

FLEX Assembler



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I . INTRODUCTION

The 6809 Mnemonic Assembler is a fast and powerful disk based assembler interfaced to the FLEXt disk operating system. It accepts all standard Motorola mnemonics for the 6809 instruction set as well as all standard 6800 and 6801 mnemonics. Macros and conditional assembly are supported as well as numerous other directives for convenient assembler control. The assembler executes in two passes and can accept any size file on the disk so long as sufficient memory is installed to contain the symbol table. Output is in the form of a binary disk file or a hexadecimal tape as well as an assembled listing output which may be routed to a printer or to a disk file through the facilities of FLEX.

This manual is by no means intended to teach the reader assembly language programming nor even the full details of the 6809 instruction set. It assumes the user has a working knowledge of assembly language programming and a manual describing the 6809 instruction set and addressing modes in full. The former can be acquired through any of a large number of books available on assembly programming, the latter from the 6809 hardware manufacturer or seller.

Throughout the manual a couple of notational conventions are used which are explained here. The first is the use of angle brackets ('<' and '>'). These are often used to enclose the description of a particular item. This item might be anything from a filename to a macro parameter. It is enclosed in angle brackets to show that it is a single item even though the description may require several words. The second notation is the use of square brackets ('[' and ']'). These are used to enclose an optional item.

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II.A GETTING THE SYSTEM STARTED

The disk version of the 6809 Mnemonic Assembler is very simple to use. There are no built-in editing functions - you must have a previously edited source file on disk before using the assembler. This file must be a standard FLEX text file which is simply textual lines terminated by a carriage return. There should be no line numbers or control characters (except for the carriage returns) in the file. When you have both the assembler and the edited source file on a disk or disks which are inserted in a powered up system, you are ready to begin.

The Command Line

The very minimum command line necessary to execute an assembly is as follows:

```
+++ASMB,<filename>
```

The three plus signs are FLEX's ready prompt, ASMB is the name of the assembler file (it has a .CMD extension), and the <filename> is the standard FLEX specification for the source file you wish to assemble. The <filename> defaults to a .TXT extension and to the assigned working drive if an explicit extension and drive number are not given. In this and forthcoming example command lines, a comma is used to separate items. It is also possible to use a space or spaces in this capacity.

As stated, this is the very minimum command which can be used. It is possible to supply many more parameters or options to the assembler, but if left off as in this example, the assembler will assume default parameters. Perhaps the most important options available are the two associated with output. We say two because there are two types of output available from the assembler: object code output and assembled source listing output. The options regarding the assembled source listing output will be described a little later.

The object code can be in the form of a binary disk file, a hex output to tape, or no object code output at all. Since no specifications are made concerning object code output in the above example, the assembler will assume the default case which is a binary disk file. Since no name was specified, the output binary file will assume the same name as the input source file specified but with a .BIN extension. If such a file already exists, you will be asked:

```
DELETE OLD BINARY (Y-N)?
```

to which you may respond 'Y' which will delete the existing file and continue to create the new file or 'N' which will immediately terminate the assembly, returning to FLEX with the old binary file remaining intact.

If you wish to create a binary file by another name or extension, you may do so by placing the desired file specification on the command line as follows:

```
+++ASMB,<input file spec>,<binary file spec>
```

This binary file specification will default to a .BIN extension and to the assigned working drive. If a file by that name already exists on the specified drive, you will be prompted as described above.

Specifying Assembly Options

Now we shall go one step further and add a set of single character option flags which may be set on the command line as follows:

```
+++ASMB,<input file spec>[,<binary file spec>][, +<option list>]
```

The square brackets indicate that the binary file spec and the option list are optional. The plus sign is required to separate the option list from the file specifications. The <option list> is a set of single character flags which either enable or disable a particular option. In all cases they reverse the sense of the particular option from its default sense. There may be any number of options specified and they may be specified in any order. There may not be spaces within the option list. Following is a list of the available options and what they represent:

- B Do not create a binary file on the disk. No binary file will be created even if a binary file name is specified. This is useful when assembling a program to check for errors before the final program is completed or when obtaining a printed source listing.
- L Suppress the assembled listing output. If not specified, the assembler will output each line as it is assembled in pass 2, Those lines containing errors will always be printed regardless of whether or not this option is specified.
- S Suppress the symbol table output. The assembler normally prints out a sorted symbol table at the end of an assembly. This option suppresses that output. Note that the L option will not suppress the symbol table output, just the source itself.

- G Turns off printing of multiple line object code instructions. Certain directives (FCB, FDB, and FCC) can produce several lines of output listing for only one instruction line. This option prints the first line of output from such an instruction (the line which contains the source) but suppresses the printing of the subsequent lines which contain only object code information.
- N Enables the printing of decimal line numbers on each output line. These numbers are the consecutive number of the line as read by the assembler. Error lines are always output with the line number regardless of the start of this option.
- T Produce a hex output directly to tape. This output is formatted in the standard Motorola 'S1-S9' format. Consult the section on object code production for further details.
- Y This option overrides the prompt for deleting an existing binary file. In other words, if the Y option (stands for YES) is specified, an existing binary file of the same name as the one to be created will be automatically deleted without a prompt.
- D Suppress printing of the date in the header at the top of each output page. The assembler normally picks up the current date from FLEX and prints it in the header. This option causes the date to be omitted.
- W Suppress warning messages. The 6809 assembler is capable of reporting a number of warning messages as well as an indicator of long jumps and branches that could be shortened. This option suppresses the printing of these messages and indicators.
- P<no> This option allows the programmer to specify a page number at which to start printing of the assembled listing. Complete instructions can be found in the next paragraph.

Specifying a Starting Page Number

As mentioned in the 'P' option above, it is possible to specify a particular page number at which printing of the assembled listing should commence. All output before that page is suppressed INCLUDING ERROR LINES! When the specified page is hit, printing begins and continues to the end of the assembly. Note that it is possible to suspend or to completely terminate an assembly during output by use of the escape or escape/return sequence found in FLEX. The desired page number is specified right with the 'P' option in the option list. It must directly follow the 'P' and should be a decimal number from 1 to 65,536. The page number itself must be directly followed by a non-alphanumeric character (terminator) such as a comma or space. This implies that the 'P' option, if specified, MUST BE THE LAST OPTION SPECIFIED. The page number may also be followed or terminated by a plus sign as used in the following paragraph. It is also important to note that the PAG mode must be selected (pagination turned on) in order for the 'P' option to have any effect. The PAG mode may be turned on as described in the section on Standard Directives.

COMMAND LINE PARAMETERS

The assembler has a facility for passing information from the command line directly into the source program. A maximum of three pieces of information or "command line parameters" may be passed to the program. These parameters are simply strings of characters that will be substituted into the source listing as it is read in by the assembler. These parameters are expressed in the command line in the manner shown here:

```
+++ASMB,<in file>,<binary file>,<options>,<prm.1>,<prm.2>,<prm.3>
```

The parameters are optional but must be separated from the rest of the line by the second plus sign and from each other by commas. As stated, these parameters are simply strings of characters. They may be supplied in two ways: as a string of characters enclosed by a delimiter or just a string of characters with no spaces or commas embedded. The "delimiters" which can be used to enclose a string are the single quote (') and the double quote ("). Either can be used but for a particular string the beginning delimiter and the ending delimiter must be the same. The reason for using a delimited string is to pass in a string with commas and/or spaces which cannot be in an un-delimited string. Note that if one wishes to enter a command line parameter but no options, he must still place both plus signs in the command as seen in this example command line:

```
+++ASMB,ANYFILE,++PARAMETER1,PARAMETER2
```

For further information on command line parameters and how to specify where in the source program these parameters should be substituted, see the section on Special Features.

OUTPUTTING TO A HARDCOPY DEVICE

The assembler does not have a built in means for outputting the assembled listing to a hardcopy device. This operation is, however, available through the facilities of FLEX. To do so one must use the 'P' command provided with FLEX. This 'P' command reads a printer driver file which you can supply to output to any hardcopy device you want. It effectively switches the output of the assembler from going to the terminal to going to the printer. For example:

```
+++P,ASMB,TESTFILE
```

would cause the assembled listing of the source file TESTFILE.TXT to be output to the printer. For further details of use of the 'P' command the FLEX User's Manual and Advanced Programmer's Guide.

EXAMPLES:

ASMB,TEST

Assembles a file called TEST-TXT on the assigned working drive and creates a binary file called TEST.BIN on the same drive. The assembled listing is output to the terminal as is the symbol table.

ASMB,TEST,+LS

Same as before except that no listing is output (except for any lines with errors) and no symbol table is output.

ASMB,0.TEST,1.TEST.CMD,+LSY

Assembles a file from drive 0 called TEST.TXT and produces a binary file on drive 1 called TEST.CMD. No listing or symbol table is output and if a file by the name of TEST.CMD already resides on drive 1, it will be automatically deleted before the assembly starts.

1.ASMB,0.TEST.BAK,+BNGS

Loads the assembler itself from drive 1 and assembles a file called TEST.BAK found on drive 0. No binary file is produced. The assembled listing is output with line numbers turned on and multiple line generated code turned off. No symbol table is printed.

ASMB,0.TEST.BAK,+GSBNP26

This command performs just like the last with two exceptions. First, the assembler itself is loaded from the whatever the assigned system drive is. Second, the assembled listing output does not begin until the assembler reaches page number 26.

0.ASMB,0.ASMB,0.ASMB,+GW,+MINI,'ASSEMBLER FOR 5" DISK'

This command looks a little confusing, but it was done to accentuate the method in which default extensions work. The assembler itself (a file called ASMB.CMD) is loaded from drive 0, the file called ASMB.TXT found on drive 0 is assembled, and a binary file is produced on drive 0 by the name ASMB.BIN. Note that it was not necessary to specify the binary file name in this case since ASMB.BIN is what the default would have been. The assembled listing is output with multiple line code generation suppressed and warning messages suppressed. There are two parameters which may be passed into the source listing. The first is the single word 'MINI'. The second parameter is the entire string, 'ASSEMBLER FOR 5" DISK', excluding the single quote delimiters (everything starting with the A and ending with the K).

