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QSS™ Precision Software Tools
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A reference manual for The ACTION! System

A complete programming environment designed for your Atari home computer system.

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This manual was written in August, 1983

This version of the manual was done with the permission of the copyright owner, Clinton Parker.
It was edited by James Patchell in June 2012.

All efforts were made by the editor to make certain that this is an accurate version of the original, however, it was made by doing an OCR on the original manual, and then editing the resulting text in Microsoft Word.

It is possible that many of the errors that were created by the OCR process were missed.
On the other hand, I managed to correct some of the errors that were in the original manual. It took me several months to complete this task, but it was done mostly to preserve what I consider to be one of the most impressive programs that came out in the early days of computing.

ACTION!, was, without any doubt on my part, the best compiler that was ever written for the 6502, as it was tailored to what that processor was capable of doing.

Preface by the Editor

This was a work of love for me. I bought the ACTION! Compiler when it first came out, however, it was about a year before I actually used it. And when I did use it, I was sorry I had waited.

My first foray into High Level Programming Languages on the Atari Computer was FORTH. I know for some that what I am about to say is heresy, but I was just never able to get the hang of it. This is probably more likely due to my lack of exposure to structured programming.

I did not have that problem with ACTION!. ACTION! Was the very first structured language I had ever used. Up to that point, BASIC and FORTRAN were the only high level languages I used, but if I was serious about the code, I used assembly. ACTIOON! gave me enough of a leg up that when I got a job that required I program in PL/M, I was right at home.

I do not know Clinton Parker, and I wish I did. I have been in contact with him and he was gracious enough to allow me to publish this document. The main reason I did this transcription was because I had always wanted to write a compiler, and ACTION! was the first one I attempted to duplicate. At that time, I did not have at my disposal the software tools that make doing such a job a lot easier. When I became disabled due to blindness, I decided I would do my darnedest to accomplish that task. Hence, this transcription. It, along with the ZoomText screen reader allow me to read this document.

Jim Patchell
August 17, 2012

Part I Introduction to ACTION!

Welcome to ACTION! We're here to introduce you to a complete software development system - one in which you can perform all of your programming tasks.

If you have programmed your Atari using Atari BASIC,

you will discover that ACTION! runs a lot faster, has a better editor, and is just as easy to learn.

If you have ever done assembly language programming, you will find that ACTION! is almost as fast as assembly language, as far as program execution is concerned. You will also find that programming ACTION! is much quicker and easier due to the nature of the language, its editor, and its library of routines.

For those of you with very little or no previous programming experience, we suggest that you read this manual very carefully, and be sure you understand one concept before moving on to the next. We say this because this is not a tutorial to teach you the ACTION! system, but rather a reference manual of all the capabilities of the system.

That is not to say that you won't understand what you're reading (quite the contrary); it simply means that we don't discuss every possible programming use of the concepts involved. We respect your ingenuity and curiosity and believe that you yourself will find some uses we haven't even dreamt of.

Notes On This Manual

The manual itself is separated into six parts and a group of appendices. Each of the parts exclusively discusses one facet of the ACTION! system, thus enabling you to learn about the different components of ACTION! without having to keep flipping pages. Each part is prefaced by a table of contents, an introduction, and a vocabulary.

The one drawback to separating the ACTION! system into its component parts is that you will learn everything about one part before starting the next part. To help alleviate this problem we suggest that you read the introduction section of each of the parts before reading one part in depth. Also, the last chapter of this introduction shows you how the ACTION! components work together to allow you to run programs.

The ACTION! system is made up of five different parts:

The ACTION! Monitor

The ACTION! Editor

The ACTION! Language

The ACTION! Compiler

The ACTION! Library

The Monitor is the boss of the ACTION! system. Through it you can call the Editor, the Compiler, or get access to some system options. This is the monitor's only job, but it is a important one, allowing you to decide which part of the ACTION! system you want to use at any given time.

The Editor is where you create new programs and modify old ones. It doesn't know anything about the ACTION! language or compiler (that is, it's simply a text editor and doesn't check language syntax), so you can use it for other word processing or program entry applications. The Editor also allows you to save the text in the editor buffer or read text from a peripheral device (disk drive, cassette, et) into the editor buffer.

The ACTION! Language is what you use to communicate with the ATARI machine and tell it to do things- You write a program in the ACTION! Language, and then tell the ACTION! Compiler to translate it into a form the computer can understand (machine language), and then you run the program.

"Why is this such an involved process? BASIC isn't like that."' First of all, the process isn't that involved once you understand what's going on and why. Secondly, BASIC isn't like that because it is an Interpreter, not a Compiler. BASIC translates each line as the program is running, and it takes some time to do that, thereby slowing down the speed of your program* ACTION!, on the other hand, breaks the running and syntax checking of your program into two parts* The Compiler checks your program for proper syntax, and does the translating* When it is through, your program can be run directly, i.e-, without any syntax checking. This makes your program run with incredible speed.

As mentioned in the previous paragraphs:, the ACTION! Compiler translates an ACTION! program into machine code. The only thing it requires is that the program be in proper ACTION! form. The compiler will give you an error if you use syntax which is illegal in the ACTION! Language just like an English teacher would give you an error (Or red mark) if you used improper English in class.

The ACTION! system also contains a group of prewritten routines which you can use in your programs. This group of routines is called the ACTION! Library, and it enables you to do all the things you can do in BASIC (i.e. , PLOT, DRAWTO, PRINT, etc.) and much more without writing any special subroutines of your own.

> **TECHNICAL NOTE: although the ACTION! compiler does translate an ACTION! program to 6502 machine language, that compiled code will not run without the ACTION! cartridge because it (the code) does some calls to routines in the cartridge. If you are writing products for resale, a runtime version of ACTION! which will make your program work without the cartridge can be licensed from OSS Inc.**

This chapter is designed to let you "get your feet wet" and become more familiar with the ACTION! System. We're going to write a little program in the Editor, Compile that program, and Run it.

When you go to the cartridge from DOS you will be in the ACTION! Editor, so the program can be entered immediately. We're going to assume that you won't make any typos, but if you do, you can use the cursor control keys (<CTRL><up arrow>, etc.) to move around and fix them. When you read the Editor part you will find out about many more editor features and commands, but these are all you need for this program.

Now let's look at the program. Enter it exactly as you see it here (no special commands are required to enter text):

```
PROC hello()
  PrintE("Hello World!")
RETURN
```

Before we compile this program, let's discuss what's going on. The 'PROC' and ' RETURN' statements are required by the ACTION! language, and make up the bones of a procedure. The language is structured into a group of subroutines called procedures and functions, with each routine doing a specific task which you define. This might seem strange at first, but it allows you to write programs in components so that you can concentrate on one part of the program at a time. It also makes programs written by others much easier to read.

The above procedure is called "hello", namely because it will print out the line "Hello World" to the screen when the program is run.

The statement starting with 'PrintE' is a library routine call. Here we are making use of one of the prewritten routines in the ACTION! library. This one will print out the specified string, and put out a <RETURN> at the end. This routine call is the only statement in the procedure 'hello' (because it is the only statement between the 'PROC' and ' RETURN').

Now that we have the program in the Editor buffer, how are we going to compile and run it? The Editor certainly can't do it for us, so we need to get to the Monitor and call the ACTION! Compiler from there. The Editor command <CTRL><SHIFT>M takes us to the Monitor, so we'll use that.

Now that we're in the Monitor, we need to call the Compiler to check the syntax of our program and translate it into machine language. This is done by typing the command 'COMPILE <RETURN>' to the Monitor.

The compiler takes over and does its job. If it finds an error, it will print out an error message and return you to the monitor. If it finds no errors, the Compiler will return us to the Monitor. From there we can run the compiled program by entering the command 'RUN <RETURN>'.

The screen should look like this after you've run the program:

Figure 1 Start screen

You have written your first ACTION! program!

If you got an error message from the compiler, it means that you didn't type the program in properly. You can go back to the Editor from the Monitor by typing 'EDITOR', and can fix your typo. You might note that the cursor is placed at the position where the compiler found the error, so you don’t have to look all over for it. Repeat the steps discussed above to re-compile and re-run your program after you've fixed the error.

> **NOTE: there is a list of the error codes with their meanings in appendix C.**

Part II The ACTION! Editor

Chapter 1: Introduction

The Editor is where you create new ACTION! programs and edit old ones. If you have used a program editor before, you will notice that the ACTION! Editor is far more sophisticated than most others: in fact, it could almost be called a word processor because it does so much.

Although it is capable of many things, you will find that the ACTION! Editor is easy to work with. If you have never been exposed to anything but the Atari screen editor, then you are in for pleasant surprise. You can use the ACTION! Editor for any editing you want to do, not just editing ACTION! programs. You could do all your editing (correspondence, programs in other languages, etc.).

1.1 Special Notations and Vocabulary

USAGE OF SINGLE QUOTE MARKS (')

Unless format and context make the use of quotes unnecessary, commands and special characters will be enclosed in single quotes.

USAGE OF '<' AND '>'

When talking about a key on the Atari keyboard, we will enclose it with the characters '<' and '>' thus:

```
<BACK SP> (the backspace key)
```

Some of the keys have more than one label written on them. In these cases, the label best describing the Editor command will be used.
There is one exception to the above; the character (A - Z) and digit {0 – 9} keys are not enclosed by the angle brackets.

MULTI-KEYSTROKE COMMANDS

Some of the Editor commands require that you press more than one key at a time. For these commands, the keys required are given back to back in the order in which you should press them. For example:

```
<SHIFT><DELETE>
```

means that you should hold the key marked 'SHIFT' down, and then press the key marked 'DELETE'.

THE MESSAGE AREA

Throughout this part of the manual the term "message area" will be used. This area is simply the inverse video line you will notice at the bottom of your screen when you enter the Editor. This line normally has

```
ACTION! (c)1983 ACS
```

written on it, but is used by some of the editor commands to ask you questions, give you information, or report an error.

When you are using two windows (see section 3.4), the message area line separates the two windows.

DEFAULT USER RESPONSE

Some of the commands which use the message area to exchange information with you remember the information you gave the last time you used the command. This information is called the "default user response". If the default user response you see in the message area is what you want, you simply press <RETURN>. This saves you time because you don't have to retype the same response many times. If you don't want to use the default user response, you have the ability to change either part or all of it.

1.2 Editor Concepts and Features

TEXT WINDOWS

When you look at your TV or monitor screen, imagine that you are looking through a window. At any one time you can only see 23 lines of 38 characters each. This seems very limiting, and would be if you couldn't move the window around. The ACTION! Editor makes it possible for you to move this window around, both horizontally and vertically, so that you can look at your whole program.

But the Editor is even more sophisticated than that! If you are looking through the window, and you want to look at one line which extends beyond the bounds of the window, you can move to that line and look at the whole thing. The line will move to fit into the window, but the window stays right where it was. When you move off that line, it pops back into its proper place (with respect to the window).

The Editor even allows you to split your screen into two windows, each of which you can control separately. This enables you to look at two different programs, or different parts of the same program, at the same time.

TEXT LINES

The ACTION! Editor is designed so that your program can be read easily. It allows lines up to 240 characters long (even though the window only shows 38 characters at a time), so you can use indentation to clarify your program without worrying about making lines too long. The Editor also allows blank lines, so you can separate the components of your program with white space.

> **NOTE: you also have control over the maximum line length, so you pick a line length you think best (or will fit on your printer). The Editor even buzzes when you reach the limit, to let you know it's time to go to the next line.**
>
> **NOTE: if a text line is longer than the window (if it extends beyond the left or right bounds of the window), the character at the edge of the window is shown in inverse video to make you aware of this.**

FIND and SUBSTITUTE

The Editor allows you to search for a given string, and will move the cursor to the first match found in the program.

The Editor also allows an extension of this. You can tell it to search for a given string, and then replace the first match with another string you specify, all with one command.

MOVING TEXT BLOCKS

Have you ever entered a program and wished that a group of lines which you entered at one location could be conveniently moved to another location? In ACTION!, this is a snap!

Saving those lines (called a text block) in the copy buffer (that's where a text block is temporarily saved) allows you to move the cursor to where you want the text block placed. You may then "paste" the contents of the copy buffer (the lines you wanted to move) back into the program. You can paste the text block at its original location, and then move somewhere else and paste it there too, thus enabling you to copy text blocks.

CURSOR MOVEMENT

The cursor is controlled not only by the movement keys on the keyboard (e.g., <CTRI>><up arrow>) but can also be made to move to a specified places in your text through the use of tags and the 'FIND' command.

TAGS

You can mark any location in your text with an invisible marker called a "tag". The Editor allows you to move the cursor to this tag (no matter where the cursor was before) through the use of a simple command.

The number of tags you allowed is limited only to the number of keys on the keyboard, since you must give a one character label to each tag you define.

Chapter 2: The Editor Commands

This chapter is devoted to the Editor commands themselves. Instead of presenting the commands in this form:

2.1 <CTRL><SHIFT>M

where you can't tell what the section discusses (unless you already know the Editor), the commands are presented by their function, e.g.;

2.2 Leaving the Editor

We hope this form makes things clearer and easier to follow.

Before going into the commands themselves, we should tell you how to stop execution of a command if you made a mistake. You can do this by pressing the <ESC> Key. Doing this will get you out of any command safely.

> **NOTE: appendix E provides a summary of the Editor commands, listed by the command itself instead of what it does.**

2.1 Getting to the Editor

When you first enter the ACTION! system, you will automatically be put into the Editor, so there is nothing involved in "getting to" it. You're already there.
If you leave the ACTION! system and go to DOS (OS/A+, DOS XL, or Atari DOS), you will be in the Monitor when you re-enter ACTION! (there is one exception to this; see NOTE below). To get to the Editor from the Monitor, you need only type

```
E<RETURN>
```

This will put you directly into the editor.

> **NOTE: if you are using OS/A+ or DOS XL, and you execute a DOS extrinsic command before returning to the ACTION! system, you will not be put into Monitor as stated above, but straight into the Editor. This is not the case with Atari DOS, since it has no extrinsic commands.**

2.2 Leaving the Editor

There is only one way to leave the Editor (aside from turning off the computer):

<CTRL><SHIFT>M

This command will cause you to go from the Editor to the Monitor, where you may call the other components of the ACTION! system or leave the system altogether and go to DOS.

2.3 Text Entry

There is no special Editor command to allow you to enter text. You simply type it in, as on a typewriter. When you have reached the maximum line length, the Editor will buzz every time you put in another character (see 2.3.2 for more information).

If you want to type a control character, you must press the <ESC> before doing so. This lets the Editor know that the control character should be interpreted as text, and not as an Editor command.

"What happens when I try to type over something I've already written?" The ACTION! Editor allows you two options in this case. Text can be entered in either “Replace" or "Insert" mode.

When in Replace mode, the text you enter will overwrite whatever was there before, replacing the old with the new character by character.

When in Insert mode, the text you enter will be inserted wherever the cursor is, and move all the previous text over without overwriting it.

The Editor command <CRTL><SHIFT>I allows you to change from one mode to another. When you use this command, the mode you have changed to will be printed in the message area (see section 2.5.2 for more information).

> **NOTE: the Editor is in Replace mode when you first enter it.**

If you want to erase all the text in a file, just put the cursor into the window you want to clear and press <SHIFT><CLEAR>. This will clear not only what you see in the window, but the entire file (see section 2.6.4 for more Information).

2.3.1 Text File I/O

If there were no way to save the program in the Editor buffer, you would have to retype it every time you wanted to use it. The Editor allows you both to read and to write files to any peripheral storage device (Disk Drive, Cassette, etc.) to save you all this trouble.

To save a program in the Editor buffer, you must first put the cursor into the window which contains the file you want saved (if you are using only one window, you needn't worry about this). Then you enter the command

<CTRL><SHIFT>W

In the message area you will see:

```
Write?
```

Simply type in the file name you want the program saved to, and press <RETURN>. The file name must be compatible with the DOS you are using. If you are not using a DOS, the file will consist only of a character representing the device (C for cassette, P for printer, etc.) followed by a colon.

Reading a file into the Editor buffer is just as easy. Move the cursor to the line preceding the line where you want the file you're reading in to start, and enter the command

<CTRL><SHIFT>R

In the message area you will see:

```
Read?
```

Type in the name of the file you want read in, following the conventions outlined above.

If you are using floppy disks, you can read the directory on a given disk by replying with the following to the "Read?" prompt in the message area:

```
Read? ?1:*.*
```

This will read the directory of the disk in drive number 1. If you want to read the directory of a disk in some other drive, simply change the '1' in the above example to the number of the drive. This ability is very useful, because you needn't go to DOS to find out what is on a disk.

2.3.2 Setting the Line Length

As mentioned in the first paragraph of section 2.3, you can set the maximum line length. You can find out how to do this in part III, section 2.5, so we need not show you here.

2.4 Cursor Movement

To move the cursor left one character, press:

<CTRL><left arrow>

To move the cursor right one character, press:

<CTRL><right arrow>

To move the cursor up one line, press:

<CTRL><up arrow>

To move the cursor down one line, press:

<CTRL> <down arrow>

The commands above are simply the normal cursor movement Keys the Atari screen editor understands.

The ACTION! Editor, however, allows you some more cursor movement commands designed to increase your program writing speed.

You can make the cursor go to the beginning of the line its on by pressing:

```
<CTRL><SHIFT> <
```

and go to the end of the line by pressing:

```
<CTRL><SHIFT> >
```

These two commands will take you to the true beginning or end of the line even if it (the beginning or end) is not visible in the window. The line will simply be shifted over so that it (again, the beginning or end) is visible in the window. When you move the cursor off the shifted line, the line will be moved back to its proper position.

You can go to the beginning of the file by pressing;

```
<CTRL> <SHIPT> H
```

2.4.1 Tabs

You can move the cursor to the next tab stop by pressing **<TAB>.**

To set a tab stop, move the cursor where you want the tab, and then press **<SHIFT><SET TAB>**.

To clear a tab stop, move to the tab stop you want cleared, and press **<CTRL><CLR TAB>**.

2.4.2 Finding Text

The Editor allows you to "find" a specified string of characters (1 - 32), and can be very useful when skipping from place to place in your file. To do this enter the command:

```
<CTRL><SHIFT> F
```

The message area will prompt you with

```
Find?
```

If you have previously used the Find command, you will see the string you last tried to find following the prompt. If you want to find the next occurrence of this string, simply press <RETURN>. If you want to find a different string, type in the new string and press <RETURN>. You will notice that the old string disappears as soon as you start typing.

If this is the first time you are using the Find, you will see nothing following the prompt, and you should type in the string you want found and press <RETURN>.

This command will start at the current cursor position and look for the first occurrence of the string you specified. If the string is found, the Editor will move the cursor to the first character in the found string and make the window move to display the surrounding section of text. If the string isn't found, the message area will display the line:

```
not found
```

2.5 Correcting Text

The following six sections will give you information on how to correct and delete text from the Editor buffer. The seventh sections shows you how to undo certain deletions if you have made a mistake.

2.5.1 Deleting a Character

To delete the character under the cursor (the one the cursor is flashing on top of), press:

<CTRL><DELETE>

The characters to the right of the character just deleted will move left to fill the empty space left by the deleted character.
To delete the character to the left of the cursor, press:

<BACK S>

If you are in Replace mode, this will replace the character to the left of the cursor with a space. If you are in Insert mode, this will delete the character to the left of the cursor, and then move all the following characters over to fill the empty space.

2.5.2 Inserting/Changing a Character

As mentioned in section 2.3, there are two different modes for text entry: Replace mode and Insert mode. When you first enter the ACTIOMI Editor, it is in Replace mode. To change from one mode to the other, press:

<CTRL><SHIFT> I

Some of the Editor commands are mode dependent; that is, they operate differently, depending on the text entry mode.

You can insert a blank character at the cursor position by entering **<CTRL><INSERT>.** The text from the cursor to the right end of the line moves right one space and a blank space is inserted at the cursor position.

> **NOTE: if you are in Insert mode, you can simply press the space bar.**

2.5.3 Line Deletions

To delete a whole line, place the cursor on the line you want deleted, and press:

<SHIFT><DELETE>

The succeeding lines move up to fill the empty space.

2.5.4 Line Insertions

To insert a blank line above the line the cursor is on, press:

<SHIFT><INSERT>

The succeeding lines move down to allow space for the new blank line.

2.5.5 Breaking & Recombining Lines

To break a single line into two adjacent lines, first position the cursor on the character you want as the first character in the second line, and then press:

<CTRL><SHIFT> <RETURN>

> **NOTE: if you are in Insert mode, simply position the cursor and press <RETURN>.**

Succeeding lines of text are moved down to allow room for the new line.

To combine two adjacent lines into a single line, first position the cursor on the first character in the second line, and then press:

<CTRL><SHIFT> <BACK S>

Succeeding lines are moved up to fill the empty space.

2.5.6 Substituting Text

The ACTION! Editor allows you to substitute a "new" string for an "old" one. You are prompted for the "new" string, and then for the "old" one. The Editor searches for the first occurrence of the "old" string (starting at the cursor position), and replaces it with the "new" string. To begin this command, press:

```
<CTRL><SHIFT> S
```

The message area will display the prompt:

```
Substitute?
```

If you have previously used this command, you will see the last "new" string you used following the prompt. If you want to keep this "new" string, simply press <RETURN>- If you want a different "new" string, type it in and press <RETURN>.

If this is the first time you are using Substitute, you will see nothing following the prompt, and you should type in the "new" string you want and press <RETURN>.

After you press the <RETURN>, the message area will prompt you with:

```
for?
```

You will see the last "old" string you used following this prompt if you have used the Substitute before. If you want to keep this "old" string, simply press <RETURN>. If you want a different "old" string, type it in and then press <RETURN>.

If this is the first time you are using Substitute, you will see nothing following the prompt, and you should type in the "old" string you want changed and press <RETURN>.

After you press this second <RETURN>, the Editor will try and do the substitution. If it can't find the "old" string you've given, the message area will show the following:

```
not found
```

If you press <CTRL><SHIFT>S again before you do any other editing, the Editor will execute the same substitution again. This enables you to substitute more than one occurrence of the "old" string with the "new" one without having to keep responding to the "Substitute?" and "for?" prompts.

> **HINT: you can delete the next occurrence of a string by using this ommand with the "new" string being nothing.**

This with substitute the "old" string with nothing, and so (in effect) delete it.

2.5.7 Restoring a Changed Line

The ACTION! Editor allows you to restore a line to its previous form if you have made an error while editing it. To do this, you must remain on the changed line and press:

```
<CTRL><SHIFT> U
```

> **WARNING: if you leave the line and then come back to it, this command will not work, because the Editor only remembers what the line was before you started editing it while you remain on the line.**

If you have accidentally deleted a whole line, you can retrieve it by pressing:

```
<CTRL><SHIFT> P
```

More information about this command may be found in section 2.7.

> **NOTE: the tags on the changed or deleted line are not restored.**

2 .6 Windows

The displayed contents of the central portion of the screen is called a window. The following five sections describe the Editor commands used to manipulate, create, and delete windows. In these sections we use the term "current window" to mean the window which the cursor is in.

2.6.1 Window Movement

You can make the window scroll up or down one line simply by moving the cursor. If you try and move the cursor off the top of the screen, the window moves up one line to keep the cursor on the screen. The same works with the bottom of the screen. This type of vertical scrolling could take a long time if your program were big, so the Editor also allows you to make the window scroll by the size of the window itself.

To move up one window, press:

```
<CTRL><SHIFT> <up arrow>
```

For the sake of continuity, what was the top line in the old window is now the bottom line of the new window.

To move down one window press:

```
<CTRL><SHIFT> <down arrow>
```

For the sake of continuity, what was the bottom line in the old window is now the top line of the new window.

The Editor also allows you to scroll the window horizontally. That is you can make the window's left margin start at any column (instead of the first column). If a line is longer than the window (if it extends beyond the left or right bounds of the window), the character at the edge of the window is shown in inverse video to make you aware of this.

To move the window one character to the right, press:

```
<CTRL><SHIFT> ]
```

To move the window one character to the left, press:

```
<CTRL><SHIFT> [
```

2.6.2 Creating a Second Window

When you first enter the ACTION! Editor there is only one window. You can create a second window by pressing:

```
<CTRL><SHIFT> 2
```

The screen will now look like this:

Figure 2 Second editor window (above the message area)

The window above the message area is window 1 and the window below it is window 2. You can use each

window Independently, so you could be working on two entirely different files without having to keep clearing window 1 and reading in a file.

> **NOTE: the size of the window 1 can be set using the Options Menu available from the monitor. For more information on how to do this, see part III, section 2.5.**

2.6.3 Moving Between Windows

To move from window 1 to window 2, press:

```
<CTRL><SHIFT> 2
```

If window 2 does not yet exist, then the Editor creates window 2, then moves the cursor into it.

To move from window 2 to window 1, press:

```
<CTRL><SHIFT> 1
```

2.6.4 Clearing a Window

To clear the text file in a window, move the cursor into that window (see previous section), and press:

```
<SHIFT><CLEAR>
```

Since this is such a powerful command, the message area will prompt you with:

```
Clear?
```

Respond with a "Y" or "N". If you have made changes to the file viewed through that window, and have not saved the changed version, the message area will prompt you with:

```
Not saved, Delete?
```

to make sure that you know that you have not saved the new version.

> **WARNING: this command does not simply delete the portion of the file visible in the window, but rather deletes the entire file.**

2.6.5 Deleting a Window

To delete a window (i.e., make the window itself go away), first position the cursor in the desired window, and then press:

```
<CTRL><SHIFT> D
```

In the message area you will see the prompt:

```
Delete Window?
```

Respond with a "Y" or "N". If you have made changes to the file viewed through that window, and have not saved the changed version, the message area will prompt you with:

```
Not saved, Delete?
```

to make sure that you know that you have not saved the new version.

When you delete a window, the screen space it occupied is given bach to the other window. If you delete window 1, then window 2 becomes window 1 (since there is only one window, it must be window 1).

2.7 Moving/Copying Blocks of Text

The ACTION! Editor allows you to move or copy text blocks through the use of a copy buffer. Whenever you use the command **<SHIFT><DELETE>** to delete a text line, that line is temporarily stored in a region called the copy buffer. You may then "paste" that deleted line using **<CTRL> <SHIFT>P**.

The copy buffer is cleared every time you use the **<SHIFT><DELETE>**, with one exception. If you use the **<SHIFT><DELETE>** consecutively (i.e., without doing any other commands or text entry between the deletes), the copy buffer is not cleared. Instead, the second (and following) deleted lines are also stored in the copy buffer, thus loading it with a text block.

Now, when you use the **<CTRL><SHIFT>P** command, the entire text block in the copy buffer is pasted back into the text.

Enough of the overview; on to the method itself.

To move a block of text, position the cursor on the first line of the block, and press **<SHIFT><DELETE>** until you have deleted the entire block. Move the cursor to the line above which you want the block to be pasted. Now simply press **<CTRL><SHTFT>P**, and the block will be pasted.

To copy a block of text, use the same method as for moving a block, but first paste the block back into its original position before moving to place where you want it copied. Since pasting does not clear the copy buffer you can paste the same block (or line) in many different places, thus allowing multiple "copy"s,

2.8 Tags

Tags allow you to mark any location in your text. To set a tag at a given cursor position, press:

```
<CTRL><SHIFT>T
```

The message area will display the prompt:

```
tag id:
```

Enter the one character identification you want for that tag and press <RETURN>. If the id you give already has a tag associated with it, the old tag will be lost, and the id will refer to the new tag,

To move to a specified tag, press:

```
<CTRL><SHIFT>G
```

The message area will display the prompt:

```
tag id:
```

Enter the id character of the tag you want to go to. If the tag exists, the cursor will be moved to it, and the window will be moved to display the surrounding text. If the tag doesn't exist, the Editor will print

```
tag not set
```

in the message area. This means that no tag with the given id character exists.

> **WARNING: Any operation which alters the contents of the line (character insertions, deletions, or changes, line breaking or recombining) clears the tags in the line.**
>
> **HINT: if you use the digits (0 - 9) as tag ids, you are more likely to remember the id character.**

Chapter 3: Comparing ACTION! and ATARI Editors

3.1 Identical Commands

<SHIFT>	Used in conjunction with letter keys to change the case of the letters or used to enter either an alternate character or command. Hold the **<SHIFT>** key down while pressing the following key in the sequence (e.g. <SHIFT>_, symbolizing the underline character "_", means that you should hold the <SHIFT> key down while pressing the "_" key) .
<CTRL>	Used in conjunction with one or more other keys to communicate a command or special character to the editor. Hold the key down while pressing the following key in the sequence (e.g., <CTRL><up arrow>, symbolizing the command to move the cursor up one line, means that you should hold the <CTRL> key down while pressing the <up arrow> key).
<Atari>	Display succeeding characters in inverse video. Press key a second time to return to normal video display of entered characters.
<ESC>	Allows the following control character to be entered as text.
<LOWR>	Shift letter entry to lower case (like unlocking the shift lock on a regular typewriter).
<SHIFT><CAPS>	Shift letter entry to upper case letters only (like pressing shift and shift lock keys simultaneously on a regular typewriter).
<SHIFT><INSERT>	Inserts a blank line on the line where the cursor is. The line where the cursor was and succeeding text lines are moved down to make room for this line.
<CTRL> <INSERT>	Inserts a blank space where the cursor is. Succeeding characters on the same line are moved right one character to make room for the inserted space.
<CTRL><up arrow>	Moves cursor up one text line.
<CTRL><down arrow>	Moves cursor down one text line.
<TAB>	Move to the next set TAB location, if any. Do not move if no additional TAB exists. Inserts spaces if no text (or spaces) exist here already.
<SHIFT><SET TAB>	Establish a TAB location at the current position of the cursor.
<CTRL><CLR TAB>	Clear the TAB, if any, at the current cursor location.

