For 8-Bit ATARI®

# Action!™

Cartridge System, Run Time, Tool Kit & Bug Sheet

Powerful !

Flexible !

Fast !

Precision Software Tools

A Division of ICD, Incorporated

A Trademark of FTe
As of January 2015 Freeware

Revised by GoodByteXL

Last Edit: 31 July 2018

Besides deleting some typos the font was modified to get a slashed zero.

a reference manual for

# The ACTION! System

comprising

Cartridge Version 3.6
Run Time Package Version 1.4
Toolkit Version 3

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

The programs, cartridges, ROMs, and manuals
comprising the ACTION! system
are Copyright (c) 1983, 1984 by
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and
Action Computer Services

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This comprehensive information
provided by Atari enthusiasts
aims at the preservation of

The ACTION! Programming Environment

3rd revised and enlarged edition (p) 2018

# Preface

As tribute to OSS and ACS this fully edited version is provided to keep the best and fastest high level programming language on ATARI 8-bit computers accessible to all being interested in this great piece of software.

Action! was released by OSS & ACS in 1983.
OSS merged into a division of ICD, Inc. in 1988.
ICD sold their ATARI 8-bit product line to FTe in 1993.
FTe disappeared supposedly in 1996.
Declared as freeware by Clinton Parker in January 2015.

Many of those famous A8 hardware and software products from OSS and ICD are still available thanks to a worldwide active A8 community. So is this manual.

As my ICD Action! manual fell apart it had to go through the scanner and some OCR software. And it is completed by the parts run time package, tool kit and bug sheet #3. All original OSS material about Action! in one book. Finally!

The new Action! manual in parts I to VI keeps the original layout for reference to the original paperback and of course for historical reasons. All entries from the original's table of contents are found on the same page, except were errors had to be corrected.

The run time manual in part VII is also kept in the original layout, except page numbering.

The toolkit in part VIII is adapted to the layout as deemed necessary.

The appendices needed amendment and changes, so their page numbering changed. Typos and errors found were corrected and bug sheet #3 is applied to all parts of the new Action! manual.

ACTION! and other OSS programming languages work best in conjunction with SpartaDOS X V. 4.47 and up provided by DLT.

Open Office was engaged to create this manual.

Enjoy ACTION! … and may your A8 always be with you!

GoodByteXL, July 2018

P.S.: Special thanks for help to Erhard and Roland.

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# Part I: Introduction to ACTION!

Welcome to ACTION! We are 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 will not understand what you are reading (quite the contrary); it simply means that we do not 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 have not even dreamed of.

## Notes On This Manual

The manual itself is separated into eight 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.

## Chapter 1: The ACTION! System

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 system is completed by two more parts:

The ACTION! Run Time Package
The ACTION! Tool Kit

These two parts were originally available separately and for better reference are now merged into this manual.

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 does not know anything about the ACTION! language or compiler (that is, it is simply a text editor and does not 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, etc.) 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 such an involved process? BASIC is not like that." First of all, the process is not that involved once you understand what is going on and why. Secondly, BASIC is not 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! source code 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.

NOTE by GBXL:
The latest known ACTION! bug sheet (#3) has been applied to this manual, which refers to the latest versions of

The Cartridge (3.6).
The Run Time Package (1.4)
The Toolkit (3.0)

Appendix K shows the full text of bug sheet #3.

## Chapter 2: How To Write and Run an ACTION! Program

This chapter is designed to let you "get your feet wet" and become more familiar with the ACTION! system. We are 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 are going to assume that you will not 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 for 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 us discuss what is 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 cannot 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 will use that.

Now that were 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 have run the program:

```
+------------------------------------------+
|  >                                       |
+------------------------------------------+
|  Hello World                             |
|                                          |
|                                          |
|                                          |
|                                          |
|                                          |
|                                          |
|                                          |
|                                          |
|                                          |
+------------------------------------------+
```

You have written your first ACTION! program!

If you got an error message from the compiler, it means that you did not 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 do not have to look all over for it. Repeat the steps discussed above to re-compile and re-run your program after you have fixed the error.

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

NOTE from bug sheet #3:
-----------------------

Running compiled ACTION! programs as '.COM' files under OS/A+ causes those programs to execute twice. It affects all versions of ACTION! under OS/A+. To fix it insert the following as the first global variable you declare:

```
BYTE RTS=[$60]
; This MUST be the first line in your program,
; aside from comments and SET commands.
```

NOTE by GBXL:
-------------

SpartaDOS X as of version 4.47 solves this by providing special loading modes for these kind of files and others.

# Part II: The ACTION! Editor


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# 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 a 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 S> (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 he used.

There is one exception to the above; the character (A - Z) and digit (Ø - 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 do not have to retype the same response many times. If you do not 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 could not 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 evens 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 is 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 is 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., <CTRL><up arrow>), but can also be made to move to 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:

    2.2 <CTRL><SHIFT>M
    ------------------

where you cannot 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 are 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 need not 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 are 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 need not 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><SHIFT>H (home), or go with <CTRL><SHIFT>E (end)

to the very end of the file.

## 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 he 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 is not 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 ACTION! 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 ACTIONI 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 <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 cannot find the "old" string you have 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 command with the "new" string being nothing. This will 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 he 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:

```
+----------------------------------------+
|                                        |
|                                        |
|                                        |
|                                        |
|                                        |
|                                        |
|                                        |
|                                        |
|                                        |
+----------------------------------------+
|  ACTION! (c)1983 ACS                   |
+----------------------------------------+
|                                        |
|                                        |
+----------------------------------------+
```

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 back 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 hack 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 the 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 does not 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 (Ø - 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>
Moves 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>
Establishes a TAB location at the current position of the cursor.

<CTRL><CLR TAB>
Clears 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>
Moves 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>
Moves 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.

## 3.3 Commands Unique to ACTION! Editor

<CTRL><SHIFT>D
Deletes the current window from the screen. The window contents are cleared from memory and the window itself disappears from the screen.

<CTRL><SHIFT>E
Moves cursor to the end of the file.

<CTRL><SHIFT>F
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
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
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
String Substitution. This commands 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
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
Writes a file to a peripheral storage device. The file name must be compatible with the DOS you are using.

<CTRL><SHIFT>]
Moves the window right 1 column (useful for editing files with lots of indentation).

<CTRL><SHIFT>[
Moves window to the left 1 column.

<CTRL><SHIFT><up arrow>
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 arrow>
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
Moves from the second window to the first window. The cursor goes to the previous cursor position, if any.

<CTRL><SHIFT>2
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 38 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.

NOTE: The maximum display line length is 40 characters. See the options menu in Part III, Chapter 2.5.

<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 he 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 cannot handle files which do not 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


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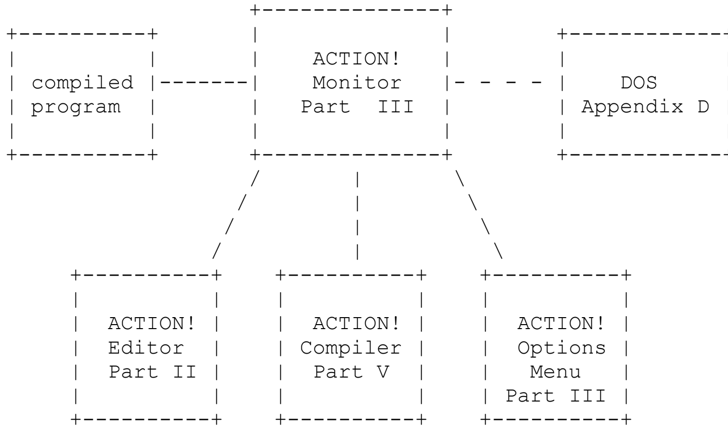
# Part III: The ACTION! Monitor

## 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 multipurpose 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:

FORMAT: 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.

NOTE: An ERROR 3 during a compile causes the system to hang when you return to the editor. Type SET $E=$491^ to the monitor to reset the ACTION! memory pointer; then go back to the Editor.

Examples:

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

      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>
```

NOTES: 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.

Exiting to ATARI DOS can cause a system crash if DUP.SYS is not present on the disk in drive 1.

## 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 the value you want, and press <RETURN>. If you do not 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 18 is converted to 18 and an entry less than 5 is converted to 5.

```
Line size?        12Ø                                    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 24Ø 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 Ø 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> is 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 load a source file stored on a peripheral device, have it compiled by the Compiler, and then it will be run. Remember that the compiled version of your program which has been saved using the 'WRITE' Monitor command must be loaded from DOS. That is, because it is now compiled object code.

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 address $400

        RUN 1024 <RETURN> (run a program at address 1024)

        R Prime    <RETURN>     (run the just-compiled
                                 procedure 'Prime()')
```

NOTE: R *<RETURN> locks up the system. <RESET> it.

## 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 is not sufficient room on the disk, or the disk is write-protected, you are warned with an error message and can try again. Important: When using SpartaDOS or OS/A+ see note in part I, chapter 2.

Examples:

```
        WRITE "PRIME.BIN" <RETURN>      (save a compiled
        W "D1:PRIME.BIN" <RETURN>        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.

NOTE: If a disk error causes a write command to fail, the IOCB is not properly closed. A disk change before performing another disk operation will have invalid data written to the new disk. If such an error occurs, type 'X Close(1) <RETURN>' to the monitor. You can then erase the file which caused the error.

## 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, the hexadecimal value of the CARD starting at the specified location, 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 using a 400/800 machine:

```
       +-----------------------------------------+
       |  >? $FFFE                               |
       +-----------------------------------------+
       |  65534,$FFFE = s $E6F3 243 59123        |
       |                                         |
       +-----------------------------------------+
```

Same example using a XL/XE machine:

```
+----------------------------------------+
|  >? $FFFE                              |
+----------------------------------------+
|  65534,$FFFE = , $C02C 44 49196        |
|                                        |
+----------------------------------------+
```

NOTE: the results might not be what you expect because 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:

```
+----------------------------------------+
|  >* $600                               |
+----------------------------------------+
|  1536,$0600  = * $0000 0 0             |
|  1537,$0601  = * $0000 0 0             |
|  1538,$0602  = * $0000 0 0             |
|  1539,$0603  = * $0000 0 0             |
|  1540,$0604  = * $0000 0 0             |
|  1541,$0605  = * $0000 0 0             |
|  1542,$0606  = * $0000 0 0             |
|  1543,$0607  = * $0000 0 0             |
|  1544,$0608  = * $0000 0 0             |
|  1545,$0609  = * $0000 0 0             |
|  1546,$060A  = * $0000 0 0             |
|  1547,$0608  = * $0000 0 0             |
+----------------------------------------+
```

## Chapter 3: Program Debugging Facilities

You have probably written programs which do not work the way that you expected, not because of syntax errors, but simply because something you are doing (or think you are doing) is not 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!: 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 <BREAK> 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 are 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 are in as well as the global ones.

If this method does not 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).

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# 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 8-bit 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 is 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 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.

# Chapter 2: ACTION! Vocabulary

In our discussion of ACTION! we will use some terminology that we should explain. We will use as little jargon as possible, but some is required to differentiate between parallel but different concepts later on. What terms we do not present here will he explained when they are first used. Before going into the special notations used in this part, we will 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     !       @
```

WARNING: You may not use the above keywords in any 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, 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.
3. 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 unfamiliar with the byte storage system, do not 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
$88       $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., |:<identifier>:| means that you could have a list of zero or more identifiers here).

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

# Chapter 3: Fundamental Data Types

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"
"58395"
"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'
$8D00  ;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. ACTION! 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 Ø and 255. At first glance this might seem a useless type, but it has two worthwhile applications. When used as a counter in loops (WHILE, UNTIL, FOR) program speed will increase because it is 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 Ø to 65,535.

TECHNICAL NOTE: a CARD is stored in the LSB, MSB form which is standard on 65Ø2-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 will not know what to do when it sees 'cost'.

Every identifier you use must be declared before it is used, whether its 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>{=<init info>} |:,<ident>{=<init info}:|
```

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> | [<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 varia-
                    ;ble and initialize it to 0

BYTE x=$8000,       ;declare 'x' as BYTE, placing it
                    ;at memory location $8000
     y= [0]         ;declare and initialize 'y'

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 6.1.1 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 |
| $ØD | 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 is 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 will 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 its meaning:

```
-    unary minus (the negative sign)  Ex: -5
*    multiplication  Ex: 4*3
/    integer division Ex: 13/5 (this equals 2,
                  since the remainder is dropped)
MOD  remainder of integer division  Ex: 13 MOD 5
                   (this equals 3, since 13/5 =2
                        with a remainder of 3)
+    addition  Ex: 4+3
-    subtraction  Ex: 4-3
```

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'
!    bit-wise 'exclusive or'
XOR  same as "!"
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.

& compares the two bits, returning a value based on this table:

| Bit-wise And | | |
|---|---|---|
| Bit A | Bit B | Result |
| 1 | 1 | 1 |
| 0 | 1 | 0 |
| 0 | 0 | 0 |
| 1 | 0 | 0 |

```
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 | Bit-wise Or Result |
|---|---|---|
| 1 | 1 | 1 |
| 0 | 1 | 1 |
| 0 | 0 | 0 |
| 1 | 0 | 1 |

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

! returns a value dependent on this table:

| Bit A | Bit B | Bit-wise XOR Result |
|---|---|---|
| 1 | 1 | 0 |
| 1 | 0 | 1 |
| 0 | 0 | 0 |
| 0 | 1 | 1 |

```
Example: 5 ! 39 -- 00000101  (5)
                   00100111  (39)
                 ! ----------
                   00100010  (result of ! 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 variable used to determine the number of single bit shifts to do |

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
```

| operation | MSB | LSB | |
|---|---|---|---|
| --- | 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) |
| RSH 2 | 00010101 | 10110010 | ($56CA RSH 2 =$15B2) |

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 does not 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:

| | |
|---|---|
| = | tests for equality Ex: 4=7 (this is obviously false) |
| # | tests for inequality Ex: 4#7 (true) |
| <> | same as "#" |
| > | tests for greater than Ex: 9>2 (true) |
| >= | tests for greater than or equal to Ex: 5>=5 (this is true) |
| < | tests for less than Ex: 2<9 (true) |
| <= | tests for less than or equal to Ex: 5<=5 (this is true) |
| AND | logical 'and': see section 4.4 |
| OR | logical 'or'; see section 4.4 |

Both 'f' 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 Ø. 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 would not know how to evaluate expressions like:

4+5*3

Is this equal to (4+5)*3 or 4+(5*3)? Without operator precedence its impossible to tell. ACTION!'s precedence is very precise but can he 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).

| Operators | Description |
|---|---|
| ( ) | parentheses |
| - @ | unary minus, address |
| * / MOD LSH RSH | mult, div, rem, etc... |
| + - | addition, subtraction |
| = # <> > >= < <= | relational operators |
| AND & | logical/bit-wise and |
| OR % | logical/bitwise or |
| XOR ! | bitwise exclusive or |

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 would 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 | +,/,- |

## 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 is an example to show you what we mean:

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

| order | expression | evaluation | simplified exp |
|---|---|---|---|
| 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 |

'order' is the order of the expression evaluation, 'expression' shows which expression is being evaluated, 'evaluation' shows the evaluation of that expression, and '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'.

Some examples follow (all lowercase words are variables 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 rows and columns 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 '*', '/' or 'MOD' operand results in an INT type, so processing 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 exp><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<=$22A7
var<>'y
5932#counter
(5&7)*8 >= (3*(cat+dog))
addr/$FF+(@ptr+offset) <> $F03D-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 its Sunday and then test whether its 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 | |
|---|---|---|---|
| exp 1 | exp 2 | AND | OR |
| true | true | true | true |
| true | false | false | true |
| false | true | false | true |
| false | false | false | false |

NOTE: you may use parentheses around one segment of a complex relational expression to insure the order of evaluation. If you do not 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 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 <= $1FFF
x!$F0<>0 OR dog>=100
(8&cat)<10 OR @ptr<>$0D
cat<>0 AND (dog>400 OR dog<-400)
ptr=$D456 OR ptr=$E000 OR ptr =$600
```

Here is 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

```
$F0<>0 AND $0F<>0
```

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

# Chapter 5: Statements

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 5.2.3.2 |
| 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 will notice a variable declaration section preceding the examples themselves. It is 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).

```
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' ($44 is "D" in ATASCII and so 'b3' and 'b4' now contain the same thing). |
| b1=b4+16 | adds 16 to the numerical value of 'b4', and puts the result into the byte reserved for 'b1'. |
| c1=23439-$Ø7D8 | puts the value 21431 ($53B7) in the two bytes reserved for 'c1'. |
| i1=c1*(-1) | puts the value -21431 ($AC49) 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 'i1' to put into 'b2' (the MSB of it is $AC; 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==& $ØF | is the same as | b2=b2 & $ØF |
| 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 will 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 (Ø) | false |
| | non-zero | true |
| relational | false | false |
| | true | true |

## 5.2.1.2 IF Statement

The IF statement in ACTION! is much like the 'if' conditional statement in English. For example:

"If I have $9 or more, I will 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)
```

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 fum...", 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 will use comparative examples:

> "If I have $9 or more I will buy the steak, otherwise I will 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 will buy the steak. If I have between $8 and $9 I will buy the fried fish. If I have between $6 and $8 I will buy the chicken. Otherwise I will 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 do not 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 ELSEIFs and ELSEs) is skipped. So, if the computer does get to "money>=8", we already know that we have less than $9, because the preceding 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.

NOTE: there is a relatively obscure bug related to the use of ELSEIF. In particular, statements similar to the form 'ELSEIF a(i) = 0 THEN ...' where 'a' is an ARRAY and 'i' is a CARD OR INT, or statements like 'ELSEIF p^ = 0 THEN' where 'p' is a Pointer, produce incorrect code. The best way around these problems seems to be to code something like:

```
t = a(i)    ; t is an INTEGER
...
ELSEIF t=0 THEN ...
```

This works properly.

## 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 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 have not yet discussed loops at all, we will simply say that timing loops are used as a time delay (e.g., if you want to pause between printing lines to the 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 are implementing are: BUY, DOWN?, FIND, QUIT, SELL, and UP?, but you have not 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 is not done, so what do you do when they type 'F'? Easy, you do nothing, hoping that someday (when FIND is ready) you will do something. Here is how the program fragment might look:

```
IF chr='B THEN
   dobuy()
ELSEIF chr='D THEN
   dodown()
```

```
ELSEIF chr='F THEN
   ;**** here is the null statement
ELSEIF chr='Q THEN
   doquit()
ELSEIF chr='S THEN
   dosell()
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 is 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 will 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 do not 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 will 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 is a program example to illustrate the DO - OD loop. Do not worry about the 'PROC' and 'RETURN' statements; they are 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
      j=i*2            ;set 'j' equal to i*2
      PrintC(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 do not be alarmed; they are only there because they do things that make the examples more visually instructive.

Output #1:

```
       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
       8 times 2 equals 16
                :
                :
```

The colons at the end of the output shows that 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/O. See Part IV, 'The ACTION! Compiler', for more information.)

Whenever you see '<DO - OD loop>' in the formats 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 is an example:

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
      PrintC(i)
      Print(" times 2 equals ")
      EXIT              ;Here is the EXIT statement
      PrintCE(j)
      OD                ;end of DO - OD loop
      ;**** execution continues here after 'EXIT'
      PrintE("End of Table")

   RETURN
```

Output #1:

```
       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 is not 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 #2:

```
PROC timestwo()

   CARD i=[0],j
   DO     ;start of DO - OD loop
   IF i=15 THEN
      EXIT  ;EXIT in an IF conditional
   FI
   i==+1
   j=i*2
   PrintC(i)
   Print(" times 2 equals ")
   PrintCE(j)
   OD     ;end of DO - OD loop
   ;**** execution continues here when i=15
   PrintE("End of Table")
RETURN
```

Output #2:

```
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
8 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 does not 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 will never throw spitwads again" one thousand times, you would call that punishment, but if you told the computer to do the same thing (with a controlled loop, of course), it would think that the task was easy and mundane.

Now we will 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 element is:

```
FOR <counter>=<initial value> TO <final value> (STEP <inc>)

        <DO - OD loop>
```

where

```
        <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
        <final value>   is the ending value of the counter
        <inc>           is the amount by which the
                        computer increments the counter
                        after every iteration
        <DO - OD loop>  is a DO - OD infinite loop
```

NOTE: the 'STEP <inc>' is optional

Instead of trying to explain this to you using metaphors, we will 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 S  ;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=Ø TO 16 STEP 2 ;this FOR loop has a 'STEP'
         DO
         PrintB(ctr)
         Print(" ")
         OD
   RETURN
```

Output #2:

```
       Ø 2 4 6 8 1Ø 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 will not 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 loop, 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 illustrate 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 ;does not affect number of repetitions
         end=10    ;does not affect number of repetitions
         PrintBE(ctr)
         ctr==*2   ;DOES affect number of repetitions
         OD
   RETURN
```

Output #3:

```
       1
       3
       7
       15
       31
```

Below is 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 might even be useful.

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

```
   BYTE ctr

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

This is just used as a time-waster; something you will use a lot if you are 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 cannot be incremented to a value greater than the given <final value>.

### 5.2.4.2 WHILE Statement

The WHILE statement (and the UNTIL statement, for that matter) is used when you do not 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

| | |
|---|---|
| <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 of testing

   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 is ")
      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 is 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 will see the output 'wrap around'; that is, you will get a number larger than the maximum a CARD allows (65535), 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 ACTIONI Compiler'.

Example #2:

```
PROC guesswhile()
;**** 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 am")
   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 is your guess?  ")
      guess=InputB()         ;get user's guess
      IF guess<num THEN      ;guess too low
         PrintE("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 am
thinking of a number from 0 to 100
What is your guess?  50
Too low, try again
What is your guess?  60
Too high, try again
What is your guess?  55
Too low, try again
What is 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 will probably understand why this is so:

```
DO
<statement>
     :
     :
<statement>
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:

```
PROC guessuntil()
;**** This procedure plays a guessing game with
;the user, using an UNTIL loop

   BYTE num,       ;the number to guess
        guess      ;the user's guess

   PrintE("Welcome to the guessing game. I am")
   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
      PrintE("Too high, try again")
   ELSE                    ;guess just right
      PrintE("Congratulations!!!!")
   FI PrintE("You got it");end of guess testing
   UNTIL guess=num         ;loop control
   OD                      ;end of UNTIL loop
RETURN                     ;end of PROC guessuntil
```

Output:

```
Welcome to the guessing game. I am
thinking of a number from 0 to 100
What is your guess?  50
Too low, try again
What is your guess?  60
Too high, try again
What is your guess?  55
Too low, try again
What is 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 5.2.4.3 (UNTIL), you can see examples of nesting an IF statement into WHILE and UNTIL loops. This type of nesting is very straightforward, and need not 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 does not 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              ;**** end of IF <expB>
  | ELSEIF <expE> THEN   ;**** ELSEIF of IF <expA>
  |         <statements>
  | ELSE                 ;**** ELSE of IF <expA>
  + FI   <statements>    ;**** end of IF <expA>
```

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

```
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
      FI              ;column
      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 are doing. Fortunately, "knowing what you are doing" does not 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.

## Chapter 6: Procedures and Functions

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 is

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 is 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 will 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 would not know what to do if someone told you "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? Because they are 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 ACTION! (small pun intended).

### 6.1.1 PROC Declaration

The ACTION! keyword 'PROC' is used to denote the start of a PROCedure declaration. 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 decl>}
   {<statement list>}
RETURN
```

where

| | |
|---|---|
| PROC | is the keyword denoting a procedure declaration |
| <identifier> | 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 decl> | 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: <parameter list>, <variable decl>, and <statement 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 parentheses 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 have not 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.

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

```
   PROC guessuntil()
   ;**** This procedure plays a guessing game with
   ;the user, using an UNTIL loop

      BYTE num,       ;the number to guess
           guess      ;the user's guess

      PrintE("Welcome to the guessing game. I am")
      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
         PrintE("Too high, try again")
      ELSE                  ;guess just right
         PrintE("Congratulations!!!!")
         PrintE("You got it")
      FI                    ;end of guess testing
      UNTIL guess=num       ;loop 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. Its output is the same as that given in the UNTIL

section, namely:

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

If you look back at the above example, you will see 'RETURN' as the last statement. We will now cover why it is 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 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 ELSEIFs, you might want to RETURN after one or more of the ELSEIF cases. The example on the following page illustrates this possibility.

```
PROC testcommand ()
;**** This procedure tests a command to see if it is
;valid. Valid commands are Ø, 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=Ø THEN
      <statementØ>
   ELSEIF 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 do not want to go through all the command tests if the command is not 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 have already seen some procedure calls, although you probably do not 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 (do not worry about the parameters now, a whole section is devoted to them later):

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

factorials()

guessuntil()

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

Of course you must already have declared the procedures 'factorials', 'guessuntil', and 'signoff' before using them here. 'PrintE' is a library procedure, so it is 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. Do not 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 is 1 through 7 inclusive.
   ;Otherwise, the function will re-prompt the user.

      BYTE command,   ;this variable holds the command
           error      ;set to 1 if an error is found

      DO
      Print("COMMAND> ")
      command=InputB()
      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 is not 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 cannot return a value.

Although there are dissimilarities between RETURNs 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 RETURNs 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:

```
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 Ø.

   IF x>255 THEN ;number would cause overflow
     PrintE("Number too big")
     RETURN (Ø) ;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 cannot 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 will 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 editor). Notice that both of them return 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=uppercase(chr)
```

'Peek' and 'Rand' are library functions, so they need not 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 us 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 do not 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 are going to declare some variables
            ;as global

CARD numgames=[0], ;number of games played
     goal=[10],    ;number of guesses to beat
     beatgoal=[0]  ;number of times you have beaten goal

PROC intro()
;**** This procedure puts the lead-in to the game on
;the screen.

   CARD ctr

   PrintE("Welcome to the guessing game. I am")
   PrintE("thinking of a number from 0 to 100.")
   PrintE("All you have to do is type in your")
   PrintE("guess when I ask you to.")
   PutE()
   PrintE("I will keep track of how many games")
   PrintE("you have played, and tell you how")
   PrintE("many times you have guessed the number")
   PrintE("in fewer tries than your goal, but")
   PrintE("first you have to give me your goal.")
   PutE()
   Print(" Type your goal here --> ")
   goal=Input()
   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,")
   Print("and in ")
   PrintC(beatgoal)
   PrintE(" of those you")
   PrintE("have beaten your goal of")
   PrintC(goal)
   PrintE(" guesses.")
   PutE()
RETURN   ;end of PROC tally
```

```
PROC playgame()

CARD numguesses,  ;the number of guesses
     ctr          ;counter used in delay loop

BYTE num,         ;the number to guess
     guess        ;the user's guess

PrintE("I am picking my number...")
FOR ctr=0 TO 4500   ;delay used to make the user
   DO               ;think the computer is picking
   OD               ;a number
PutE()
PrintE(" O.K., here we go!")
PutE()
num=Rand(101)       ;get the number to guess
numguesses=0        ;set number of guesses to 0
DO                  ;start of UNTIL loop
Print("What is your guess?  ")
guess=InputB()         ;get the user's guess
numguesses==+1         ;add 1 to number of guesses
IF guess<num THEN      ;guess too low
   PrintE("Too low, try again")
ELSEIF guess>num THEN  ;guess too high
   PrintE("Too high, try again")
ELSE                   ;guess just right
   PrintE("Congratulations 1!!1")
   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   ;does not
      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 games
   playgame()        ;play the game once
   tally()           ;show tally of games thus far
   UNTIL stop()      ;does not want to play anymore
   OD
   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, its scope, its 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 | FUNC stop | PROC main |
|---|---|---|---|---|---|---|
| numgames | global | A | A | A U | A | A U |
| goal | global | A U | AU | A U | A | A |
| beatgoal | global | A U | A | A U | A | A |
| numguesses | local | A U | | | | |
| num | local | A U | | | | |
| guess | local | A U | | | | |
| ctr | local | A U | | | | |
| again | local | | | | A U | |
| ctr | local | | A U | | | |

You can see that 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 why 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 multi-purpose use.
2) They allow you to manipulate variable values within a routine without changing the value of any global variable.

we will 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 r<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 x)
PROC jump()
```

** Parameters in PROC or FUNC calls:

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

where

```
<arith exp>      is an arithmetic expression
```

Examples:

```
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 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 do not declare 'chr' anywhere. We will 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
      FI                           ;upper 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 is not what we want the function to do. We want it 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 will not 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 is 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 is 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 dah! This is what we meant by multipurpose".

The second advantage to using parameters is more difficult to illustrate, but we are 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:

```
   PROC division(CARD num,div)

      num==/div       ;changes num to num/div
      PrintC(num)     ;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)
         Print("/")
         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 'num' 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 use 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 Ø 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 will not 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.

## Chapter 7: Compiler Directives

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 (<CTRL><SHIFT>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 occurrence 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 do not 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 will just put that in instead."

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

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

NOTE: Do not forget that the string constant must have double quotes around it (see section 3.2).

To better show you what DEFINE does and does not do, here is 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 are writing now. All you need to do is put the following command in the program you are 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 'IOSTUFF.ACT'. Note that this example assumes that the diskette with 'IOSTUFF.ACT' on it is in disk drive #1. If you do not 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:" is not valid). Here are some more examples:

```
INCLUDE "D2:IOLIB.ACT"
INCLUDE "PROG1.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 he 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 maximum 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.