III. ASSEMBLER OPERATION & SOURCE LINE COMPONENTS

The TSC Assembler is a 2 pass assembler. During pass one a symbolic reference table is constructed and in pass two the code is actually assembled, printing a listing and outputting object code if desired. The source may be supplied in free format as described below. Each line of source consists of the actual source statement terminated with a carriage return (0D hex). The source must be comprised of ASCII characters with their parity or 8th bit cleared to zero. Special meaning is attached to many of these characters as will be described later. Control characters (00 to FF hex) other than the carriage return (0DH) are prohibited from being in the actual source statement part of the line. Their inclusion in the source statement will produce undefined results. Each source line is comprised of up to four fields: Label, Opcode, Operand, and Comment. With two exceptions, every line must have an opcode while the other fields may or may not be optional. These two exceptions are:

- 1) "Comment Lines" may be inserted anywhere in the source and are ignored by the assembler during object code production. Comment lines may be either of two types:
 - a) Any line beginning with an asterisk (hex 2A) in column one.
 - b) A null line or a line containing only a carriage return. While this line can contain no text, it is still considered a comment line as it causes a space in the output listing.

- 2) lines which contain a label but no opcode or operand field.

SOURCE STATEMENT FIELDS

The four fields are described here along with their format specifications. The fields are free format which means there may be any number of spaces separating each field. In general, no spaces are allowed within a field.

LABEL OR SYMBOL FIELD:

This field may contain a symbolic label or name which is assigned the instruction's address and may be called upon throughout the source program.

- 1) The label must begin in column one and must be unique. Labels are optional. If the label is to be omitted, the first character of the line must be a space.
- 2) A label may consist of letters (A-Z or a-z), numbers (0-9), or an underscore (_ or 5F hex). Note that upper and lower case letters are not considered equivalent. Thus 'ABC' is a different label from 'Abc'.
- 3) Every label must begin with a letter.
- 4) Labels may be of any length, but only the first 6 characters are significant.
- 5) The label field must be terminated by a space or a return.

OPCODE FIELD:

This field contains the 6809 opcode (mnemonic) or pseudo-op. It specifies the operation that is to be performed. The pseudo-ops recognized by this assembler are described later in this manual.

- 1) The opcode is made up of letters (A-Z or a-z) and numbers (0-9). In this field, upper and lower case may be used interchangeably.
- 2) This field must be terminated by a space if there is an operand or by a space or return if there is no operand.

OPERAND FIELD:

The operand provides any data or address information which may be required by the opcode. This field may or may not be required, depending on the opcode. Operands are generally combinations of register specifications and mathematical expressions which can include constants, symbols, ASCII literals, etc. as explained later.

- 1) The operand field can contain no spaces.
- 2) This field is terminated with a space or return.
- 3) Any of several types of data may make up the operand: register specifications, numeric constants, symbols, ASCII literals, and the special PC designator.

COMMENT FIELD:

The comment field may be used to insert comments on each line of source. Comments are for the programmer's convenience only and are ignored by the assembler.

- 1) The comment field is always optional.
- 2) This field must be preceded by a space.
- 3) Comments may contain any characters from SPACE (hex 20) thru DELETE (hex 7F).
- 4) This field is terminated by a carriage return.

REGISTER SPECIFICATION

Many opcodes require that the operand following them specify one or more registers. EXG and TFR require two registers specified, push and pull allow any number, and the indexed addressing mode requires specification of the register by which indexing is to be done. The following are possible register names:

A,B,CC,DP,X,Y,U,S,D,PC

The EXG and TFR instructions require two register specs separated by a comma. The push and pull instructions allow any number of registers to be specified, again, separated by commas. Indexed addressing requires one of X,Y,U, or S as explained under the indexed addressing mode description.

EXPRESSIONS

Many opcodes require that the operand supply further data or information in the form of an expression. This expression may be one or more items combined by any of four operator types: arithmetic, logical, relational, and shift.

Expressions are always evaluated as full 16 bit operations. If the result of the operation is to be only 8 bits, the assembler truncates the upper half. If truncation occurs when warnings are enabled, an appropriate message will be issued.

No spaces may be imbedded in an expression.

ITEM TYPES:

The "item or items" used in an expression may be any of four types as listed below. These may stand alone or may be intermixed by the use of the operators.

- 1) NUMERICAL CONSTANTS: Numbers may be supplied to the assembler in any of the four number bases shown below. The number given will be converted to 16 bits truncating any numbers greater than that. If 8 bit numbers are required, the 16 bit number will then be further truncated to 8 bits with notification of such if warning messages are enabled. To specify which number base is desired, the programmer must supply a prefix character to a number as detailed below.

BASE	PREFIX	CHARACTERS ALLOWED
Decimal	none	0 thru 9
Binary	%	0 or 1
Octal	@	0 thru 7
Hexadecimal	\$	0 thru 9, A thru F

If no prefix is assigned, the assembler assumes the number to be decimal.

- 2) ASCII CONSTANTS: The binary equivalent of a single ASCII printable character may be supplied to the assembler by preceding it with a single quote. The character should be between 20 and 7F hex.
- 3) LABELS: Labels which have been assigned some address or constant value may be used in expressions. As described above under the label field, a label is comprised of letters, digits, and hyphens beginning with a letter. The label may be of any length, but only the first 6 characters are significant. Any label used in the operand field must be defined elsewhere in the program.
- 4) PC DESIGNATOR: The asterisk (*) has been set aside as a special PC designator (Program Counter). It may be used in an expression just as any other value and is equal to the address of the current instruction.

EXPRESSION OPERATORS

As mentioned previously, the four classes of operators are: arithmetic, logical, relational, and shift. These operators permit assembly-time operations such as addition or division to take place. "Assembly-time" means that the expression is evaluated during the assembly and the result becomes a permanent part of your program.

a) ARITHMETIC OPERATORS

The arithmetic operators are as follows:

Operator	Meaning
+	Unary or binary addition
-	Unary or binary subtraction
*	Multiplication
/	Division (any remainder is discarded)

b) LOGICAL OPERATORS

The logical operators are as follows:

Operator	Meaning
&	logical AND operator
	Logical OR operator
!	Logical NOT operator
>>	Shift right operator
<<	Shift left operator

The logical operations are full 16 bit operations. In other words for the AND operation, every bit from the first operand or item is individually AND'ed with its corresponding bit from the second operand or item. The shift operators shift the left term the number of places indicated by the right term. Zeroes are shifted in and bits shifted out are lost.

c) RELATIONAL OPERATORS

The relational operators are as follows:

Operator	Meaning
=	Equal
<	Less than
>	Greater than
<>	Not equal
<=	Less than or equal
>=	Greater than or equal

The relational operations yield a true-false result. If the evaluation of the relation is true, the resulting value be all ones. If false, the resulting value will be all zeros. Relational operations are generally used in conjunction with conditional assembly as shown in that section.

OPERATOR PRECEDENCE

Certain operators take precedence over others in an expression. This precedence can be overcome by use of parentheses. If there is more than one operator of the same priority level and no parentheses to indicate the order in which they should be evaluated, then the operations are carried out in a left to right order.

The following list classifies the operators in order of precedence (highest priority first):

- 1) Parenthesized expressions
- 2) Unary + and -
- 3) Shift operators
- 4) Multiply and Divide
- 5) Binary Addition and Subtraction
- 6) Relational Operators
- 7) Logical NOT Operator
- 8) Logical AND and OR Operators

IV. The INSTRUCTION SET

This section is a quick introduction to the 6809 architecture and instruction set. It is by no means complete. The intention is to familiarize the user who is already proficient at 6800 assembly language programming with the basic structure of 6809 assembly language. For more complete details on the 6809 instruction set you should obtain the proper documentation from the hardware manufacturer.

PROGRAMMING MODEL

The 6809 microprocessor has 9 registers that are accessible by the programmer. Four of these are 8-bit registers while the other five are 16-bit registers. Two of the 8-bit registers can, in some instances, be referenced as one 16-bit registers. The registers are as follows:

The 'A' accumulator (A)	8 bit
The 'B' accumulator (B)	8 bit
The Condition Code register (CC)	8 bit
The Direct Page register (DP)	8 bit
The 'X' index register (X)	16 bit
The 'Y' index register (Y)	16 bit
The User stack pointer (U)	16 bit
The System stack pointer (S)	16 bit
The Program Counter (PC)	16 bit

The A and B accumulators can often be referenced as one 16-bit register represented by a 'D' (for Double-accumulator). In these cases, the A accumulator is the most significant half.

THE ADDRESSING MODES

There are several possible addressing modes in the 6809 instruction set. One of the best features of the 6809 is the consistency or regularity built into the instruction set. For the most part, any instruction which addresses memory can use any of the addressing modes available. It is not necessary to remember which instructions can use which addressing modes, etc. The addressing modes and a brief description of each follow.

1) Inherent

Inherent addressing refers to those instructions which have no addressing associated with them.

Example: ABX add B accumulator to X

- 2) Accumulator
Accumulator addressing is done in those instructions which can specify the A or B accumulator. In some cases this may be the 16-bit D accumulator.
Example: DECA decrement the A accumulator

- 3) Immediate
In Immediate addressing the byte or bytes following the opcode are the information being addressed. These byte or bytes are specified as part of the instruction.
Example: LDA #8 load immediate value (8) into A

- 4) Relative - Long and Short
In Relative addressing, the value of the byte(s) immediately following the opcode (1 if short, 2 if long) are added as a two's complement number to the current value of the program counter (PC register) to produce a new PC location. In the source code, the programmer specifies the desired address to which execution should be transferred and the assembler determines the correct offset to place after the opcode.
Example: LBRA THERE the program will branch to THERE

- 5) Extended
In Extended addressing, the two bytes (16-bits) following the opcode are used as an absolute memory address value.
Example: LDA \$1000 load A from memory location 1000 hex

- 6) Direct
In Direct addressing, the single byte (8-bits) following the opcode is used as a pointer into a 256-byte window or "page" of memory. The page used for this purpose is the one currently found in the Direct Page register. Thus, the effective address is a concatenation of the Direct Page register as the most significant half and the byte following the opcode as the least significant half.
Example: LDA \$22 load A from memory location \$XX22 where XX represents the contents of the DP register

- 7) Extended Indirect
In Extended Indirect addressing, the 16-bit value following the opcode is used to point to two bytes in memory which are used as the effective address.
Example: LDA [\$A012] loads A from the address stored at locations \$A012 and \$A013

8) Indexed

The Indexed addressing mode of the 6809 is an extremely powerful method of specifying addresses which is, in general, some sort of offset from the value stored in one of the registers X, Y, U, S, or PC. There are several forms of indexed addressing which could each be considered an addressing mode in itself. We will, however, discuss each as a subset of Indexed addressing in general. Note that except for the Auto-increment and Auto-decrement modes, determining the effective address has no effect on the register being used as the index.

