Merlin 128™

The Complete Macro Assembler System
For The Commodore 128

By Glen Bredon

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Merlin 128™
Instruction Manual

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ABOUT THE AUTHOR

Glen Bredon is a professor at Rutgers University in New Jersey where he has taught mathematics for over fifteen years He purchased his first computer in 1979 and began exploring its internal operations because "I wanted to know more than my students." The result of this study was the best selling Merlin Macro Assembler and other programming aids. A native Californian and concerned environmentalist, Glen spends his summers away from mathematics and computing, preferring the solitude of the Sierra Nevada mountains where he has helped establish wilderness reserves.

MERLIN 128
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MERLIN 128

Merlin 128 is an extremely powerful, comprehensive Macro Assembler system for the Commodore 128 computer. It consists of four main modules and numerous auxiliary and utility programs which comprise one of the most complete assembler systems available for *any* personal computer. Merlin's four main modules are:

- FILE MANAGEMENT system, for disk I/O, file management, disk operations, etc.,

- EDITOR system, for writing and editing programs with word-processor-like power,

- ASSEMBLER system, with such advanced features as Macros, Macro libraries, conditional assembly, linked files, etc.,

- LINKER system, for generating relocatable code modules, library routines, run-time packages, etc.

But Merlin 128 is more than just the sum of these four parts. Here are some of the other features offered by Merlin 128:

- Merlin 128 recognizes over 50 Pseudo Opcodes for extreme programming flexibility,

- Merlin 128 has over 40 editing commands for ultimate editing power equaled only by word processors,

- Merlin 128 comes with a powerful symbolic disassembler to generate Merlin source code from raw binary programs,

- Merlin 128 comes with many sample programs, libraries and other aids to get you going with assembly language fast,

- Merlin 128 is UNLOCKED and COPYABLE for your benefit.

INTRODUCTION

Congratulations on your purchase of Merlin 128, one of the most powerful, yet easy to use assemblers for the Commodore 128 computer. Merlin 128 offers virtually every feature and function that a programmer needs, thus making it unlikely that you'll outgrow it. At the same time, Merlin 128's easy built-in editor and fast assemblies make it a pleasure to use whether you're writing a few lines of code or 30,000!

To run Merlin 128, you'll need the following:

* COMMODORE 128
* 1571 Disk drive or equivalent

If you are currently using a printer, Merlin 128 will function just fine with it, producing formatted listings with page breaks and titles.

If you're familiar with assembly language programming already, you will find Merlin 128 easy to adapt to. It follows the standards of 6502 programming, and its assembler-directed commands, or pseudo-ops are a super-set of just about every other assembler. That is, assembler directives like HEX, ASC, DS etc., that you've used in other assemblers are still there in Merlin 128, and better still, you'll find a new complement of functions to make programming easier. These include assembling directly to or from disk files, multiple data formats for numbers and strings, a complete set of assembler utilities such as cross-referencing and a source code generator (Sourceror), macro capabilities and more.

If you're new to assembly language programming, Merlin 128 is the easiest assembler there is. However, the Merlin 128 manual does not make any attempt to teach the techniques of assembly language programming itself. Those techniques are covered in various tutorial books available from a number of publishers. Because everyone has different goals and objectives, you should seek out those books which best match your current needs and experience.

Two of the better books that we recommend include:

ASSEMBLY LANGUAGE FOR KIDS - William B. Sanders. Microlit, 17857 Aguacate Way, San Diego, CA 92127

COMMODORE 64/128 ASSEMBLY LANGUAGE PROGRAMMING - Mark Andrews. Howard W. Sams & Co., Inc., 4300 West 62nd Street, Indianapolis, IN 46268

Both of these books offer Merlin program listings.

BEGINNER'S GUIDE TO USING MERLIN 128

The purpose of this section is not to provide instruction in assembly language programming. Rather, it will show you the loading, editing, and running of a short assembly language program to give you an idea of how Merlin 128 works.

Many of the Merlin 128 commands and functions are very similar in operation. This section does not attempt to present demonstrations of each and every command option. The objective is to present examples of the more common operations, sufficient to get you started writing your own programs using Merlin 128. You should not expect to immediately use all of the various commands that Me4in 128 supports in your first program. The best approach is to use the Merlin 128 manual in an encyclopedia4ike fashion, reading just those sections that provide some utility to a current programming task. We suggest that you lightly skim through the manual once, to become aware of generally what the software has to offer, and then return later to specific sections as needed.

Now, let's try your first program with Merlin 128. Just follow these steps:

1. Boot the Merlin 128 disk. A title screen appears, after which the screen changes to the MAIN MENU. The main menu is used for loading and saving files, disk operations, and of course, entering the MERLIN Editor and Assembler itself.

2. When the '%' prompt appears at the bottom of the main menu, type ‘E'. This instantly places the system in EDITOR control mode. The screen clears and the prompt changes to a colon (":").

3. The two most often used commands in the immediate mode of the Editor are 'A' (for Add lines) and 'I' for inserting lines between existing lines of your source code.

   Since we are entering an entirely new program, type 'A' at the ':' prompt and press RETURN (A = ADD). A '1' appears at the top right corner of the screen. This indicates the current line number. The cursor is on the left side of the screen, and will appear as an inverse 'I' (the meaning of the cursor appearance will be discussed a little later in this manual).

4. On line 1, enter an asterisk (*). An asterisk as the first character in any line is similar to a REM statement in BASIC it tells the assembler that this is a remark line and anything after the asterisk is to be ignored. To confirm this, type the title 'Merlin 128 Demo' after the asterisk and press the RETURN key.

5. After Return, the cursor once again drops down one line, a '2' appears at the top right to indicate the new line number. Press the space bar once and type 'ORG', space again, type '$8000', and press RETURN.

The above step instructs the assembler to create the following program so that it can run at memory location $8000. Merlin 128 almost always assembles your program in the same place in memory, but the ORG (for Origin) is used to tell Merlin 128 where you want the program to eventually be run. This is so that JMPs, JSRs and other location dependent code within your program is properly written with the final location in mind.

You'll notice that when you press the space bar, Merlin 128 automatically moves the cursor to the next field on the line. You'll recall that in assembly language programming, the position of text on each line determines what kind of information it is. Labels for routines and entry points are in the first position. On line 2 you skipped this field by pressing the space bar first, before entering any text. The second position is for the command itself. The command can either be a 6510/8502 command such as LDA, RTS, etc., or it can be a directive to Merlin 128 itself, to be used during the assembly to write a file to disk, create a label, call up a macro, or any of Merlin 128's many assembler commands.

6. Asterisk can also be used to just create a blank line. On line 3, enter another asterisk, with no text following it, and press RETURN again.

7. On line 4, do not space once after the line number. Type 'BSOUT', space, 'EQU', space, '$FFD2', space, ';' (semicolon), 'Output subroutine', RETURN.

   This defines the label BSOUT to be equal to hex FFD2. This use of a label is known as a constant. Wherever BSOUT appears in an expression, it will be replaced with $FFD2. Why don't we just use '$FFD2'? For one thing, 'BSOUT' is easier to remember than '$FFD2'. Also, if a later assembly required changing the location of BSOUT, all that needs changing is the 'EQU' statement, rather than all the other '$FFD2's throughout the listing.

   Semicolons are like asterisks, used to mark the beginning of a remark (comment). Semicolons, however, are used to mark the start of a comment at the end of a line that contains other text.

8. Line 5: Type 'BUFLEN', space 'EQU', space '20', space, ';', 'Length of string to print', RETURN.

   The program should now look like this:

```
*   Merlin 128 Demo
        ORG    $8010
*
BSOUT   EQU    $FFD2      ;Output subroutine
BUFLEN  EQU    20         ;Length of string to print
```

9. Enter the following 5 lines:

```
GETIN    EQU   $EFE4      ;Get input subroutine
KEY      EQU   $FF9F      ;Keyboard scan routine
*
START    LDX   #0         ;Set X to 0
LOOP     LDA   SIRINO,X   ;Get a character from STRINO
         JSR   BSOUT      ;Send it to the screen
```

Following the Opcode is the operand, in this case 'BSOUT'. The operand is the target information of the Opcode. Where to JSR to, what value to load, etc.

10. Enter the following lines to complete the program:

```
       INX              ;Increment X
       CPX   #BUFLEN    ;Compare X to value in BUFLEN
       BNE   LOOP       ;if not equal, go back to LOOP
SCAN   JSR   KEY        ;Scan the keyboard
       JSR   GETIN      ;Any input?
       BEQ   SCAN       ;If not, go back to SCAN
       CMP   #$0D       ;Was Return pressed?
       BEQ   DONE       ;If so, go to DONE
       JIP   SCAN       ;If not, go back to SCAN
DONE   RTS              ;All done
STRING TXT 'Press Return to Exit'
```

11. The program has been completely entered, but the system is still in ADD mode. To exit ADD, just press the Commodore key (bottom left of keyboard) and the horizontal arrow key (top left of keyboard) at *the same time.* (A Commodore command key character is typed in a manner similar to control characters, and are indicated in this manual by CC and CTRLC, respectively.) The ':' prompt reappears at the bottom of the screen, indicating that the system has returned to the immediate mode.

12. Prom the :' prompt, type L to list the program. The screen should now look like this:

```
*    Merlin 128 Demo
         ORG   $8000
*
BSOUT    EQU   $FED2       ; Output subroutine
BUFLEN   EQU   20          ;Length of string to print
GET IN   EQU   $EFE4       ;Get input subroutine
KEY      EQU   $FF9F       ;Keyboard scan routine
*
START    LDX   #0          ;Set X to 0
LOOP     LDA   STRING, X   ;Get a character from STRING
         BSOUT             ;Send it to the screen
         INX               ;Increment X
         CPX   #BUFLEN     ;Compare X to value in BUFLEN
         BNE   LOOP        ;If not equal, go back to LOOP
SCAN     JSR   KEY         ;Scan the keyboard
         JSR   GET IN      ;Any input?
         BEQ   SCAN       ;If not, go back to SCAN
         CMP   #$OD       ;Was Return pressed?
         BEQ   DONE       ;If so, go to DONE
         JMP   SCAN       ;If not, go back to SCAN
DONE     RTS              ;A11 done
STRING   TXT 'Press Return to Exit'
```

Note that throughout the entry of this program, each bit of text has been moved to a specific field. Here is a summary of the fields as used so far:

```
LABEL    OPCODE    OPERAND    COMMENT
```

Field One is reserved for labels. BSOUT, START and DONE are examples of labels.

Field Two is reserved for opcodes, such as the Merlin 128 pseudo-opcodes (also called directives) ORG and EQU, and the 6510/8502 opcodes JSR and RTS.

Field Three is for operands, such as $8000, $FFD2 and, in this case, BSOUT.

Field Four contains comments (preceded by";")

It should be apparent from this exercise that it is not necessary to input extra spaces in the source file for formatting purposes, even if these spaces seem to exist in a listing you may be using.

In summary:

1) Do not space for a label. Space once after a label or, if there is no label, once for the opcode.

2) Space once after the opcode for the operand. Space once after the operand for the comment. If there is no operand, type a space and a semicolon for a comment.

EDITING A SOURCE LISTING

Assuming no errors have been made in the text entered so far, you could now assemble the program entered with Merlin 128. Before doing that, however, let's look at the editing abilities of Merlin 128.

Editing is the process of making alterations to text that you've already entered, and this ability is one of MERLIN 128's strong points. In a sense, an assembler is just a word processor for the text that makes up a program. In that light, then, you can judge an assembler in part by how good its editing features are.

Merlin has a powerful, built-in full screen editor. Powerful in the range of operations possible but, after a little practice, remarkably easy to use.

There are two phases to editing text with Merlin 128. The first is telling the Editor which lines you wish to add, delete or edit. Sometimes a specific line number is not needed, as when you typed 'A' to start adding lines to your listing.

Other times, you will wish to edit a line that has already been entered, and a line number may be required. In addition, once you are editing a specific line, new commands become available to you to make specific changes to a line of text.

Note that in the remainder of this manual, special characters will be abbreviated as follows: **C=** = Commodore key, ← = Horizontal arrow, Esc = Escape key, Alt = Alternate key, and CTRL-C = Control-C.

Inserting and deleting lines in the source code are both simple operations. The following example will INSERT three new lines between the existing lines 5 and 6.

1. After the ':' prompt, type 'I' for (INSERT), the number '21', and press RETURN. All inserted lines will precede (numerically) the line number specified in the command.

2. Type an asterisk, and press RETURN. Note that the INSERT mode has not been exited.

3. Type another asterisk, and press RETURN again.

4. Press space once, and type 'TYA'.

The three new lines (21, 22, and 23) have been inserted, and the subsequent original source lines (now lines 24 and 25) have been renumbered. The last few lines of the program should now look like this:

```
          JMP    SCAN       ;If not, go bark to SCAN
*
*
          TYA
DONE      RTS               ;A11 done
STRING    TXT    'Press Return to Exit'
```

5. Press **C=** ← to exit the full screen editor. The system reverts to Immediate Mode (':' prompt).

Using DELETE is equally easy.

1. In Immediate Mode of the editor, type 'D21', and press RETURN. Nothing new appears on the screen.

2. Type L to list the source code. The source listing is one line shorter. You've just deleted the 'TYA' line, and the subsequent lines have been renumbered.

It is possible to delete a range of lines in one step.

1. In control mode, input 'D21,22' and press RETURN.

2. Type L to list the source.

Lines 21 and 22 from the example, which contained the inserted asterisks, have been deleted, and the subsequent lines renumbered. The listing appears the same as when you first entered the listing.

This automatic renumbering feature makes it IMPERATIVE that when you are deleting several different groups of lines at once, you must remember to begin with the group with highest numbers and work back to the lowest.

For example, if you had a long listing, and wanted to Delete lines 5-7, 15-23 and 66-72, you would type in:

```
D66, 72
D15,23
D5, 7
```

NOT:

```
D5, 7
D15,23
D66, 72
```

This is because after the first Delete of lines 5 through 7, what used to be lines 15 through 23 are now at 12 through 20! Keep this in mind and you'll avoid problems.

While Adding, Inserting, or Editing an existing line, you have many options within the line, all of which are accessed by using Control characters. To demonstrate, using the listing you've entered:

1. At the ':' prompt, enter 'E' (the EDIT command) and a line number (use '21' for this demonstration), and press RETURN. The cursor moves to the beginning of the specified line and is over the 'D' in 'DONE'.
2.

```
DONE        RTS
```

2. Type CTRL-D. The character under the cursor disappears. Type CTRL-D three more times until 'DONE' has been deleted, and the cursor is positioned to the left of the opcode (RTS).

3. Press **C= ←,** then L to list the program. In line 21 of the source code, only the opcode remains.

4. At the ':' prompt, enter 'E21' and press RETURN.

5. Don't move the cursor with the space bar or arrow keys. Type the word ‘DONE’, then press **C= ←.**

6. Press L to list the program. Line 21 has been restored.

The other sub-commands (CTRL-characters) used under the EDIT command function similarly. Read the definitions in the Editor Section and practice a few operations.

ASSEMBLY

The next step in using Merlin 128 is to assemble the source code into object code.

At the ':' prompt, type the command ASM and press RETURN. On your screen is the following:

```
ASSEMBLING


                    1   * Merlin 128 Demo
                    2             ORG   $8000
                    3   *
                    4   BSOUT     EQU   $FFD2      ;Output subroutine
                    5   BUFLEN    EQU   20         ;Length of string to print
                    6   GETIN     EQU   $FFE4      ;Get input subroutine
                    7   KEY       EQU   $EF9F      ;Keyboard scan routine
                    8   *
8000:  A2  00       9   START     LDX   #0         ;Set X to 0
8002:  BD  1D  80   10  LOOP      LDA   STRING,X   ;Get a character from STRING
8005:  20  D2  FF   11            JSR   BSOUT      ;Send it to the screen
8008:  E8           12            INX              ;Increment X
8009:  El  14       13            CPX   BUFLEN     ;Compare X to value in BUFLEN
800B:  D0  F5       14            BNE   LOOP       ;If not equal, go back to LOOP
800D:  20  9F  FF   15  SCAN      JSR   KEY        ;Scan the keyboard
8010:  20  E4  FF   16            JSR   GETIN      ;Any input?
8013:  F0  F8       17            BEQ   SCAN       ;If not, go back to SCAN
8015:  C9  0D       18            CMP   #$0D       ;Was Return pressed?
8017:  F0  03       19            BEQ   DONE       ;If so, go to DONE
8019:  4C  0D  80   20            JMP   SCAN       ;If not, go back to SCAN
801C:  60           21  DONE      RTS              ;All done
801D:  70  52  45   22  STRING    TXT   'Press Return to Exit'
8020:  53  53  20   72  45  54  55  52
8028:  4E  20  54   4F  20  65  58  49
8030:  54

--End Merlin 128 assembly, 49 bytes, Errors: 0
```

```
Symbol Table - alphabetical order:
BSOUT     =$FFD2    BUFLEN    =$14      DONE   =$801C    GETIN  =$FFE4
KEY       =$FF9F    LOOP      =$8002    SCAN   =$800D    ?START=$8000
STRING    =$801D


Symbol table - numerical order:

BUFLEN    =$14   ?  START     =$8000    LOOP   =$8002    SCAN  --$800D
DONE      =$801C    STRING    =$801D    KEY    =$FF9F    BSOUT =$FFD2
GETIN     =$FFE4
```

If instead of completing the above listing, the screen displays an error message, note the line number referenced in the message, and press RETURN until the "--END ASSEMBLY..." message appears. Then refer back to the first section where the program was first entered and compare the listing with Step 12. Look especially for elements in incorrect fields. Using the editing functions you've learned, change any lines in your listing which do not look like those in the listing in step 12, then, from the ':' prompt, type ASM and press RETURN to re-assemble.

If all went well, to the right of the column of line numbers down the middle of the screen is the now familiar, formatted Source Code.

To the left of the line numbers, beginning on line 9, is a series of numeric and alphabetic characters. This is the Object Code, which is the opcodes and operands assembled to their machine language hexadecimal equivalents.

For example, starting on line 9, the first group of characters (8000) is the program's starting address in memory (see the definition of ORG in the Assembler Section). After the '8000:' is the number 'A2'. This is the one-byte hexadecimal code for the opcode LDX.

NOTE: the label 'START' is not assembled into object code; neither are comments, remarks, or pseudo-ops such as ORG. Such elements are only for the convenience and utility of the programmer and the use of the assembler program.

On line 11, after the '8005:' is the number '20'. This is the one-byte hexadecimal code for the opcode JSR. The next two bytes (each pair of hexadecimal digits is one byte) bear a curious resemblance to the last group of characters on line 4; have a look. In line 4 of the source code we told the assembler that the label 'BSOUT' EQUated with address $FFD2. In line 11, when the assembler encountered 'BSOUT' as the operand, it substituted the specified address. The sequence of the high and low-order bytes was reversed, turning $FFD2 into D2 EF, a 6510/8502 microprocessor convention.

The rest of the information presented should explain itself. The total errors encountered in the source code was zero, and 49 bytes of object code (count of bytes following the addresses) was generated.

SAVING AND RUNNING PROGRAMS

The final step in using Merlin 128 is running the program. It is always a good idea to save the source code and object code before testing any program. Then, if the program bombs or hangs up, you'll be able to go back to your listing without having lost your work to that point. To do this, you will have to return to the Main Menu, and use the SAVE SOURCE command. You would then follow that with an OBJECT CODE SAVE. Note that OBJECT CODE SAVE can only be done if there has been a successful assembly.

Here are the actual steps to follow:

1. With the ':' prompt, type 'Q and press RETURN. The system will quit the EDITOR mode and revert to Main Menu. If the Merlin 128 system disk is still in the drive, remove it and insert an initialized work disk.

   After the '%' prompt, type 'S' (the Main Menu SAVE SOURCE FILE command). The system is now waiting for a filename. Type 'demo1', and press RETURN. After the program has been saved, the prompt returns.

2. Type 'C' (CATALOG) and look at the disk catalog. The source code has been saved as a file titled "demo1 .s". The suffix “.s” is a file-labeling convention which indicates the subject file is source code. This suffix is automatically appended to the name by the SAVE SOURCE command.

3. Press RETURN to return to Main Menu and type '0', for OBJECT CODE SAVE. The object file should be saved under the same name as was earlier specified for the source file, so press RETURN to accept 'demo 1' as the object name. There is no danger of overwriting the source file because the suffix ".0" is appended to object code file names. Type 'C' (CATALOG) to verify that the object code has been saved as a file titled "demo 1.0". Press RETURN to return to the Main Menu.

   When looking at the Main Menu, you'll also notice that the address and length of your source code text is displayed. If you have done a successful assembly, the address and length of the assembled object code is also displayed. If the object code information is NOT DISPLAYED, Merlin 128 will not let you save an object file to disk. The object code save is disabled whenever an error has occurred during an assembly, you have made a change to the source code and not yet re-assembled it, or the source code is either too big to fit or not allowed in the space you have specified for the assembly. See the sections on ORG, OBJ and Memory Allocation if this latter problem occurs.

Next type 'G' (GO) to run a program. At the prompt, type 'demo1'. The demonstration program puts the message 'Press Return to Exit' on the screen. It works!

Now you can return to the Main Menu by pressing RETURN. (All assembly language programs that end in an RTS, and that are run using Merlin 128's 'G' command in the Main Menu will return to the Main Menu when done.)

MAKING BACK-UP COPIES OF MERLIN 128

The Merlin 128 diskette is unprotected and copies may be made using any copy utility. The Merlin 128 diskette has a copy program on it. The COPY program must be run from BASIC. From the Main Menu, type 'B' to quit to BASIC, then type RUN "COPY".

It is highly recommended that you use *only* the BACK-UP copy of Merlin 128 in your daily work, and keep the original in a safe place.

PERSONALIZING MERLIN 128

Certain aspects of Merlin 128, such as the background, border and character colors, the printer line width, default tab positions for the fields in the source listing, etc. can be customized by changing the file PARMS.S on the Merlin 128 disk, and reassembling the PARMS.O file. If you would like to change any of these defaults of Merlin 128, see the section on Configuration in the Technical Information section of this manual for details on making the changes. For now, though, we recommend you leave well enough alone until you're more familiar with Merlin 128.

THE REST OF THIS MANUAL...

The preceding section was a simple look at how to enter, assemble and then save a Merlin 128 program.

The remainder of this manual is an encyclopedic reference of the various commands that are available within Merlin 128 to make writing an assembly language program easier. Remember that the commands and directives available within Merlin 128 are merely the building blocks from which you can create your own programs. It is up to you to decide when and where they are to be used.

The manual describes the following aspects of Merlin 128:

1) The Main Menu: This level of Merlin 128 is used for loading and saving files, disk operations, and entering the Editor/Assembler.

2) The Editor: This section describes the functions available for creating and editing a source listing for an assembly language program.

3) The Assembler: This section covers assembler directives within Merlin 128. Remember that these are not editing or direct user commands, but rather, text commands included within a source listing to tell the assembler to do something special while your program is being assembled. This might include using a Macro definition, writing a file to disk, or other functions.

4) Supplemental Sections: There are a number of additional sections in this manual that describe the use of Macros, the Relocating Linker, Error Messages, Sourceror and other Utilities, and many other aspects of Merlin 128's operation. These can be consulted as necessary.

THE MAIN MENU

The Main Menu is used for file maintenance operations such as loading or saving code or cataloging the disk. The following sections summarize each command available in this mode.

C (CATALOG)

When you press "C"**,** the CATALOG of the current diskette will be shown. The Main Menu prompt (%) appears. This permits you to give another Main Menu command such as ‘L’ to LOAD SOURCE while the catalog is still on the screen. If you do not want to give a command, just press RETURN. Press the space bar to pause the catalog process, and any other key to resume. Press the Run/Stop key (or Control-C) to abort the catalog.

L (LOAD SOURCE)

This is used to load a source file from disk. You will be prompted for the name of the file. You should not append ".s" since Merlin 128 does this automatically. If you have pressed ‘L’ by mistake, just press Run/Stop/Restore and the command will be cancelled without effecting any file that may be in memory.

After a LOAD SOURCE (or APPEND SOURCE) command, you are automatically placed in the editor mode, just as if you had pressed 'E'. The source will automatically be loaded to the correct address. Subsequent LOAD SOURCE or SAVE SOURCE commands will display the last used filename. If a source file had already been loaded, the cursor will be flashing under the first character of the filename. If you press RETURN, the current filename will be used for the command. If you wish to load a different filename, type the filename and press RETURN.

S (SAVE SOURCE)

Use this to save a source file to disk. As in the load command, you do not include the suffix ".s" and you can press Run/Stop/Restore to cancel the command. NOTE: the address and length of the source file are shown on the MENU, and are for information only. You should not use these for saving; the assembler remembers them better than you can and sends them automatically. As in the LOAD SOURCE command above, the last loaded or saved filename will be displayed and you may press RETURN to save the same filename, or enter another filename.

NOTE: when a SAVE or WRITE is done from the Main Menu, or when the SAV opcode is used in the source code, an error will result if the file already exists on the diskette. This can be avoided by preceding the filename with '@:' or '@0:'. The new file is saved before the old file is scratched, thus there must be enough room on the diskette for the new file.