3.2 Differing Commands

<BREAK>	This key is not used by the ACTION! editor.
<SHIFT><CLEAR>	Clears file in the current window. The editor warns you when the file has not been saved since the last text modification and allows you to cancel the command.
<RETURN>	In Replace mode, this moves the cursor to the beginning of the next line. In Insert mode, it inserts a <RETURN> into the text.
<SHIFT> <DELETE>	Removes the line the cursor is on (like Atari screen editor). Succeeding lines are moved up to replace the deleted line. Can be used repeatedly. Removed line(s) is(are) stored in a temporary holding area (called the copy buffer) for text copy/move processing. See **<CTRL><SHIFT>P** description and section 2.7.
<BACK S>	If in Replace mode (see <CTRL><SHIFT>I), then this replaces the character to the left of the cursor with a space. In Insert mode, this removes the character to the left of the cursor and scrolls the rest of the line left to fill the empty space.
<CTRL><right arrow>	This moves the cursor right one character, stopping at the end of the line. Upon encountering the right margin of the window, the editor keeps the cursor within the display by scrolling the line contents to the left one character.
<CTRL><left arrow>	This moves the cursor left one character at a time, stopping at the beginning of the line. When at the left margin of the window but not yet at the Left end of the line, the editor keeps the cursor within the display by scrolling the line contents right one character.

<CTRL><SHIPT> D	This deletes the current window from the screen. The window contents are cleared from memory and the window itself disappears from the screen.
<CTRL><SHIFT> F	This finds a specified group of alphanumeric characters in text. If the character string is found, the cursor and window are moved to display it.
<CTRL><SHIFT> G	This finds a user-specified tag anywhere in file (from any starting location). If found, the surrounding text is displayed and the cursor is positioned at the tag.
<CTRL><SHIFT> H	Moves cursor to the beginning of the file (home).
<CTRL><SHIFT> I	Alternates between the character Replace and the character Insert modes (the editor starts out in replace mode). The mode being switched to Is shown in the message area,. This command affects "<BACK S>" and "<RETURN>" handling.
<CTRL><SHIFT> M	Goes to the ACTION! Monitor (Part III).
<CTRL><SHIFT> P	After one or more lines are loaded into the copy buffer using **<SHIFT><DELETE>**, the cursor can be moved anyplace in the text. Pressing **<CTRL><SHIFT>P** causes the lines in the copy buffer to be pasted at the current cursor location. Succeeding text (with tags) is moved down.
<CTRL><SHIFT> R	This command Reads a file from a peripheral storage device. The file name given must be compatible with the DOS you are using. If no device is specified in the file name, D1: is assumed.
<CTRL><SHIFT> S	This command does String Substitution. This command allows you to substitute a new string of up to 32 characters for an old one. Can also be used successively to substitute multiple occurrences of the old string.
<CTRL><SHIFT> T	This command Sets a tag. The position of the cursor in the text is marked invisibly by a one-character alpha-numeric tag assigned to that location.
<CTRL><SHIFT> U	Undo text changes. This command restores a changed line to its unmodified state. Tags for that line are not restored. This command works only on a line not deleted by <SHIFT><DELETE> and while the cursor has not left that line.
<CTRL><SHIFT> W	This command Writes a file to a peripheral storage device. The file name must be compatible with the DOS you are using .
<CTRL><SHIFT>]	This command Moves the window right 1 column (useful for editing files with lots of indentation).
<CTRL><SHIFT> [	This command Moves window to the left 1 column.
<CTRL><SHIFT><up>	This command Moves the current window up a complete window. For continuity between the old and new windows, the top line from the last window is the new window's bottom line.
<CTRL><SHIFT><down>	Moves the current window down 1 window. The new window's top line is pulled from the previous window's bottom line.
<CTRL><SHIFT> 1	This command Moves from the second window to the first window. The cursor goes to the previous cursor position, if any.
<CTRL><SHIFT> 2	This command Moves from the first window to the second window. If the second window has not been created previously in the current editing session, then the second window is created on the screen. The editor goes to the previous cursor position, if any.
<CTRL><SHIFT> >	Moves the cursor to the end of the line and displays that end of the line. If the line is longer than 36 characters , then the cursor moves to the end of the line and the line is displayed so that only the rightmost 38 characters show.
<CTRL><SHIFT> <	Moves cursor to beginning of line and displays the beginning of the line. If the line is longer than 38 characters, then the cursor moves to the beginning of the line and the line is displayed so that only the leftmost 38 characters show.

<CTRL><SHIFT><BACK S> At the beginning of a line, this command deletes the otherwise invisible and inaccessible <RETURN> (EOL). The lower line is appended to the end of the preceding line. The succeeding lines are moved up one line, as needed. At all other times, this command acts the same as **<BACK S>**.

<CTRL><SHIFT><RETURN> Insert a <RETURN> Into the text. The line containing the cursor is broken at the cursor. The portion of the line to the left of the cursor remains on the current line. The remainder of the line is inserted in a new, left-justified line immediately below the left-hand portion or the old line. The window is redrawn, as needed.

Chapter 4: Technical Considerations

4.1 Files from Other Text Editors

The editor can't handle files which don't contain <RETURN> characters (EOL's) or have Lines longer than 240 characters. Line lengths should be less than or equal to the line width of your printer for the sake of convenience.

4.2 Key Recognition

During command line entry (in the message area), only the <ESC>, <BACK S> and <CLEAR> command keys are recognized. All text characters are allowed.

During regular text entry, all text characters and commands are allowed.

4.3 "Out of Memory" Error

This condition can result from an editing session in which you made quite a few insertions and/or substitutions, or from typing in a file which is too big (this will occur very rarely).

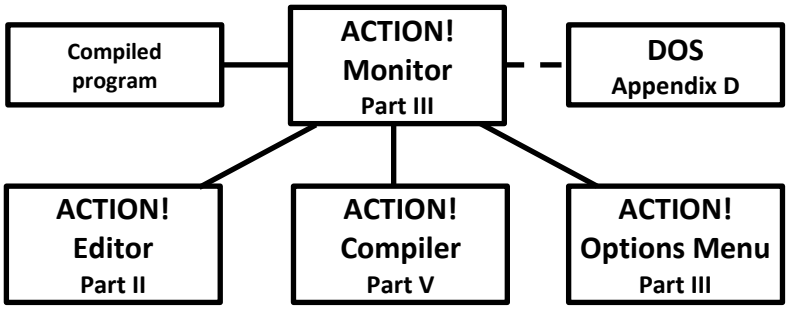
When you get this error, immediately write the text file out to a storage device, and then restart ACTION! (using the 'BOOT' command in the Monitor). You can then go back to the Editor and read your text file back in, and continue working on it.

Part III The ACTION! Monitor

Chapter 1: Introduction

Part III describes the ACTION! monitor - control center of the ACTION! system. It connects to all of the functions in ACTION!.

The monitor is characterized by an inverse video line across the top of the screen, containing the prompt '>' and the cursor at the left margin.



1.1 Vocabulary

Term	Where Defined
<address>	Part IV
<compiler constants>	Part IV
<filespec>	Below
<identifier>	Part IV
<statement>	Part IV
<value>	Part IV

When the term '<filespec>' is used in this part, it refers to a standard Atari file specifier consisting of a device (P:, C:, D1:, D2:, etc.) and a file name in the case of disk drives.

1.2 ACTION! Monitor Concepts and Features

The ACTION! monitor contains two chief features – the command line and the message area. Both are described below.

These areas are unique to the ACTION! monitor. However, the ACTION! compiler uses a similar screen format (see part IV on the ACTION! compiler).

You communicate with the ACTION! monitor through the command line. The command line is the inverted video line at the top of the screen. It contains both the prompt and the cursor at the beginning of the line.

Commands are recognized by the first character entered after the prompt ‘>’. Thus, 'E’, 'Edit', and 'Ejunk’ all tell the ACTION! monitor to call the ACTION! Editor. The various ACTION! monitor commands are summarized in chapter 2.

Below the command line is the message area. The message area is the large, outlined block in the middle of the screen. It is a multi-purpose area. When a program is running, it is used to display program results. It can also be used to trace program execution (see the options menu choice 'trace?' in chapter 2). When either the operating system or the ACTION! compiler finds an error, the message area contains the error number and the program text around the line where the error was found.

In its role as the command center of ACTION!, you can move from the ACTION! monitor to any of several different ACTION! functions. To get an idea of the relationship between the various ACTION! parts, see the diagram on the preceding page. You can execute a compiled ACTION! program (see the ACTION! Monitor’s RUN command in Chapter 2). You can also call the

ACTION! Editor (described In Part II) or call the ACTION! Compiler (described in Part V). If you are using disk drives, you can even call the DOS (see the ACTION! monitor DOS command, mentioned in Chapter 2).

Chapter 2: ACTION! Monitor Commands

2.1 **Boot** - Restarting ACTION!

Sometimes you need to restart ACTION! from the ACTION! Monitor. This might, occur after a fatal error or upon return from DOS, You can restart ACTION! by entering '**BOOT**', then pressing <RETURN>.

Examples:

```
BOOT <RETURN>
B <RETURN>
```

WARNING: text in the ACTION! Editor will be lost. Compiled programs and their program variables will also be lost.

2.2 **Compile** - Compiling Programs

In ACTION!, a program must be processed by the ACTION! compiler before it can be run from the monitor. You can call the ACTION! compiler from the monitor, using:

COMPILE "<filespec>"

The "<filespec>" is an option which allows you to compile programs which are stored on a peripheral device (disk, cassette, etc.). If no "<filespec>" is specified, then the contents of the Editor buffer is compiled. If you are using two windows, the file in the window which contained the cursor when you left the Editor is compiled.

If the Compiler finds a syntax error while compiling the program, the error number and the line on which the error occurred are display in the Monitor's message area. The Compiler then returns control back to the Monitor.

Examples:

```
COMPILE <RETURN> (compile the program in the current Editor window.)
C <RETURN>

C "C:" <RETURN> (compile from cassette)

C "D1:PRIME.ACT" <RETURN>                (compile PRIME.ACT
COMPILE "PRIME.ACT" <RETURN>             from disk drive #1.)
```

Notice that the file name specified in the last example does not have a device given. If no device is given, the device D1: is assumed.

2.3 **Dos** - Transfer to DOS

You can transfer to OS/A+, DOS XL, or Atari DOS by entering 'DOS', then pressing <RETURN>.

Examples:

```
DOS <RETURN>
D <RETURN>
```

NOTE: Since Atari DOS and some of Its utilities use the same memory that ACTION! uses, you should always take the precaution to save all files before going to Atari DOS.

2.4 **Edit** - Transfer to the ACTION! Editor

You can transfer to the ACTION! editor by entering 'EDITOR' then pressing <RETURN>.

Examples:

```
EDITOR <RETURN>
E <RETURN>
```

NOTE: if you were just compiling a program from the editor and the compile failed due to a syntax error, you will find that the ACTION! editor cursor is on the line following the error.

2.5 **Options** - The Options Menu

The options menu allows you to alter certain operational parameters of the ACTION! Monitor, Compiler, and Editor. Enter the options menu by entering '**OPTIONS**' then pressing <RETURN>.

Examples:

```
OPTIONS <RETURN>
O <RETURN>
```

Each option is displayed in the command line. If you want to change that option, type in the value you want, and press <RETURN>. If you don't want to change that option, simply press <RETURN>. If you want to exit the options menu all together, press <ESC>.

> **NOTE: a summary of the options available may be found in appendix G.**

Following is a description of each of the options Available. Each description contains the command line prompt for that option, the initial state of that option, and the components of the ACTION! system that option affects (M = Monitor, C = Compiler, E = Editor).

```
Display? Y                                                    M,C,E
```

The screen display can be turned off for greater speed during disk I/O and during ACTION! Compiler processing. You can turn the screen display off (enter 'N') or you can leave it on (enter 'Y').

```
Bell? Y                                                       M,C,E
```

The bell rings whenever errors are encountered in the ACTION! Monitor, Compiler, or Editor. It also rings whenever the ACTION! monitor is called. You can turn that bell off (enter 'N') or you can leave the bell on (enter 'Y').

```
Case sensitive? N                                               C
```

When this option is 'Y', distinction is made in variable names between upper and lower case letters (i.e., 'count' differs from 'Count' and 'COUNT') and the language statements (e.g., FOR, WHILE, DO etc.) must be in upper case. However, for the ease of beginning ACTION! programmers, case sensitivity is turned off when you enter the ACTION! system.

```
Trace? N                                                        C
```

With this option you can control the compiler's ability to trace program compilation. When this option is enabled ('Y'), the compiler will note in the Monitor's message area every routine call, together with the parameters passed to that routine. See chapter 4 for more information on the usage of this option.

```
List? N                                                         C
```

The ACTION! compiler can be commanded to display the current line being compiled in the message area of the screen. Enter 'Y' to enable this listing or enter 'N' to disable this listing.

```
Window 1 size? 18                                               E
```

The size of the ACTION! Editor's window 1 is set explicitly. Window 2 size is set implicitly by the relationship with window 1 -- the two windows have a combined size of 23 lines. When there are two windows, each can contain no less than 5 lines and no more than 18 lines. Enter the number of lines for window 1, then press <RETURN>. An entry greater than I8 is converted to 18 and an entry less than 5 is converted to 5.

```
Line size? 120                                                  E
```

The line length is the number of characters in the line, counting from the left margin (see next option). The line length is used to help you control the size of lines listed to the printer. The bell sounds whenever the actual number of characters in the line exceeds the entered line length. You enter the number of characters of the line length.

> **WARNING: you can set the line length to a value which is out of the correct range.. The options menu does not check for this error. Lines longer than 240 characters are arbitrarily shortened by the ACTION! Editor.**

```
Left margin? 2                                                M,E
```

The left margin is the starting point for the line count mentioned earlier. This option is offered so that you can get the full use of a screen which displays the leftmost 2 characters (not all TV screens can do this!). It is suggested that you keep the left margin as close to the left edge of the screen as you feel comfortable with. Normally set at 2, you can set the left margin as low as 0 and as high as 39. Enter the appropriate left margin location and then press <RETURN> .

WARNING: Do not enter a number greater than 39 when using an Atari system with the standard display.

```
EOL character? (blank)                                          E
```

The EOL (End Of Line) character is the character displayed by the ACTION! editor at the end of a line. Enter the character which you want to see displayed as the visible EOL character then press <RETURN>. Changing from a space to a visible character would generally only be useful for removing trailing spaces from lines. However, you may prefer a visible EOL for reasons of your own. If you desire such, we suggest any of the Atari graphics characters (e.g. , <CTRL>T is a solid circle).

2.6 **Proceed** - Restarting a Halted Program

Restart a halted program (continue from a stop caused by pressing the <BREAK> key using the 'Break' Library routine) by entering 'PROCEED', then pressing <RETURN>. The program continues as if the interruption had not occurred.

Examples:

```
PROCEED <RETURN>
P <RETURN>
```

2.7 **Run** - Program Execution

You can run any program which has just been compiled and is still In the program area. The command has the following formats:

RUN
RUN "<filespec>"
RUN <address>
RUN <routine>

where

<routine> ia a valid PROC or FUNC identifier (e.g., for 'PROC Prime()' you would use 'Prime' as the routine identifier).

The first format is used to run a program you have compiled from the Editor buffer.

The second allows you to run programs stored on peripheral devices. If the program is still in the ACTION! language, it is first compiled by the Compiler, and then it is run. If it is in machine code (i,e., you saved the compiled version of your program using the 'WRITE' Monitor command), the program runs immediately.

The third format allows you to run a program (or routine) which begins at a given address. This is useful when you are trying to debug a program which calls a machine language routine you have written.

The fourth is used to run only one routine from a program which you have compiled.

After program execution, control returns to the ACTION! monitor. When some kind of significant error occurs (e.g., an infinite loop), control does not return to the ACTION! Monitor. Such an error requires pressing the <SYSTEM RESET> key in order to return to the ACTION! monitor. Additional information on the behavior of running programs is in the next chapter.

Examples:

```
RUN <RETURN>                    (run a program compiled
R <RETURN>                      from the Editor buffer.)

RUN "C:" <RETURN>               (pull a program from cassette,
                                compile it, then run it)
```

```
RUN "PRIME.ACT" <RETURN>      (pull PRIME.ACT from
R "D1:PRIME.ACT" <RETURN>    disk #1, compile it, then run it)

R $400 <RETURN>               (run a program at addre&s $400)
RUN 1024 <RETURN>             (run a program at address 1024)

R Prime <RETURN>              (run the just-compiled procedure "Prime()")
RUN PrintE() <RETURN>         (run the library function to print a string to
the screen)
```

2.8 **Set** - Setting a memory value

The SET command in the Monitor works exactly as in the Language itself, so we will refer you there for a description of its usage. See part IV, section 7.3.

2.9 **Write** - Saving Compiled Programs

You can write a compiled program (called a binary file) to disk for later execution directly from DOS by entering 'WRITE', then, in quotes, a valid file specification. The format is:

WRITE "<filespec>" *<RETURN>*

The binary file in memory is saved to the specified file on the disk. The file is created, if necessary. If there isn't sufficient room on the disk, or the disk is write-protected, you are warned with an error message and can try again.

Examples:

```
WRITE "PRIME.BIN" <RETURN>
W "D1: PRIME.BIN" <RETURN>
```

(save a compiled version of the PRIME program to disk 1)

```
W "C:" (save the compiled program to cassette)
```

The OS or DOS command to execute a machine language program can be used to execute a program saved to by the 'W command. See the references mentioned in Appendix D.

2.10 **Xecute** - Immediate Commands

You can execute any ACTION! language command or any ACTION!compiler directive (except MODULE and SET) from the ACTION! Monitor. Preface any such command with the command XECUTE, then the statement(s). Press <RETURN>.

Examples:

```
XECUTE PrintE("'Hello World"!)<RETURN>
X trace = 255 <RETURN>
```

NOTE: using this command is very similar to the BASIC direct mode.

2.11 ? - Display a Memory Location

You can display the value either of a variable or of a specified memory location. Enter '?', Then enter a compiler constant, Press <RETURN>. The format is:

? <compiler constant> *<RETURN>*

The ACTION! monitor shows you the actual memory location (expressed in both decimal and hexadecimal formats), followed by the printable ATASCII value of that location, its four-digit hexadecimal value, the decimal value of the BYTE, and the decimal value of the CARD starting at the specified location. If the identifier is not in the ACTION! compiler's symbol table, then a "variable not declared error" occurs.

Example:

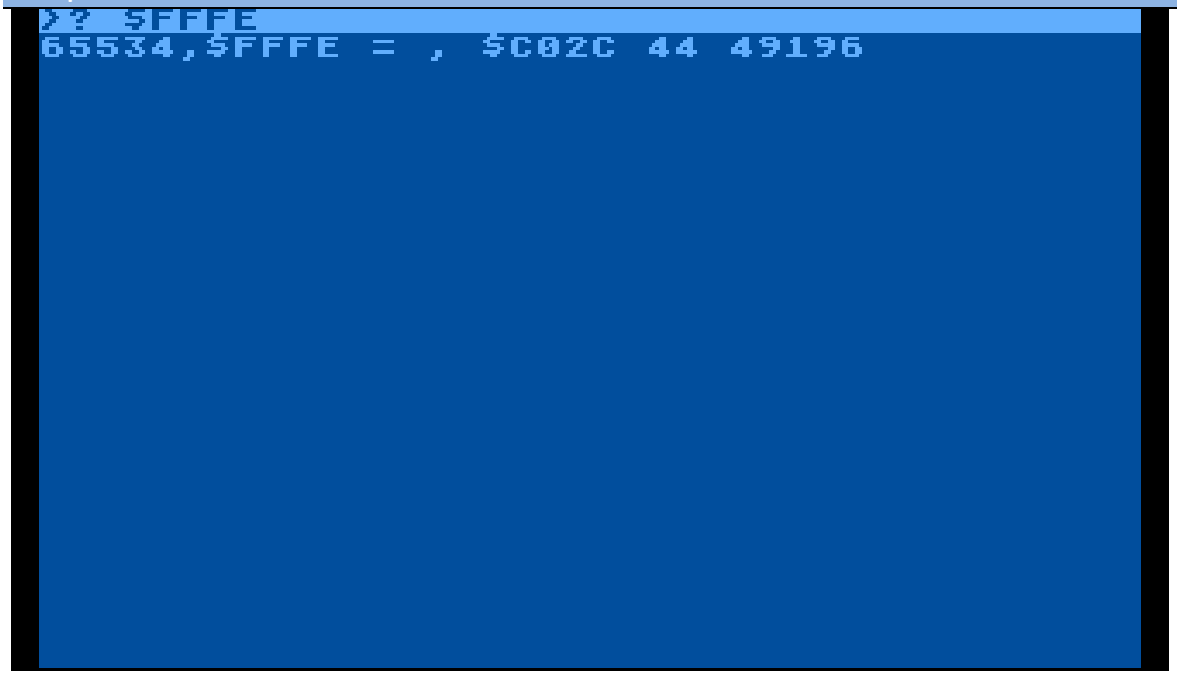


Figure 3 Monitor screen and command ? example

> NOTE: the results might not be what you expect if memory has been altered since the compile - see SYMBOL TABLE in Part V.

2.12 * - Memory Dump

Starting from a specified memory address, you can display the memory contents of sequential locations in a format identical to that described just above. Simply enter '*' and the <address>. The format is:

** <address> <RETURN>*

The monitor returns a list of the memory contents in the variety of formats (mentioned above) at the rate of one line per memory location. You can stop the listing by pressing <space bar>. You can temporarily halt the listing by entering <CTRL> 1, Press <CTRL> 1 a second time to continue the listing.

Example:

Figure 4 Monitor screen an * command example

You have probably written programs which have not work the way that you expected, not because of syntax errors, but simply because something you're doing (or think you're doing) isn't executing properly. With the ACTION! Monitor and its options menu you can debug your program step by step to determine where the error is occurring.

The Trace Option

One of the options available in the options menu is 'Trace?'. If this option is enabled ('Y'), you can follow your program's execution. When the trace is on, every time a routine is called its name and parameters are displayed on the screen. You might be able to discover what is going wrong simply by looking at the order of the routine calls and/or the parameters being passed. If this is so, fantastic! If not, you probably need to do some major debugging.

The first thing you need to do before doing any major debugging is to stop your program sometime during its execution. There are two ways to do this in ACTION I:

The <BREAK> key and the Library routine 'Break'.
The <BREAK KEY>

Although the <BREAK> key is disabled during use of the ACTION! Editor, it is usable during program execution with certain restrictions. The <BREAK> key will stop program execution only if you are:

1) doing some sort of I/O
2) calling a routine with more than 3 parameters

These might seem strange circumstances, but there is a good reason for them. The ACTION! System itself does not check to see if the <RREAK> key has been pressed during program execution, but the system does make calls to CIO in the above two circumstances, and CIO checks to see if the <BREAK> key has been pressed,

Library PROC Break()

If you want program execution to stop at any given place, simply make a call to this Library routine at that point. This routine acts exactly like the <BREAK> key, except that it works under all circumstances. Using this method to stop a program is more reliable than pressing <BREAK> because you know exactly where you are in the program when the program stop occurs.

> **NOTE: you may use this routine more than once in one program if you want to break execution at more than one place.**

Now that you have stopped the program, you can use the Monitor commands and '?' to look at the value of the variables you're using. If this method of debugging is used with the 'Trace' option on, you can even find out where you are in your program (if you are using the Library break, you already know where you are) and so look at the variables local to the procedure you're in as well as the global ones.

If this method doesn't work, we can only suggest that you insert diagnostic 'Print' statements into your program (e.g.

```
PrintE("In loop FOR x=1 to 100") PrintBE(x)
```

might be used to debug a FOR loop which has run amuck).

Part IV The ACTION! Language

Chapter 1: Introduction

The ACTION! language is the heart of the ACTION! System. It incorporates the good points of both C and PASCAL and at the same time, is the fastest high level language available for ATARI home computers. If you have a background in BASIC or some other unstructured language, you will find ACTION! a welcome change because its structure is similar to the way we structure ideas in our own minds. You can actually look at an ACTION! program someone else has written and understand what is going on, without having to wade through a thousand GOTOs and undeclared variables.

Program structure is simple in ACTION!, because programs are built component by component. The components are groups of related statements which accomplish some task. When you have written components for all the tasks required in your program, it is a simple matter to execute them. It's very similar to a list of Chores such as

1) Make your bed
2) Clean your room
3) Dust the living room furniture
4) Wash the Dog

except that the computer will do the tasks in the order in which you present them, not in whatever order it likes best.

Having separate components also makes it very easy for you to do a single task over and over, or do the same task in ten different situations and places.

The only requirement this structured approach imposes is that a program must consist of proper components (in ACTION! they are called procedures and functions) for It to be valid. A program usually contains many components, but at least one is required. This is not a restrictive requirement at all, as you will soon find out. In fact, it makes your program more comprehensible to yourself and others.

> **NOTE: when compiling and running a program with many routines the last routine is considered to be the main one, so you should use it to control your program.**

In our discussion of ACTION! we will use some terminology that we should explain. We'll use as little jargon as possible, but some is required to differentiate between parallel but different concepts later on. What terms we don't present here will be explained when they are first used. Before going into the special notations used in this part, we'll give you a list of the keywords in ACTION!. A "keyword" is any word or symbol the ACTION! compiler recognizes as something special, whether it be an operator, a data type name, a statement, or a compiler directive:

AND	FI	OR	UNTIL	=	(
ARRAY	FOR	POINTER	WHILE	<>	)
BYTE	FUNC	PROC	XOR	#	.
CARD	IF	RETURN	+	>	[
CHAR	INCLUDE	RSH	-	>=	]
DEFINE	INT	SET	*	<	"
DO	LSH	STEP	/	<=	'
ELSE	MOD	THEN	&	$	;
ELSEIF	MODULE	TO	%	^	
EXIT	OD	TYPE	!	@	

Table 1 ACTION! keywords

WARNING: You may not use the above keywords in an context other than the one defined in the ACTION! Language; specifically, you may not use these words as identifiers.

2.1 Special Notations

When discussing the language, we use some terms which might be unfamiliar to you, so their meanings are presented here. The list is in alphabetical order, with the symbols at the end.

Address

An address is a location in memory. When you tell the computer to put something into memory, you must give it an address, just like you give the post office the address of the destination of a letter on the letter's front. In the computer there are only house numbers, no streets, no cities, no states, and no zip codes. So an address to the computer is simply a number.

Alphabetic

Any letter of the alphabet, in either upper (ABC) or lower (abc) case- **"Alphanumeric**" includes the digits "0" through "9'* as well.

Identifier

Throughout the manual we will refer to the names you give to variables, procedures, etc. as identifiers. We do this because names in ACTION! must follow some guidelines:

1. They must start with an alphabetic character.
2. The rest of the characters must be alphanumeric, or the underline (_) character.

They may not be keywords.

These rules must be obeyed when you wish to create an identifier, otherwise you will get a syntax error.

MSB, LSB

MSB stands for "Most Significant Byte", and LSB stands for "Least Significant Byte". In the decimal system we have significant digits, not bytes. For example, the most significant digit of "54" is '5', and the least significant is '4'. If you are un-familiar with the byte storage system, don't worry. You can program very well in ACTION! without knowing anything about the internal workings of the computer.

Note that two-byte numbers stored and used by ACTION! are generally in LSB, MSB order, as is conventional on 6502 based machines.

$

The dollar sign, when used In front of a number, tells the computer that the number is hexadecimal (the base 16 number system useful when working directly with the computer), not the customary decimal.

Examples:

```
$24fC $0D $86 $F000
```

;

The semicolon is the comment symbol, and everything on a line after it is ignored by the compiler.

Examples:

```
;This Is a comment
```

This is not and will cause a compiler error

```
; This comment has a ; semi ;colon in it

var=3      ;comments can come
;after executable
;statements

;this is a 3 line comment
;
;with a blank line in it
```

< and >

Whatever is between these two symbols is used to define some part of a format. It is never a keyword, and usually is a term describing what goes in its place in the construction (e.g., <Identifier> means a valid identifier should be used).

{ and }

Whatever is between these is optional in the format construction ({ <identifier>} means that a valid identifier may be used here, but is not required).

|: and :|

As in music, these symbols denote repetition. Anything between them is repeatable from zero times on up (e.g., I:<Identifier>:| means that you could have a list of zero or more identlflers here).

|

This symbol shows an 'or' situation (e.g., <identifier> I <address> means you could use either an identifier or an address, but not both.

Before discussing the Fundamental Data Types, something must be said about variables and constants, since they are the basic data objects the computer manipulates.

3.1 Variables

Legal variable names must be valid identifiers. Other than this there is no restriction on variable names.

Because a working knowledge of functions and procedures is required before discussing the scope of a variable, the topic is presented later in section 6 .3.

3.2 Constants

There are three types of constants in ACTION!, numeric constants, string constants, and compiler constants.

Numeric constants may be entered in three different formats:

1) Hexadecimal
2) Decimal
3) Character

Hexadecimal constants are represented by a dollar sign ($) in front of the number.

Examples:

```
$4A00
$0D
$300
```

Decimal constants require no special character to define them as decimal.

Examples:

```
65500
2
324
46
```

> **NOTE: Both hexadecimal and decimal numeric constants may have a negative sign in front of them, thus:**
>
> **-$8C**
>
> **-4360**

Character constants are represented by a single quote (‘) preceding the character. Characters are numeric constants because they are internally represented as one byte numbers, as per the ATASCII character code set.

Examples:

```
'A
'@
'"
'v
```

String constants consist of a string of zero or more characters enclosed by double quotes ("). When stored in memory, they are preceded by their length. The double quotes are not considered as part of the string; if you want a " in your string, place two double quotes together (see examples).