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

Using a code offset greater than $7FFF (i.e., a negative offset, if you consider it to be of type INT) causes the

compiler to generate improper code, which becomes obvious especially when using the runtime library. To avoid such problems use the relocation program in Appendix J.

## 7.4 MODULE

MODULE is a very simple directive. Its 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).

## Chapter 8: Extended Data Types

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 will 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 will just give some sample pointer declarations, instead of whole program examples:

```
       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 cataloging 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 will discuss the '^' in depth.

Example #1:

```
   PROC pointerusage()

      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            ;changes 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 do not 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 ARRAYs

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 are really saying when you reference an array element is, "I want the nth 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 will show you how to declare arrays and manipulate them, and then we will talk about the limitations of arrays in ACTION!.

### 8.2.1 Array Declaration

Declaring arrays is easy in ACTION!, but that does not mean that you do not have much control over what is 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 in decimal form. |
| <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:

```
BYTE ARRAY a,b  ;declares two arrays with BYTE
                ;elements without sizes declared

INT ARRAY x(10) ;declares 'x' as an INT array,
                ;and dimensions its size

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 18] ;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 cannot or need not:

1) When you do not know how big it is going to be (i.e., as in a routine parameter, when you do not 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 const>' construction), and you are not 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 an string longer, first you must change the length byte (which is the zeroth element of the array containing the string).

### 8.2.2 Internal Representation

The internal representation of an array is very much like that of 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 CARD and INT 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 manipulating 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 will 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  ;xth element of nums is assigned
                        ;the value x+'A
         Put(nums(x))  ;put out xth element of nums as
                        ;a character
         Print(" ")    ;put a space between the chars.
         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:

```
<ident>(<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(Ø)', not 'cat(1)'. This might seem strange, but you get used to it very quickly.

Example F2:

```
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
   barray="This is string 2."   ;to (with an EOL)
   PrintC(barray)
   Print(" ")
   PrintE(barray)
RETURN
```

Output #2:

```
10352 This is string 1.
10414 This is string 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 is a string constant they are both pointing to.

You might have noticed that we have not done anything like

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

   PrintE(a)
```

That is because the above will not 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.

Example #4:

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.

```
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 messages

   addr(Ø)="Illegal command"
   addr(1)="Illegal character" See
   addr(2)="Bad File Name"    EXAMPLE 4
   addr(3)="Number Too Large" NOTES for an
   addr(4)="Wrong Type Of Number" , explaination
   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
   PrintE(errmsg)      ;number 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=Ø 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 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 does not support all these types. Instead, it groups together 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 re-declare the format of the record type every time.

The next section (8.3.1.1) shows how 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 will 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:

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

This needs some explanation so we will 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.

NOTE: a TYPE declaration will generate a spurious error whenever the code offset (contents of location $B5) is non-zero. Presumably only noticed if using the runtime library. To fix this do all TYPE declarations before changing the code offset.

### 8.3.1.2 Declaring Variables

The last section showed you how 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 variable whose data type is declared to be the record type. |
| <init info> | is information used to set some attributes of the variable. |
| <addr> | is the address in memory where you want the variable to be located. It must be a numeric constant. |

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

```
   TYPE rec=[BYTE b1,b2     ;same TYPE declaration
             INT i1         ;used in the previous
             CARD c1,c2,c3  ;section
             BYTE b]        ;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 is time to find out how to reference and manipulate records.

8.3.2 Record Manipulation
-------------------------

To learn how to manipulate records, we first must must learn how to reference a field within a record. The following program does just that, using the period ('.') operator. We will 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 is 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.entryyear=InputC()    ;get his entry year
      PrintE("O._K. Here is what I have:")
      PutE()                  +
      Print("I.D. # ")        |   Prints
      PrintCE(rec.idnum)      |   out the
      Print("Level: ")        |   information
      Put(rec.level)          |   the
      PutE()                  |   employee
      Print("Entry year: ")   |   put in
      PrintCE(rec.entry_year) +
  RETURN    ;end of PROC recordreference
```

Output #1:

```
What is your I.D. Number?  4365
What is your employment level?  L
In what year did you start working here?  1978

O.K.  Here is what I have:

I.D. #  4365
Level:  L
Entry year:  1978
```

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 will 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 a dimensioned 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 string 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 reccount=[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 poin-
   ;ter 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*recordsize)
      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
      reccount==+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 are 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 will go through these one by one. This should not only explain the statements themselves, but should also clarify the concept we are 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+(reccount*recordsize)
This assignment makes the pointer point to the current record in 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.

reccount==+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 have 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 will 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 us first modify the records a little bit. We will add one more field which will contain the employee's name in the form:

LastName, FirstName

To do this we must somehow make the field an array. Or must we? Instead, let us 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 cannot be longer than 19 characters (recall the first byte of a string is its length), so we will have to make sure the string is short enough. Without further ado, we will move onto the extended version of the 'idinfo' procedure, complete with strings.

Example #2:

```
   MODULE    ;declaring some global variables

      TYPE idinfo=[CARD idnum,     ;employee's 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)        ;employment level
      Print("Access code?  ")
      newrecord.codenum=InputC(    ) ;get secret code
      nameptr=newrecord+nameoffset   ;point '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 us 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'. Its 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 Ø 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
                                 ;in turn to do test

      BYTE ctr ;used as a counter in the FOR loop

      FOR ctr=Ø TO (reccount-1)  ;minus one because we
         DO                      ;start at Ø, not 1
         seeker=idarray+(ctr*recordsize)   ;index record
         IF seeker.idnum=testidnum THEN    ;test for an
            RETURN (seeker)       ;I.D. match and return
         FI                       ;if found
         OD
   RETURN (Ø) ;no match found. End of FUNC findmatch
```

This function needs very little explanation, since it is 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 us 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's I.D. number
                     codenum  ;his access code
                BYTE level,   ;his employment level
                     name]    ;first letter of name

   BYTE ARRAY idarray(1ØØØ)  ;enough space for 4Ø records

   DEFINE recordsize="25",
          nameoffset="5"

   CARD reccount=[Ø]
```

```
;*****************************************************
;
;                continued on following page
;
;*****************************************************
```

```
PROC fillinfo()   ;**** Again the array filling procedure

   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)      ;employment level
      Put(newrecord.level)
      PutE()
      Print("Access code?  ")
      newrecord.codenum=InputC()   ;get secret code
      nameptr=newrecord+nameoffset ;point '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
                           ;in turn to do test
   BYTE ctr            ;used as a counter in the FOR loop

  IF reccoun>Ø THEN    ; prevent endless loop if no
                       ; data have been keyed in already

   FOR ctr=Ø TO (reccount-1)        ;minus one because we
      DO                            ;start at Ø, not 1
         seeker=idarray+(ctr*recordsize) ;index record
         IF seeker.idnum=testidnum THEN  ;test for an
            RETURN (seeker)              ;I.D. match and
         FI                              ;return if found
      OD
RETURN (Ø) ;no match found. End of FUNC findmatch

;*********************************************************
;
;                 continued on following page
;
;*********************************************************
```

```
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. number input by user
        code_num,        ;code number input by user
        keyid=[65535]    ;I.D. number allowing loop exit

   BYTE mode             ;controls the operation mode

   Put(125)              ;delete garbage from screen
   PrintE("Startup....")
   PrintE("What operation mode? ")
   PrintE("X = expand list of employees")
   PrintE("A = alert/test input mode")
   Print(">> ")
   mode=GetD(7)         ;read mode
   Put(mode)
   PutE()
   IF mode#'A AND mode#'a THEN  ;anything but A or a will
      fillinfo()                ;go to X mode
   ELSE
      DO      ;loop start for interrogation routine
         Print(" Employee I;D. number >> ")
         id_num=InputC() ;get I.D. number
         IF id_num=keyid THEN ;enables exit from
            EXIT          ;the infinite loop
         ELSE ;a normal I.D. number (i.e., not keyid)
           recptr=findmatch(id_num) ;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
                 Print("Level:  ")       ; | out
                 Put(recptr.level)       ; | known
                 Print("Name:      ")    ; | info.
                 PrintE(nameptr)         ; +
                 PutE()
                 PrintE("O.K. 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 'keyid' check
      OD                ;end of infinite loop
   FI                   ;end of 'IF mode=
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.

# Chapter 9: Advanced Concepts

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 do not 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 block. 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 $FFF8]
```

Code blocks are useful for including small machine code routines, but it is 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 did not really make use of that option. We did not 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 are going to present a graphics program which makes the background color change and scroll. To do this we cannot use the normal (shadow) color registers, because they are only looked at every T.V. frame. Instead, we will 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 Ø). We have to make sure that we do not change colors in the middle of a scan line, so we will 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=[Ø], ;a counter and a color changer
        incclr          ;increments color luminance

   Graphics(Ø)          ;set graphics Ø
   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=1 TO 4
      DO
      incclr=chgclr     ;set base color to increment
        DO              ;start of UNTIL loop
       wsync=Ø          ;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==+1           ;change the base color
   DO                   ;end of infinite scrolling loop
RETURN                  ;end of PROC scrollcolors
```

## 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 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 | 16th |

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 will not go into register A
   ;(CIO expects it in X reg.)

   PROC readchannel2()

   ;**** 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 iocb2buf=$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
      iocb2len=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 could not 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 it 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 sub-
;string 'sub'. If it is found, the function returns the in-
;dex onto the string. If the substring is longer than the
;mainstring an error is returned via pointer. If the sub-
;string is not found, that is returned via another pointer.

  BYTE ARRAY tempstr ;holds temporary substring for test

  BYTE ctr1,   ;outer loop counter
       ctr2    ;inner loop counter

  IF sub(Ø)>str(Ø) THEN    ;substring bigger than string
     errorptr^=1
  ELSE
     FOR ctr1=1 TO str(Ø)  ;loop to check string
       DO
       IF sub(1)=str(ctr1) THEN  ;testing 1st characters
          tempstr(Ø)=sub(Ø)      ;dimension tempstr
          FOR ctr2=1 to sub(Ø)   ;fill tempstr
             DO
             tempstr(ctr2)=str(ctr2+ctr1-1) ;fill tempstr
             OD
          IF SCompare(tempstr,sub)=Ø THEN ;compare 2
                                          ;strings
             RETURN (ctrl) ;return index if equal
          FI
       FI ;end of testing 1st characters
       OD ;end of FOR loop
  FI
  notfound^=1   ;did not RETURN in loop, so no match found
RETURN (Ø)   ;end of FUNC substr
```

Now, when we want to call this we must use the form:

```
<index>=substr(<string>,<substring>,<errptr>,<nofindptr>)

where  <index>    is the index into <string> where
                  'substring' starts.
       <string)   is the main string
       <subetr>   is the substr 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 are 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.

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# 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.

## Chapter 2: Compiler Operation - Allocating Space

In this chapter we will 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 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.

(In case of problems see notes in part IV, chapter 7.3.)

### 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 should help your understanding of data allocation.

| data type | allocated | comments |
|---|---|---|
| BYTE | 1 byte | fundamental type |
| CHAR | 1 byte | fundamental type |
| CARD | 2 bytes | fundamental type |
| INT | 2 bytes | fundamental type |
| ARRAY | fundamental type size times number of elements | extended type |
| TYPE | sum of sizes of fundamental types,as given in declaration | extended type |
| string | all characters in the string plus a preceding byte to note length | each string is allocated separately even if set equal to the same identifier |

## 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 (statements 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 INCLUDEd 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 key word. 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 will not 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.

## Chapter 3: Using The Options Menu

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 I/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 prompt.

## Chapter 4: Technical Considerations

### 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 will not get 256 (because a single byte can only contain values up to 255), you will 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 flow. 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 alter 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). Then 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.).

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# 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 will use often which require some discussion - IOCB and channel.

IOCB stands for "Input Output Control Block". The CIO (Central I/O) uses IOCBs 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 is 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 us take one of the routines and explain what information each part of the presentation format can tell you. The routine we will 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 is 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) 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.

## Chapter 2: Output Routines

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 will 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 he 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 us 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 output 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:

| | | strings | BYTEs | CARDs | INTs |
|---|---|---|---|---|---|
| No Options | - | Print | PrintB | PrintC | Printl |
| EOL | - | PrintE | PrintBE | PrintCE | PrintBE |
| To Device | - | PrintD | PrintBD | PrintCD | PrintlD |
| Both Options | - | PrintDE | PrintBDE | PrintCDE | PrintIDE |

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, using 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)

description:
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 that arithmetic expressions can simply be a constant or variable name).

channel - is a valid channel number (Ø - 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 <RETURN> 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 ex--pressions can simply be a constant or variable name).
channel - is a valid channel number (Ø - 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 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 (Ø - 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 <RETURN> 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 PutDE(BYTE channel)
```

parameters: character - is an arithmetic expression (remember that arithmetic expressions can simply be a constant or variable name).
channel - is a valid channel number(Ø - 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 a <RETURN> 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 (Ø - 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.

purpose: to input string data

```
formats:      PROC InputS(<string>)
              PROC InputSD(BYTE channel, <string>)
              PROC InputMD(BYTE channel, <string>, BYTE max)

parameters:   <string> - 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.
       InputSD   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.
```

NOTE: When using the string input library functions (InputS, InputSD, and InputMD), there must be room in the string for the termination EOL, even though the resulting string length will not include it.

## 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.

## Chapter 4: File Manipulation Routines

This chapter is devoted to those routines which deal with external devices (printer, disk drive, cassette, 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 (Ø - 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 the device specified in <filestring>. The I/O mode can be set (see 'mode' 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 (Ø - 7)

description:
This procedure closes the specified channel. At the end of a program you should always close any devices you have opened in the course of that program.

NOTE: DO NOT Close channel 7, as ACTION! uses it.

## 4.3 PROC XIO

purpose:

format: PROC XIO(BYTE chan,Ø,cmd,auxl,aux2,<filestring>

parameters:
- chan - is a valid channel number (Ø - 7)
- cmd - is the equivalent of the IØCB COMMAND byte (ICCOM in OS/A+ and DOS XL)
- auxl - is the first auxiliary byte in the IOCB (ICAUXl 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 filename 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.

NOTE: the "Ø" given as the second parameter is required.

## 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 chan,
          CARD POINTER sector,
          BYTE POINTER offset)
```

parameters: chan - is a valid channel number (Ø - 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 chan,
           CARD sector,
           BYTE offset)
```

parameters: chan - is a valid channel number (Ø - 7)
sector - is a valid sector number (1 – 72Ø)
offset - is the byte offset within that sector.

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 will 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.

| Gr. Mode | Mode Type | Rows | (split) Cols | (full) Cols | Num of Colors |
|---|---|---|---|---|---|
| 0 | TEXT | 40 | N/A | 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 |

## 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 (Ø - 4)
- hue - is the hue of the color.
- luminance - is the luminance 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.

| SetColor hue num. | Color | SetColor hue num. | Color |
|---|---|---|---|
| Ø | Gray | 8 | Blue |
| 1 | Gold | 9 | Light Blue |
| 2 | Orange | 1Ø | 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 |

The above table shows the 16 hues available on the ATARI, and their numeric code for use as the 'hue' parameter of the SetColor procedure.

| Register | Default Color | Default Luminance | Color |
|---|---|---|---|
| Ø | 2 | 8 | Orange |
| 1 | 12 | 1Ø | Green |
| 2 | 9 | 4 | Dark Blue |
| 3 | 4 | 6 | Pink or Red |
| 4 | Ø | Ø | Black |

This table shows which colors are the defaults used when you do not 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 Ø and 15, where Ø is darkest and 15 is brightest.

## 5.3 BYTE color

'color' is not 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 have 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 |
|---|---|---|---|
| 0 | 0 | N/A | |
| and | 1 | N/A | Character luminance |
| all | 2 | N/A | Background |
| text | 3 | N/A | |
| windows | 4 | N/A | Border |
| | 0 | N/A | Character |
| | 1 | N/A | Character |
| 1,2 | 2 | N/A | Character |
| | 3 | N/A | Character |
| | 4 | N/A | Background,Border |
| | 0 | 1 | Graphics Point |
| | 1 | 2 | Graphics Point |
| 3,5,7 | 2 | 3 | Graphics Point |
| | 3 | -- | -- |
| | 4 | 0 | Gr. Pt.,Border,Backgrd |
| | 0 | 1 | Graphics Point |
| | 1 | -- | -- |
| 4,6 | 2 | -- | -- |
| | 3 | -- | -- |
| | 4 | 0 | Gr. Pt.,Border,Backgrd |
| | 0 | -- | -- |
| | 1 | 1 | Gr. Pt., luminance |
| 8 | 2 | 0 | Gr. Pt.,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 proceeded 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 end point of the line.
row - is the vertical row number of the end point of the line.

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 lower left corner of the box being filled.
row - is the vertical row number of the lower left corner of the box being filled.

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 left 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 co),BYTE row)

parameters: col - is the horizontal column number of the position desired.
row - is the vertical row number of the position desired.

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 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 is 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 the number, 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 - 16)

description:
This procedure allows you to control the sound-generating apparatus on the ATARI, much like the BASIC command of the same name. Distortion value 10 is the only useful for making music. The others are useful for airplane, race-car, etc. sound effects.

Here is a table for various musical notes using distortion 10.

| | 'pitch' | Note(s) | | 'pitch' | Note(s) |
|---|---|---|---|---|---|
| HIGH | 29 | C | | 91 | F |
| NOTES | 31 | B | | 96 | E |
| | 33 | A# or Bb | | 102 | D# or Eb |
| | 35 | A | | 108 | D |
| | 37 | G# or Ab | | 114 | C# or Db |
| | 40 | G | MIDDLE C | 121 | C |
| | 42 | F# or Gb | | 128 | B |
| | 45 | F | | 136 | A# or Bb |
| | 47 | E | | 144 | A |
| | 50 | D# or Eb | | 153 | G# or Ab |
| | 53 | D | | 162 | G |
| | 57 | C# or Db | | 173 | F# or Gb |
| | 60 | C | | 182 | F |
| | 64 | B | LOW | 193 | E |
| | 68 | A# or Bb | NOTES | 204 | D# or Eb |
| | 72 | A | | 217 | D |
| | 76 | G# or Ab | | 230 | C# or Db |
| | 81 | G | | 243 | C |
| | 85 | F# or Gb | | | |

## 5.10 PROC SndRst

purpose: to reset all the sound voices.

Format: PROC SndRst()

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.

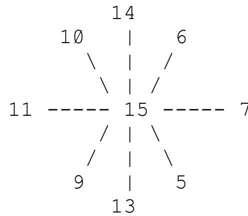
## 5.13 BYTE FUNC Stick

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.




## 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.

## Chapter 6: String Handling / Conversion

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 do not 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(<stringl>,<string2>)

parameters:
<stringl> - 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 table:

| 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>,<source>)

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.

description:
This procedure copies the contents of <source> into <dest>. Please make sure that <dest> and <source> are compatible in size.

## 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 he 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 <source>, it will be changed to the length of <source>.

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+l) in <dest> is greater than the length of <source>, then 'stop' will be changed to the length of <source>.

The copying this procedure does will overwrite the old elements of <dest> as it puts in <source>.

NOTE by GBXL: The original text for 'stop' and 'description' could be misleading for non-native readers and therefore has been changed.

## 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,<strinq>)
PROC 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 Valli(<string>)
CARD FUNC Va)C(<string>)
INT FUNC Vall(<string>)
```

parameters:
- <source> - 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.

## Chapter 7: Miscellaneous Routines

This chapter contains those routines which do not 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 Ø and ('range'-1). If 'range' is Ø, then a random number between Ø 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

   PROC main() ;your main procedure

      CARD temperr    ;holds the address of the system's
                      ;error routine (PROC Error).

      temperr=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=temperr   ;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 do not 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 to forget to check for something in your 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: SetBlock(BYTE POINTER address, CARD size, BYTE value)

parameters:
- address - is a pointer to the starting address of the block you want to set.
- size - the size of the block you want to set.
- value - 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 'value'. This block starts at 'address' and ends at location 'address'+'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-l. 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(S,"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 EOF(8)

With this library variable you can found out if you have 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 reached the End of File on channel 1 (the channel must be open), then you would use:

```
      IF EOF(1) THEN
           :
           :
```

EOF equals 1 when the End Of File has been reached, otherwise it is Ø.

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# Part VII: The Action! Run Time Package

## Chapter 1: INTRODUCTION

The Action! Run Time Package (which we will call simply "RunTime" from here on) is designed to aid users of the OSS ACTION! Cartridge-based language. Specifically, by using RunTime, you can compile an ACTION! program in such a way that the Action! cartridge is no longer needed when running the compiled program.

The primary advantage of using RunTime is that it allows you to give copies of your efforts to your friends, user group members, etc. Remember, though, that you OR your publisher MUST purchase the Commercial License for RunTime if you wish to SELL programs written in Action!

A secondary advantage of using RunTime is that you may produce extrinsic commands (i.e., programs with a ".COM" file name extension) for use with OS/A+ or DOS XL. Again, you could use these new commands at any time, not just when your ACTION! cartridge is installed.

Section 1 of this guide describes how ACTION! Compiles programs, how it builds its symbol tables, and other information you may find useful when compiling programs written in ACTION! We suggest you read Section 1 very carefully.

This documentation then presents you with four possible ways to use RunTime. We suggest that you write and compile a short program using the methods described in Section 2 first. Then you can read the first few paragraphs of each of Sections 3, 4, and 5 to see if the methods described in each of those sections will be useful to you.

Finally, Section 6 provides a memory map of the most useful and interesting memory locations used by either the compiler or the RunTime system. Many of these locations are discussed in detail in other sections, so section references are provided, if appropriate.

# Chapter 2: How ACTION! Works

## 2.1 Compiling a Program

When the Action! monitor receives a compile request, it initializes certain of its tables, sets and uses certain memory pointers, and then begins producing 6502 machine code directly into memory, it pays attention to certain system variables which will be described here.

In the discussions which follow, we use square brackets to indicate memory which is pointed to by the named or addressed location. Thus, [$02E7] means "the memory location(s) pointed to by the contents of location $02E7". In general, words which are printed in all capital letters are labels given in the memory map of Section 6.

### 2.1.1 Memory Allocation

Unless you tell it otherwise, Action! uses memory as follows:

The edit buffer starts at [APPMHI] ([$0E]). This pointer is itself derived as an offset (of about $700 bytes) from [LOMEM] ([$2E7]). The space between [LOMEM] and the initial location of [APPMHI] is used for various semi-fixed buffers, tables, etc.

As you edit your program, Action! changes APPMHI as appropriate.

When you ask to compile your program, APPMHI is copied to CODEBASE ($0491). Also, CODESIZE is cleared to zero.

Symbol table space is allocated from the top of memory downward. The symbol table itself contains symbols for both global and local variables (which part of the table is used for what is controlled by the "hash tables", part of the "semi-fixed" memory mentioned above). The amount of space allocated is determined by STSP ($0495), which may be changed by the user (see Section 3).

As your code is compiled, Action! adjusts [APPMHI] to reflect the top of the compiled code. Also, CODESIZE is incremented to reflect the amount of code generated.

After the code is compiled, the monitor's 'W' command uses CODEBASE and CODESIZE to determine what part of memory to write to the object file.

Note the most important implication of the above: if you do NOT have a program in memory, your code will be generated at the lowest practicable memory address. Supposition: If it can be compiled at the lowest address, or at a higher address determined by the top of the edit buffer, perhaps it can be compiled anywhere. Actually, that supposition is almost true.

The only real limitation is that Action! 's semi-fixed buffers, your compiled program, and your symbol table must, somehow, fit in the memory between the top of DOS ([LOMEM]) and the bottom of the screen memory ([HIMEM]).

Note that if you use DOS XL (the version titled "DOSXL.SUP" on the version 2.3 and above distribution disk), you will automatically be using a LOMEM value, which gains you a significant amount of memory. Unfortunately, the program thus compiled may not then be able to run without the Action! cartridge installed, since it will overlay part of the lowest memory used by any non-DOSXL.SYS version of DOS. However, see Section 4 for information on compiling with an offset and more notes on this subject.

### 2.1.2 Symbol Table Searches

Whenever the Action! compiler encounters a symbol (e.g., a variable name, a DEFINEd name, a TYPE name, or a PROC name) it always searches for the symbol in three places.

First, the local symbol table is searched. All symbols defined after the keywords PROC or FUNCTION are encountered (except, of course, the actual name of the PROC or FUNCTION) are considered locals. This would include even the parameters to a PROC or FUNCTION.

Second, the global symbol table is examined. All PROC and FUNCTION names are placed in the global table as well as all names encountered before the first occurrence of a PROC or FUNCTION and all names encountered between a MODULE keyword and the next succeeding PROC or FUNCTION.

[May we suggest that you refer to the Action! reference manual if you are not sure whether a given name is a global or local name.]

Finally, if a name is not found in either the local or global symbol tables, it is assumed to be a system library name. The library built into the Action! cartridge is searched for a matching name. Only if the name is not found here will Action! issue an "undefined symbol" error.

### 2.1.3 Symbol Table Allocation

When you first boot the Action! cartridge, it allocates certain tables and buffers (which we have called "semi-fixed"). These semi-fixed locations are allocated starting at [LOMEM] and occupy approximately $700 bytes. Of these $700 bytes, $400 bytes are used for two 512—byte "hash" tables-—one which will hold up to 255 local symbol pointers and a similar one for global symbol pointers. Action! searches for and stores symbols using a "hashing" algorithm, which significantly speeds up such searches but which necessitates these extra hash pointer tables. ("Hashing" is simply a means of using a mathematical formula on a symbol to produce an index-—a hash pointer—— into a specially structured table.)

When you ask Action! to begin a compilation, Action! first allocates memory for the symbol tables and their associated pointers. It uses location STSP ($0495) to determine how many pages (of 256 bytes each) to allocate to the main symbol table and allocates roughly from the top of free memory (i.e., just under the display memory) downwards.

Note that, even though there are two hash tables, there is only a single symbol table. This is possible for two reasons. First, since a symbol is never actually searched for directly in the symbol table (because Action! always searches via the hash table pointers), the global and local symbols could actually be mixed with no ill results.

But, second, Action! never adds to both tables at the same time. Action! begins by processing global names, adding all variables, etc., which it finds to the global hash table and thus increasing the size of the symbol table. However, when Action! compiles the name of a FUNCTION or PROC, it automatically switches modes--now all new names are added to the local hash table and, as a consequence, to the END of the symbol table. When a subsequent MODULE, PROC, or FUNCTION keyword is

encountered, Action! wipes out the local hash table and allows the symbol table space it accessed to be reused. Since the local names are always at the end of the global names, this procedure ensures that maximum use is made of the available symbol table space.

A last comment on this subject: this methodology explains why the monitor is able to access the local names of only the last compiled PROC or FUNCTION (as well as all global names, of course).

## 2.2 Running an Action! Program

Since the Action! compiler produces absolute machine-level code, running a compiled Action! program under any DOS for Atari computers is simplicity itself. One need simply invoke any of the normal loaders (including those built into DOS XL, OS/A+, and Atari DOS), being sure to properly pass the "run address" of the compiled program.

The "run address" may be determined by using the '?' monitor command after compiling the program. For example, assume that the name of the last PROC in your program is MAINPROC. Then using '? MAINPROC' from the Action! monitor will produce a display of the address of MAINPROC (in both hex and decimal, as well as its contents, which are not relevant here).

Note, however, that the 'W' command of the Action! monitor automatically writes not only the compiled code but a properly structured INIT vector (see your DOS manual for definition and clarification) as well. Thus, you normally do not need to concern yourself with knowing the starting address.

Since how a program is loaded and run varies from one DOS to another, we will not try to further describe the process here. We would like to note, however, that giving your compiled program a name with ".COM" as the extension will result in a valid DOS XL or OS/A+ command file, which may then be invoked from the 'Dl:' prompt by using just its name.

## 2.3 When Your Program is Running

Regardless of whether you compile your program using this RunTime package or not, when your program runs it needs to access a host of library routines. Some of these you know about: they are the various library PROCs and FUNCTIONs listed in your Action! Manual.

Others, however, are essentially invisible to you. In an attempt to produce a reasonable compromise between code size and code speed, Action! automatically compiles into your program numerous calls (JSRs) to various support routines. Examples of routines thus provided include multiply, divide, and shift routines.

When your program is compiled with the RunTime package, these routines are supplied from the built—in routines in the Action! library "bank". When you use the RunTime package, you actually compile a set of these routines right along with your own code.

A comment: you have probably heard or read about how the OSS SuperCartridge works and may be aware of the fact that it is constantly switching memory banks as it works. When your program runs, though, it uses only a single bank (where the memory resides), and thus the transition to a RAM-based RunTime package is made easier.

## Chapter 3: Compiling a Program with RunTime

You will recall from Section 1.1.2 that Action! always searches for symbols first in the current "local" library, then in the "global" library, and finally in the built-in system library. This sequence is the secret to being able to produce a RunTime Action! Program.

As an illustration, early versions of Action! (3.Ø and 3.1) had a bug in the system divide routine. Our (temporary) solution was to provide a listing of an Action! routine (which actually consisted of a set of machine code blocks). By including this subroutine (either directly or via INCLUDE) in your program, you could force the compiler to use the new divide routine instead of the built-in one.

Similarly, the RunTime actually consists of a series of Action! PROCedures and FUNCtions (which in turn consist of mainly machine code blocks) which you include with your program so that the compiler will find their names (in your global symbol table) instead of the built-in names.

### 3.1 A Simple Compile

The simplest method of compiling of a RunTime version of your program is to use a line of the form

