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A PAPERBYTE™ BOOK

RA6800ML

AN M6800 RELOCATABLE MACRO ASSEMBLER

by Jack E. Hemenway

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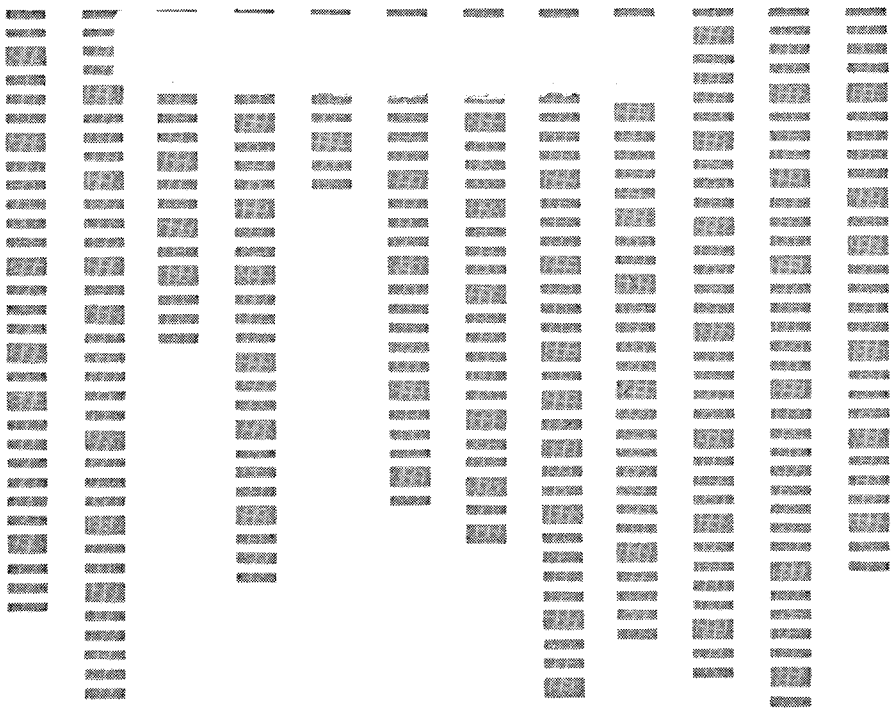

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To Begin With . . .

RA6800ML, a resident Macro Assembler for the Motorola 6800 Microprocessor, is a two pass assembler designed to run on a minimum system of 16 K bytes of memory, a system console such as a Teletype, a system monitor such as the Motorola MIKBUG read only memory program or the ICOM Floppy Disk Operating System (FDOS), and some form of mass file storage such as dual cassette recorders or a floppy disk. A system monitor other than those mentioned above could be used by simply changing two IO jumps in the Assembler, a jump to the input-a-character routine INEEE and a jump to the output-a-character routine OUTEEE, and by supplying functionally equivalent IO routines for the user's specific system.

The Assembler can produce a program listing, a sorted Symbol Table listing, and relocatable object code. The object code is loaded and linked with other assembled modules using the Linking Loader LINK6800. The companion PAPERBYTE™ publication *LINK68 – Linking Loader for Motorola 6800* gives details on how to use the Linking Loader.

This book is divided into four major sections. In the section THE SOURCE LANGUAGE, a detailed description of the 6800 assembly language and its components is given. The instruction and address type formats are outlined in addition to details about the pseudo instructions and macro facilities. This section provides the necessary background for coding programs in the 6800's assembly language and understanding the operations of the Assembler.

The section on THE ASSEMBLER describes the actual routines which make up the Assembler. Each subsection presents a logical collection of routines which provide a particular function. In addition to short descriptions of the routines, a cross reference is given showing all calling and called by routines. Additional information about pointers, flags, and temporary variables is supplied. Finally, detailed flowcharts of each routine are provided.

The exact IO interface needed for using the Assembler naturally depends on the actual configuration of the user's system. In INTERFACING AND USING THE ASSEMBLER sample IO routines for a tape system and floppy disk system are examined. Tips are given on how to design IO routines (or modify those provided as examples) to fit the user's system. Finally, information on loading and executing the Assembler, as well as source and object tape formats, are provided.

Section five is the appendices which contain error messages generated by the Assembler, the Assembler and same IO driver source code listings, the bar code representation of the assembler's relocatable object file, an implementation guide for bootstrapping RA6800ML without the use of the linking loader LINK68, and the Assembler and IO routines in absolute formats for the bootstrap process.

Finally, a detailed INDEX is included for quick reference to a variety of items.

In this book is what I believe to be a complete set of documentation for the 6800 assembler program. Every flowchart, every listing, every item was included for one purpose: to provide the user with everything needed for the use of modification of the Macro Assembler.

In addition, it was my express purpose to provide everything necessary so that the user can easily learn what he or she needs to know about the system. By providing not only the 6800 assembler language description, but also a source code listing and detailed description of every routine of the Assembler, I intend to provide the user with an opportunity to learn about the nature of assembler design and implementation as well as simply acquiring a useful software tool. It is through this kind of encouragement that I hope to advance the state of the art of home computing.

Jack E. Hemenway

The Source Language

Instruction Format

A source language statement consists of a label, an operation code, an operand, and comments. The label is used when needed as a reference point for other statements. The operation code may be a mnemonic machine operation, a pseudo instruction, or a Macro call (a reference to the Macro's name). An operand may be an expression consisting of an alphanumeric symbol, a number, a special character, or any of these combined with arithmetic operators; or in certain instances there may be no operand at all. The comments are entirely optional. The fields in a source statement are separated by at least one space character (20 hexadecimal). This source language definition is based on the original Motorola 6800 assembly language, with minor omissions and major extensions such as the Macro facility.

Statement Characteristics

The fields of the source statement appear in the following order:

[*label*] *opcode operand(s)* [*comments*]

The items in brackets ([ ]) are optional.

Field Delimiters

One or more spaces separate the fields of a statement. An End-of-Statement mark (carriage return) terminates the entire statement. A single space following an End-of-Statement mark from the previous statement indicates the absence of the label field.

Character Set

The ASCII characters recognized by the Assembler are as follows:

A through Z } "alphabetic"
0 through 9 } "numeric" } "alphanumeric"
* (asterisk)
+ (plus)
– (minus)
/ (slash)
$ (dollar sign)
' (apostrophe, single quote mark)
, (comma)
(pound sign)
& (ampersand)
(space)

Any other valid ASCII characters may appear in the comments field.

The letters A through Z, and the numbers 0 through 9 may be used in an alphanumeric symbol. In the first position of the label field an asterisk indicates a comment line; in the operand field it represents the value of the program location counter for the current instruction if it is in the first position; otherwise it is recognized as the multiplication operator for an expression.

The plus, minus, slash, and asterisk are used as operators in arithmetic expressions.

The pound sign is used to indicate the immediate addressing mode, the dollar to indicate hexadecimal numbers, the apostrophe to indicate ASCII strings, the ampersand to indicate substitutable parameters in Macro definitions, and the comma to separate operands.

Spaces separate fields of a statement and may also be used to format the output listing.

Statement Length

A statement may be up to 72 characters long.

Label Field

The *label* field serves to identify the statement and may be used as a reference by other statements in the program.

This field starts immediately following an End-of-Statement mark and is terminated by a space. A space in position one of a statement indicates that the statement is unlabeled.

Label Symbol

A label is composed of from one to six characters. The first character must be an alphabetic character. The remain-

ing characters must be alphanumeric characters. If the label is composed of more than six characters, the Assembler truncates the symbol to six characters.

An asterisk in position one indicates that the entire statement is a comment. An asterisk in any position of the *label* field other than the first position is illegal.

Opcode Field

The operation code (opcode) defines an operation to be performed by the computer or by the Assembler. This field may contain an operation code, a pseudo instruction, or a Macro reference. The *opcode* field follows the *label* field and is separated from it by at least one space. If there is no label, this field may begin anywhere after position one. The *opcode* field is terminated by a space.