This syntax may also be used for a LOAD but it has no effect other than to make the '@:'a part of the default filename.

A (APPEND FILE)

This loads in a specified source file and places it at the end of the file currently in memory. It operates in the same way as the LOAD SOURCE command, and does not affect the default file name. It does not save the appended file; you are free to do that if you wish.

N **(NEW SOURCE)**

This command, after confirming your intention, deletes the current source file from memory. This is handy when used prior to a READ command, since READ always appends the file to the existing source code, if any.

R (READ TEXT FILE)

This command reads text files into Merlin 128. They are always appended to the current buffer. To clear the buffer and start fresh, use the NEW SOURCE command. If no file is in memory, the name given will become the default filename. Appended reads will not do this.

When the read is complete, you are placed in the editor. If the file contains lines longer than 255 characters, these will be divided into two or more lines by the READ command. The file will be read only until it reaches HIMEM, and will produce a memory error if it goes beyond. Only the data read to that point will remain.

The READ TEXT FILE and WRITE TEXT FILE commands are used to LOAD or CREATE "PUT" files, or to access files from other assemblers or text editors.

W (WRITE TEXT FILE)

This writes a Merlin 128 file into a text file instead of a binary file. The WRITE command does not delete or scratch first. See the CAUTION in the SAVE command regarding the '@:' syntax.

D (DRIVE CHANGE)

When you press ‘D’**,** the ‘New Drive #’ prompt will appear. Enter the desired number. The currently selected drive number is shown on the Main Menu. When Merlin 128 is first booted, the selected drive will be the on used by the boot.

E (ENTER EDITOR/ASSEMBLER)

This command places you in the Editor/Assembler mode. It automatically sets the default tabs for the editor to those appropriate for source files. If you wish to use the editor to edit an ordinary text file, you can type TABS from the colon prompt (:) in the Editor to zero all tabs.

0 (SAVE OBJECT CODE)

This command is valid only after the successful assembly of a source file. In this case you will see the address and length of the object code on the menu. As with the source address, this is given for information only.

NOTE: the object address shown is that of the program's ORG (or $8000 by default) and not that of the actual current location of the assembled code (which is ordinarily $AOOO in bank 1).

When using this command, you are asked for a name for the object file. A '.o' suffix will be automatically appended to this filename. Thus, you can safely use the same name as that of the source file.

When this object code is saved to the disk, its address will be the correct one, the one shown on the Main Menu. When later you LOAD it, the file will load at that address, which can be anything ($lC00,$8000, etc).

G (RUN PROGRAM)

This command will LOAD and EXECUTE the specified object file. It will not run a BASIC program. The specified object file must have a '.o' suffix. It is not necessary to include the suffix when entering the filename. Therefore, pressing 'G' and entering 'filename' and pressing RETURN will LOAD and EXECUTE the object file called 'filename.o'.

The 'G' command will run a program anywhere in RAM 0. It enters with the RAMHALF configuration unless the program extends to $C000 or beyond. The program will be in conflict with Merlin 128 if the load address is between $1C00 and $6FFF. In this case, Merlin 128 will move itself into RAM 1 at $A000 and place a small interface routine at $800 before loading your program. When your program does an RTS, Merlin 128 will move itself back. You can also return to Merlin 128 with a JMP $800. While Merlin 128 is moved to $A000, pressing Reset will cause a reboot.

X (DISK COMMAND)

This sends the command to the "Error Channel. Examples of intended use are:

X then V will do a disk verify.

X then S:FILE.O will scratch “FILE.O”.

X then R:NEWFILE.S = OLDFILE.S will rename OLDFILE.S.

NOTE: the **.S** or **.O**, if any, must be entered here, and that quotes should not be used. Also, to prevent unintentional initialization, the N (New) command is not supported.

M (MONITOR)

This command uses the CBM monitor program. You can use all of the standard CBM Monitor features. Press ‘X’ to return to the Merlin 128 Main Menu. This command should not be confused with the MON command in the Merlin 128 Editor.

B (BASIC)

After confirming your intention to quit, this command exits Merlin 128 and goes to BASIC. Merlin 128 moves itself to $A000 in RAM 1. The default Function Key definitions are reinstated except for the F4 key, which becomes a Return to Merlin 128' (SYS 2048) command.

Pressing F4 to re-enter Merlin 128 is provided for safety. In fact, the source file, if any, may still be intact. It is possible, however, that a BASIC program could overwrite the re-entry routine at $800. Therefore, the F4 method of returning to should be used with caution. The recommended re-entry method is to press the Reset button to reboot.

Note: When inside Merlin 128 pressing the Reset button initializes the I/O devices and returns to the Main Menu. It does not go to BASIC or reboot.

THE EDITOR

Basically there are two modes in the Editor: the Immediate Mode and the full screen Editing Mode, which includes Adding or Inserting new lines of text.

When you first go to the Editor from the Main Menu, you will be in the Immediate Mode, which is indicated by the colon (":") prompt. No actual editing is done at this level. Rather, you can either type a command which will start up the full screen editor, or you may use a number of specific Immediate Mode commands, which are of a general utility nature, such as to print a listing, assemble a file, convert number types, etc.

When you type an editing command such as A (to Add), etc. from the Immediate Mode, the color prompt will disappear and the screen display will change to the full screen editor, but more on that in a moment.

ABOUT THE EDITOR DOCUMENTATION

For each of the commands available in the Merlin 128 Editor, the documentation consists of three basic parts:

1) the name and syntax of the command,
2) examples of the use of each available syntax,
3) a description of the function of each command.

When the syntax for each command is given:

PARENTHESES () indicate a required value,
ANGLE BRACKETS <> indicate an optional value or character.
SQUARE BRACKETS [] are used to enclose comments about the command.

THE IMMEDIATE MODE

GENERAL GUIDELINES FOR THE IMMEDIATE MODE

For most of the Immediate Mode commands, only the first letter of the command is required, the rest being optional. This manual will show the required command characters in UPPER case and the optional ones in lower case.

Line Numbers in Immediate Mode

With some commands, you must specify a line number, a range of line numbers, or a range list. A line number is just a number. A range is a pair of line numbers separated by a comma. A range list consists of several ranges separated by a slash (“/”).

Line Number examples:

10	LINE #	[a single line number]
10,30	RANGE	[the range of lines 10 to 30]
10,30/50,60	RANGE LIST	[ranges 10 to 30 AND 50 to 60]

If a line number in a range exceeds the number of the last line in the source, the editor automatically adjusts the specified line to the last line number. For example, if you wanted to Delete all the lines past 100 in a source listing, D100,9999 would probably do it!

Delimited Strings (or d-strings)

Several commands allow specification of a string. The string must be "delimited" by a non-numeric character other than the slash or comma. Such a delimited string is called a d-string. The usual delimiter is single or double quote marks (' or").

Delimited string examples:

```
'this is a delimited string'
"this is a delimited string" @this is another d-string@
```

Note that the slash"/" cannot be used as a delimiter since it is the character that delimits range lists in the editor.

Wild Card Characters in Delimited Strings

For all of the commands that use delimited strings (d-strings), the **“^”** character acts as a wild card character. Therefore, the d-string “Jon^s” is equivalent to the d-string "Jones" as well as "Jonas".

Upper and Lower Case Control

The shift and caps lock keys work as you would expect. while editing or entering a line of text, there are also special upper/lower case commands available, as will be described later.

ADD/INSERT COMMANDS

Following are the commands recognized by Merlin 128 in the Immediate Mode of the Editor. The Immediate Mode is indicated by the colon prompt (:).

Add/Insert a Line

When you first start a listing, the Add command is used to start entering lines. It can also be used later to add lines to the end of the listing. Insert is used to insert new lines in between existing lines in the source listing.

Add

```
  A                    [only option for this command]
```

The Add command places you in the Full Screen Editor at the end of the existing source listing (if any). Adding lines is much like entering additional BASIC lines with auto line numbering. To exit from ADD mode (actually to exit the Full Screen Editor), press **C=** and ←.

You may enter an *empty* line by pressing RETURN. This is useful for visually blocking off different parts of a listing.

Insert

```
Insert (line number)
  I 20                    [inserts lines "above" line 20]
```

This allows you to enter text just above the specified line. Otherwise, it functions the same as the Add command.

EDITING AN EXISTING LINE IN A SOURCE LISTING...

Once a line already exists in your Source listing, you may want to edit a particular line or range of lines. This is done using the cursor control and editing commands of the Full Screen Editor, as is described shortly.

FULL SCREEN EDITOR COMMANDS

After typing E and a line number or string in the Immediate Mode of the Editor, you are placed in the Full Screen Editor. The line specified is placed at the center of the screen with the cursor on its first character.

At the upper right hand corner of the screen, the number of the line containing the cursor is printed. Somewhat to the left of this you may see a vertical bar. This bar is the End-of-Line Marker and it indicates the position at which an assembly listing will overflow the printer line. You can put characters beyond this mark, but they should be for information only, and will not be printed within a printer listing. The position of the mark is calculated using the line length parameter in the PARMS (see the Technical Information section) file. If this is very large, the mark will not be shown.

The line is tabbed as it is in the listing, and the cursor will jump across the tabs as you move it with the arrow keys.

The Edit mode commands are divided into two types: Control key commands which are line oriented, and Commodore key commands which are global. (i.e., entire listing-oriented). The control key commands edit text and move the cursor on just the line the cursor is presently on. Use the Commodore key commands to make changes to groups of lines, or to move about in the listing. All editing commands work whether the Full Screen Editor was started up using the Add, Insert or Edit commands. When you are through editing, press **C=** and ← at the same time. The line is accepted as it appears on the screen, no matter where the cursor is when you exit the Edit mode.

To get the most out of the Merlin 128 Full Screen Editor, you should keep in mind that a full screen editor is like a word processor. That is, any character you type is immediately entered into whatever line the cursor is on.

With the Merlin 128 Full Screen Editor, if you can see it on the screen, you can edit it, and moving to a line is a simple matter of using the arrow keys or other special commands to move to the part of the listing you want to edit. Just remember, when you are using the Full Screen Editor, think of yourself as using a word processor where you can freely scroll to whatever part of the page you want to edit, and the final "document" is just your source listing.

Control Key Commands (Line oriented)

Control-A (delete all)

Deletes all characters from the cursor to the end of the line.

Control-B (beginning of line)

Moves the cursor to the beginning of the line.

Control-D (delete)

Deletes the character under the cursor. (See also the DElete key)

Control-E (memory status)

This command displays a status box showing the number free and used bytes, and the length of the clipboard, if any.

Control-F (find)

Finds the next occurrence of the character typed after the CTRL-F. The cursor changes to an inverse 'F' to indicate the Find Mode. To move the cursor to the next occurrence on the line, press the character key again.

Control-I (toggle cursor)

Toggles the cursor mode between the insert cursor (inverse 'I') and overstrike cursor (inverse block). The insert mode of the cursor should not be confused with entering the Full Screen Editor using the Add and Insert commands. The cursor can be in the insert mode regardless of whether lines are being added or inserted. The insert mode of the cursor refers only to whether individual characters are being inserted (inverse 'I' cursor) or typed over (inverse block).

The character insert mode defaults to ON upon entry. When you change it with the TAB, INST, or Control-I, it remains that way until changed again. Thus, moving from one line to another has no effect on this status.

The status is indicated by the type of cursor displayed. It is an inverse 'I' when insert mode is active, and an inverse block when the overstrike mode is active. (The cursor is an inverse 'F' when you are in find mode.)

Control-K (character case change)

This command changes the case of the character under the cursor.

Control-L (lower case convert)

Ordinarily, unless the cursor is in a comment or an ASCII string, lower case characters will be converted to UPPER CASE characters. This is also defeated when the tabs are zeroed. To override this conversion, or to reinstate it, just use the Control-L command. This conversion is also in effect when you use the **C= F**, **C= W**, or **C= L** find commands to specify the text to find.

Control-N (end of line)

Moves the cursor to the end of the line.

Control-O (other characters)

This key is used as a special 'prefix' key That is, if you wanted to type a Control-N, for example, as part of a line, the Editor would treat the Control-N as a command key, rather than entering it on the line you were editing. Likewise, you might want to type the ESCAPE key as part of a PRTR initialization string. To enter any character on a line, just press Control-O first, then immediately follow with your desired control character. The control character will appear either in inverse, or for ESCAPE and certain other keys, as a Commodore graphics character. For multiple control characters, Control-O will have to be typed once each time before each character is entered.

Control-R (restore)

This command restores the original line. For example, if you have used CTRL-A to delete all characters to the end of the line, you can press CTRL-R to undo the effects of the CTRL-A command.

Control-W (find word)

This command jumps the cursor to the next occurrence of a word in the line (alphanumeric).

Control-X (cancel global exchange)

This command can be used to cancel any global exchange while it is in progress.

Cursor keys

The cursor (4-directional) keys move the cursor in the specified direction.

DEL (delete key)

Deletes the character to the *left* of the cursor. (See also Control-D).

ESC (Escape key)

This command moves the cursor to the beginning of the next line. This is similar to Return except that ESCape does not insert a blank line.

HOME (Home key)

Pressing the Home key on any line causes that line number to be remembered when the **C= HOME** command is used.

INST (toggle cursor)

Toggles the cursor mode between the insert cursor (inverse **'I'**) and overstrike cursor (inverse block).

Moving from one line to another has no effect on the status of the cursor; it only changes when toggled with CTRL-I, INST or TAB.

RETURN

Pressing Return anywhere in the line causes the cursor to move to the beginning of the next line and insert a blank line.

TAB

Toggles the cursor mode between the insert cursor (inverse 'I') and overstrike cursor (inverse block).

Moving from one line to another has no effect on the status of the cursor; it only changes when toggled with CTRL-I, INST or TAB.

Commodore Key Commands (Entire listing oriented)

In addition to the line-oriented commands (control key commands), the Full Screen Editor uses Commodore key commands to move within the listing, and to edit entire lines of text. These commands are as follows:

C= A (select all text)

This command selects all text to be cut from the current line to the end of the listing. **C= C** will then copy the selected text, (**C= X** will cut the text), while pressing any other key will cancel the selection.

This technique can be used to move the entire listing to the clipboard.

C= B (beginning of source)

This command moves to the beginning of the source listing and places the cursor on the eleventh line.

C= C (copy)

C= C starts the select mode to “cut” or “copy” text. The first time **C= C** is pressed, the current line is selected and is shown in inverse. Use the down cursor or **ESC**ape keys to extend the selection if desired, or press any other key to cancel the selection. Additional selected lines are shown in inverse. Use the up arrow key to adjust the range selected if you go too far, however, the select mode will be canceled if you move the cursor above the first selected line or past the top of the screen.

The second time **C= C** is pressed, or if **C= A** has already been pressed, a copy is made of the selected text from the listing and is placed on the clipboard. If you want to cut the text from the listing, type **C= X**. The selected lines will disappear from the screen and are placed on the clipboard.

If you are unfamiliar with the idea of a "clipboard", this is just an analogy to how you might put piece of paper clipped from a magazine, letter, etc. on a clipboard, to hold it temporarily while you were getting ready to put it in its final location. In the Commodore 128, the clipboard just refers to a memory buffer that holds the text you have selected while you decide where you want the final text placed.

C= D (delete current line)

This command deletes the current line (**C= DEL** will delete the line *above* the cursor) and places it in a special 'undo' buffer which is independent of the clipboard.

The **C= R** command exchanges the current line with the contents of the 'undo' buffer. Therefore, to move a single line to another location, you could place the cursor on the line to be moved, and then type **C= D** to delete the line. Then move the cursor to another line, press RETURN, **C= I**, or **C= TAB** to create an empty line, and press **C= R** to replace that line with the deleted line.

C= E (global exchange) (also called 'Find & Replace')

Sometimes called 'Find & Replace', this command will let you search for a group of words, and replace them with another. The **C= E** command opens a dialog box that asks for the text to change, and the new text to replace it. If you press RETURN alone (a blank entry) for either of these, the command is aborted.

If you enter the text in both fields and press RETURN, the file is then searched for the change text. Unlike the FIND command, it looks only for full words. That is, the text found must be bounded by non-alphanumeric characters or it will be ignored.

If text is found with this method, the screen is reprinted with the replacement made and the cursor is placed on the first character of the replacement. Now you must press a key to continue. Pressing RETURN (or most any other control character) will defeat the change and the routine will look for the next occurrence of the text to change. Pressing the space bar or any other character (except 'A') will accept the change and the routine will continue.

You can back out of the global exchange while the cursor is on an entry by pressing either **ESC**ape or Control-**X**. You can also type the 'A' key, which will cause *all* occurrences to be changed. Caution: this can be aborted only by RUN/STOP or RESET.

You can tell when the routine is finished by the fact that during the exchange sequence, the line number at the top right is missing. It will return when there are no more matches for the change text, or when you press **ESC**ape or Control-**X**.

C= F (find text)

The **C= F** command opens a window which asks for the find text. It then finds the first occurrence of the text in the entire text file. The text can be anywhere on a line. After the first find, you can find the next occurrence by typing another **C= F**. The find mode is indicated by the inverse 'F' at the top right of the screen. You can edit the line and then type **C= F** to go to the next occurrence.

If there are more occurrences to be found, one or more '+' signs will be shown next to the line number at the top right of the screen. This starts from the line below the current line, and only indicates the number of lines remaining with occurrences, and not the total number of occurrences.

If the **C= F** command is used after text has been selected, only the selected text will be searched for the text to be found. When the search has been completed, the text is no longer selected. Thus, you can use the **C= A** and **C= C** commands to search just a portion of your listing.

The **C= B** command and the Control-E status command both cancel the Find mode, as does failure to find the text below the current line.

The **C= W** command is identical to **C= F** except that it finds only whole words bounded by non-alphanumeric characters. If you type either **C= W** or **C= F** to find the next occurrence, this mode will change accordingly.

In all cases the line containing the text is moved to the center of the screen, unless it is within the first 10 lines of the start of the source.

C= H (half screen)

This command toggles the split or half screen mode. In this mode, the bottom ten lines are frozen in a window. A bar is shown above these lines to separate the frozen text from the scroll window. Pressing **C= H** again will cancel the half screen mode and refresh the screen.

C= I (insert line)

Pressing **C= I** or **C= TAB** will insert a blank line at the cursor.

C= L (locate label or line)

This command will locate the first occurrence of a label or any text in the label column. Only the characters typed are compared with the labels, so in some cases you may want to end your input with a space.

If a number is entered after this command, the cursor will move to the beginning of line number specified. This is particularly handy when editing a source file from a printed listing.

The **C= L** command asks for a label or any text to locate. It finds the first occurrence of that text in the file, but only in the label column. Only the characters typed are compared with the labels, so in some cases you may wish to end your input with a space.

The intended use for this command is to move rapidly to a particular place in the source. You can use create your own 'markers' to enhance the capability of this command. Therefore, if a line starts '*7', you can specify '*7' as the text to find for this command and it will work.

If you type a number for the label in an **C= L** command, you will be sent to that line number. This is convenient when editing a source file using a printed listing.

In all cases the line containing the text is moved to the center of the screen, unless it is within the first 10 lines of the start of the source.

C= N (end of source)

This command moves the cursor to the end of the source listing.

C= P (paste)

Pastes the contents of the clipboard at the line containing the cursor. Only full lines are moved. Using this command does not change the contents of the clipboard, so this command can be used to replicate a range of lines.

If the **C= P** paste command is issued when a range of text has been selected, the range will be replaced by the text in the clipboard. Text deleted in this manner is not recoverable.

C= Q (quit)

This command quits the Full Screen Editor and goes to the Main Menu. (Does not work in Editor Immediate Mode – use ‘Q’).

C= R (replace) (See also C= D)

This command exchanges the current line with the contents of the 'undo' buffer. Therefore, pressing **C= R** a second time will cancel the effect of the first press.

Using **C= R** when the cursor is on blank line will place the contents of the undo' buffer on the line and place the empty line in the 'undo' buffer.

The **C= R** command can be used to move a single line. Place the cursor at the beginning of the line to be moved and press **C= R**. Move the cursor to the desired location, press RETURN to insert a blank line, and press **C= R** again.

C= R can be used by itself to easily interchange two lines. Just place the cursor on the first line, press ~R, move the cursor to the second line, press **C= R** again, move the cursor back to where the first line was and press **C= R** for the third, and final, time.

C= W (find word)

The **C= W** command is identical to **C= F** except that it finds only whole words bounded by non- alphanumeric characters. If you type either **C= W** or **C= F** to find the next occurrence, this mode will change accordingly.

If the **C= W** command is used after text has been selected, only the selected text will be searched for the word to be found. When the search has been completed, the text is no longer selected.

C= X (cut highlighted text)

Similar to **C= C,** but selected text is removed from the screen after being copied to the clipboard. This is in contrast to **C= C** which leaves the original text on the screen after copying to the clipboard. One use of this command is to use **£**B, then **C= A** to select everything from the beginning of the file to the end. **C= X** will then cut it; anything else will cancel the select mode. This provides a simple means of moving the entire file to the clipboard.

C= Z (reprint screen)

This command reprints the screen so that the current line becomes the eleventh line on the screen.

C= Up cursor (move up one page)

Moves the cursor up one page. The **C= Up** cursor and **C= Down** cursor commands move up or down one page at a time. This is approximately equivalent to two **C= Left** or **C= Right** cursor commands.

C= Down cursor (move down one page)

Moves the cursor down one page.

C= Left cursor (move half-screen up)

Moves the cursor up 10 lines; that line then becomes the eleventh line on the screen. This command has the effect of moving the current line to the bottom of the screen and then moving the cursor to what was the 1st line on the screen.

C= Right cursor (move half-screen down)

Moves the cursor down 10 lines; that line then becomes the eleventh line on the screen. This command has the effect of moving the current line to the top of the screen and then moving the cursor to what was the bottom line on the screen.

C= * (asterisk)

Produces a line of 32 asterisks.

C= ↑ (Vertical arrow)

Produces an asterisk, 30 spaces, and then another asterisk. This and the **C=** * command can be used to produce a large box for titles and other information.

C= - (hyphen)

Produces a line of 1 asterisk and 31 hyphens.

C= (equal sign)

Produces a line of 1 asterisk and 31 equal signs.

C= ←(Horizontal arrow)

Quits the Full Screen Editor to the Editor Immediate Mode. The colon prompt (:) appears at the bottom of the screen to indicate that the Editor is now in the Immediate Mode.

C= DEL (delete)

This command deletes the line *above the cursor* and places it in a special 'undo' buffer which is independent of the clipboard.

The **C= R** command replaces the current line with the contents of the 'undo' buffer. Therefore, you could use **C= DEL** to delete a line, move the cursor to another line, press RETURN, **C= I**, or **C= TAB** to insert a line, and press **C= R** to replace that line with the deleted line.

C= HOME

Go to the line used for the last CTRL-HOME.

C= TAB (insert line)

Pressing **C= TAB** or **C= I** will insert a blank line at the cursor.

The Editor's Handling of Strings and Comments with Spaces

When entering strings or comments in the Add/Insert or Edit modes, you will sometimes find the editor apparently inserting additional spaces. This is only a display function, however, and the editor will remove the added spaces when the line is terminated.

In the case of ASCII strings, the restoration is only done when the delimiter is a quote (")or a single quote ('). You can, however, accomplish the same thing by editing the line, replacing the first delimiter with a quote, pressing the down arrow once, then press the up arrow once. The spaces will be removed and then you can then edit the line and change the delimiter back to the desired one.

Another approach, especially where an exact number of spaces or other exact formatting of the text is necessary, is to turn off the tab formatting by typing 'TABS' in the Immediate mode. This will stop all automatic tabbing by the Editor. Tabs are automatically restored by going to the Main Menu, and then returning to the Editor.

EDITOR COMMAND SUMMARY

CONTROL KEY COMMANDS (line oriented)

The Control Key commands consist of cursor moves and line oriented commands.

Control-A	-----------	Deletes characters to end of line
Control-B	-----------	Moves cursor to beginning of line
Control-D	-----------	Deletes character under the cursor
Control-E	-----------	Displays memory status window
Control-F	-----------	Finds next occurrence of next character typed
Control-I	-----------	Toggles insert and overstrike cursor
Control-L	-----------	Toggles lower case conversion
Control-K	-----------	Changes case of character under cursor
Control-N	-----------	Moves cursor to end of line
Control-O	-----------	Prefix key for typing control characters
Control-R	-----------	Retrieves original line
Control-W	-----------	Finds next occurrence of word in line
Control-X	-----------	Cancels global exchange while in progress
Cursor keys	-----------	Moves the cursor
DEL	----------------	Deletes character to left of cursor
ESC	----------------	Moves cursor to beginning of next line
HOME	----------------	Remembers line for recall by **C=** HOME
INST	----------------	Toggles insert and overstrike cursor
RETURN	-----------	Moves cursor down and inserts blank line
TAB	----------------	Toggles insert and overstrike cursor

COMMODORE KEY COMMANDS (entire listing oriented)

The Commodore Key commands are global commands, which means they are generally oriented to the whole listing as opposed to just the current line (or a single character).