8a) Constant-Offset Indexed

This mode uses a two's complement offset value found in the byte or bytes following the opcode. The offset is added to the contents of the specified register to produce a 16-bit effective address. The offset may be represented as a number, a symbol, or any valid expression. It can be either positive or negative and can be a full 16-bits.

Example: LDA 0,X loads A from location pointed to by X
 LDA 5216,Y loads A from (Y) plus 5216
 LDA -36,U loads A from (U) minus 36
 LDA VAL,S loads A from (S) plus VAL

8b) Accumulator Indexed

In Accumulator indexing, the contents of the specified accumulator (A, B, or D) are added to the specified indexing register as a two's complement value. The result is the effective address.

Example: LDA B,Y loads A from (B)+(Y)
 LDX D,S loads X from (D)+(S)

8c) Auto-Increment

The contents of the selected register are used as the effective address with no offset permitted. After that effective address has been determined, the selected register is incremented by one (for single plus sign) or two (double plus sign).

Example: LDA 0,X+ loads A from X then bumps X by 1
 LDD ,Y++ loads D from Y then bumps Y by 2

8d) Auto-Decrement

In auto-decrementing, the selected register is first decremented by one (single minus sign) or two (double minus sign). The resulting value, with no offset, is used as the effective address.

Example: LDA 0,-U decrements U by 1 then loads A from address in U
 LDU ,--S decrements S by 2 then loads U from address in S

FURTHER ADDRESSING MODES

Indexed Indirect Addressing

All the Indexed Addressing modes above can also be used in an indirect fashion by enclosing the operand in square brackets. When this is done, the effective address as described in all the above modes is no longer the final effective address. Instead, the two bytes pointed to by that address are used as the effective address.

Examples: LDA [,X] loads A from the address pointed to by X
 LDX [D,U] loads X from the address pointed
 to by (U)+(D)

If auto-increment or auto-decrement addressing is done in an indirect fashion, they must be a double increment (two plus signs) or double decrement (two minus signs).

PC Relative Addressing

Indexing may be done from the PC register just as from the X, Y, U, or S. The general use of indexing from the PC register is to address some value in a position-independent manner. Thus if we address some value at the current PC plus 10, no matter where the program executes the value will always be addressed. The programmer does not usually know what that constant offset should be, he knows the address of the value he wants to access as an absolute value for the program as assembled. Thus a mechanism has been included in the assembler to automatically determine the offset from the current PC to that absolute address. This mechanism is called PC Relative Addressing. The value specified in a PC Relative address operand is the absolute value. The assembler takes the difference between this absolute value and the current PC and generates that offset as part of the assembled code for the instruction. PC Relative Addressing is distinguished from normal PC Offset Indexing by the use of 'PCR' as the register name instead of 'PC'.

Example: LEAX STRING,PCR
 this instruction determines the offset
 between the PC and STRING and uses it
 as an offset for the PC register to
 determine the effective address

FORCING DIRECT OR EXTENDED ADDRESSING

The 6809 assembler has a mechanism for forcing the assembler to perform either direct or extended addressing. Under normal conditions, the assembler will use direct addressing when possible. To force the assembler to use extended addressing no matter what the conditions, simply precede the operand with a greater than sign ('>'). For example, suppose the DP register was set to \$00 (this is the default on reset of the cpu), and that we have a label, BUFPNT, which is at memory location \$0010. Normally the instruction:

```
LDX BUFPNT
```

would be assembled with direct addressing. If we wished to force extended addressing we could simply enter:

```
LDX >BUFPNT
```

and the assembler would use extended addressing.

The same capability exists for forcing direct addressing by preceding the operand with a less than sign ('<'). For example:

```
LDX <BUFPNT
```

would force direct addressing. Note that in both cases the greater than or less than sign must be the first character in the operand.

THE ASSEMBLER INSTRUCTION SET

This section contains a brief listing of all the mnemonics accepted by the 6809 assembler. They are listed in four sections, standard 6809 with alternate 6800, 6800 mnemonics not found in 6809, 6801 mnemonics, and non-standard convenience mnemonics. Before the listing, we must setup some notational conventions:

- (P) Operand containing immediate, extended, direct, or indexed addressing.
- (Q) Operand containing extended, direct, or indexed addressing.
- (T) Operand containing indexed addressing only.
- R Any register specification: A, B, X, Y, U, S, PC, CC, DP, or D.
- dd 8 bit data value
- dddd 16 bit data value

6809 MNEMONICS WITH 6800 ALTERNATES

- ABX Add B into X
SOURCE FORM: ABX
- ADC Add with carry into register
SOURCE FORM: ADCA (P); ADCB (P)
6800 ALTERNATES: ADC A (P); ADC B (P)
- ADD Add into register
SOURCE FORM: ADDA (P); ADDB (P); ADDD (P)
6800 ALTERNATES: ADD A (P); ADD B (P)
- AND Logical 'AND' into register
SOURCE FORM: ANDA (P); ANDB (P)
6800 ALTERNATES: AND A (P); AND B (P)
- ANDCC Logical 'AND' immediate into CC
SOURCE FORM: ANDCC #dd
- ASL Arithmetic shift left
SOURCE FORM: ASLA; ASLB; ASL (Q)
6800 ALTERNATES: ASL A; ASL B

ASR Arithmetic shift right
 SOURCE FORM: ASRA; ASRB; ASR (Q)
 6800 ALTERNATES: ASR A; ASR B

BCC, LBCC Branch (short or long) if carry clear
 SOURCE FORM: BCC dd; LBCC dddd

BCS, LBCS Branch (short or long) if carry set
 SOURCE FORM: BCS dd; LBCS dddd

BEQ, LBEQ Branch (short or long) if equal
 SOURCE FORM: BEQ dd; LBEQ dddd

BGE, LBGE Branch (short or long) if greater than or equal
 SOURCE FORM: BGE dd; LBGE dddd

BGT, LBGT Branch (short or long) if greater than
 SOURCE FORM: BGT dd; LBGT dddd

BHI, LBHI Branch (short or long) if higher
 SOURCE FORM: BHI dd; LBHI dddd

BHS, LBHS Branch (short or long) if higher or same
 SOURCE FORM: BHS dd; LBHS dddd

BIT Bit test
 SOURCE FORM: BITA (P); BITB (P)
 6800 ALTERNATES: BIT A (P); BIT B (P)

BLE, LBLE Branch (short or long) if less than or equal to
 SOURCE FORM: BLE dd; LBLE dddd

BLO, LBLO Branch (short or long) if lower
 SOURCE FORM: BLO dd; LBLO dddd

BLS, LBLS Branch (short or long) if lower or same
 SOURCE FORM: BLS dd; LBLS dddd

BLT, LBLT Branch (short or long) if less than
 SOURCE FORM: BLT dd; LBLT dddd

BMI, LBMI Branch (short or long) if minus
 SOURCE FORM: BMI dd; LBMI dddd

BNE, LBNE Branch (short or long) if not equal
 SOURCE FORM: BNE dd; LBNE dddd

BPL, LBPL Branch (short or long) if plus
 SOURCE FORM: BPL dd; LBPL dddd

BRA, LBRA Branch (short or long) always
SOURCE FORM: BRA dd; LBRA dddd

BRN, LBRN Branch (short or long) never
SOURCE FORM: BRN dd; LBRN dddd

BSR, LBSR Branch (short or long) to subroutine
SOURCE FORM: BSR dd; LBSR dddd

BVC, LBVC Branch (short or long) if overflow clear
SOURCE FORM: BVC dd; LBVC dddd

BVS, LBVS Branch (short or long) if overflow set
SOURCE FORM: BVS dd; LBVS dddd

CLR Clear
SOURCE FORM: CLRA; CLRB; CLR (Q)
6800 ALTERNATES: CLR A; CLR B

CMP Compare
SOURCE FORM: CMPA (P); CMPB (P); CMPD (P); CMPX (P);
CMPY (P); CMPU (P); CMPS (P)
6800 ALTERNATES: CMP A (P); CMP B (P); CPX (P)

COM Complement (One's complement)
SOURCE FORM: COMA; COMB; COM (Q)
6800 ALTERNATES: COM A; COM B

CWAI Clear and wait for interrupt
SOURCE FORM: CWAI #dd

DAA Decimal adjust accumulator A
SOURCE FORM: DAA

DEC Decrement
SOURCE FORM: DECA, DECB, DEC (Q)
6800 ALTERNATES: DEC A; DEC B

EOR Exclusive 'OR'
SOURCE FORM: EORA (P); EORB (P)
6800 ALTERNATES: EOR A (P); EOR B (P)

EXG Exchange registers
SOURCE FORM: EXG R1,R2

INC Increment
SOURCE FORM: INCA, INCB, INC (Q)
6800 ALTERNATES: INC A; INC B

JMP Jump to address
 SOURCE FORM: JMP dddd

JSR Jump to subroutine at address
 SOURCE FORM: JSR dddd

LD Load register from memory
 SOURCE FORM: LDA (P); LDB (P); LDD (P); LDX (P);
 LDY (P); LDU (P); LDS (P)
 6800 ALTERNATES: LDAA (P); LDAB (P); LDA A (P); LDA B (P)

LEA Load effective address
 SOURCE FORM: LEAX (T); LEAY (T); LEAU (T); LEAS (T)

LSL Logical shift left
 SOURCE FORM: LSLA; LSLB; LSL (Q)

LSR Logical shift right
 SOURCE FORM: LSRA; LSRB; LSR (Q)
 6800 ALTERNATES: LSR A; LSR B