Examples:

```
"This is a string constant"
"a double quote in a string""56395"
"q" (a single character string constant)
```

Compiler constants are different from the above types of constants, in that they are used at compile time to set certain attributes of variables, procedures, functions, and code blocks, and are not evaluated at run-time. The following formats are valid:

1) A Numeric Constant
2) A Predefined Identifier
3) A Pointer Reference (see section 8.1.2)
4) The Sum of Any Two of the Above

We have already talked about the first format, but the other three require some explanation. When you use a predefined identifier (i.e., a variable, procedure or function name) in a compiler constant, the value used is the address of that identifier. The third format allows pointer references as compiler constants. The last one permits you do simple addition of a combination of any two of the other three types. Here are some examples which show the valid formats in use:

```
cat         ;uses the address of the variable 'cat'
$6000       ;a hex constant
dog^        ;a pointer reference as a constant

5+ptr^      ;5 plus the contents of the pointer *ptr'
$80+p       ;evaluates to $80 plus the address of *p'
```

3.3 Fundamental Data Types

Data types allow humans to make sense out of the stream of bits the computer understands and manipulates. They allow us to use concepts we understand, so we need not know how the computer does what it does. ACTI0N! supports three fundamental types and some advanced extensions of these {see chapter 8 for the extended types). The basic ones are BYTE, CARD, and INT, and each is detailed below. All of the fundamental types are numeric, and so allow you to use numeric format when entering data.

3.3.1 BYTE

The type BYTE is used for positive integers less than 256. It is internally represented as a one-byte, unsigned number — its values range between 0 and 255. At first glance this might seem a useless type but it has two worth while applications. When used as a counter in loops (WHILE, UNTIL, FOR) program speed will increase because it's easier for the computer to manipulate one byte than many.

Also, since characters are represented inside the computer as one-byte numbers, BYTE is also useful as a character type. In fact, the ACTION! compiler allows you to use the keywords BYTE and CHAR interchangeably, so those of you with PASCAL or C experience can use CHAR when dealing with characters and feel more at home.

3.3.2 CARDinal

The CARD type is very similar to the BYTE type, except that It handles much larger numbers. This is because it is internally represented as a two-byte unsigned number. Hence its values range from 0 to 65,535.

> **TECHNICAL NOTE: a CARD is stored in the LSB, MSB form which is standard on 6502-based machines.**

3.3.3 INTeger

This type is like BYTE and CARD in that it is integer only, and can be entered in numeric format, but that is where the similarity ends. INT allows both positive and negative numbers ranging from -32768 to 32767. It is internally represented as a two byte signed number.

> **TECHNICAL NOTE: INTs are Stored LSB, MSB like CARDS.**

3.4 Declarations

Declarations are used to let the computer know that you wish to define something. For example, if you want the variable 'cost’ to be of the type CARD, somehow you have to tell this to the computer. Otherwise the computer won't know what to do when it sees ‘cost'.

Every identifier you use must be declared before it is used, whether it's a variable, procedure, or function

name. Variable declarations will be explained here, followed by a note about numeric constant declarations; procedure and function declarations are explained in chapter 6.

3.4.1 Variable Declaration

The procedure for declaring a variable is the same no matter what fundamental type you want it to be. The basic format is:

<type> <ident> {=<inlt info>} |:,<ident>{=<init info>}:I

where

<type>	is the fundamental type of the variable(s) being declared
<ident>	is an identifier naming the variable
<init info>	allows you to initialize the value of the variable, or define the memory location of that variable

'<init info> ' has the form:

<addr> I [<value>]

where

<addr>	is the address of the variable and must be a compiler constant
<value>	is the initial value of that variable, and must be a numeric constant

NOTE: an explanation of <, >, {, } , |:,:|, and | can be found in the vocabulary (chapter 2).

Notice that you can optionally have more than one variable declared by one <type>. You can also optionally tell the compiler where you want each variable to reside in memory or initialize the variable to a value. The following examples should help clarify this format:

```
BYTE top,hat            ;declare 'top' and 'hat' as BYTE variables

INT num=[0]       ;declare 'num' as an INT variable and
;initialize it to 0

BYTE x=$8000,y= [0]     ;declare 'x' as BYTE, placing it at memory location
$8000
;declare and initialize 'y' to zero
CARD ctr=[$83D4],       ;declares and initializes
bignum=[0],             ;three variables as CARD
cat=[30000]             ;type
```

In the last two examples you may note that the variables need not be on the same line. The ACTION! compiler will keep reading in variables of the type given as long as there are commas separating them, so remember not to put a comma after the last variable in a list (strange things will happen if you do).

Variable declarations must come immediately after a MODULE statement (see section 7.4) or at the beginning of a procedure or function {see sections 6.1*I and 6.2.1). If you use them anywhere else you will get an error.

3.4.2 Numeric Constants

Numeric constants are not explicitly declared. Their usage declares their type. A numeric constant is considered to be of type BYTE if it is less than 256, otherwise it is considered to be of type CARD. For all practical purposes, negative constants (e.g. -7) are treated as type INT:

Constant	Type
543	CARD
$0D	BYTE
$f42	CARD
'w	BYTE

Chapter 4: Expressions

Expressions are constructions which obtain values from variables, constants, and conditions using a specific set of Operators. For example, '4+3' is an expression that equals '7' as long as we take the operator to mean addition. If the operator were instead *, multiplication would result, and the expression would equal '12' (4*3=12). ACTION! has two types of expressions, arithmetic and relational. The example given above is an arithmetic expression. Relational expressions are those which involve a 'true' or 'false' answer. '5 >=7' is false if we take '>=' to mean "is greater than or equal to". This type of expression is used to evaluate conditional statements (see section 5.2.1). A conditional statement in every day life might be, "If it Is five o'clock or later, then it's time to go home." An ACTION! relational expression for this might be:

```
hour >= 5
```

You yourself make this check (and many others) automatically when you look at a clock, but the computer needs to be told exactly what to check for.

Before going into the expressions themselves, we need to define the operators that apply to each type of expression. After that we'll discuss each expression, and then go into some special extensions of relational expressions.

4.1 Operators

ACTION! supports three kinds of operators:

1) Arithmetic operators
2) Bit-wise operators
3) Relational operators

As suggested by the names of the first and last, they specifically pertain to an expression type. The second class of operators performs arithmetic and addressing operations at bit level.

4.1.1 Arithmetic Operators

The arithmetic operators are those we commonly use in math, but some are modified so that they can be typed in from a computer keyboard. Here is a list of those ACTION! supports, each followed by it's meaning:

Op.	Explain	Example	Description
-	unary minus (the negative sing)	-5	
*	multiplication	4*3	
/	Integer division	13/5	This equals 2, since the remainder is dropped
MOD	remainder of integer division	13 MOD 5	This equals 3, since 13/5=2, with a remainder of 3
+	addition	4+3	
-	subtraction	4-3	

Table 2 Arithmetic operators in ACTION!

Notice that '=' is not an arithmetic operator. It is used only in relational expressions, certain declarations, and assignment statements.

4.1.2 Bit-wise Operators

Bit-wise operators manipulate numbers in their binary form. This means that you can do operations similar to those the computer does (since it always works with binary numbers). The following list summarizes the operators

&	Bit-wise AND	**%**	Bit-wise OR	**!** or **XOR**	Bit-wise Exclusive OR
LSH	Left shift	**RSH**	Right shift	**@**	Address of

The first three compare numbers bit by bit and return a result dependent on the operator, as seen below.

& compare the two bits, returning a value based on this table.

Bit A	Bit B	Result
0	0	0
0	1	0
1	0	0
1	1	1

Table 3 Bit-Wise AND

Example:

```
5 & 39 --- 00000101 (equals 5 decimal)
           00100111 (equals 39 decimal)
         & ------------
           00000101 (result of & is 5)
```

% returns a value dependent on this table.

Bit A	Bit B	Result
0	0	0
0	1	1
1	0	1
1	1	1

Table 4 Bit-Wise OR

Example:

```
5 % 39 --- 00000101 (5)
           00100111 (39)
         % ------------
           00100111 (result of % is 39)
```

! returns a value based on this table.

Bit A	Bit B	Result
0	0	0
0	1	1
1	0	1
1	1	0

Table 5 Bit-Wise XOR

Example:

```
5 ! 39 --- 00000101 (5)
           00100111 (39)
         ! ------------
           00100010 (result of 1 is 34)
```

Both LSH and RSH shift bits. If they operate on two-byte types (CARD and INT) the shift occurs through both bytes. In the case of INT, the sign of the number is not preserved when using RSH or LSH, and may change.

Their form is:

<operand> <operator> <number of shifts>

where

<operand>	Is a numeric constant or variable
<operator>	Is either LSH or RSH
<number of shifts>	Is a numeric constant or a variable that is used to determine the number of bits to shift the operand by.

Some examples to illustrate both LSH and RSH follow:

(5)	00000101	(39)	00100111
(5 LSH 1) = 10	00001010	(39 LSH 1) = 78	01001110
(5 RSH 1) = 2	00000010	(39 RSH 1) = 19	00010011

Table 6 8 bit shift operations

Operation	MSB	LSB	Description
----	01010110	11001010	$56CA
LSH 1	10101101	10010100	$56CA LSH 1 = $AD94
RSH 1	00101011	01100101	$56CA RSH 1 = $2B65
LSH 2	01011011	00101000	$56CA LSH 2 = $5B28
RSH2	00010101	10110010	$56CA RSH 2 = $15B2

Table 7 16 Bit Shift Operations

Notice that a LSH by one is the same as multiplying by two, and a RSH by one is like division by two (for positive numbers). In fact, this method of multiplication and division is faster than using '*2' and '/2 ' because it is closer to what the computer understands, so the computer doesn't need to translate the expression into its own binary operation format.

The '@' operator gives the address of the variable to its right. It cannot be used with numerical constants. '@ctr' will return the address in memory of the variable 'ctr'. The '@' operator is very useful when dealing with pointers.

4.1.3 Relational Operators

Relational operators are allowed only in relational expressions, and relational expressions are allowed only in IF, WHILE, and UNTIL statements. Relational operators may not appear anywhere except in these statements. As outlined in the overview of this section, relational operators test conditions of equality. A table of the ACTION! relational operators follows:

Operator	Description	Example	Result
=	Test for equality	4 = 7	this is obviously false
#	Test for inequality	4 # 7	True
<>	Same as #	4 <> 7	True
>	Test for greater than	9 > 2	True
>=	Test for greater than or equal to	5 >= 5	True
<	Test for less than	2 < 9	True
<=	Test for less than or equal to	5 <= 5	True
AND	Logical AND	See section 4.4	
OR	Logical OR	See section 4.5	

Table 8 Relational Operators

Both '#' and '<>' mean the same thing to ACTION!, so you may use the one you prefer. 'AND' and 'OR' are special relational operators, and are discussed in 'Complex Relational Expressions', section 4.4.

> **TECHNICAL NOTE: the ACTION! Compiler does comparisons by subtracting the two values in question and comparing the difference to 0. This method works correctly with one exception -- if you are comparing a large positive INT value with a large negative INT value, the outcome could be wrong (since INTs use the highest bit as a sign bit).**

4.1.4 Operator Precedence

Operators require some kind of precedence, a defined order of evaluation, or we wouldn't know how to evaluate expressions like:

$$4 + 5 * 3$$

Is this equal to (4+5)*3 or 4+(5*3)? Without operator precedence it's impossible to tell, ACTION!'s precedence is very precise but can be circumvented by using parentheses, since they have the highest precedence. In the following table the operators are listed in order of highest to lowest precedence. Operators on the same line have equal precedence and are evaluated from left to right in an expression (see examples).

( )	Parentheses
- @	Unary minus, address of
* / MOD LSH RSH	Multiply, Divide, Modulus, Shifts
+ -	Addition and Subtraction
= # <> > >= < <=	Relational Operators
AND &	Logical/bitwise AND
OR %	Logical/Bitwaise OR
XOR !	Bitwise Exclusive OR

Table 9 Operator Precedence Highest to Lowest

According to this table, our earlier example, 4+5*3, would be evaluated as 4+(5*3) because the '*' is of higher precedence than the '+'. What if (4+5)*3 were intended? You'd have to include the parentheses, as shown, to override the normal operator precedence. Here are some examples to look over?

Expression	Result	Evaluation order
`4/2*3`	6	/,*
`5<7`	True	<
`43 MOD 7 * 2 + 19`	21	MOD,*,+
`-((4+2) / 3)`	-2	+,/,-

Table 10 Examples of operator precedence

4. 2 Arithmetic Expressions

An arithmetic expression consists of a group of numerical constants, variables and operators ordered in such a way that there is a numerical result. The order is as follows:

<operand> <operator> <operand>

Where '<operand>' is a numeric constant, numeric variable, FUNCtion call (see section 6.2.3), or another arithmetic expression. The first three possibilities are straightforward enough, but the last one is a problem.
Here's an example to show you what we mean:

starting expression: 3 * (4 + (22 / 7) * 2)

Order	Expression	Evaluation	Simplified expr
Start	`3*(4+(22/7)*2)`	-	-
1	`(22/7)`	3	3*(4+3*2)
2	`(22/7)*2`	6	3*(4+6)
3	`(4+(22/7)*2)`	10	3*10
4	`3*(4+(22/7)*2)`	30	30

Table 11 Order of the expression evaluation

Column	Explain
Order	is the order of the expression evaluation
Expression	shows which expression is being evaluated
Evaluation	shows the evaluation of that expression
Simplified exp	shows the expression after the evaluation has taken place

Notice that expressions 2 through 4 contain another expression as one of their operands, but that this "expression as an operand" has already been evaluated, leaving a number in its place, as seen in 'simplified exp' .

Some examples follow (all lowercase words are variables or constants):

Expression	Evaluation order
`'A * (dog +7)/3`	+,*,/
`564`	None
`Var & 7 MOD 3`	MOD, &
`Ptr+@xyz`	@,+

Arithmetic expressions in ACTION! may involve operands of differing data types.

The result of such mixing is outlined in the table below. The type at the intersection of any row and column is the type resulting when the row's and column's types are mixed:

	BYTE	INT	CARD
BYTE	BYTE	INT	CARD
INT	INT	INT	CARD
CARD	CARD	CARD	CARD

NOTE: using the unary minus (negative sign '-') results in an Implied INT type, and using the address operator '@' results in an implied CARD type.

TECHNICAL NOTE: using the '*' operand results in an INT type, so multiplication of very large CARD values (> 32767) will not work properly.

4.3 Simple Relational Expressions

Relational expressions are used in conditional statements to perform tests to see whether a statement should be executed (more on conditional statements in section 5.2.1) . Note that they may be used ONLY in conditional statements (IF WHILE, UNTIL).

There may be only one relational operator in a simple relational expression, so tests for multiple conditions must be handled differently (They are covered in the following section on complex relational expressions). The form of a simple relational expression is:

<arith expxr><rel operator><arith exp>

where

<arith exp>	is an arithmetic expression
<rel operator>	is a relational operator

Here are some samples of valid relational expressions:

```
@cat<=$22A7
Var<>'y
5932#counter
(5&7)*e >= (3*(Ccat+dog))
addr/SPF+(@ptr+offset) <> SF03D-ptr&offset
(5+4)*9 > ctr-1
```

4.4 Complex Relational Expressions

Complex relational expressions allow you to cover a wider range of tests by including multiple tests. If you want to do something only on Sundays in July, how do you get the computer to test whether it's Sunday and then test whether it's July? ACTION! allows you to do this kind of multiple testing with the AND and OR operators (remember how they were glossed over in section 4.1.3?). The compiler treats these as special relational operators to test a condition using simple relational expressions. The form is:

<rel exp><sp op><rel exp>|:<sp op><rel exp>:|

where

<rel exp>	is a simple relational expression
<sp op>	is one of the special operators AND or OR

NOTE: there are no exceptions to this form. If you try something else, you will usually get the compiler error 'Bad Expression'.

The truth table below shows what each of these operators will do in a given situation. ‘exp 1' and 'exp 2' are the simple relational expressions on either side of the special operator; 'true' and 'false' are the possible results of a relational test.

RELATIONALS		RESULTS	
Exp1	**Exp2**	**AND**	**OR**
False	False	False	False
False	True	False	True
True	False	False	True
True	True	True	True

NOTE: you may use parentheses around one segment of a complex relational expression to insure the order of evaluation. If you don't do this, the expressions are evaluated in left to right order. (see Examples)

WARNING: at the writing of this manual, the ACTION! compiler sees the pairs AND -- &, and OR -- % as synonyms, and they are evaluated in the same way (bit-wise). If you follow the rules outlined above when using them you should have no problems. Also, if you stick to using 'AND' and 'OR’ only in the relational sense, and '&* and *%' only in the bit-wise sense, your programs will be compatible with possible upgrades of ACTION!.

Here are some samples of valid complex relational expressions:

```
cat<=5 AND dog<>13
(@ptr+7)*3 # $60FF AND @ptr<=$1FFF
X ! $F000 OR dog>=100
(8 & cat)<10 OR ptr<>$0D
cat<>0 AND tdog>=400 OR dog<-400)
ptr=$D456 OR ptr=$E000 OR ptr=$600
```

Here's a confusing situation:

```
$F0 AND $0F
```

is false because the 'AND’ is seen as a bit-wise operator being used in an arithmetic expression, whereas

```
$F000 AND $0F00
```

is true because the 'AND' join two simple relational expressions and so is a special operator as used in complex relational expressions.

A computer program would be useless if it could not actively operate on data. You would be allowed to declare variables, constants, etc., but there would be no way to manipulate them. Statements are the active part of any computer language, and ACTION! is no exception. Statements translate an action you want to do into a form which the computer can understand and execute properly. This is why statements are sometimes referred to as executable commands.

There are two classes of statements in ACTION!: simple statements and structured statements. Simple statements contain no other statements within themselves whereas structured statements are collections of other statements (either simple or structured) put together following a certain order. Structured statements may be broken down into two categories:

1) Conditional Statements
2) Looping Statements

Each category is discussed separately in the section on structured statements.

5.1 Simple Statements

Simple statements are those which do one thing only. They are the basic building blocks of a program, since any action the computer performs is a simple statement of one kind or other. There are two simple statements in ACTION!:

1) Assignment Statement (including FUNCtion Calls)
2) PROCedure Calls

PROCedure and FUNCtion calls are discussed in chapter 6, and the assignment statement follows. There are two keywords that are also simple statements,

EXIT	section 5.3.3.2
RETURN	sections 6.1.2 and 6.2.2

but the last two are used in specific constructs, and so are discussed where appropriate to their usage.

5.1.1 Assignment Statement

The assignment statement is used to give a value to a variable. Its most common form is;

<variable> = <arithmetic expression>

> **NOTE: <variable> may be a variable of a fundamental data type, or it can be an array, pointer, or record reference.**
>
> **NOTE: the expression MUST be arithmetic. If you try to use a relational expression, you will get an error because the ACTION! compiler does not assign a numerical value to the evaluation of a relational expression.**

The assignment operator is '='. It tells the computer that you want to assign a new value to the given variable. Do not confuse it with the relational '='. Although they are the same character, the compiler reads them differently, each according to its context.

The following examples illustrate the assignment statement. You'll notice a variable declaration section preceding the examples themselves. It's there because some of the examples show what happens when you mix types (i.e. the variable and value being assigned to it are not of the same data type).

Declaration of variables

```
BYTE b1,b2,b3,b4
INT i1
CARD c1
```

`b3='D`	puts the ATASCII code number for 'D' into the byte reserved for 'b3' .
`b4=$44`	puts the hex number $44 into the byte reserved for the BYTE variable 'b4' ($44 is 'D' in ATASCII and so 'b3' and 'b4' now contain the same thing).
`b1=b4+16`	adds 16 to the numerical value of 'b4', and puts the result into the byte reserved

	for ‘b1'.
`C1=23439-$07D8`	puts the value 21431 (S53B7) in the two bytes reserved for ‘c1’.
`i1=c1*(-1)`	puts the value -21431 (SAC49) in the two bytes reserved for 'i1’ .
`b2=i1`	puts the value $49 (73) into the byte reserved for 'b2'. Notice that the computer takes the LSB of 'il' to put into 'b2’ (the MSB of il is $AC, the LSB is $49).
`b2=b2+1`	adds 1 to the current value of 'b2’ and stores the sum back into ‘b2'. 'b2' now contains $4A (74).

Notice that the last example's form is:

<var>=<var> <operator> <operand>

Since programmers often use the above format, ACTION! allows the following shorthand form to do the same thing:

<var>==<operator> <operand>

The operator must be either arithmetic or bit-wise. The operand must be an arithmetic expression. The following are some examples of this shorthand form:

`b2==+1`	is the same as	`b2=b2+1`
`b2==-b1`	is the same as	`b2=b2-b1`
`b2==&$0F`	is the same as	`b2=b2 & $0f`
`b2==LSH (5+3)`	is the same as	`b2=b2 LSH (5+3)`

This shorthand form can save you a lot of typing over the long method and even generates better machine code in some instances.

5.2 Structured Statements

If only simple statements were available, you'd be severely limited in the number of things you could do on a computer:

> The only way you could repeat a group of statements a number of times would be to type them out in the same order the right number of times. If you wanted to repeat a group of ten statements ten times, you would end up typing in 100 statements!
>
> You would not be able to execute a group of statements conditionally, that Is, only execute them if some specified test is satisfied.

The purpose of structured statements is to solve these and other problems. Structured statements as a whole are divided into two separate categories; Conditional Statements and Looping Statements. We will discuss each of these categories separately.

5.2.1 Conditional Execution

Conditional execution allows you to test an expression and execute various statements depending on the outcome of the test. Since the expression controls conditional execution, it is called a conditional expression.

Three ACTION! statements allow conditional execution:

`IF` `WHILE` `UNTIL`

WHILE and UNTIL are looping statements and will be dealt with later, but we'll discuss IF immediately after the rules governing conditional expressions.

5.2.1.1 Conditional Expressions

Since a conditional expression is involved in a test, there are only two values it may have -- true or false. This does not mean a conditional expression is a new type of expression, however. In fact, a conditional expression is simply either a relational or arithmetic expression. Only the interpretation is different. The following table shows what the conditional interpretation is, depending on which type of expression it is:

Expression Type	Normal Result	Conditional Result
arithmetic	zero (0)	false
	non-zero	true
relational	false	false
	true	true

5.2.1.2 IF Statement

The IF statement in ACTION 1 is much li"ke the 'if' conditional statement in English. For example:

"If I have $9 or more, I'll buy the steak."

In ACTION! the same statement might be:

```
BYTE money,
  steak=[9],
  fish=[8],
  chicken [6],
  hotdog=[2]

IF money>=9 THEN
  buy(steak, money)
FI
```

NOTE: buy(Steak, money) is a procedure call and will be dealt with in section 6.1.3.

From the above example you can see that the basic form of the IF statement is:

```
IF <cond exp> THEN
        <statement(s)>
FI
```

'FI' is not part of "Fe fi fo fun", but **'IF'** spelled backwards, and a keyword to the compiler showing the end of an **IF** statement. Since **IF** can work on a list of statements, we need **'FI'** to terminate that list. Without this keyword the compiler would not know how many of the statements following the **THEN** went with the **IF** statement.

The above is only the basic format. The **IF** statement has two options, **ELSE** and **ELSEIF**. English also has these options, so we'll use comparative examples:

"If I have $9 or more I'll buy the steak, otherwise I'll buy the fish platter."

The ACTION! equivalent of this is:

```
IF money>=9 THEN
  buy(steak, money)
ELSE
  buy(fish, money)
FI
```

ELSEIF is somewhat different:

"If I have $9 or more I'll buy the steak. If I have between $8 and $9 I'll buy the fried fish, If I have between $6 and $8 I'll buy the chicken. Otherwise I'll buy the hotdog." would be:

```
IF money>=9 THEN
  buy(steak, money)
ELSEIF money>=8 THEN
  buy(fish, money)
ELSEIF money>=6 THEN
  buy(chicken, money)
ELSE
  Buy(hotdog, money)
FI
```

in ACTION!. Notice that we don't have to check for "money>=8 AND money<9 as in English. We can do this because the computer goes through the list sequentially from top to bottom. If any conditional case is true, the statements it controls are executed, and then the whole rest of the IF statement (including all following ELSEIF and ELSEs) is skipped. So, if the computer does get to "money>=8", we already know that we have less than $9, because the proceeding conditional tested for "money>=9" and found that condition false.

The ELSEIF option is very useful when you want to test a variable for a number of different conditions, each requiring a different action.

5.2.2 Null Statement

The null statement is used to do nothing. After showing you some statements that do something and after stressing the necessity of statements that do something, why is there a statement that does nothing? There are actually a couple of good uses for a statement that does nothing:

Timing Loops and ELSEIF cases.

Since we haven't yet (discussed loops at all, we'll simply say that timing loops are used as a time delay (e.g., if you want to pause between printing lines to the screen, you just use a timing loop to waste a few moments). You can find an example of a timing loop in section 5.2.4.1.

To illustrate the use of the null statement in ELSEIF cases, here is an example:

SCENARIO: You are writing a program that allows stock brokers to find out information about certain stocks, using the commands you have made available! The commands you're implementing are: BUY, DOWN?, FIND, QUIT, SELL, and UP?, but you haven't Implemented FIND yet. All you do is test the first letter of the entered command, so you have to test for B,D,F,Q,S, and U. But FIND isn't done, so what do you do when they type 'F'?

Easy, you do nothing, hoping that someday (when FIND is ready) you'll do something. Here's how the program fragment might look:

```
IF chr='B THEN dobuy()
ELSEIF chr='D THEN dodown()
ELSEIF chr='F THEN                ;**** here's the null statement
ELSEIF chr='Q THEN doquit()
ELSEIF chr='S THEN dosellt)
ELSEIF Chr='U THEN doup()
ELSE doerror()                    ;no command match
FI
```

All the 'do--- 's are procedures to do the given command. If you look at the case of "chr ='F", you see that nothing is done. That's the null statement. When FIND is ready, all you need to do is put the 'dofind()' procedure in Where the null statement now is, and you'll have it in the look-up table and ready for use.

5.2.3 Loops

Loops are used to repeat things, specifically statements. If, for some strange reason, you wanted to fill the screen with stars (*) you could either send out each star with a separate statement, or you could use a loop to do this for you. All you need to do is tell the loop how many times you want it to put out a single star, and it will do it (if you use the proper statement format of course).

There are two ways to tell a loop how many times you want it to do something. You can give it an explicit number, or you can give it a conditional expression and execute the loop depending on the outcome of that expression. The FOR statement uses the first method, and both WHILE and UNTIL use the second.

What happens when you don't tell the loop how many times it should execute? What happens when the conditional expression never evaluates to a value that will stop the loop? You get what is known as an 'Infinite Loop'. There is only one way to get out of an infinite loop; you have to push the <SYSTEM RESET> key.

ACTION! approaches loops in the following manner. There is a basic loop, which, when used alone, is infinite. Then there are some loop controlling statements (FOR, WHILE, UNTIL) which limit the number of times this infinite loop executes. We'll follow the same pattern; first a discussion about the basic loop structure, followed by an in depth look at the loop controlling statements.

5.2.3.1 DO and OD

'DO' and 'OD' are used to mark the beginning and end, respectively, of the basic loop. Everything between them is considered to be part of that loop. As mentioned above, a loop alone (i.e. without any loop controlling statement) is an infinite loop, and you must force a break out of it. Following ia a program example to illustrate the DO - OD loop. Don't worry about the 'PROC' and 'RETURN' statements; they're just there so that the program will compile and run properly, and will be discussed In full in the procedures and functions chapter (6).

Example 1:

```
PROC timestwo()

CARD i=[0], j

DO                                      ;start of DO - OD loop
  I==+1                                 ;add 1 to 'i'
  J=i*2                                 ;set 'j' equal to i*2
  PrinteC(i)                            ;*** See the following
  Print(" times 2 equals " )            ;PROGRAMMING NOTE for
  PrintCE(j)                            ;an explanation
OD                                      ;end of DO - OD loop
RETURN
```

PROGRAMMING NOTE: the mixed case words (PrintC, Print, PrintCE) you see in the example above are ACTION! library functions and procedures. You may learn more about them (although their jobs here are fairly obvious) in Part VI, 'The ACTION! Library', You will see library routines used throughout the rest of this chapter, so don't be alarmed; they're only there because they do things that make the examples more visually instructive.

Output #1:

```
1 times two equals 2
2 times two equals 4
3 times two equals 6
4 times two equals 8
5 times two equals 10
6 times two equals 12
7 times two equals 14
8 times two equals 16
          :
          :
```

The dot dot dot at the end of the output shows that this will go on forever, or until you press the <SYSTEM

RESET> key. On its own, a DO - OD loop is more or less useless, but when used in conjunction with the loop controlling statements FOR, WHILE, and UNTIL it becomes one of the most useful statements available.

> **NOTE: hitting the <BREAK> key would also get you out of the loop in example #1, because the loop is doing a lot of I/O. (<BREAK> only works when doing a lot of I/0. See Part IV, 'The ACTION! Compiler', for more information.)**

Whenever you see '<D0 - OD loop>' in the fromats of the loop controlling statements, remember that it means a loop, and that in turn means a DO - OD pair surrounding the loop.

5.2.3.2 EXIT Statement

The EXIT statement is used to hop gracefully out of any loop. This statement will cause program execution to skip to the statement following the next 'OD'. Here's an example:

Example #2:

```
PROC timestwo()

CARD i=[0], j

DO                                      ;start of DO - OD loop
   I==+1                                ;add 1 to 'i'
   J=i*2                                ;set 'j' equal to i*2
   PrinteC(i)
   Print(" times 2 equals " )
   EXIT                                 ;Here's the EXIT statement
   PrintCE(j)
OD                                      ;end of DO - OD loop

;******* Execution continues here after EXIT
PrintE("End of Table");

RETURN
```

Output #2

```
1 times 2 equals End of Table
```

As you can see in the output, the statement 'PrintCE(j)' is never executed. The EXIT statement forces execution to hop to the statement 'PrintE("End of Table"). EXIT isn't very useful when utilized alone, but if you use it in conjunction with an IF statement (i.e., make the EXIT into a conditional jump out of the loop), it can be very useful, as the program on the following page shows.