C=A	-----------------	Selects text for cut from line to end of file
C=B	-----------------	Moves to beginning. Cursor on eleventh line
C=C	-----------------	Start text selection/Copy selected text to clipboard
C=D	-----------------	Deletes line and places it in 'undo' buffer
C=E	-----------------	Global exchange (Search & Replace)
C=F	-----------------	Finds next occurrence of text entered
C=H	-----------------	Toggles half-screen mode
C=I	-----------------	Inserts blank line at cursor
C=L	-----------------	Finds first occurrence of label or line
C=N	-----------------	Moves cursor to end of listing
C=P	-----------------	Pastes contents of clipboard on current line

C= Q	-----------------	Quits editor and returns to Main Menu
C= R	-----------------	Exchanges current line with 'undo buffer
C= W	-----------------	Finds next occurrence of whole word
C= X	-----------------	Cut selected text to clipboard
C= Z	-----------------	Current line becomes eleventh line on screen
C= Up	-----------------	Moves cursor up one page
C= Down	-----------	Moves cursor down on page
C= Left	-----------	Moves cursor up 10 lines
C= Right	-----------	Moves cursor down 10 lines
C= DEL	-----------	Deletes line *above* cursor; puts in ‘undo’ buffer
C= HOME	-----------	Goes to line of last CTRL-HOME
C= TAB	-----------	Inserts a blank line at cursor
C= ↑	-----------------	Produces 1 *, 30 spaces, and 1 *
C= *	-----------------	Produces a line of 32 asterisks
C= -	-----------------	Produces a line of 1 * and 31 hyphens
C= =	-----------------	Produces a line of 1 * and 31 equal signs
C= ←	-----------------	Returns editor to Immediate Mode

GENERAL REMARKS

When you move the cursor between lines, its horizontal position will jump around. This is because it is based on the actual position in the line and not on the screen position. If the tabs are zeroed you will not notice this, except for the fact that the cursor is never beyond the last character in the line.

The maximum line length is 80 characters. Lines longer than that will be truncated IF they are edited.

You must return to the Immediate Mode (**C=** ←) in order to use the ASM command to assemble, MON to use the Merlin 128 Monitor, or to Quit and go to the Main Menu, etc. An assembly will delete the contents of the clipboard.

ALTKEYS AND KEYDEFS

ALTKEYS and KEYDEFS are source files that contain the ALT key macros and the Function Key definitions used by Merlin 128. You can add your own macros or definitions or edit the existing ones. Both of these programs discussed in detail, including command charts, in the section called Utilities.

OOPS

Virtually any editor action can he undone. You should remember that the proper undo command is of the same 'type' as the command you want to undo. Thus, any Control key command is undone by Control-R. This includes the **C= ***, **C= -**, and **C= =** commands which are considered line oriented commands for this purpose.

The line deletion commands **C= D** and **C= DEL** are undone by creating an empty line with **C= TAB** followed by **C= R**. If you forget to create the empty line, type another **C= R** and repeat the above procedure.

The **C= R** command undoes itself.

A CUT **(C= X)** is undone by a PASTE (**C= P**) without moving the cursor off its line.

If you are entering a line of text in response to a prompt, such as a filename, PRTR initialization, or dialog box, you can press Control-C or Control-X to cancel the line.

MORE IMMEDIATE MODE COMMANDS

Merlin 128 also has Immediate Mode Find and Change commands to allow you to list all lines that have a certain opcode, label, etc. in them (Find); or to change all or some occurrences of a certain label or opcode to something different (Change).

F (Find)

Find (d-string)
Find (line number) <d-string>
Find (range) <d-string>
Find (range list) <d-string>

F "A String"	[finds lines with "A String"]
F 10 "STRING"	[finds "STRING" if in line 10]
F 10,20 "HI"	[finds lines in range of 10 through 20 that contain "HI"]
F 10,20/50,99 "HI"	[finds lines that contain "HI" in range of 10 through 20 and 50 through 99]

This command lists those lines containing the specified string. It is aborted with CTRL-C or '/' key.

FW (Find Word)

FW (d-string)
FW (line number) <d-string>
FW (range) <d-string>
FW (range list) <d-string>

FW "LABEL"	[find all lines with "LABEL"]
FW 20 "LABEL"	[trytofind"LABEL"in20]
FW 20,30 "PTR"	[find all lines between 20 and 30 that contain "PTR"]
FW 20,30/50,99 "PTR"	[find all lines between 20 and 30 and between 50 and 99 that contain the word "PTR"]

This is an alternative to the FIND command. It will find the specified word only if it is surrounded, in source, by non-alphanumeric characters.

Therefore, FW "CAT" will find:

```
CAT
CAT-1
(CAT,X)
```

but will not find CATALOG or SCAT.

C (Change)

Change (d-string d-string)
Change (line number) <d-string d-string>
Change (range) <d-string d-string>
Change (range list) <d-string d-string>

C "hello"goodby	[finds "hello" and if told to do so will change it to "goodbye"]
C 50 "hello"bye	[changes in line 50 only]
C 50,100 "Hello"BYE	[changes lines 50 through 100]
C 50,60/65,66 "AND"OR	[changes in lines 50 through 60 and lines 65 and 66]

This changes occurrences of the first string to the second string. The strings must have the same delimiters. For example, to change occurrences of "speling" to "spelling" throughout the range 20,100, you would type C 20,100 "speling"spelling. If no range is specified the entire source file is used.

Before the change operation begins, you are asked whether you want to change "all" or "some". If you select "some" by hitting the "S" key, the editor stops whenever the first string is found and displays the line as it would appear with the change.

If you then press the "Y" key, the change will be made. If you press RETURN, the change will not be made. Typing any control character such as ESCAPE, RETURN or any others will result in the change not being made. Any other key, such as "Y" (or even "N") will accept the change. CTRL-C or"/" key will abort the change process.

CW (Change word)

Change (d-string d-string)
Change (line numbers) <d-string d-string>
Change (range) <d-string d-string>
Change (range list) <d-string d-string>

CW "FTR"PRT	[change all "FTR"s to "PRT"s]
CW 20 "PTR"PRT	[as above but only in line 20]
CW 20,30 "PTR"PRT	[do the same as the above but for lines 20 through 30]
CW 1,9/20,30 "PTR"PRT	[same as above but include lines 1 through 9 in the range]

This works similar to the CHANGE command with the added features as described under EW.

D (Delete)

```
Delete (line number)
Delete (range)
Delete (range list)
     D 10                    [deletes line number 10]
     D 10,32                 [deletes lines 10 through 32]
     D 20,30/10,12           [deletes ranges of lines 10 through 12 and 20 through30]
```

This deletes the specified lines. Since, unlike BASIC, the line numbers are fictitious, they change with any insertion or deletion. **Therefore, when deleting several blocks of lines at the same time, you MUST specify the higher range first for the correct lines to be deleted!**

COPY

```
COPY (line number) TO (line number)
COPY (range) TO (line number)
     COPY 10 TO 20           [copies line 10 to just before line 20]
     COPY 10,20 TO 30        [copies lines 10 through 20 to just before line 30]
```

This copies the line number or range to just ‘above’ the specified number. It does not delete anything.

MOVE

```
MOVE (line number) TO (line number)
MOVE (range) TO (line number)
     MOVE 10 TO 20           [Move line 10 to just before 20]
     MOVE 10,20 TO 30        [Move lines 10 through 20 to just before line 30]
```

This is the same as COPY but after copying, automatically deletes the original range. You always end up with the same lines as before, but in a different order.

L (List)

List
List (line number)
List (range)
List (range list)

L	[list entire file]
L20	[list line 20 only]
L 20,30	[list 20 through 30]
L 20,30/40,42	[list 20 through 30 and then list lines 40 through 42]

Lists the source file with line numbers. Control characters in source are shown in inverse, unless the listing is being sent to a printer or other nonstandard output device.

The listing can be aborted by RUN/STOP, CTRL-C or with “/” key. You may stop the listing by pressing the space bar and then advance a line at a time by pressing the space bar again. By holding down the space bar, the auto-repeat feature of the Commodore 128 will result in a slow listing. Any other key will resume the normal speed. This space bar technique also works during assembly and the symbol table printout. Any other key will restart it. This space bar pause also works during assembly and the symbol table print out.

. [period]
[only option for this command]

Lists starting from the beginning of the last specified range. For example, if you type "Li 0,100", lines 10 to 100 will be listed. If you then use".", listing will start again at 10 and continue until stopped (the end of the range is not remembered).

/

/ <line number>

/	[start to list at last line listed]
/50	[start listing at line 50]

This command continues the listing from the last line number listed, or, when a line number is specified, from that line. This listing continues to the end of the file or until it is stopped as in LIST.

OTHER IMMEDIATE MODE COMMANDS

TYPE (Type)

TYPE: FILENAME	[display contents of a text file with line numbers]
TYPE1: FILENAME	[display contents of a text file without line numbers]

This command will display the contents of any text file without loading it into memory. This is handy for viewing another source file without destroying the one in memory. It works with both SEQ and PRG source files, but with a PRG file, the '.S' suffix must be included. Do not use this command on files which are not text files.

This command lists the full file. The listing can be paused by pressing the space bar, or aborted by pressing RUN/STOP or the '/' key.

P (Print)

Print
Print (line number)
Print (range)
Print (range list)

P	[print entire file]
P50	[print line 50 only]
P50,100	[print lines 50 through 100]
Pl,l0/20,30	[print 1 through 10, then print lines 20 through 30]

This is the same as LIST except that line numbers are not added.

PRTR (Printer)

PRTR (command)

PRTR 2	[activate printer 4n slot 1 with no printer string]
PRTR 2 "<CTRL-I>80N"	[as above, but add Control-I80N to initialize the printer]
PRTR 2 ""Page Title"	[printer in slot 1, no init string, “Page Title” is the page header]
PRTR	[send formatted listing to screen]

This command is for sending a listing to a printer with page headers and provision for page boundary skips. (See the section on Configuration for details on setting up default parameters, also "TTL" in the Assembler Section).

The entire syntax of this command is:

```
PRTR slot# " (string) "<page header>"
```

If the page header is omitted, the header will consist of page numbers only.

The initialization string may not be omitted if a page header is to be used. If no special string is required by the printer, use a null string of two quotes only, as in the example showing "Page Title" (in which case a carriage return will be used).

No output is sent to the printer until a LIST, PRINT, or ASM command is issued.

TEXT

TEXT	[only option for this command]

This converts *all* spaces in a source file to inverse spaces. The purpose of this is for use on word processing type "text" files so that it is not necessary to remember to zero the tabs before printing such a file. This conversion has no effect on anything except the Editor's tabulation.

FIX

FIX	[only option for this command]

This undoes the effect of TEXT. It also does a number of technical housekeeping chores. It is recommended that FIX be used on all source files from external sources that are being converted to Merlin 128 source files, after which the file should be saved.

NOTE: The TEXT and FIX routines are somewhat slow. Several minutes may be needed for their execution on large files. FIX will truncate any lines longer than 255 characters.

VAL

VAL "expression"

VAL "PTR	[return value of label "PTR" I
VAL "LABEL"	[gives the address (or value) of LABEL for the last assembly done or "unknown label" if not found.]
VAL "$1000/2"	[returns $0800]
VAL "%1000"	[returns $0008]

This will return the value of the expression as the assembler would compute it. All forms of label and literal expressions valid for the assembler are valid for this command. Note that labels will have the value given them in the most recent assembly.

Hex-Dec Conversion

128 = $0080
$80 = 128

If you type a decimal number (positive or negative) in the immediate mode, the hex equivalent is returned. If you type a hex number, prefixed by "$", the decimal equivalent is returned. All commands accept hex numbers.

GET

GET (obj adrs)

GET	[put object in RAM0 at the address specified in the source's ORG]
GET $8000	[put object at location $8000 in RAM0]

This command is used to move the object code, after an assembly, from its location in RAM1 to its ORG location in RAM0. It is only accepted if the move will not overwrite the assembler and any source file that may be in memory. If an address is specified, the object code will be moved to that location in RAM0. If the program's ORG address conflicts with Merlin 128 or a source file in memory, a "RANGE ERROR" message is displayed.

This command is supplied for convenience. The recommended method for testing a program is to save the source cede, save the object code, and then run the program from BASIC or with the 'G' command from the MAIN MENU.

NEW

NEW	[only option for this command]

Deletes the present source file in memory.

PORT

PORT (2 or 4,5,6,7)

PORT 4	[can be used to send output to printer]

Selects a printer in specified port for output, but does not format output as does PRTR.

NOTE: PORT is automatically turned off after an ASM command, but not after a LIST or PRINT command. The PORT command can be used to send an assembly listing to the printer unformatted and without page breaks. If formatting and page breaks are desired, use the PRTR command. Unless you have a specific reason for using the PORT command, PRTR is recommended instead.

USER

```
USER
USER 1              [example for use with XREF]
USER 0: FILENAME    [example for use with PRINTFILER]
```

This does a JSR to the routine at $B00. The routine at $B00 must begin with a CLD instruction.

TABS

```
TABS <number><, number><,...> <"tab character">
  TABS              [clear all tabs]
  TABS 10,20        [set tabs to 10 & 20]
  TABS 10,20""      [as above, space is tab character]
```

This sets the tabs for the editor, and has no effect on the assembler listing. Up to nine tabs are possible. The default tab character is a space, but any may be specified. The assembler regards the space as the only acceptable tab character for the separation of labels, opcodes, and operands. If you don't specify the tab character, then the last one used remains. Entering **TABS** and a **RETURN** will set all tabs to zero.

LEN (Length)

```
LEN                 [only option for this command]
```

This gives the length in bytes of the source file, and the number of bytes free.

W (Where)

```
Where (line number)
  W 50              [where is line 50 in memory]
  W0                [where is end of source file]
```

This prints in hex the location in memory of the start of the specified line. "Where 0" (or "W0") will give the location of the end of source.

MON (Monitor)

MON	[Only option with this command]

The Merlin 128 Monitor is offered as an alternative to the CBM Monitor As with the CBM Monitor, the bank is specified by the first digit of a five digit address. You can use the 'G' command to run a program in memory, but the specified registers are not picked up so this is not as useful for debugging as the CBM Monitor. A BRK will send you to the CBM Monitor. You may re-enter Merlin 128 by pressing 'Q'. This goes to the Main Menu.

Merlin 128 MONITOR COMMANDS:

Prompt = $

EXAMPLE	COMMENTS
$1000: 02 1F 2C	Note that proper entry format is byte-space-byte etc.
$1000l	Disassemble 20 lines beginning at $1000. ASCII indicated at right.
$1000ll	Disassemble 40 lines beginning at $1000. ASCII indicated at right.
Multiple l's	Continues disassembly at current address.
$l000h	Does a hex dump of 16 bytes at $1000. ASCII indicated at right.
h	Alone continues the dump from current address.
Multiple h's	Dumps multiple 16 byte blocks.
$1000, 1100h	Does a hex dump of the designated range. Note comma is used here.
$1000C= 2000,201Fm	Moves range $2000 - $201F to $1000. This supports both upward and downward moves.
$1000, 2000z	Zeros this range.
$1000C= 2000,201Fv	Compares the range $2000 - $201F with that starting at $1000 and displays contents of both when differences are found.
$1000g	Jumps to a program at $1000. Return by RTS. A BRK will also send you to the CBM Monitor.

$r	Returns to Editor.
$q	Returns to the Main Menu. This is a "safe" return even if the zero page locations have been changed.

TRON (Truncate On)

TRON [only option for this command]

When used as an Immediate command, sets a flag which, during LIST or PRINT, will suppress printing of comments that follow a semicolon. It makes reading of some source files easier.

TROF (Truncate Off)

TROF [only option for this command]

When used as an Immediate command, returns to the default condition of the truncation flag (which also happens automatically upon entry to the editor from the Main Menu or from the Assembler). All source lines when listed or printed will appear normal.

FUN (Function)

FUN (Number): Definition [temporarily redefine a function key]

This command can be used to temporarily redefine any function key from within the Editor. For example, 'FUN4:TYPE' would cause the F4 key to produce 'TYPE' when pressed. It is not possible to include a carriage return in the definition. However, you could include an extra character and then use the Monitor to change the extra character to the carriage return.

Q (Quit)

Q [only option for this command]

Exits to Main Menu.

ASSEMBLING A FILE

Once you have entered and edited your source listing, you will want to assemble it. **ASM** does that!

ASM (Assemble)

ASM	[only option for this cmd]

This passes control to the assembler, which attempts to assemble the source file.

If you wish to have a formatted printed listing of an assembly, just use the PRTR command immediately before typing in the ASM command.

Assembly may be terminated at any point by pressing RUN/STOP or Control-C.

ESC (Escape)

ESC	[only option for this command]

During the second pass of assembly, pressing the ESC key will toggle the list flag, so that the listing will either stop or resume. This is defeated if a LST opcode occurs in the source, but another ESC will reinstate it.

THE ASSEMBLER

In Merlin 128, the Editor is used to create and edit the source listing from which the final program (object code) will be assembled. The Assembler is that part of Merlin 128 which actually interprets your source code to create the final program.

The Assembler portion of Merlin 128 is distinct only in concept. In practice, both the Editor and Assembler are resident in the machine at all times, and thus both are available without having to be aware of which is in operation at any given time. This is in contrast to many other assemblers, in which the Editor and Assemblers are completely separate programs, necessitating the switching between them by loading and running independent programs, and often a requirement to save the source file to disk before an assembly can even be done.

This section of the documentation explains the syntax of those commands, or directives, that can be used in the source listing itself, and which direct Merlin 128 to perform some function while assembling the object code. These are in contrast to the Editor commands which are used to merely edit the source file.

An assembler directive is used to communicate an idea to the assembler which is more complex than that addressed by just the usual opcodes of the microprocessor itself.

For example, in the simplest assembler possible, only commands like LDA, JSR, etc. would be recognized by the assembler. However, the first time that you want to create a data table, an instruction would be required by the assembler which will define one or more bytes that are pure number values, as opposed to specific opcodes. This is allowed in virtually all assemblers by creating the assembler directive, or pseudo opcode, ‘HEX’.

Thus the assembler can create a byte of data like this:

```
1    LABEL      HEX F7      ;STORES BYTE '$F7'
```

Now, suppose that the data you wanted to store was an ASCII character string. With only the HEX directive, you'd have to look up all the ASCII character equivalents, and encode them in your program with individual **HEX** statements.

Wouldn't it be nice, though, if the assembler itself had a larger repertoire of 'new' commands (i.e. directives) that included ones for defining character strings? You bet! And Merlin 128 has a lot of them.

The simplest is **‘TXT’**, and a typical line would look like this:

```
1    LABEL      TXT  'THIS IS A TEST'   ;STORE ENTIRE CHARACTER STRING
```

When assembled, Merlin 128 would automatically do the 'look up' of the ASCII character equivalents, and store the bytes in memory at wherever that statement occurred in your program. Along with the Editor, the variety and power of assembler directives is the other biggest factor in determining the power of a given assembler. Merlin 128 is outstanding in this area with a wide complement of directives for every occasion.

This section of the documentation will explain the syntax to use in your source files for each directive, and document the features that are available to you in the assembler.

About The Assembler Documentation

The assembler documentation is broken into three main sections:

1) Preliminary Definitions,
2) Assembler Syntax Conventions,
3) Assembler Pseudo Opcode Descriptions.

The last two sections are each broken down further into the following:

Assembler Syntax Conventions:
1) Number Format
2) Source Code Format
3) Expressions Allowed by the Assembler
4) Immediate Data Syntax
5) 6502 Addressing modes

Assembler Pseudo Opcode Descriptions:
1) Assembler Directives
2) Formatting Pseudo Ops
3) String Data Pseudo Ops
4) Data and Storage Allocation Pseudo Ops
5) Miscellaneous Pseudo Ops
6) Conditional Pseudo Ops
7) Pseudo Ops for Macros
8) Variables

The Assembler Syntax Conventions illustrate the syntax of a line of assembly code, the proper method to specify numbers and data, how to construct assembler expressions and the proper syntax to use to specify the different addressing modes allowed by the 6502 microprocessor. This section should be understood prior to using the assembler, otherwise it is will be difficult to determine the acceptable methods to construct a proper expression as the operand for a pseudo op.

The Assembler Pseudo Opcode Descriptions illustrate the functions of the many Merlin 128 pseudo ops, the correct syntax to use and examples of each pseudo ops use.

PRELIMINARY DEFINITIONS

The type of operand for almost all of Merlin 128's pseudo ops and the 6502 microprocessor can be grouped into one of four categories:

1) Expressions
2) Delimited Strings (d-strings)
3) Data
4) Filenames

Expressions

Expressions are defined in the Assembler Syntax Conventions section of the manual.

Delimited Strings

Delimited Strings are defined in the Editor section of the manual, but that definition is repeated here for continuity.

Several of the Pseudo Opcodes, and some of the 6502 opcodes allow their operand to be a string. Any such string must be delimited by a non-numeric character other than the slash (/) or comma (,). Such a string is called a delimited string or "d-string". The usual delimiter is a single or double quote mark (" or ').

Examples:

```
"this is a d-string"
'this is another d-string"
@another one@
Zthis is one delimited by an upper case zZ
"A"
'A'
```

Note that delimited strings used as the object of *any* 6502 opcode *must* be enclosed in single or double quotes. If not, the assembler will interpret the d-string to be a label, expression or data instead.

Take special note that some of the pseudo ops as well as the 6502 opcodes use the delimiter to determine the hi-bit condition of the resultant string. In such cases the delimiter should be restricted to the single or double quote.

Data

Data is defined as raw hexadecimal data composed of the digits 0…9 and the letters A...F.

Filenames

Filenames are defined as the name of a file without any delimiters, e.g. no quotes surrounding the name. Source file names are suffixed with **".S",** Object files are suffixed with a **".O"**. Text files, **USE** files and **PUT** files do not have a prefix or suffix. The applicable suffix should not be used when loading or saving files.

When a filename is used in a source listing, itr must be surrounded by quotes. For example:

```
DSK "MYFILE"
SAY "MYFILE"
PUT "FILEONE"
```

ASSEMBLER SYNTAX CONVENTIONS

SOURCE CODE FORMAT

Syntax of a Source Code Line

A line of source code typically looks like:

```
LABEL   OPCODE  OPERAND   ;COMMENT
```

and a few real examples:

```
1  START   LDA  #50      ;THIS IS A COMMENT
2  *    THIS IS A COMMENT ONLY LINE
3                        ;TABBED BY EDITOR
```

A line containing only a comment can begin with **"*"** as in line 2 above. Comment lines starting with **";"**, however, are accepted and tabbed to the comment field as in 3 above. The assembler will accept an empty line in the source code and will treat it just as a SKP 1 instruction (see the section on pseudo opcodes), except that the line number will be printed.

The number of spaces separating the fields is not important, except for the editor's listing, which expects just one space.

Source Code Label Conventions

The maximum allowable LABEL length is 13 characters, but more than 8 will produce messy assembly listings. A label must begin with a character at least as large, in ASCII value, as the colon, and may not contain any characters less, in ASCII value, than the number zero. Note that periods **(.)** are not allowed in labels since the period is used to specify the logical OR in expressions. Labels are CASE SENSITIYE. Thus, these are three different labels: START, Start, start.

A line may contain a label by itself. This is equivalent to equating the label to the current value of the address counter.

Source Opcode and Pseudo Opcode Conventions

The assembler examines only the first 3 characters of the **OPCODE** (with certain exceptions such as macro calls). For example, you can use **PAGE** instead of **PAG** (because of the exception, the fourth letter should not be a D, however). The assembler listing will not be aligned with an opcode longer than five characters unless there is no operand.

Operand and Comment Length Conventions

The maximum allowable combined **OPERAND + COMMENT** length is 64 characters. You will get an **OPERAND TOO LONG** error if you use more than this. A comment line by itself is also limited to 64 characters.

NUMBER FORMAT

The assembler accepts decimal, hexadecimal, and binary numerical data. Hex numbers must be preceded by **"$"** and binary numbers by **"%"**, thus the following four numbers are all equivalent:

Dec	Hex	Binary	Binary
100	$64	%1100100	%01100100

as indicated by the last binary number, leading zeros are ignored.

Immediate Data vs. Addresses

In order to instruct the assembler to interpret a number as immediate data as opposed to an address, the number should be prefixed with a **"#"**. The **"#"** here stands for "**number**" or "**data**". For example:

```
LDA  #100          LDA  #$64          LDA  #%1100100
```

These three instructions will all LOAD the Accumulator with the number 100, decimal.

A number not preceded by "#" is interpreted as an address. Therefore:

```
LDA  1000          LDA  $3E8          LOA  %1111101000
```

are equivalent ways of loading the accumulator with the byte that resides in memory location $3E8.

Use of Decimal, Hexadecimal or Binary Numbers

We recommend that you use the number format that is appropriate for clarity. For example, the data table:

```
    DA      $1
    DA      $A
    DA      $64
    DA      $3E8
    DA      $2710
```

is a good deal more mysterious than its decimal equivalent:

```
    DA      1
    DA      10
    DA      100
    DA      1000
    DA      10000
```

Similarly,

```
     ORA    #$80
```

is less informative than

```
     ORA    #%10000000
```

which sets the hi-bit of the number in the accumulator.