MUL Multiply accumulators
 SOURCE FORM: MUL

NEG Negate (Two's complement)
 SOURCE FORM: NEGA; NEGB; NEG (Q)
 6800 ALTERNATES: NEG A; NEG B

NOP No operation
 SOURCE FORM: NOP

OR Inclusive 'OR' into register
 SOURCE FORM: ORA (P); ORB (P)
 6800 ALTERNATES: ORAA (P); ORAB (P); ORA A (P); ORA B (P)

ORCC Inclusive 'OR' immediate into CC
 SOURCE FORM: ORCC #dd

PSHS Push registers onto system stack
 SOURCE FORM: PSHS (register list); PSHS #dd
 6800 ALTERNATES: PSRA; PSRB; PSH A; PSH B

PSHU Push registers onto user stack
 SOURCE FORM: PSHU (register list); PSHU #dd

PULS Pull registers from system stack
 SOURCE FORM: PULS (register list); PULS #dd
 6800 ALTERNATES: PULA; PULB; PUL A; PUL B

PULU Pull registers from user stack
 SOURCE FORM: PULU (register list); PULU #dd

ROL Rotate left
SOURCE FORM: ROLA; ROLB; ROL (Q)
6800 ALTERNATES: ROL A; ROL B

ROR Rotate right
SOURCE FORM: RORA; RORB; ROR (Q)
6800 ALTERNATES: ROR A; ROR B

RTI Return from interrupt
SOURCE FORM: RTI

RTS Return from subroutine
SOURCE FORM: RTS

SBC Subtract with borrow
SOURCE FORM: SBCA (P); SBCB (P);
6800 ALTERNATES: SBC A (P); SBC B (P)

SEX Sign extend
SOURCE FORM: SEX

ST Store register into memory
SOURCE FORM: STA (P); STB (P); STD (P); STX (P);
 STY (P); STU (P); STS (P)
6800 ALTERNATES: STAA (P); STAB (P); STA A (P); STA B (P)

SUB Subtract from register
SOURCE FORM: SUBA (P); SUBB (P); SUBD (P)
6800 ALTERNATES: SUB A (P); SUB B, (P)

SWI Software interrupt
SOURCE FORM: SWI

SWI2 Software interrupt 2
SOURCE FORM: SWI2

SWI3 Software interrupt 3
SOURCE FORM: SWI3

SYNC Synchronize to interrupt
SOURCE FORM: SYNC

TFR Transfer register to register
SOURCE FORM: TFR R1,R2

TST Test
SOURCE FORM: TSTA; TSTB; TST (Q)
6800 ALTERNATES: TST A; TST B

SIMULATED 6800 INSTRUCTIONS

ABA	Add B to A
CBA	Compare B to A
CLC	Clear carry bit
CLI	Clear interrupt mask
CLV	Clear overflow bit
DES	Decrement stack pointer
DEX	Decrement X
INS	Increment stack pointer
INX	Increment X
SBA	Subtract B from A
SEC	Set carry bit
SEI	Set interrupt mask
SEV	Set overflow bit
TAB	Transfer A to B
TAP	Transfer A to CC
TBA	Transfer B to A
TPA	Transfer CC to A
TSX	Transfer S to X
TXS	Transfer X to S
WAI	Wait for interrupt

SIMULATED 6801 MNEMONICS

ASLD	Arithmetic shift left D
LSRD	Logical shift right D
PSHX	Push the X register
PULX	Pull the X register
LDAD	Load accumulator D from memory
STAD	Store accumulator D into memory

CONVENIENCE MNEMONICS

BEC, LBEC	Branch (short or long) if error clear
BES, LBES	Branch (short or long) if error set
CLF	Clear FIRQ interrupt mask
CLZ	Clear zero condition code bit
SEF	Set FIRQ interrupt mask
SEZ	Set zero condition code bit

V. STANDARD DIRECTIVES OR PSEUDO-OPS

Besides the standard machine language mnemonics, the TSC assembler supports several directives or pseudo-ops. These are instructions for the assembler to perform certain operations, and are not directly assembled into code. There are three types of directives in this assembler, those associated with macros, those associated with conditional assembly, and those which generally can be used anywhere which we shall call "standard directives". This section is devoted to descriptions of these directives which are briefly listed here:

ORG	SETDP
END	PAG
RMB	SPC
FCB	NAM or TTL
FDB	STTL
FCC	ERR
EQU	RPT
SET	LIB
REG	OPT

Descriptions of each directive and its use follow.

ORG

The ORG statement is used to set a new code 'Origin'. This simply means that a new address is set into the location Counter (or program counter) so that subsequent code will be placed at the new location. The form is as follows:

```
ORG <expression>
```

No label may be placed on an ORG statement and no code is produced. If no ORG statement appears in the source, an origin of 0000 is assumed.

END

The END pseudo-op is used to signal the assembler that the end of the source input has occurred. This terminates whatever pass is currently being executed. No label is allowed and no code is generated. An expression may be given (as shown below) as the transfer address to be placed in a binary file. It is optional, and if supplied when no binary file is being produced, will be ignored.

```
END [<expression>]
```

Note that an end statement is not strictly required, but is the only means of getting a transfer address appended to a binary output file.

RMB

The RMB or Reserve Memory Bytes directive is used to reserve areas of memory for data storage. The number of bytes specified by the expression in the operand are skipped during assembly. No code is produced in those memory location and therefore the contents are undefined at run time. The proper usage is shown here:

```
[<label>] RMB <expression>
```

The label is optional, and the expression is a 16 bit quantity.

FCB

The FCB or Form Constant Byte directive is used to set associated memory bytes to some value as determined by the operand. FCB may be used to set any number of bytes as shown below:

```
[<label>] FCB <expr. 1>,<expr. 2>,...<expr. n>
```

Where <expr. x> stands for some expression. Each expression given (separated by commas) is evaluated to 8 bits and the resulting quantities are stored in successive memory locations. The label is optional.

FDB

The FDB or Form Double Byte directive is used to setup 16 bit quantities in memory. It is exactly like the FCB directive except that 16 bit quantities are evaluated and stored in memory for each expression given. The form of the statement is:

```
[<label>] FDB <expr. 1>,<expr. 2>,...,<expr. n>
```

Again, the label field is optional.

FCC

The FCC or Form Constant Character directive allows the programmer to specify a string of ASCII characters delimited by some non-alphanumeric character such as a single quote. All the characters in the string will be converted to their respective ASCII values and stored in memory, one byte per character. Some valid examples follow:

```
LABEL1 FCC 'THIS IS AN FCC STRING'
LABEL2 FCC .SO IS THIS.
FCC /LABELS ARE NOT REQUIRED./
```

There is another method of using FCC which is a deviation from the standard Motorola definition of this directive. This allows you to place certain expressions on the same line as the standard FCC delimited string. The items are separated by commas and are evaluated to 8 bit results. In some respects this is like the FCB directive. The difference is that in the FCC directive, expressions must begin with a letter, number or dollar-sign whereas in the FCB directive any valid expression will work. For example, %10101111 would be a valid expression for an FCB but not for an FCC since the percent-sign would look like a delimiter and the assembler would attempt to produce 8 bytes of data from the 8 ASCII characters which follow (an FCC string). The dollar-sign is an exception to allow hex values such as \$0D (carriage return) to be inserted along with strings. Some examples follow:

```
INTRO FCC 'THIS STRING HAS CR & LF', $D, $A
      FCC 'STRING 1', 0, 'STRING 2'
      FCC $04, LABEL, /DELIMITED STRING/
```

Note that more than one delimited string may be placed on a line as in the second example.

EQU

The EQU or Equate directive is used to equate a symbol to the expression given in the operand. No code is generated by this statement. Once a symbol has been equated to some value, it may not be changed at a later time in the assembly. The form of an equate statement is as follows:

```
<label> EQU <expression>
```

The label is strictly required in equate statements.

SET

The SET directive is used to set a symbol to the value of some expression, much as an EQU directive. The difference is that a symbol may be SET several times within the source (to different values) while a symbol may be Equated only once. If a symbol is SET to several values within the source, the current value of the symbol will be the value last SET. The statement form is:

```
<label> SET <expression>
```

The label is strictly required and no code is generated.

REG

The REG directive allows the user to setup a list of registers for use by the push and pull instructions. This list is represented by a value and the value is equated to the label supplied. In this respect, the REG directive is similar to the EQU directive. The correct form of the REG directive is:

```
<label> REG <register list>
```

As an example, suppose a program has a large number of occurrences of the following instructions:

```
PSHS A,B,Y,U,DP
PULS A,B,Y,U,DP
```

To make things more convenient and less error prone the REG directive could be used as shown here:

```
RLIST2    REG A,B,Y,U,DP
```

Now all the pushes and pulls referred to above could be accomplished with the statements:

```
PSHS #RLIST2
PULS #RLIST2
```

Of course, the register list may still be typed out on push and pull instructions or an immediate value (with the desired bit pattern) may be specified.

SETDP

The SETDP or Set Direct Page directive allows the user to set which memory page the assembler will use for the direct page addressing mode. The correct format is as follows:

```
SETDP [<page value>]
```

As an example, if "SETDP \$D0" is encountered, the assembler will then use direct addressing for any address in the range of \$D000 to \$D0FF. It is important to note that this directive does not actually affect the contents of the direct page register. The value set is what will be used at assembly time to determine direct addressing, but it is up to the user to be sure the DP register corresponds at run time. If there is no <page value> supplied, direct addressing will be disabled and all addresses will be full 16 bit values. Any number of SETDP instructions may occur in a program. The default value is page 0 (for 6800 compatibility).

PAG

The PAG directive causes a page eject in the output listing and prints a header at the top of the new page. Note that the 'PAG' option must have been previously selected in order for this directive to take effect. It is possible to assign a new number to the new page by specifying such in the operand field. If no page number is specified, the next consecutive number will be used. No label is allowed and no code is produced. The PAG operator itself will not appear in the listing unless some sort of error is encountered. The proper form is:

PAG [<expression>]

Where the expression is optional. The first page of a listing does not have the header printed on it and is considered to be page 0. The intention here is that all options, title, and subtitle may be setup and followed by a PAG directive to start the assembled listing at the top of page 1 without the option, title, or subtitle instructions being in the way.