Example #3:

```
PROC timestwo()

CARD i=[0], j

DO                                      ;start of DO - OD loop
   IF i=15 THEN
     EXIT                               ;Exit in an IF condition
   FI
   I==+1                                ;add 1 to 'i'
   J=i*2                                ;set 'j' equal to i*2
   PrinteC(i)
   Print(" times 2 equals " )
   EXIT                                 ;Here's the EXIT statement
   PrintCE(j)
OD                                      ;end of DO - OD loop
;******* Execution continues here after EXIT
PrintE("End of Table");
RETURN
```

Output #3:

```
1 times 2 equals 2
2 times 2 equals 4
3 times 2 equals 6
4 times 2 equals 8
```

```
5 times 2 equals 10
6 times 2 equals 12
7 times 2 equals 14
6 times 2 equals 16
9 times 2 equals 18
10 times 2 equals 20
11 times 2 equals 22
12 times 2 equals 24
13 times 2 equals 26
14 times 2 equals 28
15 times 2 equals 30
End of Table
```

This usage turns an infinite loop block into a finite one. EXIT can control the execution of a loop, but is not considered a structured loop controlling statement because it doesn't stand on its own; that is, it is only useful when used in conjunction with the structured 'IF' statement.

5.2.4 Loop Controls

ACTION! has three structured statements that control the basic DO - OD loop:

1) FOR
2) WHILE
3) UNTIL

By saying that they "control the basic DO - OD loop", we mean that they limit the number of times the infinite loop executes, thus making it a finite loop. Controllable loops are one of the devices that make computers very useful. If someone told you to write "I'll never throw spitwads again" one thousand times, you would call that punishment, but if you told the computer to do tbe same thing (with a controlled loop, of course), it would think that the task was easy and mundane.

Now we'll take a look at each loop controlling statement in depth, and then go into a property of all ACTION! structured statements: nesting.

5.2.4.1 FOR Statement

The FOR statement is used to repeat a loop a given number of times. It requires its own special variable, commonly called a counter. In the examples the counter will be called ctr, to remind you of this, but you could call it anything you like. The format of the FOR statement is:

FOR <counter>=<initial valued> TO <final value> {STEP <inc>}
<D0 - OD loop>

where

FOR <counter>	is the variable used to keep track of the number of times the loop has executed
<initial value>	is the starting value of the counter
TO <final value>	is the ending value of the counter
STEP <inc>	is the amount by which the computer increments the counter after every iteration **NOTE**: the 'STEP <inc>' is optional
<D0 - OD loop>	is a DO - OD infinite loop

Instead of trying to explain this to you using metaphors, we'll throw a few examples at you, because they more or less speak for themselves. Following each is its output.

Example #1:

```
PROC hithere()

BYTE ctr                              ;counter used in FOR loop

FOR ctr= 1 TO 5                       ;this FOR loop has no 'STEP', so
DO                                    ;an increment of 1 is assumed.
   PrintE("Hi there")
OD
RETURN
```

Output #1:

```
Hi there
Hi there
Hi there
Hi there
Hi there
```

Example #2:

```
PROC evens()

BYTE ctr                              ;counter used in FOR loop

FOR ctr=0 TO 16 STEP 2                ;this FOR loop has a 'STEP'
DO
   PrintB(ctr)
    Print(" ")
OD
RETURN
```

Output #2:

```
0 2 4 6 8 10 12 14 16
```

Look back at the format of the FOR statement. Notice that we said nothing about using numeric **variables** as <initial value>, <final value>, or <inc>. Doing this is legal, and allows you to make FOR loops execute a variable number of times.

If you change the value of the variables used as <initial value>, <final value>, or <inc> in the loop itself, you won't change the number of times the loop is executed. This is true because <initial value>, <final value>, and <inc> are set with a constant value when you enter the loop. If you do use variables, the value used when setting these is the value the variable had when the loop was first entered.

If you change the value of <counter> in the Ic op, you will change the number of times the loop executes, because <counter> is a variable in the loop. It. is variable in the loop because the FOR statement itself must change the value of <counter> every time it goes through the loop (for increments <counter> by the STEP value). Following is an example to illistrate changing <initial value>, <final Value>, and <counter> in the FOR loop itself:

Example #3:

```
PROC changeloop()

BYTE ctr,start=[1], end=[50]

FOR ctr=start TO end
DO
   Start=100                  ;doesn't affect number of repetitions
   End=10                     ;doesn't affect number of repetitions
   PrintBE(ctr)
   Ctr==*2                    ;DOES affect number of repetitions
OD
RETURN
```

Output #3:

```
1
3
7
15
31
```

Below is a table to show what is going on each time

through the Loop. ‘rep' tells which repetition the loop is on, ‘inc ctr’ shows the result of the FOR loop incrementing the value of the counter, 'Print' shows what is printed out to the screen, and ‘ctr==*2' shows how this assignment statement changes the value of the counter:

rep	inc ctr	Print	ctr==*2
1	---	1	2
2	3	3	6
3	7	7	14
4	15	15	30
5	31	31	62

After the fifth loop is through, the counter equals 62. This is greater than <final value> (50), so the loop is exited after only 5 repetitions, not 50. Manipulating the counter within its own loop can lead to very Interesting results, some of which night even be useful.

As promised in section 5.2.2, here's an example of a timing loop:

```
BYTE ctr

FOR ctr=1 TO 250
DO
     ;*** here's the null statement
OD
```

This is just used as a time-waster; something you'll use a lot if you're writing games or other programs which involve careful timing.

> **PROGRAMMING NOTE: If you write a FOR loop which continues to the limit of the data type of the counter (e.g., 'FOR ctr=0 TO 255' if ctr is a BYTE, or 'FOR ctr=0 TO 65535’ if ctr is a CARD), the loop will be infinite because the counter can't be Incremented to a value greater the the given <final value>.**

5.2.4.2 WHILE Statement

The WHILE statement (and the UNTIL statement, for that matter) is used when you don't want to execute a loop a predetermined number of times. WHILE allows you to keep looping as long as a given conditional expression is ‘true’.
It has the form:

WHILE <cond exp>
<DO - OD loop>

where

WHILE <cond exp>	is the controlling conditional expression
<DO - OD loop>	is a DO - OD infinite loop

Since the evaluation of the conditional expression is done at the start of the loop, ‘<DO OD loop>' might not be executed at all.

This is not the case with UNTIL, as you will see later. Program examples using WHILE start on the following page.

Example #1:

```
PROC factorials()       ;*** This procedure will print out the factorials
                        ; up to some specified number (the variable 'amt')
CARD fact=[1],                      ;the factorial of num
     num=[1],                       ;the counter
     amt=[6000]                     ;the upper bound

Print("Factorials less than ")
PrintC(amt)                         ;prints the upper bound
PrintE(":")                         ;print '.' a and carriage return
PutE()                              ;prints a carriage return

WHILE fact*num < amt                ;test next factorial
DO                                  ;start of WHILE loop
   fact==*num
   PrintC(num)                      ;print the number
   Print(" factorial ")
   PrintCE(fact)                    ;print number's factorial
   Num==+1                          ;increment number
OD                                  ;end of WHILE loop
RETURN                              ;end of PROC factorials
```

Output #1:

```
Factorials less than 6000:

1 factorial is 1
2 factorial is 2
3 factorial is 6
4 factorial is 24
5 factorial is 120
6 factorial ie 720
7 factorial is 5040
```

PROGRAMMING NOTE: If you go Over "Factorials less than 40000", you will discover that the compiler does no overflow error checking, because you'll see the output 'wrap around'; that is, you'll get a number larger than the maximum a CARD allows (65,535); and start at zero again. If you got up to, say, 66000, the output would show 66000*65536=464 because it went as high as it could go, and then wrapped around. The technical term for this kind of thing is 'overflow', and you can find out more about it in Part IV: 'The ACTION! Compiler'.

Example #2:

```
PROC guesswhlle()       ;**** This procedure plays a guessing game with
                        ;the user, using a WHILE loop to keep the game going
BYTE num,                               ;the number to guess
     guess=[200]                        ;guess is initialized to an
                                        ;impossible value
PrintE("Welcome to the guessing game. I'm")
PrintE("thinking of a number from 0 to 100")
num=Rand(101)                           ;gets the number to guess

WHILE guess <> num
DO ;start of WHILE loop
Print("What's your guess? ")
guess=InputB()                          ;get user's guess
IF guess <nun THEN ;guess too low
     PrlntE("Too low, try again")
   ELSEIF guess>num THEN                ;guess too high
     PrintE("Too high, try again")
   ELSE                                 ;guess just right
     PrintE("Congratulations ! ! ! !")
     PrintE("You got it")
   FI                                   ;end of guess testing
OD                                      ;end of WHILE loop
RETURN                                  ;end of PROC guesswhile
```

Output #2:

```
Welcome to the guessing game. I'm
thinking of a number from 0 to 100
What's your guess? 50
Too low, try again
What s your guess? 60
Too high try again
What's your guess? 55
Too low, try again
What's your guess? 57
Congratulations ! ! ! !
You got it
```

Notice how powerful manipulating conditionals like IF within a loop can be. It allows the computer to take care of multiple possible outcomes every time it goes through the loop.

5.2.4.3 UNTIL Statement

In the last, section we said that a WHILE loop could execute zero times because its conditional expression was evaluated before loop execution began. The form of the UNTIL statement is such that this loop always executes at least once. After you see the form you'll probably understand why this is so:

DO
<statement>
:
:
<stetement>
UNTIL <cond exp>
OD

This looks like a common DO - OD loop until you get to the statement just before the 'OD'. This UNTIL controls the infinite loop using the outcome of the conditional expression. If <cond exp> is true, then execution will continue at the statement after the 'OD', otherwise it will loop back up to the 'DO'.
Notice that the until must be the statement directly before the 'OD'. A program example should clarify this somewhat:

Example #1:

```
PROC gueesuntil()                    ;This procedure plays a guessing game
                                     ;with the user using an UNTIL loop
BYTE num,                                  ;the number to guees
     Guess                                 ;the user's guess

PrintE("Welcome to the guessing game. I'm")
PrintE("thinking of a number from 0 to 100")
num=Rand(101)                              ;get the number to guess
DO                                         ;start of UNTIL loop
   Print("What is your guess? ")
   Guess=inputB()                          ;get the user's guess
   IF guess<num THEN                       ;guess too low
      PrintE("Too low, try again")
   ELSEIF guess>num THEN                   ;guess too high
      PrirtEt("Too high, try again")
   ELSE                                    ;guess just right
      PrintE("Congratulations !!!")
      PrintE("You got it")
   FI                                      ;end of guess testing
   UNTIL guess=num                         ;floop control
OD                                         ;end of UNTIL loop
RETURN                                     ;end of PROC guessuntil
```

Output #1:

```
Welcome to the guessing game. I'm
thinking of a number from 0 to 100
What's your guesa? 50
```

```
Too low, try again
What's your guees? 60
Too high, try again
What’s your guess? 55
Too low, try again
What’s your guess? 57
Congratulations!!!
You got it
```

This is the same example as in the WHILE section, but this time implemented using an UNTIL loop. Notice that guess is not initialized in the variable declaration as it was in the WHILE equivalent. We can do this because the conditional expression 'guess=num' is not evaluated until we have gotten a guess from the user. This is one of the advantages of the UNTIL loop, and stems from the fact that the controlling conditional expression is at the end of the loop. WHILE requires evaluation of the conditional expression at the beginning of the loop, and so requires that 'guess' have a value.

5.2.5 Nesting Structured Statements

As mentioned in the overview of statements, structured statements are made up of other statements, together with some execution controlling information particular to a given structured statement. The statements within the structured statement may be either simple statements or other structured statements. Putting one structured statement inside of another is called nesting (because one of them is ‘nested' inside the other).

In sections 5.2.4.2 (WHILE) and (UNTIL), you can see examples of nesting an IF statement into WHILE and UNTIL loops. This type of nesting is very straightforward, and needn't be discussed further.

This section will deal with multiple nesting of the same type of structured statement (IFs inside IFs, FORs inside FORs, etc...).

When the IF statement is nested inside itself, confusion might seem to arise when trying to figure out what ELSE goes with which IF as you go deeper into the nested statements. The compiler avoids any confusion by IF-FI pairing. A FI is paired to the first preceding IF that doesn't already have a FI paired to it.
For example:

```
IF <expA> THEN
¦    IF <expB> THEN
¦    ¦    <statements>
¦    ELSEIF <expC> THEN      ;**** ELSEIF of IF <expB>
¦    ¦    IF <expD> THEN
¦    ¦    ¦    <statements>
¦    ¦    ELSE               ;**** else of IF <expD>
¦    ¦    ¦    <statements>
¦    ¦    FI                 ;**** end of IF <expD>
¦    FI ;**** of IF <expB>
ELSEIF <expE> THEN           ;**** ELSEIF of IF <expA>
¦    <statements>
ELSE                         ;**** else of IF <expA>
¦    <statements>
FI                           ;**** FI of IF <expA>
```

The dashed lines show the IF-FI pairings the comments show which IF statement a particular FI or ELSEIF pertains to; and the indentation shows a change of nexting levels.

The following program example contains nested FORs. This one even does something worthwhile, it prints out the multiplication table up to ten times ten.

Example:

```
PROC timestable()       ;*** This procedure prints out the multiplication
                        ;table up to 10 times 10
BYTE c1,                                    ;*counter for outer FOR loop
     c2                                     ;*counter for inner FOR loop

FOR C1=1 TO 10                              ;*outer loop control
DO        ;*start of outer loop
  IF c1<10 THEN                             ;*single digits need a space
  Print(" ")                                ;before them in the first column
  FI
  PrintB(c1)                                ;*print 1st number in column
  FOR c2-2 TO 10                            ;*inner loop control
  DO                                        ;*start of inner loop
    IF c1*c2 < 10 THEN                      ;*single digits need 3
      Print(" ")                            ;spaces
    ELSEIF c1*c2<100 THEN                   ;*double digits )
      Print(" ")                            ;need 2 spaces
    ELSE                                    ;*triple digits need 1
      Print(" ")                            ;space only
    FI                                      ;*end of digit spacing
    PrintB(c1*c2)                           ;*print the result
  OD                                        ;*end inner loop
PutE()                                      ;*put out a carriage return
OD                                          ;*end of outer loop
RETURN                                      ;*end of PROC timestables
```

Output:

```
  1   2   3   4   5   6   7   8   9  10
  2   4   6   8  10  12  14  16  18  20
  3   6   9  12  15  18  21  24  27  30
  4   8  12  16  20  24  28  32  36  40
  5  10  15  20  25  30  35  40  45  50
  6  12  18  24  30  36  42  48  54  60
  7  14  21  28  35  42  49  56  63  70
  8  16  24  32  40  48  56  64  72  80
  9  18  27  36  45  54  63  72  81  90
 10  20  30  40  50  60  70  80  90 100
```

As you can see from the above examples, nesting can be used to accomplish quite a bit, if you know what you're doing. Fortunately, "knowing what you're doing" doesn't take too much time, because the concept of nesting is universal to all structured statements. Once you understand it as applied to one statement, you can apply it to all of them.

Procedures and functions are used to make your ACTION!program more readable and usable. Almost everything we do is a procedure or function in some way or other. For example, look at this table:

Procedures	Functions
Washing the car	Balancing your checkbook
Doing dishes	Looking up a phone number
Driving to work	
Going to school	

What makes these procedures and functions? Well, for each there's

1) a group of related actions done to accomplish the task
2) an accepted order in which these actions are done

Drying the dishes before you wash them breaks the accepted order, and taking off your left sock is not an action related to "Doing the dishes". We know these things from experience, and have lumped the proper group of actions done in the proper order into a procedure, one which we call "Doing the dishes".

In computer languages it's the same way. You make a group of actions that accomplish a single large task into a procedure or function, which you then give a name. When you want to execute this task, all you do is use the procedure or function name (with some extras we'll discuss later). This is referred to as a procedure or function call. The procedure or function must have already been defined, just like in English (e.g., you wouldn't know what to do if someone told you to "readjust the widget" unless you already knew the actions required to do this).

Now, what is the difference between procedures and functions? They both go through a series of ordered steps to accomplish a task, so why two names for the same construct? That is because they're not exactly the same construct. Functions have an added property, they do their task, and then return a value.

In the table at this section's beginning we see “Balancing your checkbook" given as a function example. Why? Well, when you balance your checkbook you go through a series of steps to bring your records up to date, and come up with a (hopefully positive) number at the end. This number is returned and can be used to do other things (like determine the size of your next check).

If we wanted to make "Doing the dishes" a function, we could change the statement to the question "Do the dishes need doing?", hoping that the person would answer the question, and then do the dishes if required. This would get the dishes done (like the procedure), but also return a value (whether the dishes needed doing in the first place), and thus make it a function.

> **NOTE: Throughout the rest of this manual we will use the word "routine”, instead of saying "procedure or function". Doing this makes the concepts easier to follow. When you see "procedure" or "function", it means the concept or idea being discussed is specific to that class of routines and not applicable to both classes.**

6.1 Procedures

Procedures are used to group some statements which accomplish a task into a named block that can be called on to do this task. To utilize procedures in ACTION!, you must learn how to do two things:

1) declare procedures
2) call procedures

The following three sections will show you how to do the above and give some examples to let you see procedures in ACTlON! (small pun intended).

6.1.1 PROC Declaration

The ACTION! keyword **PROC** is used to denote the start of a PROCedure declarationt PROCedure construction looks quite like a group of statements with a name and some other Information at the beginning, and a funny **RETURN** statement at the end. Below is a diagram of the construction.

PROC <identifier>[=<addr>]({<parameter list>})
{<variable declarations>}
{<statement list>}
RETURN

where

PROC	is the keyword denoting a procedure declaration
<identlfier>	is the name of the procedure
<addr>	optionally specifies the starting address of the procedure (See 9.3)
<parameter list>	is the list of parameters required by the procedure (see section 6.4 for an explanation of parameters)
<variable declaration>	is the list of variables declared local to this procedure [see 3.4.1] for variable declaration and 6,3 for scope of variables)
<statement list>	is the list of statements In the procedure
RETURN	denotes the end of the procedure (see next section)

NOTE: <paramet«r list>, < variable decl>, and <statem«nt list> are all optional. You will probably use at least some of them, but the following would be a valid procedure declaration:

```
PROC nothing() ;the parenthesee ARE required
RETURN
```

It does nothing, but this type of "empty" procedure is useful when you are writing a program made up of many procedures. If, for example, you have written a program that calls a procedure named "dotest", but you haven t yet written "dotest", you could make it an empty procedure so you could test the rest of the program without getting an "Undeclared Variable" error.

Don't worry about '<parameter list>' and "RETURN' in the format, because they'll be discussed later. The rest should look somewhat familiar, so we'll give an example:

```
PROC gueesuntil()            ;This procedure plays a guessing game with
                             ;the user using an UNTIL loop
BYTE num,                                    ;the number to guees
  Guess                                      ;the user's guess

PrintE("Welcome to the guessing game. I'm")
PrintE("thinking of a number from 0 to 100")
num=Rand(101)                                ;get the number to guess
DO ;start of UNTIL loop
  Print("What is your guess? ")
  Guess=inputB()                             ;get the user's guess
  IF guess<num THEN ;guess too low
    PrintE("Too low, try again")
  ELSEIF guess>num THEN                      ;guess too high
    PrirtEt("Too high, try again")
  ELSE                                       ;guess just right
```

```
    PrintE( "Congratulations !!!")
    PrintE("You got it")
  FI                                          ;end of guess testing
UNTIL guess=num  ;floop control
OD                                            ;end of UNTIL loop
RETURN                                        ;end of PROC guessuntil
```

This is just the program example from section 5.2.4.3, but now you understand why the PROC statement and the variable declaration section are there. As mentioned in the introduction, an ACTION! program requires a procedure declaration or a function declaration to be compilable. The above example has a procedure declaration, so it is a valid ACTION! program and, as such may be compiled and run. It's output is the same as that given in the UNTIL section, namely:

```
Welcome to the guessing game. I'm
thinking of a number from 0 to 100
What's your guees? 50
Too low, try again
What's your guess? 60
Too high, try again
What's your guess? 55
Too low, try again
What's your gueas? 57
Congratulations!i !!
You got it
```

If you look back at the above example, you'll see 'RETURN' as the last statement. We'll now cover why it's there.

6.1.2 Return

RETURN is used to tell the compiler to leave the procedure and return control to whatever called the procedure. If your program calls a procedure, execution will continue with the statement after the procedure call. If you are compiling a single procedure (or a one procedure program), control will be returned to the ACTION! Monitor.

WARNING: the compiler cannot detect a missing RETURN. Strange and disastrous things can happen if you leave out a RETURN. This also goes for RETURNs at the end of functions as well.

There can be more than one **RETURN** in a procedure. For example, if your procedure has an **IF** statement with lots of **ELSEIF**s, you might want to **RETURN** after one or more of the **ELSEIF** cases. The example on the following page illustrates this possibility.

Example:

```
PROC testcommand( )     ;This procedure tests a command to see if it is
                        ;valid. Valid commands are 0, 1, 2, and 3. If the
                        ;command is none of these, an error message
                        ;is printed, and control is returned to
                        ;whatever called this procedure
BYTE cmd

  Print("Command>> ")
  cmd=InputB()
  IF cmd>3 THEN
    PrintE("Command Input ERROR")
    RETURN                              ; get out before command tests
  ELSEIF cmd=0 THEN
    <statement0>
  ELSE IF cmd =1 THEN
    <statement1>
  ELSEIF cmd=2 THEN
    <statement2>
  ELSEIF cmd-=3 THEN
    <statement3>
  FI
RETURN
```

Note: the 'RETURN' after the first condition, which tests for Illegal input; You don't want to go through all the

command tests if the command isn't a valid one, so you just print your error message and hop out of the procedure with a RETURN. Voila!

6.1.3 Calling Procedures

You've already seen some procedure calls, although you probably don't know it. Almost every time we used a library routine in an example, we were making a procedure call. The format is simple enough:

<identifier>({<parameter list>})

where

<identifier>	is the name of the procedure you want to call
<parameter list>	contains the values you want to send to the procedure as parameters

Here are a couple of examples (don't worry about the parameters for now, a whole section is devoted to them later):

```
PrintE("Welcome to Joe's Deli, the only")
PrintE("computerized deli in the world.")
factorials()
gueasuntil()

BYTE z
CARD add
signoff(add,z)
```

Of course you must already have declared the procedures 'factorials', 'gueseuntll', and 'signof' before using them here. 'PrintE' is a library procedure, so it's not declared by you but is declared in the ACTION! Library. Notice that the parentheses are required even when the procedures have no parameters. When a procedure you call has parameters, the call must have no more parameters than the procedure declaration (but it may have fewer). See section 6.4 for a discussion of parameters.

6.2 Functions

As mentioned in the overview of procedures and functions, the fundamental difference between the two is that functions return a value. This makes the way in which they are declared and called somewhat different from procedure declarations and calls. Since functions return a numeric value, they must be used where a number is valid (e.g., in arithmetic expressions).

6.2.1 FUNC Declaration

Declaring a function is similar to declaring a procedure, except that you must be able to show both what type of number the function returns (BYTE, CARD, or INT) and what that number is. The format is:

<type> FUNC <identifier> { = <addr>} ({<parameter list>})
{<variable decl>}
{<statement list>}
RETURN (<arith exp>)

where

<type>	is the fundamental data type of the value the function returns
FUNC	is the keyword denoting a function declaration
< identifier>	is the name of the function
<addr>	optionally specifies the starting address of the function (see 9.3)
<parameter list>	is the list of parameters required by the function {see section 6,4 for an explanation of parameters)
<variable decl>	is the list of variables declared local to this function (see section 3.4.1 for variable declaration, and 6.3 for scope of variables)
<statement list>	is the list of statements in the function
RETURN	denotes the end of the function
<arith exp>	is the value you wish returned from the function

As in procedure declarations, <parameter list>, <variable decl>, and <statement list> are all optional. In the case of procedures, leaving them out was useful only in one instance. In functions, doing this sort of thing has another (more worthwhile) use, as the following example shows:

Example #1:

```
CARD FUNC square(CARD x)
RETURN (x*x)
```

This function takes a CARD number and returns its square. Don't worry about the parameter list, as we will discuss it a little later. It was mentioned above that the value returned is in the form of an arithmetic expression. In example 1, you can see this being done in "(x*x)".

In the following example, the arithmetic expression used to return a value is simply a variable name.

Example #2:

```
BYTE FUNC getcommand() ;*** This function reads in a command number, and
                       ;then passes it out if it's 1 through 7 inclusive.
                       ;Otherwise, the function will reprompt the user
BYTE command,                              ;this variable holds the command
     Error                                 ;set to 1 If an error is found

DO
   Print("COMMAND> ")
   Cominand = lnputB()
   IF command<1 OR command>7 THEN          ;invalid command
      Error=1
      PrintE("Command Error: Only 1-7 valid.")
   ELSE                                    ;valid command
      Error=0
   FI
   UNTIL Error=0                           ;exit loop if command is valid
OD
RETURN (command)
```

NOTE: the parentheses around <arith exp> are always required in the RETURN statement.

The above is a simple example: Functions can be used to do quite complicated operations, but even the most convoluted functions must follow the format outlined In this section.

6.2.2 Return

As you probably noticed in the format of the FUNCtion declaration the RETURN isn't used in the same way as in PROCedure declarations. In functions it is followed by "**(<arith exp>)**". This feature allows a function to return a value. If you tried to put **(<arith exp>)** after the **RETURN** in a procedure declaration, you would get an error, because procedures can't return a value.

Although there are dissimilarities between **RETURN**s in functions and procedures, there is one convenient similarity: you may have more than one **RETURN** in both procedures and functions. The following example shows usage of multiple **RETURN**s in a function:

SCENARIO

Example #1 in the function declaration section (6.2.1) returned the square of a CARD, but it did no checking for overflow. If you squared 256 you would get 65536, 1 greater than the maximum CARD value allowed. There are two ways to fix this problem:

1. Require that the number being squared be of BYTE type, thus making it impossible to enter a number greater than 255.

2. Check for overflow in the function itself.

The following example illustrates the second method:

Example:

```
CARD FUNC square(CARD x)      ;***** This function tests 'x' for overflow,
                              ;and returns its square if valid. IF invalid,
                              ;the function prints an error message;
                              ;and returns 0.
  IF x>255 THEN                         ;number would cause overflow
    PrintE("Number too big")
    RETURN (0)                          ;return a zero
  FI
RETURN (x*x)                        ;return 'x' squared
```

See how easy it is? The use of multiple RETURNS can come in very handy when you are testing a lot of different conditions, each requiring that a different value be returned.

> **NOTE: As mentioned in section 6.1.2, the compiler can't tell if you leave out a RETURN, so you must make sure you have one.**

6.2.3 Calling Functions

You have already seen two examples of function calls. They can be found in section 5.2.4.2 (WHILE), example #2, and section 5.2.4.3 (UNTIL), example #1. If you look at those programs, you'll see the lines:

```
num = Rand(101)
guess=InputB()
```

The first is an example of calling a function that requires parameters, and the second an example of calling one without parameters. Both ‘Rand' and ‘InputB’ are library functions. 'Rand’ returns a random number between 0 and the number you give it (in the above case, 101) minus one. ‘InputB' reads a byte value from the default device (the screen). Notice that both of them returns a value. Because this value must go somewhere or be used somehow, function calls must be used in arithmetic expressions. In the above two cases, the arithmetic expressions consist of the function call only and are used in assignment statements (a valid use of arithmetic expressions).

Function calls can be used in any arithmetic expression, with one exception:

Functions calls may NOT be used in an arithmetic expression when that expression is used as a parameter in a routine call or declaration.

Example:

```
x = square(2*Rand(50))
```
INVALID

Here are some examples of valid function calls:

```
x=5*Rand(201)
c=square(x)-100/x
IF ptr<>Peek($8000)
chr=uppercaae(chr)
```

'Peek' and 'Rand' are library functions, so they needn't be declared by you, but 'square' and ‘uppercase’ are user written functions, and so they must be declared before they are called here.

> **PROGRAMMING NOTE: although it is not recommended, you can call functions as though they were procedures. If you do this, the value returned is ignored.**

6.3 Scope of Variables

The term “Scope of a Variable" is used to express the range of a variable’s legitimacy. To help you understand what this means, let’s apply the concept of "Scope" to a more familiar situation; the English language.

Below is a table of British English words, followed by their American English equivalent:

British	American
BONNET	HOOD
LORRY	TRUCK
LIFT	ELEVATOR
FAG	CIGARETTE

Each pair of words means the same, but the words' scopes are different. "Bonnet" (when used to mean the moveable cover over an auto's engine) is legitimate only when used in countries that speak the King's English. "Hood", on the other hand, is valid only in countries that speak American English. Hence they have ranges of legitimacy, or Scope. The words in the left column could be considered "global" to British English in the sense that any average Brit would understand what was meant by each word, and the words in the right column could be considered "global" to American English because everyone who speaks American English would associate each word with its intended meaning.

Enough of global scope, now we need to talk about "local" scope. Scope is local if it is a specific subset of some global scope. For example, the word "neat" has many different local scopes within the "global" American English language:

1) "Wow, that movie was NEAT!"
2) "Gertrude keeps the NEATest house I've ever seen."
3) "Bartender, I'll have my scotch NEAT."

In different situations "neat" can mean different things (i.e., the meaning is local to the situation), and these meanings don't overlap.

Variables in ACTION! also have an associated scope. A variable's scope determines where it may and may not be used just as, in the above analogy, a word's scope determines where it may and may not be used.