EXPRESSIONS ALLOWED BY THE ASSEMBLER

To make the syntax accepted and/or required by the assembler clear, we must define what is meant by an “expression”.

Primitive Expressions

Expressions are built up from "primitive expressions" by use of arithmetic and logical operations. The primitive expressions are:

1. A label.
2. A number (either decimal, $hex, or %binary).
3. Any ASCII character preceded or enclosed by quotes or single quotes.
4. The * character (stands for the current address).

All number formats accept 16-bit data and leading zeros are never required. In case 3, the "value" of the primitive expression is just the ASCII value of the character. The high-bit will be on (value > $7F:) if a quote **(")** is used, and off (value < $80) if a single quote **(')** is used.

Arithmetic and Logical Operations in Expressions

The assembler supports the four arithmetic operations: **+, -, /** (integer division), and ***** (multiplication). It also supports the three logical operations: **! (Exclusive OR)**, **(OR)**, and & **(AND)**.

Building Expressions

Expressions are built using the primitive expressions defined above, either with or without arithmetic and/or logical operations. This means that expressions can take the form of primitives or primitives operated on by other primitives using the arithmetic and logical operators.

Some examples of legal expressions are:

#01	(primitive expression = 1)
#$20	(primitive expression = 32 dec)
LABEL	(primitive consisting of a label)
#”A”	(primitive consisting of letter "A')
*	(primitive = current value of PC)

The following are examples of more complex expressions

LABEL1-LABEL2	(LABEL1 minus LABEL2)
2*LABEL+$231	(2 times LABEL plus hex 231)
1234+%10111	(1234 plus binary 10111)
“K”-“A”+1	(ASCII "K" minus ASCII "A" plus 1)
"0"!LABEL	(ASCII "0" EOR LABEL)
LABEL&$7F	(LABEL AND hex 71)
*-2	(current address minus 2)
LABEL.%10000000	(LABEL OR binary 10000000)

Parentheses and Precedence In Expressions

Parentheses are not normally allowed in expressions. They are not used to modify the precedence of expression evaluation. All arithmetic and logical operations are evaluated left to right (2+3*5 would assemble as 25 and not 17).

Parentheses are used to retrieve a value from the memory location specified by the value of the expression within the parentheses, much like indirect addressing. This use is restricted to certain pseudo ops, however.

For example:

```
        D0   ($300)
```

will instruct the assembler to generate code if the value of memory location $300, at the time of assembly, is non-zero.

Example of Use of Assembler Expressions

The ability of the assembler to evaluate expressions such as LAB2-LAB1-1 is very useful for the following type of code:

```
COMPARE     LDX   #EODATA-DATA- 1
LOOP        CMP   DATA, X         ;found
            BEQ   FOUND
            DEX
            BPL   LOOP
            JMP   REJECT          ;not found
DATA        HEX   CACFC5D9
EODATA      EQU   *
```

With this type of code, you can add or delete some of the DATA and the value which is loaded into the X index for the comparison loop will be automatically adjusted.

IMMEDIATE DATA SYNTAX

For those opcodes such as LDA, CMP, etc., which accept immediate data (numbers as opposed to addresses) the immediate mode is signed by preceding the expression with “#”. An example is LDX #3. In addition:

#<expression	produces the low byte of the expression
#>expression	produces the high byte of the expression
#expression	also gives the low byte (the 6502 does not accept 2-byte DATA)
#/expression	is optional syntax for the high byte of the expression

6502 ADDRESSING MODES

The Merlin 128 Assembler accepts all the 6502 opcodes with standard mnemonics. It also accepts **BLT** (Branch if Less Than) and **BGE** (Branch if Greater or Equal) as pseudonyms for BCC and BCS, respectively.

There are 12 addressing modes available. The appropriate syntax for these are:

Addressing Mode	Syntax	Example
Implied	OPCODE	CLC
Accumulator	OPCODE	ROR
Immediate (data)	OPCODE #expr	ADC #$F8
		CMP #”M”
		LDX #>LABELl-LABEL2-l
Zero page (address)	OPCODE expr	ROL 6
Indexed X	OPCODE expr,X	LDA $E0,X
Indexed Y	OPCODB expr,Y	STX LABEL,Y
Absolute (address)	OPCODE expr	BIT $300
Indexed X	OPCODE expr,X	STA $4000,X
Indexed Y	OPCODE expr,y	SBC LABEL-1,Y
Indirect	JMP (expr)	JMP ($3F2)
Preindexed X	OPCODE (expr,X)	LDA (6,X)
Postindexed Y	OPCODB (expr),Y	STA ($FE),Y

Special Forced Non-Zero Page Addressing

There is no difference in syntax for zero page and absolute modes. The assembler automatically uses zero page mode when appropriate. Merlin 128 provides the ability to force non-zero page addressing. The way to do this is to add anything (except “D”) to the end of the opcode. Example:

```
LDA  $10 assembles as zero page (2 bytes) while,
LDA: $10 assembles as non-zero page (3 bytes).
```

Also, in the indexed indirect modes, only a zero page expression is allowed, and the assembler will give an error message if the “expr” does not evaluate to a zero page address.

NOTE: The "accumulator mode" does not require an operand (the letter "A"). For example, to do an LSR of the accumulator, you can use:

```
1    LABEL      LSR         ;  LOGICAL SHIFT RIGHT
```

Some assemblers perversely require you to put an "A" in the operand for this mode.

The assembler will decide the legality of the addressing mode for any given opcode.

ASSEMBLER PSEUDO OPCODE DESCRIPTIONS

EQU or = (EQUate)

```
Label EQU expression
Label    =    expression (alternate syntax)
   START        EQU $1000        [equate START to $1000]
   CHAR         EQU "A"          [equate CHAR to ASCII value of A]
   PTR          =       *        [PTR equals present address in the assembled source
                                 listing.]
   LABEL        =       55       [LABEL equals the decimal value of 55]
```

```
    LABEL      EQU     $25
               LDA     LABEL
```

This will Load the Accumulator with the value that's stored in *location* $25.

```
    LABEL      EQU     $25
               LDA     #LABEL
```

This will Load the Accumulator with the *value* of $25.

IMPORTANT: Forgetting to include the # symbol to load an immediate value is probably the number-one cause of program bugs. If you're having a problem, double check immediate value syntax first!

EQU is used to define the value of a LABEL, usually an exterior address or an often-used constant for which a meaningful name is desired. It is recommended that these all be located at the beginning of the program.

NOTE: The assembler will not permit an "equate" to a zero page number after the label equated has been used, since bad code could result from such a situation (also see "Variables").

For Example:

```
1              LDA    #LEN
2  LABEL       DFB    $00
3              DFB    $01
4  LEN         EQU    * - LABEL
```

When assembled, this will give an **"ILLEGAL FORWARD REFERENCE IN LINE 4"** error message. The solution is as follows:

```
1              LDA    #END - LABEL
2  LABEL       DEB    $00
3              DFB    $01
4  END
```

Note that Labels are CASE SENSITIVE. Therefore, the assembler will consider the following labels as different labels:

START	[upper case label]
Start	[mixed case label]
start	[lower case label]

EXT (EXTernal label)

```
label EXT             [label is external labels name]
   PRINT EXT          [define PRINT as external]
```

This pseudo op defines a label as an external label for use by the Linker. The value of the label, at assembly time, is set to $8000, but the final value is resolved by the linker. The symbol table will list the label as having the value of $8000 plus its external reference number (0-$FE). See the LINKER section of the manual for more information on this opcode.

ENT (ENTry label)

```
label ENT
   PRINT ENT          [define PRINT as entry label]
```

This pseudo op will define the label in the label column as an **ENTRY** label. An entry label is a label that may be referred to as an **EXT**ernal label by another **REL** code module. The true address of an entry label will be resolved by the **LINKER**.

The **REL** code module being written, or assembled, may refer to the **ENT** label just as if it were an ordinary label. It can be **EQU**'d, jumped to, branched to, etc.

The symbol table listing will print the relative address of the label and will flag it as an **“E”**.

See the **LINKER** section of the manual for more information on this opcode.

ORG (set ORiGin)

```
ORG expression
ORG
ORG $1000          [start code at $1000]
ORG START+END      [start at value of expression ]
ORG                [re-ORG]
```

Establishes the address at which the program is designed to run. It defaults to $8000. Ordinarily there will be only one **ORG** and it will be at the start of the program. If more than one **ORG** is used, the first one establishes the **DLOAD** address, while the second actually establishes the origin. This can be used to create an object file that would load to one address though it may be designed to run at another address.

You cannot use **ORG *-1** to back up the object pointers as is done in some assemblers. This must be done instead by **DS -1**.

ORG without an operand is accepted and is treated as a **"REORG"** type command. It is intended to be used to reestablish the correct address pointer after a segment of code which has a different **ORG**. (When used in a **REL** file, all labels in a section between an "**ORG** address" and an "**ORG** no address" are regarded as absolute addresses. This is meant **ONLY** to be used in a section to be moved to an explicit address.)

Example of **ORG** without an operand:

```
                    1              ORG    $1000
1000:  A0  00       2              LDY    #0
1002:  20  21  10   3              JSR    MOVE        ;"MOVE" IS
1005:  4C  12  10   4              JMP    CONTINUE    ;NOT LISTED.
                    5              ORG    $300        ;ROUTINE TO
0300:  8D  08  C0   6   PAGE3      STA    MAINZP      ;BE MOVED
0303:  20  ED  FD   7              JSR    COUT
0306:  8D  09  C0   8              STA    AUXZP
0309:  60           9              RTS
                    10             ORG                ;REORG
1012:  A9  C1       11  CONTINUE   LDA    #"A"
1014:  20  00  03   12             JSR    PAGE3
```

Sometimes, you will want to generate two blocks of code with separate **ORG**s in one assembly. There are three ways of doing this. Each involves a directive **(DSK, SAV and DS)** that are described later in this manual, but all are presented here in the interest of completeness.

In this first example, two separate disk files are created with independent **ORG** values by using the **DSK** command. This command directs the assembler to assemble all code to disk *following* the **DSK** command. The file is closed when either the assembly ends or another **DSK** command is encountered.

```
*******************
* MULTIPLE ORG'S *
*  SOLUTION # 1     *
* DSK COMMAND   *
*******************

        DSK     "FIIEONE"
        ORG     $8000
        LDA     #0

        DSK     "FILETWO"
        ORG     $8100
        LDY     #1
```

In this second example, two separate disk files are again created with independent **ORG** values, but this time by using the **SAV** command. This command directs the assembler to save all code assembled previous to the SAV code disk.

```
*******************
* MULTIPLE ORG'S *
*  SOLUTION # 2     *
*  SAV COMMAND  *
*******************

        ORG     $8000
        LDA     #0
        SAV     "FILEONE"

        ORG     $8100
        LDY     #1
        SAV     "FILETWO"
```

In this last example, just one file is created on disk, but the two blocks of code are separated by approximately a $100 byte gap (less the size of the first code block, of course).

Please read the section on **SAV** for more information about multiple **ORG**s in a program.

```
*******************
* MULTIPLE ORG'S *
*  SOLUTION # 3     *
*  DS COMMAND    *
*******************

        ORG     $8000
        LDA     #0
        DS ↑                ; or could have been DS  $8100-*
        LDY     #1
```

REL (RELocatable code module)

```
REL
   REL                         [only option for this opcode]
```

This opcode instructs the assembler to generate code files compatible with the relocating linker. This opcode must occur prior to the use or definition of any labels. See the **LINKER** section of this manual for more information on this opcode.

OBJ (set OBJect)

```
OBJ expression
   OBJ      $4000              [use of hex address in RAM1]
   OBJ      START              [use with a label]
```

The OBJ opcode is accepted only prior to the start of the code and it only sets the division line between the symbol table and object code areas in memory (which defaults to $A000). The OBJ address is accepted only if it lies between $4000 and $FEE0. This may cause you a problem if you forget this fact and try to assemble a listing OBJ'ed somewhere else, such as $300, for example.

Nothing disastrous will happen if OBJ is out of range; when you return to the Main Menu to save your object file, no object file address and length values will be displayed on the screen, and Merlin 128 will simply beep at you if you try to save an object file.

The main reason for using OBJ is to be able to quit the assembler directly, test a routine in memory, and then be able to immediately return to the assembler to make any corrections. If you want to do this, simply use the GET command (Example: GET $8000) before quitting to BASIC.

Most people should never have to use this opcode. If the REL opcode is used then OBJ is disregarded. If DSK is used then you can, but should not have to, set OBJ to $FEE0 to maximize the space for the symbol table.

PUT (PUT a text file in assembly)

```
PUT "filename"
   PUT "Filename"              [PUT's file FILENAME]
   PUT "Filenarne",9           [PUT's file FILENAME from device 9 1
```

PUT "filename' reads the named file and "inserts" it at the location of the opcode.

Occasionally your source file will become too large to assemble in memory. This could be due to a very long program, extensive comments, dummy segments, etc. In any case, this is where the **PUT** opcode can make life easy. All you have to do is divide your program into sections, then save each section as a separate text file. The **PUT** opcode will load these text files and “insert” them in the “Master” source file at the location of the **PUT** opcode. This "Master" source file usually only contains equates, macros (if used), and *all* of your **PUT** opcodes.

A "Master" source file might look something like this:

```
******************
*    Master Source*
******************
*
*    LABEL DEFINITIONS
*
     LABEL1      EQU     $00
     LABEL2      EQU     $02
     BSOUT       EQU     $FFD2
*
*      MACRO DEFINITIONS
*
     SWAP        MAC
                 LDA     ]l
                 STA     ]2
                 <<<
*
*    SAMPLE SOURCE CODE
*
                 LDA     #LABEL1
                 STA     LABEL2
                 LDA     #/LABEL1
                 STA     LABEL2+1
                 LDA     LABEL1
                 JSR     BSOUT
                 RTS
*
*    BEGIN PUTFILES
*
                 PUT     "FILE1"           ;FIRST SOURCE FILE SEGMENT
                 PUT     "FILE2"           ;SECOND SOURCE FILE SEGMENT
                 PUT     "FILES"           ;THIRD SOURCE FILE SEGMENT
```

Note that you cannot define **MACRO**s from within a **PUT** file. Also, you cannot call the next **PUT** file from within a **PUT** file. All **MACRO** definitions and **PUT** opcodes must be in the "Master" source file. There are other uses for **PUT** files such as **PUT**ting portions of code as subroutines, **PUT**ting a file of global page equates, etc. The possibilities are almost endless.

Here's an example of a master program that uses 3 **PUT** files to create a final object file, "FINAL.O", that is called from a BASIC program:

```
* MASTER CALLING PROGRAM

BSOUT     EQU   $FFD2


          ORG   $8000


          PUT   "FILE1"       ; Named "FILE1" on disk
          PUT   "FILE2"       ; Named "FILE2" on disk
          PUT   "FILES"       ; Named "FILES" on disk
```

And here are the text files that the master program calls in using the PUT commands:

```
*  FILE1

          LDX   #0
LOOP1     LDA   STRING1,X

          JSR   BSOUT
          INX
          BNE   LOOP1
STRING1   TXT   'THIS IS FILE 1',00
```

```
*  FILE2

FILE2     LDX   #0
LOOP2     LDA   STRING2,X

          JSR   BSOUT
          INX
          BNE   LOOP2
STRING2   TXT   'NOW its FILE 2',00
```

```
*  FILES3

FILE3     LDX   #0
LOOP3     LDA   STRINGS,X
          BEQ   DONE
          JSR   BSOUT
          INX
          BNE   LOOP3
DONE      RTS
STRINGS   TXT   'FINALLY FILE 3',00
```

Each **PUT** file (FILE1, FILE2, FILE3) prints a message about which file it is.

NOTE: "Insert" refers to the effect on assembly and not to the location of the source. The file itself is actually placed just following the main source. These files are in memory only one at a time, so a very large program can be assembled using the PUT facility.

There are two restrictions on a PUT file. First, there cannot be MACRO definitions inside a file which is PUT; they must be in the main source or in a USE file. Second, a PUT file may not call another PUT file with the PUT opcode. Of course, linking can be simulated by having the "main program" just contain the macro definitions and call, in turn, all the others with the PUT opcode.

Any variables (such as]LABEL) may be used as "local" variables. The usual local variables]1 through]8 may be set up for this purpose using the VAR opcode.

The PUT facility provides a simple way to incorporate often used subroutines, such as PRDEC, in a program.

If there is an error during assembly, the error will show both the line number of the PUT opcode in the Master file and that in the PUT file.

The PUT opcode accepts both SEQ and PRG type source files, but if you're using the PRG type, you must include the ".S" suffix in the filename.

If you are working with PRG files written with Merlin 64, use the LOAD command and resave them with Merlin 128.

USE (USE a text file as a macro library)

```
USE filename
   USE "FILENAME"
   USE "FILENAME",9  [Device Number]
```

This works as does a PUT but the file is kept in memory. It is intended for loading a macro library that is USEd by the source file.

VAR (setup VARiables)

```
VAR expr;expr;expr...
   VAR 1;$3;LABEL     [setup VAR's 1,2 and 3]
```

This is just a convenient way to equate the variables]1-]8. "VAR 3;$42;LABEL" will set]1 = 3,]2 = $42, and]3 = LABEL. This is designed for use just prior to a PUT. If a PUT file uses]1-]8, except in PMC (or>>>) lines for calling macros, there *must* be a previous declaration of these.

SAV (SAVe object code)

```
SAV "filename"
  SAV "FILE"
  SAV "FILE",9
```

"SAVE filename" will save the current object code under the specified name. It will not add the suffix **".O"** to the file name as would happen in the Main Menu. Otherwise, it acts exactly as does the Main Menu object saving command, but it can be done several times during assembly.

This pseudo-opcode provides a means of saving portions of a program having more than one ORG. It also enables the assembly of extremely large files. After a save, the object address is reset to the last specification of OBJ or to $8000 by default.

Files saved with the SAVe command will be saved to BLOAD to the correct address.

SAV allows you to save sections of assembled OBJECT code during an assembly. It saves all assembled code in the current assembly at the point at which the SAV opcode occurs. This applies *only* to the first SAV in a source. With each additional SAV, Merlin 128 only saves the object code generated since the last SAV. This feature allows you to use one source file to assemble code and then SAVe sections in separate files. Together with the PUT and DSK, SAV makes it possible to assemble extremely large files.

```
******************
*       SAV Sample  *
******************
*
* LABEL DEFINITIONS
*
  LABEL1      EQU    $00
  LABEL2      EQU    $02
  BSOUT       EQU    $FFD2
*
* MACRO DEFINITIONS
*
  SWAP        MAC
              LDA    ]1
              STA    ]2
              <<<
*
* SOURCE PART ONE
*
              ORG    $800          ;PART ONE STARTS HERE
              LDA    #LABEL1
              STA    LABEL2
              LDA    #/LABEL1
              STA    LABEL2+1
```

```
               LDA     LABEL1
               JER     BSOUT
               RTS
               Etc.
        END    NOP                     ;NOT REQUIRED - EXAMPLE ONLY
               SAV     "FILE1"         ;SAVE CODE FROM $800 TO HERE
     *
     *    SOURCE PART TWO
     *
               ORG     $6000           ;PART TWO STARTS HERE
               LDA     #LABEL1
               STA     LABEL2
               LDA     #/LABEL1
               STA     LABEL2+1
               LDA     LABEL1
               JSR     BSOUT
               RTS
               Etc.
        END1   NOP                     ;NOT REQUIRED - EXAMPLE ONLY
               SAV     "FILE2"
               END                     ;NOT REQUIRED - EXAMPLE ONLY
```

Therefore, SAV is used to save sections of code to separate individual binary files during an assembly. With SAV, you can assemble code that may not be continuous in memory but which must be assembled all at once because the sections refer to each other, and may share labels, data, and/or subroutines.

DSK (assemble directly to DiSK)

```
DSK filename
   DSK "PROG"
   DSK "PROG",9
```

"DSK filename" will cause Merlin 128 to open a file specified in the opcode and place all assembled code in that file. It is used at the *start* of a source file before any code is generated. Merlin 128 then writes all the following code directly to disk. If DSK is already in effect, the old file will be closed and the new one begun. This is useful primarily for extremely large files.

NOTE: Files intended for use with the linking loader must be saved with the DSK pseudo op; see the REL opcode.

DSK has two basic purposes:

1) It allows you to assemble programs that result in object code larger than Merlin 128 can normally keep in memory.

2) It allows you to automatically put your object code on disk without having to remember to use the Main Menu's "O" command. Like "SAV", DSK does not automatically add the ".O" suffix to the saved file name.

The first purpose is the most often used reason for utilizing the DSK opcode.

You should be aware that using DSK will slow assembly significantly. This is because Merlin 128 will write a sector to disk every time 256 bytes of object code have been generated. If you don't need a copy of the object code on disk, you should not use (or use a conditional to defeat) the DEK opcode.

Here is an example listing of a program that creates two separate object files using the DSK command:

```
        * DSK SAMPLE *
                DSK     "F ILEONE"          ;ASSENBLE 'FILEONE' TO DISK
                ORG     $4000               ;'FILEONE' AT $4000 (SYS 4*4096)
BSOUT           EQU     $FFD2


                LDX     #0
LOOP1           LDA     STRING1,X
                BEQ     DONE1
                JSR     BSOUT
                INX
                BNE     LOOP1
DONE1           RTS
STRING1         TXT     ‘This is one’,00

                ORG     $8000               ;’FILETWO’ AT $8000
                DSK     “FILETWO”           ;ASSEMBLE ‘FILETWO’ TO DISK

                LDX     #0
LOOP2           LDA     STRING2,X
                BEQ     DONE2
                JSR     BSOUT
                INX
                BNE     LOOP2
DONE2           RTS
STRING2         TXT     ‘Now it’s two’,00
```

END (END of source file)

END

END	[only option for this opcode]

This rarely used or needed pseudo opcode instructs the assembler to ignore the rest of the source. Labels occurring after **END** will not be recognized.

DUM (DUMmy section)

DUM expression

DUM $1000	[start DUMmmy code at $1000]
DUM LABEL	[start code at value of LABEL]
DUM END-START	[start at val of END-START]

This starts a section of code that will be examined for value of labels but will produce no object code. The expression must give the desired ORG of this section. It is possible to re-**ORG** such a section using another DUMMY opcode or using **ORG**. Note that although no object code is produced from a dummy section, the text output of the assembler will appear as if code is being produced.

DEND (Dummy END)

DEND

DEND	[only option for this opcode]

This ends a dummy section and re-establishes the ORG address to the value it had upon entry to the dummy section.

DUM and DEND are used most often to create a set of labels that will exist outside of your actual program, but that your program needs to reference. Thus, the labels and their values need to be available, but you don't want any code actually assembled for that particular part of the listing.

Sample usage of DUM and DEND:

```
1           ORG   $2000
2
3           DUN   $63
4
5  FACEXP   DFB   0
6  FACHO    DFB   0
7  FACMOH   DFB   0
8  FACMO    DFB   0
9  FACLO    DFB   0
10 FACSGN   DFB   0,0
```

```
11  ARGEXP     DFB      0
12  ARGHO      DFB      0
13  ARGMOH     DFB      0
14  ARGMO      DFB      0
15  ARGLO      DFB      0
16  ARGSGN     DFB      0,0
17  FACOV      DFB      0
18
19             DEND
20
21  START      LDA      #0
23             STA      FACEXP
24  *     And  so  on
```

Note that no code is generated for lines 3 through 19, but the labels are available to the program itself, for example, on line 23.

FORMATTING PSEUDO OPS

LST ON/OFF (LiSTing control)

LST ON or OFF

LST ON	[turn listing on]
LST OFF	[turn listing off]
LST	[turn listing on, optional]

This controls whether the assembly listing is to be sent to the screen (or other output device) or not You may, for example, use this to send only a portion of the assembly listing to your printer. Any number of LST instructions may be in the source. If the LST condition is OFF at the end of assembly, the symbol table will not be printed.

The assembler actually only checks the third character of the operand to see whether or not it is a space. Therefore, LST will have the same effect as LST ON. The LST directive will have no effect on the actual generation of object code. If the LST condition is OFF, the object code will be generated much faster, but this is recommended only for debugged programs.

NOTE: ESCAPE from the keyboard toggles this flag during the second pass, and thus can be used to manually turn on or off the screen or a printer listing during assembly.

LSTDO ON/OFF (LiST DO OFF areas of code)

LSTDO ON or OFF

LSTDO ON	[list the DO OFF areas]
LSTDO OFF	[don’t list the DO OFF areas]
LSTDO	[list the DO OFF areas, optional]

LSTDO ON causes lines in DO OFF areas to be listed during assembly. LSTDO OFF will not print such lines. The default condition can be set in the PARMS.S file. Macro definitions are exceptions. These are listed, unless in a LST OFF condition, even if you have LSTDO OFF.

EXP ON/OFF/ONLY (macro EXPand control)

EXP ON or OFF or ONLY

EXP ON	[macro expand on]
EXP OFF	[print only macro call]
EXP ONLY	[print only generated code]

EXP ON will print an entire macro during the assembly. The OFF condition will print only the PMC pseudo-op. EXP defaults to ON. This has no effect on the object coded generated. EXP ONLY will cause expansion of the macro to the listing omitting the call line and end of macro line. (if the macro call line is labeled, however, it is printed.) This mode will print out just as if the macro lines were written out in the source.