```
INCLUDE "D1:SYS.ACT"
```

as the first line of your program.

The file "SYS.ACT" on your RunTime disk contains the Action! Source code (mostly in the form of cone blocks) for ALL the routines in the standard system library. Therefore, by compiling this file at the beginning of your program, you are essentially providing the Action! compiler with a full set of global names which will come before and therefor take precedence over the same names in the built-in system library.

As a trial case, may we suggest that you read in and examine the program called "SAMPLE.ACT" which you will find on your RunTime disk. Notice how it INCLUDEs the file "SYS.ACT". If you wish (and only if you are working on a COPY of your RunTime disk), you may go to the monitor and compile this program. After it compiles, simply use the "Write" command in the monitor to write the object code to disk.

Actually, we have already done this for you. We named our object file "SAMPLE.COM". If you are using OS/A+ or DOS XL, you may now exit to DOS (via the "DOS" monitor command) and (when the "D1:" prompt appears) simply type in "SAMPLE". If you are using Atari DOS, you will have to use the DOS "L" option to load the file "SAMPLE.COM". In either case, the program should run and give the expected results.

Simple, isn't that. May we suggest that you try this technique with one or two of your own programs.

## 3.2 Selective Use of Libraries

In addition to the complete system library provided as "SYS.ACT", your RunTime disk includes several other library files. They are:

```
SYSLIB.ACT     SYSIO.ACT      SYSGR.ACT
SYSMISC.ACT    SYSBLK.ACT     SYSSTR.ACT
```

(There is an additional file, "SYSALL.ACT", which simply INCLUDEs all of the above files. This is equivalent to INCLUDEing "SYS.ACT" as we did in Section 2.1.)

Each of these library files contains a part of the complete RunTime library. To use them, simply INCLUDE the ones you need in the same fashion as we INCLUDEd "SYS.ACT" in Section 2.1. Do not INCLUDE the files which contain only routines you do not use.

Thus if, for example, you knew that your program used no graphics routines, you would not INCLUDE "SYSGR.ACT". Virtually all programs need to INCLUDE "SYSLIB.ACT".

For a complete list and short description of all routines included in each of these libraries, you may read or print the file "SYS.DOC" on your RunTime disk (CTRL—SHIFT—R from Action!'s editor to read the file or

```
TYPE SYS.DOC P:
```

from DOS XL or OS/A+).

Unfortunately, there is no easy way of determining which system library routines your program is using. If you omit a RunTime library, it will get "filled in" from the built-in ROM routines. Thus you will simply have to carefully check your program for library routine calls.

In this vein, there is a program on the RunTime disk which can help you. If you compile AND run the program called "ST.ACT", it will hook itself into the Action! compiler in a unique and useful way: As each PROCedure or FUNCtion is compiled, it automatically then and there prints a list of ALL name references made by the PROC or FUNC. You will still have to check the listing by hand for all references, but at least you don't have to search through lines and lines of source code. (See also the file "ST.DOC" on the RunTime disk.)

Finally, note that the file "SAMPLE2.ACT" on the RunTime disk is another version of "SAMPLE.ACT" which we compiled and ran in the previous section. "SAMPLE2.ACT", though, INCLUDEs only those library routines which it needs. If you compile it and Write it to disk, you will notice there is some (albeit not a terribly large) savings in disk (and, consequentially, memory) space.

Again, we have written the compiled file to disk using the file name "SAMPLE2.COM". Follow the instructions above for running the program.

## Chapter 4: Compiling With Large Symbol Tables

You will recall from Section 1 we mentioned that, by default, Action! supports only up to 255 Global symbols (as well as up to 255 Local symbols). The limit on the length of any given symbol (name) is greater than the limit on the length of a line, so virtually any name is valid. However, the total space occupied by names and Action!'s associated type bytes, values, etc., cannot exceed the space reserved via STSP ($495).

This section will discuss how to bypass two of the three limitations noted above. Note that there is currently no way to have Action! recognize more than 255 different local symbols. We do not feel that this is a limitation: if you have a PROCedure or FUNCtion which uses this many symbols, it should probably be broken into two or more subroutines anyway.

### 4.1 Increasing Your Symbol Table Space

By default, Action! reserves 2K Bytes (2048 bytes, Eight "pages" of 256 bytes each) of RAM for its symbol table. To change the space reserved, you need simply change the contents of STSP (location $495). You must change STSP before you do a compile, since Action! initializes its symbol table pointers, etc., when you give the Compile command from the monitor.

For example, to allow up to 3K Bytes of symbol table space, simply give the command

```
SET $495=12
```

to the Action! <u>monitor</u> and then Compile.

Remember, the contents of STSP is the number of 256—byte pages to be reserved.

HINT: If you have a program which you know will need a particular amount of symbol table space, simply place a SET similar to the one above at the beginning of the program. The program will NOT compile the first time, because it will run out of symbol table space. However, the SET will have taken place, and if you simply compile it again the proper amount of space will then be reserved for you.

## 4.2 Increasing the Number of Global Symbols

Your RunTime disk contains a file named "BIGST.ACT". Simply compile and run this program and you may then use up to 510 global symbols.

Action! has a flag (BIGST, $4C4) which tells it that you wish to allow an expanded global symbol table. The mechanism Action! uses to accomplish this is very simple: When BIGST is set, Action! splits the global symbol table into two parts, using two separate hash tables, based solely on the first character of each symbol. Action! uses the contents of location FRSTCHAR(location $4AD) to determine which character defines the splitting point.

After determining which character you wish to split your symbol table on (usually either 'a' if you keep upper and lower case distinct or 'M' if you don't), simply Read the file "BIGST.ACT" into the editor and change it to reflect your choice. Then compile and run the program. So long as you do not reBoot Action!, the big symbol table option will be in effect.

By the way, note that Action! uses [STG2] ([$CE]) as the hash table for the other 255 globals. You can set STG2, BIGST, and FRSTCHAR yourself, but letting "BIGST.ACT" do it for you is generally easier and safer.

## Chapter 5: Compiling at a Particular Address

In Section 1, we noted that Action! places your compiled code directly in memory. Normally, it places the object code directly above the edit buffer, which in turn is above Action!'s "semi-fixed" RAM and thus above DOS. In this section we discuss methods for telling Action! where you wish to place your code.

### 5.1 Directing the Code Storage Address

So long as you have no program in the edit buffer, you may think of the memory from the top of Action!'s semi-fixed RAM to the bottom of the symbol table space as your "free" RAM. You may ask Action! To place your object code anywhere in this space.

You may determine exactly what the bounds of this space are from the monitor. Simply use a '? $E' command to determine the bottom of this space. Remember that [$0E] ([APPMHI]) define the current "code pointer" for Action! If you haven't compiled anything yet, then APPMHI points to where code WILL be stored.

The top of this space may be determined via a '? $B0' command. Actually, location $B0 (STBASE) contains a single BYTE value (so be sure and look at the least significant byte of the contents of $B0 after using '?'). This byte value is the page number of the start of the symbol table (less 1, actually).

Now, if you compile your program and then again look at the contents of APPMHI (or at CODESIZE), you know how big your compiled program is. If it does not occupy all of the "free" memory, you may, if you wish, move it upward within the free memory.

Basically, Action! needs both APPMHI (otherwise labeled CODE) and CODEBASE (location $491) SET to the initial code address. You do this by simply including two SETs at the very beginning of your program. For example, if I would like my object code located at location $5000, I would put these two lines as the first two lines of my program:

```
SET $E=$5000
SET $491=$5000
```

ONCE MORE: The important thing to remember, here, is that your compiled object code MUST fit between [$0E] and the bottom of the symbol table.

## 5.2 Compiling With an Offset

Since the Action! cartridge, DOS, and Action!'s buffers and tables occupy fixed or semi-fixed RAM locations, you often cannot place your Action! code in the actual memory locations that you want to use. For example, if you wanted to write a program which replaced all or part of DOS, you could not do it by simply SETting location APPMHI.

But have no fear. Action! has provided for you. Action! allows you to compile code into one set of memory locations even though it is designed to run at a different set of locations!

The mechanism Action! uses is simple: there is a location called CODEOFF ($B5) which contains a 16-bit address offset. By default, CODEOFF contains a zero, so code is generated which is designed to run at the same addresses at which it is stored. When you change CODEOFF, though, strange and wonderful things can happen.

Every time Action! generates an address for a PROC, FUNC, variable, etc., it uses the actual location defined by [APPMHI]. However, every time Action! compiles a REFERENCE to such an address, it adds CODEOFF to the address. For example, suppose that as Action! compiles it sees the following source code fragment:

```
SET $B5=$1000 ; set CODEOFF to 4K Bytes
; assume that APPMHI contains $4000 at this point
PROC P()
...
PROC Q()
P()
...
```

The compiler "knows" that the PROCedure named "P" is located at address $4000. Yet, when it compiles PROCedure "Q" and encounters the reference to "P", it generates the equivalent of

```
JSR P+[CODEOFF]
  or
JSR P+$1000
  or
JSR $5000
```

Since Action! ignores any overflow/carry which results in adding CODEOFF to an address, we could 'SET $B5=$F000' and effectively subtract $1000 from each address instead (remember, Action! does not allow negative compiler constants except via this mechanism).

As an example, then, let us suppose that we do indeed wish to replace DOS. Thus we want a program which will run at location $700. Let us further suppose that we are using Action! with a DOS which causes a LOMEM of $2100. Thus the initial contents of APPMHI will be approximately $2800 (plus a little). We might, then, start our Action! program with the following lines:

```
SET $E=$2F00 ; just to make the setting ...
SET $491=$2F00 ; ...of CODEOFF easier
SET $B5=$D800 ; equivalent of $B5= -$2800
```

And, lo and behold, if we dumped the compiled code we would find that we had indeed generated code designed to run at location $700.

Now, if we use the Write command from the Action! monitor, Action! automatically adjusts the starting and ending addresses for our object code file so that it will be LOAded in (via LOAD in DOS XL, the L option of Atari DOS, etc.) at the offset address! In other words, Action! has done all the hard work for us.

Special Note: Sometimes, though, you do not want the code you have generated loaded into its intended running address. In our example, we certainly wouldn't want DOS to try and Load our program at $700: we would wipe out part of DOS and surely do nasty things to our system. Presumably, we would want our code to Load in where it was generated. Then we would have a small routine which would move the code to its intended address and run it.

You may accomplish this purpose by simply noting the values of CODEBASE and APPMHI at the end of your compile. Then go to DOS (via the 'D' command of the monitor) and SAVe that part of memory. It will now LOAd where it was compiled, so you will have to somehow have a routine which will move it and run it (may we suggest simply appending such a routine--written in assembly language and placed, say, in page 6--to your main program).

FINAL NOTE: This offset technique may also be useful if you have an Action! program which almost, but not quite, fits in its allotted "free" RAM. Since arrays (other than small BYTE arrays) are allocated semi-dynamically after the end of your program (and may thus occupy the symbol table's space, for example), they do not affect the size of your compiled code. Thus you may "recover" the $700 bytes "lost" to Action!'s semi-fixed RAM by coding an offset of $F900. The space thus gained is not huge (1700 bytes or so), but it may make all the difference to you.

On this same note, remember that using DOS XL can save you up to 5K bytes of RAM during a compile. Then, if you remove the Action! cartridge to run your program, DOS will have to move LOMEM higher (since it will now all reside at $700 up), but HIMEM will have moved up by 8K bytes. Some work with offsets, etc., here could be very beneficial when you are working with very large programs.

## 5.3 Using Large Assembly Language Modules

Since you can direct Action!'s code generation, you can obviously "tell" it to reserve any given area of memory. This implies that you may assemble code for some specific address range, make a list of the subroutine entry points and/or variables to be accessed from Action!, and compile an Action! program which avoids the assembly language area. If the Action! program equates PROCedures, FUNCtions, and variable names to locations within this area, the assembly language routines, etc., may be used interchangeably with Action! Routines.

Here is a small example of what we are discussing:

Assembly language:

```
        *=$3000
  LSH3          ; FUNCTION: left shift argument by 3
        ASL A
        ASL A
        ASL A ; left shift 3 times
        STA $A0 ; put where Action! puts function
        LDA #0 ; ...return values
        STA $A1
        RTS
  MASK  .BYTE 1,2,4,8,16,32,64,128 ; set of bit masks
```

Action!:

```
  BYTE FUNC LSH3=$3000 (BYTE N)
  BYTE ARRAY MASK(0) = $300A
```

For this particular example, you would probably be better off putting the small routine and array directly in your Action! program, via code blocks. But for larger, more complex operations, etc., this technique is very workable.

## Chapter 6: Compiling ROMmable Code

If you have just finished reading Section 5, you should have a pretty good idea of how to ask the Action! compiler to produce code which will run in the normal cartridge space (i.e., $A000 to $BFFF, where Action! itself resides). Presumably, you know how to compile your code somewhere safe in RAM with CODEOFF set such that the code will run in ROM space (e.g., compiling to $6000 in RAM with CODEOFF set to $4000).

However, there is still a rather sticky problem: what do we do about variables? Normally, Action! compiles in such a way that global variables, PROCedures, FUNCtions, and local variables all share the same address space (i.e., they are all mixed up together, according to Action!'s own schemes). What we need is some way to tell Action! to keep programs and variables separate.

### 6.1 RAM and ROM Variables

Actually, there is one very simple way: simply assign addresses to ALL your variables. When you make a declaration such as

```
BYTE Temp = $D4
```

Action! assumes you know what you are doing. All references to "Temp" actually become references to location $D4.

There is a second class of variables which need no special care: those which aren't really "variable". If you initialize the contents of a variable or array (or string) and then never change its contents, then you actually want that variable in ROM. A declaration of the form

```
BYTE ARRAY Bits(0)=[1 2 4 8 16 32 64 128]
```

will generate and initialize an 8-element byte array. Presuming that you never store into Bits(n), the array actually should be in ROM.

But the vast majority of variables in most programs fall into neither of the above two categories. They are variables which we intend to change and which we want the compiler to assign space for.

Truthfully, Action! was not designed to produce code with variables and program separated. But the workings of the SET compiler instruction let us access a sophisticated method which we feature here.

Before reading further, it might be a good idea to read or print the listing of the file "KALROM.ACT", supplied on your RunTime disk. This is a somewhat smaller version of the famous Action! Kaleidoscope demo, but this version is designed to be compiled into ROM!

We call your attention to the two DEFINEs at the head of the program (please see note on page 311):

```
         DEFINE RAM =   "SET $682 = $E^
                         SET $B5 = $C800
                         SET $E = $680^"
         DEFINE ROM =   "SET $680 = $E^
                         SET $B5 = $5800
                         SET $E = $682^"
```

Note also the various SETs a little further in the program:

```
         SET $E=$6000 SET $491=$6000
         SET $B5=$5800 SET $680=$5800
```

And then let us note, before explaining how all this ties together, that this program will compile at address $6000, where APPMHI and CODEBASE ($E and $491), are initially set. The code will be compiled to run at address $A800, the sum of APPMHI and CODEOFF ($E and $B5).

The RAM used by this program will be compiled at $5800 (the initial value of location $680, see below) and be placed, when the ROMmed code is run, at location $2000 ($5800 + $C800, the alternative value for CODEOFF, ignoring the overflow from the addition).

HOW IT WORKS: The initialSETs (not the ones in the DEFINEs) are given values which will start Action! producing code designed to reside at $A800, as we noted. When the compiler reaches the label "RAM", though, it executes the SETs defined thereby. Specifically, it saves the current value of the code pointer (APPMHI) in a "spare" location ($682) via "SET $682=$EA". Did you remember that you can use constant pointers in a SET? "$E^" simply means "the contents of location $E".

The expansion of the RAM definition also causes CODEOFF ($B5) to be changed and APPMHI ($E, also called CODE) to be loaded from the contents of location $680, another "spare" chunk of memory. (Did you remember that $680 was initialized to $5800, just for this purpose?)

When Action! encounters and expands a "ROM" definition, the effective opposites happen: APPMHI is saved in $680, CODEOFF is changed to the value needed for ROM generation, and APPMHI is reloaded from $682, where it had been saved by the "RAM" definition.

Whew! It all seems complicated, but once you have set up the DEFINEs for "ROM" and "RAM" the rest is easy.

The only other thing to watch out for is just WHEN do you use these ROM and RAM definitions? Generally, you simply code "RAM" just before you define some variables you want to reside in RAM. In the case of local symbols, then, you code "RAM" just before defining them and "ROM" just after doing so.

There is just one place which is a little tricky: after compiling some ROM-based definitions of global variables, you need to code "RAM" to cause the parameters and local variables of the next PROCedure or FUNCtion to be compiled in RAM. However, due to the method by which Action! generates code and address references, you must code "RAM" after the keyword PROC or FUNC.

Again, we refer you to the listing of "KALROM.ACT" for further examples and techniques. You will note the BYTE ARRAYs in the beginning being generated in ROM. These are invariant masks, as we discussed above. Also, note that it does not matter whether "ROM" or "RAM" was last coded when you define variables which are assigned to specific addresses.

PROCedures and FUNCtions which receive no parameters and have no local variables may be considered completely ROM-resident. Code block PROCs and FUNCs which use only the parameters passed in the registers (remember, the first three bytes of parameters are passed in A, X, and Y) may include the notation "=*", as shown in several PROCs in the example, and will generate no actual variable storage.

## 6.2 Other Considerations

Once you have tackled the general problem of separating RAM and ROM space, there are a few other things to watch out for when producing ROMmable Action! Code.

### 6.2.1 FOR loops

In general, you cannot use FOR loops in Action! code which is to be placed in ROM. When Action! encounters a statement of the form

```
FOR LoopVar=Begin TO Finish STEP Increment
```

it realizes that it needs space to store the "Finish" and "Increment" values. If these values are not constants, they are evaluated at run time and stored in-line among the compiled code!

This is not a major matter: you can easily modify the above FOR loop to be a WHILE loop instead. For example:

```
LoopVar=Begin
WHILE LoopVar <= Finish
DO
   ...
LoopVar ==+ Increment
OD
```

A little lengthier than the equivalent FOR loop, but actually no less efficient in most cases.

### 6.2.2 PROCedure variables

Action! allows PROC names to be used in expressions, including assignments to a PROC name. For example, you are allowed and encouraged to handle your own errors via the following (paraphrased from the Action! reference manual):

```
PROC HandleError()
        ...
RETURN
...
SaveError = Error
Error = HandleError

...
```

Action! handles PROC names in this fashion thanks to a usually invisible mechanism: Each PROC or FUNC is compiled to start with a JMP instruction. Normally, the target of the JMP is the byte immediately following the JMP, the actual code for the PROC or FUNC.

When you assign a value to a PROC (as in 'Error = HandleError', above), the code generated actually modifies the last two bytes of the JMP instruction, the target address.

Unfortunately, when a PROC or FUNC is in ROM, you obviously can NOT modify the target of the JMP instruction. If you desperately need this capability, may we suggest the following scheme:

```
PROC HandleError = $600 ( )
        ; or any other "safe" address
BYTE Hjmp = $600 ; same address
...
PROC RealHandler( )
...
RETURN

...
MAIN()
   Hjmp = $4C ; a JMP instruction
   HandleError = Realflandler
   ...
   ; and now you can assign to 'HandleError'
   ; as and when you wish
```

The important part of this "trick" is that you MUST set the JMP instruction in place "by hand", as we did in the first line following MAIN().

## 6.2.3 Action!'s System DEVICE

Many of the I/O routines in the Action! library (both the cartridge library and the RunTime version) perform their operations to a channel (file) defined by the contents of a location called DEVICE. For example, PRINT() and INPUTS() both use DEVICE.

Normally, Action! initializes the contents of DEVICE to zero. You can thus easily change the default output channel by simply OPENing a file on another channel and placing a new channel number in DEVICE.

When using the RunTime package, you must take responsibility for initializing DEVICE. You may do this by coding

```
DEVICE = 0
```

in your code. Or, if you intend to never change the contents of DEVICE, you might code a declaration of

```
BYTE DEVICE = [0]
```

as an early global variable. See the file "SYS.DOC" on the RunTime disk for other comments.

## 6.2.4 File Names

The library in the Action! cartridge automatically adds a "D:" filename prefix to a filename if the filename does not begin with a device name (e.g., “D2:", "P:",etc.). The RunTime library does NOT do so.

Be sure that your Action! programs include sufficient filename validation.

## Chapter 7: Action! Memory Map

The important locations used by the Action! compiler and RunTime are given here in memory location order. The address, label used by internal routines, and a short description of each location are all given. If changing a location might be useful to you, the description will say so and possibly point you to another Section for more information.

The labels given here are shown in mixed upper and lowercase, as used by Action!'s author. In other Sections of this document, these labels are shown in all upper case, simply to make them easy to distinguish from surrounding text.

In the listing which follows, a period between the address and the label indicates a system location which is two bytes long, in normal 6502 low/high format. It may, of course, thereby be an address pointer.

```
Addr Label   Description
---- -----   -----------
000E.code    The "location counter" used by Action!
      or     (Also Atari OS's "application program
     APPMHI   high  memory".)  Points  to  where next byte
              of  code  will  be  stored  during  an  Action!
              compile.  Generally  should  only  be  changed
              before a program is compiled  (Section 4.1),
              but can be changed with caution to produce
              ROMmable object code (Section 5.1).

009B.buf      Address  of  Action!'s  edit  buffer.   More
              importantly,  though,  this  buffer  is  also
              used  by  the  library  OPEN  procedure  to
              validate the filename it is passed. It must
              be  initialized  to  a  valid  address  when  a
              compiled program is run with the cartridge.
              CAUTION!! OPEN in the RunTime library does
              NOT validate filenames.
              See Section 5.2.4 and comments about the use
              of locations $500-$5FF, below.

00A0 args    This portion of zero page  is used  to  store
 to          function  and  procedure  parameters  and  as
00AF         temporaries   for   evaluation   of   many
              expressions.  Parameters  start  at  $A0  and
              work up. Temporaries start at $AF and work
              down.

00B0 stBase   High  byte  of  address of  start of  symbol
              table.
```

| | |
|---|---|
| ØØB1.stGlobal | Location of 512-byte hash table for global symbols. |
| ØØB3.stLocal | Location of 512-byte hash table for local symbols. |
| ØØB5.codeOff | Offset between compiled-at address (as determined by "code", location $ØE) and compiled-for address (e.g., when compiling code to be placed in ROM or in place of the DOS code). See Section 4.2. |
| ØØB7 device | Current default device number. If changed to a valid OPENed file number, all library output normally sent to the screen will go to that file instead. Described in the Action! Reference manual, but see also the source code comments on the RunTime disk and warning in Section 5.2.3 re ROMmable code. |
| ØØCE.stG2 | Used only if the "big symbol table flag" (bigST, $4C4) is set. This is the address of the 512-byte hash table used for the second half of the global names. See the file BIGST.ACT on the RunTime disk and Section 3.2. |
| Ø491.codeBase | The first address used to store code in the current compile. It is preserved for later use with the "Write" monitor command. See Sections 1.1 and 4.1. |
| Ø493.codeSize | The number of bytes of code generated by the current compile. See Section 1.1. |
| Ø495 stSp | Symbol Table SPace. Simply the number of 256-byte pages available for the symbol tables (both locals and globals). May be easily altered as needed by the user. See Section 3.1. |
| Ø49A list | Action!'s "List the program as it is compiled" flag. Changed by the "LIST?" query in the Options. Can also be changed at any point in a compile via a SET. |
| Ø4AD frstChar | When a big symbol table is in use (see $Ø4C4), this character determines the division point between the lower and upper halves of the global symbol table. See also Section 3.2 and the file "BIGST.ACT". |

04C0 bckgrnd — Background color. Use at your own risk.

04C4 bigST — A flag. If set, the global symbol table is divided into two parts (see also $04AD). Thus you may use a total of 510 global symbols. See also Section 3.2 and the file "BIGST.ACT" on the RunTime disk.

04CB Error — A JMP to the current error handling routine. As far as the compiler is concerned, this is the address of the Error procedure. See the Action! reference manual for a method of substituting your own error handler. See section 5.2.2 for comments re ROMmable code.

0500-05FF — A buffer used by the RunTime library OPEN routine. When OPEN is passed a filename, it moves the name here and appends a RETURN ($9B) character. The cartridge routines do this differently, using a buffer pointed to by BUF (location $9B, see above) instead. You can easily change the location of this buffer by changing the DEFINEs at the beginning of the RunTime library.

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# Part VIII:  The ACTION! Toolkit

## Chapter 1: Introduction

Welcome to the Programmers' Tool Kit (V. 3). This diskette contains routines written in ACTION! which extend your ACTION! programming capabilities. The following is a list of the files on the disk, together with a short description of what each fi1e does.

| | |
|---|---|
| ABS.ACT | a routine which will return the absolute value of an INT. |
| ALLOCATE.ACT | routines which allow dynamic runtime memory manipulation. |
| CHARTEST.ACT | routines which perform various tests and functions on characters. |
| CIRCLE.ACT | a circle drawing routine using neither Sine nor Cosine. |
| CONSOLE.ACT | a routine which both debounces the console keys and allows you to tie routines into them. |
| IO.ACT | routines which implement some advanced I/O operations. |
| JOYSTIX.ACT | routines which make interpreting joystick input easier. |
| PMG.ACT | player/missile graphics routines. |
| PRINTF.ACT | an extended version of the ACTION! Library 'PrintF'. |
| REAL.ACT | routines which allow you to use floating point numbers. |
| SORT.ACT | QuickSort for BYTE, CARD, INT, and string data. |
| TURTLE.ACT | an implementation of turtle graphics, ala LOGO. |
| GEM.DEM | a four person game written in ACTION!. |
| KALSCOPE.DEM | a colorful demo of ACTION!'s speed. |

| | |
|---|---|
| MUSIC.DEM | a demo which creates a playable organ. |
| SNAILS.DEM | a two person game translated from BASIC to ACTION!. |
| WARP.DEM | a one person game which uses many of the advanced constructs and abilities of ACTION!. |

There are also some files with the extension '.DMn', where 'n' is a number. These are demos of the routines in a specific file, designed to help you better understand the procedure required to make use of the Tool Kit routines.

NOTE: In most of the ACTION! source files there are global variables and procedures which contain the underline character ('_'). These variables and routines are internal to the Toolkit routines, and should be neither called nor accessed by you unless you are positive you know for what they are used.

<u>To Boot This Disk</u> simply boot your DOS disk with the ACTION! Cartridge inserted, and then put this disk in your drive. THIS D1SKETTE DOES NOT HAVE DOS ON IT AND WILL NOT BOOT DIRECTLY.

NOTE: On the latest version 3, the file ABS.ACT starts with the version number.

# Chapter 2: Toolkit Routines

## 2.1 ABS.ACT

### 2.1.1 INT FUNC

Purpose: To return the absolute value of an INTeger.

Syntax:  INT FUNC Abs(INT n)

Params:  n - the INTeger whose absolute value is returned.

Description: This function will return the absolute value of the INT passed to it.

## 2.2 ALLOCATE.ACT

The routines in this file allow you to allocate and free blocks of memory at runtime. If you want to use this capability, you must first call the AllocInit routine. AllocInit expects a global CARD variable called EndProg to contain the address of the end of your program. To do this, compile your program, and then type the following in the monitor immediately after compiling:

```
SET EndProg=* [RETURN]
```

Now you can run your program.

TECHNICAL NOTE: The Alloc and Free routines operate on a 'free list'. This list gives the location and size of every free memory block. Alloc simply removes a block from the free list, and Free puts a block back into the list.

### 2.2.1 PROC AllocInit

Purpose: To set up the free list and initialize the allocation routines.

Syntax:  PROC AllocInit(CARD p)

Params:  p - the address of the first free memory location in memory.

Description: This routine is used to create the free list so that Alloc and Free may be used. See the introduction

to this section for instructions on its use.

NOTE: If you are planning to use P/M graphics and/or bit-map graphics, you should enable the P/Ms and be in the most memory intensive graphics mode you plan to use when you call AllocInit, since it considers all memory up to MEMHI ($2E5) to be free space. (Alternatively, you can merely change the value of MEMHI.)

## 2.2.2 CARD FUNC Alloc

Purpose: To allocate a block of memory of a specified size, returning the address of that block.

Syntax: CARD FUNC Alloc(CARD nBytes)

Params: nBytes - the size in bytes of the block to be allocated.

Description: This routine allows you to reserve a block of memory 'nBytes' long. The starting address of the block is returned, so, for example, you could use it to allocate space for a large array at runtime, after you've determined the size array you need:

```
PROC Test()
  CARD size
  BYTE ARRAY bigarray

  Print("Size of Array>> ")
  size=InputC()
  bigarray=Alloc(size)
RETURN
```

NOTE: the smallest block you can allocate is 3 bytes.

## 2.2.3 PROC Free

Purpose: To free a block of memory which has previously been reserved using the Alloc function.

Syntax: PROC Free(CARD target,nBytes)

Params: target - starting address of the block to free.
nBytes - length in bytes of the block to free.

Description: This procedure allows you to return a block of memory used by Alloc to the free list.

### 2.2.4 PROC PrintFreeList

Purpose: To print out the free list.

Syntax: PROC PrintFreeList()

Params: none

Description: This procedure will print out the current free list, and should be used mostly for diagnostic debugging reasons.

## 2.3 CHARTEST.ACT

The routines in this file are very diverse, including:

IsAlpha - a character test
IsUpper - a character test
IsLower - a character test
IsDigit - a character test
ToUpper - a character manipulation
ToLower - a character manipulation

### 2.3.1 BYTE FUNC IsAlpha

Purpose: To test a single character to see if it is a letter.

Syntax: BYTE FUNC IsAlpha(BYTE c)

Params: c - the character to be tested.

Description: This function checks c to see if it is an alphabetic character. If it is, a 1 is returned; otherwise a 0 is returned.

### 2.3.2 BYTE FUNC IsUpper

Purpose: To test a single character to see if it is an uppercase letter.

Syntax: BYTE FUNC IsUpper(BYTE c)

Params: c - the character to be tested.

Description: This function checks c to see if it is an uppercase alphabetic character. If it is, a 1 is returned; otherwise a 0 is returned.

### 2.3.3 BYTE FUNC IsLower

Purpose: To test a single character to see if it is a lowercase letter.

Syntax: BYTE FUNC IsLower(BYTE c)

Params: c - the character to be tested.

Description: This function checks c to see if it is a lowercase alphabetic character. If it is, a 1 is returned; otherwise a Ø is returned.

### 2.3.4 BYTE FUNC IsDigit

Purpose: To test a single character to see if it is a digit.

Syntax: BYTE FUNC IsDigit(BYTE c)

Params: c - the character to be tested.

Description: This function checks c to see if it is a digit (Ø - 9). If it is, a 1 is returned; otherwise a Ø is returned.

### 2.3.5 BYTE FUNC ToUpper

Purpose: To Change lowercase letters to uppercase.

Syntax: BYTE FUNC ToUpper(BYTE c)

Params: c - the character to be tested.

Description: This function will return the uppercase of the character passed to it. If the character is already uppercase, or is not alphabetic, then the character is returned unchanged.

### 2.3.6 BYTE FUNC ToLower

Purpose: To change uppercase letters to lowercase.

Syntax: BYTE FUNC ToLower(BYTE c)

Params: c - the character to put into lowercase.

Description: This function will return the lowercase of the character passed to it. If the character is already

lowercase, or is not alphabetic, then the character is returned unchanged.

## 2.4 CIRCLE.ACT

The circle drawing routine in this file is somewhat special, since it does not need to compute Sine or Cosine, and so is very fast. One caveat, however, this routine does no screen bounds checking, so either make sure your circle will fit on the screen, or add your own bounds checking.

### 2.4.1 PROC Circle

Purpose: To draw a circle of specified center, radius, and color.

Syntax:  PROC Circle(INT x BYTE y,r,c)

Params:  x - the horizontal position of the center of the circle to be drawn.
Y - the vertical position of the center of the circle to be drawn.
R - the radius of the circle.
C - the color of the circle.

Description: This procedure allows you to draw a circle of specified center, radius, and color. The system variable color is set to c, so c should not be the actual color number as used in the SetColor procedure, but rather the 'color' value in the current graphics mode which corresponds to the SetColor register which contains the color you want to use.

## 2.5 IO.ACT

The routines in this file allow you to do advanced disk file manipulation from an ACTION! program. Operations implemented are:

```
      Rename a file  Format a diskette
      Erase a file   Block Get of data from disk
      Protect a file Block Put of data to disk
      Unprotect a file
```

NOTE: The first four of the above operations (those involving a disk fill) require that the file name have the 'Dn:' (n=1-8) device specifier prepended to the actual file name; otherwise you will get a 'Nonexistent Device' error.

### 2.5.1 PROC Rename

Purpose: To rename a disk file.

Syntax:  PROC Rename(BYTE ARRAY filename)

Params:  filename - the old and new file names.

Description: This routine will rename the specified disk file, and should be used as follows:

```
      Rename("D1:TEMP1.ACT TEMP.ACT")
```

This example will rename TEMP1.ACT on drive 1 to TEMP.ACT. Notice that the new name follows the old name in the file name string, with only a space or comma separating the two. Note that the new name may NOT have a device specifier.

### 2.5.2 PROC Erase

Purpose: To erase a disk file.

Syntax:  PROC Erase(BYTE ARRAY filename)

Params:  filename - the file to erase.

Description: This procedure will erase a disk file and should be used as follows:

```
      Erase("D2:JUNK.ACT")
```

This example will erase JUNK.ACT on drive 2.

## 2.5.3 PROC Protect

Purpose: To protect a disk file.

Syntax: PROC Protect(BYTE ARRAY filename)

Params: filename - the file to protect.

Description: This will protect a disk file, and should be used as follows:

```
Protect("D:*.*")
```

This example will protect all files on the current drive, mostly 1.

## 2.5.4 PROC UnProtect

Purpose: To unprotect a disk file.

Syntax: PROC UnProtect(BYTE ARRAY filename)

Params: filename - the file to unprotect.

Description: This procedure will unprotect a file which has been protected using either the Protect routine above, or the DOS XL PRO command. It is used in the same way as Protect above.

## 2.5.5 PROC Format

Purpose: To format a diskette.

Syntax: PROC Format(BYTE ARRAY DriveSpec)

Params: DriveSpec - the drive containing the disk to be initialized.

Description: This routine allows you to initialize disks, and should be used as follows:

```
Format("D2:")
```

This example will format whatever disk is in drive 2 (unless of course it has a write protect tab on it).

### 2.5.6 CARD FUNC Bget

Purpose: To read a block of binary or text data from a specified device.

Syntax: CARD FUNC Bget(BYTE chan CARD addr,len)

Params: chan - the channel.
addr - the address at which to put the data.
len - the number of bytes of data.

Inscription: This function allows you to read a block of data, returning the actual number of data bytes read (this will be different from len if End-Of-File was reached before 'len' bytes were read).

### 2.5.7 PROC BPut

Purpose: To write a block of binary or text data to a specified device.

Syntax: PROC BPut(BYTE chan CARD addr,len)

Params: chan - the channel
addr - the address from which to get the data.
len - the number of bytes of data.

Description: This procedure allows you to write a block of data, and is the complement to BGet.

## 2.6 JOYSTIX.ACT

### 2.6.1 INT FUNC HStick(BYTE port)

Purpose: To return the horizontal reading of a specified joystick.

Syntax:

Params: port - the port of the joystick whose horizontal reading is desired.

Description: This routine reads the value of a joystick and returns the following values:

```
      -1 - horizontal movement left
       Ø - no horizontal movement
       1 - horizontal movement right
```

This routine is much easier to use than the Stick function in the ACTION! Library.

### 2.6.2 INT FUNC VStick

Purpose: To return the vertical reading of a specified joystick.

Syntax: INT FUNC VStick(BYTE port)

Params: port - the port of the joystick whose vertical reading is desired.

Description: This routine reads the value of a joystick and returns the following values:

```
      -1 - vertical movement up
       Ø - no vertical movement
       1 - vertical movement down
```

This routine is much easier to use than the Stick function in the ACTION! Library.

## 2.7 PMG.ACT

The routines in this file allow you easy implementation of the ATARI's playrr/missile (thereafter called P/M's) graphics capabilities. To give you a sense of the extent of this implementation, we'll give a quick synopsis of the routines before going into them in detail:

```
PMGraphics - Set up P/M graphics
PMSetColor - Set a P/M's color
PMAdr      - Give the address of a P/M
PMClear    - Erase a P/M
PMMOVE     - Move a P/M
PMCreate   - Create a P/M
PMHit      - Test the P/M collision registers
PMHitClr   - Reset the collision registers
PMHPos     - Horizontal positions of P/Ms
PMVPos     - Vertical positions of P/Ms
Graphics   - A modified Graphics
```

Introductory Notes: In several of the routines in this section you will see the parameter num, referring to the number of the player/missile. This number is assigned values as follows:

```
Ø - player Ø   4 - missile Ø
1 - player 1   5 - missile 1
2 - player 2   6 - missile 2
3 - player 3   7 - missile 3
```

In some cases only the values Ø - 3 will be valid or make sense.

### 2.7.1 PROC PMGraphics

Purpose: To turn P/M graphics on or off.

Syntax: PROC PMGraphics(BYTE mode)

Params: mode - determines which P/M mode.

Description: This procedure is very much like the Graphics routine in the ACTION! Library, except that this one controls player/missile graphics. The mode values are as follows:

```
Ø - turn off P/Ms
1 - single line resolution P/Ms
2 - double line resolution P/Ms
```

NOTE: This procedure moves all the players and missiles

off the screen, but does not erase the P/M memory. To erase it, use PMClear.

2.7.2 PROC PMSetColor
---------------------

Purpose: To set the hue and luminance of a player and its associated missile.

Syntax:  PROC PMSetColor(BYTE num,hue,lum)

Params:  num - the player number (Ø-3).
hue - the hue for the player.
lum - the luminance for the player.

Description: This procedure is very much like the SetColor Library routine. In fact the colors corresponding to hue and lum art exactly as shown in the ACTION! manual under SetColor. The difference is that it allows you to set the color of a P/M, not a playfield.

2.7.3 CARD FUNC PMAdr
---------------------

Purpose: To return the address of a given P/M's memory block.

Syntax:  CARD FUNC PMAdr(BYTE nm)

Params:  num - the P/M number.

Description: This function returns the starting address of the memory block allotted to the P/M specified by num. Since the missiles all occupy the same block of memory, num values 4 - 7 will all return the same address.

2.7.4 PROC PMClear
------------------

Purpose: To clear out the memory block of a specified P/M.

Syntax:  PROC PMClear(BYTE num)

Params:  num - the P/M number.

Description: This procedure zeroes all the bytes in the memory block of the P/M given by num. If it is a missile, only that part of the block allotted to the missile will be zeroed.

### 2.7.5 PROC PMMove

Purpose: To move a specified P/M.

Syntax: PROC PMMove(BYTE num,x,y)

Params: num - the P/M number.
x - horizontal position to which to move the P/M.
y - vertical position to which to move the P/M.

Description: This procedure allows you to move P/Ms easily and quickly. You simply need to specify the P/M number and the x,y position to which you want it moved.

### 2.7.6 PROC PMCreate

Purpose: To allow easy creation of a P/M.

Syntax: PROC PMCreate(BYTE num BYTE ARRAY pm BYTE len, width,x,y)

Params: num - the P/M number.
pm - the array which contains the P/M's shape data.
len - the length of the array pm.
width - the width of the player.
x - the starting horizontal position of the P/M.
y - the starting vertical position of the P/M.

Description: This routine allows you to create a P/M. You need to pass it the P/M number, the name of the array which contains its shape, the length of that array,the P/M's width (1=single, 2=double, 4=quadruple), and the starting x,y position of the P/M.

### 2.7.7 BYTE FUNC PMHit

Purpose: To determine whether a specified, P/M has collided with a specified player or playfield.

Syntax: BYTE FUNC PMHit(BYTE num,cnum)

Params: num - the P/M number.
Cnum - the player or playfield to test for a collision.

Description: This function allows you to see if a given P/M has collided with a specified player or play field, returning a 1 if there is a collision, a 0 otherwise. The num values are described in the beginning of this section,

but the cnum values need to be explained:

```
0 - player 0    8 - playfield 0
1 - player 1    9 - playfield 1
2 - player 2   10 - playfield 2
3 - player 3   11 - playfield 3
```

The playfield numbers 0-3 are the same as those used in the SetColor Library routine to set playfield colors.

## 2.7.8 BYTE PMHitClr

Purpose: To clear the P/M collision registers.

Syntax: BYTE PMHitClr

Params: Not Applicable.

Description: By using the statement: PMHitClr=0 you can clear the P/M collision registers. You should do this just before you do something which might result in a collision (such as PMMove), or you may have information from previous collisions still in the registers.

## 2.7.9 BYTE ARRAY PMHPos

Purpose: To keep track of the current horizontal positions of the P/Ms.

Syntax: BYTE ARRAY PMHPos(0)

Params: The element number of the array (same as P/M number).

Description: By accessing an element of this array you can find out the current horizontal position of any P/M. Simply use the P/M number as the array element (e.g. PMHPos(3) will give the horizontal position of player 3).The values in this array should not be changed by you.

## 2.7.10 BYTE ARRAY PMVPos

Purpose: To keep track of the current vertical positions of the P/Ms.

Syntax: BYTE ARRAY PMVPos(0)

Params: The element number of the array (same as P/M number).

Description: By accessing an element of this array you can find out the current vertical position of any P/M. Simply use the P/M number as the array element (e.g. PMVPos(5) will give the vertical position of missile 1).The values in this array should not be changed by you.

## 2.7.11 PROC Graphics

Purpose: To turn off P/M graphics whenever changing bit-map graphics modes.

Syntax: PROC Graphics(BYTE mode)

Params: mode - same as in the Graphics Library routine.

Description: This procedure simply turns off the P/M graphics every time you change bit-map graphics modes, and replaces the normal Graphics Library routine. This routine is necessary, for the P/M graphics memory is allocated just below screen memory, so changing screen modes could wipe out part of the P/M space. If you are changing between graphics modes which use the same amount of memory, you can comment out this procedure from the source listing and so keep Graphics just the way it was.

## 2.8 PRINTF.ACT

The following two procedures are extensions of the library PrintF routine, and allow you to control field size and justification as well as the type of data output.

The following routines are internal to the PRINTF routines, and should not be used by you unless you are sure of their function:

```
BYTE FUNC PF_ToLower
BYTE FUNC PF_IsDigit
CARD FUNC PF_Nbase
```

### 2.8.1 PROC PrintF

Purpose: To allow formatted output of data.

```
Syntax:  PROC PrintF(BYTE ARRAY control
                     CARD c1,c2,c3,c4,c5,c6)
```

Params:  control - the string which determines the format of the following data.

c1 thru c6 - the data to be output

Description: This procedure is an upgrade to the PrintF routine in the ACTION! Library. The difference lies in the controls available and the modifications which can be made to the controls. The controls themselves are:

```
%D - Decimal Notation
%O - Octal Notation
%H - Hexadecimal Notation
%U - Unsigned CARD Notation
%C - Character
%S - String (BYTE ARRAY)
%E - Carriage Return/End-of-Line
%% - the '%' character
```

So far this looks very similar to the 'normal' PrintF routine. However, the best is yet to come. Between the '%' and the control character (except 'E' and '%') you may insert some field size and justification information as follows:

A minus sign: this indicates left justification of the data within its field (right justification is the default).

A number: determines the minimum field size for the data. The data will be printed in a field at least number wide, and wider if the data is too long. If the data is shorter than the field size it will be right justified in the field unless the '-' modifier has been used.

A '.' followed by a number: indicates the maximum number of characters of data to print into the field.

NOTE by GBXL: Make sure the bug fix for this routine has been applied to the respective toolkit file.

Example: The following list of control strings show how the different modifiers affect the printing of the string "ACTION!" (we have placed broken bars to show the field size):

```
%S      |ACTION!|
%5S     |ACTION!|
%10S    |   ACTION!|
%-10S   |ACTION!   |
%10.4S  |      ACTI|
%-10.4S |ACTI      |
%.4S    |ACTI|
```

2.8.2 PROC PrintFD
------------------

Purpose: To allow formatted output of data to a specified channel.

Syntax:
```
PROC PrintFD(BYTE chan BYTE ARRAY control
                       CARD c1,c2,c3,c4,c5,c6)
```

Params: chan - the channel number (0-7)
control - same as PrintF
c1 thru c6 - same as PrintF

Description: This procedure is exactly like the above PrintF, except that it allows you to direct the output to a specific channel (device).

## 2.9 REAL.ACT

This file contains routines which allow you to access the ROM floating point routines from ACTION!, thus making the ACTION! language more useful when writing numerically oriented programs.

To use the floating point routines (hereafter called the Real routines), you must declare variables of the type REAL, for example:

```
REAL x,y,z
```

The type REAL is actually a record type, so the name of the variable is a pointer to the record itself. This makes it very similar to an array.

You cannot use the assignment statement to assign a value to a real, since the ACTION! Compiler does not internally understand reals. You must instead use RealAssign, ValR, IntToReal, InputR, or InputRD.

Also included in this file are some mathematical routines to manipulate reals, as well as routines to print out reals.

Following each routine's description section are some examples of that routine's usage. For these examples, assume the following declarations:

```
REAL xreal,yreal,zreal
BYTE ARRAY astring
INT xint,yint,zint
BYTE channel
```

The following routines are internal to the ACTION! real routines, and should not be used by you:

```
PROC ROM_AFP      PROC ROM_FASC
PROC ROM_IFP      PROC ROM_FPI
PROC ROM_FSUB     PROC ROM_FADD
PROC ROM_FMULT    PROC ROM_FDIV
PROC ROM_EXP      PROC ROM_EXP10
PROC ROM_LOG      PROC ROM_LOG10
PROC ROM_INIT
```

NOTE: You will often see the type REAL POINTER in the declaration of the parameters of a routine. This simply means that you should use the name (identifier) of the real, since the name alone is a pointer to the real.

## 2.9.1 REAL Conversion Routines

### 2.9.1.1 PROC IntoReal

Purpose: To put an INI value into a REAL variable.

Syntax:  PROC IntoReal(INT i REAL POINTER r)

Params:  i - the INT value to be assigned to the REAL.
         r - the REAL to which the INT value is assigned.

Description: This procedure allows you to assign the value of an INT to a REAL variable. If the ACTION! compiler could manipulate reals, this routine would be the equivalent of: r=i.

Examples:
```
xint=453
IntToReal(xint,xreal) ;xreal now equals 453
IntToReal(2534,yreal) ;yreal now equals 2534
```

### 2.9.1.2 INT FUNC RealToInt

Purpose: To return the INT value of a REAL variable.

Syntax:  INT FUNC RealToInt(REAL POINTER r)

Params:  r – the REAL variable

Description: This function will return the INT value of the REAL passed to it as a parameter.

Example:
```
xint=RealToInt(xreal)  ;xint now equals the INT
                        value of xreal
```

### 2.9.1.3 PROC StrR

Purpose: To convert a REAL to a string.

Syntax:  PROC StrR(REAL POINTER r BYTE ARRAY s)

Params:  r - the REAL to convert.
         s - the string in which to store the character representation of the REAL.

Description: This procedure converts a REAL into its character representation.

Examples:
```
IntToReal(3926,xreal) ;xreal = 3926
StrR(xreal,astring) ;astring now contains "3926"
```

### 2.9.1.4 PROC ValR

Purpose: To convert a string to a REAL.

Syntax: PROC ValR(BYTE ARRAY s REAL POINTER r)

Params: s - the string to convert.
r - the REAL to which the value of s will be assigned.

Description: This procedure will convert as much of the string as possible into a REAL variable (i.e., if the string is "abcde", this routine will put 0 into the REAL).

Examples:
```
astring="45.276"
ValR(astring,xreal) ;same as xreal="45.276"
ValR("2.7E-4",yreall ;same as xreal=2.7*10^-4
ValR("70.2agr",zreal) ;same as zreal=70.2
```

## 2.9.2 REAL Mathematical Routines

### 2.9.2.1 PROC RealAssign

Purpose: To assign the value of one REAL variable to another.

Syntax: PROC RealAssign(REAL POINTER a,b)

Params: a - the REAL value to assign.
b - the REAL to which the value a is assigned.

Description: This procedure allows you to assign the value of one REAL to another one. If the ACTION! Compiler could manipulate reals, the equivalent would be: b=a.

Examples:
```
RealAssign(xreal,yreal) ;same as yreal=xreal
RealAssign(zreal,yreal) ;same as zreal=yreal
```

### 2.9.2.2 PROC RealAdd

Purpose: To add two REALs

Syntax: PROC RealAdd(REAL POINTER a,b,c)

Params: a - an addend
b - an addend
c - the sum

Description: This procedure allows you to add two REAls. If the ACTION! Compiler could manipulate reals, this routine would equivalent to: c=a+b.

```
Example: RealAdd(xreal,yreal,zreal)
                   ;same as zreal=xreal+yreal
```

2.9.2.3 PROC RealSub
--------------------

Purpose: To subtract two REALs

Syntax:  PROC RealSub(REAL POINTER a,b,c)

```
Params:  a - the subtrahend
         b - the minuend
         c - the difference
```

Description: This procedure allows you to subtract two REALs. If the ACTION' Compiler could manipulate reals, this routine would equivalent to: c=a-b.

```
Example: RealSub(xreal,yreal,zreal)
                   ;same as zreal=xreal-yreal
```

2.9.2.4 PROC RealMult
---------------------

Purpose: To multiply two REALs

Syntax:  PROC RealMult(REAL POINTER a,b,c)

```
Params:  a - the multiplicand
         b - the multiplier
         c - the product
```

Description: This procedure allows you to multiply two REALs. If the ACTION! Compiler could manipulate reals, this routine would equivalent to: c=a*b.

```
Example: RealSub(xreal,yreal,zreal)
                   ;same as zreal=xreal*yreal
```

2.9.2.5 PROC RealDiv
--------------------

Purpose: To divide two REALs

Syntax:  PROC RealDiv(REAL POINTER a,b,c)

```
Params:  a - the dividend
         b - the divisor
         c - the quotient
```

Description: This procedure allows you to divide two REALs. If the ACTION! Compiler could manipulate reals, this routine would equivalent to: c=a/b.

```
Example: RealDiv(xreal,yreal,zreal)
                   ;same as zreal=xreal/yreal
```

2.9.2.6 PROC Exp
----------------

Purpose: To raise e to the a power.

Syntax:  PROC Exp(REAL POINTER a,b)

```
Params:  a - the power to which to raise e.
         b - the result of raising e to the a power.
```

Description: This procedure allows you to get the base e exponential of a REAL. The equivalent of this is: b=e^a.

Example: Exp(xreal,yreal) ;same as yreal=e^xreal

2.9.2.7 PROC Exp10
------------------

Purpose: To raise 10 to the a power.

Syntax:  PROC Exp10(REAL POINTER a,b)

```
Params:  a - the power to which to raise 10.
         b - the result of raising 10 to the a power.
```

Description: This procedure. allows you to compute the base 10 exponential of a REAL. Its equivalent is: b=10^a.

Example: Exp10(xreal,yreal) ;same as yreal=10^xreal

2.9.2.8 PROC Power
------------------

Purpose: To raise REAL to a REAL power.

Syntax:  PROC Power(REAL POINTER a,b,c)

```
Params:  a - the base of the power.
         b - the power to which to raise a.
         c - the result of raising a to the b power.
```

Description: This routine allows you to raise one REAL to a power specified by another REAL, and is equivalent to: c=a^b.

Example: Power(xreal,yreal,zreal) ;same as zreal=xreal^yreal

### 2.9.2.9 PROC Ln

Purpose: To take the natural logarithm of a REAL.

Syntax:  PROC Ln(REAL POINTER a,b)

Params:  a - the REAL whose natural log is taken.
         b - the result of taking the natural log of a.

Description: This procedure allows you to take the natural (base e) logarithm of a REAL, and is equivalent to: b=ln(a).

Example: Ln(xreal,yreal) ;same as yreal=ln(xreal)

### 2.9.2.10 PROC Log10

Purpose: To take the common (base 10) logarithm of a REAL.

Syntax:  PROC Log10(REAL POINTER a,b)

Params:  a - the REAL whose common log is taken.
         b - the result of taking the common log of a.

Description: This procedure allows you to take the common (base 10) logarithm of a REAL. and is equivalent to: b=log(a).

Example: Log10(xreal,yreal) ;same as yreal=log(xreal)

## 2.9.3 I/O Routines

### 2.9.3.1 PROC PrintR

Purpose: To output a REAL to the default device.

Syntax:  PROC PrintR(REAL POINTER a)

Params:  a - the REAL to be output.

Description: This procedure outputs a real number to the default device without a RETURN.

2.9.3.2 PROC PrintRD
--------------------

Purpose: To output a REAL to a specified channel (device).

Syntax:  PROC PrintRD(BYTE channel REAL POINTER a)

Params:  channel - the output channel
         a - the REAL to be output.

Description: This procedure outputs a real number to the device specified by channel without a RETURN.

2.9.3.3 PROC PrintRE
--------------------

Purpose: To output a REAL to the default device with a RETURN.

Syntax:  PROC PrintRE(REAL POINTER a)

Params:  a - the REAL to be output.

Description: This procedure outputs I real number to the default device with a RETURN.

2.9.3.4 PROC PrintRDE
---------------------

Purpose: To output a REAL to a specified channel (device) with a RETURN.

Syntax:  PROC PrintRDE(BYTE channel REAL POINTER a)

Params:  channel - the output channel.
         a - the REAL to be output.

Description: This procedure outputs a real number to the specified device with a RETURN.

2.9.3.5 PROC InputR
-------------------

Purpose: To input a REAL from the default device.

Syntax:  PROC InputR(REAL POINTER a)

Params:  a - the REAL variable in which to store the input value.

Description: This procedure inputs a real number from the default device and stores it in the specified REAL variable.

### 2.9.3.6 PROC InputRD

Purpose: To input a REAL from a specified channel (device).

Syntax: PROC InputRD(BYTE channel REAL POINTER a)

Params: channel - the input channel.
a - the REAL variable in which to store the input value.

Description: This procedure inputs a real number from the specified device and stores it in the given REAL variable.

## 2.10 SORT.ACT

The following four sort routines all us the QuickSort algorithm. This algorithm was used because it is very fast (order N log N). In the best case QuickSort is, in fact, among the fastest sorting algorithms known. For comparison, both the Bubble and the Shell algorithms are of order N^2. The QuickSort can deteriorate to this speed when sorting presorted data.

If you take a look at the SORT.ACT source you will see that you can create your own routines to sort REALs or complex record TYPEs simply by writing your own Compare and Swap routines.

Usage note: Before using any of these routines you should first change the source line which reads

```
DEFINE SortMax="10000"
```

to the maximum size of the data array you expect to encounter. An alternative is to change the sort routines so that they INCLUDE ALLOC.ACT and dynamically create the 'list' array.

### 2.10.1 PROC SortB

Purpose: To sort one-byte data in either ascending or descending order.

Syntax: PROC SortB(BYTE ARRAY data CARD len BYTE order)

Params: data - the array containing the data to be sorted.
len - the length of the data array.
order - determines order of sort (0=ascending, 1=descending)

Description: This procedure allows you to sort one-byte data very quickly.

## 2.10.2 PROC SortC

Purpose: To sort two-byte unsigned data in either ascending or descending order.

Syntax: PROC SortC(CARD ARRAY data CARD len BYTE order)

Params: data - the array containing the data to be sorted.
len - the length of the data array.
Order - determines order of sort (0=ascending, 1=descending)

Description: This procedure allows you to sort two-byte unsigned data very quickly.

## 2.10.3 PROC SortI

Purpose: To sort two-byte signed data in either ascending or descending order.

Syntax: PROC SortI(INT ARRAY data CARD len BYTE order)

Params: data - the array containing the data to be sorted.
len - the length of the data array.
order - determines order of sort (0=ascending, l=descending)

Description: This procedure allows you to sort two-byte signed data very quickly.

## 2.10.4 PROC SortS

Purpose: To sort string data in either ascending or descending order.

Syntax: PROC SortS(CARD ARRAY data CARD len BYTE order)

Params: data - the array containing the addresses of the strings to be sorted.
len - the length of the data array.
order - determines order of sort (0=ascending, 1=descending)

Description: This procedure allows you to sort strings very quickly. Notice that the "addresses" of the strings to be sorted must be the elements of the CARD ARRAY data.

## 2.11 TURTLE.ACT

The routines in this file implement turtle graphics ala LOGO.

These routines require that the screen be in a bit-map graphics mode in which Plot and DrawTo are useable. Also, the length of a line drawn depends on the graphics mode, and there is no screen bounds checking.

Also, the color of the line drawn by the turtle depends entirely upon the current value of the system variable color, so you should use SetColor and color to choose the color you want.

The following routines are internal to the turtle graphics and should not be called by you