The following program is a concrete example of variable scope:

Example #1:

```
MODULE                  ;we're going to declare some variables as global
CARD numgames=[0],                ;number of ganiee played
  goal=[10],                      ;number of guesses to beat
  beatgoal=[0]                    ;number of times you've beaten goal

PROC intro()            ;**** This procedure puts the leadin to
                        ;     the game on the screen.
CARD ctr

  PrintE("Welcome to the guessing game. I'm”)
  PrintE("thinking of a number from 0 to 100.")
  PrintE("All you have to do is type in your")
  PrlntE("guess when I ask you to.")
  PutE()
  PrintE(“I'll keep track of how many games")
  PrintE("you’ve played, and tell you how")
  PrintE("many times you've guessed the number")
  PrintE("in fewer tries than your goal, but")
  PrintE("first yoo have to give me your goal.")
  PutE()
  Print("Type your goal here --> ")
  goal=InputC()
  FOR ctr=0 to 2500                          ;a delay loop to give the
  DO                                         ;sense of real-time to the
  OD                                         ;player.
  Put($7D)                                   ;clear the screen
RETURN                                       ;end of PROC Intro
```

```
PROC tally()           ;***** This procedure prints out the current tally
  Print("you have played”)
  PrintC(numgames)
  PrintE(" games,")
  Prlnt("and in ")
  PrlntC(beatgoal)
  PrintE(“of those you")
  PrintE("have beaten your goal of")
  PrlntC(goal)
  PrintE(" guesses.”)
  PutE()
RETURN                                          ;end of PROC tally

PROC playgame()
CARD numguesses,                                ;tbe number of guesses
     ctr                                        ;counter used in (delay loop
BYTE num,                                       ;the number to guess
     Guess                                      ;the user's guess

  PrintE(“I'm picking my number---")
  FOR ctr=0 TO 450                              ;delay used to make the user
  DO                                            ;think the computer is
  OD                                            ;picking a number
  PutE()
  PrintE(" OK, here we gol")
  PutE()
  Num=Rand(101)                                 ;get the number to guess
  Numgueeses=0                                  ;set number of guesses to 0
  DO ;start of UNTIL loop
    Print( "What' s your guess?” )
    Guess=InputB()                              ;get the user's guess
    Nujnguesses==+1                             ;add 1 to number of guesses
    IF guess<num THEN                           ;guess too low
      PririteE(“Too low, try again")
    ELSEIF guess>num THEN                       ;guess too high
      PrintE("Too high, try again")
    ELSE                                        ;guess just right
      PrintE("Congratulations !!!!")
      Print("You got it in ")
      PrintCE(numguesses)
      IF numguesses<goal THEN
        beatgoal==+1
      FI
    FI                                          ;end of guess testing
  UNTIL guess=num                               ;loop control
  OD                                            ;end of UNTIL loop
RETURN                                          ;end of PROC playgame

BYTE FUNC stop()       ;**** This function finds out if the player wants
                       ;to play another game.
BYTE again
  PrintE(“Do you want to play'*)
  Print(''another game? (Y or N) ")
  again=GetD(1)                                 ;get player's response
                                                ;from K: to avoid getting a
                                                ;RETURN as the first guess
                                                ;of the next game.
  PutE()
  IF again= ‘N OR again=’n THEN                 ;doesn't
    RETURN (1)                                  ;want to play
  FI
RETURN (0)                                      ;end of FUNC stop

PROC main()
  Close( 1)                                     ;just for safety's sake
  Open(1,"K:",4,0)                              ;open K: to read only
  Intro( )                                      ;print out the introduction
```

```
  DO
    Numgames==+1                          ;increment total number of
    playgame()                            ;games play the game once
    tally()                               ;show tally of games thus
    UNTIL stop()                          ;far doesn't want to play
  OD                                      ;anymore
  PutE()
  PrintE("Come play again soon”)
  Close(1)                                ;close K:
RETURN                                    ;end of PROC main
```

The following table shows how this program uses variables. It gives the variable name, it's scope, it's availability and use in each routine:

KEY: A variable Available for use in routine
U variable Used in routine

VARIABLE NAME	SCOPE	PROC playgame	PROC intro	PROC tally	PROC stop	PROC main
numgames	global	A	A	A U	A	A U
goal	global	A U	A U	A U	A	A
beatgoal	global	A U	A	A U	A	A
numguesses	local	A U				
num	local	A U				
quess	local	A U				
ctr	local	A U				
again	local				A U	
ctr	local		A U			

You can see that the global variables are available for use in every one of the routines, whereas the local variables are available only in the routine in which they are declared. Notice that there are two local variables called 'ctr', one in PROC playgame, and the other in PROC intro. Although they have the same name, these two variables are not the same just as 'neat' meaning "clean" and 'neat' meaning "undiluted" were not the same earlier. The two 'ctr's have different local scopes (because they are declared in two different procedures).

6.4 Parameters

Parameters allow you to pass values into a routine. You may wonder wliy this is necessary, since you could use global variables for passing values into and between routines. Well, there are two reasons that parameters exist:

1) They make your routines capable of multipurpose use.
2) They allow you to manipulate variable values within a routine without changing the value of any global variable.

We'll discuss each of these advantages separately, following the above order; but first we should give the format of a parameter list, for those of you who already know all about parameters:

** Parameters in PROC or FUNC declarations:

({<variable decl>} |: ,<variable decl> :|)

where

<variable decl> is a variable declaration, except that it may not contain the '=<**addr**> or **[<const>]**' option

Examples:

```
PROC test(BYTE Chr,num,i, CARD x,y)
INT FUNC docommand( INT cmd, CARD ptr, BYTE offset)
CARD FUNC square (BYTE t)
PROC jump()
```

** Parameters in PROC or FUNC calls:

({<arith exp>} |:,<arith exp>:|)

where

<arith exp> is an arithmetic expression

Example:

```
Test(cat,dog,ctr,2500,$8D00)
sqr=square(num)
jump()
x=docommand (temp, var, 'A)
```

NOTE: A routine may have up to 8 parameters. Use any more, and you will get a compiler error.

We need to do some explaining now. The following example will show you how to use parameters, and clarify the first of the two advantages to using parameters.

The following function checks to see if the BYTE variable 'chr' is a lowercase letter. If it is, the function will return the uppercase of it. Otherwise the function will simply return 'chr'. Notice that we don't declare 'chr' anywhere. We'll discuss where it should be declared after the example.

```
BYTE FUNC lowertoupper()
  IF chr>='a AND chr<='z THEN                ;$20 is the offset
    RETURN (chr-$20)                         ;between lower and upper
  FI                                         ;case in the ATASCII set
RETURN (chr)
```

Now we must decide where to declare 'chr'. We already know that we could declare it global, or just local to 'lowertoupper'. If we declare it locally, how will we give it a value? There seems to be no use to having it local, because then the function itself would have to give the variable a value, and that's not what we want the function to do. We want to be able to call lowertoupper' in a form similar to

```
chr=lowertoupper()
```

and have the function test 'chr' and make It uppercase if necessary. So we won't declare it local. How about declaring it global? That would do what we wanted, because now the 'chr' in the function call and the 'chr' in the function itself would be the same global variable. There's only one drawback to declaring 'chr' as a global variable every time we wanted to use 'lowertoupper', we would get the uppercase of 'chr'. If we want to uppercase the variable 'cat', we would have to do the following:

```
chr=cat
chr=lowertoupper()
cat=chr
```

This could get very tiresome if you wanted to uppercase a lot of different variables. Also, if you wanted to use 'lowertoupper' in another program, you would have to declare a global variable 'chr' there too.

What if we declared 'chr' as a parameter to the function? "HOW...?" you ask. Here's how:

```
BYTE FUNC lowertoupper(BYTE chr) ;<- the parameter declaration
  IF chr>='a AND chr<='z THEN
    RETURN (chr-$20)
  FI
RETURN (chr)
```

"But now how do we call it now?" Easy. All you have to do is give it the variable you want tested as a parameter. Examples:

```
chr=lowertoupper(chr)
cat=lowertoupper(cat)
var=lowertoupper('a)
```

Making 'chr' a parameter to the function allows you to use it for testing any variable in any program, because 'lowertoupper' now stands on its own. It uses no variables declared elsewhere (i.e., global variables), and yet you can give it a variable to test. We have overcome the pitfalls of declaring 'chr' either locally or globally. Tah dahl This is what we meant by "multipurpose".

The second advantage to using parameters is more difficult to illustrate, but we're going to make it as clear as possible, again by using an example. The following procedure takes two CARD type numbers, divides the first by the second, and prints out the result:

Example:

```
PROC division(CARD num,div)
  num==/div                              ;changes num to num/div
  PrintC(nun)                            ;print out num
RETURN
```

And now to use the 'division' procedure in a program:

Example #1;

```
PROC main()
CARD ctr,number=[713]

  FOR ctr=1 TO 10
  DO
    PrintC(number)
    Prlnt("/")
    PrintC(ctr)
    Print("=")
    division(number,ctr)
    PutE()
  OD
RETURN
```

Output #1:

```
713/1 = 713
713/2 = 356
713/3 = 237
713/4 = 178
713/5 = 142
713/6 = 118
713/7 = 101
713/8 = 89
713/9 = 79
713/10 = 71
```

Notice that 'number' remains constant, although 'num' changes. The value of 'number' is passed into 'num' when the procedure is called, but the value of 'num' is not passed back into 'number' when the procedure is exited.

If the value of 'nun' were passed back into ‘number' the output would be:

```
713/1 = 713
713/2 = 356
356/3 = 118
118/4 = 29
29/5 = 5
5/6 = 0
0/7 = 0
0/8 = 0
0/9 = 0
0/10 = 0
```

The flow of information through parameters is one-way. Information can be sent to a routine through parameters, but information generally may not be sent out using parameters. If you want to send a single value back from a routine, make that routine a function, and then you can send it back in the function RETURN statement. If you want to send out more things, you can uee global variables or you can pass pointers as parameters (see 9.5).

A Note On Parameter Pairing:

When you call a routine that has parameters, the first parameter you give in the call will go into the first variable in the list of parameters in the routine declaration, the second will go into the second, and so on.... You can pass fewer parameters than the routine requires, but no more. For example, if there are 5 parameters in the declaration, you could pass the routine 0 to 5 parameters. This allows you to write routines that, require a variable number of parameters, depending on the job it must do. HINT: if you do this, the first parameter should probably be the number of parameters being passed.

A Note On Type Compatibility:

If the value you pass as a parameter and the value expected by the routine are of different data types, you won't get a compiler error because the ACTION! compiler insures parameter type compatibility. For example, if you pass a CARD when the procedure wants a BYTE, the LSB of the CARD will be put into the BYTE variable, and the procedure will carry on as though you had passed it a BYTE (see Part IV for more info).

A Note On Parameter Variable Types:

All of the following are valid as parameters:

1) Fundamental Data Type variables
2) Array, Pointer, and Record References
3) Array, Pointer, and Record Names

In the third case, the names are used as pointers to the first element, the value, or the first field in the named variable.

6.5 Module

MODULE is a very Simple directive. It’s form is:

MODULE

It simply tells the compiler that you wish to declare some more global variables. It is useful when you have written a large program in sections, each with its own global variables. If you say MODULE at the beginning of each section, then the compiler will add all the global variables to the global variable table.

A program need not have a MODULE directive, because the compiler assumes one MODULE directive at the beginning of the program, whether you put it there or not.

The declaration of global variables must come either immediately after a 'MODULE', or at the very beginning of the program (which is really right after the ‘MODULE’ assumed by the compiler).

Compiler directives are different from the standard language commands in that they are executed at compile-time rather than run-time. A language command, such as an assignment statement (see section 5.1.2) is evaluated after you tell the ACTION! Monitor to RUN your program, when your program has control over what is being done. A compiler directive is evaluated when you tell the monitor to COMPILE your program, so the compiler, not your program, has control. The ramifications of this will soon become apparent.

7.1 Define

The **DEFINE** directive is very similar to the editor's substitution (<CS> S) command, except that it does the substitution at compile time. To clarify this, we first need to show the format:

DEFINE <ident>=<str const>{,<ident>=<str const>}

where

<ident>	is a valid identifier
<str const>	is a valid ACTION! string constant (That is, with surrounding double quotes)

DEFINES are not really used in generating any object code when the program is compiled, but are used to clarify ACTION! source programs. The compiler substitutes <str const> for <ident> every time <ident> is used in a program. For example, when you compile a program with the line

```
DEFINE size = "256"
```

in it, the compiler will replace every occurence of 'size' with '256'. This allows for some interesting options (and problems if misused). Since DEFINE will replace any string, you can change the keywords themselves. If you don't like the keyword CARD, you could change it to, say, FROG with this command:

```
DEFINE FROG = "CARD"
```

Now whenever you compile the program, every time the compiler sees 'FROG', it will think to Itself, " Oh, he really means CARD, so I'll just put that in instead."

Here are some more examples to let you become thoroughly familiar with the form:

```
DEFINE listen = "SET $49A=1"
DEFINE begin = "DO", end = "OD"

DEFINE one = "1"
```

NOTE: Don't forget that the string constant must have double quotes around it (see section 3.2).

To better show you what DEFINE does and doesn't do, here's a table showing the effects of a DEFINE on different program parts.

statement	comments
`DEFINE four = " 4 "`	the directive
`PrintBE(four)`	prints *4' with EOL
`; four score and`	converts 'four' to '4'
`; four-score and`	does not alter ' four'-score'
`PrintE("four score")`	does not replace inside quotes

7.2 Include

The **INCLUDE** directive allows you to include other programs into the program being compiled. Suppose you have a program named 'IOSTUFF.ACT' that does input/output functions and you want to use the I/O routines it offers in some other program you're writing now. All you need to do is put the following command in the program you're writing:

```
INCLUDE "D1:IOSTUFF.ACT"
```

NOTE: The file specifier must have double quotes around it.

The above statement must come before you use any of the I/O routines in the file 'IOSTUPF.ACT'. Note that

this example assumes that the diskette with 'IOSTUFF.ACT' on it is in disk drive D1:. If you don't specify a device with your file name, the compiler assumes the device is "D1:". You can INCLUDE files from any readable device {i,e,, "P:" isn't valid). Here are some more examples:

```
INCLUDE "D2:IOLIB.ACT"
INCLUDE "PROG.DAT"
INCLUDE "C:"
```

NOTE: Most operating systems require that the file specifiers be in uppercase.

A useful feature of the **INCLUDE** command is that you can have an **INCLUDE** in a program which you are already INCLUDEing {i e., it can be nested). ACTION! Allows you to nest it to a maximum of 6 levels, but peripheral devices and the operating system have other limits. When the OS limits are ignored, error # 161 (too many files open) occurs. The cassette limit is 1 INCLUDE, and the disk drive limit Is 3 INCLUDES. If no program is currently in the ACTION! editor buffer, then the maximam number of levels of INCLUDE commands is reduced by one.

7.3 Set

The **SET** directive is used to modify the computer's RAM (Random Access Memory). **SET** pokes a new value into a specified memory location at compile time. In most cases, this command is used for changing Editor and Compiler options from a user program, but it can be used to modify user operating system and hardware variables as well. The format of the SET command is:

SET <address> = <value>

NOTE: <address> and <value> must be compiler constants.

The result of the set statement is to set memory location <address> to <value>. If <value> is greater than 255, then memory locations <address> and <address> + 1 are assigned <value>. This occurs because 255 ($FF) is the biggest decimal number that can fit into one byte, so any number greater than this requires two bytes for storage.

Examples:

```
SET $600=64             ;sets address $600 equal to 64
SET max=16              ;sets max =16
SET 10000=$FFFF         ;sets 10000 and 10001 to $FFFF
SET $CF00=cat           ;sets $CF00 and $CF01 =cat

DEFINE add=-"$7000"
SET add=$42
```

The last example shows a DEFINEd numeric constant used in a SET statement. Since DEFINES are constants at compile time, they are valid in the SET directive. Just make sure you DEFINE the constant before you use it in a SET statement.

NOTE: do not confuse the compile-time effect of SET with the similar run-time effect of Poke and PokeC.

The extended data types make the ACTION! language more flexible than many others available on the ATARI. Just as the structured statements manipulate groups of simple statements thereby extending the capabilities of the ACTION! language, the extended types manipulate groups of fundamental type variables and extend the language capabilities even more.

The three extended data types in ACTION! are:

1) Pointers
2) Arrays
3) Records

We will discuss each separately, following the order of the above list.

8.1 Pointers

Pointer. Sounds like the thing the weatherman uses to show us a place on his map. Well, it is. In the context of ACTION!, "pointer" means something very similar.

Pointers contain a memory address, and so point to a memory location. You can change the value of a pointer and make it point to a new place, just like moving the weatherman's pointer to another place on the map. The big difference is that he points to cities or states, whereas ACTION! pointers can point to BYTE, CARD, or INT values.

Somehow we have to let the compiler know what type of value we want a given pointer to point to. The declaration section will show you how to do this.

After we've gone over the method used to declare a pointer, we'll show you how it can be used. This is done in the manipulation section through the use of program examples.

8.1.1 Pointer Declaration

The format used to declare a pointer looks quite similar to the format of fundamental data type variable declarations, except that we tell the compiler that the variable Is a pointer, and not just a fundamental data type:

<type> POINTER <ident>{=<addr>} |:,<ident>{=<addr>}

where

<type>	is the fundamental type of the information the pointer points to.
POINTER	is the keyword used to show that the variables declared are Pointers.
<ident>	is the name of the pointer variable
<addr>	tells where in memory you want the pointer to point to initially. It must be a compiler constant.

Because a pointer variable actually contains an address, it must be able to take on values ranging from 0 to 65535 ($0 to $FFFF), since an ATARI with 64k of memory has that many separate memory locations. Pointers are stored as a two byte unsigned numbers (in LSB, MSB order) to allow this range. That means that they are stored as CARDs, except that they can be interpreted as addresses.

Since the use of pointers is dealt with in the next section, we'll just give some sample pointer declarations, instead of whole program examples:

Example:

```
BYTE POINTER ptr            ;declares ptr as a pointer to a BYTE value
CARD POINTER cpl            ;declares cpl as a pointer to a CARD
INT POINTER ip=$8000        ;declares ip as a pointer to an INT
                            ;and points it to memory location $8000
```

8.1.2 Pointer Manipulation

Pointers can be used to manipulate a variety of things in ACTION! for the simple reason that they can easily be made to point to different memory locations. This makes cataloguing and tabulating information very easy.

The program on the following page is just a simple example to give you an idea of what a pointer actually does. It will introduce the '^' address operator used with pointers; after the example we'll discuss the '^' in depth.

Example #1

```
PROC pointeruaage()
BYTE num=$E0,                           ;declare and place two
     Chr=$E1                            ;BYTE variables,
BYTE POINTER bptr                       ;declare a pointer to BYTE type.

  Bptr=@num                             ;make bptr point to num
  Print(" bptr now points to address ")
  PrintF( "%H",bptr)                    ;prints out num's address
  PutE()

  Bptr^=255                             ;puts 255 into the location bptr
                                        ;points to(i.e, into num)
  Print ("num now equals ")
  PrintBE(num)                          ;shows that 255 really went
                                        ;into num
  Bptr^=0                               ;puts 0 into num
  Print("num now equals ")
  PrintBE(num)                          ;shows that num equals 0 now
  Bptr=@chr                             ;makes bptr point to chr now.
  Print('bptr now points to address ")
  PrintF(''%H" ,bptr)                   ;prints out chr's address, so we
  PutE()                                ;know that bptr really changed,
  Bptr^='q                              ;puts 'q' into the location bptr
                                        ;points to (i.e., into chr)
  Print(chr now equals ")
  Put(chr)                              ;shows that chr really equals 'q'
  PutE()
  Bptr^='z                              ;changed chr to 'z
  Print("chr now equals ")
  Put(chr)                              ;shows that chr is equal to *z
                                        ;PutE()
RETURN
```

Output #1:

```
bptr now points to address $E0
num now equals 255
num now equals 0
bptr now points to address $E1
chr now equals q
chr now equals z
```

Notice that we use the '^' operator when we want to put a value into the place the pointer points to. So the line "bptr^=0" in the above example is the same as saying "num=0", because 'bptr' is pointing to 'num' at that time. Although we don't use it in the above example pointer references can be used in arithmetic expressions, as follows:

```
X=ptr^
```

Also notice that "PrintF("%H", bptr)" is valid. What this means is that 'bptr' can be accessed as a CARDinal number as well as an address. This is useful when debugging your program, because you can find out where the pointer is pointing easily.

8.2 Arraays

Arrays allow you to manipulate lists of variables by making each variable in the list accessible using only the array name and a subscript. The variables in the list must be of the same data type, and only the fundamental data types are allowed. The array name tells which array you want and the subscript tells which element of that array you want. The subscript is just a number, so what you're really saying when you reference an array element is, "I want the n'th element of array x," where 'n' is the subscript and 'x' is the array name.
In the following section we will discuss the internal representation of an array. After that we'll show you how to declare arrays and manipulate them, and then we'll talk about the limitations of arrays in ACTION!.

8.2.1 Array Declaration

Declaring arrays is easy in ACTION!, but that doesn't mean that you don't have much control over what's going on. There are many options you can use to define different characteristics of the array, including its address, its size, and even its initial contents. Because of all these options, the format looks somewhat cluttered, but the examples should clear up any confusion.

<type> ARRAY <var init>|:,<var init>:|

where

<type>	is the fundamental type of the elements of the array.
ARRAY	is the keyword denoting an array.
<var init>	is the information required to declare one variable as an array of <type> data type elements.

<var init> has the form:

<ident>{(size)}{=<addr> | [<values>] | <str const>}

where

<ident>	is the name of the variable
<size>	is the size of the array, and must be a numeric constant
<addr>	is the address of the first element of the array, and must be a compiler constant
[<values>]	sets the initial values of the elements of the array. Each value must be a numeric constant.
<str const>	sets the initial values of the elements of the array to the string constant, with the first element being the length of the string

We warned you that it was cluttered! But now to organize some of this clutter with some instructive (hopefully) examples:

Example:

```
BYTE ARRAY a,b                ;declares two arrays with BYTE elements without
                              ;sizes declared
INT ARRAY x(10)               ;deelares 'x' as an INT array,
                              ;and dimensions its size to 10 elements
BYTE ARRAY str="This is a string constant"     ;this declares 'str' as a
                              ;BYTE array, and ;fills it
                              ;with a string constant
CARD ARRAY junk=$8000         ;declares 'junk' as a CARD array, which
                              ;starts at $8000 in memory, without any
                              ;size implied
BYTE ARRAY tests=[4 7 19]     ;declares 'tests' as a BYTE array and
                              ;fills in its values
```

PROGRAMMING NOTES: You should dimension the size of an array whenever possible, but there are some instances where you can't or needn't:

1. **When you don't know how big it's going to be (i.e., as in a routine parameter, when you don't know how big an array Is going to be passed)**
2. **When you are filling the array in the declaration (using either the '[<values>]' or '<str conat>' construction), and you aren't planning to add to the array.**

Also remember that the first byte of a string constant contains the length of that string. So, to make a string longer, first you must change the length byte (which is element 0 of the array that contains the string).

8.2.2 Internal Representation

The internal representation of an array is very much like that o0f a pointer. This is because the array name is actually a pointer to the first element of the array. The array itself is simply a contiguous group of cells, each containing an array element. The size of a cell is determined by the data type of the elements: one byte cells for BYTE type, two byte cells for both INT and CARD types. However, having the array name be a pointer leads to some very interesting ramifications, as shown in examples 2 through 4 of the following section.

8.2.3 Array Manipulation

Using and manipulation arrays is not very difficult once you know how to declare the array and reference its elements. You already know how to declare arrays, so now we'll show you how to reference elements:

Example #1:

```
PROC reftest()
  BYTE x
  BYTE ARRAY nums(10)

  FOR x=0 TO 9                ;although nums is ten elements long
                              ;the subscripts run from 0 to 9, not 1 to 10
  DO
    nums(x) = x + 'A          ;creates the alphabet, the xth element of
                              ;nums is assigned x + 'A
    Put(nums(x))              ;output the xth element of nums to the screen
    Print(" ")                ;put a space between characters
  OD
  PutE()
RETURN
```

Output #1:

```
A B C D E F G H I J
```

There are two array references in the above program -- 'nums(x)' in the assignment statement, and 'nums(x)' as a parameter to the 'Put' library procedure. They, and all other array references, have the form:

<identifier> (<subscript>)

where

<identifier> is the name of the array you want to reference
<subscript> is the number of the element in that array, and is an arithmetic expression

As mentioned In the comment explaining the FOR loop, array subscripts do not start at 1, as you might expect. The first element in array 'cat' is 'cat(0)', not 'cat(1)'. This might seem strange, but you get used to it very quickly.

Example #2:

```
PROC changearray()
BYTE ARRAY barray

  barray="This is string 1”
  PrintC(barray)                    ;prints the CARD 'barray' contains
  Print(" ")
  PrintE(barray)                    ;prints the string 'barray points to
                                    ;(with an EOL)
  barray= “This is string 2”
  PrintC(barray)
  Print(“ “)
  PrintE(barray)
RETURN
```

Output #2:

```
10352 This Is string 1
10414 This is atring 2.
```

> **EXAMPLE 2 COMMENTS: Notice from the output that the address to which ‘barray' is pointing changes. Reassigning the whole array (When doing it using string constants) does not put the new string into the memory space occupied by the old one, but rather allocates new space for the new string, and then changes the value of 'barray” to point to the starting address of the new string. The old string is still in memory, but nothing is pointing to it any more, so it is inaccessible.**

Notice that "PrintE(barray)" is valid, because ‘barray’ points to a valid string constant, which is the type of parameter the PrintE library procedure requires. Pretty sneaky!

Example #3:

```
PROC equatearrays()
BYTE ARRAY a="This is a string constant",
    barray

  barray = a
  PrintE(a)
  PrintE(barray)
RETURN
```

Output #3:

```
This is a string constant
This is a string constant
```

> **EXAMPLE 3 NOTES: All this program does is show you that you can equate two arrays simply by making them point to the same memory location, in this case it's a string constant they're both pointing to.**

You might have noticed that we have not done anything like

Example:

```
BYTE ARRAY a=['A ' `s 't 'r 'i 'n 'g]
PrintE(a)
```

That's because the above won't work. Remember that string constants are different from simple strings because their first byte contains their length, so procedures that expect a string constant will balk when you attempt to send them anything else.

And now for a program that uses all the applications of arrays which we have discussed.

SCENARIO

You have a program that only gives error numbers when the user makes an error, and you want it to print out error messages as well. You could do this using arrays, as in the following program. We will discuss how the program works after the program itself.

Example #4:

```
PROC doerror(BYTE errnum);**** This procedure reads in the error number and
                          ;prints out the related message. See the discussion
                          ;following the program for an explanation of how it
                          ;works.

BYTE ARRAY errmsg                          ;the message printed out
CARD ARRAY addr(6)                         ;holds the addresses of the
                                           ;error medsages
  addr(0)="lllegal command"                ;|
  addr(1)="Illegal character"              ;|    See
  addr(2)="Bad File Name"                  ;| Example 4
  addr(3)="Number Too Large"               ;| Note for an
  addr(4)="Wrong Type Of Number"           ;| explanation
  addr(5)="Unknown Error"                  ;|
  errmsg=addr(errnum)                      ;puts the error message asso<
  Print("ERROR :")                         ;ciated with 'errnum' in
  PrintB(errnum)                           ;'errmsg' and prints it
  Print(": ")                              ;out after the error num-
  PrintE(errmsg)                           ;ber itself
  PutE()
RETURN                                     ;**** End of procedure doerror

PROC main()               ;This procedure is just a dummy used to call
                          ;the above procedure, using all valid error numbers,
                          ;to show that the table works
BYTE error

  FOR error=0 TO 5
  DO
    doerror(error)
  OD
RETURN                                     ;**** End of procedure main
```

Output #4:

```
ERROR #0 Illegal command
ERROR #1 Illegal character
ERROR #2 Bad File Name
ERROR #3 Number Too Large
ERROR #4 Wrong Type Of Number
ERROR #5 Unknown Error
```

EXAMPLE 4 NOTES: The way in which we fill the CARD array in this example is strange (how can you fill a CARD array element with a string?) but is perfectly valid because the string constant itself is not being assigned to the array element, rather Its address is. This makes each element of the array an implicit pointer to a string. All we have to do is assign the value of the proper array element (i.e , the one pointing to the needed error message) to the BYTE array 'errmsg' thus making 'errmsg' point to the proper message. Then we just print out the message.

We understand that the above program is very confusing until you completely understand the concept of arrays and their internal representation, but it is here so that you can see some of the advanced capabilities of arrays.

8.3 Records

Records are constructions which allow you to group together some pieces of information, which, although related in some way, are not of the same type. Your driver's license is an example of a record. It has your name, photo, address, and license number all together. These pieces of information belong together in that they all describe you to some degree, but they are of different types. Your name is a character string, your photo is a picture, and your address is made up of both numbers and characters, as is your license number. Of course the ACTION! language doesn't support all these types. Instead it groups together only the types of information the compiler understands, the fundamental data types.

8.3.1 Declaring Records

ACTION! records manipulate the fundamental data types by creating a new data type composed of one or more of the fundamental types. Then you declare variables of that type just as you declare variables of type BYTE, INT, or CARD. This allows you to declare as many variables of one record type as you want, without having to redeclare the format of the record type every time.

The next section (8.3.1,1) shows bow to create a record data type, and section 8.3.1.2 demonstrates how to declare variables of a predefined record type.

8.3.1.1 The TYPE Declaration

Without further ado, we'll present the form used to declare a record data type:

TYPE <ident>=[<var decls>]

where

TYPE	is the keyword denoting the definition of a record type
<ident>	is the name of that record type
<var decls>	are valid variable declarations(as in section 3.4.1, except that the '<Init info>' option shown there is forbidden

At this point, an example would probably help:

Example:

```
TYPE rec=[BYTE b1,b2        ;two BYTE fields first,
     INT i1       ;then one INT field,
     CARD c1,c2,c3     ;tben three CARD fields
     BYTE b3]     ;ending with a BYTE
```

This needs some explanation so we'll go through it piece by piece:

`TYPE rec`	We are defining a new data type called rec
`BYTE b1,b2`	The first two fields of this type are of BYTE type, and are called 'bl' and 'b2 '
`INT i1`	The third field is of type INT, and its name is 'i1'
`CARD C1,C2,C3`	The fourth through sixth fields are CARD type, and are named c1, c2, and c3, respectively
`BYTE b3`	The seventh and final field of the record type 'rec' is of BYTE type and is called 'b3'

Notice that there are no commas between the different variable declarations (between the CARD and BYTE declarations, for example). If you do put commas in, the compiler will try to read the fundamental type words (CARD, BYTE, INT) as variables, and that will cause a compiler error.