Operand Field

The meaning and format of the *operand* field is dependent on the type of operation code used in the source statement.

This field follows the *opcode* field and is separated from it by at least one space. When dual operand instructions are used, the first operand must be either an "A" or a "B", indicating the A or B accumulator, respectively. The single characters "A" or "B" must be preceded and followed by one or more spaces. The *operand* field is terminated by a space except when there are no comments; in that case it may be terminated by an End-of-Statement mark.

Symbolic Terms

A symbolic term (symbol) follows the same rules for the formation of labels. A symbol used in the *operand* field must be defined elsewhere in the program. An asterisk may be used to refer to the value of the location counter at the time the source statement is encountered.

Numeric Terms

A numeric term (number) may be either decimal or hexadecimal. A decimal number is represented by one to five decimal digits within the range 0 to 65535. A hexadecimal number is indicated by one to four hexadecimal digits within the range 0 to FFFF and is preceded by a dollar sign ($).

Strings

An ASCII string is any sequence of valid ASCII characters preceded by a single quote mark and followed by a single quote mark. If an embedded apostrophe is needed, two apostrophes are used (which count as a single character.) The value of a string is formed by the 8 bit ASCII characters enclosed between the delimiting apostrophes.

Expression Operators

The asterisk, symbols, and numbers may be joined by the four arithmetic operators (+ – * /) to form arithmetic expressions. The Assembler evaluates expressions from left to right *without* regard to precedence or operator heirarchy. A fractional result, if obtained *during* the evaluation of an expression, is truncated to an integer value.

Example:

$$3/2 + 1 = 1 + 1 = 2$$

Macro Call Argument Lists

Macros are passed arguments by placing the arguments in the *operand* field separated by commas. The actual arguments are substituted as character strings into the positions of the corresponding dummy arguments in the macro definition. If comments are to be included in the statement, a comma must follow the last argument.

Evaluation of Symbols and Expressions

Because of the two pass nature of the Assembler, only one level of forward referencing is legal in the use of symbols and expressions in the *operand* field of source statements.

Comment Field

A *comment* field may be included in a source statement as long as it is separated by at least one space from the *operand* field. However, when a comment is included on a macro call statement, the last macro argument must be followed by a comma.

Addressing Modes

Dual Operand

These instructions require two operands in the *operand* field. The first operand must always reference either the A or B accumulator and is separated from the second operand by at least one space. The second operand is formed in accordance with the rules for Direct, Extended, Immediate, or Indexed addressing.

Accumulator

These instructions reference only one operand in the *operand* field; this operand is always either the A or B accumulator represented by the single character "A" or "B".

Inherent

These instructions require no operands, as the information needed is implied by the instruction itself.

Indexed

These instructions reference the Index register X. The *operand* field of the instruction is evaluated and placed in the second byte of the instruction. When the instruction is executed the contents of this byte are added to the Index register to form the complete address. The format is:

$$\left\{\begin{array}{l}\text{number}\\ \text{symbol}\\ \text{expression}\end{array}\right\},X$$

where number, symbol, or expression evaluates to a value between 0 and 255. If a larger value is generated only the

low order eight bits are used.

Examples:

5, X
TEST, X
G + 55, X

Immediate

For these instructions the actual value of the operand is placed in the object code itself following the instruction machine code. The Immediate mode of addressing is indicated by preceding the operand with a pound sign (#). The format is:

{ number / symbol / expression / ASCII string }

Examples:

#100
#TEST
#'ABC

Relative

These two byte instructions are always branch instructions. The branch address is taken relative to the current contents of the Program Counter. The second byte contains a signed number in two's complement notation that specifies the relative branch address. The address of the destination of the branch must be in the range of −126 to +129 relative to the address of the first byte of the branch instruction. The format is:

{ number / symbol / expression }

Direct and Extended

For those instructions that allow it, the Assembler will select the Direct mode of addressing if the evaluated operand address is in the numerical range of 0 to 255, provided that the evaluated address is not relocatable or common. In these cases the Extended mode will be selected. The Direct mode generates two bytes of machine code: the second byte contains the eight bit address in unsigned binary; the upper 8 bits of the sixteen bit address are assumed to be zeroes. If the evaluated operand is greater than 255 (ie: Extended mode is used) then the Assembler generates three bytes of machine code. The second and third bytes contain the sixteen bit unsigned binary address. The source language format is:

{ number / symbol / expression }

Address Type Formats

There are nine basic address type formats which employ Immediate, Direct, Extended, Relative, Indexed, Accumulator (ACCX), or Inherent modes of addressing. In the formats given below, the bracket symbols { } indicate that any one of the enclosed items may be chosen for the position indicated (but only one). In addition, the symbol ␣ will be used to indicate that one or more blanks must appear in that position. All 6800 instructions which use the format are shown at the left in these examples.

Address Type 1

Immediate mode (two bytes):

{ ADC ADD / AND BIT / CMP LDA / ORA SBC / SUB } ␣ { A / B } ␣ # { number / symbol / expression / ASCII string }

Direct mode (two bytes) or Extended mode (three bytes):

{ ADC ADD AND / BIT CMP LDA / ORA SBC SUB } ␣ { A / B } ␣ { number / symbol / expression }

Indexed mode (two bytes):

{ ADC ADD AND / BIT CMP LDA / ORA SBC SUB } ␣ { A / B } ␣ { number / symbol / expression },X

Address Type 2

Extended mode (three bytes) or Direct mode (two bytes):

STA ␣ { A / B } ␣ { number / symbol / expression }

Indexed mode (two bytes):

STA ␣ { A / B } ␣ { number / symbol / expression },X

Address Type 3

Accumulator mode (one byte):

{ ASL ASR CLR COM / DEC INC LSR NEG / ROL ROR TST } ␣ { A / B }

Extended mode (three bytes):

{ ASL ASR CLR COM / DEC INC LSR NEG / ROL ROR TST } ␣ { number / symbol / expression }

Indexed mode (two bytes):

{ ASL ASR CLR COM / DEC INC LSR NEG / ROL ROR TST } ␣ { number / symbol / expression } ,X

Address Type 4

Accumulator mode (one byte):

{ PSH / PUL } ␣ { A / B }

Address Type 5

Immediate mode (three bytes):

{ CPX / LDS / LDX } ␣ # { number / symbol / expression / ASCII string }

Direct mode (two bytes) or Extended mode (three bytes):

{ CPX / LDS / LDX } ␣ { number / symbol / expression }

Indexed mode (two bytes):

{ CPX / LDS / LDX } ␣ { number / symbol / expression } ,X

Address Type 6

Direct mode (two bytes) or Extended mode (three bytes):

{ STX / STS } ␣ { number / symbol / expression }

Indexed (two bytes):

{ STX / STS } ␣ { number / symbol / expression } ,X

Address Type 7

Extended mode (three bytes):

{ JMP / JSR } ␣ { number / symbol / expression }

Indexed mode (two bytes):

{ JMP / JSR } ␣ { number / symbol / expression } ,X

Address Type 8

Relative mode (two bytes):

{ BCC BCS BEQ BGE BGT / BHI BLE BLT BMI BRA / BSR BVC BVS } ␣ { number / symbol / expression }

Address Type 9

Inherent mode (one byte):

ABA	CBA	CLC	CLI	CLV
DAA	DES	DEX	INS	INX
NOP	RTI	RTS	SBA	SEC
SEI	SEV	SWI	TAB	TAP
TBA	TPA	TSX	TXS	WAI

Pseudo Instructions

In this section, the set of "pseudo instructions" which are defined for this Assembler are described. A pseudo instruction (sometimes called a pseudo operation or "pseudop") gives instructions to the Assembler itself, not to the machine. Often a pseudo instruction results in no object code generation. Sometimes data is allocated with or without initial values. Pseudo operations are also differentiated from Macro instructions in that a Macro is user defined while the pseudo operation is defined by the Assembler.