```
CARD FUNC TG_ISin
CARD FUNC TG_ICos
```

### 2.11.1 PROC Right

Purpose: To turn the turtle right (clockwise) theta degrees.

Syntax:  PROC Right(INT theta)

Params:  theta - the angle to turn the turtle clockwise.

Description: This procedure allows you to turn the turtle clockwise a specified number of degrees.

### 2.11.2 PROC Left

Purpose: To turn the turtle left (counterclockwise) theta degrees.

Syntax:  PROC Left(INT theta)

Params:  theta - the angle to turn the turtle counter-clockwise.

Description: This procedure allows you to turn the turtle counterclockwise a specified number of degrees.

### 2.11.3 PROC Turn

Purpose: To turn the turtle either clockwise or counter-clockwise.

Syntax: PROC Turn(INT theta)

Params: theta - the angle to turn the turtle.

Description: This routine allows you to turn the turtle either clockwise or counterclockwise, depending on the sign of the angle. If theta is positive, the turtle will turn counterclockwise, otherwise it will turn clockwise.

### 2.11.4 PROC Forward

Purpose: To move the turtle forward a specified length.

Syntax: PROC Forward(INT length)

Params: length - the length to move forward.

Description: This procedure allows you to move the turtle forward a specified length. This length depends entirely upon the current graphics mode.

### 2.11.5 PROC SetTurtle

Purpose: To move the turtle to a specified x,y position at a given angle.

Syntax: PROC SetTurtle(INT x,y,theta)

Params: x - the horizontal position at which to set the turtle.
y - the vertical position at which to set the turtle.
theta - the angle at which to set the turtle.

Description: This procedure allows you to move the turtle to an absolute x,y position and point it in a specific direction. At theta=0° the turtle points right, at 90° it points up, at 180° it points left, and at 270° it points down. In essence, increasing positive values of theta turn the turtle counterclockwise. And increasing negative theta values turn it clockwise.

## Chapter 3: Demonstrations

### 3.1 GEM.DEM

Gem is a game which was written by Joel Gluck after having the ACTION! cartridge for only 2 days. If you look at the code, you will notice how similar it is to BASIC. This reflects Joel's previous programming experience (BASIC only) and is not due to its being originally written in BASIC (which it was not). Enough of its history, Gem is designed for 1 to 4 players, each using a joystick. The object is to steal the gem in the center of the screen and return to your home base before one of the robots or other players zaps you. However, before the game itself begins, you are prompted for some information, specifically:

How many points to win the game?

How many robots in the final round?

Winning Points - to win a point, you must get the Gem and return with it to your corner.

Robots - the number of robots increase each round. Although they seem to die off, whenever the gem is picked up they all come back. If one of the robots is destroyed while one of the players is carrying the gem, it is reincarnated immediately.

Zapping - to zap a robot or another player, press the joystick trigger while pointing the joystick in the direction of the target. While you are zapping you cannot move. You can also zap by running into the target, but this also zaps you, so only use this method when on a Kamikaze run to keep another player from getting the gem home.

Getting Zapped - when you get zapped, you are reincarnated back at your home base and the gem is taken from you if you are carrying it. There is no limit to the number of times you can be reincarnated.

Winning - when one of the players has accumulated the required number of points, he wins the gem, and you may either play again, or quit and go to the ACTION! Monitor.

Technical notes - to use this game, do not read it into the ACTION! Editor and then compile it, since there is not enough memory to do both. Instead, RUN it from the ACTION! Monitor directly from disk. (This note does not apply if you are using DOS XL, since you have more memory and can

have the game in the Editor while compiling it).

The maximum recommended number of robots is 100. Bugs will appear in the program if you use many more, but do not fret. The most robots survived to date is 45 in a one player game.

## 3.2 KALSCOPE.DEM

This demo program uses advanced math and display list algorithms to achieve the effect of a kaleidoscope on your TV. When you run it you will be amazed by its speed. You can even change the kaleidoscope's speed and persistence (amount of time a point remains on the screen) by moving joystick 0 vertically or horizontally, respectively. After playing with it a while you will be surprised by the number and variety of the different patterns it can create.

P.S. - you can freeze the picture by pressing the trigger.

## 3.3 MUSIC.DEM

This demo program uses a couple of the Toolkit utilities and knowledge of the Atari's keyboard matrix to produce an organ which will play as you press the keys.

The letters on the keyboard represent the notes, and the letters above and below the keyboard represent the actual computer keys you must press to get the note. By pressing <SHIFT><note> you can access the middle octave, and by pressing <CONTROL><note> you can access the high octave.

This organ is special (for Atari's) in that it only plays a note as long as you keep the key depressed. Few people know how to determine how long a key is pressed (unless they've deciphered the "Type-a-Tune" demo in the BASIC reference manual, or waded through the hardware manual), so if you look at the source code you can discover something useful (possibly).

## 3.4 SNAILS.DEM

Games similar to "SNAILS' TRAILS" have been around for a long time. A version called "SURROUND" was one of the first games available for the Atari 2600. But, in the tradition of the video game industry, we present a

storyline:

You are a giant, mutant snail. Wherever you travel, you leave a trail of radioactive slime behind. So poisonous and impenetrable is this slime that should any being (including you yourself) touch it, it dies instantly. (Yes, yes. If it's that poisonous, how could you lay the trail in the first place? How should we know … YOU are the mutant.)

Further, the scientists of far off H'tra-E have discovered your kind and have imprisoned you and another of your race in a large rectangular arena. Unfortunately, both of you are neither male or female. Instead, you are each a S'ti, specially bred to do battle until death! You don't know the meaning of the word "STOP".

So, as the scientists release you from stasis (you hear three bells as the stasis field is lifted), you begin by charging straight toward your opponent. But wait! A bit of intelligence enters your crazed brain. If your slime trail is so deadly, perhaps you can entice your enemy to run into it, thus killing the other S'ti without damage to yourself. Great strategy!

What's this, though? Your opponent has developed the same strategy. Now you and the other S'ti must race around the arena, with the strategic goal of forcing each other to touch a poisonous trail or to run into the electrified outer fence. (Well, we had to keep you in the arena somehow, didn't we?). But tactics can be important as well. Look, you are running straight across the arena. At the last second, you veer in front of your enemy! He can't avoid your trail in time! He's going to … Oops. You forgot about the wall. Too bad. R.I.P.

To make a long story into a short game, you and another human opponent must each use a joystick (plugged into ports 1 and 2) to control your snail. The first snail to run into a slime trail or a wall loses, and the other snail scores a point. The first snail to score 10 points wins the game. Also, if both snails die at the same instant, neither scores a point. Good Luck!

P.S. This game was converted from BASIC XL to ACTION! in about two hours. The original BASIC XL version is in Chapter 29 of "Thirty Days to Understanding BASIC XL" and is on the BASIC XL Toolkit diskette.

## 3.5 WARP.DEM

Warp Attack is a game for only the most daring interstellar pilots. You have been chosen as one of this special breed and are sent on a surface patrol over the planet Stripes. You can move your ship left or right and you can dive or climb as in an airplane, but your on-board navigational equipment won't allow you to crash into the planet surface. As you are flying along minding your own business, an Hospites (your sworn enemy) Stellar Fortress warps right into your path,and she's armed to the teeth with Seeker Plasma Balls. One touch of them and you're dust. And all you have are puny pulse cannons.

Now you know why only the best were chosen for this assignment: very few know how to destroy a Stellar Fortress, and you are one of them. You first must destroy its right engine (on your left as it approaches), then its left engine, and finally its main engine, and each must be a direct hit. While completing this feat of precision marksmanship you must remember to avoid those Plasma Balls. Piece of Cake!

Technical Notes: Warp Attack uses quite a few advanced programming techniques, including a modified display list, display list interrupts, vertical blank interrupts, and a block fastdraw. The DLI and VBI together create the scrolling planet surface, and the fastdraw is used to move the Stellar Fortress (it's not a player!).

Note from bugsheet #3: this file can only be run when compiled from disk (unless you are using DOS XL to gain extra memory). WARP.DEM is just too big for ACTION! to hold both the source and object in memory at one time.

NOTE by GBXL: SpartaDOS X 4.47 will do as well, when configured properly.

# Appendix A: ACTION! Language Syntax

The following is the syntax of the ACTION! language in Backus-Naur form. 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:

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```
A.1 ACTION! Constants

Numeric Constant
----------------
<num const> ::= <dec num> | <hex num> | <char>
<dec num> ::= <dec num><digit> | <digit>
<hex num> ::= <hexnum><hex digit> | $<hex digit>
<char> ::= '<any printable character>
<hex digit> ::= <digit> | A | B | C | D | E | F
<d ig i t> ::= 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9

String Constant
---------------
<str const> ::= "<string>"
<string> ::= <string><str char> | <str char>
<str char> ::= <all printable characters, except " >

Compiler Constant
-----------------
<comp const> ::= <comp const>+<base 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> ::= + | -
<mult op> ::= * | / | MOD | LSH | RSH
<unary op> ::= @ | -


Fundamental Data Types
----------------------
<fund type> ::= CARD | CHAR | BYTE | INT


A.3 ACTION! Program Structure
-----------------------------

ACTION! Program
---------------
<program> ::= <program> MODULE <prog module> |
                                   {MODULE} <prog module>
<prog module> ::= {<system decls>} <routine list>
```

## A.4 Declarations

### System Declarations

```
<system decls> ::= <DEFINE decl> | <TYPE decl> | <var decl>
```

### DEFINE Directive

```
<DEFINE decl> ::= <DEFINE> <def list>
<def list> ::= <def list>,<def> | <def>
<def> ::= <identifier>=<str const>
```

### 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 decl> ::= <fund decl> <base fund decl> |
                                         <base fund decl>
<base fund decl> ::= <fund type> <fund ident list>
<fund type> ::= CARD | CHAR | BYTE | INT
<fund ident list> ::= <fund ident list>,<fund ident> |
                                             <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 list>,<ptr ident> |
                                              <ptr ident>
<ptr ident> ::= <identifier>{=<value>}
```

Variable Declaration for Arrays

```
<ARRAY decl> ::= <fund type> ARRAY <arr ident list>
<arr ident list> ::= <arr ident list>,<arr ident> |
                                               <arr ident>
<arr ident> ::= <identifier>{(<dim>)}{=<arr init opts>}
<dim> ::= <num conat>
<arr init opts> ::= <addr> | [<value>] | <str const>
<addr> ::= <comp const>
<value list> ::= <value list><value> | <value>
<value> ::= <comp const>
```

Variable Declaration for Records

```
<record decl> ::= <identifier> <rec ident list>
<rec ident list> ::= <rec ident list>,<rec ident> |
                                               <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

### Routines

```
<routine list> ::= <routine list> <routine> | <routine>
<routine> ::= <proc routine> | <func routine>
```

### Procedure Structure

```
<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: max. of 8 parameters allowed

## A.7 Statements

```
<stmt list> ::= <stmt list> <stmt> | <stmt>
<stmt> ::= <simp stmt> | <struc stmt> | <code block>
<simp stmt> ::= <assign stmt> | <EXIT stmt> | <routine call>
<struc stmt> ::= <IF stmt> | <DO loop> | <WHILE loop> |
                                              <FOR loop>
```

## Assignment Statement

```
<assign stmt> ::= <mem contents>=<arith exp>
```

## EXIT Statement

```
<EXIT stmt> ::= EXIT
```

## IF Statement

```
<IF stmt> ::= IF <cond exp> THEN {stmt list}
                        {|:ELSEIF exten:|}{ELSE exten} 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> ::= UNTIL <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 list> <comp const> |
                                             <comp const>
```

## A.8 Expressions

### Relational Expressions

```
<complex rel> ::= <complex rel><special op><simp rel exp> |
                  <simp rel exp><special op><simp rel exp>
<simple rel exp> ::= <arith exp><rel op><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

```
      $00  +----------------------------+
           |        OS and ACTION!      |
           |          Variables         |
      $CA  +----------------------------+
           |         Free Memory        |
      $CE  +----------------------------+
           |      ACTION! Variables     |
      $D4  +----------------------------+
           |    ATARI Floating Point    |
           |         Registers          |
     $100  +----------------------------+
           |      Operating System      |
     $480  +----------------------------+
           |      ACTION! Variables     |
     $580  +----------------------------+
           |    ATARI Floating Point    |
           |          Buffer            |
     $600  +----------------------------+
           |       Operating System     |
    MEMLO  +----------------------------+
           | ACTION! Compiler Stacks    |
  LO+$200  +----------------------------+
           |    ACTION! Editor Line     |
           |          Buffer            |
  LO+$300  +----------------------------+
           |     ACTION! Hash Tables    |
  LO+$750  +----------------------------+
           |    ACTION! Editor Text     |
           |          Buffer            |
           +- - - - - - - - - - - - - --+
           |    ACTION! Compiler Code   |
           |           Space            |
 TOP-$800  +----------------------------+
           |   ACTION! Compiler Symbol  |
           |           Table            |
   MEMTOP  +----------------------------+
           |        Screen Memory       |
    $A000  +----------------------------+
           |      ACTION! Cartridge     |
    $C000  +----------------------------+
           |       OS, ROMs, etc.       |
    $FFFF  +----------------------------+
```

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 will 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 cannot tell you which error you have made. |
| 12 | Missing THEN |
| 13 | Missing FI |

| Error Code | Explanation |
|---|---|
| 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 | Cannot allocate memory. You have impaired the ACTION! system, and it is unable 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. |

## Appendix D: Bibliography and References

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ATARI Operating System Manuals
ATARI User and Hardware Manuals

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Larry's Action! Tutorial

# Appendix E: Editor Commands Summary

## E.1 I/O Commands

| | |
|---|---|
| Read a File | position cursor, <CTRL><SHIFT> R, enter filespec |
| Disk Directory | <CTRL><SHIFT> R ?n:*.* (n = device num) |
| Write a File | <CTRL><SHIFT> W, enter filespec |
| List to Printer | <CTRL><SHIFT> 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><SHIFT> < |
| End of Line | <CTRL><SHIFT> > |
| Next Line | <RETURN> |
| 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 |
| End of File | <CTRL><SHIFT>E |
| Up one Screen | <CTRL><SHIFT> <up arrow> |
| Down one Screen | <CTRL><SHIFT> <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     do not move cursor, <CTRL><SHIFT> U
     Recall Line      do not move cursor, <CTRL><SHIFT> 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,
                     <RETURN>, enter old string
```

## E.11 Breaking s Combining Lines

```
     Break Line      position cursor, <CTRL><SHIFT> <RETURN
     Combine Line    put cursor at front of second line,
                     <CTRL><SHIFT> <BACK S>
```

## E.12 Leaving the Editor

```
     Leave Editor    <CTRL><SHIFT> M
```

## Appendix F: Summary of ACTION! Monitor Commands

| Command | Description |
|---|---|
| B | restart ACTION! system |
| C {"<filespec>"} | 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 {"<filespec>"} | run an ACTION! program |
| SET <address> = <value> | sets a value in a specified memory location |
| W {"<filespec>"} | 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 |
|---|---|---|
| Display on | Y | Y or N |

Controls the screen during compile & device I/O

| prompt | default | range |
|---|---|---|
| Bell off | N | Y or N |

Controls bell response.

| prompt | default | range |
|---|---|---|
| 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.

| prompt | default | range |
|---|---|---|
| Trace on | N | Y or N |

Controls compiler setup of programs so that the program, during execution, notes entry into any PROCedure or FUNCtion.

| prompt | default | range |
|---|---|---|
| List on | N | Y or N |

Controls compiler listing of program lines to screen during compile process.

| prompt | default | range |
|---|---|---|
| Window size | 18 | 5 to 18 |

Controls window 1 size. Window 1 and window 2, combined, use 23 lines.

| prompt | default | range |
|---|---|---|
| Line size | 120 | 1 to 240 |

Controls line length.

| prompt | default | range |
|---|---|---|
| Left margin | 2 | 0 to 39 |

Controls left margin in window; set as low as you find comfortable.

| prompt | default | range |
|---|---|---|
| EOL character | $9B | any ATASCII character |

Change the End-Of-Line character to aid visualization of program.

# Appendix H: "PRIMES" Benchmark

This is the benchmark test from September, 1981 BYTE Magazine, pp. 180-198, as implemented in ACTION! Here is a table of our times to compare with those in the magazine:

| Mode | Time |
|---|---|
| Compilation | ~.25 sec. |
| Display off | 12.2 sec. |
| Display on | 17.9 sec. |

```
   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              IF a<>0 THEN
20 B=1 : C=A*2                    b=1  c=a*2
30 EM                          FI

10 IF A=0 THEN B=1 GOTO 30     IF a=0 THEN b=1
20 B=7                         ELSE b=7
30 REM                         FI

FOR I=1 TO 100 ...             FOR i = 1 TO 100 DO ...
        NEXT I                 OD

PRINT "HELLO"                  PrintE("HELLO")

PRINT "HELLO";                 Print("HELLO")

PRINT #5;"HELLO"               PrintDE(5,"HELLO")

PRINT #5;"HELLO";              PrintD(5,"HELLO")

PRINT I                        PrintIE(i)
```

```
PRINT "I=";I                 PrintF("I=AIAE", i)
                                  or
                             Print("I=") PrintIE(i)

PRINT #3; B*3;               PrintBD(3, b*3)

INPUT I                      Put('?) : i=InputI()
```

Note the use of the optional colon (:) in the ACTION! example. Colons are 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:")
                                 or 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                   Graphics(8)

COLOR 3                      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 :         Graphics(24) : color = c
  PLOT 200,150 :                Plot(200,150)
  DRAWTO 120,20 :               DrawTo(120,20
  POSITION 40,150 :             Fill(40,150)
  POKE 765,C :
  XIO 18,#6,0,0,"S:"

SOUND 0,121,10,6                Sound(0,121,10,6)

C=PADDLE(B)                     c = Paddle(b)

C=STRIG(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 :            Zero(4000, 1001)
    POKE C,0 : NEXT C

STOP                            Break()

B$=STR$(I)                      StrI(i, ba)

I=VAL(S$)                       i = ValI(s)
```

## Appendix J: Run Time Library

The Runtime was disassembled by Erhard. The process is not finished, but this is the current status. The interdependency between some of the routines are marked by dotted underlines. For the writing of a custom runtime these need to be obeyed.

The table scheme is noted below.

<table>
<tr><td>Address</td><td colspan="2">Routine</td></tr>
<tr><td colspan="2">Sourcecode</td><td>Sourcecode</td></tr>
</table>

<table>
<tr><td>$6000</td><td colspan="2"><pre>MODULE ; SYS.ACT

; (c) 1983,1984 ACS

; Copyright (c) 1983,1984
; by Action Computer Services (ACS)
; All rights reserved.
;
; version 1.4
; last modified March 27, 1984

DEFINE STRING="CHAR ARRAY"
DEFINE EOL="$9B"
DEFINE OpenBuf =  "$0500"
DEFINE OpenBufL = "$00"
DEFINE OpenBufH = "$05"

STRING copy_right(0) = "(c)1983 Action Computer Services"</pre></td></tr>
<tr><td colspan="2"><pre>        *= $6000
;
        .BYTE $01,$20</pre></td><td></td></tr>
</table>

<table>
<tr><td>$6002</td><td colspan="2"><pre>;Primitive IO routines
PROC Clos=*(BYTE d)
[$FFA2$A686$CA0$AD0]</pre></td></tr>
<tr><td colspan="2"><pre>P_CLOS  LDX #$FF       ; A2 FF
        STX L00A6      ; 86 A6
        LDY #$0C       ; A0 0C
        BNE L6014      ; D0 0A</pre></td><td></td></tr>
</table>

<table>
<tr><td>$600A</td><td colspan="2"><pre>PROC Output=*(BYTE d,STRING s)
[$A684$BA0$4D0]</pre></td></tr>
<tr><td colspan="2"><pre>P_OUTPUT STY L00A6     ; 84 A6
        LDY #$0B       ; A0 0B
        BNE L6014      ; D0 04</pre></td><td></td></tr>
</table>

| $6010 | PROC In=*(BYTE d,STRING s)<br>[$A684$5A0$A586$A2$0$A386] |
|---|---|

```
P_IN      STY L00A6      ; 84 A6
          LDY #$05       ; A0 05
L6014     STX L00A5      ; 86 A5
          LDX #$00       ; A2 00
          STX L00A3      ; 86 A3
```

| $601A | PROC XIOstr=*(BYTE d,x,c,a1,a2,STRING s)<br>[$A0A$A0A$98AA$9D$342$A3A5$AF0$9D$34A$A4A5$9D$34B$A9$0$9DA8$349$A5B1$9D$348$12F0$18$A5A5$169$9D$344$A6A5$69$0$9D$345$4C$E456$60] |
|---|---|

```
P_XIOSTR  ASL A          ; 0A
          ASL A          ; 0A
          ASL A          ; 0A
          ASL A          ; 0A
          TAX            ; AA
          TYA            ; 98
          STA ICCOM,X    ; 9D 42 03
          LDA L00A3      ; A5 A3
          BEQ L6031      ; F0 0A
          STA ICAX1,X    ; 9D 4A 03
          LDA L00A4      ; A5 A4
          STA ICAX2,X    ; 9D 4B 03
          LDA #$00       ; A9 00
L6031     TAY            ; A8
          STA ICBLH,X    ; 9D 49 03
          LDA (L00A5),Y  ; B1 A5
          STA ICBLL,X    ; 9D 48 03
          BEQ L604E      ; F0 12
          CLC            ; 18
          LDA L00A5      ; A5 A5
          ADC #$01       ; 69 01
          STA ICBAL,X    ; 9D 44 03
          LDA L00A6      ; A5 A6
          ADC #$00       ; 69 00
          STA ICBAH,X    ; 9D 45 03
          JMP CIOV       ; 4C 56 E4
L604E     RTS            ; 60
```

| $604F | PROC Opn=*(BYTE d,STRING s,BYTE m,o)<br>[$A586$A684$3A0$4CXIOstr] |
|---|---|

```
P_OPN     STX L00A5      ; 86 A5
          STY L00A6      ; 84 A6
          LDY #$03       ; A0 03
          JMP P_XIOSTR   ; 4C 1A 60
```

| $6058 | PROC Prt=*(BYTE d,STRING s)<br>[$A586$A684$A2$0$A386$9A0$20XIOstr$AD0$BA9$9D$342$9BA9$4C$E456$60] |
|---|---|

```
P_PRT     STX L00A5      ; 86 A5
          STY L00A6      ; 84 A6
          LDX #$00       ; A2 00
          STX L00A3      ; 86 A3
          LDY #$09       ; A0 09
          JSR P_XIOSTR   ; 20 1A 60
          BNE L6071      ; D0 0A
          LDA #$0B       ; A9 0B
          STA ICCOM,X    ; 9D 42 03
          LDA #$9B       ; A9 9B
          JMP CIOV       ; 4C 56 E4
L6071     RTS            ; 60
```

```
        PROC Error(BYTE err)
        [$6C$A$0$1113$8301]

L6072        CLC              ; 18
P_ERROR()    JMP L6076        ; 4C 76 60
L6076        STA L6072        ; 8D 72 60
             JMP (DOSVEC)     ; 6C 0A 00
             .BYTE $13,$11,$01,$83
```

```
$6080   PROC Break=*()
        [$BA$8E$4C1$80A0$98$4C Error]

P_BREAK      TSX              ; BA
             STX L04C1        ; 8E C1 04
             LDY #$80         ; A0 80
             TYA              ; 98
             JMP P_ERROR()    ; 4C 73 60
```

```
$608A   ;math library routines
        PROC LShift=*()
        [$84A4$AF0$8586$A$8526$88$FAD0$85A6$60]

P_LSHIFT     LDY L0084        ; A4 84
             BEQ L6098        ; F0 0A
             STX L0085        ; 86 85
L6090        ASL A            ; 0A
             ROL L0085        ; 26 85
             DEY              ; 88
             BNE L6090        ; D0 FA
             LDX L0085        ; A6 85
L6098        RTS              ; 60
```

```
$6099   PROC RShift=*()
        [$84A4$AF0$8586$8546$6A$88$FAD0$85A6$60]

P_RSHIFT     LDY L0084        ; A4 84
             BEQ L60A7        ; F0 0A
             STX L0085        ; 86 85
L609F        LSR L0085        ; 46 85
             ROR A            ; 6A
             DEY              ; 88
             BNE L609F        ; D0 FA
             LDX L0085        ; A6 85
L60A7        RTS              ; 60
```

```
$60A8   PROC SetSign=*()
        [$D3A4$1010]
$60AC   PROC SS1=*()
        [$8685$8786$38$A9$0$86E5$A8$A9$0$87E5$AA$98$60]

P_SETSIGN    LDY L00D3        ; A4 D3
             BPL L60BC        ; 10 10
P_SS1        STA L0086        ; 85 86
             STX L0087        ; 86 87
             SEC              ; 38
             LDA #$00         ; A9 00
             SBC L0086        ; E5 86
             TAY              ; A8
             LDA #$00         ; A9 00
             SBC L0087        ; E5 87
             TAX              ; AA
             TYA              ; 98
L60BC        RTS              ; 60
```

| $60BD | PROC SMOps=*()<br>[$D386$E0$0$310$20SS1$8285$8386$85A5$E10$AA$D345$D385$84A5$20SS1$8485$8586$A9$0$8785$60] |
|---|---|

```
P_SMOPS   STX L00D3      ; 86 D3
          CPX #$00       ; E0 00
          BPL L60C6      ; 10 03
          JSR P_SS1      ; 20 AC 60
L60C6     STA L0082      ; 85 82
          STX L0083      ; 86 83
          LDA L0085      ; A5 85
          BPL L60DC      ; 10 0E
          TAX            ; AA
          EOR L00D3      ; 45 D3
          STA L00D3      ; 85 D3
          LDA L0084      ; A5 84
          JSR P_SS1      ; 20 AC 60
          STA L0084      ; 85 84
          STX L0085      ; 86 85
L60DC     LDA #$00       ; A9 00
          STA L0087      ; 85 87
          RTS            ; 60
```

| $60E1 | PROC MultB=*()<br>[$1BF0$CA$C786$AA$15F0$C686$A9$0$8A2$A$C606$290$C765$CA$F6D0$18$8765$8785$86A5$87A6$60] |
|---|---|

```
P_MULTB   BEQ L60FE      ; F0 1B
          DEX            ; CA
          STX L00C7      ; 86 C7
          TAX            ; AA
          BEQ L60FE      ; F0 15
          STX L00C6      ; 86 C6
          LDA #$00       ; A9 00
          LDX #$08       ; A2 08
L60EF     ASL A          ; 0A
          ASL L00C6      ; 06 C6
          BCC L60F6      ; 90 02
          ADC L00C7      ; 65 C7
L60F6     DEX            ; CA
          BNE L60EF      ; D0 F6
          CLC            ; 18
          ADC L0087      ; 65 87
          STA L0087      ; 85 87
L60FE     LDA L0086      ; A5 86
          LDX L0087      ; A6 87
          RTS            ; 60
```

| $6103 | PROC MultI=*()<br>[$20SMOps$82A6$1BF0$C686$84A6$15F0$CA$C786$8A2$A$8726$C606$690$C765$290$87E6$CA$F0D0$8685$82A5$85A6$20MultB$83A5$84A6$20MultB$4CSetSign] |
|---|---|

```
P_MULTI   JSR P_SMOPS    ; 20 BD 60
          LDX L0082      ; A6 82
          BEQ L6125      ; F0 1B
          STX L00C6      ; 86 C6
          LDX L0084      ; A6 84
          BEQ L6125      ; F0 15
          DEX            ; CA
          STX L00C7      ; 86 C7
          LDX #$08       ; A2 08
L6115     ASL A          ; 0A
          ROL L0087      ; 26 87
          ASL L00C6      ; 06 C6
          BCC L6122      ; 90 06
          ADC L00C7      ; 65 C7
          BCC L6122      ; 90 02
          INC L0087      ; E6 87
L6122     DEX            ; CA
          BNE L6115      ; D0 F0
L6125     STA L0086      ; 85 86
          LDA L0082      ; A5 82
          LDX L0085      ; A6 85
          JSR P_MULTB    ; 20 E1 60
          LDA L0083      ; A5 83
          LDX L0084      ; A6 84
          JSR P_MULTB    ; 20 E1 60
          JMP P_SETSIGN  ; 4C A8 60
```

| $6138 | PROC DivI=*()<br>[$20SMOps$85A5$27F0$8A2$8226$8326$8726$38$83A5$84E5$A8$87A5$85E5$490<br>$8785$8384$CA$E7D0$82A5$2A$A2$0$83A4$8684$4CSetSign$10A2$8226$8326$2<br>A$4B0$84C5$390$84E5$38$CA$EFD0$8226$8326$8685$82A5$83A6$4CSetSign] |
|---|---|

```
P_DIVI      JSR P_SMOPS     ; 20 BD 60
            LDA L0085       ; A5 85
            BEQ L6166       ; F0 27
            LDX #$08        ; A2 08
L6141       ROL L0082       ; 26 82
            ROL L0083       ; 26 83
            ROL L0087       ; 26 87
            SEC             ; 38
            LDA L0083       ; A5 83
            SBC L0084       ; E5 84
            TAY             ; A8
            LDA L0087       ; A5 87
            SBC L0085       ; E5 85
            BCC L6157       ; 90 04
            STA L0087       ; 85 87
            STY L0083       ; 84 83
L6157       DEX             ; CA
            BNE L6141       ; D0 E7
            LDA L0082       ; A5 82
            ROL A           ; 2A
            LDX #$00        ; A2 00
            LDY L0083       ; A4 83
            STY L0086       ; 84 86
            JMP P_SETSIGN   ; 4C A8 60
L6166       LDX #$10        ; A2 10
L6168       ROL L0082       ; 26 82
            ROL L0083       ; 26 83
            ROL A           ; 2A
            BCS L6173       ; B0 04
            CMP L0084       ; C5 84
            BCC L6176       ; 90 03
L6173       SBC L0084       ; E5 84
            SEC             ; 38
L6176       DEX             ; CA
            BNE L6168       ; D0 EF
            ROL L0082       ; 26 82
            ROL L0083       ; 26 83
            STA L0086       ; 85 86
            LDA L0082       ; A5 82
            LDX L0083       ; A6 83
            JMP P_SETSIGN   ; 4C A8 60
```

| $6186 | PROC RemI=*()<br>[$20 DivI$86A5$87A6$60] |
|---|---|

```
P_REMI      JSR P_DIVI      ; 20 38 61
            LDA L0086       ; A5 86
            LDX L0087       ; A6 87
            RTS             ; 60
```

| $618E | PROC SArgs=*()<br>[$A085$A186$A284$18$68$8485$369$A8$68$8585$69$0$48$98$48$1A0$84B1$8285$C8$84B1$8385$C8$84B1$A8$B9$A0$0$8291$88$F810$11A5$FD0$11E6$4C Break$6308$1109$1819$2113$3323$60] |
|---|---|

```
P_SARGS     STA FRET        ; 85 A0
            STX FRET+1      ; 86 A1
            STY BPTR2       ; 84 A2
            CLC             ; 18
            PLA             ; 68
            STA L0084       ; 85 84
            ADC #$03        ; 69 03
            TAY             ; A8
            PLA             ; 68
            STA L0085       ; 85 85
            ADC #$00        ; 69 00
            PHA             ; 48
            TYA             ; 98
            PHA             ; 48
            LDY #$01        ; A0 01
            LDA (L0084),Y   ; B1 84
            STA L0082       ; 85 82
            INY             ; C8
            LDA (L0084),Y   ; B1 84
            STA L0083       ; 85 83
            INY             ; C8
            LDA (L0084),Y   ; B1 84
            TAY             ; A8
L61B2       LDA FRET,Y      ; B9 A0 00
            STA (L0082),Y   ; 91 82
            DEY             ; 88
            BPL L61B2       ; 10 F8
            LDA BRKKEY      ; A5 11
            BNE L61CD       ; D0 0F
            INC BRKKEY      ; E6 11
            JMP P_BREAK     ; 4C 80 60
            .WORD $6308
            .WORD $1109
            .WORD $1819
            .WORD $2113
            .WORD $3323
L61CD       RTS             ; 60
```