8.3.1.2 Declaring Variables

The last section showed you bow to declare a record type, and this section will show you how to declare variables of a given record type. The format is very similar to that used when declaring variables of fundamental types, but it does have its peculiarities:

<ident> <var> { = <addr>} |: , <var> {=<addr> } :|

where

<ident>	is the name of the record type
<var>	is a varible whose data type is declared to be the record type
<addr>	is the address you want the record located at

Here's an example using the record type declared in the previous section. After the example is an explanation of what's going on.

Example:

```
TYPE rec=[BYTE b1,b2                          ;two BYTE fields first,
     INT i1                                   ;then one INT field,
     CARD c1,c2,c3                            ;then three CARD fields
     BYTE b3]                                 ;ending with a BYTE

rec arec,                                     ;declares arec as data type 'rec'
    brec=$8000                                ;declares brec as type 'rec' and
                                              ;places it at address $8000
```

EXPLANATION:

rec	Shows that the following variables are of data type 'rec', just as BYTE, INT, and CARD (when used in variable declarations) show that the following variables are of those types.
arec	Declares 'arec' to be a variable of data type 'rec'
brec=$8000	Declares 'brec' to be a variable of data type 'rec', and places it at memory location $8000

So now that you know how to declare a record data type, and then declare variables of that type, it's time to find out how to reference and manipulate records.

8.3.2 Record Manipulation

To learn how to manipulate records, we first must learn how to reference a field within a record. The following program does just that, using the period ('.') operator. We'll discuss its usage after the program itself.

Example #1:

```
PROC recordreference();*** This procedure reads in some information about
                       ;an employee, and then prints it out to let the
                       ;employee know it's correct.
TYPE idinfo [BYTE level                       ;employee's level
     CARD idnum,                              ;his I,D. number
     entry_year]                              ;year he started
idinfo rec                                    ;declaring 'rec' as record type
                                              ;'idinfo'
  Print('What is your I.D. number? ")
  rec.idnum=InputC( )                         ;get his I.D. number
  Print("What is your employment level (A-Z)? ")
  rec.level=GetD(7)                           ;get his employment level
  Print("In what year did you start working here? ")
  rec.entry_year=InputC()                     ;get his entry year
  PrintE("O.K Here's what I have.")
  PutE()
  Print("I.D. # ")                           ;|
  PrintCE(rec.idnum)                          ;| Print
  Print("Level: ")                           ;| out the
  Put(rec.level)                              ;| information
  PutE()                                      ;| the employee
```

```
  Print("Entry year: ")                    ;| entered
  PrintCE(rec.entry_year)                  ;|
RETURN                                     ;end of PROC recordreference
```

Output #1:

```
What is your I.D. nunber? 4365
What is your employment level? L
In what year did you start working here? 1975

O.K. Here's what I have:

I.D. # 4365
Level: L
Entry year: 1975
```

The '.' is used to notify the compiler that you are making a record reference (and is only valid in record references). From the above program example you can see that the format of a record reference is:

```
<record name>.<field name>
```

Note that < field name> and < record name> are defined in different declaration statements, as shown in the previous section. <field name> is defined in the TYPE declaration, when you define the fields of a record type, whereas <record name> is defined in a variable declaration, when you declare the variable to be of a record type.

8.4 Advanced Use of the Extended Types

The extended data types seem to be limited by the fact that they may only operate on the fundamental types, that is, you cannot have arrays of records, an array field in a record, etc.. However, there are ways to get around these limitations, as seen in example 4, section 8.2.3. In that example we created an array of pointers by using the elements of a CARD array as pointers, not cardinal numbers. In this section we'll demonstrate some other ways to get more out of the extended types, including a program using records with array fields, and another program which uses an array of records.

"But you just said that was illegal." It is illegal if you try it directly, but, as we mentioned above, there are ways around, over, under, and between the literal definition of the extended types.

The following example will fill an undimensioned array with a list of records. The way it does this is simple once we define a "virtual record", because the array is actually a BYTE array with blocks of bytes being grouped into virtual records.

A virtual record is not a record in the sense that we declare It as a record type. It is a record only because we access a section of memory as though it were a record, although it is really just a atring of bytes. All we do is fill a BYTE array so that it looks like contiguous records, not bytes. This is done by declaring a record data type, and then declaring a pointer to that data type. Then we manipulate the array in blocks the size of one record by making the pointer jump through the array in leaps the size (in bytes) of one record. We will expand on this in the technical discussion following the example itself.

Example #1:

```
MODULE                                     ;declaring some global variables
TYPE idinfo=[CARD idnum,                   ;employee's I.D. number
        Codenum                            ;his access code
        BYTE level]                        ;his employment level
BYTE ARRAY idarray(1000)                   ;enough space to hold 200 records
DEFINE recordsize="5"
CARD recount=[0]

PROC fillinfo()
;**** This procedure will take some information on a given employee,
;put it into an array of ;records using a pointer to the record type
;and indexing that pointer in the array. This process will continue as
;long as the user desires ;to input more information
```

```
idinfo POINTER newrecord
BYTE continue

DO
  newrecord=idarray+(reccount*recordiize)
  Print("I.D. number ")
  newrecord,idnum=InputC()                    ;get I.D. number
  Print("Employment level (A-Z)”)
  newrecord.level=GetD(7)                     ;employment level
  Print("Access code? ”)
  newrecord.codenum=InputC()                  ; get secret code
  recount==+1
  PutE()
  Print("Input another record (Y or N)? ")
  continue=GetD(7)
  PutE()
  UNTIL continue = ‘N OR continue=’n
OD
RETURN
```

PROGRAMMING NOTE: This procedure does not make sure you're within the bounds of the array, nor does ACTION! itself, so you might want to add a boundary checking routine.

EXAMPLE 1 NOTES: There are a couple things this procedure does that require a detailed explanation, including these procedure lines:

```
DEFINE recordsize="5"
idinfo POINTER newrecord
newrecord=idarray+(reccount*recordsize)
newrecord.XXX = xxx
reccount==+1
```

We’ll go through these one by one. This should not only explain the statements themselves, but should also clarify the concept we're using to accomplish the array of records.

`DEFINE recordsize="5”`

This DEFINE is used as the "jump" size when we are going through the array. The record type 'idinfo' is 5 bytes long (2 CARDS and 1 BYTE), so this will allow us to go through the array in 5-byte leaps. Every time we leap like this we will skip over one record, thus eliminating the possibility of writing one record partially on top of another.

`idinfo POINTER newrecord`

Here we are defining a pointer to the type 'idinfo'. We can fill fields of a virtual record in the array simply by pointing the pointer to the first field in one of the virtual records, and then using the pointer in a record reference to access a single field.

`newrecord=idarray+(recount*recordsize)`

This assignment makes the pointer point to the end of the array. It does this by adding the space occupied by all the other records to the starting address of the array. The space occupied by all the other records is simply the number of records ('reccount’) times the size of each record (‘recordsize’).

`newrecord.XXX=xxx`

'XXX’ is one of the field names of the record type, and 'xxx’ is the corresponding input function used to fill the array. Since we made 'newrecord’ point to the end of the array, we can start filling in the new record. We can use the pointer in the record reference because we declared it as a pointer to that record type.

```
recount==+1
```

Here we are simply incrementing the variable that keeps track of the number of records currently in the array. We do this because we just put another one in.

In example #4 we will use this array we've filled to verify the information typed in by someone trying to gain entrance into a restricted area (by making sure they key in the proper secret code), but we'll have to remember to access the array as an array of records, using the same format in which the array was filled, otherwise some strange problems will arise.
Before we go on to show the program that looks into the filled array, let's first modify the records a little bit. We'll add one more field which will contain the employee's name in the form:

```
Last Name, First Name
```

To do this we must somehow make the field an array. Or must we? Instead, let's simply add a BYTE field to the end of the record type, and then change the DEFINE directive to make the size given each record increase. If we increase it by 20, suddenly we have 25 bytes reserved for 6 bytes of field (2 CARDs and 2 BYTEs). Then we just put the string in the extra space, by accessing the last field (our new BYTE field) and putting in a string instead of a byte. The string can't be longer than 19 characters (recall the first byte of a string is its length), so we'll have to make sure the string is short enough. Without further ado, we'll move onto the extended version of the 'idinfo' procedure, complete with strings.

Example #2:

```
MODULE                                  ;declaring some global variables
TYPE idinfo=[CARD idnum,                ;employee'a I.D. number
        bcodenum                        ;his access code
       BYTE level,                      ;his employment level
        name]                           ;first letter of name

BYTE ARRAY idarray(1000)                ;enough space to hold 40 records.
DEFINE recordsize="25",nameoffset="5"
CARD reccount=[0]

PROC fillinfo()                         ;***** This is simply the modified
                                        ;VARSION of the previous example
idinfo POINTER newrecord
BYTE POINTER nameptr                    ;pointer to 'name' field
BYTE continue

DO
  newrecord=idarray+(reccount*recordsize)
  Print("I.D. number? ")
  newrecord.idnum=InputC()              ;get I.D, number
  Print("Employment level (A-Z)? ")
  newrecord.level=GetD(7)               ;employtnent level
  Print( "Access code? ")
  newrecord.codenum=InputC()            ;get secret code
  nameptr=newrecord+nameoff             ;set pointer 'nameptr' to
  PrintE("Employee's name? ")           ;start of name field
  Print ("'( form: Last, First) ")
  InputS(nameptr)                       ;read name into name field
  reccount==+1
  PutE()
  Print("Input another record (Y or N)? ")
  continue=GetD(7)
  PutE()
  UNTIL continue='N OR continue='n
OD
RETURN
```

EXAMPLE 2 NOTES: As in the previous example, there are some program lines which need explanation, including:

```
nameoffset="5"
BYTE POINTER nameptr
nameptr=newrecord+nameoffset
Inputs(nameptr)
```

Before discussing the lines individually, let's go over the method used to put the name into the array of records. First of all, we need to find where to put the name once we've read it in, then we need to figure out a way to read the name in. The explanations of the above statements show you how we do it:

`nameoffset = "5"`	This DEFINEs the distance you have to go into a single record to get to the first byte of the string, and is used when getting the pointer to the string to point to the right position.
`BYTE POINTER nameptr`	This pointer is used to point to the first byte of the 'name' field in a record.
`nameptr=newrecord+nameoffset`	Here we are setting the value (i.e., where we want the pointer to point) of the pointer 'nameptr'. It's set by taking the address of the start of the record ('newrecord') and adding the offset distance to the first byte of the string storage location.
`InputS(nameptr)`	This is used to read in the name, and uses 'nameptr' as a pointer to the storage location just as shown in section 8.2.3 (example 2), except that we are using a pointer instead of an array name (which is just a pointer to the first element anyway).

Now that we have a way to put the records into the array, we need a way to search through the array record by record when looking for a match. The following is a function designed to do just that. It will access the array as using the record format of example 2, and return the address of the start of the first record with an 'idnum' matching the one passed in as a parameter. If no match is found, then 0 is returned as the address. Note that this function uses variables declared in the global statement section {i.e,, after the MODULE) of the previous example.

Example #3:

```
CARD FUNC findmatch(CARD testidnum)
idinfo POINTER seeker        ;points to each record ln turn to do test
BYTE ctr                     ;used as a counter in the FOR loop

  FOR ctr=0 TO (reccount-1)              ;minus one because we
  DO                                     ;start at 0, not 1
    seeker=idarray+(ctr*recordsize)      ;index record
    IF seeker.idnum=testidnun THEN       ;test for an
      RETURN (seeker)                    ;I.D. match and return
    FI                                   ;if found
  OD
RETURN (0)                    ;no match found. End of FUNC findmatch
```

This function needs very little explanation, since it's straightforward compared to the previous examples. All we do is go to every record and test its 'idnum' field for a match with 'testidnum'. Now let's turn the past two examples into a true program by putting a shell around it.

Example #4:

```
MODULE                                   ;declaring some global variables
TYPE idinfo=[CARD idnum,                 ;employee'a I.D. number
             codenum                     ;his access code
             BYTE level,                 ;his employment level
             name]                       ;first letter of name
BYTE ARRAY idarray(1000)                 ;enough space to hold 40 records.
DEFINE recordsize="25",nameoffset="5"
CARD reccount=[0]

PROC fillinfo()                          ;***** This is simply the modified
                                         ;version of the previous example
idinfo POINTER newrecord
BYTE POINTER nameptr                     ;pointer to 'name' field
BYTE continue

DO
  newrecord=idarray+(reccount*recordsize)
```

```
  Print("I.D. number? ")
  newrecord.idnum=InputC()              ;get I.D, number
  Print("Employment level (A-Z)? ")
  newrecord.level=GetD(7)               ;employtnent level
  Print( "Access code? ")
  newrecord.codenum=InputC()            ;get secret code
  nameptr=newrecord+nameoff             ;set pointer 'nameptr' to
  PrintE("Employee's name? ")           ;start of name field
  Print ("'( form: Last, First) ")
  InputS(nameptr)                       ;read name into name field
  reccount==+1
  PutE()
  Print("Input another record (Y or N)? ")
  continue=GetD(7)
  PutE()
  UNTIL continue='N OR continue='n
OD
RETURN

CARD FUNC findmatch(CARD testidnum)
  idinfo POINTER seeker           ;points to each record ln turn to do test
  BYTE ctr                        ;used as a counter in the FOR loop

  FOR ctr=0 TO (reccount-1)             ;minus one because we
  DO                                    ;start at 0, not 1
    seeker=idarray+( ctr* recordsize)   ; index record
    IF seeker. idnum= testidnun THEN    ;test for an
      RETURN (seeker)                   ;I.D. match and return
    FI                                  ;if found
  OD
RETURN (0)                        ;no match found. End of FUNC findmatch

PROC main() ;**** This procedure controls the whole shebang
  Idinfo POINTER recptr                 ;pointer to a record
  BYTE POINTER nameptr                  ;pointer to 'name' field
  CARD id_num,                          ;I.D. nximber input by user
       code num,                        ;code number input by user
       keyid=[65535]                    ;I.D. number allowing loop exit
  BYTE mode                             ;controls the operation mode

  PrintE("Startup….")
  PrintE("What operation mode?")
  PrintE("X = expand list of employees")
  PrlntE("A = alert/test input mode")
  Print(">> "')
  mode=InputB() ;read mode
  IF mode='A OR mode='a THEN                  ;anything but A or a
    fillinfo()                                ;will go to X mode
  ELSE                                        ;interrogation routine
    DO                                        ;loop start
      Print(" Employee I.D. number >> ")
      id_num=InputC()                         ;get I.D. number
      IF id_nuni=keyid THEN                   ;enables exit from
        EXIT                                  ;the infinite loop
      ELSE      ;a normal I.D. number (i.e., not keyed)
    recptr=findmatoh( id_nuin)                ;look for I,D- match
        IF recptr=0 THEN    ;no match
          PrintE("DO NOT PASS")
        ELSE          ;an I.D. match
          Print("Code Number >> ")
          code_num=InputC()                   ;get access code
          IF recptr.codenum=code_num THEN     ;a match
            nameptr=recptr+nameoffset
            Print("I.D. # ")
            PrintCE(recptr.idnum)
            Print("Levels ")
            Put(recptr.level)
```

```
              Print("Name: ")
              PrintE(nameptr) PutE()
              PrintE("OK TO PASS")
            ELSE                                  ;code does not match
              PrintE("DO NOT PASS")
            FI                                    ;end of access code testing
          FI                                    ;end of I D. number verification
        FI                                      ;end of 'keyld' check
      OD                                        ;end of infinite loop
  FI                                            ;end of 'IF mode='A
  PrintE("System Shutdown...")
RETURN                                          ;end of PROC main
```

All the main procedure does is go through a series of checks to determine what needs to be done at any given point. The nested IFs are somewhat confusing, but they are lined up (that is, indented the same amount) so you can do IF-FI paring by placing a ruler vertically on the page and sliding it back and forth to change levels of nesting.

This chapter deals with some techniques the experienced programmer might find useful. Thus far, we have limited our discussion of the ACTION! language to a study of the language with respect to itself; that is, without reference to the rest of the computer. Most of this chapter is devoted to interfacing ACTION! to information external to ACTION! itself, including operating system routines and system variables.

9.1 Code Blocks

Code blocks allow you to include machine code in your program. When the compiler sees a code block, it will put the values in the block into the code generated, just as though it were code generated by the compiler. No checks are made, so we don't recommend that you use code block unless you know quite a bit about assembly and machine language.

The format for a code block is:

[<value>|: <value>:|]

where

<value> is one of the values In the code blocks. It must be a compiler constant (see section 3,2). If it is greater than 255, then it is stored in LSB, MSB order.

Examples:

```
[$40 $0D $51 $F0 $600]

BYTE b1,b2,b3

['A b1 342 b3 4+$A7]

DEFINE on=1

[54 on on+'t $FFFa]
```

Code blocks are useful for including small machine code routines, but it's too much trouble to insert a large one. If you want to use a lot of machine code routines, see section 9.4 for some hints.

9.2 Addressing Variables

In sections 3.4.1, 8.1.1, and 8.2.1 (Fundamental, POINTER, and ARRAY variable declarations) we showed that a variable's address could be specified when that variable was declared, but we didn't really make use of that option. We didn't even explain the usefulness of doing this.

This option allows you to declare an ACTION! variable which has the same address as any hardware register. Then you can manipulate graphics and sound directly, change operating system characteristics, etc.. To illustrate the advantages of this, we're going to present a graphics program which makes the background color change and scroll. To do this we can't use the normal (shadow) color registers, because they're only looked at every TV frame.

Instead, we'll directly manipulate the hardware color registers. In this way we can change the background color during one frame. In fact, we can do it 12 times (and so get 12 colors in graphics 0). We have to make sure that we don't change colors in the middle of a scan line, so we'll make use of the hardware variable WSYNC, which tells when a scan line is done, and the next one has not yet begun. The variable VCOUNT tells how many scan lines have been put out, and we use it to time the scrolling.

Example #1:

```
PROC scrollcolors()
  BYTE wsync=54282,                    ;the "wait for sync" flag
    vcount=54283,                      ;the "scan line count" flag
    clr=53272,                         ;hardware register for background
    ctr,chgclr=[0],                    ;a counter and a color changer
    incclr                             ;increments color luminance
```

```
  Graphics(0)                          ;set graphics 0
  PutE()
  FOR ctr=1 TO 23                      ;print Out demo message
  DO
    PrintE("A DEMO OF SHIFTING BACKGROUND COLORS")
  OD
  Print("A DEMO OF SHIFTING BACKGROUND COLORS")
  DO                                   ;Start of infinite scrolling loop
    FOR ctr=l1TO 4
    DO
    incclr=chgclr                      ;set base color to Increment
    DO ;start of UNTIL loop
      wsync=0                          ;waits for end of scan line
      clr=incclr                       ;change displayed color
      incclr==+1                       ;change luminance
      UNTIL vcount&128                 ;end of screen test
    OD                                 ;end of UNTIL loop
  OD                                   ;end of FOR loop
  chgclr= +l                           ;change the base color OD
                                       ;rend of infinite scrolling loop
RETURN                                 ;end of PROG scrolIcolors
```

9.3 Addressing Routines

The concept behind specifying the address of a routine is similar to that of specifying the address of a variable. Only the reason behind the concept changes. In the last section we talked about using Atari system registers directly by addressing an ACTION! variable to the proper location. Because you can define a routine's address, you can make direct calls to OS and hardware routines directly, and do your own manipulation of I/O. The method used will be discussed in the following section, because this method applies to all machine language routines, whether written by you, resident on the OS, or resident in the ROMs.

9.4 Assembly Language and ACTION!

ACTION! allows you to make calls to machine language routines very easily. There are only two requirements:

You need to know the starting address of the routine

The routine must end with an "RTS" (if you want to get back to ACTION!)

For assembly language programmers these are not difficult requirements to fill.

"What about parameters?" "Yes" is the answer. You can even send parameters to machine language routines. The compiler stores parameters in this way:

Address	nth byte of parameters
A register	1st
X register	2nd
Y register	3rd
$A3	4th
$A4	5th
:	:
:	:
$AF	16 th

And now for an example:

```
PROC CIO=$E456(BYTE areg,xreg)      ;**** Declaring the OS procedure CIO.
                                    ;'xreg' will contain the iocb number
                                    ;times 16 and 'areg' is a filler, so
                                    ;the number won't go into register A
                                    ; (CIO expects it ln X reg . )
PROC reatichannel2 ()               ;This procedure will open channel 2 to
                                    ;the given file name, and call CIO to read
                                    ;'buflen' bytes
DEFINE buflen="$2000"                     ; length of the buffer array

BYTE ARRAY fIlename(30),                  ;the file name array
     buffer(buflen)                       ;the buffer array
BYTE iocb2cmd=$362                        ; iocb 2's command byte
CARD locb2buf=$364,                       ;iocb 2,s buffer start address
     iocb2len=$368                        ;iocb 2's buffer length

  PutE()
  Print("File name >> ")
  InputS(filename)                  ;get the filename
  Open(2,filename,4,0)                    ;open channel 2 for read only
  iocb2cmd=7                              ;get binary record command
  iocb2buf=buffer                         ;set iocb buffer to our buffer
  iocb21en=buflen                         ;set Iocb buffer length
  CIO(0,$20)                              ;***** the call to CIO *****
  Close(2)                                ;closing channel 2
RETURN
```

See how easy it is? For those of you with an extensive set of assembly language routines, this ability of ACTION! allows you to use them in a high level language, where building the framework of a program is easy.

9.5 Advanced Use of Parameters

In section 6.4 we discussed parameters and their usage, mentioning that you couldn't pass a value out of a routine using a parameter. Well, that was a little white lie. You can pass values out through parameters, if you use pointers. All you do is create a pointer which points to the variable you really want to pass into a routine, and pass the pointer instead. Then, when you access what the pointer is pointing to, you are really accessing the variable you wanted to pass. You can then change the value of that variable using a pointer reference.

This method involves some indirection (i.e., using a pointer to a variable instead of the variable itself) but is very efficient and useful in some cases, as the following example shows.

Example #1:

```
BYTE FUNC substr(BYTE ARRAY str,sub BYTE POINTER errptr, notfound)
;**** This function will search *str* looking for the substring 'sub'.
;If it's found, the function returns the index onto the string.
;If the substring is longer than the main string an error is returned
;via pointer. If the substring isn't found, that is returned via
;another pointer.

BYTE ARRAY tempstr                ;holds temporary substring for test
BYTE Ctrl,                              ;outer loop counter
  ctr2                                  ;linnar loop counter

IF sub(0)>str(0) THEN                   ;substring bigger than string
  errorptr^=1
ELSE
  FOR ctrl=1 TO str(0)                  ;loop to check string
  DO
    IF sub(1)=str(ctr) THEN             ;testing 1st characters
      tempstr(0)=sub(0)                 ;dimension tempstr
      FOR ctr2=1 TO sub(0)              ;fill tempstr
      DO
```

```
          tempstr(ctr2)=str(ctr2+ctrl-1) ;fill tempstr
        OD
        IF SCompare(tempstr, sub)=00 THEN ;compare 2 strings
          RETURN (Ctrl)                   ;return index if equal
        FI
      FI                                  ;end of testing 1st chsractere
    OD                                    ;end of FOR loop
FI
notfound^=1                    ;didn't RETURN in loop, so no match found
RETURN (0)                     ; end of FUNC substr
```

Now, when we want to call this we must use the forn:

<index>=substr(<string>,<substring>,<errptr>,<nofindptr>)

where

<index>	is the index into <string> where 'substring' starts.
<string>	is the main string
<substr>	is the substring we want to find in the main string
<errptr>	is a pointer to a byte error flag
<nofindptr>	is a pointer to a byte 'substring not found' flag

This kind of parameter manipulation takes some practice if you're not used to the concept of pointers, but is a quick and easy way get more information passed out of a routine without having to resort to using global variables. This means that the routine remains "multipurpose" , as discussed in section 6.4.

Part V The ACTION! Compiler

Chapter 1: Introduction

Atari BASIC offers you great convenience in that you can write a program in a somewhat English-like language, then immediately test that program without going through any other steps. This twofold advantage is gained at the expense of requiring that each command, on each line be figured out by a special program (called the BASIC interpreter) at the time of execution.

ACTION! is somewhat more sophisticated. It requires that your program be figured out by a special program, called a compiler, before the actual execution of your program. This requires an intermediate step between your entry of the program and its execution by the computer. The step is technically known as "the compile". During the compile, the ACTION! compiler analyzes your program on a line-by-line basis. Your program is converted into a different language (called machine language) with storage for both global and local variables. The converted program can then be executed by your Atari, running at a speed much greater than that of the interpreted Atari BASIC.

1.1 Vocabulary

This chapter refers to several terms which you first learned about in Part IV. Those terms are listed here, with each term briefly defined:

term	comments
<ident>	any valid identifier
<value>	any valid hex or decimal value
<compiler constant>	evaluates <ident>'s address
<address>	memory location

1.2 Compiler Directives

The compiler directives are discussed in depth in part IV, chapter 7, and little more need be added here. We simply remind you that the compiler directives are executed at compile time, not run time, so do not use them when you want to change an operational parameter while your program is running.

In this chapter we'll discuss how the the ACTION! Compiler allocates memory space for your compiled program, its variables, its routines, and its symbol tables.

When called, the first thing the ACTION! Compiler does is to decide where to put the code it will generate as it compiles your ACTION! source program. It does this by looking at memory location 14. The CARD value this and the following location contain gives the address of the start of free memory. This address will vary, depending on the size of the Editor buffer (see appendix B). Unless you specify otherwise, the compiler will put your compiled code in memory starting with this address. To tell the compiler where you want your program compiled, give the following two commands to the Monitor right before you compile:

```
SET 14=<address>
SET $491=<address>
```

Where

<address> is the starting address for the compiled code.

2.1 Comments, SET, DEFINE

Neither comments, the SET directive, nor the DEFINE directive generate any machine code. This is because they do not do anything at run time, and so are not required.

2.2 Variable Allocation

Information on variables is stored in two different locations by the ACTION! Compiler, in the code itself and in the symbol table. The symbol table is discussed later.

Variables are stored in front of the machine code where they are used. Some variables are declared before the first routine is entered. These variables (called global variables) can be used by any succeeding routine. They need no additional declaration within the routine.

The allocated variables are assigned space according to the definition of the basic data types. The following table should help your understanding of data allocation.

Data Type	Allocated	Comments
BYTE	1 byte	fundamental type
CHAR	1 byte	fundamental type
CARD	2 byte	fundamental type
INT	2 byte	fundamental type
ARRAY	fundamental type size time the number of elements	extended type
TYPE	sum of sizes of fundamental types, as given in the declaration	extended type
string	all characters in the string plus a preceeding byte to denote length	each string is allocated separately even if set equal to the same identifier

Table 12 Space according to the definition of the basic data types.

2.3 Routines

The compiler allocates space for routines (procedures and functions) following that space allocated to the declared global variables. The variables declared local to a given routine precede the executable language statements in that routine. Program text (statenents within procedures and/or functions) is evaluated and converted directly into machine code.

2.4 Included Programs

Programs can be included at any place in the program. Of course, the included text must not conflict with the text currently being processed. The things to watch out for are conflicting identifiers and out-of-context insertions. When errors are detected in the include text, they are usually displayed in the message area. The error # is always shown in the Monitor s command line and the bell sounds.

2.5 Additional global variables - MODULE

Additional global variables, arrays, and records can be added, as needed, through the use of the MODULE keyword . The variables are assigned space following the last previous routine. The identifiers are also included in the compiler's global symbol table.

2.6 Symbol Tables

The ACTION! Compiler maintains two symbol tables -- one for the global variables and one for the local variables from the last-compiled routine. The symbol tables are accessible from the ACTION! Monitor through the '?', '*', and SET commands (see Part III). They are also used by the ACTION! compiler whenever a variable's address is required.

The Compiler allocates 8 memory pages (2K) for these tables, located right at the top of available memory. Because they are placed there, you can wipe them out if you run a program which changes into a graphics mode which requires more memory than graphics 0. This means that you won't be able to go back to the Monitor during program execution and look at the values in your variables. The Compiler will have no record of their existence since you just overwrote them,

The options menu offers you several ways to enhance or alter the performance of the ACTION! compiler. The various options are discussed here and in part III. The options are also summarized in Appendix G.

Increasing compiler speed:

You can gain at least a 30% improvement in compilation speed by using the options menu to turn off the screen display during both disk l/O and program compilation. Simply press 'N<RETURN>' to the 'Screen?' prompt in the options menu.

> **NOTE: this also turns off the screen for other ACTION! system functions, so you should turn the display back on after you have finished compiling**

Turning the bell off:

When you are debugging a new program and have lots of errors, such as typographical errors, you might want to turn the bell off. Simply press 'N<RETURN>' to the 'Bell?' prompt in the options menu.

Making the Compiler case sensitive:

Sometimes, particularly as you get more sophisticated in your programming style, you might desire that the compiler help you in your programming by reminding you whenever you forget to enter an ACTION! key word in upper case. You also might wish to benefit from the increased flexibility of using different or mixed cases in your identifiers. You can do both by pressing ‘Y<RETURN>' to the options menu prompt ‘Case sensitive?’.

Use of this option is not necessary to successful ACTION! programming. However, it is useful as an aid to documentation and in providing a much greater diversity in identifiers.