SPC

The SPC or Space directive causes the specified number of spaces (line feeds) to be inserted into the output listing. The general form is:

SPC [<space count>[,<keep count>]]

The space count can be any number from 0 to 255. If the page option is selected, SPC will not cause spacing past the top of a new page. The <keep count> is optional and is the number of lines which the user wishes to keep together on a page. If there are not enough lines left on the current page, a page eject is performed. If there are <keep count> lines left on the page (after printing <space count> spaces), output will continue on the current page. If the page option is not selected, the <keep count> will be ignored. If no operand is given (ie. just the directive SPC), the assembler will default to one blank line in the output listing.

TTL OR NAM

The TTL or NAM directive allows the user to specify a title or name to the program being assembled.. This title is then printed in the header at the top of each output listing page if the page option is selected. If the page option is not selected, this directive is ignored. The proper form is:

TTL <text for the title>
or
NAM <text for the title>

All the text following the TTL or NAM directive (excluding leading spaces) is placed in the title buffer. Up to 32 characters are allowed with any excess being ignored. It is possible to have any number of TTL

or NAM directives in a source program. The latest one encountered will always be the one used for printing at the top of the following page(s).

STTL

The STTL or Subtitle directive is used to specify a subtitle to be printed just below the header at the top of an output listing page. It is specified much as the TTL directive:

```
STTL <text for the subtitle>
```

The subtitle may be up to 52 characters in length. If the page option is not selected, this directive will be ignored. As with the TTL option, any number of STTL directives may appear in a source program. The subtitle can be disabled or turned off by an STTL command with no text following.

ERR

The ERR directive may be used to insert user-defined error messages in the output listing. The error count is also bumped by one. The proper form is:

```
ERR <message to be printed>
```

All text past the ERR directive (excluding leading spaces) is printed as an error message (it will be preceded by three asterisks) in the output listing. Note that the ERR directive line itself is not printed. A common use for the ERR directive is in conjunction with conditional assembly such that some user-defined illegal condition may be reported as an error.

RPT

The RPT or Repeat directive causes the succeeding line of source to be repeated some specified number of times. The syntax is as follows:

```
RPT <count>
```

where <count> may be any number from 1 to 127. For example, the following two lines:

```
RPT 4  
ASLB
```

would produce an assembled output of:

```
ASLB
ASLB
ASLB
ASLB
```

Some directives, such as IF or MACRO, may not be repeated with the RPT command. These cases are where it is illogical or impractical to do so. If attempted, the RPT will simply be ignored.

LIB

The LIB or Library directive allows the user to specify an external file for inclusion in the assembled source output. Under normal conditions, the assembler reads all input from the file specified on the calling line. The LIB directive allows the user to temporarily obtain the source lines from some other file. When all the lines in that external file have been read and assembled, the assembler resumes reading of the original source file. The proper syntax is:

```
LIB <file spec>
```

where <file spec> is a standard FLEX file specification. The default drive is the assigned working drive and the default extension is .TXT. Any END statements found in the file called by the LIB directive are ignored. The LIB directive line itself does not appear in the output listing. Any number of LIB instructions may appear in a source listing. It is also possible to nest LIB files up to 12 levels. Nesting refers to the process of placing a LIB directive within the source that is called up by another LIB directive. In other words, one LIB file may call another.

OPT

The OPT or Option directive allows the user to choose from several different assembly options which are available to him. These options are generally related to the format of the output listing and object code. The options which may be set with this command are listed below. There are several options not listed here which may be set from the FLEX command line. See the appropriate section earlier in the manual for these options. The proper form of this instruction is:

```
OPT <option 1>,<option 2>,...,<option n>
```

Note that any number of options may be given on one line if separated by commas. No label is allowed and no spaces may be imbedded in the option list. The options are all set during pass one only although the instruction is parsed in pass two as well for error reporting purposes. If contradicting options are specified, the last one appearing takes precedence. If a particular option is not specified, the default case for that option takes effect. The default cases are signified below by an asterisk.

The allowable options are:

PAG	enable page formatting and numbering
NOP*	disable pagination
CON	print conditionally skipped code
NOC*	suppress conditional code printing
MAC*	print macro calling lines
NOM	suppress printing of macro calls
EXP	print macro expansion lines
NOE*	Suppress macro expansion printing

* denotes default option and is not part of option name

VI. CONDITIONAL ASSEMBLY

This assembler supports "conditional assembly" or the ability to assemble only certain portions of your source program depending on the conditions at assembly time. Conditional assembly is particularly useful in situations where you might need several versions of a program with only slight changes between versions.

As an example, suppose we required a different version of some program for 4 different systems whose output routines varied. Rather than prepare four different source listings, we could prepare one which would assemble a different set of output routines depending on some variable which was set with an EQU directive near the beginning of the source. Then it would only be necessary to change that one EQU statement to produce any of the four final programs. This would make the software easier to maintain, as besides only needing to keep track of one copy of the source, if a change is required in the body of the program, only one edit is required to update all versions.

THE IF-ENDIF CLAUSE

In its simplest form, conditional assembly is performed with two directives: IF and ENDIF. The two directives are placed in the source listing in the above order with any number of lines of source between. When the assembler comes across the IF statement, it evaluates the expression associated with it (we will discuss this expression in a moment) and if the result is true, assembles all the lines between the IF and ENDIF and then continues assembling the lines after the ENDIF. If the result of the expression is false, the assembler will skip all lines between the IF and ENDIF and resume assembly of the lines after the ENDIF. The proper syntax of these directives is as follows:

```
IF <expression>
    . conditional code goes here
ENDIF
```

The ENDIF requires no additional information but the IF requires an expression. This expression is considered FALSE if the 16-bit result is equal to zero. If not equal to zero, the expression is considered TRUE.

A more powerful conditional assembly construct is possible with the ELSE directive. The ELSE directive may be placed between the IF and ENDIF statements. Its effect is to switch the sense of the test for the lines between it and the ENDIF. In effect, the lines of source between the IF and ENDIF are split into two groups by the ELSE statement. Those lines before the ELSE are assembled if the expression is true while those after (up to the ENDIF) are ignored. If the expression is false, the lines before the ELSE are ignored while those after it are assembled. The IF-THEN-ELSE construct appears as follows:

```

IF <expression>
.   this code assembled if expression is true
.
ELSE
.   this code assembled if expression is false
.
ENDIF

```

The ELSE statement does not require an operand and there may be only one ELSE between an IF-ENDIF pair.

It is possible to nest IF-ENDIF clauses (including ELSE's). That is to say, an IF-ENDIF clause may be part of the lines of source found inside another IF-ENDIF clause. You must be careful, however, to terminate the inner clause before the outer.

There is another form of the conditional directive, namely IFN which stands for "IF Not". This directive functions just like IF except that the sense of the test is reversed. Thus the code immediately following is assembled if the result of the expression is NOT TRUE. An IFN-ELSE-ENDIF clause appears as follows:

```

IFN <expression>
.   this code assembled if expression is FALSE
.
ELSE
.   this code assembled if expression is TRUE
.
ENDIF

```

THE IFC-ENDIF CLAUSE

Another form of conditional assembly is very similar to the IF-ENDIF clause defined above, but depends on a comparison of two strings for its conditionality instead of a true-false expression. This type of conditional assembly is done with the IFC and IFNC directives (for "IF Compare" and "IF Not Compare") as well as the ELSE and ENDIF discussed above. Thus for the IFC directive we have a clause like:

```

IFC <string 1>,<string 2>
.   this code assembled if strings are equal
.
ELSE
.   this code assembled if strings are not equal
.
ENDIF

```

As can be seen, the two strings are separated by a comma. There are two types of strings, one enclosed by delimiters the other not. The delimited type may use either a single quote (') or double quote (") as the delimiter. This type of string is made up of all the characters after the first delimiter until the second delimiter is found. The second type of string is simply a group of characters, starting with a non-space and containing no spaces or commas. Thus if you need spaces or commas in a string, you must use the delimited type of string. It is possible to specify a null string by placing two delimiters in a row or by simply leaving the string out completely. Note that there may be no spaces after string 1 and before the separating comma nor after the comma and before string 2. As with IFN, the IFNC directive simply reverses the sense of the test such that code immediately following an IFNC directive would be assembled if the strings did NOT compare.

A common application of this type of conditional assembly is in macros (defined in the next section) where one or both of the strings might be a parameter passed into the macro.

THE IF-SKIP CLAUSE

The IF-skip type of conditional assembly is a method which does not use (in fact does not allow) a related ENDIF or ELSE. Instead, the assembler is caused to skip a specified number of lines of source depending on the result of the expression or string comparison.

IMPORTANT NOTE:

This type of conditional assembly is
ONLY allowed within the body of a macro.
Any use of it outside a macro will
result in an error. Macros are defined
in the next section.

As before, the possible directives are: IF, IFN, IFC, and IFNC. This type of conditional assembly is performed with a single instruction. Instead of code being assembled on a true result, the specified number of lines are SKIPPED. This number of lines can be in a forward or reverse direction. The syntax is as shown:

```
IF <expression>,<skip count>
   or
IFC <string 1>,<string 2>,<skip count>
```

The skip count must be a decimal number between 1 and 255. It may be preceded by a plus or minus sign. A positive number produces a forward skip while a negative number produces a backwards skip. A skip count of zero has no effect (the instruction following the IF directive will be executed next). A skip count of one will cause the second line after the IF statement to be the next one executed (the one line directly following the IF statement is ignored). A skip count of negative one will cause the line just before the skip count to be the next one executed. The assembler will not skip past the end or beginning of the macro which contains the IF-skip statement. If a skip count is specified which is beyond these limits, the assembler will be left

to the last statement in the macro or the first, depending on whether the skip count was positive or negative. There can be no spaces before or after the comma which separates the skip count from the expression or from string 2.

IMPORTANT NOTE

In order for conditionals to function properly, they must be capable of evaluation in pass one so that the same result will occur in pass two. Thus if labels are used in a conditional expression, they must have been defined in the source before the conditional directive is encountered.