CMN

This is used to reserve (declare) an area in Common for interprogram data communication. The syntax is:

␣ CMN ␣ symbol, { number / symbol / expression }

The second operand is evaluated and the value obtained is used to reserve that amount of bytes in the Common area. The CMN must not be labeled.

END

This terminates a program. It marks the physical end of the source language program. The last statement of a program must be an END statement. The END statement must not be written with a *label*, generates no object code, and has no operand.

ENT

This is used to declare an "entry point", a symbol that may be referenced by separately assembled programs. The syntax is:

␣ ENT ␣ symbol

This statement must not be labeled and the *operand* field must contain a symbol that is defined elsewhere in the program.

EXT

This is used to declare an "external reference", a symbol which may be referenced by the program but which is defined in some other program. The syntax is:

␣ EXT ␣ symbol

This statement must not be labeled. The symbol in the *operand* field must be declared by an ENT statement in the program in which it is defined.

EQU

This assigns to a symbol a value other than the value normally assigned by the Program Location Counter. The syntax is:

label ␣ EQU ␣ { number / symbol / expression }

The EQU statement must be labeled. Symbols appearing in the *operand* field must be previously defined in the source program. This pseudo instruction generates no object code.

FCB

This generates one byte of object code. An eight bit unsigned binary number corresponding to the value of the operand is stored in the object code. The format is:

[label] ␣ FCB ␣ { number / symbol / expression }

If the operand evaluates to a value larger than 255, only the least significant eight bits will be used. The FCB pseudo instruction may be labeled.

FCC

This translates strings of characters into their seven bit ASCII code. The format is:

[label] ␣ FCC ␣ ASCII string

The ASCII string is text enclosed between apostrophes. If an apostrophe is needed in the text it is represented by two apostrophes; however, only one will be put into the object code. This statement may be labeled.

FDB

This generates two bytes of object code. A sixteen bit unsigned binary number corresponding to the value of the operand is stored in the object code. The format is:

[label] ␣ FDB ␣ { number / symbol / expression }

This statement may be labeled.

IF

This is used to cause the Assembler to process the following code normally if the value of the operand is not zero; but the Assembler is to ignore all source statements until a matching NIF statement is encountered if the value of the operand is zero. The format is:

ϕ IF ϕ { number / symbol / expression }

The IF pseudo instruction must not be labeled but must have an operand. This implements the simplest form of conditional assembly and can be used either within or independent of a Macro.

MAC

This is used in the definition of a Macro. All statements following the MAC instruction up to the next MEND are stored in the Macro Table as a Macro definition. The syntax is:

label ϕ MAC [C]

A label is required on the MAC statement. The label is the symbol (its name) by which a Macro is expanded or called. The *operand* field may contain a "C"; the "C" is used to specify whether or not comment lines in the Macro definition are to be stored in the Macro Table. A "C" in the *operand* field indicates that all comment lines are to be included in the expansion of the Macro. By omitting the "C", the user can lower the main memory requirements needed to store the Macro definition. Macro definitions may not be nested but may contain calls to other Macros.

MEND

This indicates the end of a Macro definition. It must not have a label or an operand.

NAM

This names the program. The syntax is:

ϕ NAM ϕ symbol

The symbol in the *operand* field is passed to the Linking Loader as an Entry point. It must not be used as a label elsewhere in the program. A NAM pseudo instruction must be included in each program as the first statement.

NIF

This is used as a terminator to an IF pseudo operation. It must be unlabeled and has no operand.

PAG

This causes the listing device to advance to the top of the next page. This statement does not appear on the listing, causes no object code to be generated, and must be unlabeled.

RMB

This reserves a block of memory whose length is the value of the operand. The syntax is:

[label] ϕ RMB ϕ { number / symbol / expression }

This statement may be labeled. The block of memory reserved is cleared to zeroes. Symbols used in the *operand* field must have been previously defined in the program.

Example 1: A Macro Prototype

```
line  1  LOOP  MAC C
line  2        LDX #$&0      LOAD X WITH ARGUMENT 0
line  3        LDA B #$&1    LOAD B WITH ARGUMENT 1
line  4  *
line  5        DEX           X:=X–1
line  6        BNE *–1       X .ne. 0
line  7  *
line  8        DEC B         B:=B–1
line  9        BNE *–5       B .ne. 0
line 10  *
line 11        RTS           ALL DONE
line 12        MEND
```

Line 1 is the header. It names the Macro as LOOP and specifies that comment lines in the body are to be stored with the Macro definition in the Macro Table.

Lines 2 and 3 are source statements with substitutable arguments (parameters) in the variable field (&0, &1). A parameter is recognized by the presence of the ampersand. The digit after the "&" is the argument number. Ten arguments is the maximum number of arguments allowable in a single Macro, numbered 0 thru 9.

Lines 4 thru 11 make up the rest of the prototype body.

Line 12 is the termination line.

Lines 2 thru 11 are stored in the Macro Table by the Assembler for later use. If the "C" had not been on the header statement, lines 4, 7 and 10 would not have been saved.

The Macro name "LOOP" is stored in the Symbol Table with a pointer to the location of the Macro definition in the Macro Table.

A typical reference to the Macro "LOOP" might be:

```
LABEL    LOOP 1000, 12
```

This would expand into the following:

```
         LDX #$1000    LOAD X WITH ARGUMENT 0
         LDA B #$12    LOAD B WITH ARGUMENT 1
*
         DEX           X:=X–1
         BNE *–1       X .ne. 0
*
         DEC B         B:B–1
         BNE *–5       B .ne. 0
*
         RTS           ALL DONE
```

The argument "1000" is substituted for &0, and the argument "12" is substituted for &1.

Example 1: An example of a Macro prototype and a reference to the Macro.

Macros

Macros are sections of code which are defined once at the beginning of a program and used and referenced by a mnemonic code (with or without parameters) in the rest of the program.

Usually the code one places in a macro consists of statements that are repeated many times at different places throughout a program. Macros provide a shorthand notation for repeating these sections of code.

The statements of any given Macro are grouped in one place at the beginning of the program. This "Macro definition" is preceded by the MAC pseudo instruction and followed by a series of instructions, and finally the MEND pseudo instruction. The Macro is named by placing the name in the *label* field of the MAC statement. The Macro is called by placing the name of the Macro in the *opcode* field of a statement, and any parameters to be passed to the Macro are placed in the *operand* field separated by commas.

The expansion of a Macro is sometimes thought of as an open subroutine in that it produces the same inline code every time. The inline code is inserted in the normal flow of the program so that the generated statements are assembled with the rest of the program. *[Unlike a conventional subroutine, the open subroutine is repeated every time it is used without a call and return linkage . . .* **Carl Helmers.***]*

The Macro definition is also known as the prototype. The source statements included in the prototype may be any legal Assembler or processor instruction except for another MAC pseudo operation.

Macro prototypes are of the form:

header	label	MAC [C]	
body	.....	.....	any statements
	.....	.....	
termination		MEND	

Where:

label is the name of the Macro;

"C" is an optional operand to control the storing of comment lines along with the prototype body;

body is the sequence of source statements;

termination is the line containing the pseudo instruction MEND.

MEND is recognized by the Assembler as the end of the Macro definition.

Program Linkage

Linking pseudo instructions are used to provide a means of communications between a main program and its subroutines, or among several subprograms that are to be linked together to run as a single program.

Common

$$\not\phi \quad \text{CMN} \quad \not\phi \quad \text{symbol,} \left\{ \begin{matrix} \text{number} \\ \text{symbol} \\ \text{expression} \end{matrix} \right\}$$

CMN reserves a block of storage locations that may be used in common by several programs. Each symbol (the first operand) identifies a segment of the block for the subprogram in which the CMN statement appears. The second operand is the length of the related segment.

Any number of CMN statements may appear in a subprogram. Storage locations in Common are assigned contiguously. The length of the Common block is equal to the sum of the lengths of all segments named in CMN statements in the subprogram.