PAU (PAUse)

PAU

PAU	[only option for this opcode]

On the second pass this causes assembly to pause until a key is pressed. This can also be done from the keyboard by pressing the space bar. This is handy for debugging.

PAG (new PAGe)

PAG

PAG	[only option for this opcode]

This sends a formfeed ($8C) to the printer. It has no effect on the screen listing.

AST (send a line of ASTerisks)

AST expression

AST 30	[send 30 asterisks to listing]
AST NUM	[send NUM asterisks]

This sends a number of asterisks (*) to the listing equal to the value of the operand. The number format is the usual one (base 10), so that AST10 will send (decimal) 10 asterisks, for example. The number is treated modulo 256 with 0 being 256 asterisks.

SKP (SKiP lines)

```
 SKP expression
   SKP 5                 [ skip 5 lines in listing]
   SKP LINES             [skip “LINES” lines in listing]
```

This sends "expression" number of carriage returns to the listing. The number format is the same as in AST.

TR ON/OFF (TRuncate control)

```
TR ON or OFF
   TR ON                 [limit object code printing]
   TR OFF                [don't limit object code print]
```

TR ON or TR (alone) limits object code printout to three bytes per source line, even if the line generates more than three. TR OFF resets it to print all object bytes.

CYC (calculate and print CYCle times for code)

```
CYC
CYC OFF
CYC AVE
   CYC                   [print opcode cycles & total]
   CYC OFF               [stop cycle time printing]
   CYC AVE               [print cycles & average]
```

This opcode will cause a program cycle count to be printed during assembly. A second CYC opcode will cause the accumulated total to go to zero. CYC OFF causes it to stop printing cycles. CYC AVE will average in the cycles that are undeterminable due to branches, indexed and indirect addressing.

The cycle times will be printed (or displayed) to the right of the comment field and will appear similar to any one of the following:

```
   5    ,0326        or       5'   ,0326        or        5' ',0326
```

The first number displayed (the 5 in the example above) is the cycle count for the current instruction. The second number displayed is the accumulated total of cycles in decimal. The position of the cycle count can be changed by altering the file PARMS.S. See the Technical Information Section for details.

A single quote after the cycle count indicates a possible added cycle, depending on certain conditions the assembler cannot foresee. If this appears on a branch instruction then it indicates that one cycle should be added if the branch occurs. For non-branch instructions, the single quote indicates that one cycle should be added if a page boundary is crossed.

A double quote after the cycle count indicates that the assembler has determined that a branch would be taken and that the branch would cross a page boundary. In this case the extra cycle is displayed and added to the total.

TTL ‘page header’

TFL

```
TFL     "Title Page"          [Change page header to "Title Page"]
```

This lets you change the page header at any point in an assembly, provided the PRTR command is in effect.

STRING DATA PSEUDO OPS

General notes on String Data and String Delimiters

Different delimiters have different effects. Any delimiter less than (in ASCII value) the single quote (') will produce a string with the high-bits on, otherwise the high-bits will be off. For example, the delimiters !"#$%& will produce a string in "negative" ASCII, and the delimiters '( )+? will produce one in "positive" ASCII. Usually the quote (") and single quote (') are the delimiters of choice, but other delimiters provide the means of inserting a string containing the quote or single quote as part of the string. Example delimiter effects:

"HELLO"	[negative ASCII, hi bit set]
HELLO!	[negative ASCII, hi bit set]
#HELLO#	[negative ASCII, hi bit set]
&HELLO&	[negative ASCII, hi bit set]
ENTER "HELLO"!	[string with embedded quotes]
'HELLO'	[positive ASCII, hi bit clear]
(HELLO(	[positive ASCII, hi bit clear]
'ENTER "HELLO"'	[string with embedded quotes]

All of the opcodes in this section, except REV, also accept hex data after the string. Any of the following syntaxes are acceptable:

```
    TXT "string"878D00
    DCI "string",878D00
    ASC "string",87,8D,00
    ASI "STRING",878D00
    REV "string"
```

Command	Input	Comments	Assembles as (hex)
TXT	'Abc"	Commodore ASCII	61 42 43
DCI	'Abc"	Commodore ASCII	61 42 C3
ASC	'Abc"	Standard ASCII	41 62 63
ASI	'Abc"	Standard ASCII	41 62 E3
REV	'Abc"	Commodore ASCII	43 42 61

TXT (define Commodore ASCII TeXT)

TXT d-string

TKF "STRING"	[negative Commodore ASCII string]
TXT 'STRING'	[positive Commodore ASCII string]
TXT "Bye,Bye",8D	[negative with added hex bytes]

This puts a delimited Commodore ASCII string into the object code. The only restriction on the delimiter is that it does not occur in the string itself.

DCI (define Commodore ASCII text - Dextral Character Inverted)

DCI d-string

DCI "STRING"	[negative Commodore ASCII, except for the "G"]
DCI 'STRING'	[positive Commodore ASCII, except for the "G"]
DCI 'Hello',878D	[positive Commodore with two added hex bytes]

This is the same as TXT except that the Commodore ASCII string is put into memory with the last character having the opposite high bit to the others.

ASC (define Standard ASCII text)

ASC d-string

ASC "STRING"	[negative ASCII string]
ASC 'STRING'	[positive ASCII string]
ASC "Bye,Bye",8D	[negative with added hex bytes]

This puts a delimited Standard ASCII string into the object code. The only restriction on the delimiter is that it does not occur in the string itself.

ASI (define Standard ASCII Inverted text)

ASI d-string

ASI "STRING"	[negative ASCII, except for the "G"]
ASI 'STRING'	[positive ASCII, except for the "G"]

This is the same as ASC except that the Standard ASCII string is put into memory with the last character having the opposite high bit to the others. ASI is to ASC as DCI is to TXT.

REV (define REVerse Commodore ASCII text)

```
REV &string
   REV "Insert"            [ negative ASCII, reversed in memory ]
   REV 'Insert'            [ same as above but positive ]
```

This puts the d-string in memory backwards. Example:

REV "COMMODORE"

gives ERODOMMOC (delimiter choice as in TXT). HEX data may *not* be added after the string terminator.

STR (define a Commodore ASCII STRing with a leading length byte)

```
 STR d-string
   STR "HI"                [ negative Commodore ASCII result = 02 C8 C9 ]
   STR 'HI',8D             [ positive Commodore ASCII result  02 48 49 8D ]
```

This puts a delimited string into memory with a leading length byte. Otherwise it works the same as the TXT opcode. Note that following HEX bytes, if any, are not counted in the length.

DATA AND STORAGE ALLOCATION PSEUDO OPS

DA or DW (Define Address or Define Word)

```
DA expression or DW expression
   DA $FDF0            [results: FO FD in memory]
   DA 10,$300          [results: OA OO Oo 03]
   DW LAB1,LAB2        [example of use with labels]
```

This stores the two-byte value of the operand, usually an address, in the object code, low-byte first.

These two pseudo ops also accept multiple data separated by commas (such as DA 1,10,100).

DDB (Define Double-Byte)

```
DDB expression
   DDB $FDED+1         [results: FD EE in memory]
   DDB 10,$300         [results: 00 0A 03 00 ]
```

As above with DA, but places high-byte first. DDB also accepts multiple data (such as DDB 1,10,100).

DFB or DB (DeFine Byte or Define Byte)

```
DFB expression or DB expression
   DFB 10              [results: 0A in memory ]
   DFB $10             [results: 10 in memory]
   DB >$FDED+2         [results: FD in memory]
   DB LAB              [example of use with label]
```

This puts the byte specified by the operand into the object code. It accepts several bytes of data, which must be separated by commas and contain no spaces. The standard number format is used and arithmetic is done as usual.

The "#" symbol is acceptable but ignored, as is"<". The “>” symbol may be used to specify the high-byte of an expression, otherwise the low-byte is always taken. The “>” symbol should appear as the first character only of an expression or immediately after #. That is, the instruction DFB >LAB1-LAB2 will produce the high-byte of the value of LAB 1-LAB 2.

For example:

```
DFB $34,100,LAB1-LAB2,%10l 1,>LAB1-LAB2
```

is a properly formatted DFB statement which will generate the object code (hex):

```
34 64 DE 0B 09
```

assuming that LAB 1=$81A2 and LAB2=$77C4.

FLO expression (FLOAT)

```
FLO expression
   FLO LABEL          [floats 5 bytes in memory]
   FLO $FFFF          [results: 90 7F FF 00 00 in memory]
   FLO 1              [results: 81 00 00 00 00 in memory ]
   FLO-1              [results: 81 80 00 00 00 in memory]
```

This assembles the five byte packed floating point equivalent of the expression. If the expression begins with a minus sign, then the operand is floated as a signed integer. Otherwise, it is floated as an unsigned integer. It should be noted that Merlin 128 first computes a 16 bit integer using unsigned arithmetic, which is then floated accordingly. Thus, $FFFF will float as 65535,-1 will float as -1, and -$FFFF will float as 1. The file called "pi.main.s" has examples of the use of this opcode. Note that you can use "FLOAT" instead of "FLO" since only the first three characters are examined, unless used in a macro name.

HEX (define HEX data)

```
HEX hex-data
   HEX 0102030F       [results: 0l 02 03 0F in memory]
   HEX FD,ED,C0       [results: FD ED C0 in memory]
```

This is an alternative to DFB which allows convenient insertion of hex data. Unlike all other cases, the "$" is not required or accepted here. The operand should consist of hex numbers having two hex digits (for example, use 0F, not F). They may be separated by commas or may be adjacent. An error message will be generated if the operand contains an odd number of digits or ends in a command, or as in all cases, contains more than 64 characters.

DS (Define Storage)

```
DS expression
DS expression1, expression2
DS ↑
     DS ↑,expression2
     DS 10              [zero out 10 bytes of memory]
     DS 10,$80          [put $80 in 10 bytes of memory]
     DS ↑               [zero memory to next memory page]
     DS ↑,$80           [put $80 in memory to next page]
```

This reserves space for string storage data. It zeros out this space if the expression is positive. DS 10, for example, will set aside 10 bytes for storage.

Because DS adjusts the object code pointer, an instruction like DS -1 can be used to back up the object and address pointers one byte.

The first alternate form of DS, with two expressions, will fill expression1 bytes with the value of (the low byte of) expression2, provided expression2 is positive. If expression2 is missing, 0 is used for the fill.

The second alternate form, "DS ↑", will fill memory (with 0's) until the next memory page. The "DS ↑,expression2" form does the same but fills using the low byte of expression2.

Notes for REL files and the Linker

The "↑" options are intended for use mainly with REL files and work slightly differently with these files. Any "DS ↑" opcode occurring in a REL file will cause the linker to load the next file at the first available page boundary, and to fill with 0's or the indicated byte. Note that, for REL files, the location of this code has no effect on its action. To avoid confusion, you should put this code at the end of a file.

USING DATA TABLES IN PROGRAMS

Merlin's various data commands are used by the programmer to store pure data bytes (as opposed to executable program instruction bytes) in memory for use by the program. As an example, here is a program that prints the sum of two numbers squared.

```
* DATA TABLE DEMO *

               ORG     $8000

CLEAR          EQU     $E544
CHROUT         EQU     $FFD2
SCNKEY         EQU     $FE9F
GETIN          EQU     $FFE4

START          JSR     CLEAR
               LDY     #-1                ;START WITH 1 LESS THAN '0'  ($FF)
PRINT1         INY                        ;Y = Y + 1
               LDA     DATA1,Y            ;GET CHAR FROM TABLE
               JSR     CHROUT             ;PRINT NUMBER TO SE SQUARED
               LDX     #0
LOOP1          LDA     DATA2,X            ;LOOP TO PRINT TEXT
               BEQ     PRINT2
               JSR     CHROUT
               INX
               BNE     LOOP1
PRINT2         LDA     DATA3,Y            ;PRINT SQUARED VALUE
               JSR     CHROUT
               LDA     #$8D
               JSR     CHROUT
               CPY     #$03               ;THREE LOOPS COMPLETE?
               BCS     WAIT               ;IF SO WAIT FOR RETURN
               JMP     PRINT1             ;IF NOT BEGIN AGAIN
WAIT           JSR     SCNKEY
               JSR     GETIN
               BEQ     WAIT
               CMP     #$0D               ;WAS RETURN PRESSED?
               BEQ     DONE
               JMP     WAIT
DONE           RTS
DATA1          DFB     #48,49,50,51
DATA2          ASC     “ SQUARED IS”
               HEX     00
DATA3          DFB     #48,49,52,57
```

MISCELLANEOUS PSEUDO OPS

KBD (define label from KeyBoarD)

```
label KBD
label KBD d-string
   OUTPUT KBD                    [get value of OUTPUT from keyboard]
   OUTPUT KBD "send to printer"  [prompt with the d-string for the value of OUTPUT]
```

This allows a label to be equated from the keyboard during assembly. Any expression may be input, including expressions referencing previously defined labels, however a BAD INPUT error will occur if the input cannot be evaluated.

The optional delimited string will be printed on the screen instead of the standard "Give value for LABEL:" message. A colon is appended to the string.

LUP (begin a loop)

```
LUP expression      (Loop)
   --↑              (end of LUP)
```

The LUP pseudo-opcode is used to repeat portions of source between the LUP and the --↑ "expression" number of times. An example of this is:

```
LUP     4
ASL
--↑
```

which will assemble as:

```
ASL
ASL
ASL
ASL
```

and will show that way in the assembly listing, with repeated line numbers.

Perhaps the major use of this is for table building. As an example:

```
]A   =       0
     LUP     $FF
]A   =       ]A+1
     DPB     ]A
     --↑
```

will assemble the table 1, 2, 3, ...,$FF.

The maximum LUP value is $8000 and the LUP opcode will simply be ignored if you try to use more than this.

NOTE: the above use of incrementing variables in order to build a table *will not* work if used within a macro. Program structures such as this must be included as part of the main program source.

In a LUP, if the @ character appears in the label column, it will be increased by the loop count (thus A,B,C...). Since the loop count is a countdown, these labels will go backwards (the last label has the A). This makes it possible to label items inside a LUP. This will work in a LUP with a maximum length of 26 counts, otherwise you will get a BAD LABEL error and possibly some DUPLICATE LABEL errors.

CHK (place CHecKsum in object code)

CHK
CHK [only option for this opcode]

This places a checksum byte into object code at the location of the CHK opcode. This is usually placed at the end of the program and can be used by your program at runtime to verify the existence of an accurate image of the program in memory.

The checksum is calculated with exclusive-or'ing each successive byte with the running result. That is byte 1 is EOR'ed with byte 2 and the result put in the accumulator. Then that value is EOR'ed with byte 3 and the process continued until the last byte in memory has been involved in the calculation. It is not a foolproof error checking scheme, but is adequate for most uses. If you were publishing your source listing in a magazine, or loading object code in any situation in which you want to assure that a functional copy of the object code has been loaded, then the use of the checksum pseudo-op is recommended.

The following program segment will confirm the checksum at run time:

```
STARTCHK    LDA   #<STARTCHK
            STA   PTR
            LDA   #>STARTCHK
            STA   PTR+1
            LDY   #$00
            LDA   #$00
            PHA                       ; PUSH ZERO ON STACK

LOOP        PLA                       ; RETRIEVE CURRENT OSKEUM
            ROR   (PTR),Y
            PHA                       ; PUT TENIP BACK
            INC   PTR
            BNE   CHK                 ; WRAP AROUND YET?
            INC   PTR+1               ; YEP
```

```
 CHK           LDA    PTR+1
               CMP    #>PROGEND      ; SEE IF WE'RE DONE YET...
               BCC    LOOP           ; NOT YET...
               LDA    PTR
               CMP    #<PROGEND
               BCC    LOOP           ; NOPE
               BEQ    LOOP
 CHKCS         PLA                   ; RETRIEVE CALCULATED VALUE
               CMP    CHKSUM         ; COMPARE TO MERLIN'S VALUE
               BNE    ERROR          ; ERROR HANDLER....
                                     ; FALL THROUGH IF O.K.
REALSTART      ???                   ; REAL PROGRAM STARTS HERE
               ???
…

PROGEND        RTS                   ; END OF FUNCTIONAL PROGRAM
CHNSUM         CHK                   ; Merlin 128 CHECKSUM DIRECTIVE
```

ERR (force ERRor)

```
ERR expression
ERR ↑expression
   ERR     $80-($300)              [error if $80 not in $300 ]
   ERR *-1/$4100                   [error if PC > $4100]
   ERR ↑$5000                      [error if REL code address exceeds $5000]
```

"ERR expression" will force an error if the expression has a non-zero value and the message "BREAK IN LINE???" will be printed.

This may be used to ensure your program does not exceed, for example, $95FF by adding the final line:

```
ERR    *-l/$9600
```

NOTE: The above example would only alert you that the program is too long, and will not prevent writing above $9600 during assembly, but there can be no harm in this, since the assembler will cease generating object code in such an instance. The error occurs only on the second pass of the assembly and does not abort the assembly.

Another available syntax is: ERR ($300)-$4C

which will produce an error on the first pass and abort assembly if location $300 does not contain the value $4C.

Notes for REL Files and the ERR Pseudo Op

The "ERR ↑expression" syntax gives an error on the second pass if the address pointer reaches expression or beyond. This is equivalent to "ERR *-1/expr", but it when used with REL files, it instructs the linker to check that the last byte of the current module does not extend to expression or beyond (expression must be absolute). If the linker finds that the current module *does* extend beyond expression, linking will abort with a message Constraint error:" followed by the value of expression in the ERR opcode. You can see how this works by trying to link the PI file to an address over $1C20. Note that the position of this opcode in a REL file has no bearing on its action, so that it is best to put it at the end.

USR (USeR definable op-code)

```
USR optional expressions
   USR expression                    [examples depend on definition]
```

To prevent accidents, USR opcode routines are required to start with the CLD instruction at location $E00. (Note that this is different from USER). For purposes of loading, they may actually begin at $DFF with an RTS.

This is a user definable pseudo-opcode. It does a JSR $E00. This location will contain an RTS after a boot, a BRUN MERLIN or BRUN BOOT ASM. To set up your routine you should BRUN it from the EXEC command after CATALOG. This should just set up a JMP at $B00 to the main routine and then RTS.

The following flags and entry points may be used by your routine:

```
USRADS      = $EOO        ;must have a CLD instruction
PUTBYTE     = $4C06       ;see below
EVAL        = $4C09       ;see below
PASSNUM     = $4          ;contains assembly pass number
ERRCNT      = $lF         ;error count
VALUE       = $55         ;value returned by EVAL
OPNDLEN     = $2B         ;contains combined length of
                          ;operand and comment
NOTFOUND    = $30         ;see discussion of EVAL
MORKSP      = $980        ;contains the operand and
                          ;comment in positive ASCII
```

Your routine will be called by the USR opcode with A=0, Y=0 and carry set. To direct the assembler to put a byte in the object code, you should JSR PUTBYTE with the byte in A.

PUTBYTE will preserve Y but will scramble A and X. It returns with the zero flag clear (so that BNE always branches). On the first pass PUTBYTE *only* adjusts the object and address pointers, so that the contents of the registers are not important. You *must* call PUTBYTE the *same number of times* on each pass or the pointers will not be kept correctly and the assembly of other parts of the program will be incorrect!

If your routine needs to evaluate the operand, or part of it, you can do this by a JSR EVAL. The X register must point to the first character of the portion of the operand you wish to evaluate (set X=0 to evaluate the expression at the start of the operand). On return from EVAL, X will point to the character following the evaluated expression. The Y register will be 0, 1, or 2 depending on whether this character is a right parenthesis, a space, or a comma or end of operand.

Any character not allowed in an expression will cause assembly to abort with a BAD OPERAND or other error. If some label in the expression is not recognized then location NOTFOUND will be non-zero. On the second pass, however, you will get an UNKNOWN LABEL error and the rest of your routine will be ignored. On return from EVAL, the computed value of the expression will be in location VALUE and VALUE+1, low byte first. On the first pass this value will be insignificant if NOTFOUND is non-zero.

You may use zero page locations $62-$6F, but should not alter other locations. Upon return from your routine (RTS), the USR line will be printed (on the second pass).

When you use the USR opcode in a source file, it is wise to include some sort of check (in source) that the required routine is in memory. If, for example, your routine contains an RTS at location $El0 then:

```
        ERR ($E10)-$60
```

will test that byte and abort assembly if the RTS is not there. Similarly if you know that the required routine should assemble exactly two bytes of data, then you can (roughly) check for it with the following code:

```
LABEL     USR    OPERAND
          ERR    *-LABEL-2
```

This will force an error on the second pass if USR does not produce exactly two object bytes.

It is possible to use USR for several different routines in the same source. For example, your routine could check the first operand expression for an index to the desired routine and act accordingly. Thus “USR 1, whatever” would branch to the first routine, “USR 2,stuff" to the second, etc.

CONDITIONAL PSEUDO OPS

DO (DO if true)

DO expression

DO 0	[turn assembly off]
DO 1	[turn it on]
DO LABEL	[if LAB EL<>0 then on]
DO LAB1/LAB2	[if LAB l<LAB2 then off]
DO LAB1-LAB2	[if LAB l-LAB2 then off]

This together with ELSE and FIN are the conditional assembly pseudo ops. If the operand evaluates to zero, then the assembler will stop generating object code (until it sees another conditional). Except for macro names, it will not recognize any labels in such an area of code. If the operand evaluates to a non-zero number, then assembly will proceed as usual. This is very useful for macros.

It is also useful for sources designed to generate slightly different code for different situations. For example, if you are designing a program to go on a ROM chip, you would want one version for the ROM and another with small differences as a RAM version for debugging purposes. Conditionals can be used to create these different object codes without requiring two sources.

Every DO should be terminated somewhere later by a FIN and each FIN should be preceded by a DO. An ELSE should occur only inside such a DO/FIN structure. DO/FIN structures may be nested up to eight deep (possibly with some ELSE's between). If the DO condition is off (value 0), then assembly will not resume until its corresponding FIN is encountered, or an ELSE at this level occurs. Nested DO/FIN structures are valuable for putting conditionals in macros.

ELSE (ELSE do this)

ELSE

ELSE	[only option for this opcode]

This inverts the assembly condition (ON becomes OFF and OFF becomes ON) for the last DO.

IF (IF so then do)

IF char,]var (IF char is the first character of]var)

```
   IF (,]1               [if first char of ]1 is"(" then assemble following code]
   IF ",]TEMP            [if first char is ", assem]
   IF"=]1                [alternate use with "="]
```

This checks to see if char is the leading character of the replacement string for]var. Position is important: the assembler checks the first and third characters of the operand for a match. If a match is found then the following code will be assembled. As with DO, this must be terminated with a FIN, with optional ELSEs between. The comma is not examined, so any character may be used there. For example:

```
          IF  "=]1
```

could be used to test if the first character of the variable]1 is a double quote (“) or not, perhaps needed in a macro which could be given either an ASCII or a hex parameter.

FIN (FINish conditional)

FIN

```
   FIN                   [only option for this opcode]
```

This cancels the last DO or IF and continues assembly with the next highest level of conditional assembly, or ON if the FIN concluded the last (outer) DO or IF.

EXAMPLE OF THE USE OF CONDITIONAL ASSEMBLY:

```
   * Macro "MOV', moves data from ]1 to ]2: (see also 'local Variables", this Section)

        MOV       MAC
                  LDA    ]1
                  STA    ]2


   * Macro "MOVD", moves data from ]l to ]2 with many available
   * syntaxes

        MOVD      MAC
                  MOV    ]1;12
                  IF   (,]1             ;Syntax MOVD (ADR1),Y;????
                  INY
                  IF   (,]2             ;  MOVD (ADR1),Y;(ADR2),Y
        MOV     ]1;]2
        ELSE                    ;  MOVD (ADR1),Y;ADR2
        MOV     ]1;]2+1
        FIN
        ELSE
        IF      (,]2            ;Syntax MOVD ????;(ADR2),Y
        INY
        IF      #,]1            ;  MOVD #ADR1;(ADR2),Y
        MOV     ]1/$l00;]
        ELSE                    ;  MOVD ADR1;(ADR2),Y
        MOV     ]1+1;]2
        FIN
        ELSE                    ;Syntax MOVD ????;ADR2
        IF      #,]1            ;  MOVD #ADR1;ADR2
        MOV     ]1/$l00;]2+1
        ELSE                    ;  MOVD ADR1;ADR2
        MOV     ]1+1;]2+1
        FIN                     ;MUST close ALL
        FIN                     ;conditionals, Count DOs
        FIN                     ;& Ifs, deduct FINs.  Must
        <<<
```

Call syntaxes supported by MOW):

```
MOVD ADR1;ADR2
MOVD (ADR1),Y;ADR2
MOVD ADR1; (ADR2) ,Y
MOVD (ADR1),Y; (ADR2),Y
MOVD #ADR1;ADR2
MOVD #ADR1;(ADR2},Y
```

MACRO PSEUDO OPS

MAC (begin MACro definition)

Label MAC

This signals the start of a MACRO definition. It must be labeled with the macro name. The name you use is then reserved and cannot be referenced by things other than the PMC pseudo-op (things like DA NAME will not be accepted if NAME is the label on MAC).