VII. MACROS

A macro is a facility for substituting a whole set of instructions and parameters in place of a single instruction or call to the macro. There are always two steps to the use of macros, the definition and the call. In the definition we specify what set of instructions make up the body of the macro and assign a name to it. This macro may then be called by name with a single assembler instruction line. This single line is replaced by the body of the macro or the group of lines which were defined as the macro. This replacement of the calling line with the macro body is called the macro "expansion". It is also possible to provide a set of parameters with the call which will be substituted into the desired areas of the macro body.

A simple example will assist in the understanding of macros. Let us define a macro which will shift the 'D' register left four places. This is such a simple operation that it does not really require or make effective use of macros, but it will suffice for learning purposes. In actuality this routine would probably be written in-line or, if required often, written as a subroutine.

The first step is to define the macro. This must be done BEFORE THE FIRST CALL to the macro. It is good practice to define all macros early in a program. The definition is initiated with a MACRO directive and terminated by an ENDM directive. The definition of our example would be as follows:

```
ASLD4  MACRO
        ASLB
        ROLA
        ASLB
        ROLA
        ASLB
        ROLA
        ASLB
        ROLA
        ENDM
```

The first line is the MACRO directive. Note that the name of the macro is specified with this directive by placing it in the label field. This macro name should follow all the rules for labels. It will NOT be placed in the symbol table, but rather in a macro name table. The body of the macro follows and is simply lines of standard assembly source which shift the 'D' register left four places. The definition is terminated by the ENDM directive.

When this macro definition is encountered during pass 1, the assembler will not actually assemble the source, but instead copy it into a buffer for future access when the macro is called. During pass 2 this definition is ignored.

At this point we may continue with our assembly program and when we desire to have the 'D' register shifted left four places, simply call the macro as follows:

```

      .
      .
      LDA   VALUE
      LDB   VALUE+1
      ASLD4          here is the macro call
      STD   RESULT
      .
      .

```

You can see that calling a macro consists of simply placing its name in the mnemonic field of a source line. When the assembler sees the above call, it realizes that the instruction is not a standard 6809 mnemonic, but rather a macro that has been previously defined. The assembler will then replace the ASLD4 with the lines which make up the body of that macro or "expand" the macro. The result would be the following assembled code:

```

      .
      .
      LDA   VALUE
      LDB   VALUE+1
      ASLB          the body of the macro
      ROLA          replaces the call
      ASLB
      ROLA
      ASLB
      ROLA
      ASLB
      ROLA
      STD   RESULT
      .
      .

```

You should note that a macro call differs from a subroutine call in that the macro call results in lines of code being placed in-line in the program where a subroutine call results in the execution of the routine at run-time. Five calls to a subroutine still only requires one copy of the subroutine while five calls to a macro results in five copies of the macro body being inserted into the program.

PARAMETER SUBSTITUTION

If macros were limited to what was described above, they would probably not be worth the space it took to implement them in the assembler. The real power of macros comes in "parameter substitution". By that we mean the ability to pass parameters into the macro body from the calling line. In this manner, each expansion of a macro can be different.

As an example, suppose we wanted to add three 16-bit numbers found in memory and store the result in another memory location. A simple macro to do this (we shall call it ADD3) would look like this:

```
ADD3  MACRO
      LDD    LOC1    get first value in 'D'
      ADDD   LOC2    add in second value
      ADDD   LOC3    add in third value
      STD    RESULT  store result
      ENDM
```

Now let's assume we need to add three numbers like this in several places in the program, but the locations from which the numbers come and are to be stored are different. We need a method of passing these locations into the macro each time it is called and expanded. That is the function of parameter substitution. The assembler lets you place up to nine parameters on the calling line which can be substituted into the expanded macro. The proper form for this is:

```
MACNAM <prm.1>,<prm.2>,<prm.3>,...,<prm.9>
```

where "MACNAM" is the name of the macro being called. Each parameter may be one of two types: a string of characters enclosed by like delimiters and a string of characters not enclosed by delimiters which contains no embedded spaces or commas. The delimiter for the first type may be either a single quote (') or a double quote (") but the starting and ending delimiter of a particular string must be the same. A comma is used to separate the parameters. These parameters are now passed into the macro expansion by substituting them for 2-character "dummy parameters" which have been placed in the macro body on definition. These 2-character dummy parameters are made up of an ampersand (&) followed by a single digit representing the number of the parameter on the calling line as seen above. Thus any occurrence of the dummy parameter, "&1", would be replaced by the first parameter found on the calling line.

Let's re-do our ADD3 macro to demonstrate this process. The definition of ADD3 now looks like this:

```
ADD3  MACRO
      LDD    &1    get first value in 'D'
      ADDD   &2    add in second value
      ADDD   &3    add in third value
      STD    &4    store result
      ENDM
```

Now to call the macro we might use a line like:

```
ADD3 LOC1,LOC2,LOC3,RESULT
```

When this macro was expanded, the &1 would be replaced with LOC1, the &2 would be replaced with LOC2, etc. The resulting assembled code would appear as follows:

```
LDD    LOC1    get first value in 'D'
ADDD   LOC2    add in second value
ADDD   LOC3    add in third value
STD    RESULT  store result
```

Another call to the macro might be:

```
ADD3 ACE,TWO,LOC3,LOC1
```

which would result in the following expansion:

```
LDD    ACE     get first value in 'D'
ADDD   TWO     add in second value
ADDD   LOC3    add in third value
STD    LOC1    store result
```

Now you should begin to see the power of macros.

There is actually a tenth parameter which may be passed into a macro represented by the dummy parameter "&0". It is presented on the calling line as so:

```
<prm.0> MACNAM <prm.1>,<prm.2>,<prm.3>,...,<prm.9>
```

This parameter is somewhat different from the others in that it must be a string of characters that conform to the rules for any other assembly language label since it is found in the label field. It is in fact a standard label which goes into the symbol table and can be used in other statement's operands like any other label.

Ignoring a Dummy Parameter

There may be times when a programmer wishes to have an ampersand followed by a number in a macro which is not a dummy parameter and should therefore not be replaced with a parameter string. An example would be an expression where the value of MASK was to be logically 'anded' with the number 4. The expression would appear like:

```
MASK&4
```

If this expression were in a macro, upon expansion the &4 would be replaced with the fourth parameter on the calling line. It is possible to prevent this, however, by preceding the ampersand with a backslash (\) like this:

MASK\&4

When the assembler expands the macro containing this expression, it will recognize the backslash, remove it, and leave the ampersand and following number intact.

Another case where this can be useful is when a macro is defined within a macro (that is possible!) and you wish to place dummy parameters in the inner macro.

THE EXITM DIRECTIVE

Sometimes it is desirable to exit a macro prematurely. The EXITM directive permits just that. During expansion of a macro, when an EXITM command is encountered the assembler immediately skips to the ENDM statement and terminates the expansion. This probably does not seem logical, and is not except when used with conditional assembly.

To portray the use of EXITM, assume we have some macro called XYZ which has two parts. The first part should always be expanded, but the second should only be expanded in certain cases. We could use EXITM and the IFNC directives to accomplish this as follows:

```

XYZ MACRO
    .
    .           code that should always be generated
    .
    IFNC &2,YES
    EXITM
    ENDIF
    .
    .           code that is only sometimes generated
    .
    ENDM

```

The following calls would result in the second part being expanded or producing code:

```

XYZ "PARAMETER 1",YES
XYZ "PARAMETER 1","YES"
XYZ 0,YES

```

while all of the following would result in the second part not being expanded:

```

XYZ "PARAMETER 1",NO
XYZ JUNK,NO
XYZ JUNK
XYZ PRM1,PRM2

```

The EXITM directive itself requires no operand.

THE DUP AND ENDD DIRECTIVES

There is another type of assembler construct which may only be used inside of a macro, called the DUP-ENDD clause. The assembler will duplicate the lines placed between the DUP and ENDD (end dup) instructions some specified number of times. The proper form is:

```
DUP <dup count>
.
.           code to be duplicated
.
ENDD
```

where the <dup count> is the number of times the code should be duplicated. The <dup count> may be any valid expression, but must be in the range of 1 to 255 decimal. Note that DUP-ENDD clauses may NOT be nested. That is to say, one DUP-ENDD clause may not be placed inside another.

As an example, let's take our first example in this section on macros and spruce it up a little. Assume we want a macro that will shift the 'D' register to the left 'x' places where 'x' can vary in different calls to the macro. The DUP-ENDD construct will work nicely for this purpose as seen here:

```
ASLDX MACRO
      DUP   &1
      ASLB
      ROLA
      ENDD
      ENDM
```

Now to shift the 'D' register left four places we call the macro with:

```
ASLDX 4
```

To shift it left 12 places we simply use the instruction:

```
ASLDX 12
```

And so on.

MORE ON MACROS

A few more hints on using macros may be of value.

One important thing to remember is that parameter substitution is merely replacing one string (the dummy parameter or &x) with another (the parameter string on the calling line). You are not passing a value into a macro when you have a parameter of "1000", but rather a string of four characters. When the expanded source code of the macro is assembled, the string may be considered a value, but in the phase of parameter substitution it is merely a string of characters. An example macro will help clarify this point.

```

TEST  MACRO
      LDA    #&1    COMMENT FIELD IS HERE
      LDB    L&1
      NOP
      NOP          PARAMETERS CAN EVEN BE
      NOP          SUBSTITUTED INTO
      NOP          COMMENTS &2
      &3          OR THEY CAN BE A MNEMONIC
&4    TST    M&1M   OR LABEL OR INSIDE A STRING
      ENDM

```

Now if this macro were called with the following command:

```
TEST 1000,'LIKE THIS',SEX,"LABEL"
```

The expanded source code would look like this:

```

      LDA    #$1000 COMMENT FIELD IS HERE
      LDB    L1000
      NOP
      NOP          PARAMETERS CAN EVEN BE
      NOP          SUBSTITUTED INTO
      NOP          COMMENTS LIKE THIS
      SEX
LABEL TST    M1000M OR LABEL OR INSIDE A STRING

```

Note that in the LDA instruction the parameter "1000" is used as a number but in the LDB and TST instructions it is part of a label. The second parameter is not even substituted into the actual program, but rather into the comment field. The use of parameter number one in the TST instructions shows that the dummy parameter does not have to be a stand alone item but can be anywhere in the line.