To refer to the Common block, other subprograms must also include a CMN statement. The segment names and lengths may be the same or they may differ. Regardless of the names and lengths specified in the separate subprograms, there is only one Common block for the combined set of programs. It has the same relative origin; the content of the nth byte of Common storage is the same for all subprograms. Thus a key part of designing a large user software system is allocation and definition of the common variables used to communicate between separate modules.

The segment names that appear in the CMN statements can be used in the *operand* fields of EQU, FDB, or any memory reference statement; they may not be used as labels elsewhere in the program. All references to Common are relocatable.

The user establishes the origin of the Common block when the Linking Loader is executed.

Note that two or more subprograms may declare Common blocks that differ in size, although example 2 shows the same size for both programs.

Entry

$\not\phi$ ENT $\not\phi$ symbol

ENT defines entry points to the program or subprogram. Symbol is an assigned label for some statement in the program. Entry points allow another program to refer to the program in which the ENT occurs. All entry points must be defined in the program.

External

$\not\phi$ EXT $\not\phi$ symbol

EXT designates labels in other programs that are referenced in this program. Symbol must be defined by an ENT in some other program.

The CMN pseudo operation is provided to allow data communication and the EXT and ENT pseudo instructions are provided to allow control communication between separately assembled or compiled subprograms that are linked together to form a single program to be executed as a unit.

The following Macro prototypes may be useful to the programmer. Each was designed with a special purpose in mind, such as an arithmetic operation on a 16 bit integer quantity.

To increment a 16 bit quantity, the following Macro could be used:

```
INC16   MAC
        INC  &0+1
        BNE  *+5
        INC  &0
        MEND
```

Here there is only one parameter, &0. When the Macro is referenced, a parameter would be included as in the statement:

```
INC16 AAA
```

This would generate the instructions needed to increment variable AAA by one:

```
INC  AAA+1
BNE  *+5
INC  AAA
```

Similar Macro prototypes, a sample reference, and the code generated by that reference are given below. Note that in these examples, the macros PSHX, PULX, PSHREG and PULREG use self-modifying code techniques and *will not work* if a program using them is stored in read only memory.

To decrement a 16 bit quantity:

Prototype:

```
DEC16   MAC
        TST  &0+1
        BNE  *+5
        DEC  &0
        DEC  &0+1
        MEND
```

Sample reference followed by generated code:

```
DEC16  BBB
TST    BBB+1
BNE    *+5
DEC    BBB
DEC    BBB+1
```

To add two 16 bit quantities together, placing the sum into a third 16 bit variable (note that 3 parameters are needed):

Prototype:

```
ADD16   MAC
        LDA  A  &0+1
        LDA  B  &0
        ADD  A  &1+1
        ADC  B  &1
        STA  A  &2+1
        STA  A  &2
        MEND
```

Sample reference followed by generated code:

```
ADD16 AAA,BBB,CCC
LDA  A  AAA+1
LDA  B  AAA
ADD  A  BBB+1
ADC  B  BBB
STA  A  CCC+1
STA  A  CCC
```

To subtract two 16 bit quantities, placing the difference into the first 16 bit variable:

Prototype:

```
SUB16   MAC
        LDA  A  &0+1
        LDA  B  &0
        SUB  A  &1+1
        SBC  B  &1
        STA  A  &2+1
        STA  B  &2
        MEND
```

Sample reference followed by generated code:

```
SUB16 AAA,BBB,AAA
LDA  A  AAA+1
LDA  B  AAA
SUB  A  BBB+1
SBC  B  BBB
STA  A  AAA+1
STA  B  AAA
```

To push the X register onto a stack:

Prototype:

```
PSHX    MAC
        DES
        DES
        STS  *+4
        STX  *+1
        MEND
```

Sample reference followed by generated code:

```
PSHX
DES
DES
STS  *+4
STX  *+1
```

To pull the X register off of the stack:

Prototype:

```
PULX    MAC
        STS  *+4
        LDX  *+1
        INS
        INS
        MEND
```

Sample reference followed by generated code:

```
PULX
STS  *+4
LDX  *+1
INS
INS
```

To push the X, A, and B registers onto a stack (note the nested Macro reference):

Prototype:

```
PSHREG  MAC
        PSHX
        PSH A
        PSH B
        MEND
```

Sample reference followed by generated code:

```
PSHREG
PSHX
DES
DES
STS  *+4
STX  *+1
PSH  A
PSH  B
```

To pull the B, A, and X registers off of the stack (again, note the nested Macro reference):

Prototype:

```
PULREG  MAC
        PUL  B
        PUL  A
        PULX
        MEND
```

Sample reference followed by generated code:

```
PULREG
PUL  B
PUL  A
PULX
STS  *+4
LDX  *+1
INS
INS
```

Example 2: This example shows the linkage of two external routines via the Common Block. The Common Block layout shows the locations of the symbolic terms defined in PROG1 and PROG2 within the block. Note that the LDA A instruction in both routines refer to the same COMMON block byte.

Example 2: A Common Block and Its References

```
NAM       PROG1
CMN       AAA,5      ALLOCATE 5 BYTES OF COMMON
CMN       BBB,10     ALLOCATE 10 BYTES OF COMMON
CMN       CCC,10     ALLOCATE 10 BYTES OF COMMON
  .
  .
  .
LDA   A   BBB+1      LOAD BYTE 2 OF SEGMENT BBB
  .
  .
END

NAM       PROG2
CMN       DDD,2      ALLOCATE 2 BYTES OF COMMON
CMN       EEE,2      ALLOCATE 2 BYTES OF COMMON
CMN       FFF,1      ALLOCATE 1 BYTE OF COMMON
CMN       GGG,20     ALLOCATE 20 BYTES OF COMMON
  .
  .
LDA   A   GGG+1      LOAD BYTE 2 OF SEGMENT GGG
  .
  .
END
```

The memory layout of this common block shows the different symbols applied to corresponding bytes in PROG1 and PROG2:

COMMON BLOCK

	PROG1	PROG2
0	AAA	DDD
1	AAA + 1	DDD + 1
2	AAA + 2	EEE
3	AAA + 3	EEE + 1
4	AAA + 4	FFF
5	BBB	GGG
6	BBB + 1	GGG + 1
7	BBB + 2	GGG + 2
8	BBB + 3	GGG + 3
9	BBB + 4	GGG + 4
10	BBB + 5	GGG + 5
11	BBB + 6	GGG + 6
12	BBB + 7	GGG + 7
13	BBB + 8	GGG + 8
14	BBB + 9	GGG + 9
15	CCC	GGG + 10
16	CCC + 1	GGG + 11
17	CCC + 2	GGG + 12
18	CCC + 3	GGG + 13
19	CCC + 4	GGG + 14
20	CCC + 5	GGG + 15
21	CCC + 6	GGG + 16
22	CCC + 7	GGG + 17
23	CCC + 8	GGG + 18
24	CCC + 9	GGG + 19