EOM (<<<)

EOM
<<< **(alternate syntax)**

This signals the end of the definition of a macro. It may be labeled and used for branches to the end of a macro, or one of its copies.

PMC (>>>) (macro-name)

PMC macro-name	
>>> macro-name	(alternate syntax #1)
macro-name	(alternate syntax #2)

This instructs the assembler to assemble a copy of the named macro at the present location. See the section on MACROS. It may be labeled.

VARIABLES

Labels beginning with"]" are regarded as *Variables.* They can be redefined as often as you wish. The designed purpose of variables is for use in macros, but they are not confined to that use.

Forward reference to a variable is impossible (with correct results) but the assembler will assign some value to it. That is, a variable should be defined before it is used.

It is possible to use variables for backwards branching, using the same label at numerous places in the source. This simplifies label naming for large programs and uses much less space than the equivalent once-used labels.

For example:

```
1            LDY   #0
2   ]JLQOP   LDA   TABLE,Y
3            BEQ   NOGOOD
4            JSR   DOIT
5            INY
6            BNE   ]JLOOP          ;BRANCH TO LINE 2
7   NOGOOD   LDX   #-1
8   ]JLOOP   INX
9            STA   DATA,X
10           LDA   TBL2,X
11           BNE   ]JLOOP          ;BRANCH TO LINE 8
```

LOCAL LABELS

A local label is any label beginning with a colon. A local label is "attached" to the last global label and can be referred to by any line from that global label to the next global label. You can then use the same local label in other segments governed by other global labels. You can choose to use a meaningless type of local label such as :1, :2, etc., or you can use meaningful names such as :LOOP, :EXIT, and so on.

Example of local labels:

```
1   START    LDY   #0
2            LDX   #0
3   :LOOP    LDA   (JUNK),Y        ;:loop is local to start
4            STA   (JUNKDEST),Y
5            INY
6            CPY   #100
7            BNE   :LOOP           ;branch back to  LOOP in 3
8   L00P2    LDY   #0
9   :LOOP    LDA   (STUFF),Y       ;:loop is now local to loop2
10           STA   (STUFFDEST),Y
11           INY
12           CPY   #100
13           BNE   :LOOP           ;branch back to  LOOP in 9
14           RTS
```

Some restrictions on use of local labels:

Local labels cannot be used inside macros. You cannot label a MAC, ENT or BXT with a local label and you cannot EQUate a local label. The first label in a program cannot be a local label.

Local Labels, Global Labels and Variables

There are three distinct types of labels used by the assembler. Each of these are identified and treated differently by Merlin.

Global Labels	labels not starting with “]” or “:”
Local labels	labels beginning with”:”
Variables	labels beginning with"]"

Note that local labels do not save space in the symbol table, while variables do. Local labels *can* be used for forward and backward branching, while variables cannot. Good programming practice dictates the use of local labels as branch points, variables for passing data, etc.

MACROS

Why Macros?

Macros represent a shorthand method of programming that allows multiple lines of code to be generated from a single statement, or macro call. They can be used as a simple means to eliminate repetitive entry of frequently used program segments, or they can be used to generate complex portions of code that the programmer may not even understand.

Examples of the first type are presented throughout this manual and in the “MACRO LIBRARY.S”. Examples of the second, more complex type, can be found in the "FP MACROS" file.

Macros literally allow you to write your own language and then turn that language into machine code with just a few lines of source code. Some people even take great pride in how many bytes of source code they can generate with a single Macro call.

How Does a Macro Work?

A macro is simply a user-named sequence of assembly language statements. To create the macro, you simply indicate the beginning of a definition with the macro name in the LABEL field, followed by the definition of the macro itself.

The macro definition ends with a terminator command in the opcode field of either "EOM" (for "End Of Macro"), or the character"<<<".

For example, suppose in your program that locations $06 and $07 need to be incremented by one, as in this listing:

```
INC     INC     $06         ; INC LO BYTE
        BNE     DONE
        INC     $07         ; INC HIGH BYTE
DONE    ???                 ; PROGRAM CONTINUES HERE...
```

Further, suppose that this is to be done a number of different times throughout the program. You could make the operation a subroutine, and JSR to it, or you could write the three lines of code out at each spot its needed.

However, a macro could be defined to do the same thing like this:

```
INK     MAC                 ; define a macro named INK
        INC     $06
        BNE     DONE
        INC     $07
DONE                        ; NO OPCODE NEEDED
        <<<                 ; this signals the end of the macro
```

Now whenever you want to increment bytes $06,07 in your program, you could just use the macro call:

```
100     >>>     INK             ; use the macro "INK"
```

or:

```
100     PMC     INK             ; alternate for ">>>"
```

Now, suppose you notice that there are a number of different byte-pair locations that get incremented throughout your program. Do you have to write a macro for each one? Wouldn't it be nice if there was a way to include a variable within a macro definition? You could then define the macro in a general way, and when you use it, via a macro call, "fill in the blanks" left when you defined it Here's a new example:

```
1       INK     MAC                     ; define a macro named INK
2               INC     ]1              ; increment 1st location
3               BNE     DONE
4               INC     ]1+1            ; increment location +    1
5       DONE                            ; NO OPCODE NEEDED
6               <<<                     ; this signals the end of the macro
```

This can now be called in a program with the statement:

```
100     >>>     INK,$06
```

In the assembled object code, this would be assembled as:

```
100             INC     $06
100             BNE     DONE
100             INC     $07
100     DONE                            ;  NO OPODDE NEEDED
```

Notice that during the assembly, all the object code generated within the macro is listed with the same line number. Don't worry though, the bytes are being placed properly in memory, as will be evidenced by the addresses printed to the left in the actual assembly.

Later, if you need to increment locations $0A,0B, this would do the trick:

```
150             >>>  INK,$0A
```

In the assembled object code, this would be assembled as:

```
150             INC     $0A
150             BNE     DONE
150             INC     $0B
150     DONE                            ; NO OPCODE NEEDED
```

Now, let's suppose that you want to use several variables within a macro definition. No problem! Merlin lets you use 8 variables within a macro,]1 through]8.

Here's another example:

```
MOVE      MAC                ; define a macro named MOVE
          LDA     ]1         ; load accum with variable ]1
          STA]2              ; store accum in location ]2
          <<<                ; this signals the end of the macro
```

This is a macro that moves a byte (or value) from one location to another. In this example the variables are 11 and 12. When you call the MOVE macro you provide a parameter list that "fills in" variables]1 and]2. What actually happens is that the assembler substitutes the parameters you provide at assembly time for the variables. The order of substitution is determined by the parameter's place in the parameter list and the location of the corresponding variable in the macro definition. Here's how MOVE would be called and then filled in:

```
MOVE      $00;$01

  MOVE: macro being called
  $00: takes place of ]1 (1st variable)
  $01: takes place of ]2 (2nd variable)
```

then, the macro will be "expanded" into assembly code,

```
    >>>        MOVE,$0D;$01
    LDA        $00              {$00 in place of ~1}
    STA     $01             {$01 in place of 121
```

It is very important to realize that *anything* used in the parameter list will be substituted for the variables. For example:

```
    >>>        MOVE,#"A";DATA
```

would result in the following:

```
    >>>        MOVE, #"A";DATA
    LDA        #"A"
    STA        DATA
```

You can get even fancier if you like:

```
    >>>        MOVE,#"A"; (STRING),Y
    LDA        #”A”
    STA        (STRING),Y
```

As illustrated, the substitution of the user supplied parameters for the variables is quite literal. It is quite possible to get into trouble this way also, but Merlin will inform you, via an error message, if you get too carried away.

One common problem encountered is forgetting the difference between immediate mode *numbers* and *addresses.*

The following two macro calls will do quite different things:

```
        >>>    MOVE,l0;20
        >>>    MOVE,#10;#20
```

The first stores the contents of memory location 10 (decimal) into memory location 20 (decimal). The second macro call will attempt to store the *number* 10 (decimal) in the *number* 20! What has happened here is that an illegal addressing mode was attempted. The second macro call would be expanded into something like this (if it were possible):

```
       >>>     MOVE,#10;#20         ;call the MOVE macro
       LDA     #10                  ;nothing wrong here
       STA     #20                  ;woops! can't do this!
***  BAD ADDRESS MODE  ***          ;Merlin will let you know!
```

In order to use the macros provided with Merlin, or to write your own, study the macro in question and try to visualize how the required parameters would be substituted. With a little time and effort you'll be using them like a Pro!

MORE ABOUT SPECIAL VARIABLES

Bight variables, named]1 through]8, are predefined and are designed for convenience in macros. These can be used in any macro call. Macros can be called one of three ways, and this will affect the syntax of accompanying variable expressions.

In the first two methods,

```
          >>>      NAME,exprl;expr2;expr3...
  and
          PMC      NAME,exprl;expr2;expr3…
```

will assign the value of expr1 to the variable]1, that of expr2 to]2, and so on. An example of this usage is: SWAP,$6;$7;TEMP

```
     MACRO DEFINITION            RESULTANT CODE EXAMPLE

  TEMP      EQU    $10
  SWAP      MAC
            LDA    ]1            LDA    $06
            STA    ]3            STA    TEMP
            LDA    ]2            LDA    $07
            STA    ]l            STA    $06
            LDA    ]3            LDA    TEMP
            STA    ]2            STA    $07
            <<<

            >>>    SWAP,$6;$7;TEMP
```

```
        >>>     SWAP,$1000;$6;TEMP    (2nd macro call with new argument)
```

This program segment swaps the contents of location $6 with that of $7, using TEMP as a scratch depository, then swaps the contents of $6 with that of $1000.

If, as above, some of the special variables are used in the Macro definition, then values for them must be specified in the PMC (or >>>) statement. In the assembly listing, the special variables will be replaced by their corresponding expressions.

The number of values must match the number of variables used in the macro definition. A BAD VARIABLE error will be generated if the number of values is less than the number of variables used. No error message will be generated, however, if there are more values than variables.

Note that in giving the parameter list, the Macro is followed by a comma, and then each parameter separated with a semicolon. The assembler will accept some other characters in place of the comma between the macro name and the expressions in a macro call (see the following examples). You may use any of these characters:

```
        . / , -     ( and the space character
```

The semicolons are required, however, between the expressions, and no extra spaces are allowed.

Macro names may also be put in the opcode column, without using the PMC or >>>, with the following restriction: The macro name cannot be the same as any regular opcode or pseudo opcode, such as LDA, STA, ORG, EXP, etc. Also, it cannot begin with the letters DEND or POPD.

Note that the PMC or >>> syntax is not subject to this restriction.

Macros will accept literal data. Thus the assembler will accept the following type of macro call:

MACRO DEFINITION

```
   MUV      MAC
            LDA     ]1
            STA     ]2
            <<<

            >>>     MUV . (PNTR),Y;DEST
            >>>     MUV . #3;FLAG,X
```

with the resultant code from the above two macro calls being:

```
    >>>     MUV. (PNTR),Y;DEST       ;macro call
    LDA     (PNTR),Y                 ;substitute first parm.
    STA     DEST                     ;substitute second parm.
```

and,

```
    >>>     MUV.#3;FLAG,X            ;macro call
    LDA     #3                       ;substitute first parm.
    STA     FLAG,X                   ;substitute second parm.
```

It will also accept:

MACRO DEFINITION	**RESULTANT CODE EXAMPLE**
`PRINT   MAC`	`PRINT. "Example"`
`        JSR     SENDMSC`	`JER     SENDMSG`
`        AEC     ]1`	`AEC     "Example"`
`        BRK`	`BRK`
`        <<<`	

Some additional examples of the PRINT macro call:

```
        >>>  PRINT. "quote"!
        >>>  PRINT. 'This is an exarpie'
        >>>  PRINT. "So's this, understand?"
```

LIMITATION: If such strings contain spaces or semicolons, they *must* be delimited by quotes (single or double). Also, literals such as >>>WHAT."A" must have the final delimiter. (This is only true in macro calls or VAR statements, but it is good practice in all cases.)

MORE ABOUT DEFINING A MACRO

A macro definition begins with the line:

```
 Name MAC      (no operand)
```

with Name in the label field. Its definition is terminated by the pseudo-op EOM or <<<. The label you use as Name cannot be referenced by anything other than a valid Macro call: NAME, PMC NAME or >>> NAME.

Forward reference to a macro definition is not possible, and would result in a NOT MACRO error message. That is, the macro must be defined before it is called by NAME, PMC or >>>.

The conditionals DO, IF, ELSE and FIN may be used within a macro.

Labels inside macros are updated each time the macro NAME, PMC or >>> NAME is encountered.

Error messages generated by errors in macros often abort assembly, because of possibly harmful effects. **Important:** Such messages will usually indicate the line number of the macro call rather than the line inside the macro where the error occurred. Thus, if you get an error on a line in which a macro has been used, you should check the macro definition itself for the offending statement.

Nested Macros

Macros may be nested to a depth of 15. Here is an example of a nested macro in which the definition itself is nested. (This can only be done when both definitions end at the same place.)

```
TROB    MAC
        >>>     TR.]1+1;]2+1
TR      MAC
        LDA     ]1
        STA]2
```

In this example >>> TR.LOC;DEST will assemble as:

```
LDA     LOC
STA     DEST
```

and >>> TRDB.LOC;DEST will assemble as:

```
LDA     LOC+1
 STA    DEST+1
LDA     LOC
 STA    DEST
```

A more common form of nesting is illustrated by these two macro definitions:

```
TABMAP      EQU     $354
POKE        MAC
            LDA     #]2
            STA]1
            <<<
HTAB        MAC
            >>> POKE.TABMAP+] 1;]2
```

The HTAB macro could then be used like this:

```
        HTAB    2;20                ;set tab #2 to column 20 decimal
```

and would generate the following code:

```
        LDA  #20              ;]2 in POKE macro
        STA     TABMAP+2      ;11 in POKE macro, 1st parm.
                              ; in H~AB macro
```

Macro Libraries and the USE Pseudo Op

There are a number of macro libraries on the Merlin disk. These libraries are examples of how one could set up a library of often used macros. The requirements for a file to be considered a macro library are:

1) Only Macro definitions and label definitions exist in the file,
2) The file is a text file,
3) The file must be accessible at assembly time (it must be on an available disk drive).

The macro libraries included with Merlin include:

Macro Library functions

MACRO LIBRARY.S	Often-used macros for general use
FP MACROS	Floating point math routines
PT.MACROS	Macros used for the "PI" linker demonstration programs

Any of these macro libraries may be included in an assembly by simply including a USE pseudo op with the appropriate library name. There is no limit to the number of libraries that may be in memory at any one time, except for available memory space. See the documentation on the USE pseudo op for a discussion on its use in a program.

THE LINKER

Why a Linker?

The linking facilities built into Merlin offer a number of advantages over assemblers without this capability:

1) Extremely large programs may be assembled in one operation, over 41000 bytes long,

2) Large programs may be assembled much more quickly with a corresponding decrease in development time,

3) Libraries of subroutines (for disk access, graphics, screen/modem/printer drivers, etc.) may be developed and linked to any Merlin 128 program,

4) Programs may be quickly re-assembled to run at any address.

With a linker, you can write portions of code that perform specific tasks, such as general disk I/O handler, and perform whatever testing and debugging is required. When the code is correct, it is assembled as a REL file and placed on a disk. Whenever you need to write a program that uses disk I/O you won't have to re-write or re-assemble the disk I/O portion of your new program. Just link your general disk I/O handler to your new program and away you go. This technique can be used for a variety of often used subroutines.

Wouldn't a PUT file or Macro USES library serve the same purpose? A PUT file comes the closest to duplicating the utility of REL files and the linker, but there are a few rather large drawbacks for certain programs. First, using a PUT file to add a general purpose subroutine would result in much slower assembly. Second, any label definitions contained in the PUT file would be global within the entire program. With a REL file, only labels defined as ENTry in the REL file (and EXTernal in the current file) would be shared by both programs. There is no chance for duplicate label errors when using the linker. Consider the following simple example:

A REL file has been assembled that drives a plotter. There are six entry points into the driver: PENUP, PENDOWN, NORTH, SOUTH, EAST, WEST. To further illustrate the value of a linker, assume the driver was written by a friend who has moved 2000 miles from you. Your job is to write a simple program to draw a box. The code would look something like this:

```
1                REL         ;RELOCATABLE CODE
2 PENUP          EXT         ;EXTERNAL LABEL
3 PENDOWN        EXT         ;ANOTHER ONE
4 NORTH          EXT
5 SOUTH          EXT
6 EAST           EXT
```

```
NEST          EXT

BOX           LDY      #00                   ; INITIALIZE Y
              JSR      PENDOWN               ; GET READY TO DRAW
:LOOP         JSR      NORTH                 ; MOVE UP
              INY                            ; INC COUNTER
              CPY#100                    ; 100 MOVES YET?
              BNE      :LOOP                 ; NOTICE LOCAL LABEL
              LDY      #00                   ; INIT Y AGAIN
:LOOP2        JSR      EAST                  ; NOW MOVE TO RIGHT
              INY
              CPY#100
              BNE      :LOOP2                ; FINISH MOVING RIGHT
* YOU GET THE IDEA, DO SOUTH, THEN WEST, AND DONE!
```

This simple sample program illustrates some of the power of RELocatable, linked files. Your program doesn't have to concern itself with conflicts between it's labels and the REL files labels, you don't concern yourself with the location of the EXTernal labels, your program listing is only 30 to 40 lines and it is capable of drawing a box on a plotter!

Let's look at another example that illustrates points 1 and 2 above. This time you are writing a data base program. You have broken the program down into 6 modules, all of which are REL files:

1) User interface
2) ISAM file system
3) Sort subsystem
4) Search subsystem
5) Report generator
6) Memory management subsystem

You would first design and write the user interface for your program. This would then be assembled and stored as a REL file. Next, the ISAM file system is written and de-bugged. You would then link the two modules together to see how they worked together. Next, you would complete the Sort, the Search, and all the rest. In fact, by using REL files, and documenting the ENTry points and their conditions, six different people could be working simultaneously on the same project and need no more from one another than the ENT labels!

To illustrate point 2, assume that the six modules are all coded as PUT files and that the resulting program was 40k bytes long. The time it would take to assemble and cross reference such a large program would be measured in hours or days. Changing one byte in the source code would require a complete re-assembly and a quite a wait! By assembling each section independently as REL files and then linking them, the one byte change would require assembly of only one module in the 40k program. In short, with REL files and a linker, changes to large programs can be made quickly and efficiently, greatly speeding the program development process.

About the Linker Documentation

There are three pseudo opcodes that deal directly with relocatable modules and the linking process. These are:

REL - Informs the assembler to generate relocatable files
EXT - Defines a label as external to the current file
ENT - Defines a label in the current file as accessible to other REL files.

There are two other pseudo opcodes that behave differently when used in a REL file, relative to a normal file. These are:

DS - Define Storage opcode,
ERR- Force an ERRor opcode.

Each of these five pseudo opcodes will be defined or redefined in this section as they pertain to REL files. Also, an Editor command unique to REL files will be defined: LINK.

In order to use the Linker, the files to be linked must be specified. The linker uses a file containing the names of the files to be linked for this purpose.

The Linker documentation will make no additional attempts to educate the user as to when (or when not) to use REL files.

PSEUDO OPCODES FOR USE WITH RELOCATABLE CODE FILES

REL (generate a RELocatable code file)

REL [only options for this opcode]

This opcode instructs the assembler to generate a relocatable code file for subsequent use with the relocating linker.

This *must* occur prior to definition of any labels. You will get a BAD "REL" error if not. REL files are incompatible with the SAV pseudo op and with the EXEC mode's object code save command. *To get an object file to the disk you must use the* DSK *opcode for direct assembly to disk.*

There are additional illegal opcodes and procedures that are normally allowed with standard files, but not with REL files. For example, an ORG at the start of the code is not allowed. In addition, multiplication, division or logical operations can be applied to absolute expressions but not to relative ones.

Examples of absolute expressions are:

- An EQUate to an explicit address,
-The difference between two relative labels,
-Labels defined in DUMMY code sections.

Examples of relative expressions that are not allowed are:

-Ordinary labels,
-Expressions that utilize the PC, like: LABEL = *.

The starting address of an REL file, supplied by the assembler, is $8000. Note that this address is a fictional address, since it will later be changed by the linker. It is for this reason that no ORG opcode is allowed.

There are some restrictions involving use of EXTernal labels in operand expressions. No operand can contain more than one external. For operands of the following form:

```
#>expression  or  >expression
```

where the expression contains an external, the value of the expression must be within 7 bytes of the external labels value. For example:

```
LDA #>EXTERNAL+8 [illegal expression]
DFB >EXTERNAL-1  [legal expression]
```

Object files generated with the REL opcode are given the file type USR.

EXT (define a label EXTernal to the current REL module)

```
label EXT
  PRINT EXT            [define label PRINT as EXT]
```

This defines the label in the label column as an external label. Any external label must be defined as an ENTry label in its own REL module, otherwise it will not be reconciled by the linker (the label would not have been found in any of the other linked modules). The EXTernal and ENTry label concepts are what allows REL modules to communicate and use each other as subroutines, etc.

The value of the label is set to $8000 and will be resolved by the linker. In the symbol table listing, the value of an external will be $8000 plus the external reference number ($0-$FE) and the symbol will be flagged with an “X”.

ENT (define a label as an ENTry label in a REL code module)

```
label ENT
  PRINT ENT                [define label PRINT as ENTry]
```

This defines the label in the label column as an ENTry label. This means that the label can be referred to as an external label. This facility allows other REL modules to use the label as if it were part of the current REL module. If a label is meant to be made available to other REL modules it must be defined with the ENT opcode, otherwise, other modules wouldn't know it existed and the linker would not be able to reconcile it.

The following example of a segment of a REL module will illustrate the use of this opcode:

```
21            STA    POINTER      ;some meaningless code
22            INC    POINTER      ;for our example
23            BNE    SWAP         ;CAN BE USED AS NORMAL
24            JMP    CONTINUE
25   SWAP     ENT                 ;MUST BE DEFINED IN THE
26            LDA    POINTER      ;CODE PORTION OF THE
27            STA    PTR          ;MODULE AND NOT USED
28            LDA    POINTER +l   ;AS AN EQUated label
29            STA    PTR +l
30   * etc.
```

Note that the label SWAP is associated with the code in line 26 and that the label may be used just like any other label in a program. It can be branched to, jumped to, used as a subroutine, etc.

ENT labels will be flagged in the symbol table listing with an "E."

DS (Define Storage)

```
DS ↑
DS ↑expression
 DS ↑            [start next module, fill memory with zeros to next page break]
 DS ↑,1          [start next module, fill memory with the value 1 to next page]
```

When this opcode is found in an REL file it causes the linker to load the next file in the "linker name file" at the first available page boundary and to fill memory either with zeros or with the value specified by the expression. This opcode should be placed at the end of your source file.

ERR (force an ERRor)

```
ERR ↑expression
   ERR ↑$4200              [error if current code passes address $4200]
```

This opcode will instruct the linker to check that the last byte of the current file does not extend to expression" or beyond. Note that the expression must be absolute and not a relative expression.

If the linker finds that this is not the case, linking will abort with the message: CONSTRAINT ERROR:, followed by the value of the expression in the ERR opcode. You can see how this works by trying to link the PI file on the Merlin disk to an address greater than $1C20.

Note that the position of this opcode in a REL file has no bearing on its action. It is recommended that it be put at the end of a file.

LINK (LINK REL files, this is an editor command)

```
LINK adrs "filename'

  LINK $1000 "NAMES"     [link files in NAMES]
```

This editor command invokes the linking loader. For example, suppose you want to link the object files whose names are held in a "linker name file' called NAMES. Suppose the start address desired for the linked program is $1000. Then you would type: LINK $1000 “NAMES” <RETURN>. (The final quote mark in the name is optional and you can use other delimiters such as “’” or”;”.). The specified start address has no effect on the space available to the linker.

Note that this command is only accepted if there is no current source file in memory, since the linker would destroy it.

Linker Name Files

The linker name file is just a text file containing the file names of the REL object modules you want linked. It should be written with the Merlin editor and written to the disk with the “W” EXEC command.

Thus, if you want to link the object files named MYPROG.START, MYPROG.MID, and LIB.ROUTINE,9 you would create a text file with these lines:

```
MYPROC.START
MYPROG.MID
LIB.ROUTINE, 9
```

Then you would write this to disk with the "W" command under the filename (for example) MYPROG.NAMES. (Use any filename you wish here, it is not required to call it NAMES.). Then you would link these files with a start address of $4000 by typing NEW and then issuing the Editor command: LINK $4000 "MYPROG.NAMES'.

The names file may contain empty lines and comment lines starting with "*".

The linker will not save the object file it creates. Instead, it sets up the object file pointers for the Main Menu Object command ("O") and returns you directly to Main Menu upon the completion of the linking process.

The Linking Process

Various error messages may be sent during the linking process (see the ERRORS section of this manual for more information). If a error occurs involving the file loading, then that error message will be seen and linking will abort. If the error FILE TYPE MISMATCH occurs after the message "Externals:" has been printed then it is being sent by the linker and means that the file structure of one of the files is incorrect and the linking cannot be done.