Listing the compiled code:

You can command the Compiler to list each program line as it is evaluated. This may seem unnecessary because most errors which occur are noted and displayed on the screen during the compiling process. However, you might have a long program which includes routines from other sources (remember the INCLUDE command?). If this is so, then you might never be able to get the source code together for a complete listing otherwise. You can get such a listing, and even redirect it to the printer (see part VI, section 7.9). To enable the listing, press ‘Y<RETURN>' to the 'List?’ options menu prompts.

4.1 Overflow and Underflow

The ACTION! Compiler does no checks for mathematical overflow or underflow.

"What is overflow and underflow anyway?" They are opposite sides of the same coin.

If you have a BYTE variable which currently equals 255, and you add 1 to it, you won't get 256 (because a single byte can only contain values up to 255), you'll get 0. Similarly, if you are using the decimal system, and only have two digits of display, you can run into the same problem if you add 1 to 99. You know that it equals 100, but you only have two digits of display, so you see "00".

Underflow is the exact opposite of this. If you subtract 1 from 0, you get 255.

As mentioned in part IV, section 4.2, some of the mathematic operators result in a specified type of output, so you can sometimes avoid the above problems by making use of these automatic type changes.

Likewise, shift operations can cause overflow and underflow. A shift of the contents of a variable produces similar (but not identical) results to those achieved by multiplying or dividing by 2.

4.2 Type Compatibility and Boundary Checking

You must also be careful because the ACTION! compiler supports no boundary checking of simple variables or ARRAYS. This is deliberately done in order to allow you more flexibility in your data manipulation. The price for this freedom is increased vigilance. You must set up and maintain your own procedures for checking boundary limits and the error-handling responses. This is another good place for a standard set of subroutines which can be INCLUDEd.

4.3 Channel 7 Restriction

When you enter the ACTION! system. It opens channel 7 for reading from the keyboard (K:). You may use this channel for this purpose, but do not alt.er its attributes by reOpening or Closing it.

> **NOTE: if you do make use of channel 7 (and assume that its already open), your programs will not run without the ACTION! cartridge.**

4.4 Available space

You might be working on a big program and suddenly find that you are out of space. When this happens, you can do one of three things, depending on what you are doing at the moment when the error appears.

If you are Editing:

Immediately save your file (<CTRL><SHIFT>W), go to the Monitor, and reboot the system (BOOT), you may go back to the Editor and read your file back in.

If you are Compiling:

Go to the Editor and save your program. Then go back to the Monitor, reboot the system, and Compile your program from the storage device (disk, cassette, etc.).

Part VI THE ACTION! Library

Chapter 1: Introduction

The ACTION! library makes it possible for you to do a lot of common I/O and graphics routines without having to write them first. The ACTION! cartridge contains almost 70 prewritten routines which you can call as though they were routines written by you. This convenience can save you quite a bit of time and effort whether you are a beginning or advanced programmer.

1.1 Vocabulary

Most of the vocabulary used in this part has been defined previously, but there are two terms we'll use often which require some discussion IOCB and channel. IOCB stands for “Input Output Control BlocK”. The CIO (Central I/O) uses ICOBs to perform I/O functions. The ACTION! library I/O routines set up an IOCB to tell the CIO what it (the routine) wants done, and then makes a direct call to CIO.

The IOCBs are numbered (0-7). When you use routines which require channel numbers, the number is actually the number of the IOCB which contains the information about a given peripheral device. That does not mean that certain IOCBs handle certain peripherals. You must set up one of the IOCBs so that it will handle the peripheral you want it to. This ie done using the Library routine "Open", and so is not a difficult task to accomplish.

When you see the term "default channel" it refers to the IOCB ACTION! sets up and uses for screen display purposes. This means that routines which do I/O using "default channel" will get and put information from and to the screen (device "E:").

> **NOTE: the default channel is channel 0.**
>
> **NOTE: for more information on IOCBs, see your Operating System reference manual.**

1.2 Library Format

The library routines are presented in a manner which makes it very easy to understand how to use and call them. To show you what we mean, let’s take one of the routines and explain what information each part of the presentation format can tell you. The routine we'll look at is "Locate".

Example:

5.8 BYTE FUNC Locate

purpose: Determine the color or character at a given screen location

format: BYTE FUNC Locate (CARD *col*, BYTE *row*)

parameters:
- *col* is a column number valid in the current graphics mode
- *row* is a row number valid in the current graphics mode

description:

This routine retrieves the ATASCII code of the character or the number of the color at the specified location. The registers this routine uses are incremented so as to point to the adjacent horizontal position (the first position in the next line if you located the last position on a line). All of the Get, Put, Print, and Input routines also use these registers as references for the current cursor location, so you can use this to move to any position and then use another routine to manipulate what's there.

The first thing you see is the section number and name of the routine, including what type of routine it is (in this case a BYTE FUNCtion). This is followed by a short description of the purpose of the routine. The format of the routine itself is then given in the form of a routine declaration. The declaration form is used instead of the form used to call that routine because it tells you more information about the routine in question, including:

1) the routine's type (PROC or FUNC)
2) all the parameters
3) the data type of each parameter

After the format of the routine is given the parameters required by that routine are explained one by one. The last piece of information is a description which discusses the use of the routine in general and its performance in certain special conditions.

The ACTION! Library provides an extremely extensive group of routines to put both numeric and string data out to any channel.

The two basic output routines -- Print and Put -- have options which allow you to direct the output to a specific channel and/or output an EOL (End of Line, a.k.a. <RETURN>) following the data. We'll go into these options in more detail in the following sections.

2.1 The Print Procedures

The procedures we are about to discuss all have one thing in common: they begin with the word "Print". From this alone you can tell that they print something out somewhere, but who knows what and where? The answers to these questions can be found by looking at the option(s) tagged onto the end of the word "Print".

These options all consist of a single letter, but you can employ up to three options at one time because different options control different aspects of the output. "Is this ever confusing?", it might seem that way, but let's look at the format of Print to see how these options are grouped:

Print<data type>{D}{E}(<parameters>)

where

Print is the basic function name.

<data type> tells what type of data you want to output. The options here are:

B	BYTE type data
C	CARD type data
I	INT type data
<nothing>	a string
D	stands for "device", and is used when you want to define which device (channel) you want the output to go to.
E	stands for EOL (End Of Line), and is used to ouput a <RETURN> after the data

<parameters> are the parameters required by the procedure, and range in number.

NOTE: Both the 'D' and 'E' are optional, but a data type is always specified (because 'a string' is assumed to be the type of data output if no type is explicitly given).

From the above format you can see that the following are all the possible Print routines:

	string	BYTE	CARD	INT
no options	Print	PrintB	PrintC	PrintI
with EOL	PrintE	PrintBE	PrintCE	PrintIE
to Device	PrintD	PrintBD	PrintCD	PrintID
both options	PrintDE	PrintBDE	PrintCDE	PrintIDE

Table 13 Combination table of Print routines

Notice that we have grouped the procedures according to the type of data which they output. This is the way in which we group them in the following sections, with each section giving the purpose, format, parameters, and discussion for each option of the Print procedure basic to that type of data.

There is one Print procedure not in the above list because it is a very special case as far as output is concerned. Its name is PrintF, and it allows you to format output which contains numbers and strings. A separate section is devoted to this routine alone.

2.1.1 Printing Strings

There are four string printing procedures, thus making all the options discussed in the previous section available.

purpose: to print out a string, uajng some format options

formats: PROC Print(*<string>*)
PROC PrintE(*<string>*)
PROC PrintD(BYTE *channel*, *<string>*)
PROC PrintDE(BYTE *channel*, *<string>*)

parameters:

<string>	is either a string constant with double quotes or the identifier of a BYTE ARRAY (which you want printed out as a string)
channel	is a valid channel number (0 – 7)

descriptions:
These four procedures print out strings, thus:

Print	outputs the string to the default channel without a <RETURN> at the end.
PrintE	outputs the string to the default channel with a <RETURN> at the end.
PrintD	outputs the string to a specified channel without a <RETURN> at the end.
PrintDE	outputs the string to a specified channel with a <RETURN> at the end.

Their usage is very straightforward and simple, but you must remember that, with the procedures which require a channel, the channel must first be opened.

2.1.2 Printing BYTE Numbers

The following four procedures are used to print BYTE type data in decimal format. They start with the 'PrintB' base, and then add the possible options.

purpose: to output one byte of data as a decimal number.

formats: PROC PrintB(BYTE *number*)
PROC PrintBE(BYTE *number*)
PROC PrintBD(BYTE *channel*, *number*)
PROC PrintBDE(BYTE *channel*, *number*)

parameters:

number	is an arithmetic expression (remember the arithmetic expressions can simply be a const, int or variable name)
channel	is a valid channel number (0 – 7)

description:
The above procedures output BYTEs as follows:

PrintB	outputs the byte to the default channel without a <RETURN> at the end.
PrintBE	outputs the byte to the default channel with a <RETURN> at the end.
PrintBD	outputs the byte to a specified channel without a <RETIJRN> at the end,
PrintBDE	outputs the byte to a specified channel with a <RETURN> at the end,

2.1.3 Printing CARD Numbers

purpose: to output numbers as CARDs in decimal format.

formats: PROC PrintC(CARD *number*)
PROC PrintCE(CARD *number*)
PROC PrintCD(CARD *channel*, *number*)
PROC PrintCDE(CARD *channel*, *number*)

parameters:

number	is an arithmetic expression (remember that arithmetic expressions can simply be a constant or variable name).
channel	is a valid channel number (0 – 7)

description:
The above procedures output CARDs as follows:

PrintC	outputs the CARD to the default channel without a <RETURN> at the end.
PrintCE	outputs the CARD to the default channel with a <RETURN> at the end.
PrintCD	outputs the CARD to a specified channel without a <RETURN> at the end.
PrintCDE	outputs the CARD to a specified channel with a <RETURN> at the end.

2.1.4 Printing INT Numbers

purpose: to output numbers as INTs in decimal format.

formats: PROC PrintI(INT *number*)
PROC PrintIE(INT *number*)
PROC PrintID(INT *channel*, *number*)
PROC PrintIDE(INT *cbarinel*, *number*)

parameters:

number	is an arithmetic expression (remember that arithmetic expressions can simply be a constant or variable name).
channel	is a valid channel number (0 – 7)

description:
The above procedures output INTs as follows:

PrintI	outputs the INT to the default channel without a <RETURN> at the end.
PrintIE	outputs the INT to the default channel with a <RETURN> at the end.
PrintID	outputs the INT to a specified channel without a <RETlfRN> at the end.
PrintIDE	outputs the INT to a specified channel with a <RETURN> at the end,

2.1.5 PROC PrintF - Formatted Output

The PrintF procedure allows you to output numbers and strings on the same line through the use of a "format control string". This string tells the procedures exactly how you want the output to look.

purpose: formatted output of data

format: PrintF("*<control string>*", *<data>* |:, *<data>* :|)

arguments:

<control string>	the control string is made up of format controls and string text. The text is output directly, and the controls (maximum of 5) give information for outputting the <data> parameters given.
<data>	is an arithmetic expression, which will be formatted according to its format control. The first control tells how to output the first <data>, the second control tells how to output the second <data>, and so on.

description:
This is a sophisticated procedure enabling you to output formatted data to the default channel. Up to five different data elements can be interspersed into a string, each with its own output format. The format controls are as follows:

<control>	**formatted data type**
%S	output data as a string
%I	output data as an INT
%U	output data as an Unsigned CARD
%C	output data as a CHARacter
%H	output data in unsigned hexadecimal
%%	output the % character
%E	output an EOL (<RETURN>)

Notice that two of the controls (%E and %%) do not manipulate or require data elements. They are used to change the page formatting, not the data element formatting.

A maximum of five controls are allowed, and each data element requires its own control.

Characters in the control string which are not themselves controls are output directly, that is, exactly as they are in the string.

2.2 The Put Procedures

The "Put" group of library routines are used to output single characters (i.e., output BYTE type data as an ATASCII character). These routines use options very similar to those in "Print", and so the options need not be re-introduced here.

purpose: to output a single ATASCII character, using specified format options.

formats:
PROC Put(CHAR *character*)
PROC PutE()
PROC PutD(BYTE *channel*, CHAR *character*)
PROC PutDEBYTE *channel*, CHAR *character*)

parameters:

character	is an arithmetic expression (remember that arithmetic expressions can simply be a constant or variable name).
channel	is a valid channel number(0 – 7)

description:
These procedures output characters as follows:

Put	outputs the character to the default channel without a <RETURN> at the end,
PutE	outputs an EOL (<RETURN>) character to the default channel.
PutD	outputs the character to a specified channel without a <RETURN> at the end,
PutDE	outputs the EOL (<RETURN>) character to a specified channel.

Chapter 3: Input Routines

In this chapter we discuss the routines which complement the Print and Put routines, that is, they input data from somewhere. Similar to the Output routines, the type of data that is input and where it comes from is defined through the use of options.

'Input' and 'Get' are the input routines, and each has its own set of options very similar to those available in the output routines.

The Input routines are grouped into two categories: those which input numeric data, and those which input string data. Each will be dealt with separately.

There is only one Get routine (GetD), and it will be discussed in the last section of this chapter.

3.1 Numeric Input

The following six functions allow you to input any type of numeric data from any channel. We have grouped them all together because they are very easy to understand and so do not require separate sections, as did the routines used to output numbers did.

purpose: to input numeric data

formats:
BYTE FUNC InputB()
BYTE FUNC InputBD(BYTE *channel*)
CARD FUNC InputC()
CARD FUNC InputCD(BYTE *channel*)
INT FUNC InputI()
INT FUNC InputID(BYTE *channel*)

parameters:

channel	is a valid channel number (0-7)

description:
The functions input data as follows:

InputB	inputs a BYTE number from the default channel.
InputBD	inputs a BYTE number from a specified channel.
InputC	inputs a CARD number from the default channel.
InputCD	inputs a CARD number from a specified channel.
InputI	inputs an INT number from the default channel.
InputID	inputs an INT number from a specified channel.

3.2 String Input

String inputting is accomplished by suffixing the "Input" base with the character "S". There are three such procedures in the ACTION! Library, and they allow you to input a string from any channel and/or define the maximum length of the input string.

purposes: to input string data

formats: PROC InputS(*<string>*)
PROC InputSD(BYTE *channel*, *<string>*)
PROC InputMD(BYTE *channel*, *<string>*, BYTF *max*)

parameters:

<stririg>	is the identifier of a BYTE ARRAY
channel	is a valid channel number (0 - 7)
max	is the maximum length allowable for the input string. The string is truncated to 'max' length if it is too long.

description:
Here is an outline of what each procedure does:

InputS	inputs a string of up to 255 characters from the default channel.
InpatSD	inputs a string of up to 255 characters from a specified channel.
InputMD	inputs a string of up to 'max' characters from a specified channel.

3.3 CHAR FUNC GetD

purpose: to input a single character from a given channel.

format: CHAR FUNC GetD(BYTE *channel*)

parameters:

channel	is a valid channel number (0-7)

description:
This function is used to get one character from the device specified by 'channel'. The character is returned through the function as its ATASCII character set number.

This chapter is devoted to those routines which deal with external devices (printer, disk drive, caeaette, etc.). With these routines you can open a channel (an IOCB), close a channel, and do extensive disk file manipulation.

4.1 PROC Open

purpose: set up an IOCB channel to allow i/o using a peripheral device.

format: PROC Open(BYTE *channel*, *<filestring>*, BYTE *mode*, *aux2*)

parameters:

channel	is a valid channel number (0-7)
<filestring>	is the string constant (or array identifier of that string constant) used as the device (D:, P:, S: etc.) being opened on the given channel (IOCB) number. "D:" files also require a filename.
mode	is the number designating the type of I/O, thus: 4 read only 6 read directory 8 write only 9 write append 12 read/write (update)
aux2	a device dependent value (usually zero).

description:
This procedure opens a given channel to the device specified in <filestring>. The I/O mode can be set (see 'table' above for the number codes). Any device dependent codes are passed through 'aux2'.

> **WARNING: do not Open channel 7, because it is used by the ACTION! system to do its own screen input. You can use channel 7 in your program for getting characters from K:, but, since that assumes that channel 7 is open, you need the ACTION! cartridge to run the compiled version of the program (because ACTION! opens channel 7 to K:.**

4.2 PROC Close

purpose: to close an IOCB channel to a device

format: PROC Close(BYTE *channel*)

parameters:

channel	is a valid channel number (0-7)

description:
This procedure closes the specified channel. At the end of a program you should always close any devices that you have opened in the course of that program.

> **NOTE: DO NOT Close channel 7, as ACTION! uses it.**

4.3 PROC XIO

purpose: provides access to the device specific commands. For example, to change the baud rate on an RS232 device, you would make a call to the XIO handler for the R: device to do this.

format: PROC XIO(BYTE *channel*, 0 ,*cmd* ,*aux1* ,*aux2*, *<filestring>*)

parameters:

channel	is a valid channel number (0-7)
cmd	is the equivalent of the IOCB COMMAND byte (ICCOM in OS/A+ and DOS XL)
aux1	is the first auxiliary byte in the IOCB (ICAUX1 in OS/A+ and DOS XL)
aux2	is the second auxiliary byte in the IOCB (ICAUX2 in OS/A+ and DOS XL)
<filestring>	is a character string specifying a standard device (with a file name in the case of D:)

description:
This procedure is a system call designed to provide access to DOS. Those of you familiar with Atari Basic, BASIC A+, or BASIC XL will recognize XIO as a direct translation of BASIC's XIO statement.

Rather than give a complete list of all the possible uses of XIO here, we will refer you to chapter 8 of either the OS/A+ or DOS XL manual. The ACTION! XIO procedure can perform all the system commands listed therein other than NOTE, POINT, and the various data transfer operations – all of which are available via other ACTION! library routines.

4.4 PROC Note

purpose: to return the current file sector and byte offset within that sector on a specified disk drive.

format: PROC Note (BYTE *channel*, CARD POINTER *sector*, BYTE POINTER o*ffset*)

parameters:

channel	is a valid channel number (0-7)
sector	is a pointer to the sector number variable.
offset	is a pointer to the byte offset variable.

description:
This procedure returns the disk sector and byte offset within that sector of the next byte to be read or written (i.e., it returns the value of the disk file pointer).

4.5 PROC Point

purpose: to set the disk file pointer (sector and byte offset) to allow random file access.

format: PROC Point(BYTE *channel*, CARD *sector*, BYTE *offset*)

parameters:

channel	is a valid channel number (0-7)
sector	is a pointer to the sector number variable.
offset	is a pointer to the byte offset variable.

description:
This procedure allows you to set the disk file pointer to any location within a disk file, thus enabling random access of information.

> **NOTE: the disk file must have been Opened mode 12 (update) for the Point routine to work.**

Chapter 5: Graphics and Game Controllers

The ACTION! Library contains quite a few routines designed specifically to make game writing (using visual and sound effects) easy and quick. At your fingertips you have the ability to manipulate bit-map graphics (i.e., the BASIC graphics modes), the myriad of sounds available on the ATARI, and get information about the game controllers (both paddle and joystick).

Since the description of each routine best illustrates its usage, we'll jump right into the routines themselves without further discussion.

5.1 PROC Graphics

purpose: to enable bit-map ATARI graphics.

format: PROC Graphics(BYTE *mode*)

parameters:

mode is the number of the graphics mode, as in the BASIC 'Graphics' routine. (see table below)

description:

This procedure is exactly equivalent to the BASIC command of the same name, and allows you access to the many varied graphics modes available on the ATARI.

The following table gives some information about the 9 base graphics modes. These modes are all split screen, to get full screen, add 16 to the base mode number, to preserve the current screen as you change modes, add 32 to the base mode number, to get both of these options, add 48 to the base mode number.

Graphics Mode	Mode Type	Rows	(split) Columns	(full) Columns	Number of Colors
0	Text	40	NA	24	2
1	Text	20	20	24	5
2	Text	20	10	12	5
3	Graphics	40	20	24	4
4	Graphics	80	40	48	2
5	Graphics	80	40	48	4
6	Graphics	160	80	96	2
7	Graphics	160	80	96	4
8	Graphics	320	160	192	1/2

Table 14 Graphics modes of 'Graphics' routine.

5.2 PROC SetColor

purpose: sets the specified color register to the color given by 'hue' and 'luminance'.

format: PROC SetColor(BYTE *register*, *hue*, *luminance*)

parameters:

register	is one of the five color registers (0 - 4)
hue	is the hue of the color.
luminance	is the luminaire of the color.

description:
This routine allows you to set the color of a specific color register, and so manipulate the colors displayed in a given mode. The following tables give some information pertinent to the usage of this procedure.

Set Color hue number	Color	Set Color Hue number	Color
0	Gray	8	Blue
1	Gold	9	Light Blue
2	Orange	10	Turquoise
3	Red-Orange	11	Green Blue
4	Pink	12	Green
5	Purple	13	Yellow-Green
6	Purple-Blue	14	Orange-Green
7	Blue	15	Light Orange

Table 15 The 16 hues available on the ATARI and their numeric code.

The above table shows the hues for use as the 'hue' parameter of the SetColor procedure.

Register	Default Color	Default Luminance	Color
0	2	8	Orange
1	12	10	Green
2	9	4	Dark Blue
3	4	6	Pink or Red
4	0	0	Black

This table shows which colors are the defaults used when you don't specify your own color for a given SetColor 'register'.

> **NOTE: Colors may vary depending upon the television or monitor type, condition, and adjustment.**

The luminance value (a measure of the brightness" of a color) ranges between 0 and 15, where 0 is darkest and 15 is brightest.

5.3 BYTE color

'color' isn't a library routine, but a variable defined in the library for use with the 'Plot', 'DrawTo', and 'Fill' library procedures. After you pick your graphics mode (using 'Graphics') and set up the color registers (using 'SetColor'), you can plot and draw in that mode using any of the colors you've specified by first using the assignment:

color=<number>

where

<number> is related to the color register containing the color you want to use.

The following table shows this relationship for the different graphics modes. For every group of related modes, each SetColor 'register' is followed by its associated 'color' <number>, and some descriptive comments.

Graphics Mode	SetColor 'register'	Color number	Description and Comments
Mode 0 and all text windows	0	N/A	--
	1	N/A	--
	2	N/A	Character Lumance
	3	N/A	Background
	4	N/A	Boarder
Modes 1 and 2 (text modes)	0	N/A	Character
	1	N/A	Character
	2	N/A	Character
	3	N/A	Character
	4	N/A	Background
Modes 3,5 and 7 (four-color modes)	0	1	Graphics Point
	1	2	Graphics Point
	2	3	Graphics Point
	3	--	--
	4	0	Gr. Pt. Background, Border
Modes 4 and 6 (two-colors modes)	0	1	Graphics Point
	1	--	--
	2	--	--
	3	--	--
	4	0	Gr. Pt. Border, Background
Mode 8 (1 color/2 Luminances)	0	--	--
	1	1	Graphics Point Luminance
	2	0	Graphics point Background
	3	--	--
	4	--	Border

5.4 PROC Plot

purpose: to position the cursor at a specified location, and then display a color using the library variable 'Color'.

format: PROC Plot(CARD *col*, BYTE *row*)

parameters:

col	is the horizontal column number of the point being plotted
row	is the vertical row number of the point being plotted

description:
This procedure is used in graphics modes 3 - 8 to plot a point on the screen. The size of the point displayed depends on the graphics mode, and the color of the point depends on the current value of the library variable 'Color' (see previous section).

5.5 PROC DrawTo

purpose: (must be preoreded by a 'Plot') to draw a line between the point just Plotted and the specified position.

format: PROC DrawTo(CARD *col*, BYTE *row*)

parameters:

col	is the horizontal column number of the point being plotted
row	is the vertical row number of the point being plotted

description:
This procedure is used in graphics modes 3 - 8 to draw a line from the point just plotted (using 'Plot') and the position given by the parameters. The color of the line depends on the current value of the library variable 'Color' (see section 5.3).

5.6 PROC Fill

purpose: (must be preceded by a 'Plot') fills a box with a color.

format: PROC Fill(CARD *col*, BYTE *row*)

parameters:

col	is the horizontal column number of the point being plotted
row	is the vertical row number of the point being plotted

description:
This Allows you to make boxes of color in graphics modes 3 – 8. The upper left corner of the box is defined by the position of the 'Plot' immediately before the 'Fill', and the lower right corner is given by the parameters. The color used is decided by the contents of the library variable 'Color'.

5.7 PROC Position

purpose: to position the cursor anywhere on the screen

format: PROC Position(CARD *col*, BYTE *row*)

parameters:

col	is the horizontal column number of the point being plotted
row	is the vertical row number of the point being plotted

description:
This procedure sets the cursor location to the specified position in any graphics mode. The library routines Print, Put, Input, and Get use the cursor registers this command sets when doing their respective functions.

5.8 BYTE FUNC Locate

purpose: determine the color or character at a given screen location.

format: BYTE FUNC Locate(CARD *col*, BYTE *row*)

parameters:

col	is the horizontal column number of the point being plotted
row	is the vertical row number of the point being plotted

description:
This routine retrieves the ATASCIT code of the character or the number of the color at the specified location. The registers this routine uses are incremented so as to point to the adjacent horizontal

position (the first position in the next line if you Located the last position on a line). All of the Get, Put, Print, and Input routines also use these registers as references for the current cursor location, so you can use this to move to any position and then use another routine to manipulate what's there.

5.9 PROC Sound

purpose: to enable the sound capabilities of the ATARI.

format: PROC Sound(BYTE *voice*, *pitch*, *distortion*, *volume*)

parameters:

voice	is one of the four voices available on the ATARI (0 – 3)
pitch	is the frequency of the sound. The lower thenumber is, the higher the pitch.
distortion	is a measure of the sound's "fuzziness" (0 – 14 even values).
volume	is the volume of the sound(0 - 15)

description:
This procedure allows you to control the sound-generating apparatus on the ATARI, much like the BASIC command of the same name. Distortion values 10 is the only one useful for making music. The others are useful for airplane, racecar, etc, sound effects.

pitch	Note	Comment
29	C	High Notes
31	B	
33	A# (Bb)	
35	A	
37	G# (Ab)	
40	G	
42	F# (Gb)	
45	F	
47	E	
50	D# (Eb)	
53	D	
57	C# (Db)	
60	C	
64	B	
68	A# (Bb)	
72	A	
76	G# (Ab)	
81	G	
85	F# (Gb)	
91	F	
96	E	
102	D# (Eb)	
108	D	
114	C# (Db)	
121	C	Middle C
128	B	
136	A# (Bb)	
144	A	
153	G# (Ab)	
162	G	
173	F# (Gb)	
182	F	
193	E	Lower Notes
204	D# (Eb)	
217	D	
230	C# (Db)	
243	C	

Table 16 Various musical notes using distortion 10.

5.10 SndRst

purpose: to reset all the sound voices.

format: PROC SndRat()

parameters: none

description: This procedure resets all the sound voices to produce no sound.

5.11 BYTE FUNC Paddle

purpose: to return the current numeric value (position) of one of the paddles.

format: BYTE FUNC Paddle(BYTE *port*)

parameters:

port is the port number (0 - 7) of the desired paddle.

description:
This function returns the current value of the specified paddle port.

5.12 BYTE FUNC PTrig

purpose: to determine whether a paddle trigger has been pressed.

format: BYTE FUNC PTrig(BYTE *port*)

parameters:

port is the port number (0 - 7) of the desired paddle.

description:
This function returns the current value of the given paddle's trigger. A value of 0 is returned if the trigger is pressed, otherwise the value returned is non-zero.

5.13 BYTE FUNC Stick

purpose: to return the current numeric value of a specified joystick.

format: BYTE FUNC Stick(BYTE *port*)

parameters:

port is the port number (0 - 3) of the desired joystick.

description:
This function returns the current position of the joystick, using codes as in the following diagram:

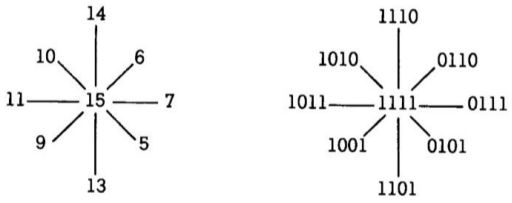


Table 17 Joystick numerical of directions

5.14 BYTE FUNC STrig

purpose: to determine whether a joystick trigger has been pressed.

format: BYTE FUNC STrig(BYTE *port*)

parameters:

port is the port number (0 - 3) of the desired joystick.

description:
This function returns the current value of the given joystick's trigger. A value of 0 is returned if the trigger is pressed, otherwise the value returned is non-zero.

The routines discussed in this chapter allow you to manipulate strings, change a number to a string, and change a string into a number. No further discussion is necessary since the routine descriptions speak for themselves.

6.1 String Handling Routines

The following four routines make possible some advanced string manipulation, including string comparison, string copying, and substring insertion. There is one caution, however, and that is: remember that the maximum length of a string is 255 characters, so don't try to use these routines to create or to manipulate big CHARacter arrays.

6.1.1 INT FUNC SCompare

purpose: to compare alphabetically two strings.

format: INT FUNC SCompare(*<string1>*, *<string2>*)

parameters:

<string1> is a string with double quotes, or the identifier of a CHAR ARRAY which is a string.

<string2> is a string with double quotes, or the identifier of a CHAR ARRAY which is a string.

description:
This function returns a value dependent on the following tables:

comparison	**value returned**
<string1> < <string2>	value < 0
<string1> = <string2>	value = 0
<string1> > <string2>	value > 0

The comparison is alphabetic, so this is a good way to alphabetize a list of strings.

6.1.2 PROC SCopy

purpose: to copy one string into another.

format: PROC SCopy(*<dest>*, *<soorce>*)

parameters:

<dest> is the identifier of the destination string (CHAR ARRAY) for the string copy.

<soorce> is the string with double quotes or identifier of the CHAR ARRAY used as the source string for the copy.

description:
This procedure copies the contents of <source> into <dest>. If <dest> is dimensioned to be shorter than the length of <source>, then only the part of <source> which fits into <dest> will be copied, if <dest> is longer than <source>, then SCopy will copy all of <source> into <dest>, but not alter the rest of <dest>.