Another convenient method of using macros is in conjunction with the IF-skip type of conditional directive. With a negative or backward skip we can cause a macro to loop back on itself during expansion. A good example of this would be a case where the programmer must initialize one hundred consecutive memory locations to the numbers one through one hundred. This would be a very tedious task if all these numbers had to be setup by FCB directives. Instead we can use a single FCB directive, the IF-skip type of directive, and the SET directive to accomplish this task.

```

INIT   MACRO
COUNT SET 0           INITIALIZE COUNTER
COUNT SET COUNT+1    BUMP BY ONE
      FCB COUNT       SET THE MEMORY BYTE
      IF COUNT<100,-2
      ENDM

```

If you try this macro out, you will see that it expands into quite a bit of source if the macro expansions are being listed because the 3rd, 4th and 5th line are expanded for each of the one hundred times through. However, only one hundred bytes of object code are actually produced since lines 3 and 5 don't produce code.

This assembler does not allow local variables. If a label is specified on a line in the macro, you will receive a multiply defined symbol error if the macro is called more than once. There is a way to get around this shortcoming that is somewhat crude, but effective. That is to use a dummy parameter as a label and require the programmer to supply a different label name as that parameter each time the macro is called. For example, consider the following example:

```

SHIFT MACRO
      PSHS D
      LDA &1
      LDB #&2
&3   ROLA
      DECB
      BNE &3
      STA &1
      PULS D
      ENDM

```

Now if this macro was called with the line:

```
SHIFT FLAG,3,CALL1
```

The resulting macro expansion would look like:

```

      PSHS D
      LDA FLAG
      LDB #3
CALL1 ROLA
      DECB
      BNE CALL1
      STA FLAG
      PULS D

```

There is no problem here, but if the macro were called again with the same string for parameter 3 (CALL1), a multiply defined symbol error would result. Thus any subsequent calls to SHIFT must have a unique string for parameter 3 such as CALL2, CALL3, etc.

IMPORTANT NOTES ON MACROS

- 1) A macro must be defined before the first call to it.
- 2) Macros can be nested both in calls and in definitions. That is, one macro may call another and one macro may be defined inside another.
- 3) Comment lines are stripped out of macros when defined to save storage space in the macro text buffer.
- 4) Local labels are not supported.
- 5) A macro cannot call a LIBrary file. That is, a LIB directive cannot appear within a macro.
- 6) No counting of parameters is done to be sure enough parameters are supplied on the calling line to satisfy all dummy parameters in the defined macro. If the body of a macro contains a dummy parameter for which no parameter is supplied on the calling line, the dummy parameter will be replaced with a null string or effectively removed.
- 7) The macro name table is searched before the mnemonic table. This means that a standard mnemonic or directive can be effectively redefined by replacing it with a macro of the same name.
- 8) Once a macro has been defined, it cannot be purged nor re-defined.

VIII. SPECIAL FEATURES

This section covers a few special features of the 6809 Mnemonic Assembler that don't seem to fit under any other specific category.

END OF ASSEMBLY INFORMATION

Upon termination of an assembly, and before the symbol table is output, three items of information may be printed: the total number of errors encountered, the total number of warnings encountered, and the address of the last byte of code assembled.

The number of errors is always printed in the following manner:

```
0 ERROR(S) DETECTED
```

The number of warnings are printed only if warnings have not been suppressed by the 'W' option on the command line and if the number is greater than zero (ie. only if there was a warning):

```
0 ERROR(S) DETECTED    2 WARNING(S) REPORTED
```

The last assembled address is printed only if the assembled output listing is turned off by the 'L' option on the command line. It is actually the last address which the assembler's program counter register was pointing to, so there may not really be an assembled byte of code at this address. For example if the last instruction in a program except for the END was an RMB directive, the address would be the last byte reserved by that command. This information is presented as follows:

```
LAST ASSEMBLED ADDRESS: 1055
```

The address is printed as a 4-digit hexadecimal value.

EXCESSIVE BRANCH OR JUMP INDICATOR

A mechanism has been included in the assembler to inform the programmer when a long branch or jump could be replaced by a short branch. The purpose is to allow size and speed optimization of the final code. This indicator is a greater-than sign placed just before the address of the long branch or jump instruction which could be shortened. The following section of code shows just how it looks:

```

3420 B6 E004 INCH LDA $E004
3423 84 01 ANDA #$01
>3425 1027 FFF7 LBEQ INCH
3429 B6 E005 LDA $E005
342C 81 20 CMPA #$20
342E 24 06 BHS OUTCH
>3430 BD 3436 JSR OUTCH
>3433 7E 3420 JMP INCH
3436 34 04 OUTCH PSHS B
.
.
.
```

These indicator flags may be suppressed by selecting the 'W' option in the command line option list.

AUTO FIELDING

The assembler automatically places the four fields of a source line (label, mnemonic, operand, and comment) in columns in the output assembled listing. This allows the programmer to edit a condensed source file without impairing the readability of the assembled listing. The common method of doing this is to separate the fields by only one space when editing. The assembled output places all mnemonics beginning in column 8, all opcodes beginning in column 15, and all comments beginning in column 25 assuming the previous field does not extend into the current one. There are a few cases where this automatic fielding can break down such as lines with errors, but these cases are rare and generally cause no problem.

AUTO TABLE SETUP

The assembler automatically sets up all necessary tables and buffers depending on the amount of memory contained in your system. The amount of memory contained is determined by reading the memory end value (MEMEND) in FLEX. The tables or buffers which can vary in size are as follows:

SYMBOL TABLE

This table is where all symbols are maintained during assembly. Each entry into the symbol table requires 8 bytes, 6 for the name and two for the address or value associated with it. This assembler uses a hashed symbol table technique which can mean that symbols are pseudo-randomly scattered throughout the table. This method is very fast but has one drawback - the assembler is usually not able to completely fill all positions in the table. Thus a symbol table full error message does not necessarily mean that every position in the table is really full. It simply means the assembler was unable to put any more symbols in the table due to the hashing technique used. The larger the table, the faster the hashing method will execute and accordingly, the faster the assembler will run. If possible, it is good to have 50% more space in the symbol table than will be required to actually hold the number of symbols in a program.

SOURCE BUFFER

This is the buffer which holds the source program to be assembled. To gain speed, the assembler reads as many lines as it can into this buffer all at once. The assembly operation is carried out on each buffer individually. This buffer may be any size so long as it will hold the longest line that may be encountered in the source. There must also be a reserved 256-byte overflow area directly following the end of the source buffer.

MACRO TEXT BUFFER

This is the buffer where macros are stored upon definition. If few macros are to be used, it can be very small. The more macros anticipated, the larger the buffer should be.

MACRO NAME TABLE

This is a table where macro names and locations are stored. Each entry requires 8 bytes, 6 for the macro name and 2 for the address of the macro body in the macro text buffer. Again, if few macros are to be defined, this table can be quite small.

MACRO ACTIVATION BUFFER

This buffer is an area where the macro processor builds an activation stack for all macros currently under execution. Each time a macro is called, certain information about it is placed on this stack. If no parameters are supplied on the calling line, an entry on the stack requires some 10 bytes. Any calling line parameters will raise this amount. If macros are not nested, only one entry will be on the stack at a time. However, if one macro calls another, there must be two entries on the stack and so on. The minimum size of the stack necessary depends on the amount of macro nesting done.

The assembler attempts to provide a general sizing of these tables for any size system in which it is run. This sizing is done according to the following approximate formulae:

Let $AVM = MEMEND - MEMBEG$
 where AVM implies available memory
 $MEMEND$ refers to the end of memory as in FLEX
 $MEMBEG$ is the start of the RAM buffer area

Then

$SYMBOL\ TABLE = (AVM - 1K) * 0.625$
 $MACRO\ TEXT\ BUFFER = (AVM - 1K) * 0.188$
 $MACRO\ NAME\ TABLE = (AVM - 1K) * 0.031$
 $MACRO\ ACTIVATION\ BUFFER = (AVM - 1K) * 0.031$
 $SOURCE\ BUFFER = AVM - 256 - (\text{sum of above spaces})$

These formulae change if there is enough memory to produce a symbol table of larger than 16K according to the symbol table formula given above. In that case, the symbol is limited to 16K (enough for almost 2000 symbols) and the remaining space is divided equally between the macro text buffer and the source buffer.

These table sizes can be set manually by the programmer if so desired. See the section on adapting to your system for details.

COMMAND LINE PARAMETERS

In the section on using the assembler at the beginning of this manual, command line parameters are discussed. That section describes how to place a parameter on the command line for passing into the source, but it does not elaborate on how the programmer tells the assembler where in the source to substitute those parameters. If you have read the section on macros, you should already understand the concept of parameter substitution. If not, read that section before continuing here.

Much as in macro parameter substitution, there are 2-character symbols or dummy parameters which, if placed anywhere in the source, will be replaced by the parameters supplied on the command line. In macros, the parameters from the macro calling line were substituted into the macro body during expansion of the macro. Here, the parameters from the command line are substituted into the source as it is read in from the disk. In macros, there were 10 possible parameters. Here there are three possible. The 2-character dummy parameters for these three are '&A', '&B', and '&C'. These correspond to the three possible command line parameters represented here:

```
+++ASMB,<filename>,+<options>,+<prm.A>,<prm.B>,<prm.C>
```

As can be seen, the three parameters are separated by commas. Just as in macros, the dummy parameters can be ignored by placing a backslash directly in front of the ampersand. Thus the following line of edited source:

```
VALUE EQU MASK\&COUNT
```

would be read into the assembler as:

```
VALUE EQU MASK&COUNT
```

A quick example should help clarify the preceding descriptions. The following program contains one dummy parameter, '&A'.

```
* ROUTINE TO OUTPUT TO ONE OF TWO PORTS
  OPT   PAG,CON
  TTL   OUTPUT ROUTINE FOR PORT #&A
  PAG
  IFN   (&A=0)|(&A=1)
  ERR   NOT A VALID PORT NUMBER
  ELSE
  IF    &A=0
ACIA  EQU  $E000
  ELSE
ACIA  EQU  $E004
  ENDEF
  ENDEF
```

```

OUTCH LDB  ACIA
      ANDB #$02
      BEQ  OUTCH
      STA  ACIA
      RTS

      END

```

Now if this file were assembled with a command line like:

```
+++ASMB,FILE,+BGDS,+1
```

(assuming the file is very creatively called, 'FILE'), we would see the following assembled output:

```

OUTPUT ROUTINE FOR PORT #1                TSC ASSEMBLER PAGE    1
                                           IFN    (1=0)1(1=1)
                                           ERR    NOT A VALID PORT NUMBER
                                           ELSE
                                           IF     1=0
                                           ACIA  EQU   $E000
                                           ELSE
                                           E004 ACIA EQU   $E004
                                           ENDIF
                                           ENDIF

0000 F6  E004  OUTCH  LDB   ACIA
0003 C4  02          ANDB  #$02
0005 27  F9          BEQ   OUTCH
0007 B7  E004       STA   ACIA
000A 39              RTS

                                           END

```

```
0 ERROR(S) DETECTED
```

Note that the first page of output is not shown.