The message MEMORY IN USE may occur for two reasons. Either the object program is too large to accept (the total object size of the linked file cannot exceed about $A100) or the linking dictionary has exceeded its allotted space ($B000 long). Each of these possibilities is exceedingly remote.

After all files have been loaded, the externals will be resolved. Each external label referenced will be printed to the screen and will be indicated to have been resolved or not resolved. An indication is also given if an external reference corresponds to duplicate entry symbols. With both of these errors the address of the field (one or two bytes) effected is printed. This is the address the field will have when the final code is DLOADed.

If you use the TRON command prior to the LINK command, only the errors will be printed in the external list (NOT RESOLVED and DUPLICATE errors).

This listing may be stopped at any point using the space bar. The space bar may also be used to single step through the list. If you press the space bar while the files are loading then the linker will pause right after resolving the first external reference.

The list can be sent to a printer by using the PRTR command prior to the LINK command. At the end, the total number of errors (external references not resolved and references to duplicate entry symbols) will be printed. After pressing a key you will be sent to the MAIN Menu and can save the linked object file with the object save command, using any filename you please. You can also return to the editor and use the GET command to move the linked code to RAM0.

TECHNICAL INFORMATION

The source is placed at START OF SOURCE when loaded, regardless of its original address.

The important pointers are:

START OF SOURCE	in	$C,$D	(set to $7000 unless changed)
HIMEM	in	$E,$F	($FF00, don't change)
END OF SOURCE	in	$10,$11	

GENERAL INFORMATION

When you exit to BASIC or to the monitor, these pointers are saved. They are restored upon re-entry to Merlin 128.

Re-entry after exit to BASIC is made by the "SYS 2048" command or by the F4 function key.

If during assembly the object code exceeds usable RAM then the code will not be written to memory, but assembly will appear to proceed as normal and its output sent to the screen or printer. The only clue that this has happened, if not intentional, is that the OBJECT CODE SAVE command at EXEC level is disabled in this event. There is ordinarily a 23K space for object code, which can be changed with the OBJ opcode.

SYMBOL TABLE

The symbol table is printed after assembly unless LST OFF has been invoked. It is displayed first sorted alphabetically and then sorted numerically. The symbol table can be aborted at any time by pressing RUN/STOP. Stopping it in this manner will have no ill effect on the object code which was generated.

The symbol table is flagged as follows:

MD	=	Macro Definition
M	=	label defined within a Macro
V	=	Variable (symbols starting with"]")
?	=	A symbol that was defined but never referenced
X	=	External symbol
E	=	Entry symbol

(local labels are not shown in the symbol table listing.)

The symbol printout uses the first tab to determine the space to allocate to each symbol. Thus, if you change the default tabs to enable more label space, the symbol table printout will change also. Note that you may have to change the parameter for number of symbols per line in the table.

CONFIGURATION

The configuration registers $D101-$D504 are set up as shown below. These should not be changed, or reset to values shown. Return to MAIN MENU via $2000 or $2500 will reset them.

```
$D501: %00000000   (ROM)
$D502: %01111111   (RAM1)
$D503: %00111111   (RAM0)
$D504: %00001110   (RAMHALF)
```

RAM HALF leaves RAM below $C000, ROM and I/O above. The RAM HALF configuration is the one usually in effect at any given time.

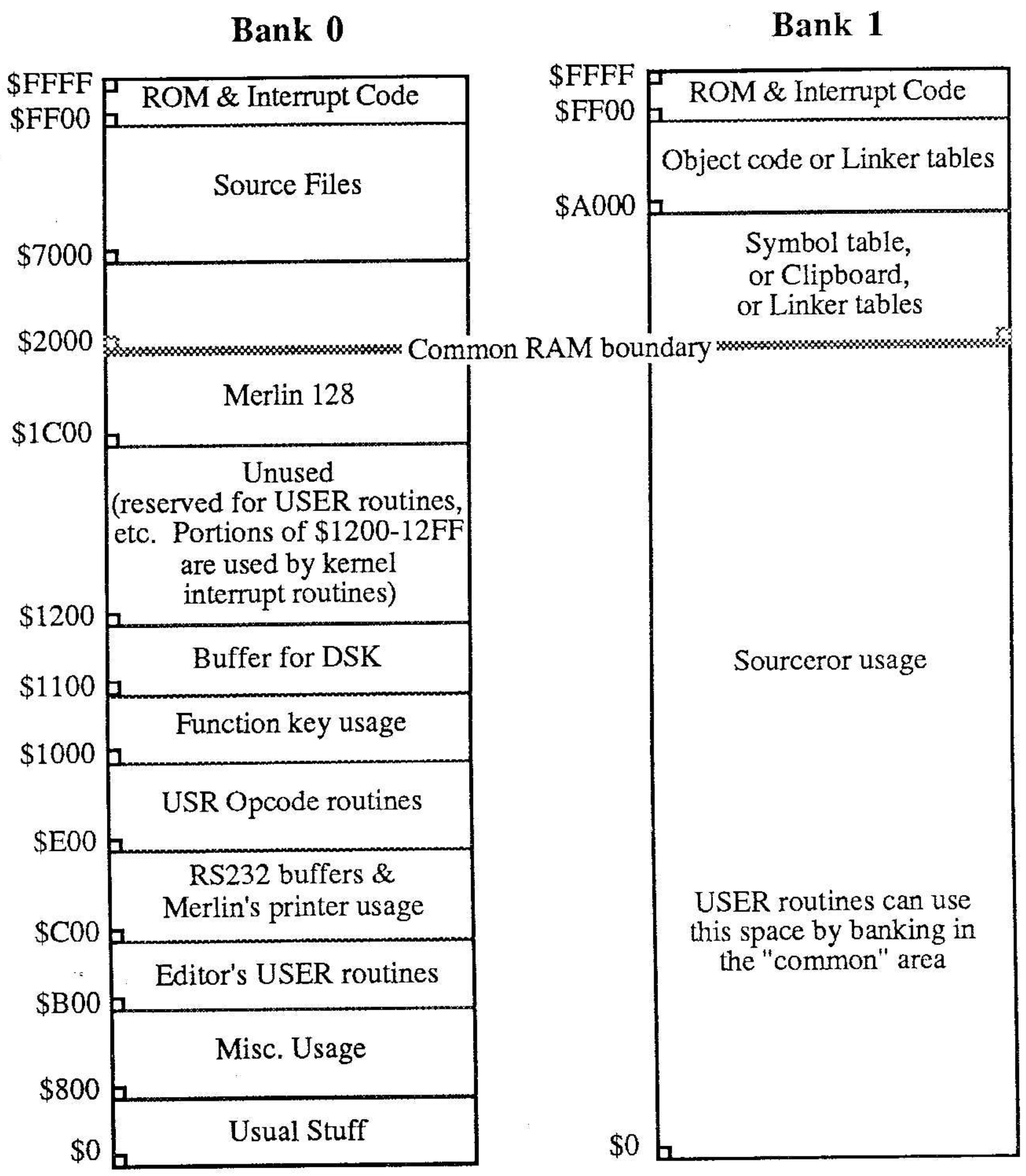
Merlin 128 configuration data is stored in a file the PARMS.O file which is loaded at boot. To change any of these values, load the source file, PARM.S, make the desired changes, then reassemble it.

Use the 'S' command to save the source code as PARMS. Use the 'O' command to save the object code as PARMS. Merlin 128 will add the appropriate suffix (.S or .O).

CONTENTS OF PARMS

```
*------------------------------
*   PARMS for Merlin-128
*------------------------------

    SRC         =       $7000           ;Source address (=> $7000)
    HIM         =       $FF00           ;Don't change

                ORG$2506                ;Do not change the org

    SPEED       DFB     0               ;Printer output speed (RS232)
    ERRFLG      DFB     $80             ;0 to defeat keywait on error

    PNTSAV      DA      SRC             ;Don't change these
                DA      HIM             ; "
                DA      SRC             ; "

                DFB     #"^"            ;Editors wild card (cmd mode)

                DFB     4               ;Number of symbols/line in
                                        ; symbol table printout

    CYCHORIZ    DFB     80-8            ;Column for CYC printing

    LSTDOFLG    DFB     0               ;$FF to not list DO OFF areas

    DEFBKGND    DFB     0               ;Foreground/background color
    CHRCOLOR    DFB     149             ;Char color

    *       For DEFBKGND use the following table:
    *
    * 0  -  black           8   -   red
    * 1  -  medium grey     9   -   light red
    * 2  -  blue            10  -   orange
    * 3  -  light grey      11  -   purple
    * 4  -  green           12  -   brown
    * 5  -  light green     13  -   yellow
    * 6  -  dark grey       14  -   light grey
    * 7  -  cyan            15  -   white
    *
    *       For CHRCOLOR use the character codes for colors, i.e.:
    *
    * 5      =  white           151 =   dark cyan
    * 28     =  red             152 =   grey
    * 30     =  green           153 =   light green
    * 31     =  blue            154 =   light blue
    * 129    =  dark purple     155 =   light grey
    * 144    =  black           156 =   purple
    * 149    =  dark yellow     158 =   light cyan
    * 150    =  light red       159 =   cyan

    RS232       DFB     %00000110   ;Control reg. for RS232
                DFB     %00010000   ;Command reg.
                DFB     0           ;Baud low (if used)
                DFB     0               ;Baud hi

    RPTDFLT         DFB     $80             ;Repeat key default

    NUMLINES        DFB     60              ;Printer lines/page

    PAGSKIP         DFB     0               ;# of lines skipped at perf
                                            ; will formfeed if 0.
                                            ;If printer does not recognize
                                            ; formfeed then usually you
                                            ; should put a 7 here.

    NUNCHRS         DFB     80              ;Printer width

    PRNTRCR         DFB     $80             ;Put a 0 here if your printer
                                            ; will not do an automatic CR
                                            ; after the # of chars in
                                            ; NUMCHRS (eg. if the printer
                                            ; width is more than NUNCHRS).
                                            ;This is so that output can
                                            ; keep an accurate line count.
                                            ;For almost all printers you
                                            ; should use $80 here - unless
                                            ; you use a NUMCHRS less than
                                            ; the actual printer width.

    LFD             DFB     0               ;Line feed default 0=no,$D=yes

    CNUMSK          DFB     0               ;UC/LC conversion for printer
                                            ; Put a 32=$20 here to convert
                                            ; lc/uc for printer output.

    ECHO            DFB     $61             ;$61=echo printer output
                                            ; 0 = no echo (to screen)

    *    Editor and assembler tabs (use 5 more than column) :

    DFLTABS         DFB     14              ;Opcode column (+5)
                DFB     20              ;Operand column (+5)
                DFB     31              ;Comment column (+5)

                ERR     *-$2523         ;That's it folks
```

Merlin 128 Memory Map



ERROR MESSAGES

BAD ADDRESS MODE

The addressing mode is not a valid 6510 instruction; for example, JSR (LABEL) or LDX (LABEL),Y.

BAD BRANCH

A branch (BEQ, BCC, etc.) to an address that is out of range, i.e. further away than +127 bytes.

NOTE: Most errors will throw off the assembler's address calculations. Bad branch errors should be ignored until previous errors have been dealt with.

BAD EXTERNAL

EXT or ENT in a macro or an equate of a label to an expression containing an external, or a branch to an external (use JMP).

BAD INPUT

This results from either no input (RETURN alone) or an input exceeding 37 characters in answer to the KBD opcodes request for the value of a label.

BAD LABEL

This is caused by an unlabeled EQU, MAC, ENT or EXT, a label that is too long (greater than 13 characters) or one containing illegal characters (a label must begin with a character at least as large in ASCII value as the colon and may not contain any characters less than the digit zero).

BAD OBJ

An OBJ after code start or OBJ not within $4000 to $FEEO.

BAD OPCODE

Occurs when the opcode is not valid (perhaps misspelled) or the opcode is in the label column.

BAD ORG

Results from an ORG at the start of a REL file.

BAD "PUT"

This is caused by a PUT inside a macro or by a PUT inside another PUT file.

BAD REL

A REL opcode occurs after some labels have been defined.

BAD “SAV”

This is caused by a SAV inside a macro or a SAV after a multiple OBJ after the last SAV.

BAD VARIABLE

Occurs when you don’t pass the number of variables to a macro that it expects. It can also occur for a syntax error in a string passed to a macro variable, such as a literal without the final quote.

BREAK

This message is caused by the ERR opcode when the expression in the operand is found to be non-zero.

DICTIONARY FULL

Overflow of the relocation dictionary in a REL file.

DUPLICATE SYMBOL

On the first pass, the assembler finds two identical labels.

ILLEGAL CHAR IN OPERAND

A non-math character occurs in the operand where the assembler is expecting a math operator. This usually occurs in macro calls with improper syntax resulting from the textual substitution.

ILLEGAL FORWARD REFERENCE

A label equated to a zero page address after it has been used. This also occurs when an unknown (on the first pass) label is used for some things that must be able to calculate the value on the first pass (e.g. ORG< OBJ DUM). It also occurs if a label is used before it is defined in a DUM section on zero page.

ILLEGAL RELATIVE ADRS

In REL mode a multiplication, division or logical operation occurs in a relative expression. This also occurs for an operand of the type #>expr or a DFB >expr when the expr contains an external and the offset of the value of the expr from that of the external exceeds 7.

MEMORY FULL

This is usually caused by one of two conditions: Source code too large or symbol table too large. See "Special Note" at the end of this section.

NESTING ERROR

Macros nested more than 15 deep or conditionals nested more than 8 deep will generate this error.

NOT MACRO

Forward reference to a MACRO, or reference by PMC or >>> to a label that is not a MACRO.

OUT OF MEMORY

An attempt has been made to paste more text from the clipboard than will fit in the current source listing, or to paste from an empty clipboard (such as after an assembly).

RANGE ERROR

Results when using GET to move a program with an ORG that conflicts with Merlin 128 or a source file in memory.

TWO EXTERNALS

Two or more externals in an operand expression.

UNKNOWN LABEL

Your program refers to a label that has not been defined. This also occurs if you try to reference a MACRO definition by anything other than PMC or >>>. It can also occur if the referenced label is in an area with conditional assembly OFF. The latter will not happen with a MACRO definition.

256 EXTERNALS

The file has more than 255 externals.

MEMORY FULL Errors

There are three common causes for the MEMORY FULL error message. They are as follows:

MEMORY FULL IN LINE: xx. Generated during assembly.

CAUSE #1: Too many symbols have been placed into the symbol table, causing it to exceed available space.
REMEDY: Make the symbol table larger by setting OBJ to $FEE0 and use DSK to assemble directly to disk.

CAUSE #2: If the combined size of the source file and a PUT file is too large.
REMEDY: Split either file into two smaller files.

ERR:MEMORY FULL. Generated immediately after you type in one line too many.

CAUSE: The source code is too large and has exceeded available RAM.
REMEDY: Break the source file up into smaller sections and bring them in when necessary by using the "PUT" pseudo-op.

ERROR MESSAGE: None, but no object code will be generated (there will be no OBJECT information displayed on the MAIN menu).

CAUSE: Object code generated from an assembly would have exceeded the available 16K space.
REMEDY: Set OBJ to an address less than its $8000 default or use DSK.

GENERAL NOTE: When an error occurs that aborts assembly, the line containing the error is printed to the screen. This may not have the same form as it has in the source, since it shows any textual substitutions that may have occurred because of macro expansion. If it is in a macro call, the line number will be that of the call line and not of the line in the macro (which is unknown to the assembler).

SOURCEROR

INTRODUCTION

SOURCEROR is a sophisticated and easy to use co-resident disassembler designed to create Merlin 128 source files out of binary programs, usually in a matter of minutes.

Using SOURCEROR

To use SOURCEROR, follow these steps:

1. Use the Main Menu 'G' command to run SOURCEROR

2. Press 'E' to enter the Editor.

3. From the Immediate mode prompt (:), type:

   USER (RETURN)

   There must be no source in memory when the USER command is issued. If there is, the USER command will be ignored, and you will not be able to continue the disassembly.

4. If there is no source in memory, the following prompt will appear:

   Do you want an object file loaded? (Y/N):

5. If you type 'N', the following prompt appears:

   If the present location of the program to be disassembled is its original location, hit RETURN. If not, give PRESENT location:

   After pressing RETURN or entering the PRESENT location, the following prompt appears:

   In disassembling, use the ORIGINAL location. Please specify it:

   Enter the ORIGINAL location and press RETURN. Skip to item 10.

6. If you pressed 'Y' to the 'Do you want an object file loaded?' prompt, the following appears:

   Name of file:

7 Type the complete filename and press RETURN.

8. The following prompts appear:

```
searching for filename loading

Original location is $####,$####

Use this for disassembly.

HIT A KEY
```

9. Note the addresses shown for 'Original location'. These are the beginning and ending addresses for the file to be disassembled.

10. The SOURCEROR menu appears displaying the commands available for disassembly. You may start disassembling now, or use any of the other commands. Your first command must include a hex address. Thereafter this is optional, as explained shortly.

    NOTE: When disassembling, you must use the ORIGINAL address of the program, not the address where the program currently resides. It will appear that you are disassembling the program at its original location, but actually, SOURCEROR is disassembling the code at its present location and translating the addresses.

11. When SOURCEROR’s final processing is done, the Merlin 128 Main Menu appears. SOURCEROR always disassembles an area in RAM 0. Thus, it is not possible to disassemble the ROMs without saving a portion of the ROM code to a disk file and having SOURCEROR load that into RAM.

COMMANDS USED IN DISASSEMBLY

All commands accept a 4-digit hex address before the command letter. If this number is omitted, then the disassembly continues from its present address. A number must be specified only upon initial entry.

If you specify a number greater than the present address, a new ORG will be created.

More commonly, you will specify an address less than the present default value. In this case, the disassembler checks to see if this address equals the address of one of the previous lines. If so, it simply backs up to that point. If not, then it backs up to the next used address and creates a new ORG. Subsequent source lines are "erased". It is generally best to avoid new ORGs when possible. If you get a new ORG and don't want it, try backing up a bit more until you no longer get a new ORG upon disassembly.

This "backup" feature allows you to repeat a disassembly if you have, for example, used a HEX or other command, and then change your mind.

SOURCEROR COMMAND DESCRIPTIONS

L (List)

This is the main disassembly command. It disassembles 20 lines of code. It may be repeated (e.g. 2OOOLLL will disassemble 60 lines of code starting at $2000).

If an illegal opcode is encountered, the bell will sound and opcode will be printed as three question marks in flashing format. This is only to call your attention to the situation. In the source code itself, unrecognized opcodes are converted to HEX data, but not displayed on the screen.

H (Hex)

This creates the HEX data opcode. It defaults to one byte of data. If you insert a one byte (one or two digit) hex number after the H, that number of data bytes will be generated.

T (Text)

This attempts to disassemble the data at the current address as an ASCII string. Depending on the form of the data, this will automatically be disassembled under the pseudo-opcode TXT or DCI. The appropriate delimiter (" or') is automatically chosen. The disassembly will end when the data encountered is inappropriate, when 62 characters have been treated, or when the high bit of the data changes. In the last condition, the TXT opcode is automatically changed to DCI.

Sometimes the change to DCI is inappropriate. This change can be defeated by using TT instead of T in the command.

Occasionally, the disassembled string may not stop at the appropriate place because the following code looks like ASCII data to SOURCEROR. In this event, you may limit the number of characters put into the string by inserting a one or two digit hex number after the T command.

This, or TT, may also have to be used to establish the correct boundary between a regular ASCII string and a flashing one. It is usually obvious where this should be done.

W (Word)

This disassembles the next two bytes at the current location as a DA opcode. Optionally, if the command WW is used, these bytes are disassembled as a DDB opcode.

If W- is used as the command, the two bytes are disassembled in the form DA LABEL-1. The latter is often the appropriate form when the program uses the address by pushing it on the stack. You may detect this while disassembling, or after the program has been disassembled. In the latter case, it may be to your advantage to do the disassembly again with some notes in hand.

HOUSEKEEPING COMMANDS

/ (Cancel)

This essentially cancels the last command. More exactly, it re-establishes the last default address (the address used for a command not necessarily attached to an address). This is a useful convenience which allows you to ignore the typing of an address when a backup is desired.

As an example, suppose you type T to disassemble some text. You may not know what to expect following the text, so you can just type L to look at it. Then if the text turns out to be followed by some Hex data (such as $8D for a carriage return), simply type / to cancel the L and type the appropriate H command.

Q (Quit)

This ends disassembly and goes to the final processing which is automatic. If you type an address before the Q, the address pointer is backed to (but not including) that point before the processing. If, at the end of the disassembly, the disassembled lines include:

```
2341-   4C  03  E0      JMP     $E003
2344-   A9  BE  94      LDA     $94BE,Y
```

and the last line is just garbage, type 2344Q. This will cancel the last line, but retain all the previous.

FINAL PROCESSING

After the Q command, the program does some last minute processing of the assembled code. If you press RESET at this time, you will return to Merlin 128 and lose the disassembled code.

The processing may take from a second or two for a short program and up to several minutes for a long one. Be patient.

When the processing is done, you are returned to Merlin 128 with the newly created source in the text buffer. You can use Merlin 128's Save command to save it to disk when you want.

DEALING WITH THE FINISHED SOURCE

In most cases, after you have some experience and assuming you used reasonable care, the source will have few, if any, defects.

You may notice that some DA's would have been more appropriate in the DA LABEL-1 or the DDB LABEL formats. In this, and similar cases, it may be best to do the disassembly again with some notes in hand. The disassembly is so quick and painless, that it is often much easier than trying to alter the source directly.

The source will have all the exterior or otherwise unrecognized labels at the end in a table of equates. You should look at this table closely. It should not contain any zero page equates except ones resulting from DA's, JMP's or JSR's. This is almost a sure sign of an error in the disassembly (yours, not SOURCEROR's). It may have resulted from an attempt to disassemble a data area as regular code.

NOTE: If you try to assemble the source under these conditions, you will get an error as soon as the equates appear. If, as eventually you should, you move the equates to the start of the program, you will not get an error, but the assembly may *not be correct.*

It is important to deal with this situation first as trouble could occur if, for example, the disassembler finds the data AD008D. It will disassemble it correctly, as LDA $008D. The assembler always assembles this code as a zero page instruction, giving the two bytes A5 8D. Occasionally you will find a program that uses this form for a zero page instruction. In that case, you will have to insert a character after the LDA opcode to have it assemble identically to its original form. Often it was data in the first place rather than code, and must be dealt with to get a correct assembly.

The Memory Full Message

When the source file reaches within $600 bytes of the end of its available space you will see MEMORY FULL and "HIT A KEY". When you hit a key, SOURCEROR will go directly to the final processing. The reason for the $600 byte gap is that SOURCEROR needs a certain amount of space for this processing. There is a "secret" override provision at the memory full point. If the key you press is CTRL-O (for override), then SOURCEROR will return for another command. You can use this to specify the desired ending point. You can also use it to go a little further than SOURCEROR wants you to, and disassemble a few more lines. Obviously, you should not carry this to extremes. If you get too close to the end of available space, Sourceror will no longer accept this override and will automatically start the final processing.

Changing Sourceror's Label Tables

One of the nicest features of the SOURCEROR program is the automatic assignment of labels to all recognizable addresses in the binary file being disassembled. Addresses are recognized by being found in a table which SOURCEROR references during the disassembly process. This table is on the disk under the name LABELS.O. For example, all JSR $FFD2 instructions within a binary file will be listed by SOURCEROR as JSR BSOUT. This table of address labels may be edited by using the program LABELER.

To use Labeler, press 'G' from the MAIN MENU, type 'LABELER', and press RETURN.

LABELER COMMANDS

L: LIST

This allows you to list the current label table. After ‘L’, press any key to start the listing. Pressing any key will go to the next page; CTRL-C will abort the listing.

A: ADD LABEL

Use this option to add a new label to the list. Simply tell the program the hex address and the name you wish associated with that address. Press RETURN only, to abort this option at any point.

D: DELETE LABEL(S)

Use this option to delete any address labels you do not want in the list. After entering the 'D' command, simply enter the NUMBER of the label you want to delete. If you want to delete a range, enter the beginning and ending label numbers, separated by a comma.

F: FREE SPACE

This tells you how much free space remains in the table for new table entries.

Q: QUIT

When finished with any modifications you wish to make to the label table, press 'Q' to exit the LABELER program. If you wish to save the new file, press 'S'. Otherwise, press ESCAPE to exit without saving the table, for instance, if you had been reviewing the table.

SOURCEROR.XL

SOURCEROR can disassemble an object file up to about 6K in length. For files longer than that, you can use SOURCEROR.XL. This is a disk based version of the disassembler capable of disassembling object files up to nearly 32K in length. After using the Main Menu 'G' command to run SOURCEROR.XL.O, you follow the same procedures as with the standard SOURCEROR.

After the object file has been loaded and you have been told its address range, you will be prompted to insert a blank formatted diskette. The diskette does not have to be blank, but it must have a large amount of free space on it, and it must not have filenames that are the same as those used by SOURCEROR. XL. The loaded object file must be at least a page shorter than 32K since it must fit in memory between $8000 and $FF00.