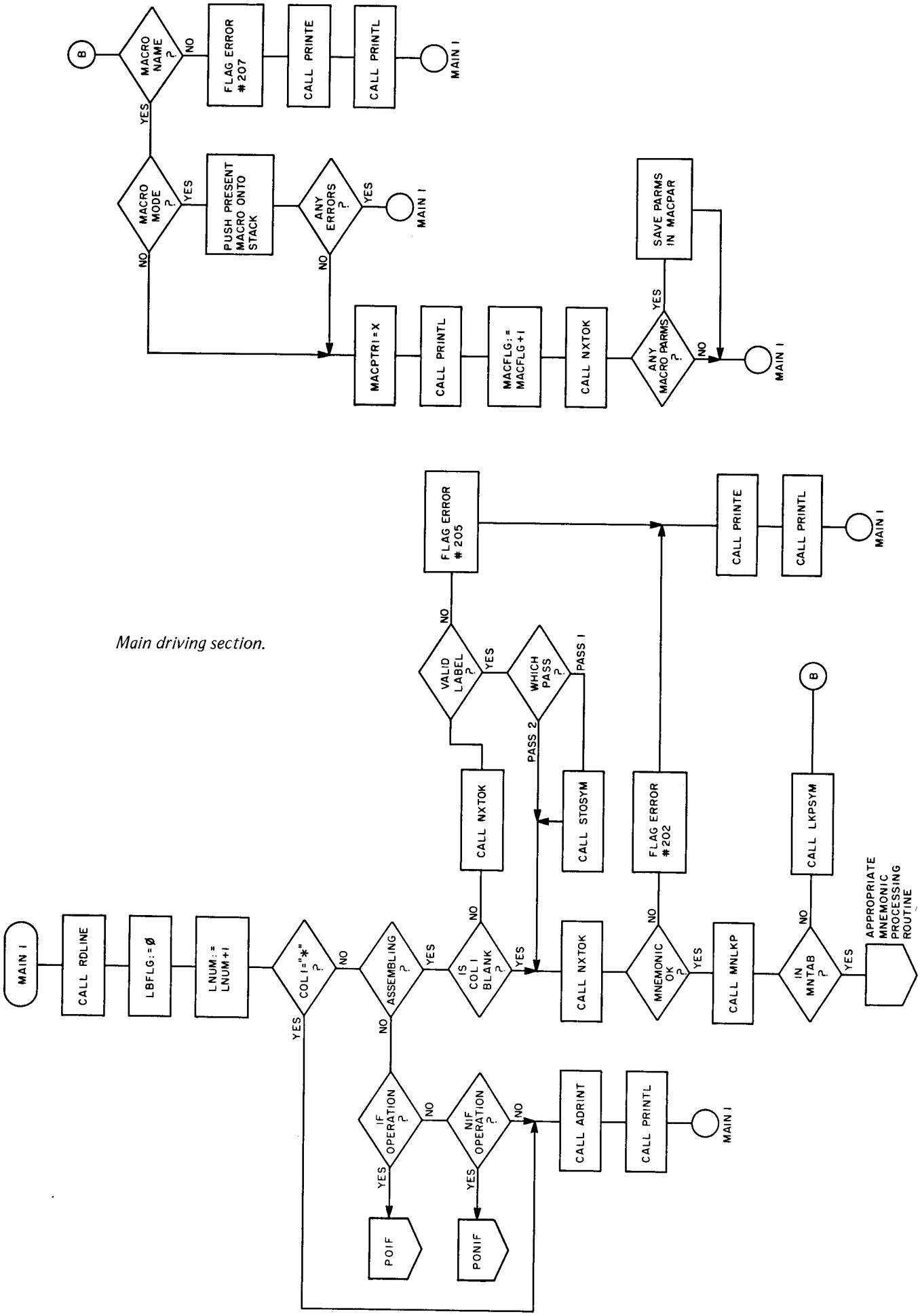
Example 3: Entry Points and External References

Here we show two programs which refer to symbols in each other using ENT and EXT pseudo operations to establish linkages.

```
        NAM PROG1
*
        ENT SUB1      DEFINE SUB1 AS AN ENTRY POINT
        ENT SUB2      DEFINE SUB2 AS AN ENTRY POINT
*
SUB1    LDX #$0000
          .
          .
        RTS
*
SUB2    LDA B#'C
          .
          .
        RTS
        END

        NAM PROG2
        EXT SUB1      DEFINE SUB1 AS EXTERNAL
        EXT SUB2      DEFINE SUB2 AS EXTERNAL
*
        JSR SUB1      CALL SUB1 IN PROG1
        JSR SUB2      CALL SUB2 IN PROG2
          .
          .
        END
```

Example 3: This example shows some of the linkage possible between external routines using the ENT and EXT pseudo instructions. The routine PROG1 is shown here with two entry points, SUB1 and SUB2. PROG2 defines these labels as EXTernal and references them with a jump instruction.■



Main driving section.

The Assembler

Assembler Modules Overview

With this section a detailed description of the inner workings of the Assembler begins. As stated previously, this is a two pass assembler: pass 1 is used to determine values and resolve all references (labels, externals, etc.); pass 2 generates and outputs relocatable machine code, prints listings and messages. This is all controlled from the main program module MAIN1.

Main

MAIN1 is the driving section or top level of the Assembler. It is in one of two logical states, Pass 1 or Pass 2. The state is reflected in the value of system variable PASS. If PASS has the value hexadecimal 00 then the Assembler is executing Pass 1. If PASS has the value hexadecimal FF then the Assembler is executing Pass 2.

Calls:	ADRINT, LKPSYM, MACPSH, MNLKP, NXTOK, PRINTE, PRINTL, RDLINE, STOSYM
Flags:	IFFLG, LBFLG, MACFLG, PASS
Pointers:	CUCHAR, CULINE, DESCRA, DESCRC, MACPTR
Temporaries:	MACSAV
Buffers:	MACPAR

Pass 1 of Main

The purpose of this pass is to assign a location to each data defining pseudo operation and to each instruction and thus, to assign a value to labels (symbols) appearing in the *label* fields of the input source program. To facilitate this a Location Counter (LC) is kept. This counter contains the address of the first byte of the line currently being processed. The Location Counter is initialized to hexadecimal 0000 at the beginning of Pass 1 and is incremented at the end of the processing of an instruction. The value of the increment is equal to the number of bytes the instruction just processed requires.

Pass 1 proceeds by reading a line of source code from the input file. The *label* field is then scanned to see if there is a label present. If there is, the label (symbol) is stored in the Symbol Table (SYMTAB) along with the value of the Location Counter.

The next field scanned is the *opcode* field. A search of the Mnemonic Table (MNTAB) is done to find the address of the processing routine that handles the mnemonic opcode found. MNTAB contains this address along with part of the machine code for processing the opcode. The rest of the machine code is calculated by the processing routine. For the pseudo operations the machine code part of the entry in MNTAB is ignored.

When a mnemonic opcode is found in MNTAB, the address of the processing routine is extracted, the partial machine code is loaded into a register, and control is passed to the processing routine for the mnemonic found.

If the search of MNTAB was unsuccessful in locating the particular opcode, a search of the Symbol Table (SYMTAB) is made to see if the mnemonic is the name of a Macro.

If the mnemonic is a Macro call then the value of the symbol found in the Symbol Table is the address of the Macro definition in the Macro Table (MACTBL). A flag (MACFLG) is set and control is passed back to the main loop. This switches the pointers so that lines of source code now come from the Macro Table rather than from the input file. When the end of the Macro is identified, MACFLG is cleared and the lines of source code come once again from the input file.

Because the number of bytes that an operation or pseudo instruction requires is dependent on the *operand* field, PASS1 must evaluate the *operand* field to determine the increment that is to be added to the Location Counter.

When processing is complete for that opcode, control is passed back to the main program loop and another line of source code either from the input file or Macro Table is read and processed. When the pseudo instruction END is encountered, PASS1 finishes up by requesting that the input source file be rewound and jumping to PASS2.

Pass 2 of Main

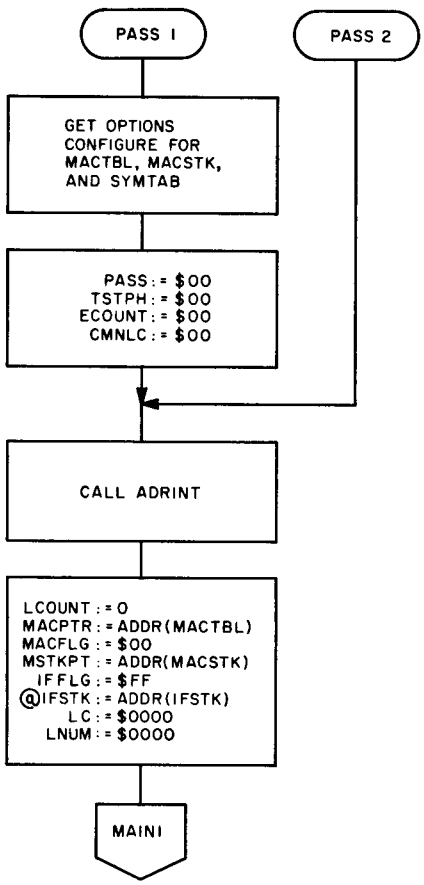
The purpose of PASS2 is to generate and output the machine code, print listings (if selected by the user) and print

any error messages found in the input source program. (PASS1 also prints some error messages.)

