

The FORTRAN form of a character constant will be accepted when the debugger's currently established language is FORTRAN.

13.3.4 Memory References

In addition to referring to memory locations by symbolic name or line number, you can also refer to them using a combination of constants, register names, and symbol names. In the Intel 80x86 architecture, a memory reference requires a segment and offset specification. When symbol names are used, these are implicit. The general form of a memory reference is:

[segment:]offset

When an offset is specified alone, the default segment value is taken from the CS, DS or SS register depending on the circumstances.

13.3.5 Predefined Debugger Variables

The debugger defines a number of symbols which have special meaning. These symbols are used to refer to the computer's registers and other special variables.

General Purpose Registers
eax, ax, al, ah, ebx, bx, bl, bh, ecx, cx, cl, ch, edx, dx, dl, dh

Index Registers
esi, si, edi, di

Base Registers
esp, sp, ebp, bp

Instruction Pointer
eip, ip

Segmentation Registers
cs, ds, es, fs, gs, ss

Flags Registers
fl, fl.o, fl.d, fl.i, fl.s, fl.z, fl.a, fl.p, fl.c, efl, efl.o, efl.d, efl.i, efl.s, efl.z, efl.a, efl.p, efl.c

8087 Registers
st0, st1, st2, st3, st4, st5, st6, st7

8087 Control Word
cw, cw.ic, cw.rc, cw.pc, cw.iem, cw.pm, cw.um, cw.om, cw.zm, cw.dm, cw.im

8087 Status Word
sw, sw.b, sw.c3, sw.st, sw.c2, sw.c1, sw.c0, sw.es, sw.sf, sw.pe, sw.ue, sw.oe, sw.ze, sw.de, sw.ie

Miscellaneous Variables
dbg$32, dbg$bottom, dbgbp, dbgcode, dbgcpu, dbgctid, dbg$data, dbg$etid, dbgfpu, dbgip, dbg$left, dbg$monitor, dbgos, dbgpid, dbgpsp, dbgradix, dbg$remote, dbg$right, dbgsp, dbgtop, dbgnil, dbgsrc, dbg$loaded

The debugger permits the manipulation of register contents and special debugger variables (e.g., dbg$32) using any of the operators described in this chapter. By default, these predefined names are accessed just like any other variables defined by the user or the application. Should the situation ever arise where the application defines a variable whose name conflicts with that of one of these debugger variables, the module specifier `_dbg` may be used to resolve the ambiguity. For example, if the application defines a variable called `cs` then `_dbg@cs` can be specified to resolve the ambiguity. The "_dbg@" prefix indicates that we are referring to a debugger defined symbol rather than an application defined symbol. See "Predefined Symbols" on page 201.

13.3.6 Register Aggregates

There are times when a value may be stored in more than one register. For example, a 32-bit "long" integer value may be stored in the register pair DX:AX. We require a mechanism for grouping registers to represent a single quantity for use in expressions.

We define the term "register aggregate" as any grouping of registers to form a single unit. An aggregate is specified by placing register names in brackets in order from most significant to least significant. Any aggregate may be specified as long as it forms an 8, 16, 32 or 64-bit quantity. The following are examples of some of the many aggregates that can be formed.

Example:
```
    8-bit    [al]
    16-bit   [ah al]
    16-bit   [bl ah]
    16-bit   [ax]
    32-bit   [dx ax]
    32-bit   [dh dl ax]
    32-bit   [dh dl ah al]
    32-bit   [ds di]
    64-bit   [ax bx cx dx]
    64-bit   [edx eax]       (386/486/Pentium only)
```

In some cases, the specified aggregate may be equivalent to a register. For example, the aggregates "[ah al]" and "[ax]" are equivalent to "ax".

The default type for 8-bit, 16-bit, and 32-bit aggregates is integer. The default type for 64-bit aggregates is double-precision floating-point. To force the debugger into treating a 32-bit aggregate as single-precision floating-point, the type coercion operator "[float]" may be used.

13.4 Operators for the C Grammar

The debugger supports most C operators and includes an additional set of operators for convenience. The *WATCOM C Language Reference* manual describes many of these operators.

The syntax for debugger expressions is similar to that of the C programming language. Operators are presented in order of precedence, from lowest to highest. Operators on the same line have the same priority.

```
                                        Lowest Priority
Assignment Operators
    =  +=  -=  *=  /=  %=  &=  |=  ^=  <<=  >>=
Logical Operators
    ||
    &&
Bit Operators
    |
    ^
    &
Relational Operators
    ==  !=
    <   <=   <   >=
Shift Operators
    <<  >>
Arithmetic Operators
    +  -
    *  /  %
Unary Operators
    +  -  ~  !  ++  --  &  *  %
    sizeof unary_expr
    sizeof(type_name)
    (type_name) unary_expr
    [type_name] unary_expr
    ?
Binary Address Operator
    :
                                        Highest Priority
```

Parentheses can be used to order the evaluation of an expression.

In addition to the operators listed above, a number of primary expression operators are supported. These operators are used in identifying the object to be operated upon.

[]	subscripting, substringing
()	function call
.	field selection
->	field selection using a pointer

The following sections describe the operators presented above.

13.4.1 Assignment Operators for the C Grammar

=	Assignment: The value on the right is assigned to the object on the left.
+=	Additive assignment: The value of the object on the left is augmented by the value on the right.
-=	Subtractive assignment: The value of the object on the left is reduced by the value on the right.
***=**	Multiplicative assignment: The value of the object on the left is multiplied by the value on the right.
/=	Division assignment: The value of the object on the left is divided by the value on the right.
%=	Modulus assignment: The object on the left is updated with MOD(left,right). The result is the remainder when the value of the object on the left is divided by the value on the right.
&=	Bit-wise AND: The bits in the object on the left are ANDed with the bits of the value on the right.
|=	Bit-wise inclusive OR: The bits in the object on the left are ORed with the bits of the value on the right.
^=	Bit-wise exclusive OR: The bits in the object on the left are exclusively ORed with the bits of the value on the right.
<<=	Left shift: The bits in the object on the left are shifted to the left by the amount of the value on the right.

>>=	Right shift: The bits in the object on the left are shifted to the right by the amount of the value on the right. If the object on the left is described as unsigned, the vacated high-order bits are zeroed. If the object on the left is described as signed, the sign bit is propagated through the vacated high-order bits. The debugger treats registers as unsigned items.

13.4.2 Logical Operators for the C Grammar

&&	Logical conjunction: The logical AND of the value on the left and the value on the right is produced. If either of the values on the left or right is equal to 0 then the result is 0; otherwise the result is 1.
||	Logical inclusive disjunction: The logical OR of the value on the left and the value on the right is produced. If either of the values on the left or right is not equal to 0 then the result is 1; otherwise the result is 0. If the value on the left is not equal to 0 then the expression on the right is not evaluated (this is known as short-circuit expression evaluation).

13.4.3 Bit Operators for the C Grammar

&	Bit-wise AND: The bits of the value on the left and the value on the right are ANDed.
|	Bit-wise OR: The bits of the value on the left and the value on the right are ORed.
^	Bit-wise exclusive OR: The bits of the value on the left and the value on the right are exclusively ORed.

13.4.4 Relational Operators for the C Grammar

==	Equal: If the value on the left is equal to the value on the right then the result is 1; otherwise the result is 0.
!=	Not equal: If the value on the left is not equal to the value on the right then the result is 1; otherwise the result is 0.
<	Less than: If the value on the left is less than the value on the right then the result is 1; otherwise the result is 0.

<=	Less than or equal: If the value on the left is less than or equal to the value on the right then the result is 1; otherwise the result is 0.
>	Greater than: If the value on the left is greater than the value on the right then the result is 1; otherwise the result is 0.
>=	Greater than or equal: If the value on the left is greater than or equal to the value on the right then the result is 1; otherwise the result is 0.

13.4.5 Arithmetic/Logical Shift Operators for the C Grammar

<<	Left shift: The bits of the value on the left are shifted to the left by the amount described by the value on the right.
>>	Right shift: The bits of the value on the left are shifted to the right by the amount described by the value on the right. If the object on the left is described as unsigned, the vacated high-order bits are zeroed. If the object on the left is described as signed, the sign bit is propagated through the vacated high-order bits. The debugger treats registers as unsigned items.