Disassembly proceeds in the same way as with the standard SOURCEROR. However, after about 6K has been disassembled, a portion of the disassembled source will be saved to disk in the file called TEMP.A. After more disassembly, another portion is saved as TEMP.B and so on. Since the saved portion leaves a sizable remainder still in memory, the interactive feature of SOURCEROR.XL is maintained. Thus, you can still 'back up' a reasonable distance after an automatic file save.

When you press 'Q' to quit, the final TEMP file, or possibly two, will be saved. The SOURCEROR.XL program will then go into its final processing stage. Do not interrupt this processing. When it is done, you will be return to the Merlin 128 Main Menu.

While in final processing, each of the TEMP files is read into memory twice. During the second pass, each file is deleted and the final result of the processing is saved in files named SOURCE.A.S, SOURCE.B.S, and so on. The equates are saved in a separate file called EQUATEFILE.S. These are all PRG file types and can be loaded by Merlin 128 as long as the *full* filename is used. You may prefer, however, to load them and then use the ‘W’ command to write them as TXT files.

As with the standard SOURCEROR, you may have to make some changes regarding any zero page equates in order to get the file to assemble correctly.

Of course, to assemble the resulting file, you will have to write a short master program that calls all of the other files by using the PUT opcode. For example, it might look like this:

```
PUT "EQUATESFILE.S"
PUT "SOURCE.A.S"
PUT "SOURCE.B.S"
PUT "SOURCE.C.S"
```

UTILITIES

FORMATTER

This program is provided to enhance the use of Merlin 128 as a general text editor. It will automatically format a file into paragraphs using a specified line length. Paragraphs are separated by empty lines in the original file.

To use FORMATTER, you should use the MAIN MENU 'G' command. FORMATTER will then load itself into high memory.

This will simply set up the editor's USER vector. To format a file which is in memory, issue the USER command from the editor.

The formatter program will request a range to format. If you just specify one number, the file will be formatted from that line to the end. Then you will be asked for a line length, which must be less than 250. Finally, you may specify whether you want the file justified on both sides (rather than just on the left).

The first thing done by the program is to check whether or not each line of the file starts with a space. If not, a space is inserted at the start of each line. This is to be used to give a left margin using the editor's TAB command before using the PRINT command to print out the file.

Formatter uses inverse spaces for the fill required by two sided justification. This is done so that they can be located and removed if you want to reformat the file later. It is important that you do not use the FIX or TEXT commands on a file after it has been formatted (unless another copy has been saved). For files coming from external sources, it is desirable to first use the FIX command on them to make sure they have the form expected by FORMATTER. For the same reason, it is advisable to reformat a file using only left justification prior to any edit of the file.

Don't forget to use the TABS command before printing out a formatted file.

XREF, XREFA

These utilities provide a convenient means of generating a cross-reference listing of all labels used within a Merlin assembly language (i.e., source) program.

Such a listing can help you quickly find, identify and trace values throughout a program. This becomes especially important when attempting to understand, debug or fine tune portions of code within a large program.

The Merlin assembler by itself provides a printout of its symbol table only at the end of a successful assembly (provided that you have not defeated this feature with the

LST OFF pseudo op code). While the symbol table allows you to see what the actual value or address of a label is, it does not allow you to follow the use of the label through the program.

This is where the XREF programs come in.

XREF gives you a complete alphabetical and numerical printout of label usage within an assembly language program. XREFA gives a cross reference table by ADDRESS. This is more useful for large sources containing lots of PUT files. It also does not use as much space for its cross-reference data and therefore can handle larger source files than XREF.

Sample Merlin Symbol Table Printout:

Symbol table - alphabetical order:

```
ADD          =$F786       BC        =$F7B0       BK        =$F706
```

Symbol table - numerical order:

```
BK           =$F706       ADD       = $F786      BC        =$F7BD
```

Sample Merlin XREF Printout:

Cross referenced symbol table - alphabetical order:

```
ADD      =$F786   101        185*
BC       =$F7B0   90         207*
BK       =$F706   104        121*
```

Cross referenced symbol table - numerical order:

```
BK       =$F706   104        121*
ADD      =$F786   101        185*
BC       =$F7B0   90         207*
```

As you can see from the above example, the "definition" or actual value of the label is indicated by the "=" sign, and the line number of each line in the source file that the label appears in is listed to the right of the definition. In addition, the line number where the label is either defined or used as a major entry point is suffixed ("flagged") with a “*”.

An added feature is a special notation for additional source files that are brought in during assembly with the PUT pseudo opcode: "134.82", for example, indicates line number 134 of the main source file (which will be the line containing the PUT opcode) and line number 82 of the PUT file, where the label is actually used.

XREF Instructions

1. From the Main Menu, make sure you've S)aved the file that you're working on.

2. Type 'G' and at the 'RUN:' prompt, type 'XREF' and press RETURN.

2a. Again from the MAIN MENU, type 'L' to load your file. Enter the Editor by pressing 'E', and from the colon prompt, enter your appropriate PRTR command.

3. Enter the Editor, then type the appropriate USER command

   USER 0- Print assembly listing and alphabetical cross reference only. (USER has the same effect as USER 0).

   USER 1 - Print assembly listing and both alphabetical and numerically sorted cross reference listings.

   USER 2 - Do not print assembly listing but print alphabetical cross reference only.

   USER 3 - Do not print assembly listing but print both alphabetical and numerical cross reference listings.

   For example, to print a cross-reference listing only to your printer, you could type in:

```
PRTR 4
USER 3
ASM
```

   USER commands 0-3 (above) cause labels within conditional assembly areas with the DO condition OFF to be ignored and not printed in the cross reference table.

   There are additional USER commands (4-7) that function the same as USER 0-3, except that they cause labels within conditional assembly areas to be printed no matter what the state of the DO setting is. The only exception to this is that labels defined in such areas and not elsewhere will be ignored.

   NOTE: You may change the USER command as many times as you wish (e.g., from USER 1 to USER 2). The change is not permanent until you enter the ASM command (below).

4. Enter the ASM command to begin the assembly and printing process.

Since the XREF programs require assembler output, code in areas with LST OFF will not be processed and labels in those areas will not appear in the table. In particular, it is essential to the proper working of XREF that the LST condition be ON at the end of assembly (since the program also intercepts the regular symbol table output). For the same reason, the CTRL-D flush command must not be used during assembly. The program attempts to determine when the assembler is sending it an error message on the first pass and it aborts assembly in this case, but this is not 100% reliable.

Another thing to look out for when using macros with XREF. Labels defined within macro definitions have no global meaning and are therefore not cross-referenced.

```
DEF     MAC                     <---Macro definition
        CMP     #]1
        BNE     DONE
        ASL
DONE    <<<
--------------------------------------  <---Beg. of program
        >>>     DEF.GLOBAL      <---Macro call
```

In the above example, variable GLOBAL will be cross referenced, but local label DONE will not.

XREFA

This is an ADDRESS cross reference program and is handy when you have lots of PUT files. Since this program needs only four bytes per cross reference instead of six, it can handle considerably larger sources. Also the "where defined" reference is not given here because it would equal the value of the label except for EQUated labels where it would just indicate the address counter when the equate is done. This also saves considerable space in the table for a larger source.

PRINTFILER

PRINTFILER is a utility included on the Merlin diskette that saves an assembled listing to disk as a sequential disk file. It optionally allows you to also select "file packing" for smaller space requirements and allows you to turn video output off for faster operation.

Text files generated by PRINTFILER include the object code portion of a disassembled listing, something not normally available when saving a source file. This allows a complete display of an assembly language program and provides the convenience of not having to assemble the program to see what the object code looks like. Applications include:

- Incorporating the assembled text file in a document being prepared by a word processor.
- Sending the file over a telephone line using a modem.
- Mailing the file to someone who wants to work with the complete disassembly without having to assemble the program (such as magazine editors, etc.)

How To Use PRINTFILER

1. From the Main Menu, press 'G', then type 'PRINTFILER and press RETURN. This need only be done the first time, and is not necessary for additional source files you may want to assemble with PRINTFILER.

2. From the Main Menu, type ‘L’ to load followed by the source filename.

3. Insert a disk with a lot of free space on it to receive the file generated by PRINTFILER.

4. Press 'E' to enter the Editor, and from the colon prompt, type:

   ```
   USER N  :FILENAME
   ```

   where FILENAME is the name to be used for the text file generated by PRINTFILER.

   'N' must be in the range of 0 TO 3. 'N' defaults to 0 if it is omitted. The meaning of the 'N' is as follows:

N = 0 Do not echo output to screen, do not compress file.
N = 1 Echo output to screen, do not compress file.
N = 2 Do not echo to screen, compress file.
N = 3 Echo output to screen, compress file.

PRINTFILER works by redirecting output from what would normally go to the screen to the disk file called FILENAME. Since there must be output, the LST OFF pseudo-op must not be in the source file to be used with PRINTFILER (unless you do not want to capture some portion of the file). Do not press ESCAPE during assembly.

Writing to a disk file is much slower than printing to the screen, so be patient. It is faster than sending the output to the printer.

Because of memory conflicts, it is not possible to use PRINTFILER at the same time as other USER utilities such as XREF.

PRINTFILER sends all assembly output to the disk file, including the symbol table at the end, unless you have a LST OFF at the end of the source.

If you choose one of the compression options, packed spaces are shown as inverse characters. All spaces in the file will be replaced by a byte representing the number of contiguous spaces plus $80. Thus, an inverse 'A' ($81) represents one space, an inverse 'B' ($82) represents two spaces, and soon. If you are unable to write a program that will read such a packed file, you should avoid using the compression option.

ALTKEYS

The ALT key can be used with another key to produce a keyboard macro. A macro definition lets you type one key to perform a series of actions or place a string of text on the screen. This should not be confused with Assembler macros that Merlin 128 also supports.

An assembler macro is a definition of a set of assembler instructions, usually with variables, that you define within a given source listing. When the program is assembled, Merlin 128 replaces the macro call with the series of lines that have been assigned to that macro.

A keyboard macro is a substitute for a small amount of typing that you might do while you're using the editor.

For example you've probably typed 'LDA' many times in assembly language programs. With Merlin 128, you can press the ALT key and the 'a' key at the same time, and the characters 'LDA' would appear in the opcode field and the cursor would be at the beginning of the operand field.

Merlin 128 comes with over thirty Alternate key commands as shown below. These commands are user definable. You can load the source file called 'altkeys.s' and add to or edit any of the existing commands.

You type:	You get:	Comments
ALT a	LDA	
ALT b	DFB	
ALT c	CMP	
ALT d	DEC	
ALT e	EOR	
ALT i	INC	
ALT j	JSR	
ALT l	LUP	Cursor at LUP operand field
	- - ↑	
ALT m	MAC	Cursor at MAC label field
	<<<	
ALT o	ORA	
ALT p	PHA	Save A,X,Y on stack
	TXA	All 5 lines with one macro
	PHA	
	TYA	
	PHA	
ALT t	TXT ‘ ‘	Cursor inside quotes
ALT x	LDX	
ALT y	LDY	
ALT A	STA	

ALT P	PLA		Retrieve A,X,Y from stack
	TAY		All 5 lines with one macro
	PLA		
	TAX		
	PLA		
ALT X	STX		
ALT Y	STY		
ALT S	DFB	%	
ALT 6	AND		
ALT 8	( ),Y		Cursor inside parentheses
ALT 9	(,X)		Cursor inside parentheses
ALT 0	LDA	#0	Cursor on line after STA
	STA	$FFOO	
ALT Down arrow			Move cursor down 10 lines
ALT Up arrow			Move cursor up 10 lines
ALT V arrow	ERR ↑		
ALT DEL			Deletes current comment, if any
ALT RETURN			Move cursor to end of next line
ALT ;			Moves cursor to comment field of next line and inserts a semicolon
ALT .	LDA	#>	
ALT ,	LDA	#	
ALT =	=	$	
ALT +	ADC		
ALT -	SBC		
ALT *	ORG	$	
ALT English Pound	* Merlin-128 Macro-assembler *		

KEYDEPS

The function key definitions can be changed by loading the file called ‘keydef.s’, making the desired changes and then assembling. Save the assembled source and object code using the original name of ‘keydefs’.

The current definitions are:

You press:	Definition:	Comments
SHIFT-RUN	Q RETURN	Quits Editor and goes to Main Menu
HELP	ASM RETURN	Assembles source
F1	Q RETURN L	Quits Editor and issues Load command
F2	Q RETURN S	Quits Editor and issues Save command
F3	Q RETURN C	Quits Editor and issues Catalog command
F4	Q RETURN X	Quits Editor and issues Disk command
F5	USER	Issues USER without RETURN
F6	USER RETURN	Issues USER with RETURN

F7	PRTR4::
F8	PRTR0::

SAMPLE PROGRAMS AND FILES

The Merlin 128 diskette comes with many sample programs and source files that have been fully commented. These samples can be loaded, read, or run, and have been supplied to illustrate various commands and techniques available with Merlin 128.

DEMO

This is the program used in the Introduction section of the manual. It demonstrates a string loop and keyboard scan for input.

COPY

This is a 1571 disk copy program which uses one or two drives. It illustrates direct disk access methods. The program has a BASIC header and MUST be run from BASIC.

ZAP

This is a 1571 disk zap program that also demonstrates disk access techniques.

HIRES

This program contains a set of line drawing and hires plotting routines that can be accessed from assembly. These routines are approximately four times faster than the Commodore 128 built-in routines. The source files illustrate graphics techniques.

SWISH

This is a sample hires demo which uses the HIRES program to do some dazzling color graphics. The source illustrates graphics techniques. The object file, SWISH.O, is loaded and accessed from the BASIC program called SWISH.

RAM TEST

This is a RAM testing program which uses the hires screen and 80 Column text. It can be run from Merlin 128 or from BASIC. You have to press reset to exit this program.

PI

This is a series of files that all have the prefix 'PI'. The purpose of these source files is to illustrate the proper use of the linking capabilities of Merlin 128. The object files have the '.o' suffix and are 'USR' file types. These object files can be linked by typing 'LINK $1C03.PI.NAMES' from the immediate mode prompt (:) in the editor. The linked file is also on the disk under the name 'PI.O'. It can be run from the Main Menu (press 'G', type 'PI', then RETURN). It can also be run from BASIC by typing 'BOOT 'PI.O'' (RETURN)'.

PRDEC

A subroutine to print A,X in decimal. It uses locations NL, NH, NFL (scratch) and JUST. Just should contain 0 for left justification, and $20 for right justification.

PRINTHEX

A routine to print A,X in hex. The entry at PRBYTE can also be used to print the byte in A only, or the entry at PRNIB can be used to print a nibble. VAR must be used to set]1 to 0 if the UC/graphics character set is in use, or]1 must be set to $20 if the LC/UC character set is in use.

INPUT

This routine gets input from the current input device (usually the keyboard) and stores it at]2. The input is terminated by a carriage return and can be a maximum of]1 characters in length (256 characters if]1 = 0). If the standard input buffer $200 is used for]2, then]1 cannot be greater than $58.

GETERR

This routine gets the error message from the current disk drive and prints it to the screen. The device number is assumed to be in FA.

READKEY

A routine to get a key from the keyboard or input device. The routine turns on the cursor, then turns it off when the character has been received. The character is returned in the A-register.

MULTIDIV

This file contains 16 bit multiply and divide routines. Three 16 bit (two byte) locations ACC, AUX, and EXT must be set up, preferably on zero page.

ASCHEX

This routine converts the ASCII string located at ASCSTR to a two byte hex number located at NUM and NUM+1. Use the VAR statement to set]1 to 'f or 'F' according to which ASCII set is desired . This routine ignores extra leading digits, thus 'ABCDE' will be converted to $BCDE and so on.

BASIC HEADER

Put this routine at the start of a program to be able to 'RUN' it.

KERNEL EQUATES

This file contains over 70 common kernel equates.

GLOSSARY

ABORT	terminate an operation prematurely.
ACCESS	locate or retrieve data.
ADDRESS	a specific location in memory.
ALGORITHM	a method of solving a specific problem.
ALLOCATE	set aside or reserve space.
ASCII	industry standard system of 128 computer codes assigned to specified alpha-numeric and special characters.
BASE	in number systems, the exponent at which the system repeats itself; the number of symbols required by that number system.
BINARY	the base two number system, composed solely of the numbers zero and one.
BIT	one unit of binary data, either a zero or a one.
BRANCH	continue execution at a new location.
BUFFER	large temporary data storage area.
BYTE	Hex representation of eight binary bits.
CARRY	flag in the 6502 status register.
CHIP	tiny piece of silicon or germanium containing many integrated circuits.
CODE	slang for data or machine language instructions.
CTRL	abbreviation for control or control character.
CURSOR	character, usually a flashing inverse space, which marks the position of the next character to be typed.
DATA	facts or information used by, or in a computer program.
DECREMENT	decrease value in constant steps.

DEFAULT	nominal value or condition assigned to a parameter if not specified by the user.
DELIMIT	separate, as with a: in a BASIC program line.
DISPLACEMENT	constant or variable used to calculate the distance between two memory locations.
EQUATE	establish a variable.
EXPRESSION	actual, implied or symbolic data.
FETCH	retrieve or get.
FIELD	portion of a data input reserved for a specific type of data.
FLAG	register or memory location used for preserving or establishing a status of a given operation of condition.
HEX	the Hexadecimal (BASE 16) number system, composed of the numbers 0-9 and the letters A-F.
HIGH ORDER	the first, or most significant byte of a two-byte Hex address or value.
HOOK	vector address to an I/O routine or port.
INCREMENT	increase value in constant steps.
INITIALIZE	set all program parameters to zero, normal, or default condition.
I/O	input/output.
INTERFACE	method of interconnecting peripheral equipment.
INVERT	change to the opposite state.
LABEL	name applied to a variable or address, usually descriptive of its purpose.
LOOKUP	slang; see table.
LOW-ORDER	the second, or least significant byte of a two-byte Hex address or value.
LSB	least significant (bit or byte) one with the least value.

MACRO	in assemblers, the capability to "call" a code segment by a symbolic name and place it in the object file.
MICROPROCESSOR	heart of a microcomputer.
MOD	algorithm returning the remainder of a division operation.
MODE	particular sub-type of operation.
MODULE	portion of a program devoted to a specific function.
MNEMONIC	symbolic abbreviation using characters helpful in recalling a function.
MSB	most significant (bit or byte), one with the greatest value.
NULL	without value.
OBJECT CODE	ready to run code produced by an assembler program.
OFFSET	value of a displacement.
OPCODE	instruction to be executed by the 6502.
OPERAND	data to be operated on by a 6502 instruction.
PAGE	a 256-byte area of memory named for the first byte of its Hex address.
PARAMETER	constant or value required by a program or operation to function.
PERIPHERAL	external device.
POINTER	memory location containing an address to data elsewhere in memory.
PORT	physical interconnection point to peripheral equipment.
PROMPT	a character asking the user to input data.
PSEUDO	artificial, a substitute for.
RAM	Random Access Memory.
REGISTER	single 6502 or memory location.

RELATVE	branch made using an offset or displacement.
ROM	Read Only Memory.
SIGN BIT	bit eight of a byte; negative if value greater than $80.
SOURCE CODE	Data entered into an assembler which will produce a machine language program when assembled.
STACK	temporary storage area in RAM used by the 6502 and assembly language programs.
STRING	a group of ASCII characters usually enclosed by delimiters such as ' or ".
SWEET 16	program which simulates a 16 bit microprocessor.
SYMBOL	symbolic or mnemonic label.
SYNTAX	prescribed method of data entry.
TABLE	list of values, words, data referenced by a program.
TOGGLE	switch from one state to the other.
VARIABLE	alpha-numeric expression which may assume or be assigned a number of values.
VECTOR	address to be referenced or branched to.

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Merlin 128 Quick Reference Card

Full Screen Editor Commands

CONTROL KEY COMMANDS (line oriented)

The Control Key commands consist of cursor moves and line oriented commands.

Control-A	-----------------	Deletes characters to end of line
Control-B	-----------------	Moves cursor to beginning of line
Control-D	-----------------	Deletes character under the cursor
Control-E	-----------------	Displays memory status window
Control-F	-----------------	Finds next occurrence of next character typed
Control-I	-----------------	Toggles insert and overstrike cursor
Control-L	-----------------	Toggles lower case conversion
Control-K	-----------------	Changes case of character under cursor
Control-N	-----------------	Moves cursor to end of line
Control-O	-----------------	Prefix key for typing control characters
Control-R	-----------------	Retrieves original line
Control-W	-----------------	Finds next occurrence of word in line
Control-X	-----------------	Cancels global exchange while in progress
Cursor keys	-----------------	Moves the cursor
DEL	---------------------	Deletes character to left of cursor
ESC	---------------------	Moves cursor to beginning of next line
HOME	---------------------	Remembers line for recall by **C=** HOME
INST	---------------------	Toggles insert and overstrike cursor
RETURN	-----------------	Moves cursor down and inserts blank line
TAB	---------------------	Toggles insert and overstrike cursor
Q	---------------------------	Quit Immediate Mode to Main Menu

COMMODORE KEY COMMANDS (entire listing oriented)

The Commodore Key commands are global commands, which means they are generally oriented to the whole listing, as opposed to just the current line (or a single character).

C= A	----------------------	Selects text for cut from line to end of file
C= B	----------------------	Moves to beginning. Cursor on eleventh line
C= C	----------------------	Start text selection/Copy selected text to clipboard
C= D	----------------------	Deletes line and places it in 'undo' buffer
C= E	----------------------	Global exchange (Search & Replace)
C= F	----------------------	Finds next occurrence of text entered
C= H	----------------------	Toggles half-screen mode
C= I	----------------------	Inserts blank line at cursor
C= L	----------------------	Finds first occurrence of label or line
C= N	----------------------	Moves cursor to end of listing
C= P	----------------------	Pastes contents of clipboard on current line
C= Q	----------------------	Quits editor and returns to Main Menu
C= R	----------------------	Exchanges current line with 'undo' buffer
C= W	----------------------	Finds next occurrence of whole word
C= X	----------------------	Cut selected text to clipboard
C= Z	----------------------	Current line becomes eleventh line on screen
C= Up	----------------------	Moves cursor up one page
C= Down	-----------------	Moves cursor down on page
C= Left	-----------------	Moves cursor up 10 lines
C= Right	-----------------	Moves cursor down 10 lines
C= DEL	-----------------	Deletes line above cursor; puts in 'undo' buffer
C= HOME	-----------------	Goes to line of last CTRL-HOME
C= TAB	-----------------	Inserts a blank line at cursor
C= ↑	----------------------	Produces 1*, 30 spaces, and 1 *
C= *	----------------------	Produces a line of 32 asterisks
C= -	----------------------	Produces a line of 1 * and 31 hyphens
C= =	----------------------	Produces a line of 1 * and 31 equal signs
C= ←	----------------------	Returns editor to Immediate Mode

Merlin 128™

Merlin 128 is an extremely powerful and complete macro assembler designed specifically for the Commodore 128. Best of all, like any powerful tool, it makes programming a breeze for the novice or pro! It consists of the **Merlin 128 Editor/Assembler** itself, plus extra demonstration and utility programs to make one of the most complete assembler systems available for any personal computer. Merlin 128 includes:

- **FILE MANAGEMENT** commands such as Load and Save Source, Save Object Code, Read and Write Text Files, Catalog disks, Append File, Drive Change, Run Program, Disk Commands, Go to Basic, and Go to Monitor.
- **EDITOR** system for writing and editing programs with word-processor-like power. The **Full Screen Editor** offers over **45 commands** including Cut, Copy, Paste, Add, Edit, Insert, Delete, Goto Label, Global Find and Replace, and more. Printouts are formatted with headers and page breaks.
- **ASSEMBLER** system which incorporates such advanced features as Macros (can be nested), on-line Macro Libraries, Conditional Assembly, Assemble to Disk, Linked Files, Dummy program segments, and more.
- **LINKER** system for generating relocatable object code. Linker allows multiple input and output files.

Merlin 128 supports over **50 Assembler Directives** for extreme programming flexibility in data storage, string definition, checksums, cycle counts and more. It also provides support for **Local and Global Labels**, and **Entry and External Label Definitions** for use with the Linker.

Merlin 128 comes with a **Macro Library** of over 20 commonly used macro definitions and fundamental operations such as Add, Subtract, Print, Increment, Decrement, Move, Swap, Set Pointer, Compare Address, and Goto X, Y.

Sourceror is a sophisticated and easy-to-use disassembler that creates Merlin 128 source files from binary programs. It is very fast and automatically assigns labels (from a list you can edit) to all recognizable addresses.

Merlin 128 also includes over **20 additional Sample and Utility Programs** such as:

- **XREF** to generate cross-reference listings of all labels and addresses used within the source program.
- **Altkeys** and **Keydefs** to create your own keyboard command macros and Function Key assignments. Includes 36 handy, predefined macros for your convenience.
- **Copy** and **Zap**, 1571 disk copy and editing programs which use one or two drives.
- **Hires** and **Swish**, demonstrations of fast Hi-Res graphics line drawing and plotting routines.
- **Ram Test**, a RAM testing program that uses the Hi-Res screen and 80 column text.

Merlin 128 requires a Commodore 128 and at least one 1571 disk drive or equivalent.

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