| $61CE | SET $4E4=LShift<br>SET $4E6=RShift<br>SET $4E8=MultI<br>SET $4EA=DivI<br>SET $4EC=RemI<br>SET $4EE=SArgs<br><br>PROC ChkErr=*(BYTE r,b,eC)<br>[$1610$88C0$8F0$98$80C0$12F0$4C Error$8A$4A4A$4A4A$98AA$9D EOF$60] |
|---|---|

```
P_CHKERR    BPL L61E6       ; 10 16
            CPY #$88        ; C0 88
            BEQ L61DC       ; F0 08
            TYA             ; 98
            CPY #$80        ; C0 80
            BEQ L61EB       ; F0 12
            JMP P_ERROR()   ; 4C 73 60
L61DC       TXA             ; 8A
            LSR A           ; 4A
            LSR A           ; 4A
            LSR A           ; 4A
            LSR A           ; 4A
            TAX             ; AA
            TYA             ; 98
            STA EOF,X       ; 9D C0 05
L61E6       RTS             ; 60
```

| $61E7 | PROC Break1=*(BYTE err)<br>[$1A2$1186$48$20 Break$68$A8$60] |
|---|---|

```
P_BREAK1    LDX #$01        ; A2 01
            STX BRKKEY      ; 86 11
L61EB       PHA             ; 48
            JSR P_BREAK     ; 20 80 60
            PLA             ; 68
            TAY             ; A8
            RTS             ; 60
```

```
$61F2     PROC Open=*(BYTE d,STRING f,BYTE m,a2)
          [$48$A186$A284$A8$A9$0$99 EOF$A8$A1B1$8D OpenBuf
          $A8$C8$9BA9$2D0$A1B1$99 OpenBuf $88$F8D0$68$A2 OpenBufL $A0
          OpenBufH $20Opn$4C ChkErr]

P_OPEN    PHA             ; 48
          STX FRET+1      ; 86 A1
          STY BPTR2       ; 84 A2
          TAY             ; A8
          LDA #$00        ; A9 00
          STA EOF,Y       ; 99 C0 05
          TAY             ; A8
          LDA (FRET+1),   ; B1 A1
          STA OPENBUF     ; 8D 00 05
          TAY             ; A8
          INY             ; C8
          LDA #$9B        ; A9 9B
          BNE L620B       ; D0 02
L6209     LDA (FRET+1),Y  ; B1 A1
L620B     STA OPENBUF,Y   ; 99 00 05
          DEY             ; 88
          BNE L6209       ; D0 F8
          PLA             ; 68
          LDX # <OPENBUF  ; A2 00
          LDY # >OPENBUF  ; A0 05
          JSR P_OPN       ; 20 4F 60
          JMP P_CHKERR    ; 4C CE 61
```

```
$621C     PROC PrintE=*(STRING s)
          [$A186$AA$A1A4$A5device]
          PROC PrintDE=*(BYTE d,STRING s)
          [$20 Prt$4C ChkErr]

P_PRINTE  STX FRET+1      ; 86 A1
          TAX             ; AA
          LDY FRET+1      ; A4 A1
P_PRINTDE LDA DEVICE      ; A5 B7
          JSR P_PRT       ; 20 58 60
          JMP P_CHKERR    ; 4C CE 61
```

```
$6229     PROC Close=*(BYTE d)
          [$20 Clos$4C ChkErr]

P_CLOSE   JSR P_CLOS      ; 20 02 60
          JMP P_CHKERR    ; 4C CE 61
```

```
$622F     PROC Print=*(STRING s)
          [$A186$AA$A1A4$A5device]
$6236     PROC PrintD=*(BYTE d,STRING s)
          [$20Output$4C ChkErr]

P_PRINT   STX FRET+1      ; 86 A1
          TAX             ; AA
          LDY FRET+1      ; A4 A1
          LDA DEVICE      ; A5 B7
P_PRINTD  JSR P_OUTPUTQ   ; 20 0A 60
          JMP P_CHKERR    ; 4C CE 61
```

```
$623C     PROC InS=*()
          [$20In$A084$BD$348$3F0$38$1E9$A0$0$A591$A0A4$60]

P_INS     JSR P_IN        ; 20 10 60
          STY FRET        ; 84 A0
          LDA ICBLL,X     ; BD 48 03
          BEQ L6249       ; F0 03
          SEC             ; 38
          SBC #$01        ; E9 01
L6249     LDY #$00        ; A0 00
          STA (L00A5),Y   ; 91 A5
          LDY FRET        ; A4 A0
          RTS             ; 60
```

```
$6250   PROC InputS=*(STRING s)
        [$A286$AA$A2A4$A5device]
$6257   PROC InputSD=*(BYTE d,STRING s)
        [$48$FFA9$A385$68]
$625D   PROC InputMD=*(BYTE d,STRING s,BYTE m)
        [$48$A186$A284$A0$0$A3A5$A191$68$A2A4]
$626B   PROC InputD=*(BYTE d,STRING s)
        [$20InS$4C ChkErr]
```

```
P_INPUTS    STX BPTR2        ; 86 A2
            TAX              ; AA
            LDY BPTR2        ; A4 A2
            LDA DEVICE       ; A5 B7
P_INPUTSD   PHA              ; 48
            LDA #$FF         ; A9 FF
            STA L00A3        ; 85 A3
            PLA              ; 68
P_INPUTMD   PHA              ; 48
            STX FRET+1       ; 86 A1
            STY BPTR2        ; 84 A2
            LDY #$00         ; A0 00
            LDA L00A3        ; A5 A3
            STA (FRET+1),Y   ; 91 A1
            PLA              ; 68
            LDY BPTR2        ; A4 A2
P_INPUTD    JSR P_INS        ; 20 3C 62
            JMP P_CHKERR     ; 4C CE 61
```

```
$6271   CHAR FUNC GetD=*(BYTE d)
        [$7A2]
$6273   PROC CCIO=*()
        [$A386$A0A$A0A$AA$A3A5$9D$342$A9$0$9D$348$9D$349$98$20$E456$A085$4C
        ChkErr]
```

```
F_GETD      LDX #$07         ; A2 07
P_CCIO      STX L00A3        ; 86 A3
            ASL A            ; 0A
            ASL A            ; 0A
            ASL A            ; 0A
            ASL A            ; 0A
            TAX              ; AA
            LDA L00A3        ; A5 A3
            STA ICCOM,X      ; 9D 42 03
            LDA #$00         ; A9 00
            STA ICBLL,X      ; 9D 48 03
            STA ICBLH,X      ; 9D 49 03
            TYA              ; 98
            JSR CIOV         ; 20 56 E4
            STA FRET         ; 85 A0
            JMP P_CHKERR     ; 4C CE 61
```

```
$6290   PROC PutE=*()
        [$A9$9B]
$6292   PROC Put=*(CHAR c)
        [$AA$A5device]
$6295   PROC PutD=*(BYTE d,CHAR c)
        [$A186$A1A4]
$6299   PROC PutD1=*()
        [$BA2$4C CCIO]
```

```
P_PUTE      LDA #$9B         ; A9 9B
P_PUT       TAX              ; AA
            LDA DEVICE       ; A5 B7
P_PUTD      STX FRET+1       ; 86 A1
            LDY FRET+1       ; A4 A1
P_PUTD1     LDX #$0B         ; A2 0B
            JMP P_CCIO       ; 4C 73 62
```

```
$629E   PROC PutDE=*(BYTE dev)
        [$A0$9B$F7D0]
```

```
P_PUTDE     LDY #$9B         ; A0 9B
            BNE P_PUTD1      ; D0 F7
```

| $62A2 | PROC XIO=*(BYTE d,f,c,a1,a2,STRING s)<br>[$20XIOstr$4C ChkErr] |
|---|---|

```
P_XIO        JSR P_XIOSTR   ; 20 1A 60
             JMP P_CHKERR   ; 4C CE 61
```

| $62A8 | PROC CToStr=*()<br>[$D485$D586$20$D9AA$20$D8E6$FFA0$A2$0$C8$E8$F3B1$9D$550$F710$8049$9D $550$8E$550$60] |
|---|---|

```
P_CTOSTR     STA L00D4      ; 85 D4
             STX L00D5      ; 86 D5
             JSR IFP        ; 20 AA D9
             JSR FASC       ; 20 E6 D8
             LDY #$FF       ; A0 FF
             LDX #$00       ; A2 00
L62B6        INY            ; C8
             INX            ; E8
             LDA (L00F3),Y  ; B1 F3
             STA L0550,X    ; 9D 50 05
             BPL L62B6      ; 10 F7
             EOR #$80       ; 49 80
             STA L0550,X    ; 9D 50 05
             STX L0550      ; 8E 50 05
             RTS            ; 60
```

| $62C8 | PROC PrintB=*(BYTE n)<br>[$A2$0] |
|---|---|
| $62CA | PROC PrintC=*(CARD n)<br>[$20 CToStr$A5device] |
| $62CF | PROC PNum=*()<br>[$50A2$5A0$20 Output$4C ChkErr] |

```
P_PRINTB     LDX #$00       ; A2 00
P_PRINTC     JSR P_CTOSTR   ; 20 A8 62
             LDA DEVICE     ; A5 B7
P_PNUM       LDX #$50       ; A2 50
             LDY #$05       ; A0 05
             JSR P_OUTPUTQ  ; 20 0A 60
             JMP P_CHKERR   ; 4C CE 61
```

| $62D9 | PROC PrintBE=*(BYTE n)<br>[$A2$0] |
|---|---|
| $62DB | PROC PrintCE=*(CARD n)<br>[$20PrintC$4CPutE] |

```
P_PRINTBE    LDX #$00       ; A2 00
P_PRINTCE    JSR P_PRINTC   ; 20 CA 62
             JMP P_PUTE     ; 4C 90 62
```

| $62E1 | PROC PrintBD=*(BYTE d, n)<br>[$A0$0] |
|---|---|
| $62E3 | PROC PrintCD=*(BYTE d, CARD n)<br>[$A085$8A$A284$A2A6$20 CToStr$A0A5$4CPNum] |

```
P_PRINTBD    LDY #$00       ; A0 00
P_PRINTCD    STA FRET       ; 85 A0
             TXA            ; 8A
             STY BPTR2      ; 84 A2
             LDX BPTR2      ; A6 A2
             JSR P_CTOSTR   ; 20 A8 62
             LDA FRET       ; A5 A0
             JMP P_PNUM     ; 4C CF 62
```

| Address | Declaration |
|---|---|
| $62F2 | PROC PrintBDE=*(BYTE d,n)<br>[$A0$0] |
| $62F4 | PROC PrintCDE=*(BYTE d,CARD n)<br>[$20PrintCD$A0A5$4CPutDE] |

```
P_PRINTBDE  LDY #$00       ; A0 00
P_PRINTCDE  JSR P_PRINTCD  ; 20 E3 62
            LDA FRET       ; A5 A0
            JMP P_PUTDE    ; 4C 9E 62
```

| Address | Declaration |
|---|---|
| $62FC | PROC PrintI=*(INT n)<br>[$A286$AA$A2A4$A5device] |
| $6303 | PROC PrintID=*(BYTE d,INT n)<br>[$C0$0$1610$48$A186$A284$2DA0$20PutD1$38$A9$0$A1E5$AA$A9$0$A2E5$A8$68$4CPrintCD] |

```
P_PRINTI    STX BPTR2      ; 86 A2
            TAX            ; AA
            LDY BPTR2      ; A4 A2
            LDA DEVICE     ; A5 B7
P_PRINTID   CPY #$00       ; C0 00
            BPL L631D      ; 10 16
            PHA            ; 48
            STX FRET+1     ; 86 A1
            STY BPTR2      ; 84 A2
            LDY #$2D       ; A0 2D
            JSR P_PUTD1    ; 20 99 62
            SEC            ; 38
            LDA #$00       ; A9 00
            SBC FRET+1     ; E5 A1
            TAX            ; AA
            LDA #$00       ; A9 00
            SBC BPTR2      ; E5 A2
            TAY            ; A8
            PLA            ; 68
L631D       JMP P_PRINTCD  ; 4C E3 62
```

| Address | Declaration |
|---|---|
| $6320 | PROC PrintIE=*(INT n)<br>[$20PrintI$4CPutE] |

```
P_PRINTIE   JSR P_PRINTI   ; 20 FC 62
            JMP P_PUTE     ; 4C 90 62
```

| Address | Declaration |
|---|---|
| $6326 | PROC PrintIDE=*(BYTE d,INT n)<br>[$20PrintID$A0A5$4CPutDE] |

```
P_PRINTIDE  JSR P_PRINTID  ; 20 03 63
            LDA FRET       ; A5 A0
            JMP P_PUTDE    ; 4C 9E 62
```

| | |
|---|---|
| $632E | PROC StrB=*(BYTE n, STRING s)<br>[$A286$A384$A2$0$A2A4] |
| $6336 | PROC StrC=*(CARD n, STRING s)<br>[$A284$20 CToStr$C8$B9$550$A291$88$F810$60] |
| $6345 | PROC StrI=*(INT n, STRING s)<br>[$E0$0$ED10$A085$A186$A284$38$A9$0$A0E5$A8$A9$0$A1E5$AA$98$20 CToStr$E8$8A$A8$B9$54F$A291$88$F8D0$8A$A291$C8$2DA9$A291$60] |

```
P_STRB      STX BPTR2       ; 86 A2
            STY L00A3       ; 84 A3
            LDX #$00        ; A2 00
            LDY BPTR2       ; A4 A2
P_STRC      STY BPTR2       ; 84 A2
            JSR P_CTOSTR    ; 20 A8 62
            INY             ; C8
L633C       LDA L0550,Y     ; B9 50 05
            STA (BPTR2),Y   ; 91 A2
            DEY             ; 88
            BPL L633C       ; 10 F8
            RTS             ; 60
P_STRI      CPX #$00        ; E0 00
            BPL P_STRC      ; 10 ED
            STA FRET        ; 85 A0
            STX FRET+1      ; 86 A1
            STY BPTR2       ; 84 A2
            SEC             ; 38
            LDA #$00        ; A9 00
            SBC FRET        ; E5 A0
            TAY             ; A8
            LDA #$00        ; A9 00
            SBC FRET+1      ; E5 A1
            TAX             ; AA
            TYA             ; 98
            JSR P_CTOSTR    ; 20 A8 62
            INX             ; E8
            TXA             ; 8A
            TAY             ; A8
L6361       LDA L054F,Y     ; B9 4F 05
            STA (BPTR2),Y   ; 91 A2
            DEY             ; 88
            BNE L6361       ; D0 F8
            TXA             ; 8A
            STA (BPTR2),Y   ; 91 A2
            INY             ; C8
            LDA #$2D        ; A9 2D
            STA (BPTR2),Y   ; 91 A2
            RTS             ; 60
```

| | |
|---|---|
| $6372 | BYTE FUNC InputB=*()<br>CARD FUNC InputC=*() |
| $6374 | INT FUNC InputI=*()<br>[$A5 device] |
| $6384 | BYTE FUNC InputBD=*(BYTE d)<br>CARD FUNC InputCD=*(BYTE d)<br>INT FUNC InputID=*(BYTE d)<br>[$13A2$8E$550$50A2$5A0$20InputD$50A9$5A2]<br>BYTE FUNC ValB=*(STRING s)<br>CARD FUNC ValC=*(STRING s)<br>INT FUNC ValI=*(STRING s)<br>[$A485$A586$A0$0$A084$A184$A284$A4B1$A385$A3E6$20A9$C8$A4D1$5D0$C8$<br>A3C4$F730$A4B1$2DC9$3D0$A285$C8$A3C4$3610$A4B1$30C9$3030$3AC9$2C10$<br>38$30E9$AA$A1A5$48$A0A5$A$A126$A$A126$18$A065$A085$68$A165$A185$A00<br>6$A126$18$8A$A065$A085$290$A1E6$C8$A3C4$CA30$A2A5$DF0$38$A9$0$A0E5$<br>A085$A9$0$A1E5$A185$60] |

```
F_INPUTBCI   LDA DEVICE     ; A5 B7
F_INPUTBCID  LDX #$13       ; A2 13
             STX L0550      ; 8E 50 05
             LDX # <L0550   ; A2 50
             LDY # >L0550   ; A0 05
             JSR P_INPUTD   ; 20 6B 62
             LDA # <L0550   ; A9 50
             LDX # >L0550   ; A2 05
F_VALBCI     STA L00A4      ; 85 A4
             STX L00A5      ; 86 A5
             LDY #$00       ; A0 00
             STY FRET       ; 84 A0
             STY FRET+1     ; 84 A1
             STY BPTR2      ; 84 A2
             LDA (L00A4),Y  ; B1 A4
             STA L00A3      ; 85 A3
             INC L00A3      ; E6 A3
             LDA #$20       ; A9 20
             INY            ; C8
L6399        CMP (L00A4),Y  ; D1 A4
             BNE L63A2      ; D0 05
             INY            ; C8
             CPY L00A3      ; C4 A3
             BMI L6399      ; 30 F7
L63A2        LDA (L00A4),Y  ; B1 A4
             CMP #$2D       ; C9 2D
             BNE L63AB      ; D0 03
             STA BPTR2      ; 85 A2
             INY            ; C8
L63AB        CPY L00A3      ; C4 A3
             BPL L63E5      ; 10 36
L63AF        LDA (L00A4),Y  ; B1 A4
             CMP #$30       ; C9 30
             BMI L63E5      ; 30 30
             CMP #$3A       ; C9 3A
             BPL L63E5      ; 10 2C
             SEC            ; 38
             SBC #$30       ; E9 30
             TAX            ; AA
             LDA FRET+1     ; A5 A1
             PHA            ; 48
             LDA FRET       ; A5 A0
             ASL A          ; 0A
             ROL FRET+1     ; 26 A1
             ASL A          ; 0A
             ROL FRET+1     ; 26 A1
             CLC            ; 18
             ADC FRET       ; 65 A0
             STA FRET       ; 85 A0
             PLA            ; 68
             ADC FRET+1     ; 65 A1
             STA FRET+1     ; 85 A1
             ASL FRET       ; 06 A0
             ROL FRET+1     ; 26 A1
             CLC            ; 18
             TXA            ; 8A
             ADC FRET       ; 65 A0
             STA FRET       ; 85 A0
             BCC L63E0      ; 90 02
             INC FRET+1     ; E6 A1
L63E0        INY            ; C8
             CPY L00A3      ; C4 A3
             BMI L63AF      ; 30 CA
L63E5        LDA BPTR2      ; A5 A2
             BEQ L63F6      ; F0 0D
             SEC            ; 38
             LDA #$00       ; A9 00
             SBC FRET       ; E5 A0
             STA FRET       ; 85 A0
             LDA #$00       ; A9 00
             SBC FRET+1     ; E5 A1
             STA FRET+1     ; 85 A1
L63F6        RTS            ; 60
```

| | |
|---|---|
| $63F7 | PROC PrintH=*(CARD n) [$A485$A586$4A9$A685$24A9$20Put$A9$0$4A2$A406$A526$2A$CA$F8D0$3069$3AC9$230$669$20Put$A6C6$E5D0$60] |

```
P_PRINTH    STA L00A4       ; 85 A4
            STX L00A5       ; 86 A5
            LDA #$04        ; A9 04
            STA L00A6       ; 85 A6
            LDA #$24        ; A9 24
            JSR P_PUT       ; 20 92 62
L6404       LDA #$00        ; A9 00
            LDX #$04        ; A2 04
L6408       ASL L00A4       ; 06 A4
            ROL L00A5       ; 26 A5
            ROL A           ; 2A
            DEX             ; CA
            BNE L6408       ; D0 F8
            ADC #$30        ; 69 30
            CMP #$3A        ; C9 3A
            BMI L6418       ; 30 02
            ADC #$06        ; 69 06
L6418       JSR P_PUT       ; 20 92 62
            DEC L00A6       ; C6 A6
            BNE L6404       ; D0 E5
L641F       RTS             ; 60
```

| | |
|---|---|
| $6420 | PROC PrintF=*(STRING f, CARD a1,a2,a3,a4,a5) [$C085$C186$8C$5F0$A0$0$C0B1$C285$C2E6$DA2$A2B5$9D$5F0$CA$F8D0$8B86$8A86] |
| $643D | PROC PF2=*() [$8AE6$8AA4$C2C4$DAB0$C0B1$25C9$FD0$8AE6$C8$C0B1$25C9$6F0$45C9$8D0$9BA9$20Put$4CPF2$8BA4$8BE6$8BE6$A085$B9$5F0$BE$5F1$A0A4$43C0$E6F0$53C0$6D0$20Print$4CPF2$49C0$6D0$20PrintI$4CPF2$48C0$6D0$20PrintH$4CPF2$20PrintC$4CPF2] |

```
P_PRINTF    STA L00C0       ; 85 C0
            STX L00C1       ; 86 C1
            STY L05F0       ; 8C F0 05
            LDY #$00        ; A0 00
            LDA (L00C0),Y   ; B1 C0
            STA L00C2       ; 85 C2
            INC L00C2       ; E6 C2
            LDX #$0D        ; A2 0D
L6431       LDA BPTR2,X     ; B5 A2
            STA L05F0,X     ; 9D F0 05
            DEX             ; CA
            BNE L6431       ; D0 F8
            STX L008B       ; 86 8B
            STX L008A       ; 86 8A
P_PF2       INC L008A       ; E6 8A
            LDY L008A       ; A4 8A
            CPY L00C2       ; C4 C2
            BCS L641F       ; B0 DA
            LDA (L00C0),Y   ; B1 C0
            CMP #$25        ; C9 25
            BNE L645A       ; D0 0F
            INC L008A       ; E6 8A
            INY             ; C8
            LDA (L00C0),Y   ; B1 C0
            CMP #$25        ; C9 25
            BEQ L645A       ; F0 06
            CMP #$45        ; C9 45
            BNE L6460       ; D0 08
            LDA #$9B        ; A9 9B
L645A       JSR P_PUT       ; 20 92 62
            JMP P_PF2       ; 4C 3D 64
L6460       LDY L008B       ; A4 8B
            INC L008B       ; E6 8B
            INC L008B       ; E6 8B
            STA FRET        ; 85 A0
            LDA L05F0,Y     ; B9 F0 05
            LDX L05F1,Y     ; BE F1 05
            LDY FRET        ; A4 A0
            CPY #$43        ; C0 43
            BEQ L645A       ; F0 E6
            CPY #$53        ; C0 53
            BNE L647E       ; D0 06
            JSR P_PRINT     ; 20 2F 62
            JMP P_PF2       ; 4C 3D 64
L647E       CPY #$49        ; C0 49
            BNE L6488       ; D0 06
            JSR P_PRINTI    ; 20 FC 62
            JMP P_PF2       ; 4C 3D 64
L6488       CPY #$48        ; C0 48
            BNE L6492       ; D0 06
            JSR P_PRINTH    ; 20 F7 63
            JMP P_PF2       ; 4C 3D 64
L6492       JSR P_PRINTC    ; 20 CA 62
            JMP P_PF2       ; 4C 3D 64
```

| | |
|---|---|
| $6498 | PROC Note=*(BYTE d,CARD POINTER s,BYTE POINTER o)<br>[$A186$A284$A0A$A0A$AA$26A9$9D$342$20$E456$20<br>ChkErr$A0$0$BD$34E$A391$BD$34C$A191$BD$34D$C8$A191$60] |

```
P_NOTE      STX FRET+1      ; 86 A1
            STY BPTR2       ; 84 A2
            ASL A           ; 0A
            ASL A           ; 0A
            ASL A           ; 0A
            ASL A           ; 0A
            TAX             ; AA
            LDA #$26        ; A9 26
            STA ICCOM,X     ; 9D 42 03
            JSR CIOV        ; 20 56 E4
            JSR P_CHKERR    ; 20 CE 61
            LDY #$00        ; A0 00
            LDA ICAX5,X     ; BD 4E 03
            STA (L00A3),Y   ; 91 A3
            LDA ICAX3,X     ; BD 4C 03
            STA (FRET+1),Y  ; 91 A1
            LDA ICAX4,X     ; BD 4D 03
            INY             ; C8
            STA (FRET+1),Y  ; 91 A1
            RTS             ; 60
```

| | |
|---|---|
| $64BF | PROC Point=*(BYTE d,CARD s,BYTE o)<br>[$A186$A0A$A0A$98AA$9D$34D$A1A5$9D$34C$A3A5$9D$34E$25A9$9D$342$20$E<br>456$4C ChkErr] |

```
P_POINT     STX FRET+1      ; 86 A1
            ASL A           ; 0A
            ASL A           ; 0A
            ASL A           ; 0A
            ASL A           ; 0A
            TAX             ; AA
            TYA             ; 98
            STA ICAX4,X     ; 9D 4D 03
            LDA FRET+1      ; A5 A1
            STA ICAX3,X     ; 9D 4C 03
            LDA L00A3       ; A5 A3
            STA ICAX5,X     ; 9D 4E 03
            LDA #$25        ; A9 25
            STA ICCOM,X     ; 9D 42 03
            JSR CIOV        ; 20 56 E4
            JMP P_CHKERR    ; 4C CE 61
```

| | |
|---|---|
| $64DF<br><br>$64E9 | MODULE ; GRAPHIC ROUTINES<br><br>STRING dev_S="S:", dev_E="E:"<br><br>PROC Graphics=*(BYTE m)<br>[$48$A9$0$20 Close$CA9$A385$A9$0$AEdev_E$ACdev_E+1$20Open$6A9$20<br>Close$68$A485$3029$1C49$A385$6A9$AEdev_S$ACdev_S+1$4COpen] |

```
DEV_S       .BYTE $02,$53,$3A
L64E2       .BYTE $DF
L64E3       .BYTE $64
DEV_E       .BYTE $02,$45,$3A
L64E7       .BYTE $E4
L64E8       .BYTE $64
P_GRAPHICS  PHA             ; 48
            LDA #$00        ; A9 00
            JSR P_CLOSE     ; 20 29 62
            LDA #$0C        ; A9 0C
            STA L00A3       ; 85 A3
            LDA #$00        ; A9 00
            LDX L64E7       ; AE E7 64
            LDY L64E8       ; AC E8 64
            JSR P_OPEN      ; 20 F2 61
            LDA #$06        ; A9 06
            JSR P_CLOSE     ; 20 29 62
            PLA             ; 68
            STA L00A4       ; 85 A4
            AND #$30        ; 29 30
            EOR #$1C        ; 49 1C
            STA L00A3       ; 85 A3
            LDA #$06        ; A9 06
            LDX L64E2       ; AE E2 64
            LDY L64E3       ; AC E3 64
            JMP P_OPEN      ; 4C F2 61
```

| $6517<br><br>$651D | PROC Position=*(CARD c,BYTE r)<br>[$5B85$5C86$5A84]<br>PROC Pos1=*()<br>[$5585$5686$5484$60] |
|---|---|

```
P_POSITION  STA OLDCOL     ; 85 5B
            STX OLDCOL+1   ; 86 5C
            STY OLDROW     ; 84 5A
P_POS1      STA COLCRS     ; 85 55
            STX COLCRS+1   ; 86 56
            STY ROWCRS     ; 84 54
            RTS            ; 60
```

| $6524 | PROC GrIO=*()<br>[$20Pos1$AD$2FD$8D$2FB$ADdev_S$A585$ADdev_S+1$A685$A9$0$A385$A485$6A9$60] |
|---|---|

```
P_GRIO      JSR P_POS1     ; 20 1D 65
            LDA FILDAT     ; AD FD 02
            STA ATACHR     ; 8D FB 02
            LDA L64E2      ; AD E2 64
            STA L00A5      ; 85 A5
            LDA L64E3      ; AD E3 64
            STA L00A6      ; 85 A6
            LDA #$00       ; A9 00
            STA L00A3      ; 85 A3
            STA L00A4      ; 85 A4
            LDA #$06       ; A9 06
            RTS            ; 60
```

| $6540 | PROC DrawTo=*(CARD c,BYTE r)<br>[$20GrIO$11A0$4CXIO] |
|---|---|

```
P_DRAWTO    JSR P_GRIO     ; 20 24 65
            LDY #$11       ; A0 11
            JMP P_XIO      ; 4C A2 62
```

| $6548 | BYTE FUNC Locate=*(CARD c,BYTE r)<br>[$20Position$6A9$4CGetD] |
|---|---|

```
F_LOCATE    JSR P_POSITION ; 20 17 65
            LDA #$06       ; A9 06
            JMP F_GETD     ; 4C 71 62
```

| $6550 | PROC Plot=*(CARD c,BYTE r)<br>[$20Pos1$6A9$AE$2FD$4CPutD] |
|---|---|

```
P_PLOT      JSR P_POS1     ; 20 1D 65
            LDA #$06       ; A9 06
            LDX FILDAT     ; AE FD 02
            JMP P_PUTD     ; 4C 95 62
```