13.4.6 Binary Arithmetic Operators for the C Grammar

+	Addition: The value on the right is added to the value on the left.
_	Subtraction: The value on the right is subtracted from the value on the left.
*	Multiplication: The value on the left is multiplied by the value on the right.
/	Division: The value on the left is divided by the value on the right.
%	Modulus: The modulus of the value on the left with respect to the value on the right is produced. The result is the remainder when the value on the left is divided by the value on the right.

13.4.7 Unary Arithmetic Operators for the C Grammar

+	Plus: The result is the value on the right.
_	Minus: The result is the negation of the value on the right.
~	Bit-wise complement: The result is the bit-wise complement of the value on the right.
!	Logical complement: If the value on the right is equal to 0 then the result is 1; otherwise it is 0.
++	Increment: Both prefix and postfix operators are supported. If the object is on the right, it is pre-incremented by 1 (e.g., ++x). If the object is on the left, it is post-incremented by 1 (e.g., x++).
_ _	Decrement: Both prefix and postfix operators are supported. If the object is on the right, it is pre-decremented by 1 (e.g., --x). If the object is on the left, it is post-decremented by 1 (e.g., x--).
&	Address of: The result is the address (segment:offset) of the object on the right (e.g., &main).
*	Points: The result is the value stored at the location addressed by the value on the right (e.g., *(ds:100), *string.loc). In the absence of typing information, a near pointer is produced. If the operand does not have a segment specified, the default data segment (DGROUP) is assumed.

```
          (SS:00FE) = FFFF
    var:  (SS:0100) = 0152
          (SS:0102) = 1240
          (SS:0104) = EEEE
```

%	Value at address: The result is the value stored at the location addressed by the value on the right (e.g., %(ds:100), %string.loc). In the absence of typing information, a far pointer is produced. If the operand does not have a segment specified, the default data segment (DGROUP) is assumed.

```
          (SS:00FE) = FFFF
    var:  (SS:0100) = 0152
          (SS:0102) = 1240
          (SS:0104) = EEEE
```

Note that this operator is not found in the C or C++ programming languages.

13.4.8 Special Unary Operators for the C Grammar

sizeof unary_expression

Example:
```
sizeof tyme
sizeof (*tyme)
```

sizeof(type_name)

Example:
```
sizeof( struct tm )
```

(type_name) unary_expression The type conversion operator *(type_name)* is used to convert an item from one type to another. The following describes the syntax of "type_name".

type_name ::= type_spec { ["near" | "far" | "huge"] "*" }
type_spec ::= typedef_name
| "struct" structure_tag
| "union" union_tag
| "enum" enum_tag
| scalar_type { scalar_type }
scalar_type ::= "char" | "int" | "float" | "double"
| "short" | "long" | "signed" | "unsigned"

Example:
```
(float) 4
(int) 3.1415926
```

[type_name] unary_expression You can force the debugger to treat a memory reference as a particular type of value by using a type coercion operator. A type specification is placed inside brackets as shown above. The basic types are ***char*** (character, 8 bits), ***short*** (short integer, 16 bits), ***long*** (long integer, 32 bits), ***float*** (single-precision floating-point, 32 bits), and ***double*** (double-precision floating-point, 64 bits). Unless qualified by the ***short*** or ***long*** keyword, the ***int*** type will be 16 bits in 16-bit applications and 32 bits in 32-bit applications (386, 486 and Pentium systems). The character, short integer and long integer types may be treated as ***signed*** or ***unsigned*** items. The default for the character type is unsigned. The default for the integer types is signed.

Example:
```
    [char]                  (default unsigned)
    [signed char]
    [unsigned char]
    [int]                   (default is signed)
    [short]                 (default is signed)
    [short int]             (default is signed)
    [signed short int]
    [long]                  (default is signed)
    [long int]              (default is signed)
    [signed long]
    [unsigned long int]
    [float]
    [double]
```

Note that it is unnecessary to specify the ***int*** keyword when ***short*** or ***long*** are specified.

? Existence test: The "?" unary operator may be used to test for the existence of a symbol.

Example:
```
    ?id
```

The result of this expression is 1 if "id" is a symbol known to the debugger and 0 otherwise. If the symbol does not exist in the current scope then it must be qualified with its module name. Automatic symbols exist only in the current function.

13.4.9 Binary Address Operator for the C Grammar

: Memory locations can be referenced by using the binary ":" operator and a combination of constants, register names, and symbol names. In the Intel 80x86 architecture, a memory reference requires a segment and offset specification. A memory reference using the ":" operator takes the following form:

segment:offset

The elements *segment* and *offset* can be expressions.

Example:
```
    (ES):(DI+100)
    (SS):(SP-20)
```

13.4.10 Primary Expression Operators for the C Grammar

[] Elements of an array can be identified using subscript expressions. Consider the following 3-dimensional array defined in the "C" language.

Example:
```
    char *ProcessorType[2][4][2] =
        { { { "Intel 8086",   "Intel 8088"  },
            { "Intel 80186",  "Intel 80188" },
            { "Intel 80286",  "unknown" },
            { "Intel 80386",  "unknown" } },

          { { "NEC V30",      "NEC V20" },
            { "unknown",      "unknown" },
            { "unknown",      "unknown" },
            { "unknown",      "unknown" } } };
```

This array can be viewed as two layers of rectangular matrices of 4 rows by 2 columns. The array elements are all pointers to string values.

By using a subscript expression, specific slices of an array can be displayed. To see only the values of the first layer, the following expression can be issued.

Example:
```
    processortype[0]
```

To see only the first row of the first layer, the following expression can be issued.

Example:
```
    processortype[0][0]
```

To see the second row of the first layer, the following command can be issued.

Example:
```
    processortype[0][1]
```

To see the value of a specific entry in a matrix, all the indices can be specified.

Example:
```
    processortype[0][0][0]
    processortype[0][0][1]
    processortype[0][1][0]
```

() The function call operators appear to the right of a symbol name and identify a function call in an expression. The parentheses can contain arguments.

Example:
```
    ClearScreen()
    PosCursor( 10, 20 )
    Line( 15, 1, 30, '-', '+', '-' )
```

. The "." operator indicates field selection in a structure. In the following example, `tyme2` is a structure and `tm_year` is a field in the structure.

Example:
```
    tyme2.tm_year
```

-> The "->" operator indicates field selection when using a pointer to a structure. In the following example, `tyme` is the pointer and `tm_year` is a field in the structure to which it points.

Example:
```
    tyme->tm_year
```

13.5 Operators for the C++ Grammar

Debugger support for the C++ grammar includes all of the C operators described in the previous section entitled "Operators for the C Grammar" on page 152. In addition to this, the debugger supports a variety of C++ operators which are described in the *C++ Programming Language* manual.

Perhaps the best way to illustrate the additional capabilities of the debugger's support for the C++ grammar is by way of an example. The following C++ program encompasses the features of C++ that we will use in our debugging example.

Example:

```
// DBG_EXAM.C: C++ debugging example program

struct BASE {
    int a;
    BASE() : a(0) {}
    ~BASE(){}
    BASE & operator =( BASE const &s )
    {
        a = s.a;
        return *this;
    }
    virtual void foo()
    {
        a = 1;
    }
};

struct DERIVED : BASE {
    int b;
    DERIVED() : b(0) {}
    ~DERIVED() {}
    DERIVED & operator =( DERIVED const &s )
    {
        a = s.a;
        b = s.b;
        return *this;
    }
    virtual void foo()
    {
        a = 2;
        b = 3;
    }
    virtual void foo( int )
    {
    }
};

void use( BASE *p )
{
    p->foo();
}
```

```
void main()
{
    DERIVED x;
    DERIVED y;

    use( &x );
    y = x;
}
```

Compile and link this program so that the most comprehensive debugging information is included in the executable file.

13.5.1 Ambiguity Resolution in the C++ Grammar

Continuing with the example of the previous section, we can step into the call to `use` and up to the `p->foo()` function call. Try to set a breakpoint at foo.

You will be presented with a window containing a list of "foo" functions to choose from since the reference to `foo` at this point is ambiguous. Select the one in which you are interested.

You may also have observed that, in this instance, `p` is really a pointer to the variable `x` which is a `DERIVED` type. To display all the fields of `x`, you can type cast it as follows.

Example:
```
*(DERIVED *)p
```

13.5.2 The "this" Operator for the C++ Grammar

Continuing with the example of the previous sections, we can step into the call to `f->foo()` and up to the `b=3` statement. You can use the "this" operator as illustrated in the following example.