PASS2 proceeds through the same main loop as PASS1; however, when control is passed to the processing routines, they calculate the machine code and output it, whereas PASS1 did not. As noted earlier the Assembler can tell what pass it is executing by testing the one byte flag called PASS.

The output listing is unbuffered and is printed line by line after a statement is processed.

When the END pseudo instruction is encountered in the source code the Assembler writes out any machine code that is in the output buffer, prints the Symbol Table (if that option was selected by the user), and terminates by passing control back to the system monitor.



PASS1 and PASS2 initialization. ADDR(Y) indicates the address of item Y.

Tables

There are four tables used by the Assembler: MNTAB, SYMTAB, CHRTB, and MACTBL.

MNTAB AND CHRTAB are permanent tables and SYMTAB AND MACTBL are constructed by the Assembler.

Mnemonic Table (MNTAB)

MNTAB is the table that contains the valid machine mnemonics and pseudo instructions recognized by the Assembler. Each entry in the table is six bytes long. The format is:

CCCXXY

where:

CCC	=	3 byte mnemonic;
XX	=	2 byte address of the processing routine for this instruction;
Y	=	1 byte part of the machine code for this instruction. The other part of the machine code is calculated by the processing routine in PASS2. This field is ignored by the pseudo operation processing routines.

Symbol Table (SYMTAB)

SYMTAB is the symbol table and is maintained with access by means of a hash code. Each entry is 9 bytes long. The format is:

CCCCCCXXF

where:

CCCCCC	=	6 byte symbol. If a symbol is less than 6 bytes long, blanks are inserted on the right.
XX	=	2 byte address or value of the symbol.
F	=	1 byte of flags.
bit 7		Redefined flag
bit 6		Relocation flag
bit 5		Macro flag
bit 4		Common flag
bit 3		External flag
bit 2		Entry flag
bit 1		Reserved for future use
bit 0		Reserved for future use

If a bit is set (1) it means that the associated symbol has that bit position's attribute. If the symbol is a Macro, the XX above is the address location of the Macro definition in the Macro Table (MACTBL). The length of SYMTAB is calculated based on the length of the Assembler and the Macro Table. It is approximately 4 K bytes long, enough for over 300 symbols. This length can be changed by modifying the Symbol Table initialization routine in the main program of the Assembler.

Character Table (CHRTAB)

CHRTAB is used by the lexical analysis routines to facilitate the classification of characters. Each recognizable ASCII character value hexadecimal 20 to 5F is in the table.

The table is indexed by using the value of the ASCII character plus the base address of the table.

The definition of the individual bits in the single byte entry are:

bit 7	Alpha character
bit 6	Numeric character
bit 5	Arithmetic operator

bit 4	Location separator
bit 3	Mnemonic separator
bit 2	Operand separator
bit 1	Hexadecimal character
bit 0	A, B, or X register character

Macro Table (MACTBL)

The Macro Table (MACTBL) is the location where the actual Macro definition code is stored. The size of MACTBL is approximately 2 K bytes. Its organization is free form; ie: one Macro could be anywhere from one instruction to 2 K bytes long. A pointer in the Symbol Table keeps track of where the Macro definition begins, and another MAC pseudo instruction signals the end of the previous Macro definition. The length of the MACTBL is a function of the length of the Assembler, the length of the Symbol Table, and the overall length assumed required for execution of the Assembler (16 K). This length can be modified by changing the table initialization routine in the main program of the Assembler.

Stacks

If Stack (IFSTK)

This is a stack used by the IF and NIF pseudo instruction processing routines to allow the nesting of the IF and NIF pseudo instructions. Eight levels of nesting are allowed.

Macro Stack (MACSTK)

This stack is used to allow the nesting of Macro calls. The number of allowed calls varies depending upon the number of parameters on each Macro. A maximum of 35 levels is possible if no parameters are on the nested calls. A minimum of about four levels is the limit if the maximum number of parameters is used on each nested Macro call. Its actual length is 100 bytes. Note that while Macro *definitions* cannot be nested at all, *expansions* can be nested within these limits when one Macro references another Macro within its definition.

Utility Routines

These utility routines perform comparisons, additions, conversions, etc., as needed by other routines. They operate on numeric or alphabetic data depending on their specific function.

COMPAR

This routine is used to compare variable length character strings or variable length byte strings. The string lengths can be up to 255 bytes. When COMPAR is called the Index register X points to a parameter list of 5 bytes:

Bytes 1, 2..... Address of first string
Bytes 3, 4..... Address of second string
Byte 5..... Number of bytes to be compared.

On returning from COMPAR the result of the comparison is reflected in the 6800's condition codes register. For example, a typical call might look like the following:

```
LDX   - - - (pointer to parameter list) - - -
JSR   COMPAR
BNE   NOMATCH   taken if string 1 is not equal to
                string 2
BEQ   MATCH     taken if string 1 equals string 2
```

Calls: none
Called By: MNLKP, POEND, POMAC, SYMCMP
Flags: none
Pointers: Index Register
Temporaries: XSAV

CVHB

This routine converts hexadecimal character strings into a sixteen bit binary value. When CVHB is called location DESCRA contains the address of the hexadecimal string, and location DESCRC contains the string length. The length cannot exceed four. The converted value is returned in the Index register.

Calls: CVHBS
Called By: NSEVL
Flags: none
Pointers: DESCRA, DESCRC
Temporaries: HVAL

CVHBS

This routine is used by the CVHB routine to convert an ASCII hexadecimal character to binary. On entry the Index register points to the character and on return the A register contains the binary value.

Calls: none
Called By: CVHB

CVDB

This routine converts decimal character strings into a sixteen bit binary value. When CVDB is called location DESCRA contains the address of the string and location DESCRC contains the length. The length cannot exceed five. The converted value is returned in the Index register.

Calls: MPY16
Called By: NSEVL
Pointers: DESCRA, DESCRC
Temporaries: DCOUNT, DVAL, DXSAV, TENVL

CVBTD

This routine converts a sixteen bit binary value into a five character decimal string. On entry, registers A and B contain the sixteen bit binary value to be converted and the Index register points to an area of storage where the converted string is to be stored.

Calls: none
Called By: POEND, PRINTE
Pointers: Index register
Temporaries: SAVEA, SAVEX, SAVEX1

ADD16

This routine adds together two unsigned sixteen bit values. On entry, the Index register points to a four byte area of storage that contains the values to be added together. Bytes 1 and 2 are added to bytes 3 and 4 and the result is stored in bytes 1 and 2.

Calls: none
Called By: GCHRTB, HASH, MNLKP, NSEVL

SUB16

This routine subtracts two unsigned sixteen bit values. On entry, the Index register points to a four byte area of storage that contains the values to be subtracted. Bytes 3 and 4 are subtracted from bytes 1 and 2 and the result is stored in bytes 1 and 2.

Calls: none
Called By: NSEVL

MPY16

This routine multiplies two unsigned sixteen bit values. On entry, the first value is in registers A and B and the second value is in the two bytes pointed to by the Index register.

The result is truncated to sixteen bits and returned to registers A and B.

Calls: none
Called By: CVDB, HASH, MNLKP, NSEVL

DIV16

This routine divides two unsigned sixteen bit values. On entry, the dividend is in registers A and B and the divisor is in the two bytes pointed at by the Index register. The result is placed into registers A and B, and the remainder is returned in the Index register.