| $655B | PROC SetColor=*(BYTE reg,hue,lum)<br>[$5C9$1610$A085$98$F29$A285$8A$A0A$A0A$A205$A0A6$9D$2C4$9D$D016$60] |
|---|---|

```
P_SETCOLOR  CMP #$05        ; C9 05
            BPL L6575       ; 10 16
            STA FRET        ; 85 A0
            TYA             ; 98
            AND #$0F        ; 29 0F
            STA BPTR2       ; 85 A2
            TXA             ; 8A
            ASL A           ; 0A
            ASL A           ; 0A
            ASL A           ; 0A
            ASL A           ; 0A
            ORA BPTR2       ; 05 A2
            LDX FRET        ; A6 A0
            STA COLOR0,X    ; 9D C4 02
            STA COLPF0,X    ; 9D 16 D0
L6575       RTS             ; 60
```

| $6576 | PROC Fill=*(CARD c,BYTE r)<br>[$20GrIO$12A0$4CXIO] |
|---|---|

```
P_FILL      JSR P_GRIO      ; 20 24 65
            LDY #$12        ; A0 12
            JMP P_XIO       ; 4C A2 62
```

| $657E | BYTE FUNC Rand=*(BYTE r)<br>[$AE$D20A$C9$0$9F0$8486$A2$0$8586$20MultI$A086$60] |
|---|---|

```
F_RAND      LDX RANDOM      ; AE 0A D2
            CMP #$00        ; C9 00
            BEQ L658E       ; F0 09
            STX L0084       ; 86 84
            LDX #$00        ; A2 00
            STX L0085       ; 86 85
            JSR P_MULTI     ; 20 03 61
L658E       STX FRET        ; 86 A0
            RTS             ; 60
```

| $6591 | PROC Sound=*(BYTE v, p, d, vol)<br>[$A$A284$A8$7C9$530$64A0$20<br>Error$998A$D200$A2A5$A0A$A0A$A305$99$D201$60] |
|---|---|

```
P_SOUND     ASL A           ; 0A
            STY BPTR2       ; 84 A2
            TAY             ; A8
            CMP #$07        ; C9 07
            BMI L659E       ; 30 05
            LDY #$64        ; A0 64
            JSR P_ERROR()   ; 20 73 60
L659E       TXA             ; 8A
            STA AUDF1,Y     ; 99 00 D2
            LDA BPTR2       ; A5 A2
            ASL A           ; 0A
            ASL A           ; 0A
            ASL A           ; 0A
            ASL A           ; 0A
            ORA L00A3       ; 05 A3
            STA AUDC1,Y     ; 99 01 D2
            RTS             ; 60
```

| $65AE | PROC SndRst=*()<br>[$AD$232$EF29$8D$232$8D$D20F$A9$0$8A2$9D$D200$CA$FA10$60] |
|---|---|

```
P_SNDRST    LDA SSKCTL      ; AD 32 02
            AND #$EF        ; 29 EF
            STA SSKCTL      ; 8D 32 02
            STA SKCTL       ; 8D 0F D2
            LDA #$00        ; A9 00
            LDX #$08        ; A2 08
L65BD       STA AUDF1,X     ; 9D 00 D2
            DEX             ; CA
            BPL L65BD       ; 10 FA
            RTS             ; 60
```

| $65C4 | BYTE FUNC Paddle=*(BYTE p)<br>[$BDAA$270$A085$60] |
|---|---|

```
F_PADDLE    TAX             ; AA
            LDA PADDL0,X    ; BD 70 02
            STA FRET        ; 85 A0
            RTS             ; 60
```

| $65CB | BYTE FUNC PTrig=*(BYTE p)<br>[$A2$0$4C9$330$E8$329$A8$BD$D300$39*+5$A085$60$804$8040] |
|---|---|

```
F_PTRIG     LDX #$00        ; A2 00
            CMP #$04        ; C9 04
            BMI L65D4       ; 30 03
            INX             ; E8
            AND #$03        ; 29 03
L65D4       TAY             ; A8
            LDA PORTA,X     ; BD 00 D3
            AND L65DE,Y     ; 39 DE 65
            STA FRET        ; 85 A0
            RTS             ; 60
L65DE       .BYTE $04,$08,$40,$80
```

| $65E2 | BYTE FUNC Stick=*(BYTE p)<br>[$A2$0$2C9$330$E8$129$BDA8$D300$88$4D0$4A4A$4A4A$F29$A085$60] |
|---|---|

```
F_STICK     LDX #$00        ; A2 00
            CMP #$02        ; C9 02
            BMI L65EB       ; 30 03
            INX             ; E8
            AND #$01        ; 29 01
L65EB       TAY             ; A8
            LDA PORTA,X     ; BD 00 D3
            DEY             ; 88
            BNE L65F6       ; D0 04
            LSR A           ; 4A
            LSR A           ; 4A
            LSR A           ; 4A
            LSR A           ; 4A
L65F6       AND #$0F        ; 29 0F
            STA FRET        ; 85 A0
            RTS             ; 60
```

| $65FB | BYTE FUNC STrig=*(BYTE p)<br>[$BDAA$D010$A085$60] |
|---|---|

```
F_STRIG     TAX             ; AA
            LDA TRIG0,X     ; BD 10 D0
            STA FRET        ; 85 A0
            RTS             ; 60
```

| $6602 | BYTE FUNC Peek=*(CARD a)<br>CARD FUNC PeekC=*(CARD a)<br>[$A285$A386$A0$0$A2B1$A085$C8$A2B1$A185$60] |
|---|---|

```
F_PEEKC     STA BPTR2       ; 85 A2
            STX L00A3       ; 86 A3
            LDY #$00        ; A0 00
            LDA (BPTR2),Y   ; B1 A2
            STA FRET        ; 85 A0
            INY             ; C8
            LDA (BPTR2),Y   ; B1 A2
            STA FRET+1      ; 85 A1
            RTS             ; 60
```

| | |
|---|---|
| $6612 | PROC Poke=*(CARD a,BYTE v)<br>[$A085$A186$A098$9100$60A0] |

```
P_POKE      STA FRET        ; 85 A0
            STX FRET+1      ; 86 A1
            TYA             ; 98
            LDY #$00        ; A0 00
            STA (FRET),Y    ; 91 A0
            RTS             ; 60
```

| | |
|---|---|
| $661C | PROC PokeC=*(CARD a,v)<br>[$20Poke$A5C8$91A3$60A0] |

```
P_POKEC     JSR P_POKE      ; 20 12 66
            INY             ; C8
            LDA L00A3       ; A5 A3
            STA (FRET),Y    ; 91 A0
            RTS             ; 60
```

| | |
|---|---|
| $6625<br><br>$662B | PROC Zero=*(BYTE POINTER a,CARD s)<br>[$48$A9$0$A485$68]<br>PROC SetBlock=*(BYTE POINTER a,CARD s,BYTE v)<br>[$A085$A186$A284$A0$0$A4A5$A3A6$10F0$A091$C8$FBD0$A1E6$A3C6$F5D0$3F0$A091$C8$A2C4$F9D0$60] |

```
P_ZERO      PHA             ; 48
            LDA #$00        ; A9 00
            STA L00A4       ; 85 A4
            PLA             ; 68
P_SETBLOCK  STA FRET        ; 85 A0
            STX FRET+1      ; 86 A1
            STY BPTR2       ; 84 A2
            LDY #$00        ; A0 00
            LDA L00A4       ; A5 A4
            LDX L00A3       ; A6 A3
            BEQ L6649       ; F0 10
L6639       STA (FRET),Y    ; 91 A0
            INY             ; C8
            BNE L6639       ; D0 FB
            INC FRET+1      ; E6 A1
            DEC L00A3       ; C6 A3
            BNE L6639       ; D0 F5
            BEQ L6649       ; F0 03
L6646       STA (FRET),Y    ; 91 A0
            INY             ; C8
L6649       CPY BPTR2       ; C4 A2
            BNE L6646       ; D0 F9
            RTS             ; 60
```

| | |
|---|---|
| $664E | PROC MoveBlock=*(BYTE POINTER d,s,CARD sz)<br>[$A085$A186$A284$A0$0$A5A5$16F0$A2B1$A091$C8$F9D0$A1E6$A3E6$A5C6$F1D0$5F0$A2B1$A091$C8$A4C4$F7D0$60] |

```
P_MOVEBLOCK STA FRET        ; 85 A0
            STX FRET+1      ; 86 A1
            STY BPTR2       ; 84 A2
            LDY #$00        ; A0 00
            LDA L00A5       ; A5 A5
            BEQ L6670       ; F0 16
L665A       LDA (BPTR2),Y   ; B1 A2
            STA (FRET),Y    ; 91 A0
            INY             ; C8
            BNE L665A       ; D0 F9
            INC FRET+1      ; E6 A1
            INC L00A3       ; E6 A3
            DEC L00A5       ; C6 A5
            BNE L665A       ; D0 F1
            BEQ L6670       ; F0 05
L666B       LDA (BPTR2),Y   ; B1 A2
            STA (FRET),Y    ; 91 A0
            INY             ; C8
L6670       CPY L00A4       ; C4 A4
            BNE L666B       ; D0 F7
            RTS             ; 60
```

| $6675 | INT FUNC SCompare=*(STRING a,b) [$A485$A586$A284$A0$0$A084$A184$A4B1$A2D1$3F0$20*+21$C9$0$1D0$60$A685$C8$A4B1$A2D1$5D0$A6C4$F590$60$FFA2$A086$390$A2B1$E8$A186$60] |
|---|---|

| | | | | | |
|---|---|---|---|---|---|
| F_SCOMPARE | STA L00A4 | ; 85 A4 | L6691 | INY | ; C8 |
| | STX L00A5 | ; 86 A5 | | LDA (L00A4),Y | ; B1 A4 |
| | STY BPTR2 | ; 84 A2 | | CMP (BPTR2),Y | ; D1 A2 |
| | LDY #$00 | ; A0 00 | | BNE L669D | ; D0 05 |
| | STY FRET | ; 84 A0 | | CPY L00A6 | ; C4 A6 |
| | STY FRET+1 | ; 84 A1 | | BCC L6691 | ; 90 F5 |
| | LDA (L00A4),Y | ; B1 A4 | | RTS | ; 60 |
| | CMP (BPTR2),Y | ; D1 A2 | L669D | LDX #$FF | ; A2 FF |
| | BEQ L668A | ; F0 03 | | STX FRET | ; 86 A0 |
| | JSR L669D | ; 20 9D 66 | | BCC L66A6 | ; 90 03 |
| L668A | CMP #$00 | ; C9 00 | | LDA (BPTR2),Y | ; B1 A2 |
| | BNE L668F | ; D0 01 | | INX | ; E8 |
| | RTS | ; 60 | L66A6 | STX FRET+1 | ; 86 A1 |
| L668F | STA L00A6 | ; 85 A6 | | RTS | ; 60 |

| $66A9 | PROC SCopy=*(STRING d,s) [$A085$A186$A284$A0$0$A2B1$A091$8F0$A8$A2B1$A091$88$F9D0$60] |
|---|---|

| | | | | | |
|---|---|---|---|---|---|
| P_SCOPY | STA FRET | ; 85 A0 | L66B7 | TAY | ; A8 |
| | STX FRET+1 | ; 86 A1 | L66B8 | LDA (BPTR2),Y | ; B1 A2 |
| | STY BPTR2 | ; 84 A2 | | STA (FRET),Y | ; 91 A0 |
| | LDY #$00 | ; A0 00 | | DEY | ; 88 |
| | LDA (BPTR2),Y | ; B1 A2 | | BNE L66B8 | ; D0 F9 |
| L66B3 | STA (FRET),Y | ; 91 A0 | L66BF | RTS | ; 60 |
| | BEQ L66BF | ; F0 08 | | | |

| $66C0 | PROC SCopyS=*(STRING d,s,BYTE b,e) [$A085$A186$A284$A0$0$A2B1$A5C5$2B0$A585$A4C6$18$A2A5$A465$A285$290$A3E6$38$A5A5$A4E5$2B0$A9$0$4CSCopy+10] |
|---|---|

| | | | | | |
|---|---|---|---|---|---|
| P_SCOPYS | STA FRET | ; 85 A0 | | ADC L00A4 | ; 65 A4 |
| | STX FRET+1 | ; 86 A1 | | STA BPTR2 | ; 85 A2 |
| | STY BPTR2 | ; 84 A2 | | BCC L66DD | ; 90 02 |
| | LDY #$00 | ; A0 00 | | INC L00A3 | ; E6 A3 |
| | LDA (BPTR2),Y | ; B1 A2 | L66DD | SEC | ; 38 |
| | CMP L00A5 | ; C5 A5 | | LDA L00A5 | ; A5 A5 |
| | BCS L66D0 | ; B0 02 | | SBC L00A4 | ; E5 A4 |
| | STA L00A5 | ; 85 A5 | | BCS L66E6 | ; B0 02 |
| L66D0 | DEC L00A4 | ; C6 A4 | | LDA #$00 | ; A9 00 |
| | CLC | ; 18 | L66E6 | JMP L66B3 | ; 4C B3 66 |
| | LDA BPTR2 | ; A5 A2 | | | |

| $66E9 | PROC SAssign=*(STRING d,s,BYTE b,e)<br>[$A085$A186$A284$A0$0$A2B1$DF0$A685$A4C6$38$A5A5$A4E5$2F0$1B0$AA60$A6C5$890$18$A6A5$AA$A465$A585$A5A5$A0D1$390$A091$18$A0A5$A465$A085$290$A1E6$4C8ASCopy+14] |
|---|---|

```
P_SASSIGN   STA FRET        ; 85 A0
            STX FRET+1      ; 86 A1
            STY BPTR2       ; 84 A2
            LDY #$00        ; A0 00
            LDA (BPTR2),Y   ; B1 A2
            BEQ L6702       ; F0 0D
            STA L00A6       ; 85 A6
            DEC L00A4       ; C6 A4
            SEC             ; 38
            LDA L00A5       ; A5 A5
            SBC L00A4       ; E5 A4
            BEQ L6702       ; F0 02
            BCS L6703       ; B0 01
L6702       RTS             ; 60
L6703       TAX             ; AA
            CMP L00A6       ; C5 A6
            BCC L6710       ; 90 08
            CLC             ; 18
            LDA L00A6       ; A5 A6
            TAX             ; AA
            ADC L00A4       ; 65 A4
            STA L00A5       ; 85 A5
L6710       LDA L00A5       ; A5 A5
            CMP (FRET),Y    ; D1 A0
            BCC L6719       ; 90 03
            STA (FRET),Y    ; 91 A0
            CLC             ; 18
L6719       LDA FRET        ; A5 A0
            ADC L00A4       ; 65 A4
            STA FRET        ; 85 A0
            BCC L6723       ; 90 02
            INC FRET+1      ; E6 A1
L6723       TXA             ; 8A
            JMP L66B7       ; 4C B7 66
            RTS             ; 60
```

| | MODULE ; for user |
|---|---|

```
;
```

## Appendix K: ACTION! BUG SHEET #3

This document supersedes the previous two bug sheets published for ACTION! - November 6, 1984

NOTE: Bugs affecting the latest ACTION! versions are already applied to this manual. It is recommended to change the cartridge ROMs to V. 3.6, the Run Time Package to V. 1.4, and the Toolkit to V. 3.Ø.

### PART 1 - GENERAL INFORMATION

Before getting to the bad stuff (the bugs), here are some goodies about ACTION! which we would like to pass on to you:

#### Tips on Temps

A magazine article titled "Lights, Camera, ACTION!" by Dave Plotkin, which appeared in the July 1984 issue of ANTIC, featured a set of routines to facilitate writing ACTION!-based interrupt handlers.

The article gave the listings for two routines (more properly, two DEFINEs) named "SaveTemps" and "GetTemps". These routines are adequate only if no math beyond addition and subtraction is performed in the interrupt service routine. The following versions of these two routines will work properly in the more general case:

Make the following DEFINEs in your program before you declare your interrupt routine (comments may be omitted--they exist only for clarification):

```
DEFINE SaveTemps=
  "[
     $A2 $Ø7     ;       LDX #7
     $B5 $CØ     ; LOOP  LDA $CØ,X
     $48         ;       PHA
     $B5 $AØ     ;       LDA $AØ,X
     $48         ;       PHA
     $B5 $8Ø     ;       LDA $8Ø,X
     $48         ;       PHA
     $B5 $A8     ;       LDA $A8,X
     $48         ;       PHA
     $CA         ;       DEX
     $1Ø $F1     ;       BPL LOOP
     $A5 $D3     ;       LDA $D3
     $48         ;       PHA
  ]"
```

```
DEFINE GetTemps=
  "[
     $68         ;       PLA
     $85 $D3     ;       STA $D3
     $A2 $ØØ     ;       LDX #Ø
     $68         ; LOOP  PLA
     $95 $A8     ;       STA $A8,X
     $68         ;       PLA
     $95 $8Ø     ;       STA $8Ø,X
     $68         ;       PLA
     $95 $AØ     ;       STA $AØ,X
     $68         ;       PLA
     $95 $CØ     ;       STA $CØ,X
     $E8         ;       INX
     $EØ $Ø8     ;       CPX #8
     $DØ $EF     ;       BNE LOOP
  ]"
```

Use these routines inside your interrupt routine as follows:

```
   ; Your interrupt routine.
   PROC InterruptRoutine()
   ; Local declarations, if any.
      BYTE a, b, c, etc.
      ; First line of code within
      ; procedure SaveTemps

      ; Your interrupt
      ; code goes here.

      GetTemps           ; Last line of code
                         ; within procedure.
   [$6C OldVBI]          ; A special way to
                         ; end for VBIs- see
                         ; below.
```

For example, the following program will set up the routine ChangeColor as a vertical blank interrupt routine (hit the <START> key to exit the program):

```
DEFINE SaveTemps=
  "[ $A2 $Ø7 $B5 $CØ $48
     $B5 $AØ $48 $B5 $8Ø
     $48 $B5 $A8 $48 $CA
     $1Ø $F1 $A5 $D3 $48 ]"

DEFINE GetTemps=
  "[ $68 $85 $D3 $A2 $ØØ $68
     $95 $A8 $68 $95 $8Ø $68
     $95 $AØ $68 $95 $CØ $E8
     $EØ $Ø8 $DØ $EF ]"
```

```
CARD OldVBI    ; Will hold previous
               ; contents of vertical
               ; blank interrupt
               ; vector.

; This procedure will change the
; background color to random values.
; The main routine will set up this
; code to operate during the
; deferred vertical blank interrupt.
   PROC ChangeColor()
      BYTE hue, lum

      SaveTemps
      hue = Rand( 16 )
      lum = Rand( 16 )
      SetColor(2,hue,lum)
      GetTemps

   [ $6C OldVBI ]  ; Vertical blank
                   ; interrupts must end
                   ; like this ($6C is a
                   ; 65Ø2 indirect jump
                   ; instruction).

   PROC Test()     ; Main routine
      BYTE critic=$42,     ; Critical I/O flag
           console=$DØ1F   ; Console key
                           ; hardware location
      CARD VBIvec=$224     ; Deferred vertical
                           ; blank interrupt vector

      ; You must install a VBI
      ; routine like this:
      critic = 1    OldVBI = VBIvec
      VBIvec = ChangeColor
      critic = Ø

      ; ChangeColor is now running
      ; as the vertical blank interrupt
      ; routine-- since our mainline
      ; code has nothing more to do,
      ; we just go into a loop waiting
      ; for the START key to be
      ; pressed.#    WHILE console&1
      DO
      OD

      ; Now turn off the VBI routine.
      critic = 1
      VBIvec = OldVBI
      critic = Ø
   RETURN
```

This method of saving and restoring ACTION zero page variables may also be used to write BASIC machine language subroutines in ACTION! Your main ACTION routine should then have SaveTemps as the first executable line, and GetTemps as the last executable line before the RETURN statement.

## PART 2 - BUGS IN THE ACTION! CARTRIDGES

The following is a list of all bugs we currently know exist in the ACTION! cartridge. We list these bugs separately from those in the runtime library and/or the Programmer's Aid Disk (PAD) or Toolkit, which occur in following pages. Each bug is described in detail and, when possible, bug fixes are given. Many of these bugs deal only with specific versions of ACTION!. To find out which version of ACTION! you own, type the following from the ACTION! monitor:

```
?$B000 [RETURN]
```

Below is an actual copy of what printed following that command for one of our cartridges.

```
45055,$B000 = 0 $0730 48 1840
              ^
```

To find out the version number, look at the character to the right of the equals sign (here printed with a caret under it). The "0" in this case implies that the cartridge is version 3.0. If yours has a "6", you own version 3.6, etc. As of the date of this bug sheet, the current cartridge version is 3.6.

### 1. Offsets with TYPE Declaration

Using a TYPE declaration will generate a spurious error whenever the code offset (contents of location $B5) is non-zero.

Affects: All versions of the cartridge to date. (Presumably only noticed if using runtime disk, though.)

Fix: Make all TYPE declarations before changing the code offset.

Example:

```
; Beginning of program --
; First, declare TYPEs
TYPE IOCB = [ BYTE Id, Devnum,
              Command, Status ]
; Then, if desired,
; change offset
SET $B5 = $1000
; example: offset=4096
```

2. Offsets
----------

Using a code offset greater than $7FFF (i.e., a negative offset, if you consider it to be of type INT) causes the compiler to generate improper code.

Affects: All versions, especially when used with the runtime disk.

Fix: No direct fix, but you may use the relocator program described later in this document (which is also usable with assembly language).

3. ATARI DOS
------------

Exiting to ATARI DOS from ACTION! can cause a system crash if DUP.SYS is not present on the disk in drive 1.

Affects: All versions, but only when used with ATARI DOS.

Fix: Use DOS XL (or be careful when exiting to DOS).

4. Arrays and ELSEIF
--------------------

We have just learned that there is a relatively obscure bug in ACTION! related to the use of ELSEIF. In particular, statements similar to the form

```
ELSEIF a(i) = 0 THEN ...
```

where 'a' is an ARRAY and 'i' is a CARD OR INT, or statements like

```
ELSEIF p^ = 0 THEN
```

where 'p' is a Pointer, produce incorrect code.

Affects: All versions.

Fix: There is no direct fix at this time. The best way around the problem seems to be to code something like this:

```
     t = a(i)    ; t is an INTEGER
     ...
     ELSEIF t=Ø THEN ...
```

This works properly.

## 5. Writing Object Files

If a monitor Write command fails because of a disk error (e.g., disk full, 162, or device done, 144), the IOCB is not properly closed. If the disk is changed before another disk operation is performed, the new disk can have invalid data written to it.

Affects: All versions.

Fix: If you get an error when writing an ACTION! object file, type the following command to the monitor:

```
     X Close( 1 ) [RETURN]
```

You can then erase the file which caused the error.

## 6. Hex Array Sizes

Hexadecimal values as array dimensions cause incorrect code to be generated.

Affects: All versions.

Fix: Use decimal array dimensions.

## 7. TYPE Pointer Arguments

PROC or FUNC declarations with record pointer arguments other than the first do not compile correctly. For example, the following code generates an error 7 (invalid argument list):

```
     TYPE REC=[...]
         ...
      PROC Test( BYTE x, REC POINTER p )
```

Affects: All versions.

Fix: Omit the comma in the argument list for the PROC/FUNC, as in:

```
PROC Test( BYTE x
           REC POINTER p )
```

As this is just a temporary fix, it may not work in future versions, but the correct declaration (with the comma) will.

8. Monitor Lockup
-----------------

Typing the following command from the monitor will lock up the system:

```
R* <RETURN>
```

Affects: All versions.

Fix: Do not do it! If you do type that command, hit <RESET>.

9. Paddle Function
------------------

The Paddle function does not work properly in all versions of the ACTION! cartridge.

Affects: Versions 3.0 to 3.5.

Fix: Make the following declaration in your program:

```
BYTE ARRAY Paddle(4) = 624
```

10. Sound on Channels 3 and 4
-----------------------------

If you use a Sound() procedure call after having done any disk I/O, sound channels 3 and 4 will remain silent. This is because ATARI's OS does not reset some of the serial control registers completely.

Affects: Versions 3.0 to 3.5.

Fix: Type in and use the following procedure. You should call this before doing any Sound() calls and/or in place of any SndRst() calls:

```
; Contributed by Michael Ross
PROC SoundOff()
BYTE AudCtl = $D208,
     SSKCtl = $232,
```

```
        SKCtl  = $D20F
        SSKCtl = 3
        SKCtl  = 3
        AudCtl = 0
        SndRst()
   RETURN
```

## 11. TYPE Fields as Parameters

Using fields of TYPEs as parameters to PROCs or FUNCs generates incorrect code. For example,

```
   MoveBlock( rec.addr1,
              rec.addr2, length )
```

Affects: Versions 3.0 to 3.5.

Fix: Assign the TYPE field to a temporary variable and pass that as a parameter:

```
     temp1 = rec.addr1
     temp2 = rec.addr2
     MoveBlock(temp1,temp2,length)
```

## 12. SAssign Problems

SAssign does not work properly when the source string has a length of zero.

Affects: Versions 3.0 to 3.5.

Fix: No fix available at this time.

## 13. CARD FIELDS IN TYPES

Accessing CARD fields of TYPEs generates incorrect code.

Affects: Versions 3.0 to 3.2.

Fix: No fix available at this time.

## 14. MoveBlock Problems

MoveBlock does not move more than 256 bytes of data.

Affects: Versions 3.0 to 3.2.

Fix: No fix at this time. You could write an ACTION! routine to do the equivalent.

## 15. Editor Command <CONTROL><SHIFT><RETURN>

Using <CONTROL><SHIFT><RETURN> to split a line into two lines generates garbage in the second line.

Affects: Versions 3.0 and 3.1.

Fix: No fix available, but not a disastrous problem.

## 16. Division Errors

On old cartridges, neither the "/" operator nor the "MOD" operator works properly under certain conditions.

Affects: Versions 3.0 and 3.1.

Fix: Insert the following code into your program before any of your own PROCedure or FUNCtion declarations (this can be done easily using INCLUDE):

```
; Copyright (c) 1983 by
; Action Computer Services
;
; Permission is granted to
; duplicate and/or distribute
; the contents of this file
; to ACTION! users.  Copies of
; this file may not be sold or
; used for monetary gain.

PROC DivI=*()
[$20 $A06C $85 $86 $A2 $10
 $26 $82 $26 $83 $26 $86 $26
 $87 $38 $A5 $86 $E5 $84 $A8
 $A5 $87 $E5 $85 $90 $04 $85
 $87 $84 $86 $CA $D0 $E5 $A5
 $82 $2A $26 $83 $A6 $83
 $4C $A032]

PROC RemI=*()
[$20 DivI $86A5 $87A6 $60]

SET $4EA=DivI
SET $4EC=RemI
```

## 17. Error Routine Not Initialized

The address of the Error PROCedure is not restored by ACTION! if a user program has changed it.

Affects: Versions 3.0 and 3.1.

Fix: Make sure to restore the original Error vector upon exiting a program, if you changed it.

## 18. Complex Expressions in UNTIL

Complex relational expressions in an UNTIL statement generate incorrect code. For example,

```
DO
   ...
   UNTIL a>0 AND b=3
OD
```

Affects: Versions 3.0 and 3.1.

Fix: Assign the expression to a temporary variable and test that variable, instead:

```
DO
   ...
   temp = a>0 AND b=3
   UNTIL temp
OD
```

## 19. Bank Switch Bug

When loading and running compiled ACTION! object files from DOS, the system can crash when using older cartridges. This is because the ACTION! library is not accessible.

Affects: Version 3.0 only.

Fix: Put the following program lines at the VERY BEGINNING of your main procedure (i.e., the last procedure in your program):

```
BYTE bank = $D500
; This declares the variable
; 'bank' to reside at $D500.

bank = 0 ; This must be the
; first executable statement.
```

## 20. '.COM' Programs

Running compiled ACTION! programs as '.COM' files under OS/A+ causes those programs to execute twice.

Affects: All versions, but only when using a version of OS/A+. DOS XL is not affected.

Fix: Insert the following as the first global variable you declare:

```
BYTE RTS=[$60]
; This MUST be the first
; line in your program,
; aside from comments and
; SET commands.
```

## 21. PROC Addressing

Under certain conditions, specifying the address of a procedure (e.g., to interface to a machine code routine) causes ACTION! to generate incorrect code which could cause your program to "hang".

Affects: Versions 3.1 and 3.4.

Fix: Insert an empty code block after the declaration of a procedure whose address is specified. For example:

```
PROC CIO = $E456() []
; An empty code block!
```

## 22. Error #3

If you get an ERROR 3 during a compile, the system hangs when you return to the editor.

Affects: All versions.

Fix: Do not go to the editor until you type the following line to the monitor. This command resets the ACTION! memory pointer.

```
SET $E=$491^
```

## 23. String Input

When using the string input library functions (InputS, InputSD, and InputMD), there must be room in the string for the termination EOL, even though the resulting string length will not include it.

Affects: All versions.

Fix: Adjust your declaration appropriately.

## PART 3 - BUGS IN THE ACTION! RUNTIME LIBRARY

We have found a few bugs in the original version(s) of the Runtime Library Disk. Fortunately, they are all easy to fix. The runtime library is independent of the cartridge, so bugs affect all versions.

In the fixes given below, the portion to be changed (to implement the fix) is underlined. The rest of the line remains the same. To make the fixes, simply load the library file containing the affected PROCedure, edit, and save it back to disk.