Example:
```
this->a
*this
```

13.5.3 "operator" Functions in the C++ Grammar

Continuing with the example of the previous sections, we can set breakpoints at C++ operators using expressions similar to the following:

Example:
```
    operator =

        DERIVED & operator =( DERIVED const &s )
        {
            a = s.a;
            b = s.b;
            return *this;
        }
```

13.5.4 Scope Operator "::" for the C++ Grammar

We can use the scope operator "::" to identify what it is that we wish to examine. Continuing with the example of the previous sections, we can enter an address like:

```
    base::foo
```

In some cases, this also helps to resolve any ambiguity. The example above permits us to set a breakpoint at the source code for the function `foo` in the class `BASE.`

```
        virtual void foo()
        {
            a = 1;
        }
```

Here are some more interesting examples:

```
    derived::foo
    derived::operator =
```

The first of these two examples contains an ambiguous reference so a prompt window is displayed to resolve the ambiguity.

13.5.5 Constructor/Destructor Functions in the C++ Grammar

We can also examine the constructor/destructor functions of an object or class. Continuing with the example of the previous sections, we can enter expressions like:

Example:
```
    base::base
    base::~base
```

The examples above permit us to reference the source code for the constructor and destructor functions in the class `BASE.`

13.6 Operators for the FORTRAN Grammar

The debugger supports most FORTRAN 77 operators and includes an additional set of operators for convenience. The additional operators are patterned after those available in the C programming language.

The grammar that the debugger supports is close to that of the FORTRAN 77 language but there are a few instances where space characters must be used to clear up any ambiguities. For example, the expression

```
    1.eq.x
```

will result in an error since the debugger will form a floating-point constant from the "1." leaving the string "eq.x". If we introduce a space character after the "1" then we clear up the ambiguity.

```
    1 .eq.x
```

Unlike FORTRAN, the parser in the debugger treats spaces as significant characters. Thus spaces must not be introduced in the middle of symbol names, constants, multi-character operators like .EQ. or //, etc.

Operators are presented in order of precedence, from lowest to highest. Operators on the same line have the same priority.

```
                                                Lowest Priority
Assignment Operators
    =  +=  -=  *=  /=  %=  &=  |=  ^=  <<=  >>=
Logical Operators
    .EQV.  .NEQV.
    .OR.
    .AND.
    .NOT.
Bit Operators
    |
    ^
    &
Relational Operators
    .EQ.  .NE.  .LT.  .LE.  .GT.  .GE.
Shift and Concatenation Operators
    <<  >>  //
Arithmetic Operators
    +  -
    *  /  %
    ** (unsupported)
Unary Operators
    +  -
    ~  ++  --  &   *   %
    [type_name] unary_expr
    ?
Binary Address Operator
    :
                                                Highest Priority
```

Parentheses can be used to order the evaluation of an expression.

In addition to the operators listed above, a number of primary expression operators are supported. These operators are used in identifying the object to be operated upon.

()	subscripting, substringing, or function call
.	field selection
->	field selection using a pointer

The following built-in functions may be used to convert the specified argument to a particular type.

```
INT( )      conversion to integer
REAL( )     conversion to real
DBLE( )     conversion to double-precision
CMPLX( )    conversion to complex
DCMPLX( )   conversion to double-precision complex
```

The following sections describe the operators presented above.

13.6.1 Assignment Operators for the FORTRAN Grammar

=	Assignment: The value on the right is assigned to the object on the left.
+=	Additive assignment: The object on the left is augmented by the value on the right.
-=	Subtractive assignment: The object on the left is reduced by the value on the right.
*=	Multiplicative assignment: The object on the left is multiplied by the value on the right.
/=	Division assignment: The object on the left is divided by the value on the right.
%=	Modulus assignment: The object on the left is updated with MOD(left,right). The result is the remainder when the value of the object on the left is divided by the value on the right.
&=	Bit-wise AND: The bits in the object on the left are ANDed with the bits of the value on the right.
|=	Bit-wise inclusive OR: The bits in the object on the left are ORed with the bits of the value on the right.
^=	Bit-wise exclusive OR: The bits in the object on the left are exclusively ORed with the bits of the value on the right.
<<=	Left shift: The bits in the object on the left are shifted to the left by the amount of the value on the right.
>>=	Right shift: The bits in the object on the left are shifted to the right by the amount of the value on the right. If the object on the left is described as unsigned, the vacated high-order bits are zeroed. If the object on the left is

described as signed, the sign bit is propagated through the vacated high-order bits. The debugger treats registers as unsigned items.

13.6.2 Logical Operators for the FORTRAN Grammar

.EQV.	Logical equivalence: The logical equivalence of the value on the left and the value on the right is produced.
.NEQV.	Logical non-equivalence: The logical non-equivalence of the value on the left and the value on the right is produced.
.OR.	Logical inclusive disjunction: The logical OR of the value on the left and the value on the right is produced.
.AND.	Logical conjunction: The logical AND of the value on the left and the value on the right is produced.
.NOT.	Logical negation: The logical complement of the value on the right is produced.

13.6.3 Bit Operators for the FORTRAN Grammar

|	Bit-wise OR: The bits of the value on the left and the value on the right are ORed.
^	Bit-wise exclusive OR: The bits of the value on the left and the value on the right are exclusively ORed.
&	Bit-wise AND: The bits of the value on the left and the value on the right are ANDed.

13.6.4 Relational Operators for the FORTRAN Grammar

.EQ.	Equal: If the value on the left is equal to the value on the right then the result is 1; otherwise the result is 0.
.NE.	Not equal: If the value on the left is not equal to the value on the right then the result is 1; otherwise the result is 0.
.LT.	Less than: If the value on the left is less than the value on the right then the result is 1; otherwise the result is 0.

.LE.	Less than or equal: If the value on the left is less than or equal to the value on the right then the result is 1; otherwise the result is 0.
.GT.	Greater than: If the value on the left is greater than the value on the right then the result is 1; otherwise the result is 0.
.GE.	Greater than or equal: If the value on the left is greater than or equal to the value on the right then the result is 1; otherwise the result is 0.

13.6.5 Arithmetic/Logical Shift Operators for the FORTRAN Grammar

<<	Left shift: The bits of the value on the left are shifted to the left by the amount described by the value on the right.
>>	Right shift: The bits of the value on the left are shifted to the right by the amount described by the value on the right. If the object on the left is described as unsigned, the vacated high-order bits are zeroed. If the object on the left is described as signed, the sign bit is propagated through the vacated high-order bits. The debugger treats registers as unsigned items.

13.6.6 Concatenation Operator for the FORTRAN Grammar

//	String concatenation: The concatenation of the character string value on the left and right is formed.

13.6.7 Binary Arithmetic Operators for the FORTRAN Grammar

+	Addition: The value on the right is added to the value on the left.
_	Subtraction: The value on the right is subtracted from the value on the left.
*****	Multiplication: The value on the left is multiplied by the value on the right.
/	Division: The value on the left is divided by the value on the right.
%	Modulus: The modulus of the value on the left with respect to the value on the right is produced. The result is the remainder when the value on the left is divided by the value on the right.
******	Exponentiation: This operation is not supported by the debugger.

13.6.8 Unary Arithmetic Operators for the FORTRAN Grammar

+	Plus: The result is the value on the right.
_	Minus: The result is the negation of the value on the right.
~	Bit-wise complement: The result is the bit-wise complement of the value on the right.
++	Increment: Both prefix and postfix operators are supported. If the object is on the right, it is pre-incremented by 1 (e.g., ++x). If the object is on the left, it is post-incremented by 1 (e.g., x++).
_ _	Decrement: Both prefix and postfix operators are supported. If the object is on the right, it is pre-decremented by 1 (e.g., --x). If the object is on the left, it is post-decremented by 1 (e.g., x--).
&	Address of: The result is the address (segment:offset) of the object on the right (e.g., &main).
*****	Points: The result is the value stored at the location addressed by the value on the right (e.g., *(ds:100), *string.loc). In the absence of typing information, the value on the right is treated as a pointer into the default data segment (DGROUP) and a near pointer is produced.

```
          (SS:00FE) = FFFF
    var:  (SS:0100) = 0152
          (SS:0102) = 1240
          (SS:0104) = EEEE
```

% Value at address: The result is the value stored at the location addressed by the value on the right (e.g., %(ds:100), %string.loc). In the absence of typing information, the value on the right is treated as a pointer into the default data segment (DGROUP) and a far pointer is produced.

```
          (SS:00FE) = FFFF
    var:  (SS:0100) = 0152
          (SS:0102) = 1240
          (SS:0104) = EEEE
```

Note that this operator is not found in the FORTRAN 77 programming language.