Calls: none
Called By: HASH, NSEVL

Listing Routines

The following section includes routines used to output print lines for listings and messages in their proper formats (see listings 1 and 2). These routines utilize the input and output routines outlined in the section **Input and Output Routines** to do the actual detail IO functions.

PRINTL

This routine checks the options byte during Pass 2 to see if the L option and the M option have been selected. PRINTL calls routine OUTL to print a line of listing if the L option has been selected. PRINTL also checks to see if the Assembler is in the Macro mode; if it is, it checks the M option to see if expansion lines from macros are to be listed.

Calls: LINCK, OUTL, SPACER
Called By: ADDR9, LCNAB1, LCN2, LCN3, MAIN, POCMN, POEND, POENT, POEQU, POEXT, POFCB, POFCC, POFDB, POIF, POMAC, PONIF, PORMB
Flags: MACFLG, OPTNS, PASS

OUTL

This routine does the actual printing of the listing. On entry, the following system global values are used to format the listing:

MCOUNT	Number of bytes of machine code (0, 1, 2, or 3)
POP	Pseudo instructions to be printed 0,1, or 2 bytes.
OPCD	Opcode in hexadecimal to be printed
ADR1,ADR2	Second and third bytes of machine code
LINEN	Line number
MACFLG	Macro mode flag
CMNFLG	Common flag
RELFLG	Relocatable flag
ENTFLG	Entry flag
EXTFLG	External flag

For all flags, hexadecimal 00=no, and FF=yes

Calls: OUT2HS, OUT4HS, OUTCHR, PDATA1, PRINTL
Called By: PRINTL
Entries: OUTL7A (from PRINTE)

PRINTE

This routine prints error messages on the system console. Error messages are always printed as the errors occur during both PASS1 and PASS2. On entry, the Index register contains the error number in a binary coded decimal format. The routine prints the error number and the source line that caused the error, then increments the error count in ECOUNT. This count is printed at the very end of the assembly.

Calls: CVBTD, OUTL7A, PDATA1
Called By: ADDR1-5,7,8, INXCK, LBLCK, MACMOV, MAIN, POCMN, POEND, POENT, POEQU, POEXT, POFCB, POFCC, POFDB, POMAC, PONAM, PORMB, P2ERR, RDMAC, STOSYM
Pointers: ECOUNT
Temporaries: ERNUM

LINCK

This routine is called to make sure that the output listing is formatted into pages of 60 lines each. If the line count (LCOUNT) is equal to zero, the system console is spaced to the top of the next page.

Calls: SPACER
Called By: POEND, PRINTL
Pointers: LCOUNT

SPACER

This routine performs the above spacing and also prints a

Listing 1: Output listing format. A sample of the Assembler listing option showing the format of a program listing.

(1) Columns 1 to 4; line number generated by the Assembler.

(2) Column 5; plus sign (+) if this line is a Macro expansion, blank otherwise. Column 6; blank.

(3) Columns 7 thru 10; the hexadecimal memory location. Column 11; blank.

(4) Columns 12 and 13; the hexadecimal operation code. Column 14; blank.

(5) Columns 15 thru 18; the operand, either 2 or 4 hexadecimal characters. Column 19; blank.

(6) Column 20; type indicator: Relocatable (R), Macro (M), Entry (E), External (X), or Common (C). Column 21; blank.

(7) Columns 22 thru 72; the first 51 characters of the source statement. Note that the source statement is not reformatted.

(8) This line of periods acts as a logical page separator. It is repeated every 66 lines, preceded by 3 blank lines and followed by 2 blank lines. Thus there are 60 lines of code possible per page. This page separator is provided for those whose printers use roll paper, and will result in 11 inch pages if line spacing is 66 lines per inch.

(9) If the Statement is a comment (designated in the source by an asterisk (*) in the first column of the source), then columns 1 thru 5 ((1) and (2) above) are the same as above, columns 6 thru 21 are blank, and columns 22 thru 72 are again the first 51 characters of the source statement (in this case, the comment).

```
1409  0966 CE 093E R        LDX   #ENSIZ     GET ENTRY LENGTH
1410  0969 5A               DEC B            B=IP-1
1411  096A BD 0B7D R        JSR   MPY16      GET (IP-1)*6
1412  096D B7 07E3 R        STA A PSING1     SAVE
1413  0970 F7 07E4 R        STA B PSING1+1
1414  0973 CE 0006 R        LDX   #MNTAB
1415  0976 FF 07E5 R        STX   PSING2     PSING2=BASE OF MNTAB
1416  0979 CE 07E3 R        LDX   #PSING1    POINT TO PARMS
1417  097C BD 0BEC R        JSR   ADD16      PSING1=(IP-1)*6+MNTAB
1418  097F FE 07E3 R        LDX   PSING1
1419  0982 FF 07E6 R        STX   TBADD      SAVE
1420                  *
1421                  * COMPARE MNEMONIC WITH ENTRY IN MNTAB
1422                  *
.....
1423  0985 FE 027B R        LDX   DESCRA     GET MNEMONIC ADDRESS
1424  0988 FF 07E5 R        STX   PSING2     INIT PARM FOR COMPARE
1425  098B CE 07E3 R        LDX   #PSING1    POINT TO PARMS
1426  098E BD 06C5 R        JSR   COMPAR     COMPARE
1427  0991 25 0B            BCS   MNLI       ENTRY<MNEMONIC
1428  0993 26 11            BNE   MNMI       ENTRY>MNEMONIC
1429                  *
1430  0995 4F               CLR A            ENTRY FOUND
1431  0996 FE 07E6 R        LDX   TBADD      POINT TO ENTRY
1432  0999 E6 05            LDA B 5,X        GET MC
1433  099B EE 03            LDX   3,X        GET BRANCH ADDRESS
1434  099D 39               RTS
1435                  *
1436                  * ENTRY<MNEMONIC LP=IP
1437                  *
1438  099E B6 093D R MNLI   LDA A IP
1439  09A1 B7 093B R        STA A LP
1440  09A4 20 A9            BRA   MNLKPA     TRY AGAIN
1441                  *
1442                  * ENTRY>MNEMONIC MP=IP
1443                  *
1444  09A6 B6 093D R MNMI   LDA A IP
1445  09A9 B7 093C R        STA A MP
1446  09AC 20 A1            BRA   MNLKPA     TRY AGAIN
```

Listing 2: Symbol table listing format. A sample of the Assembler listing option showing the format of a symbol table listing.

(1) Columns 1 thru 6; the symbol name. Column 7; blank.

(2) Columns 8 thru 11; the hexadecimal address at which the symbol is defined. Column 12; blank.

(3) Column 13; the symbol type: Relocatable (R), Macro (M), Entry (E), External (X), or Common (C).

(4) This line of periods acts as a logical page separator. It is repeated every 66 lines, preceded by 3 blank lines and followed by 2 blank lines. Thus there are 60 lines of table entries possible per page. This page separator is provided for those whose printers use roll paper, and will result in 11 inch pages if line spacing is 66 lines per inch.

```
OUTS    1872 R
P2ERR   10D7 R
P2ERRA  10E3 R
P2ERRB  10E9 R
PAGEA   17B2 R
PAGEND  17BB R
PASS    0275 R
PASS1   038E R
PASS2   0467 R
PBLK2   143D R
PBLOCK  1438 R
PBXS    144F R
PCOUNT  07E7 R
PDATAP  185E RN
PDATA2  185A R
PLEND   0C29 R
POCMN   11D4 R
POCMN0  11E1 R
POCMN1  11E4 R
POCMN2  11E9 R
POCMN3  122F R
.....
POCMN4  1246 R
POEND   124E R
POEND0  1254 R
POEND2  1268 R
POENT   13D8 R
POENT1  13ED R
POENT2  1401 R
POENT3  1426 R
POENT4  1435 R
POEQU   1451 R
POEXT   14AC R
POEXT1  14C4 R
POEXT2  14E0 R
POEXT3  1508 R
POEXT4  150B R
POFCB   150E R
POFCC   1543 R
POFDB   159A R
POIF    15EE R
POIFA   15FB R
POIFB   1603 R
POIFC   1621 R
POIFE   1626 R
POMAC   162E R
POMAC1  164F R
POMAC2  166F R
POMAC5  168F R
POMAC6  16A1 R
POMAC7  16D0 R
POMAC8  16CA R
POMACA  16E0 R
PONAM   1723 R
PONAM1  1739 R
PONAM2  1744 R
PONIF   1758 R
POP     0C66 R
POPAG   179D R
PORMB   17BE R
```

series of periods that are at convenient 11 inch intervals (assuming 6 lines per inch) to allow the listing to be torn off and put into a page size notebook.