HINT: don't dimension <dest> to avoid all the above problems.

6.1.3 PROC SCopyS

purpose: to copy part of a string into another string.

format: PROC SCopyS(*<dest>*, *<source>*, BYTE *start*, *stop*)

parameters:

<dest>	is the identifier of the destination string (CHAR ARRAY) for the string copy.
<source>	is the string with double quotes or identifier of the CHAR ARRAY used as the source string for the copy.
start	is the starting point in <source> for the copy.
stop	is the stopping point in <source> for the copy. If 'stop' is greater than the length of <source>, it is changed to equal the length of <source>.

description:
This procedure will copy the elements of <source> from element 'start' to element 'stop' into <dest>. In essence, this works just like SCopy, but copies only a part of <source> instead of the whole thing.

6.1.4 PROC SAssign

purpose: to copy one string into part of another string.

format: PROC SAssign(*<dest>*, *<source>*, BYTE *start*, *stop*)

parameters

<dest>	is the identifier of the destination string (CHAR ARRAY) for the string copy.
<source>	is the string with double quotes or identifier of the CHAR ARRAY used as the source string for the copy.
start	is the starting point in <dest> for the copy.
stop	is the stopping point in <dest> for the copy. If 'stop' is greater than the length of <dest>, then the length of <dest> is changed to 'stop'.

description:
This procedure is used to copy one string (<source>) into part of another (<dest>). <source> will be copied starting at element 'start' of <dest>, and the copying will stop at element 'stop' of <dest>. If the space allowed (stop-start+1) in <dest> is greater than the length of <source>, then 'stop' will be changed to make the space available and the length equal.

The copying this procedure does will overwrite the old elements of <dest> as it puts in <source>.

6.2 Number to String Conversions

The following three procedures convert the number given as a parameter into a character string. There is one procedure for each of the numeric data types.

purpose: to change a number into a character string,

format: PROC StrB(BYTE *number*, *<string>*)
PRCC StrC(CARD *number*, *<string>*)
PROC StrI(INT *number*, *<string>*)

parameters:

number	is an arithmetic expression (remember that arithmetic expressions can simply be a constant or variable name).
<string>	is the identifier of a CHAR ARRAY.

description:
These procedures turn BYTE, CARD, or INT values into character strings composed of the digits of the given number.

6.3 String to Number Conversions

purpose: to convert a string composed of digits into a number.

format: BYTE FUNC ValB*(<string>*)
CARD FUNC ValC*(<string>*)
INT FUNC ValI*(<string>*)

parameters:

<string> is a string with double quotes or identifier of a CHAR ARRAY, composed of digits ("0" - "9") only.

description:
These functions will return the numeric value (BYTE, CARD, or INT, depending on the function used) of the given string.

This chapter contains those routines which don't really fit into any category, but are useful nonetheless. The routines themselves are:

Rand	a random number generator
Break	a routine useful when debugging
Error	a system routine you can replace
Peek	view a byte of memory
PeekC	view two bytes of memory (as a CARD)
Poke	put a BYTE value into memory
PokeC	put a CARD value into memory
Zero	zero out a section of memory
SetBlock	fill a block of memory with a value
MoveBlock	move a block of memory
Device	the "default device" variable
Trace	controls the 'TRACE' compile option
List	controls the 'LIST' compile option
EOF	contains EOF status for all channels

As you can see, the tasks these routines perform are quite diverse; hence their own chapter.

7.1 BYTE FUNC Rand

purpose: to generate a random number

format: BYTE FUNC Rand(BYTE *range*)

parameters:

range is the upper limit for the random number.

description:
This function will return a random number between 0 and 'range'. If 'range' is 0, then a random number between 0 and 255 is returned.

7.2 PROC Break

purpose: to stop program execution*

format: PROC Break()

parameters: none

description:
This procedure allows you to stop your program's execution to examine variables and do other debugging. You can continue program execution starting with the statement following the 'Break' routine call by using the 'PROCEED' monitor command.

7.3 PROC Error

This is the procedure the ACTION! system itself calls when it (or CIO) encounters an error. If you want to trap your own errors, you could write a routine to do this, and then make ACTION! use your error routine instead of its own simply by having the following statements in your program:

```
PROC MyError(BYTE errcode)   ;*** this is your error routine, and the
                             ;error code number is passed to it by
                             ;the ACTION! system.
; your error handling routines go here
RETURN                                  ;end of PROC MyError

PKOC main()                             ;your main procedure
CARD temperr                            ;holds the address of the
                                        ;system's error routine
                                        ;(PROC Error)
temper=Error                            ;save the address of the system
                                        ;error routine
Error=MyError                           ;make the address of the system
                                        ;error routine point to the
                                        ;start of your error routine
;the body of your program goes here.

Error=temper                            ;reset the address of the
                                        ;system error routine back to
                                        ;the real system error
                                        ;routine not yours*
RETURN                                  ;end of program*
```

All you are really doing is changing the pointer to the system error routine so that it points to your error routine instead. You don't have to call this routine
because it will be called by the ACTION! system when an error is encountered.

Notice that we saved the original error routine pointer, and then, at the end of the program, we reset that pointer (which was changed to point to your error routine) back to the system error routine. This was done so that the system could again use its error routine after your program finished running.

> **WARNING: the capability of substituting your error routine for the system's should be used very carefully, because you might forget to check for something in you routine, and thereby cause the entire system to crash.**

7.4 BYTE FUNC Peek and CARD FUNC PeekC

purpose: to return the value (BYTE or CARD) at a given memory location.

format: BYTE FUNC Peek(CARD *address*)
CARD FUNC PeekC(CARD *address*)

parameters:

address is the address of the memory location you desire to look at.

description:
These two functions allow you to look at memory during program execution, either as a BYTE or a CARD In LSB,MSB order.

7.5 PROC Poke and PROC PokeC

purpose: to insert new values (BYTE or CARD) into a specified memory location.

format: PROC Poke(CARD *address*, BYTE *value*)
PROC: PokeC(CARD *address*, *value*)

parameters:

address	is the address of the memory location you desire to change.
value	is the value you want put into the memory location specified by 'address'. When using PokeC, the CARD value is stored in 'address' and 'address'+1 in LSB, MSB order.

description:
These procedures allow you to change the contents of memory during program execution by changing the given address to the specified value.

7.6 PROC Zero

purpose: to zero out a block of memory.

format: PROC Zero(BYTE POINTER *address*, CARD *size*)

parameters:

address	is a pointer to the starting address of the block you want zeroed.
size	is the size of the block you want zeroed.

description:
With this procedure you can set all the values of the memory locations in a block to 0- This block starts at 'address' and ends at location 'address' + 'size'-1.

7.7 PROC SetBlock

purpose: to set the memory locations of a memory block to a specified value.

format: PROC SetBlock (BYTE POINTER *addr*, CARD *size*, BYTE *val*)

parameters:

addr	is a pointer to the starting address of the block you want to set.
size	is the size of the block you want to set.
val	is the value you want the bytes in the block set to.

description:
With this procedure you can set all the values of the memory locations in a block to 'val'. This block starts at 'addr' and ends at location 'addr' + 'size' – 1.

7.8 PROC MoveBlock

purpose: to move the contents of a block of memory.

format: PROC MoveBlock(BYTE POINTER *dest*, *source*, CARD *size*)

parameters:

dest	is a pointer to the start of the destination memory block.
source	is a pointer to the start of the source memory block.
size	is the size of the block you want to move.

description:
This procedure moves the values in a block starting at address 'source and ending at address 'source'+ 'size'-1 to a block starting at address 'dest' and ending at address 'dest'+'size'-1. If 'dest' is greater than 'source', and there is not 'size' space between them, then the move will not work properly because part of the 'source' you are trying to move is in the 'dest' space.

7.9 BYTE device

'device' is a variable defined in the ACTION! Library, and allows you to control the 'default channel' (device) for i/o. The number contained by 'device' is the channel number of the default device, so, for example, you send default output to the printer using the following statements:

```
Close(5)                              ;avoid a 'File already Opened' error
Open(5,"P:",8)
device=5
```

and then reset it to the screen (when you want to) using the following statements:

```
Close(5)                              ;close "P:"
device=0
```

7.10 BYTE TRACE

This library variable allows you to control the 'TRACE' compiler option from within your program. You must use it with the 'SET' compiler directive, and it must come at the beginning of your program. Setting 'TRACE' to 0 turns off the option and setting it to 1 turns it on.

Example:

```
SET TRACE=0
```

7.11 BYTE LIST

This library variable controls the 'LIST' compiler. As with 'TRACE above, this variable must be used in a 'SET' directive, and it must come at the beginning of your program. A 0 turns the listing off, and a 1 turns it on.

7.12 BYTE ARRAY E0F(8)

With this library variable you can find out if you've reached the End Of File on any channel. Simply give the number of the channel as the subscript to the EOF array. For example, if you wanted to find out if you have reached the End of File on channel 1 (the channel must be open), then you would use:

```
IF EOF(1) THEN
  ;do something here
     :
     :
FI
```

EOF equals 1 when the End Of File has been reached, otherwise it is 0.

Appendix A ACTION! Language Syntax

Retyped in by Jim Patchell on February 13, 2010
It should be noted that I have made some additions to and correction to this BNF grammar. I added in the assign ops and also "fixed" the complex rel production. Maybe they were correct in the original, but I have a hard time reading these days. Anyway, the grammar seems to more or less work this way.

The following is the syntax of the ACTION! Language in Backus-Naur form (BNF). This form has a couple of special characters:

Symbol	Meaning
:=	is defined as
|	or
[]	optional

The appendix is set up to allow you easy access to the particular information you want, with subsections as follows:

A.1 ACTION! Constants

Numeric Constant

```
<num const> ::= <dec num> | <hex num> | <char>
<dec num> ::= <digit> | <dec num> <digit>
<hex num> ::= '$' <hex digit> | <hex num> <hex digit>
<hex digit> ::= <digit> | 'A' | 'B' | 'C' | 'D' | 'E' | 'F'
<dec digit> ::= '0' | '1' | '2' | '3' | '4' | '5' | '6' | '7' | '8' | '9'
<char> ::= ' ' ' <any printable character>
```

String Constant

```
<str const> ::= '"' <string> '"'
<string> ::= <str char> | <string> <str char>
<str char> ::= <all possible characters except '"'>
```

Compiler Constant

```
<comp const> ::= <base comp const> | <comp const> '+' <base comp const>
<base comp const> ::= <identifier> | <num const> | <ptr ref > | '*'
```

A.2 Operators and Fundamental Data types

Operators

```
<special op> ::= AND | OR | '&' | '%'
<rel op> ::= XOR | '!' | '=' | '#' | '>' | '<' | '<>' | '>=' | '<='
<add op> ::= '+' | '-'
<mul op> ::= '*' | '/' | MOD | LSH | RSH
<unary op> ::= '@' | '-'
```

Fundamental Data Types

```
<fund type> ::= CARD | CHAR | BYTE | INT
```

A.3 ACTION! Program Structure

```
<program> ::= <program> MODULE <prog module> | < [MODULE] <prog module>
<prog module> ::= [<system decls>] <routine list>
```

A.4 Declarations

System Declarations

```
<system decls> ::= <system decl>
| <system decls><system decl>

<system decl> ::= <DEFINE decl>
| <TYPE decl>
                  | <fund decl>
```

```
                    | <POINTER decl>
                    | <ARRAY decl>
                    | <record decl>
```

DEFINE Directive

```
<DEFINE decl> ::= DEFINE <def list>
 <def list> ::= <def> | <def list> ',' <def>
<def> ::= <identifier> '=' <constant>
```

TYPE Declaration (for records)

```
<TYPE decl> ::= TYPE <rec ident list>
<rec ident list> ::= <rec ident list> <rec ident>
       | <rec ident>
<rec ident> ::= <rec name> = '[' <field init> ']'
<rec name> ::= <identifier>
<field init> ::= <fund var decl>
```

Variable Declarations

```
<var decl> ::= <var decl:> [','] <base var decl> | < base var decl>
<base var decl> ::= <fund decl>
     | <POINTER decl>
     | <ARRAY decl>
     | <record decl>
```

Variable Declaration for Fundamental Data Types

```
<fund cecl> ::= <fund type> <fund ident list>

<fund type> ::= CARD | CHAR | BYTE | INT
<fund ident list> := <fund ident> | <fund ident list> ',' <fund ident>
<fund ident> ::= <identifier> [ '=' <init opts>]
<init opts> ::= <addr> | '[' <value> ']'
<addr> ::= <comp const>
<value> ::= <num const>
```

Variable Declaration for Pointers

```
<POINTER decl> ::= <ptr type> POINTER <ptr ident list>
<ptr type> ::= <fund type> | <rec name>
<ptr ident list> ::= <ptr ident> | <ptr ident list> ',' <ptr ident>
<ptr ident> ::= <identifier> [ '=' <value> ]
```

Variable Declarations for Arrays

```
<ARRAY decl> ::= <fund type> ARRAY <arr ident list>
<arr ident list>::= <arr ident> | <arr ident list> ',' <arr ident>
<arr ident> ::= <identifier> [ '(' <dim> ')' ] [ '='<array init opts>]
<dim> ::= <num const>
<arr init opts> ::= <addr> | '[' <value list> ']' | <str const>
<value list> ::= <value> | <value list> <value>
<value>::= <comp const>
```

Variable Declaration for Records

```
<record decl> ::= <identifier> <rec ident list>
<rec ident list> ::= <rec ident> | <rec ident list> ',' <rec ident>
<rec ident> ::= <identifier> [ '=' <address> ]
<address> ::= <comp const>
```

A.5 Variable References

Memory References

```
<mem reference> ::= <mem contents> | '@'<identifier>
<mem contents> ::= <fund ref> | <arr ref> | <ptr ref> | <rec ref>
<fund ref> ::= <identifier>
<arr ref> ::= <identifier> '(' <arith exp> ')'
<ptr ref> ::= <identifier> '^'
<rec ref> ::= <identifier> '.' <identifier>
```

A.6 ACTION! Routines

```
<routine list> ::= <routine>| <routine list> <routine>
<routine> ::= <proc routine> | <func routine>
```

Procedure Structured

```
<proc routine> ::= <PROC decl> [ <system decls> ][stmt list>][RETURN]
<proc decl> ::= PROC <identifier> [ '=' <addr>] '(' [ <param decl>] ')'
<addr> ::= <comp const>
```

Function Structure

```
<func routine> ::= <FUNC decl> [ <system decls> ] [<stmt list>][RETURN
'(' <arith exp> ')']
<FUNC decl> ::= <fund type> FUNC <identifier> ['=' <addr>] '(' [<param
decl>] ')'
<addr> := <comp const>
```

Routine calls

```
<routine call> ::= <FUNC call> | <PROC call>
<FUNC call> ::= <identifier> '(' [ <params>] ')'
<PROC call> ::= <identifier> '(' [<params>] ')'
```

Parameters

```
<param decl> ::= <var decl>
```

> **NOTE: maximum of 8 paramters allowed.**

A.7 Statements

```
<stmt list> ::= <stmt> | <stmt list> <stmt>
<stmt> ::= <simp stmt> | <struct stmt> | <code block>
<simp stmt> ::= assign stmt> | <EXIT stmt> | <routine call>
<struct stmt> ::= <IF stmt> | <DO loop> | <WHILE loop> | <FOR loop>
```

Assignment Statements

```
<assign stmt> ::= <mem contents> '=' <arith expr>
                | <mem contents> "==+" <arith expr>
                | <mem contents> "==-" <arith expr>
                | <mem contents> "==/" <arith expr>
                | <mem contents> "==*" <arith expr>
                | <mem contents> "==&" <arith expr>
                | <mem contents> "==%" <arith expr>
                | <mem contents> "==|" <arith expr>
                | <mem contents> "==LSH" <arith expr>
                | <mem contents> "==RSH" <arith expr>
                | <mem contents> "==MOD" <arith expr>
```

EXIT Statement

```
<EXIT stmt> ::= EXIT
```

IF Statement

```
<IF stmt> ::= IF <cond exp> THEN [ <stmt list>] [<ELSEIF exten>][<ELSE
stmt>] FI
<ELSEIF exten> ::= ELSEIF <cond exp> THEN [<stmt list>]
<ELSE exten> ::= ELSE [<stmt list>]
```

DO – OD Loop

```
<DO loop> ::= DO [<stmt list>] [<UNTIL stmt>] OD
```

UNTIL statement

```
<UNTIL stmt> ::= UNTILE <cond exp>
```

WHILE Loop

```
<WHILE loop> ::= WHILE <cond exp> <DO loop>
```

FOR Loop

```
<FOR loop> ::= FOR <identifier> '=' <start> TO <finish> [STEP <inc>] <Do
loop>
<start: ::= <arith exp>
<finish> ::= <arith exp>
<inc> ::= <arith exp>
```

Code Blocks

```
<code block> ::= '[' <comp const list>']'
<comp const list> ::= <comp const> | <comp const list> <comp const>
```

A.8 Expressions

Relational Expressions

```
<complex rel> ::= <complex rel> <special op> <simp rel exp>
                | <simp rel exp>

<simp rel exp> ::= arith exp> <rel op> <arith exp>
           | <arith exp>
```

Arithmetic Expressions

```
<arith exp> ::-= <arith exp><add op> <mult exp> | <mult exp>

<mult exp> ::= <mult exp><mult op><value> | <value>

<value> ::= <num const> | <mem reference> | '(' <arith exp> ')'
```

Appendix B ACTION! Memory Map

Address	Description
$00-$C9	OS and ACTION! Variables
$CA-$CD	Free Space
$CE-$D3	ACTION! Variables
$D4-$FF	Atari Floating Point Registers
$100-$3FF	Operating System
$400-$4FF	ACTION! Variables
$500-$5FF	Atari Floating Point Buffer
$600-MEMLO-1	Operating System
MEMLO	ACTION! compiler STACKS
MEMLO+$200	ACTION! Editor Line Buffer
MEMLO+$300	ACTION! Hash Tables
MEMLO+$750	ACTION! Editor Text Buffer
	ACTION! Compiler Code Space
TOP-$800	ACTION! Compiler Symbol Table
MEMTOP	Screen Memory
$A000	ACTION! Cartridge
$C000-$FFFF	O.S., ROMS, etc.

NOTE: the Compiler Code Space starts wherever the Editor Text Buffer ends. This makes both the Editor Buffer and the Compiler Buffer dynamic in memory. For more information on this, see part V, chapter 2.

Appendix C Error Code Explanation

In this appendix we'll describe the meaning of each of the error numbers you could encounter while programming in ACTION!. Included are those errors which the ACTION! system itself discovers, but not those which the operating system discovers (errors 128 - 255).

Error Code	Explanation
0	Out of system memory. See Part II, section 4.3, and Part V, section 4.4, to find out how to remedy this error.
1	Missing " (double quote) in a string.
2	Nested DEFINES. You can not nest the DEFINE directive.
3	Global variable symbol table full.
4	Local variable symbol table full
5	SET directive syntax error
6	Declaration error. You used the wrong declaration format when declaring something
7	Invalid argument list. You gave a statement or routine too many arguments
8	Variable not declared. Remember, you must declare your variables before you use them
9	Not a constant. You used a variable where a constant of some kind was required
10	Illegal assignment. You are trying to do some sort of assignment that is not allowed (e.g., var=5>7 is illegal)
11	Unknown error. You have somehow impaired the ACTION! system error routines, so it can't tell you which error you have made
12	Missing THEN
13	Missing FI
14	Out of code space. See Part V, section 4.4, for more information
15	Missing DO
16	Missing TO
17	Bad Expression. You have used an illegal expression format
18	Unmatched parentheses
19	Missing OD
20	Can’t allocate memory. You have impaired the ACTION! system, and it is uneble to allocate any more memory
21	Illegal array reference
22	The input file is too large. You need to break it into smaller pieces
23	Illegal Conditional Expression
24	Illegal FOR statement syntax
25	Illegal EXIT. There is no DO - OD loop for the EXIT to exit out of
26	Nesting too deep (16 levels maximum)
27	Illegal TYPE syntax
28	Illegal RETURN
61	Out of Symbol Table space. See Part IV for more information
128	<BREAK> key was used to stop program execution

Table 18 ACTION! Error Codes

Appendix D Bibliography and References

D.1 Atari 400/800 Hardware Systems

Atari Publications:

ATARI Personal Computer System Operating System User's Manual and Hardware Manual

ATARI 810 Disk Drive Operator's Manual

ATARI 400/800 Disk Utility

ATARI 400/800 Operating Systems

ATARI 400/800 Disk Operating Systems II Reference Manual

Other Atari References:

Poole, McNiff, Cook - Yoor Atari Computer

D.2 Optimized Systems Software References

OSS OS/A+ reference manual

OSS DOS XL reference manual

Appendix E Editor Commands Summary

E.1 I/O Commands

Read A File	position cursor, <CTRL><SKIFT> R, enter file spec
Disk Directory	<CTRLi <SHIPT> R ?n:*.* (n is the device name)
Write a File	<CTBL><SHIFT> W, enter fllespec
List to Printer	<CTRL><SHIPT> W, enter P:

E.2 Cursor Movement within Window

Up	<CTRL><up arrow>
Down	<CTRL><down arrow>
Right	<CTRL><right arrow>
Left	<CTRL><left arrow>
Start of Line	<CTRL><SHIPT> <
End of Line	<CTRL><SHIFT> >
Next Line	<RETl]RN>
Tab	<TAB>

E.3 Tab Handling

Set Tab	<SHIFT><SET TAB>
Clear Tab	<CTRL><CLR TAB>

E.4 Window Movement

Start of File	<CTRL> <SHIFT> H
Up one screen	<CTRL><SHIFT><up arrow>
Down one Screen	<CTRL><SHTFT><down arrow>
Left 1 Char	<CTRL><SHIFT>]
Right 1 Char	<CTRL><SHIFT> [

E.5 Text Entry

Enter Program	enter text
Next Line	<RETURN>
Control Chars	precede each character with <ESC>

E.6 Delete Text

Back 1 Char	<BACK S>
Cursor	<CTRL><DELETE>
Delete Line	position cursor on line, <SHIFT><DELETE>

E.7 Insert / Replace Text

Toggle Modes	<CTRL><SHIFT> I
Insert Line	<SHIFT><INSERT>

E.8 Restore Altered Line

Restore Line	don't move cursor, <CTRL><SHIFT> U
Recall Line	don't move cursor, <CTRL><SHTPT> P

E.9 Text Blocks

Load Block	position cursor, <SHIFT><DELETE> until done
Paste Block	position cursor, <CTRL><SHIFT> P

E.10 Searches / Substitutions

Find String	<CTRL><SHIFT> F, enter string
Substitute	<CTRL><SHIFT> S, enter new string, <RETIIRN>, enter old string

E.11 Breaking & Combining Lines

Break Line	position cursor, <CTftL><SHlFT> <RETURN>
Combine Line	put cursor at front of second line, <CTRL><SHIFT> <BACK S>

E.12 Leaving the Editor

Leave Editor	<CTRL><SHIPT> M

Appendix F Summary of ACTION! Monitor Commands

B	restart ACTION! system
C {"<flleftpec>"}	compile an ACTION! program
D	call DOS
E	go to the ACTION! Editor
O	go to the ACTION! Options Menu
P	proceed from program halt
R {"<fllespec>"}	run an ACTION! program
SET <address> = <value>	sets a value in a specified memory location
W {"<flleflpec>"}	save a compiled program to disk
X <statement> |: <statement> :|	execute ACTION! language statement(s)
? <address>	display value of an address (or compiler constant)
** <address>*	display values of all addresses, starting at an address (or compiler constant)

Appendix G Options Menu Summary

prompt	default	range	Comment
Display on?	Y	Y or N	Controls the screen during compile & device I/O
Bell off?	N	Y or N	Controls bell response.
Case insensitive?	N	Y or N	Controls the compiler check for upper case key words in the language and the case distinction in variable names.
Trace on?	N	Y or N	Controls compiler setup of programs so that the program, during execution, notes entry into any PROCedure or FUNCtion.
List on?	N	Y or N	Controls compiler listing of program lines to screen during compile process
Window size?	18	5 to 18	Controls window 1 size. Window 1 and window 2, combined, use 2 3 lines
Line size?	120	1 to 240	Controls line length
Left margin?	2	0 to 39	Controls left margin in window; set as low as you find comfortable
EOL character?	$9B		any ATASCII character Change the End-Of-Line character to aid visualization of program

Appendix H "PRIMES" Benchmark

This is the benchwark that from September, 1981 BYTE Magazine, pp. 160-198, as implemented in ACTION!. Here is a table of our times to compare with those in the magazine:

Mode	Time
Compilation	~0.25sec
Display OFF	12.2sec
Display ON	17.9sec

```
DEFINE size = "8190",
     ON -="1",
     OFF = "0"

BYTE ARRAY flags(size+1)

CARD count, I, k, prime

BYTE DISPLAY=$22F,
  iter,
  tick=20,
  tock=19

PROC Primes()
  DISPLAY = 0 ;comment this line to leave display On
  tick = 0
  tock=0

  FOR iter=1 TO 10
  DO
     count = 0
     ; turn flags on (non-zero)
     SetBlock(flags, size, ON)
     FOR i = 0 TO size
     DO
        IF flags(i) THEN
          prime = i+i+3
          ;PrintCE(prime) ;Uncomment to print primes
          k = prime + i
          WHILE k <= size
          DO
             flags(k) = OFF
             k ==+ prime
          OD
          count ==+ 1
        FI
     OD
  OD
  i=tick+256*tock
  DISPLAY = $22 :turn display back on
  PrintF("%U Primes done in %U ticks %E", count, i)
RETURN
```

Appendix I Converting BASIC Concepts to ACTION! Programs

This appendix presents several BASIC functions, routines, statements, etc. For each BASIC example given, a corresponding ACTION! example is also given.

In the BASIC examples given, no line numbers are shown unless necessary for illustration purposes-. You should assume the existence of appropriate line numbers in most cases.

In the ACTION! examples shown, assume the following variable declarations:

```
INT i,j,k
CARD c,d,e
BYTE a,b
BYTE ARRAY s,t,aa,ba
CARD ARRAY ca,da,ea
INT ARRAY ia,ja,ka
```

BASIC statements	ACTION! equivalents
`C=D+I*A`	`c = d + i * a`
`IF A <>0 THEN B=1`	`IF a<>0 THEN b=1 FI`

`10 IF A=0 THEN 30`
`20 B=1:C=A*3`
`30 REM`
	`IF a<>0 THEN b=1 c=a*2`
	`FI`

`10 IF A=0 THEN B=1 GOTO 30`
`20 B=7`
`30 REM`
	`IF a=0 THEN b=1 ELSE b=7 FI`

`FOR I=1 TO 100`
…
`NEXT I`
	`FOR i = 1 TO 100 DO … OD`

`PRINT "HELLO"`	`PrintE("HELLO")`
`PRINT "HELLO";`	`Print("hello")`
`PRINT #5;"HELL0"`	`PrintDE(5,"HELLO")`
`PRINT #5;"HELLO";`	`PrintD(5,"HELLO")`
`PRINT I`	`PrintIE(I)`
`PRINT "I=";I`	`PrintF("I=%I%E",I) or` `Print("I=") PrintIE(I)`
`PRINT #3;B*3;`	`PrintBD(3,b*3)`
`INPUT I`	`Put("?") I = InputI()` Note: **the use of tbe optional colon (s) in the ACTION! example. Colons ignored by ACTION! and so may used as statement separators.**
`INPUT B$`	`Put('?) InputS(ba)`
`PUT #0,65`	`Put('A) or Put(65) or Put($41)`
`GET #C,B`	`b = GetD(c)`
`OPEN #1,4,0,"K:"`	`Open(1, "K:" 4, 0)`
`CLOSE #3`	`Close(3)`
`NOTE #1,C,B`	`Note(1,@c, @b)`
`POINT #1,C,B`	`Point(1, c, b)`
`XIO 18,#6,0,0,"S:"`	`XIO(6,0,18,0,0,"S:")` Note: **see also the Fill library routine**

`B=PEEK(C)`	`b=Peek(c)`
	or, in better ACTION! form:
	`ba=c`
	`b=ba^`

`POKE C,B`	`Poke(c,b)`
	or, in better ACTION! form,
	`ba = c`
	`ba^= b`

`GRAPHICS 8`
`COLOR 3`
	`Graphics(8)`
	`color = 3`
	Note: **color is a system library variable and**

is predefined by ACTION!

```
DRAWTO C,D                              DrawTo(c,d)
LOCATE C,D,B                            b = Locate(c,d)
PLOT C,D                                Plot(c,d)
POSITION C,D                            Position(c,d)
SETCOLOR 0,1,C                          SetColor(0,1,c)
GRAPHICS 24 : COLOR C                   Graphlcs(24) : color = c

PLOT 200,150:DRAWTO 120,20              Plot(200,150) DrawTo(120,20)
POSITION 40,150:POKE 765,C

XIO I8,#6,0,0,"S;"                      Fill(40,150)
SOUND 0,121,10,6                        Sound(0,121,10,6)
C = PADDLE( B )                         c = Paddle(b)
C = PTRIG( B )                          c = Ptrig(b)
C = STICK( B )                          c = Stick(b)
C = STRIG( B )                          c = Strig(b)
B$ = S$                                 SCopy(ba, s)
B$ = S$(3,5)                            SCopyS(ba,s, 3, 5)
B$(3,5) = S$                            SAssign(ba, s, 3, 5)
B=INT(6*RND(0) )+ 1                     b = Rand(6) + 1
FOR C = 4000 TO 5000:POKE C,0 : NEXT C  Zero(4000, 1001)
STOP                                    Break()
B$ = STR$( I )                          StrI(i, ba)
I = VAL (S$)                            i = ValI(s)
```

ACTION!
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