13.6.9 Special Unary Operators for the FORTRAN Grammar

? Existence test: The "?" unary operator may be used to test for the existence of a symbol.

```
?id
```

The result of this expression is 1 if "id" is a symbol known to the debugger and 0 otherwise. If the symbol does not exist in the current scope then it must be qualified with its module name. Automatic symbols exist only in the current subprogram.

13.6.10 Binary Address Operator for the FORTRAN Grammar

: Memory locations can be referenced by using the binary ":" operator and a combination of constants, register names, and symbol names. In the Intel 80x86 architecture, a memory reference requires a segment and offset specification. A memory reference using the ":" operator takes the following form:

segment:offset

The elements *segment* and *offset* can be expressions.

Example:
```
(ES):(DI+100)
(SS):(SP-20)
```

13.6.11 Primary Expression Operators for the FORTRAN Grammar

() Elements of an array can be identified using subscript expressions.

. The "." operator indicates field selection in a structure. This operator is useful in mixed language applications where part of the application is written in the C or C++ programming language. In the following example, `tyme2` is a structure and `tm_year` is a field in the structure.

```
tyme2.tm_year
```

-> The "->" operator indicates field selection when using a pointer to a structure. This operator is useful in mixed language applications where part of the application is written in the C or C++ programming language. In the following example, `tyme` is the pointer and `tm_year` is a field in the structure to which it points.

```
tyme->tm_year
```

Appendices

A. Debugger Commands

This section describes the syntax of debugger commands as well as a description of each of the debugger commands.

A.1 Syntax Definitions

A debugger command may contain any of the following syntax elements:

- A word in angle brackets, like <anything> is a defined term. Its definition will appear after the syntax description of the command.
- [x] indicates that "x" is an optional item. It may or may not be included in the command.
- [x|y|z] indicates that on of x, y or z should be included in the command.
- [x [x [...]]] indicates that x may be repeated zero or more times in the command.
- CApital indicates that ca,cap,capi,... are accepted short forms for the command "capital".
- (GUI only) indicates that this command is only available in a GUI debugger.
- (character-based) indicates that this command is only available in a character mode debugger.
- <expr> indicates an expression. These may include any of the variables, etc in the program being debugged, and are evaluated in the current program context. See "Watcom Debugger Expression Handling" on page 141.
- <integer> is an integer constant
- <intexpr> is an an expression which evaluates to an integral value. See "Watcom Debugger Expression Handling" on page 141.

- <command> is any debugger command or group of debugger commands.

  You can group debugger commands with braces and separate them with semi-colons. The resulting compound command may be considered as an atomic command.

  ```
  {<command>;<command>;<command>}
  ```

- <address> is any expression which evaluates to an address. See "Watcom Debugger Expression Handling" on page 141.

- <string> is a string of text, optionally enclosed in braces. For example,

  ```
  this_is_a_string
  {so is this}
  ```

- <wndname> is the name of a window. Valid window names (with acceptable short forms indicated in capitals) are:

  - ASsembly
  - ALl
  - BReak
  - Calls
  - Watch
  - FIle
  - FPu
  - FUnctions
  - FILEScope
  - LOCals
  - LOG
  - MEmory
  - MOdules
  - Register
  - SOurce
  - STack
  - Thread
  - IO
  - Globals
  - Variable
  - BInary
  - IMage
  - GLobalfunctions
  - Accelerators
  - TMPFile
  - REPlay
  - CUrrent

- <file> represents any valid operating system file name. For example,

```
c:\autoexec.bat
```

- <path> represents any valid operating system directory path. For example,

```
c:\dir1\dir2
```

A.2 Command Summary

A summary of each command follows.

A.2.1 Accelerate

This command behaves as if a menu item from the main menu was selected:

```
Accelerate main <menu> {<menu_string>}
```

This command behaves as if the named menu item in the floating pop-up menu for the current window was selected:

```
Accelerate {<menu_string>}
```

<menu>	the string appearing on the main menu bar (File, Run, Break, Code, etc)
<menu_string>	is enough of the text appearing in a menu to uniquely identify it.

For example:

```
accelerate main run {until return}
```

behaves as if "Until return" is selected from the run menu

```
accelerate {Home}
```

behaves as if "home" were picked from the floating pop-up menu of the current window.

A.2.2 Break

This command prints a list of all breakpoints into the log window:

```
Break
```

This command sets a break point. See the section entitled "Breakpoints" on page 85 for details about breakpoint operation.

```
Break [|/Set|/Byte|/Word|/DWord|/Modify]
          <address> [ {<do_command>} [ { <condition> } [ <countdown> ]]]
```

This command deactivates a breakpoint:

```
Break/Deactivate <brkid>
```

This command enables a breakpoint:

```
Break/Activate <brkid>
```

This command clears a breakpoint:

```
Break/Clear <brkid>
```

This command toggles a breakpoint through the active/inactive/deleted states:

```
Break/Toggle <brkid>
```

This command turns on the resume option in the breakpoint:

```
Break/Resume <brkid>
```

This command turns off the resume option in the breakpoint:

```
Break/UnResume <brkid>
```

The Break options are:

/Set (default)	the breakpoint triggers when <address> is executed
/Byte	the breakpoint triggers when the byte at <address> is modified
/Word	the breakpoint triggers when the word at <address> is modified
/DWord	the breakpoint triggers when the double word at <address> is modified
/Modify	the breakpoint triggers when integer at <address> is modified
<condition>	an expression that must be true (non-zero value) before the breakpoint stops program execution

<countdown>
an integer. The breakpoint will not stop program execution until <countdown> is decremented to zero.

Note: If you specify both <condition> and <countdown>, <countdown> decrements only when <condition> evaluates to true.

<do_command>
a command that is executed each time the breakpoint stops program execution

<brkid> option can be three possible values:

<address>	Perform the operation on breakpoint with the given address.
*****	Perform the operation on all breakpoints.
#<integer>	Names a breakpoint by its index. This index can be discovered on the title line of the Breakpoint dialog.

Some examples of the break command and a description follow:

This command sets a breakpoint at "foo" the 20th time that i equals 10. When this occurs ’do j7’ is executed:

```
Break /Set foo {do j7} {i10} 20
```

This command clears the breakpoint at foo:

```
Break /Clear foo
```

This command activates breakpoint #1:

```
Break /Activate #1
```

This command deactivates all breakpoints:

```
Break /Deactivate *
```

A.2.3 Call

Use the Call command to call a routine. The Call command options are:

```
Call [/Far|/Interrupt|/Near]
         <address>
         [([<parm>[,<parm>[...]]])] [/|<printlist>]
```

This command calls the routine at <address> with parameters.

/Far Use a far call instruction.

/Near Use a near call instruction.

/Interrupt Call the routine as if it were an interrupt handler.

<parm> is [/<location>] <expr>

<location> is [/|<regset>]

/ means to put the parm on the stack.

/<regset> means to put the parm into the named registers.

<regset> is a register aggregate. See "Watcom Debugger Expression Handling" on page 141.

<printlist> See the print command for details.

Some examples of the Call command follow: This command calls the function foo:

```
call foo
```

This command calls the function bar passing the parameters 1, 2, and 3:

```
call bar( 1,2,3 )
```

This command calls foo putting 1 on the stack, 2 in AX and 3 in CX:BX printing out the value of AX and DX in decimal and hexadecimal respectively on return:

```
call /near foo( // 1, /ax 2, /[cx bx] 3 ) {%d %x} ax,dx
```

The Call command only uses very basic symbolic information - it’s designed that way so that it can work even when no symbolic information is available. This has a number of implications. The first is that the debugger pays no attention to any information on where parameters are stored. For example, in 32-bit applications, unless explictly instructed otherwise, the first parm is placed in EAX, the second in EDX, and so on (as defined by the "set call" command). That means that you have to do something like:

```
call foo( // &a, // 3 )
```

to get things on to the stack. This leads to a second, very important consideration.