IX. OBJECT CODE PRODUCTION

The assembler is capable of producing two kinds of object code output. One is a binary file in the standard FLEX binary file format. The first section of this manual explains how to produce such a file and how to assign a name to it. The second type is a direct output to tape. This object code is produced in the standard Motorola '51-S9' tape format. This is an ASCII hex record format as shown:

```
S1BBAAAADDDDDDDDDDD.....DDDDCC
```

where

- S1 is a record start marker
- BB is a byte count which includes all bytes in the record past the byte count itself
- AAAA is the load address of the first data byte
- DD is the actual data
- CC is a checksum equivalent to the one's complement of the modulo 256 sum of all bytes preceding the checksum (except the S1)

This data is output, character at a time, through a jump vector located near the beginning of the assembler. As supplied this jump vector is pointing to the PUTCHR or output character routine of FLEX. If your tape device is located on the same port as your terminal, this should be satisfactory. If, however, you have a tape device located elsewhere, you will need to patch this jump vector to point to a routine you must supply to output a character to your tape device and then return. Directions for patching this address can be found in the section on adapting to your system.

Note that this data is output periodically during an assembly. If your tape device is on the same port as your terminal you will want to turn off the listing and symbol table printing options so that only the object code data is output to your tape.

X. ERROR AND WARNING MESSAGES

The assembler supports warning messages and two types of error messages: fatal and non-fatal. A fatal error is one which will cause an immediate termination of the assembly such as not enough memory. A non-fatal error results in an error message being inserted into the listing and some sort of default code being assembled if the error is in a code producing line. The assembly is allowed to continue on non-fatal errors. Warning messages are handled much like non-fatal errors: the message is inserted in the output listing and the assembly is allowed to continue. These warning messages may be suppressed by the 'W' option in the command line. Error messages may not be suppressed.

All messages are output as English statements - not as error numbers. These messages announce violations of any of the rules and restrictions set forth in this manual and are, therefore, essentially self-explanatory. Error messages are output with three asterisks preceding the message. Warning-messages are output with two asterisks preceding the message. This can be used to quick locate the messages either by, eye or with an editor.

Possible NON-FATAL error messages are as follows:

- UNDEFINED SYMBOL
- MULTIPLY DEFINED SYMBOL
- UNRECOGNIZABLE MNEMONIC OR MACRO
- ILLEGAL LABEL
- ILLEGAL OPERAND
- RELATIVE BRANCH TOO LONG
- SYNTAX ERROR
- ILLEGAL INDEXED MODE
- ILLEGAL CONSTANT
- ILLEGAL OPTION
- OPERAND OVERFLOW!
- OVERFLOW!
- UNBALANCED CLAUSE
- UNDEFINED IN PASS 1
- NOT ALLOWED IN THIS CONTEXT
- MACRO EXISTS
- PHASING ERROR DETECTED

A couple of these could use some elaboration. The OPERAND OVERFLOW message results from attempting to generate too much data from a single FCB, FDB, or FCC instruction. A maximum of 256 bytes of data can be generated by a single instruction of that type. An example of the OVERFLOW error is when LIB files are nested more than 12 levels deep. The UNBALANCED CLAUSE message results when one directive of a clause is missing such as an ENDIF with no IF. The NOT ALLOWED IN THIS CONTEXT message is generally associated with macros, ie. when an operation is attempted that is illegal inside a macro or vice versa.

Possible FATAL error messages are:

```
ILLEGAL FILE NAME
NO SUCH FILE
ILLEGAL OPTION SPECIFIED
INSUFFICIENT MEMORY
MACRO OVERFLOW!
```

The first three are associated with errors in the command line. The INSUFFICIENT MEMORY message is issued when automatic table setup is enabled and there is not at least 3K of buffer area. The MACRO OVERFLOW message occurs when any of the macro buffers is overflowed.

Possible warning messages are as follows:

```
FORCED ADDRESS TRUNCATED
IMMEDIATE VALUE TRUNCATED
ILLOGICAL FORCING IGNORED
```

The first warning is printed if an address is forced to 8 bits (with the '<' character) and must be truncated to fit. The second occurs on lines where an immediate value must be truncated to fit in 8 bits. For example, 'LDB #\$42E5' would result in such a warning. The third is issued if address length forcing (with the '<' or the '>') is done in an operand where not possible. For example, the instruction 'LDB <[BUFCNT]']' would result in such a warning.

As stated in a previous section, the total number of errors is reported at the end of the assembly and if warning messages are enabled, the number of warnings are also output.

XI. ADAPTING TO YOUR SYSTEM

In general, if you have FLEX up and running and have at least 16K of user memory, there will be no need for any adapting whatsoever. Some users, however, always feel the need to modify certain things and this section describes how to make all the changes which we felt might be desired (and which would be feasible). With the exception of MEMEND, these changes must all be made to the object code of the assembler. This can be done by loading the assembler (with a GET ASMB.COMD command), making the desired changes in memory, and saving the result on disk (with the SAVE command).

MEMEND

If using the automatic table setup which the assembler performs for you, the MEMEND value in FLEX should be set to the last address which the assembler should use. FLEX initializes MEMEND to the actual end of user memory. You may have an application where you don't want this to be the case. If so, set MEMEND manually before executing the assembler.

EXIT ADDRESS

When the assembler is finished, it jumps into FLEX's warm start. If you wish it to exit to some other address, place that address at location \$0027.

OUTPUT CHARACTER ROUTINE

As supplied, the assembler outputs through FLEX's PUTCHR routine. This takes advantage of the escape-return sequence in FLEX to pause or terminate an output listing. If, however, you wish to output through some user supplied output routine, place the address of such a routine at location \$002A. This routine should output the character in the A register and return without affecting any registers except the condition codes.

TAPE OUTPUT CHARACTER ROUTINE

Presently, tape output is performed character at a time through the PUTCHR routine in FLEX. This causes any tape output to be routed to the terminal which may be the same port on which the tape device is located. If you require a different output routine for tape, place the address of such a routine at location \$002D. This routine should output the character in the A register to the tape device and return without affecting any registers except the condition codes.

LINES PER PAGE

If the page mode is selected, the assembler automatically places a header at the top of each page (with the current page number) and performs a page eject at the bottom. The number of lines which are output before the page eject occurs (including the header lines) is set at location \$0018 in the assembler. This value is currently set to 58 lines. Change if desired.

LABELS PER LINE

The symbol table output is done with multiple symbols per line. Currently there are 5 labels per line. If desired, this number can be changed by setting the byte at location \$0019.

AUTO FIELDING COLUMNS

As explained in the special features section, this assembler performs auto fielding. The columns in which the fields are placed are currently set to 8, 15, and 25 for the mnemonic, operand, and comment fields respectively. If desired, these columns can be changed by altering the three bytes beginning at location \$001A.

TAPE CONTROL

When tape output is selected, the assembler turns on the tape unit, delays for a set period, then begins the output. When the last data has been output, the assembler turns the tape unit off. This tape on and off control is performed by outputting up to four characters for each function (on and off). Currently these characters are all set to nulls (\$00) as the assembler expects manual tape control. If you wish to set these characters, the four tape on characters should be placed at locations \$001E through \$0021. The four tape off characters should be placed at locations \$0022 through \$0025.

The time delay for tape turn-on can also be adjusted by altering the byte at location \$001D. This byte is currently set to 4 (roughly 2 seconds) and should be raised for longer delays or lowered for shorter delays (can be zero for no delay).

SETTING UP THE TABLES MANUALLY

If you wish to set up the necessary tables and buffers manually, you may do so. This requires that you supply the starting and ending addresses of the five tables described in the section on special features and set a byte called MANUAL to some non-zero value. This MANUAL byte is located at \$0003 and is currently equal to zero. The assembler tests this byte and if zero, performs automatic table setup. If non-zero, the assembler picks up the table start and end addresses from the following locations:

SOURCE BUFFER BEGIN	\$0004
SOURCE BUFFER END	\$0006
MACRO NAME TABLE BEGIN	\$0008
MACRO NAME TABLE END	\$000A
MACRO ACTIVATION BUFFER BEGIN	\$000C
MACRO ACTIVATION BUFFER END	\$000E
MACRO TEXT BUFFER BEGIN	\$0010
MACRO TEXT BUFFER END	\$0012
SYMBOL TABLE BEGIN	\$0014
SYMBOL TABLE END	\$0016

NOTES:

- 1) The Macro Name Table and the Symbol Table must be an even multiple of 8 bytes in size!
- 2) The assembler uses a large stack area to maintain all its temporary variables and buffers. This stack requires 0720 hex bytes of RAM starting at FLEX's MEMEND and growing down from there. This implies two things: if manually setting up the tables you must leave this space free and if you want to move where the stack resides, you must set MEMEND accordingly as the assembler will always place its stack so that it sets up against MEMEND.
- 3) When manually setting up the tables, you will probably want to use all the space between the end of the assembler itself and (MEMEND-\$0720). Thus the lowest table would start just after the last byte of the assembler as found on the disk and the highest table would end at (MEMEND-\$721).