1. Hex numbers are printed incorrectly by PrintH and the %H parameter of PrintF.

Fix: Change second line of CCIO:

```
   PROC CCIO=*()
   [$A386$A0A$A0A$AA$A3A5$9D$342 ...
    ---            ---
```

2. PrintBDE can cause a spurious compile time error.#

Fix: Change first line of PrintBDE:

```
   PROC PrintBDE =*(BYTE d,n)[$A0$0]
```

3. A minor error exists in ChkErr.#

Fix: Change second line of ChkErr:

```
   PROC ChkErr=*(BYTE r,b,eC)
        [$1610$88C0$8F0
          $98$80C0$12F0 ...
                  ---
```

4. If your program redefines a library procedure (e.g., one which declares its own version of PROC Graphics), it will compile with no errors using the cartridge only (because declared procedures take precedence over built-in ones). However, since the RunTime library uses this same precedence trick to include its own definitions of library procedures, your program will generate Error 6 (doubly defined name) if you do not delete the appropriate PROCedure (or FUNCtion) from the RunTime library before INCLUDEing it.

Fix: Make a custom version of the RunTime library on a COPY (please, only on a copy) of your RunTime disk which does not contain the routines you wish to replace.

5. On page 17 of the Reference Guide for the Runtime Package (p. 208 here), the DEFINE for ROM will cause incorrect code if you use local variables. (Not verified yet).

Fix: Use the following form of definition, instead:

```
DEFINE ROM = "BYTE ZZQQJUNK
             -------------
                SET $680 = $E^
                SET $B5  = $5800
                SET $E   = $682^"
```

## PART 4(a) - PROBLEMS WITH PROGRAMMER'S AID DISK

We will list the problems (and solutions) regarding the Programmer's Aid Disk (PAD) here in reasonably compact form.

### 1. IO.ACT - BGet/BPut Problems

The BGet and BPut routines in the IO.ACT file do not work properly under certain conditions. To fix this bug, replace the BGet and BPut routines with the following ACTION! code:

```
;**************************************
;Burst (Block) I/O routines to do quick
;disk I/O, utilizing a call to CIO
;**************************************

PROC CIO=$E456( BYTE areg, xreg )
;********************************
```

```
      CARD FUNC Burst( BYTE chan, mode,
                       CARD addr, buflen )

      TYPE IOCB=[BYTE id,num,cmd,stat
                 CARD badr,padr,blen
                 BYTE a1,a2,a3,a4,a5,a6]

      IOCB POINTER iptr

      chan ==& $07
      iptr = $340+(chan LSH 4)
      iptr.cmd  = mode
      iptr.blen = buflen
      iptr.badr = addr
      CIO( 0, chan LSH 4 )
   RETURN( iptr.blen )
   ;*******************************

   CARD FUNC BGet( BYTE chan,
                   CARD addr, len )
   CARD temp

      temp = Burst(chan,7,addr,len)
   RETURN( temp )
   ;*******************************

   PROC BPut(BYTE chan,
             CARD addr,len)
      Burst( chan, 11, addr, len )
   RETURN
```

2. PRINTF.ACT - Bug
-------------------

This routine has a bug which was reported and fixed in the Spring, 1984 newsletter. In the file PRINTF.ACT, use the ACTION! editor to find

```
     args ==+ s
```

and change it to

```
     args ==+ 2
```

3. PMG.ACT - Player/Missile Base Address
----------------------------------------

Because S: uses some memory just below the display list (undocumented), our method of finding the base address for Player/Missile Graphics needs a slight revision. Use the ACTION! editor with the file PMG.ACT to find

```
   PM_BaseAdr=(HiMem-PM_MemSize(mode))&PM_AdrMask(mode)
```

and change it to

```
PM_BaseAdr=(HiMem-PM_MemSize(mode)-$80)&PM_AdrMask(mode)
```

## 4. PMG.ACT - PMMove

If you use the PMMove procedure and specify a vertical movement of zero, the horizontal movement does not take place (it should). To fix this, change the lines in PMG.ACT which read

```
   IF deltaY=0 THEN
         RETURN ; do nothing
   FI
```

to the following:

```
   IF deltaY=0 THEN
      ; do horizontal anyway
      PMHpos(n)=x
      RETURN
   FI
```

## 5. PMG.ACT - PMHpos

The documentation for PMG.ACT states that you may read the contents of PMHpos to find the horizontal position of a player or missile. This is simply not true. PMHpos is a set of write-only hardware registers. (Note that in the ToolKit we have added a shadow array and changed the name of the hardware registers, so this works correctly. If you wish, you could consider doing something similar on your PAD.)

## 6. REAL.ACT - Documentation

There are two discrepancies in PROCedure names in the REAL.ACT library as compared to the REAL.DOC documentation, as follow:

| Name in .DOC | Name in .ACT |
|---|---|
| StrR | RealToStr |
| ValR | StrToReal |

We suggest that you change the source code in REAL.ACT to reflect the names given in the documentation (rather than vice versa), since this makes the names appear compatible with the library's other number-string conversion routines.

7. REAL.ACT - RealToStr
------------------------

In that same area, the routine RealToStr (or should that be StrR?) needs to change the line which reads

```
     ptr=LBuff
```

to the following:

```
     ptr=InBuff
```

8. ALLOC.ACT - Changes Necessary
--------------------------------

The free list pointer may not be set up properly. Also, when freeing a block, right adjacency is not handled properly if left adjacency has already been found. Fix these problems as follows:

In the PROCedure Free, after the line reading:

```
     last.size==+nBytes
```

insert the line:

```
     target=last
```

Also, in the same procedure, change the line reading:

```
     IF target+nBytes=current THEN
```

to read:

```
     IF target+target.size=current THEN
```

In the PROCedure AllocInit, replace the line reading:

```
     FreeList.next=p
```

with the following lines:

```
     FreeList=p
     p==+4
     FreeList.next=p
```

# PART 4(b) - TOOLKIT TROUBLES

It is hard to believe that a product as new as the ACTION! ToolKit can already have bug reports. Sigh. Anyway, there are already three versions of the ToolKit. Version 1 has 31 free sectors (when you list its directory). Version 2 has fewer free sectors and the second line of the file MUSIC.DEM reads ";Version 2". On version 3, the file ABS.ACT starts with the version number. This last convention will be followed in future versions. The comments here are organized by affected version(s).

## VERSION 1 ONLY

### 1. I/O ROUTINES

The manual describes a routine called Format (in the IO.ACT library), but no such procedure exists on the disk. However, the routine is there--it is just called Init instead. You should change your disk to match your manual.

### 2. MUSIC.DEM

The program called MUSIC.DEM will not work as is on older 400/800 machines. This is because it uses a call to Graphics(15), which is only available on XL machines. You may change the program to use Graphics(8) with no effect except that the true colors of mode 15 become artifact colors in mode 8 instead.

## VERSIONS 1 AND 2

### 1. REAL ROUTINES

There are two discrepancies in PROCedure names in the REAL.ACT library as compared to the REAL.DOC documentation, as follow:

| Name in .DOC | Name in .ACT |
| --- | --- |
| StrR | RealToStr |
| ValR | StrToReal |

We suggest that you change the source code in REAL.ACT to reflect the names given in the documentation (rather than vice versa), since this makes the names appear compatible

with the library's other number-string conversion routines.

## 2. SORT ROUTINES

There are four discrepancies in PROCecure names in the SORT.ACT library as compared to the SORT.ACT documentation, as follows:

| Name in .DOC | Name in .ACT |
|---|---|
| SortB | BSort |
| SortC | CSort |
| SortI | ISort |
| SortS | SSort |

Please change your disk file to agree with your manual.

## 3. PRINTF

The PRINTF routine has a bug which was reported and fixed in the Sprint, 1984 newsletter. In the file PRINTF.ACT, use the ACTION! editor to find

```
args ==+ s
```

and change it to

```
args ==+ 2
```

# VERSIONS 1, 2, AND 3

## 1. ALLOC ROUTINES

The manual indicates that the procedure AllocInit requires that you pass it the address of the first free byte of memory (because Alloc "dispenses" memory from the first free byte through the top of memory, as correctly described in the manual). However, since you MUST follow the procedure described in the introduction to ALLOCATE.ACT (that is, you must declare in your program a CARD called EndProg and use the command

```
SET EndProg=*
```

after compiling), the parameter to AllocInit is not really needed and so has been eliminated. (AllocInit uses EndProg just as Alloc does). If you pass a parameter to AllocInit, it will be ignored.

2. WARP.DEM
-----------

No mention is made in the Toolkit manual that this file can only be run when compiled from disk (unless you are using DOS XL to gain extra memory). WARP.DEM is just too big for ACTION! to hold both the source and object in memory at one time.

3. ALLOCATE.ACT
---------------

The free list pointer may not be set up properly. Also, when freeing a block, right adjacency is not handled properly if left adjacency has already been found. Fix these problems as follows:

In the PROCedure Free, after the line reading:

```
      last.size==+nBytes
```

insert the line:

```
      target=last
```

Also, in the same procedure, change the line reading:

```
      IF target+nBytes=current THEN
```

to read:

```
      IF target+target.size=current THEN
```

In the PROCedure AllocInit, replace the line reading:

```
      p=EndProg
```

with the following lines:

```
      FreeList=EndProg
      p=EndProg+4
```

4. PRINTF
---------

The PrintF routine on the Action! Toolkit works great unless you try to print a CARD value greater than 32767, or try to print the INT value -32768. The reason these problems occur is that the PROC PF_NBase in the PRINTF.ACT file uses the "/" and "MOD" operators, which call the cartridge divide routine. The divide routine is a SIGNED divide, so it does not work for large card values. The solution is to insert an UNSIGED divide routine into the PRINTF.ACT file and use it, instead. First, insert the following code at the beginning of PRINTF.ACT:

```
CARD Quotient, Remainder

PROC UDiv(CARD a, divisor)
    DEFINE GETCARRY="~[$2E carry]"
    BYTE carry, i
    CARD temp
    Remainder = 0
    FOR i = 1 TO 16
      DO
        Remainder ==LSH 1
        Quotient ==LSH 1
        IF (a&$8000)#0 THEN
            Remainder ==% 1
        FI
        a ==LSH 1
        temp = Remainder - divisor
        GETCARRY
        IF (carry&1)#0 THEN
            Remainder = temp
            Quotient ==+ 1
        FI
      OD
RETURN
```

Some code in the PROCedure PF_NBase must also be changed. Find the section of code that reads as follows:

```
WHILE n>0
  DO
  d=n MOD base      <-
  IF d<10 THEN
    d==+'0
  ELSE
    d==+55
  FI
  s(ptr)=d
  ptr==-1
  length==+1
  n=n/base          <-
  OD
```

And change the two lines indicated so the code reads like this:

```
WHILE n>0
  DO
  UDiv( n, base )   <-
  d=Remainder       <-
  IF d<10 THEN
    d==+'0
  ELSE
    d==+55
```

```
    FI
    s(ptr)=d
    ptr==-1
    length==+1
    n=Quotient        <-
    OD
```

The resulting PrintF routine will work properly for all CARD and INTeger numbers.

## Part 5 - ACTION MANUAL ERRATA

First of all, you need to know which version of the manual you have. If Part III is the Language, then you have the first version of the manual. Otherwise, you have the second (newest) version. Unfortunately, both manuals contain content as well as typographical errors. we will skip the typos and concentrate on the content errors, since typos do not impair your understanding of the language (although you may wonder where we learned to spell).

### VERSION 1 ERRATA

#### Page 2

In the last paragraph, it says that the library is on the disk. This is not true. It is in your cartridge.

#### Page 23

Under the description of <BACK-S>, the comparison with the ATARI screen editor is exactly reversed. If you are in REPLACE mode, this key works as in the ATARI editor.

#### Page 26

Under <CTRL><SHIFT>T, it says you may not use lower-case characters as tags. This is untrue.

#### Page 48

In the NOTE preceeding 4.3, you should add "The *, /, and MOD operators result in an implied INT type. For this reason, multiplication, division, and modulus of large CARD numbers does not always work properly."

#### Page 48

Section 4.4 says that you may only have one special operator in a complex relational expression. This is untrue. For example, the following is perfectly legal:

```
(x=7 AND y#10) OR z<100
```

#### Page 82

Section 6.2.3 implies that you may not use a function as a procedure. This is not true. You may call a function as though it were a procedure, but the value returned from the function is ignored.

## Page 97

Section 8.1.1 states that you may either initialize a POINTER to an address or give it a value. Only the second is possible, and you should use this form:

```
BYTE POINTER x=<value>
```

Not this:

```
BYTE POINTER x=[<value>]
```

## Page 48

In example #1 there are two PrintF statements which have "ptr" as one parameter. These should be "bptr", not "ptr".

## Page 101

In the last example of ARRAY declaration (BYTE ARRAY tests(5)...), the dimension is overruled by the initialization options, and so its dimension is only three. To fill only the first 3 of 5 elements, do the following:

```
BYTE ARRAY tests(5)=[4 7 18 0 0]
```

## Page 104

In example #3 you see the program line "PrintE(b)". This should read "PrintE(barray)".

## Page 108

Section 8.3.1.2 states that you can initialize the fields of a record when you declare it. This is untrue; you may only initialize its address.

## Page 110

The program line "rec.level=InputB()" should read "rec.level=GetD(7)".

## Page 112

Same as previous error.

## Page 115

Same as previous error.

Page 112
--------
The program line "continue=InputB()" should read "continue=GetD(7)".

Page 120
--------
The program line "mode=InputB()" should read "mode=GetD(7)", and the program line "PrintE(name)" should read "PrintE(nameptr)".

Page 115
--------
Same as previous error.

Page 122
--------
The program line "incctr=chgclr" should read "incclr=chgclr".

Page 142
--------
Section 5.3 states that you should not use channel 7. ACTION! uses this channel to get characters from the keyboard, and you may use it to do this also. However, do not close this channel or alter its configuration in any way.

Page 153
--------
The example of declaring an ACTION! procedure at an address is wrong! If you do this, the internal pointer to the procedure will point to the specified address, but the code generated by the procedure will not be there. Instead, it will be in with your main code. Use procedure and function addressing ONLY to call machine language routines.

Page 161
--------
Where the table of contents lists the routines in section 2.3, it should read:

```
PrintBD  NOT  PrintDB
PrintCD  NOT  PrintDC
PrintID  NOT  PrintDI
```

Page 162
--------

Where the table of contents lists the routines in sections 6.7 and 6.8, it should read:

```
PeekC  NOT  CPeek
PokeC  NOT  CPoke
```

Page 165
--------

Error in section 2.3. See changes for pg. 161 and make similar corrections.

Page 179
--------

Section 6.4 states some information concerning the results of misusing the SCopy routine, detailing that the routine does string trucation, etc., to make the procedure work. This is not true. You must make sure that the strings are compatible in size.

Page 181
--------

Section 6.8 states that the parameters to Poke and PokeC consist only of an address. Instead, they consist of an address and a value, as follows:

```
Poke(<address>,<BYTE value>)
PokeC(<address>,<CARD value>)
```

Page 182
--------

Section 6.11. MoveBlock will move a maximum block of 256 bytes in versions 3.0 to 3.4 of ACTION! Versions 3.5 and up will move any number of bytes.

Page 191
--------

Some error numbers are wrong. The corrections are:

```
14  Out of Space
15  Missing DO
19  Missing OD
24  Illegal FOR statement
26  Nesting Too Deep
27  Illegal TYPE reference
28  Illegal RETURN
128 BREAK key abort
```

Also, error 62 is error 61, and 54 & 56 do not exist.

Page 197
--------
In the PrintF statement, %D should be changed to %U.

VERSION 2 ERRATA
----------------

Page 38
-------

Section 2.7, paragraph 3. The last sentence states that you can RUN compiled ACTION! programs from disk. This is untrue. The RUN command will only compile and run ACTION! source files. Use DOS to run compiled object files.

Page 39
-------
The last RUN example (RUN PrintE()) will not work, since RUN expects a file name. Use the "Xecute" command instead.

Page 63
-------
In the TECHNICAL NOTE preceeding section 4.3, "*" should be changed to "*, /, or MOD".

Page 126
--------
The last assignment on the page makes newrecord point to the current record in the array, not the end of the array.

Page 132
--------
The program line "mode=InputB()" should be changed to "mode=GetD(7)".

Page 138
--------
The program line "IF sub(1)=str(ctr)" should read "IF sub(1)=str(ctrl)".

Page 163
--------
The PutDE procedure requires only a channel as a parameter, and does not put out both a character and a <RETURN>. Rather, it puts out a <RETURN> only.

Page 172
--------
In graphics mode Ø and all text windows, color 1 is the character luminance, color 2 is the background color, and color 3 is unused.

Page 174
--------
In section 5.6, references to the "lower right corner" should instead be "lower left corner".

Page 180
--------
Section 6.1.2 states some information concerning the results of misusing the SCopy routine, detailing that the routine does string truncating, etc.  This is not true. You must make sure that the strings are compatible in size.

Page 182
--------
Section 6.11.  MoveBlock will move a maximum block of 256 bytes in versions 3.0 to 3.4 of ACTION!  Versions 3.5 and up will move any number of bytes.

## Part 6 - ACTION OBJECT CODE RELOCATION PROGRAM

The program SIMPLREL.ACT on this BBS may be used to cause an ACTION! program to load and run at a different address than that address at which it was compiled. The same program will also work for assembly language object files, providing you also follow the given instructions.

The program takes two object files as input and produces a third file which will load and run at a desired address. The relocating program prompts the user for the two input files, which must have been compiled one page (256 bytes) apart. It then prompts for an output file name (the relocated file), the page number of the starting address of the first file, and the page number of the desired destination address. Both page numbers must be decimal values. For example, specifying 32 as the destination page will cause the output file to load at address 32*256 ($2000), not $3200.

See part V, "The ACTION! Compiler", chapter 2, page 144, for information on compiling programs to a specified address (Used to compile the two object files one page apart).

In order to use the relocating program, download SIMPLEREL.ACT and read the instructions therein.

NOTE: I was not able to identify a source where from it might be obtainable. Support welcome!

Alternatively, there are programs available written by John DeMar which provide such functionality.

Instructions for:

  RELGEN.ACT:== Relocation Generator
& RELOC.ACT:== Run-time Relocator

These programs were intended to create a self-relocating object file from either an ACTION! compiled program or an Assembled program. The original object file must be a single-stage boot with only one origin except for the trailing run or init address. The following instructions detail the steps to make the target object file. This file may be appended to other binary load files and may have other binary files appended to it. The program will load at the next possible page boundary (increment of 256) after MEMLO.

Because RELGEN compares two versions of you object file, you may want to init all variables to zero to keep the relocation table at a minimum. Stray data in the uninitialized variables may be interpreted as machine code that needs relocating.

1) Compile (or Assemble) your code at a convenient area but not conflicting with DOS. In ACTION!, use the following commands to force the program's origin to a specified value ($3000 for example):

```
SET 14=$3000
SET $491=$3000
```

2) Re-Compile your code at $100 higher than the first. For the above example, this would be at $3100.

3) From the ACTION! monitor, RUN the program RELGEN.ACT. It will prompt you for the filenames for the two object code files that you compiled above. Remember to give the Dn: prefix to the filenames. The program will compare the two object files and note their differences as offsets into the file. This information is saved in ACTION! form in a file with the original name and a ".GEN" extention. This will be used in the next step. Also, the program creates an object file image of the original but with an origin of zero. This is done to make the relocation process easier and this file, with a ".REL" extention will be used in step 5.

NOTE: RELGEN.ACT requires four open DOS files simultaneously. By default, DOS usually has buffers for only 3. You must use the command:

```
SET $709=4
```

in the ACTION! monitor and type D for DOS. Rewrite DOS to the disk and reboot. Now, DOS will allow the four files to be opened.

4) Now, Read the program RELOC.ACT into the ACTION! Editor. This is a "generic" run-time relocator. The file generated with the RELGEN.ACT program (with the ".GEN" extention) must be merged into this program with the editor Read function. Position the cursor where instructed and read in the file. Compile this code but be sure that it is SET to compile above the expected end of YOUR program's target location. Save this object code to disk and go to DOS.

5) Using the DOS Copy command, append the ".REL" file generated in RELGEN.ACT, to the merged relocator file saved in step 4. For example:

```
C
Copy from,to:
TEST.REL,AUTORUN.SYS/A
```

This assumes that you saved the file in Step 4 as AUTORUN.SYS.

6) Finally, the appended file can be loaded from DOS or named AUTORUN.SYS as above for permanent applications.

If you have question, send E-Mail to:
John DeMar 71066,337 on Compuserve
or leave a message on the ACE-BASE
BBS at (315)451-7747. Good Luck!

Please see the latest known versions:

```
MODULE ;RELGEN2.ACT

;COPYRIGHT 1984, QMI, JS DeMar
;REV. 1.1, March 20, 1984

;OBJECT CODE RELOCATION GENERATOR for
;ACTION! compiled binary-load files.

;WARNING!!! This program requires
;four OPEN files simultaneously.
;Be sure that DOS is configured for
;this. With DOS 2.0, set $709 equal
;to at least 4, rewrite DOS and
;reboot.

;Requires the second file compiled
;at any even page increment higher
;than the first file, for example:
;$3000 and $3100.

;Generates a table of the locations
;that require relocating and saves
;it in a ".GEN" file in ACTION!.
;  The ".REL" file is the original
;object code with an origin of "0".
;The actual relocator is compiled
;from the generic relocator source
;called "RELOC.ACT" merged with the
;".GEN" file generated here. Append
;".REL" file to that code and it
;will load and relocate to MEMLO.

DEFINE in1="1",
       in2="2",
       out1="3",
       out2="4"
```

```
BYTE abrt

;---------------------------------

PROC MyError(BYTE a,x,y)

IF y=170 THEN
  PrintE("ERROR File not found!")
ELSE
  Print("ERROR! ")
  PrintBE(y)
FI
abrt=1
RETURN
;---------------------------------

PROC Ferror()

BYTE t,clock=$14

PrintE("ERROR in Output filespec!")
t=clock-$80
DO
UNTIL t=clock
OD
RETURN
;---------------------------------

PROC EndIt()

Close(in1)
Close(in2)
Close(out1)
Close(out2)
RETURN
;---------------------------------

PROC Main()

CARD start1,start2,end1,end2
CARD offsets,offsete,i,count,hits
CARD test1,test2,old1,old2,old3,old0
BYTE x,z,j,wnum,d1,d2,
     sthigh

BYTE ARRAY fname1(18),fname2(18),
           fnameout1(18),fnameout2(18)

DO
PrintE("}    Relocation Code Generator II ")
PrintE("#             JS DeMar, 8/84 ")
PutE()
PrintE("  Requires two code files compiled")
```

```
PrintE("      with an offset of $0100.")
PutE()

Print("Filespec for code A >")
InputMD(device,fname1,18)
PutE()
Print("Filespec for code B >")
InputMD(device,fname2,18)
PutE()

Scopy(fnameout1,fname1)
SCopy(fnameout2,fnameout1)
j=1
IF fnameout1(1)#'D
      OR fnameout1(0)<4 THEN
  Ferror()
ELSEIF fnameout1(2)=': THEN
  z=0
ELSEIF fnameout1(3)=': THEN
  z=1
FI
DO
  x=fnameout1(j)
  j==+1
  IF x=$20 THEN
    EXIT
  ELSEIF x='. THEN
    EXIT
  ELSEIF j>fnameout1(0) THEN
    j==+1
    EXIT
  ELSEIF j>11+z THEN
    Ferror()
  FI
OD

fnameout1(j-1)='.
fnameout1(j)='G
fnameout1(j+1)='E
fnameout1(j+2)='N
fnameout1(0)=j+2

j=1
IF fnameout2(1)#'D
      OR fnameout2(0)<4 THEN
  Ferror()
ELSEIF fnameout2(2)=': THEN
  z=0
  EXIT
ELSEIF fnameout2(3)=': THEN
  z=1
  EXIT
FI
```

```
OD
DO
  x=fnameout2(j)
  j==+1
  IF x=$2Ø THEN
    EXIT
  ELSEIF x='. THEN
    EXIT
  ELSEIF j>fnameout2(Ø) THEN
    j==+1
    EXIT
  ELSEIF j>11+z THEN
    Ferror()
    EXIT
  FI
OD

fnameout2(j-1)='.
fnameout2(j)='R
fnameout2(j+1)='E
fnameout2(j+2)='L
fnameout2(Ø)=j+2

Print("Generation file = ")
PrintE(fnameout1)
Print("Relocation file = ")
PrintE(fnameout2)

Error=MyError
abrt=Ø
Close(in1)
Close(in2)
Close(out1)
Close(out2)
Open(in1,fname1,4)
Open(in2,fname2,4)
IF abrt=1 THEN
  Close(1)
  Close(2)
  RETURN
FI
Open(out1,fnameout1,8)
Open(out2,fnameout2,8)

x=GetD(in1) ;throw away two $FF's.
x=GetD(in1)
PutD(out2,$FF)
PutD(out2,$FF)
x=GetD(in1)
PutD(out2,x)
start1=x    ;start addr of file1.
x=GetD(in1)
PutD(out2,x)
```

```
start1==+(x*256)
x=GetD(in1)
PutD(out2,x)
end1=x
x=GetD(in1)
PutD(out2,x)
end1==+(x*256) ;end addr of file1.

x=GetD(in2) ;throw away two $FF's.
x=GetD(in2)
x=GetD(in2)
start2=x    ;start addr of file2.
x=GetD(in2)
start2==+(x*256)
x=GetD(in2)
end2=x
x=GetD(in2)
end2==+(x*256) ;end addr of file2.

offsets=start2-start1
sthigh=start1/256
offsete=end2-end1


PrintDE(out1,"MODULE")
PrintD(out1,";For file ")
PrintDE(out1,fnameout2)
PrintDE(out1,"")
Print("Code starts at ")
PrintD(out1,"CARD start=[")
PrintCE(start1)
PrintCD(out1,start1)
PrintDE(out1,"]")
Print("   and ends at ")
PrintD(out1,"CARD finish=[")
PrintCE(end1)
PrintCD(out1,end1)
PrintDE(out1,"]")
Print("Compile offset was ")
PrintCE(offsets)

IF offsete#offsets THEN
  PrintE("Diferrent size files!")
  PrintE("ABORTED!")
  EndIt()
  RETURN
FI
PrintDE(out1,"")
PrintD(out1,"CARD ARRAY otable=[")
wnum=0
hits=0
count=0
FOR i=start1 TO end1
```

```
DO
  d1=GetD(in1)
  d2=GetD(in2)
  IF d1#d2 THEN
    hits==+1
    IF wnum=0 THEN
      PrintD(out1,"  ")
      Print(" ")
    ElSE
      PrintD(out1," ")
      Print(" ")
    FI
    PrintCD(out1,count)
    Print(" ")
    PrintC(count)
    wnum==+1
    IF wnum>4 THEN
      PrintDE(out1,"")
      PrintE("")
      wnum=0
    FI
    d1==-sthigh
  FI
  PutD(out2,d1)
  count==+1
OD
FOR i=0 TO 2
DO
  d1=GetD(in1)
  d2=GetD(in1)
OD
test1=d1
test1==+(d2*256)
IF test1>=start1 AND test1<=end1 THEN
  PrintDE(out1,"]")
  PrintE("]")
  PrintD(out1,"CARD hits=[")
  PrintCD(out1,hits)
  PrintDE(out1,"]")
  PrintDE(out1,"")
  Print("CARD hits=[")
  PrintC(hits)
  PrintE("]")
  PrintE("")
  PrintD(out1,"CARD runaddr=[")
  Print("CARD runaddr=[")
  test1==-start1
  PrintCD(out1,test1)
  PrintC(test1)
  PrintDE(out1,"]")
  PrintE("]")
ELSE
  PrintE("No Run Address! - ABORTED!")
```

```
FI
PrintE("")
PrintDE(out1,"")
EndIt()
PrintE("Finished!}")
RETURN


MODULE ;RELOCATE.ACT

;Run-time Relocator Code.
;For use with RELGEN.ACT
;COPYRIGHT 1984, JS DeMar
;Rev. 2.0, August 17,1984
;---------------------------------

SET 14=$6000
SET $0491=$6000
;---------------------------------
;The beginning of the relocator
;table and code should be higher
;than the end of the original
;compiled program. But, there must
;be enough space left for the table
;and the relocator code itself!
;---------------------------------



;---------------------------------
;Read the ".GEN" file above here.
;---------------------------------
;Compile this after reading in the
;".GEN" file above. Then append this
;code to the ".REL" file using the
;DOS C (COPY) command with /A after
;the filenames:
; PROGRAM.OBJ,PROGRAM.REL/A
;Then rename the ".REL" file to
;AUTORUN.SYS to run at boot-time.
;---------------------------------

PROC Relocate()

BYTE offset,memlohi=$02E8,x,y
CARD memlo=$02E7,i,j,top,entry
CARD POINTER p
BYTE ARRAY newplace

[$8E y $4E y $4E y $4E y $4E y]

newplace=memlo
newplace==&$FF00
```

```
offset=memlohi
i=memlo&$00FF
IF i#0 THEN
  newplace==+$0100
  offset==+1
FI

j=0
FOR i=start TO finish
DO
  p=i
  x=p^
  newplace(j)=x
  j==+1
OD

FOR i=0 TO hits-1
DO
  entry=otable(i)
  newplace(entry)==+offset
OD
runaddr==+newplace
[$6C runaddr]
```

# ACTION!
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ACTION!

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