The debugger has no idea of the memory model that the program is compiled in (recall that the 32-bit compiler does support large memory models and far pointers, even if we don’t supply versions of the libraries for it). That means that the debugger has no idea on whether the address of a symbol should be far or near. It always assumes far, since that never loses information. A far pointer would be truncated to a near pointer when moved into a 32-bit register like EAX but not so when pushed onto the stack. In this case, `// &a` and `// 3` cause 48-bit far pointers to be pushed onto the stack (they are actually pushed as 64 bits for alignment reasons). Thus the pointer to `b` is in the wrong place for the routine to access it (assuming it is expecting near pointers) and this will likely cause a task exception. To avoid this problem and properly pass arguments to the routine, you need to do the following:

```
call foo( // (void near *)&a, // (void near *)3 )
```

This forces the debugger to push near pointers onto the stack.

Similar considerations apply for the 16-bit case.

A.2.4 CAPture

Use the Capture command to execute a command and put the resulting program output into a window. The format of the command follows:

```
CAPture <command>
```

For example, this command calls a routine, foo, and puts its output into a debugger window.

```
capture call foo
```

A.2.5 COnfigfile

```
COnfigfile
```

Used by the debugger to save and restore the configuration. When "configfile" appears in a command file, it identifies that file as the default configuration file. The debugger will overwrite the command file when autosaving the current configuration. Also, the name of this file is displayed in the filename field when the "Save Setup" dialog initially appears.

If more than one file is encountered containing the "configfile" command, the last one seen is used to establish the configuration file name.

A.2.6 Display

The display command allows you to open any window. The general Display command is:

```
Display <wndname> [/Open|/Close|/New|/MInimize|/MAximize|/Restore]
[<ord>,<ord>,<ord>,<ord>]
```

This command causes the debugger screen to repaint:

```
Display
```

This command displays the toolbar as either fixed (default) or floating:

```
Display TOolbar [/Open] [/FLoating/Fixed] [<ord>]
```

This command closes the toolbar:

```
Display TOolbar [/Close]
```

This command opens the status line:

```
Display Status [/Open]
```

This command closes the status line:

```
Display Status /Close
```

This command brings a window to the front:

```
Display <wndname>
```

The options for the Display command follow:

<ord>	The height to be used for toolbar buttons.
<ord>,<ord>,<ord>,<ord>	These are the x and y coordinates of the top left corner, and the width and the height of the window respectively. 0,0,10000,10000 is a window covering the entire screen.
/Open	Open a new window or resize an existing one.
/New	Open a new window regardless of an existing one.
/Close	Close the window.
/MInimize	Iconize the window.
/MAximize	Make the window full screen size.
/REstore	Restore a window from a minimize or maximize.

Some examples of the display command follow: This command opens a register window in the top left quarter of the screen:

```
display register /open 0,0,5000,5000
```

This command minimizes the source window if it is open:

```
display source /minimize
```

A.2.7 DO (or /)

Use the DO command to evaluate an arbitrary C/C++ or FORTRAN expression. The format of the command is:

```
DO <expr>
```

For example:

```
DO i = 10
```

A.2.8 ERror

Use the Error command to display a string as an error message. The format of the command is:

```
ERror <string>
```

For example:

```
error {An error has been detected}
```

A.2.9 Examine

Use the Examine command to examine memory at a specific address.

```
Examine [/<type>] [<address>] [,<follow> [,<len>]]
```

where "<type>" is one of

```
Byte
Word
Dword
Qword
Char
Short
Long
__int64
Unsigned_Char
Unsigned_Short
Unsigned_Long
Unsigned___int64
0:16_Pointer
16:16_Pointer
0:32_Pointer
16:32_Pointer
Float
Double
Extended_Float
```

To show an assembly window at a specific address:

```
Examine /Assembly [<address>]
```

To show a source window at a specific address

```
Examine /Source [<address>]
```

To add an address to the I/O window as a byte, word, or dword:

```
Examine [/IOByte|/IOWord|/IODword] [<address>]
```

The options for the Examine command follow:

/<type> where "<type>" is one of `Byte`, `Word`, `Dword`, `Qword`, `Char`, `Short`, `Long`, `__int64`, `Unsigned_Char`, `Unsigned_Short`, `Unsigned_Long`, `Unsigned___int64`, `0:16_Pointer`, `16:16_Pointer`, `0:32_Pointer`, `16:32_Pointer`, `Float`, `Double`, or `Extended_Float.` Set the initial display type of the memory window.

/IOByte /IOWord /IODword
Set the initial display type of the line in the I/O window.

<address> the address to examine.

<follow> an expression which will be used if the memory window’s Repeat function is chosen.

<len>	an integer expression indicating the length of memory to examine.

For example, this command opens a memory window positioned at the address of "foo". The initial display type will be 2 byte words. If the ***Repeat*** menu item is used, it will follow a near pointer 4 bytes past the beginning of the window *(.+$). The window will display 16 bytes of data at a time:

```
examine /word foo,*(.+4),16
```

A.2.10 Flip

Use the Flip command to configure screen flipping. See the section entitled "The Options Dialog" on page 36 for details

```
Flip ON
Flip OFf
```

A.2.11 FOnt

Use the Font command to set the font for the specified window. The command is:

```
FOnt <wndname> <fontinfo>
```

<wndname>	the name of the affected window
<fontinfo>	operating system specific font data.

A.2.12 Go

Use the Go command to start or continue program execution. Execution then resumes at the specified address or at the location defined by the current contents of the CS:IP or CS:EIP register pair. The format of the Go command is:

```
Go [/Until] [/Keep] [/Noflip] [[<start>,]<stop>]
```

The options are:

/Until	skips breakpoints until the specified stop address is reached.
/Keep	allows you to keep a previous temporary breakpoint. If you keep the previous breakpoint you cannot create a new one.

/Noflip	keeps the debugger from flipping to the application’s screen.
<start>	the <address> at which to start execution (optional).
<stop>	the <address> at which to stop execution.

Some examples of the Go command are:

This command will resume execution until function "foo" is executed without flipping to the application screen:

```
go /noflip foo
```

This command starts execution at "foo" and runs until "bar" is executed.

```
go foo,bar
```

A.2.13 Help

Bring up the help screen:

```
Help
```

A.2.14 HOok

Use the Hook command to execute a command when a defined event occurs. The format of the Hook command is:

```
HOok <event> <command>
```

<event> can be any of the following:

PROGStart	a program is loaded
PROGEnd	a program terminates
DLLStart	a DLL is loaded
DLLEnd	a DLL is unloaded
EXECStart	program execution is beginning
EXECEnd	program execution is stopped

Sourceinfo the current location being examined has debugging information

Assemblyinfo
the current location being examined has no debugging information

Modulechange
the current location being examined has changed modules

This example causes the locals and source window to come to the front whenever a region with symbolic debugging information is entered:

```
hook sourceinfo {display locals; display source}
```

A.2.15 IF

Use the If command to evaluate an expression and then, depending on the results, execute a list of commands. The format of the If command is:

```
IF <expr> { <command> }
[ ELSEIF <expr> { <command> } [ ELSEIF <expr> { <command> } [...]]]
[ELSE { <command> }]
```

If the expression results in a non-zero value, the list of debugger commands contained after the IF expression are executed. Otherwise, the list of commands that appear after the ELSEIF expression are executed.

A.2.16 INvoke (or <)

Use the Invoke command to invoke a file containing a number of debugger commands. The format of the Invoke command is:

```
INvoke <file> [<string> [<string> [...]]]
<      <file> [<string> [<string> [...]]]
```

<file> is the name of the command file to invoke.

<string> will be passed as a parameter. These parameters may be referenced in the command file as <1>, <2>, etc.

A.2.17 Log (or >)

Use the Log command to send the Dialog window output to a specified file. The following commands start logging to a file:

```
Log        <file>
Log /Start <file>
>          <file>
```

The following commands start appending log information to a file.

```
Log >       <file>
>>          <file>
Log /Append <file>
```

The following commands stop logging:

```
Log
>
```

A.2.18 MOdify

Use the Modify command to change memory at an address to the values specified by the list of expressions.

```
MOdify [/Byte|/Pointer|/Word|/Dword|/IOByte|/IOWord|/IODword]
<address>[,<expr>[...]]
```

The options for the modify command are:

/Byte /Pointer /Word /Dword Control the size of memory to be modified.

/IOByte /IOWord /IODword Control the size of the I/O port to be modified.

<address>	The address to modify.
<expr>	The values to be placed in memory.

This command changes the 3 bytes at location "foo" to the values 1, 2 and 3:

```
modify /byte foo 1,2,3
```

This command changes the 4 bytes at location "foo" to the value 12345678 hex:

```
modify /dword foo 0x12345678
```

A.2.19 NEW

Use the New command to initialize various items. The format of the New command is:

```
NEW [<args>]
NEW /Program [[:<symfile>] <progfile> [<args>]]
NEW /Restart [<args>]
NEW /STDIn <file>
NEW /STDOut <file>
NEW /SYmbol <file> [seg [,seg [...]]
```

<symfile>	represents a file containing the symbolic information.
<progfile>	represents the executable file.
<args>	represent the arguments to be passed to the program.
/Restart	Reload the current application and place it into an initial state so that you may begin execution again. The application may have already partially or completely executed.
/STDIn	associate the standard input file handle with a particular file or device.
/STDOut	associate the standard output file handle with a particular file or device.
/Symbol	load additional symbolic debugging information and specify the mapping between the linker addresses and the actual execution addresses.

A.2.20 PAint

Use the Paint command to define window or dialog colours. To define the colour for windows, use the following command:

```
PAint [Status|<wndname>] <wndattr> <color> ON <color>
```

To define the colour for dialogs in the character-based version of the debugger, use the following command:

```
PAint DIalog <dlgattr> <color> ON <color>
```

The paint options are as follows:

<wndattr> allows you to define the window attributes. You can choose from the following items:

MEnu Plain menu text (character-based)

MEnu STandout menu accelerator key (character-based)

MEnu Disabled grayed menu item (character-based)

MEnu Active menu item under the cursor (character-based)

MEnu Active STandout menu accelerator key under the cursor (character-based)

MEnu Frame frame of the menu (character-based)

MEnu Disabled Active grayed menu item under the cursor (character-based)

TItle Disabled a non active window's title

Frame Active the frame of the active window (character-based)

Frame Disabled the frame an inactive window (character-based)

ICon	an icon
Plain	normal text within a window
Active	window text under the cursor
SElected	window text being selected
STandout	window text the debugger wishes to highlight

Active STandout window text the debugger wishes to highlight under the cursor

BUtton the gadgets on the left side of a window (character-based)

<dlgattr> option allows you to define the dialog attributes. The possible options are:

Plain	normal text
Frame	the dialog frame
SHadow	the shadow of a button
BUtton Plain	normal button text
BUtton STandout	button accelerator key character
BUtton Active	a button which has focus
BUtton Active STandout	button accelerator key character of a button with focus

<color> You can choose from the following colours:

- BLAck
- BLUe
- GREEn
- Cyan
- Red
- MAgenta
- BROwn
- White
- GREY
- GRAy
- BRIght BLUe
- BRIght GREEn
- BRIght Cyan
- BRIght Red

- BRIght MAgenta
- Yellow
- BRIght BROwn
- BRIght White

Some examples of the paint command follow:

```
paint all plain black on white
paints plain text black on white in all windows.
paint dialog button standout bright green on yellow
```

A.2.21 Print (or ?)

Use the Print command to prompt for an expression and then print it to the log window. Use this command to examine the values of variables and expressions. The Print command is:

```
Print [/Window|/Program] [<printlist>]
```

/Window open up a watch window containing the listed expressions.

/Program print the results to the application's screen.

<printlist> is [<format>] [<expr> [,<expr> [...]]]

<format> is a printf like format string. It consists of plain text intermixed with control sequences, which will be substituted with values from the expression list. The control sequences are:

%i The corresponding argument is printed out as a signed decimal integer value.

%d The corresponding argument is printed out as a signed decimal integer value.

%u The corresponding argument is printed out as an unsigned decimal integer value.

%x The corresponding argument is printed out as an unsigned hexadecimal integer value. Letter digits are printed in lower case (a-f).

%X	The corresponding argument is printed out as an unsigned hexadecimal integer value. Letter digits are printed in upper case (A-F).
%o	The corresponding argument is printed out as an unsigned octal integer value.
%p	The corresponding argument is printed out as a pointer (segment:offset) value in hexadecimal notation.
%c	The corresponding argument is printed out as a single character value.
%s	The corresponding argument is printed out as a C/C++ string value. The argument must point to a string of characters terminated by a byte whose value is zero.
%%	To print out a percentage symbol, the "%" must be doubled up (i.e., %%).
%f	The corresponding argument is printed out in floating-point representation. If the floating-point value has a very large or small magnitude, you should use one of "g", "G", "e" or "E" formatting.
%g	The corresponding argument is printed out in floating-point representation. Numbers of very large or small magnitude are printed out in scientific "E" notation (e.g., 1.54352e+16). The exponent letter is printed in lower case.
%G	The corresponding argument is printed out in floating-point representation. Numbers of very large or small magnitude are printed out in scientific "E" notation (e.g., 1.54352E+16). The exponent letter is printed in upper case.
%e	The corresponding argument is printed out in scientific "E" notation (e.g., 1.23456e+02). The exponent letter is printed in lower case.
%E	The corresponding argument is printed out in scientific "E" notation (e.g., 1.23456E+02). The exponent letter is printed in upper case.
%r	The corresponding argument is printed out in the current default numeric radix.

%a	The corresponding argument is printed out as a symbol reference (symbol_name+offset) when possible; otherwise it is printed out as a pointer (segment:offset) value in hexadecimal notation.
%l	The corresponding argument is printed out as a line number reference (module_name@line_number+offset) when possible; otherwise it is printed out as a pointer (segment:offset) value in hexadecimal notation.

Some examples of the print command follow. This command prints the value of "i":

```
? i
```

This command prints "decimal=100 hex=0x64":

```
print {decimal=%d hex=%x} 100,100
```

A.2.22 Quit

Use the Quit command to leave the debugger.

A.2.23 RECord

Use the Record command to add a command to the replay window. This command is for internal use only. The format of the command is:

```
REcord<expr> <command>
```

A.2.24 Register

The format of the Register command is:

```
Register <intexpr>
```

If intexpr is negative, this is equivalent to using the menu item Undo/Undo -<intexpr> times. If intexpr is positive, this is equivalent to using the menu item Undo/Redo <intexpr> times.

A.2.25 REMark (or *)

Use the Remark command to enter lines of comments. The format of the command is:

```
REMark <string>
```

A.2.26 Set

These commands are used internally by the debugger to save and restore the configuration. The syntax is:

```
Set AUtosave [ON|OFf]
Set ASsembly [Lower|Upper] [Outside|Inside] [Source|NOSource]
[Hexadecimal|Decimal]
Set Variable [Entire|Partial] [CODe|NOCODe] [INherit|NOINherit]
[COMpiler|NOCOMpiler] [PRIvate|NOPRIvate] [PROtected|NOPROTected]
[Members|NOMembers]
Set FUnctions [Typed|All]
Set GLobals [Typed|All]
Set REGister [Hexadecimal|Decimal] [Extended|Normal]
Set Fpu [Hexadecimal|Decimal]
Set Bell [ON|OFf]
Set Call [/Far|/Interrupt|/Near] [ ( [<location> [,<location> [...]]] ) ]
Set Dclick <expr>
Set Implicit [ON|OFf]
Set INput <wndname>
Set Radix <expr>
Set RECursion [ON|OFf]
Set SEarch [CASEIgnore|CASERespect] [Rx|NORx] <string>
Set SOurce [/Add] [<path> [<path>] [...]]]
Set SYmbol [/Add|/Ignore|/Respect] [<lookspec> [<lookspec> [...]]]
Set Tab <intexpr>
Set Level [Assembly|Mixed|Source]
Set LAnguage [CPP|C|FORTRAN]
Set SUpportroutine <string>
Set MAcro <wndname> <key> <command>
```

<location> see call command.

<lookspec> [/Ignore|/Respect] <string>

A.2.27 SHow

The Show commands are used internally by the debugger to save and restore its configuration. The syntax is:

```
SHow Paint
SHow Display
SHow Font
SHow Set
SHow Set AUtosave
SHow Set ASsembly
SHow Set Variable
SHow Set FUnctions
SHow Set GLobals
SHow Set REGister
SHow Set Fpu
SHow Set Bell
SHow Set Call
SHow Set Dclick
SHow Set Implicit
SHow Set INput
SHow Set Radix
SHow Set RECursion
SHow Set SEarch
SHow Set SOurce
SHow Set SYmbol
SHow Set Tab
SHow Set Level
SHow Set LAnguage
SHow Set MAcro
SHow Set SUpportroutine
SHow Flip
SHow Hook
```

A.2.28 SKip

Use the Skip command to set CS:EIP to a specific address. The format of the command is:

```
SKip <address>
```

A.2.29 STackpos <intexpr>

The Stackpos command is the same as using Undo/Unwind. The <intexpr> allows you to define the number of times to undo or unwind.

A.2.30 SYstem (or !)

Use the System command to spawn an operating shell to execute a given string. The format of the system command is:

```
SYstem [/Remote|/Local] <string>
```

/Remote	the shell is started on the program side of a remote debug link.
/Local	the shell is started on the debugger side of a remote debug link.

A.2.31 THread (or ~)

Use the Thread command to manipulate the threads of execution of a multi-threaded application under OS/2 or NetWare 386. The format of the Thread command is:

```
THread [/Show|/Freeze|/Thaw|/Change] [<threadid>]
```

/Show	display the status of the current thread.
/Freeze	freeze a thread and make it unrunnable.
/Thaw	make a frozen thread runnable.
/Change	to select a specific thread.
<threadid>	is the identification number of the thread.

A.2.32 Trace

Use the Trace command to step through the execution of your program. The Trace command is:

```
Trace [/Assembly|/Mixed|/Source] [/Into|/Next|/Over]
```

/Assembly	trace through your assembly code on instruction at a time.
/Mixed	trace execution of the application one source statement at a time, or one instruction at a time when no source text is available.
/Source	trace execution of the application one source statement at a time.
/Into	continue execution to the next statement or assembly instruction. If the current statement or instruction invokes a routine, then the next statement or instruction is the first one called in the routing.
/Next	continue execution to the next statement or assembly instruction that immediately follows the current statement or instruction in memory. If the current statement or instruction is one that branches, be sure that the execution

path eventually executed the statement or instruction that follows. If the program does not executed this point, the program may execute to completion.

/Over continue execution to the next statement or assembly instruction. If the current statement or instruction invokes a routine, then the next statement or instruction is the one that follows the invocation of the routine.

A.2.33 Undo

The format of the Undo command is:

```
Undo <intexpr>
```

If intexpr is positive, this is equivalent to using the menu item Undo/Undo <intexpr> times. If intexpr is negative, this is equivalent to using the menu item Undo/Redo -<intexpr> times.

A.2.34 View

Use the View command to show a file in a window. The format of the command is:

```
View [/Binary] [<file>|<module>]
```

/Binary show the file contents in binary.

<file> the file to be shown.

<module> the module to be shown. The default is the current module.

A.2.35 While

Use the While command to permit the execution of a list of commands while the specified expression is true. The While command is:

```
While <expr> { <command> }
```

A.2.36 WIndow

This command operates on the current window. It is useful when defining accelerators that perform window operations.

WIndow CLose
close the window

WIndow CURSORStart
move the cursor to start of line

WIndow CURSOREnd
move the cursor to end of line

WIndow CURSORDown
move the cursor down one line

WIndow CURSORLeft
move the cursor left

WIndow CURSORRight
move the cursor right

WIndow CURSORUp
move up one line

WIndow Dump
dump the window to a file

WIndow Log
dump the window to a log window

WIndow FINDNext
find the next occurrence of the current search string

WIndow FINDPrev
find the previous occurrence of the current search string

WIndow Next
make another window the current window

WIndow PAGEDown
move the window down one page

WIndow PAGEUp
move the window up one page

WIndow POpup
show the window’s floating pop-up menu

WIndow SEarch
search for a given string

WIndow SCROLLDown
scroll the window down one line

WIndow SCROLLUp
scroll the window up one line

WIndow SCROLLTop
scroll the window to the very top

WIndow SCROLLBottom
scroll the window to the very bottom

WIndow TABLeft
move to the previous tabstop

WIndow TABRight
move to the next tabstop

WIndow MAXimize
maximize the window

WIndow MINimize
minimize the window

WIndow REStore
restore the window

WIndow TIle
tile all windows

WIndow CAscade
cascade all windows

WIndow PRevious
move to the previous window

B. Predefined Symbols

The Watcom Debugger defines a number of symbols which have special meaning. Each of the registers is designated by a special name.

eax	32-bit EAX register (32-bit mode only)
ax	16-bit AX register
al	8-bit AL register
ah	8-bit AH register
ebx	32-bit EBX register (32-bit mode only)
bx	16-bit BX register
bl	8-bit BL register
bh	8-bit BH register
ecx	32-bit ECX register (32-bit mode only)
cx	16-bit CX register
cl	8-bit CL register
ch	8-bit CH register
edx	32-bit EDX register (32-bit mode only)
dx	16-bit DX register
dl	8-bit DL register
dh	8-bit DH register
eip	Instruction pointer register (32-bit mode only)
ip	Instruction pointer register
esi	Source index register (32-bit mode only)
si	Source index register
edi	Destination index register (32-bit mode only)
di	Destination index register
esp	Stack pointer register (32-bit mode only)
sp	Stack pointer register
ebp	Base pointer register (32-bit mode only)
bp	Base pointer register
cs	Code segment register
ds	Data segment register
es	Extra segment register
fs	Segment register (32-bit mode only)

gs	Segment register (32-bit mode only)
ss	Stack segment register
fl	Flags register
efl	Flags register (32-bit mode only)

fl.flg_bit_name Individual bits in Flags register

flg_bit_name ::= "c" | "p" | "a" | "z" | "s" | "i" | "d" | "o"

efl.flg_bit_name Individual bits in Flags register

flg_bit_name ::= "c" | "p" | "a" | "z" | "s" | "i" | "d" | "o"

The following table lists the full name for each of the flags register bits:

fl.o, efl.o	overflow flag
fl.d, efl.d	direction flag
fl.i, efl.i	interrupt flag
fl.s, efl.s	sign flag
fl.z, efl.z	zero flag
fl.a, efl.a	auxiliary carry flag
fl.p, efl.p	parity flag
fl.c, efl.c	carry flag

st0 - st7	Numeric Data Processor registers (math coprocessor registers)
cw	8087 control word (math coprocessor control word)

cw.cw_bit_name Individual bits in the control word

cw_bit_name ::= "ic" | "rc" | "pc" | "iem" | "pm" |
"um" | "om" | "zm" | "dm" | "im"

The following table lists the full name for each of the control word bits:

cw.ic infinity control

0 = projective
1 = affine

cw.rc rounding control (2 bits)

00 = round to nearest or even
01 = round down (towards negative infinity)
10 = round up (towards positive infinity)
11 = chop (truncate toward zero)

cw.pc	precision control (2 bits) 00 = 24 bits 01 = reserved 10 = 53 bits 11 = 64 bits
cw.iem	interrupt enable mask (8087 only) 0 = interrupts enabled 1 = interrupts disabled (masked)
cw.pm	precision (inexact result) mask
cw.um	underflow mask
cw.om	overflow mask
cw.zm	zero-divide mask
cw.dm	denormalized operand mask
cw.im	invalid operand mask

sw 8087 status word (math coprocessor status word)
sw.sw_bit_name Individual bits in the status word

sw_bit_name ::= "b" | "c3" | "st" | "c2" | "c1" |
"c0" | "es" | "sf" | "pe" | "ue" |
"oe" | "ze" | "de" | "ie"

The following table lists the full name for each of the status word bits:

sw.b	busy
sw.c3	condition code bit 3
sw.st	stack stop pointer (3 bits) 000 = register 0 is stack top 001 = register 1 is stack top 010 = register 2 is stack top . . . 111 = register 7 is stack top
sw.c2	condition code bit 2
sw.c1	condition code bit 1

sw.c0	condition code bit 0
sw.es	error summary (287, 387 only)
sw.sf	stack fault (387 only)
sw.pe	precision (inexact result) exception
sw.ue	underflow exception
sw.oe	overflow exception
sw.ze	zero-divide exception
sw.de	denormalized operand exception
sw.ie	invalid operation exception

The debugger permits the manipulation of register contents using any of the operators described in the following chapter. By default, these predefined names are accessed just like any other variables defined by the user or the application. Should the situation ever arise where the application defines a variable whose name conflicts with that of one of these debugger variables, the module specifier `_dbg` may be used to resolve the ambiguity. For example, if the application defines a variable called `cs` then `_dbg@cs` can be specified to resolve the ambiguity. The "_dbg@" prefix indicates that we are referring to a debugger defined symbol rather than an application defined symbol.

The flags register, the 8087 control word, and the 8087 status word can be accessed as a whole or by its component status bits.

Example:
```
    /fl.c=0
    /cw.um=0
    ?sw.oe
```

In the above example, the "carry" flag is cleared, the 8087 underflow mask of the control word is cleared, and the 8087 overflow exception bit of the status word is printed.

The low order bit of the expression result is used to set or clear the specified flag.

Example:
```
    fl.c=0x03a6
```

In the above example, the "carry" flag is cleared since the low order bit of the result is 0.

The debugger also defines some other special names.

dbg$32	This debugger symbol represents the mode in which the processor is running.

0	16-bit mode
1	32-bit mode

dbg$bp This debugger symbol represents the register pair SS:BP (16-bit mode) or SS:EBP (32-bit mode).

Example:
```
    ? dbg$bp
```

dbg$code This debugger symbol represents the current code location under examination. The dot address "." is either set to dbg$code or dbg$data, depending on whether you were last looking at code or data.

dbg$cpu This debugger symbol represents the type of central processing unit which is in your personal computer system.

0	Intel 8088, 8086 or compatible processor
1	Intel 80188, 80186 or compatible processor
2	Intel 80286 or compatible processor
3	Intel 80386 or compatible processor
4	Intel 80486 or compatible processor
5	Intel Pentium processor

dbg$ctid This debugger symbol represents the identification number of the current execution thread. Under DOS and QNX, the current thread ID is always 1. The current execution thread can be selected using the Thread window or the Thread command.

dbg$data This debugger symbol represents the current data location under examination. The dot address "." is either set to dbg$code or dbg$data, depending on whether you were last looking at code or data.

dbg$etid This debugger symbol represents the identification number of the thread that was executing when the debugger was entered. Under DOS and QNX, the executing thread ID is always 1.

dbg$fpu This debugger symbol represents the type of numeric data processor (math coprocessor) that is installed in your personal computer system.

-1	An 80x87 emulator is installed
0	No coprocessor is installed
1	An Intel 8087 is installed
2	An Intel 80287 is installed
3	An Intel 80387 is installed
4	An Intel 80486 processor, supporting coprocessor instructions, is installed
5	An Intel Pentium processor, supporting coprocessor instructions, is installed

dbg$ip This debugger symbol represents the register pair CS:IP (16-bit mode) or CS:EIP (32-bit mode).

Example:
```
    ? dbg$ip
```

dbg$monitor This debugger symbol represents the type of monitor adapter which is in use.

0	IBM Monochrome Adapter
1	IBM Colour Graphics Adapter (CGA)
2	IBM Enhanced Graphics Adapter (EGA)
3	IBM Video Graphics Array (VGA)

dbg$os This debugger symbol represents the operating system that is currently running the application.

1	DOS
2	OS/2
3	386|DOS-Extender from Phar Lap Software, Inc.
5	NetWare 386 from Novell, Inc.
6	QNX from QNX Software Systems Ltd.
7	DOS/4GW from Tenberry Software, Inc. (included in the Watcom C/C++^{32} and Watcom FORTRAN 77^{32} packages)
8	Windows 3.x from Microsoft Corporation
10	Windows NT or Windows 95 from Microsoft Corporation
11	AutoCAD from Autodesk, Inc.

dbg$pid (OS/2, NetWare 386, QNX, Windows NT, Windows 95 only) This debugger symbol contains the process identification value for the program being debugged.

dbg$psp (DOS only) This debugger symbol contains the segment value for the DOS "program segment prefix" of the program being debugged.

dbg$radix	This debugger symbol represents the current default numeric radix.
dbg$remote	This debugger symbol is 1 if the "REMotefiles" option was specified and 0 otherwise.
dbg$sp	This debugger symbol represents the register pair SS:SP (16-bit mode) or SS:ESP (32-bit mode). *Example:* `? dbg$sp`
dbg$loaded	This debugger symbol is 1 if a program is loaded. Otherwise, it is 0.
dbg$nil	This debugger symbol is the null pointer value.
dbg$src	This debugger symbol is 1 if you are currently debugging in an area that contains debugging information.

C. Wiring For Remote Debugging

This appendix describes both serial and parallel port cable wiring for remote debugging.

C.1 Serial Port Wiring Considerations

If you plan to use the serial port Debug Server "SERSERV", a cable must connect the serial ports of the two computer systems. The following diagram illustrates the wiring between the two serial ports. If your computer systems have more than one serial port, any serial port may be used.

```
    Task Machine          Debugger Machine
      Serial                Serial
     Connector               Connector

     Pin #              Pin #
         1 (PG) <---------->1 (PG)

         2 (TxD)<---------->3 (RxD)

         3 (RxD)<---------->2 (TxD)

 ------- 4 (RTS)            4 (RTS) -------
|                                          |
 ------> 5 (CTS)            5 (CTS) <------

 ------> 6 (DSR)            6 (DSR) <------
|                                          |
|        7 (SG) <---------->7 (SG)         |
|                                          |
|------> 8 (DCD)            8 (DCD) <------|
|                                          |
 ------ 20 (DTR)           20 (DTR) -------
```

Figure 25. *Serial Port Wiring Scheme*

Note that the wiring is symmetrical (i.e., either end of the cable can be plugged into either PC). This particular arrangement of the wiring is sometimes called a "null modem" (since pins 2 and 3 are crossed and no modem is involved).

C.2 Parallel Port Wiring Considerations

If you plan to use the parallel port Debug Server "PARSERV" or "PARSERVW", a cable must connect the parallel ports of the two computer systems. Three cabling methods are supported - the LapLink cable, the Flying Dutchman cable, and WATCOM’s own design. There are two advantages to using the LapLink or Flying Dutchman cable:

1. They are commercially available (you may already own one).

2. They may work with more PC "compatibles" than WATCOM’s cable. WATCOM’s cabling requires 8 bi-directional data lines in the parallel port and some PC "compatibles" do not support this.

The disadvantage with the LapLink and Flying Dutchman cables is that they are slower than WATCOM’s cable since only 4 bits are transmitted in parallel versus 8 bits for WATCOM’s. Thus WATCOM’s cable is faster but it will have to be custom made.

The LapLink cable is available from:

Travelling Software, Inc.
18702 North Creek Parkway
Bothell, Washington,
U.S.A. 98011
Telephone: (206) 483-8088

The Flying Dutchman cable is available from:

Cyco,
Adm. Banckertweg 2a,
2315 SR Leiden,
The Netherlands.

The following diagram illustrates WATCOM’s cable wiring between the two parallel ports.

```
   Task Machine       Debugger Machine
Parallel Connector   Parallel Connector

     Pin Number         Pin Number
         1 <--------------> 2
         2 <--------------> 1
         3 <--------------> 14
         4 <--------------> 16
         5 <--------------> 15
         6 <--------------> 13
         7 <--------------> 12
         8 <--------------> 10
         9 <--------------> 11
        10 <--------------> 8
        11 <--------------> 9
        12 <--------------> 7
        13 <--------------> 6
        14 <--------------> 3
        15 <--------------> 5
        16 <--------------> 4
        17 <--------------> 17
        18 <--------------> 18
```

Figure 26. *WATCOM Cable Wiring Scheme*

The following diagram illustrates the LapLink cable wiring between the two parallel ports.

```
   Task Machine       Debugger Machine
Parallel Connector   Parallel Connector

     Pin Number         Pin Number
         2  --------------> 15
         3  --------------> 13
         4  --------------> 12
         5  --------------> 10
         6  --------------> 11
        10 <--------------   5
        11 <--------------   6
        12 <--------------   4
        13 <--------------   3
        15 <--------------   2
        25 <--------------> 25
```

Figure 27. *LapLink Cable Wiring Scheme*

The following diagram illustrates the Flying Dutchman cable wiring between the two parallel ports.

```
   Task Machine       Debugger Machine
Parallel Connector   Parallel Connector

     Pin Number         Pin Number
         1  --------------> 11
         2  --------------> 15
         3  --------------> 13
         4  --------------> 12
         5  --------------> 10
        10 <--------------   5
        11 <--------------   1
        12 <--------------   4
        13 <--------------   3
        15 <--------------   2
```

Figure 28. *Flying Dutchman Cable Wiring Scheme*

For the IBM PC and PS/2, the connectors are standard "male" DB-25 connectors. Note that, in all cases, the wiring is symmetrical (i.e., either end of the cable can be plugged into either PC).

Note: Although the wiring is different for all three cables, WATCOM’s parallel communications software can determine which one is in use.