Calls: PDATA1
Called By: LINCK, PRINTL

Mnemonic and Symbol Table Routines

The following routines provide the table look-up, comparison, and insertion functions necessary for maintenance of the Mnemonic and Symbol Tables.

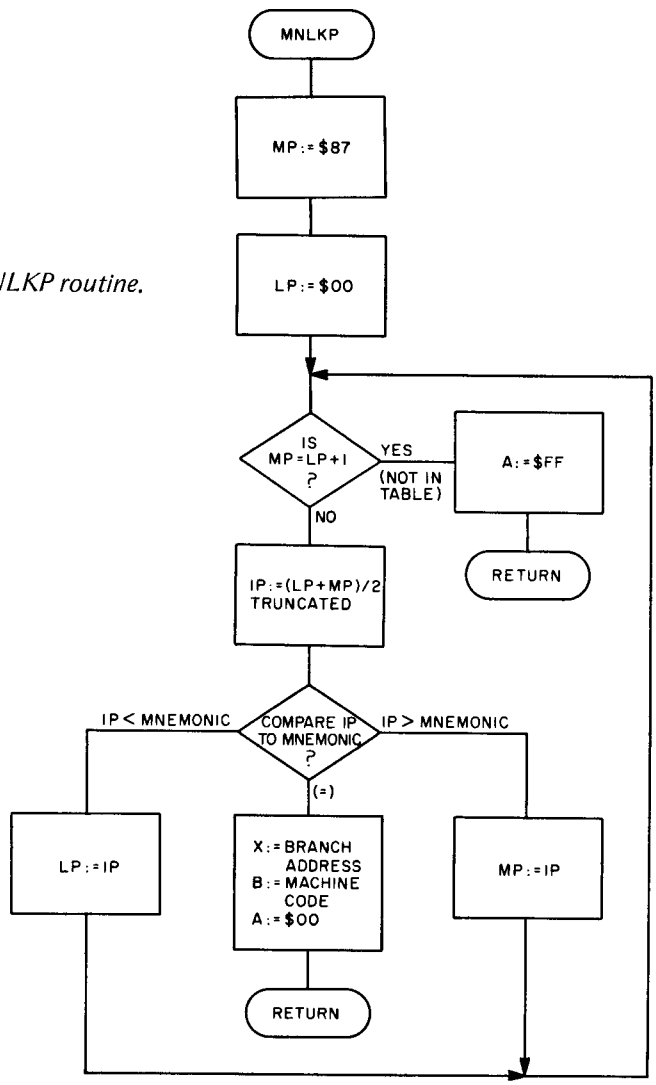
MNLKP

This routine is used to search the Mnemonic Table (MNTAB). On entry, DESCRA points to the mnemonic opcode to be searched for, and DESCRC contains the length of the mnemonic opcode (3). On return register A contains a return code. Hexadecimal FF is the return code if the mnemonic is not in MNTAB. Hexadecimal 00 is the return code if the mnemonic is in the table, and on return register X contains the processing routine's address and register B contains the partial opcode.

The algorithm used is a binary search in which the interval to be searched is divided into two nearly equal parts, the part which does not contain the searched for item is discarded, and the part which contains the sought item is similarly processed until the wanted item is located. The binary search is used because it is significantly faster than a linear search.

Calls: ADD16, COMPAR, MPY16
Called By: MAIN
Pointers: DESCRA, DESCRC, PCOUNT, PSTNG1, PSTNG2, TBADD
Temporaries: ENSIZ, IP, LP, MP

Flowchart of MNLKP routine.



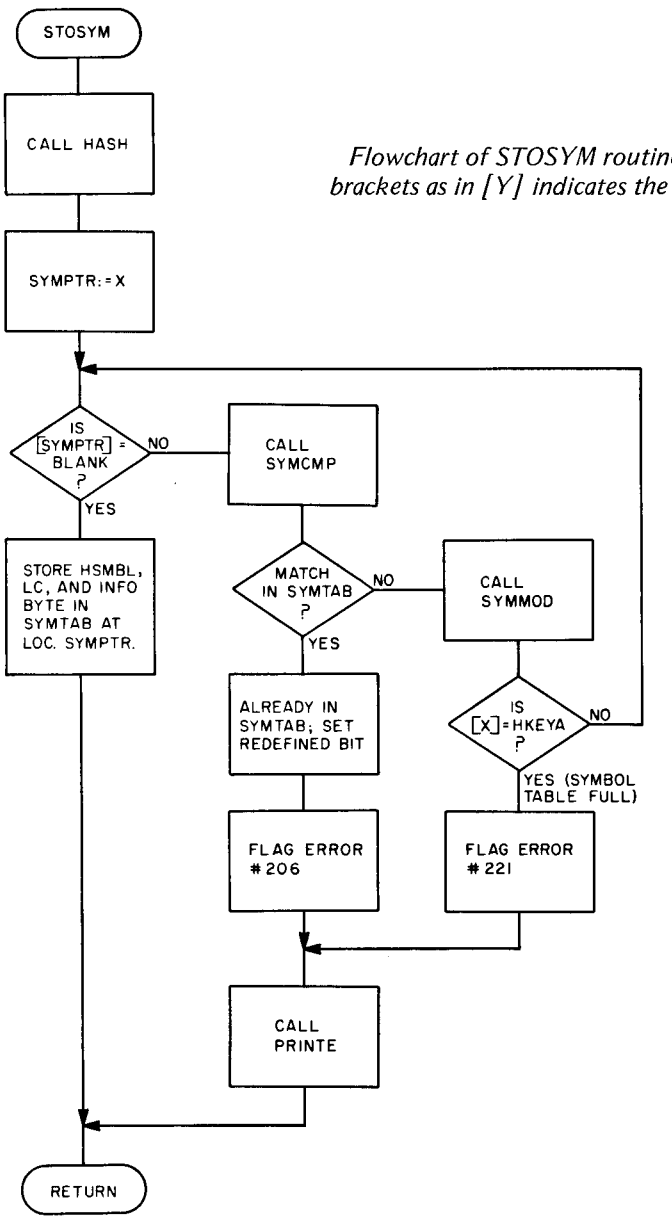
STOSYM

This routine is used to store a symbol and its value into the hash coded Symbol Table (SYMTAB). Hash coding is the method by which the actual symbol that is to be stored in the table is used to find the address of the Symbol Table entry. Hashing means simply to hash or to jumble up the bits of the ASCII characters in a symbol in such a way that a fairly unique number is generated. This number, after further manipulation, becomes the actual address of the location in the Symbol Table where the symbol is to be stored (located).

On entry, DESCRA contains the address of the symbol (from the *label* field) to be stored and DESCRC contains the length. Routine HASH is called to create a hashed code to access the table. If the entry at this address, called the probe address, is empty then the symbol and its value is stored there and the routine returns. If the entry at this probe address is not empty then a new probe must be calculated. This is done by looking at the next sequential address after the first probe to see if it is empty. If it is the symbol and its value are stored at this new location. If this new entry is also occupied then the next sequential address after this new probe is checked, etc. This manner of rehashing is called the Linear Rehash method.

If the symbol is already in the Symbol Table then an error message is printed and the routine returns. If the entire table is found to be full then an error message is printed and the routine returns.

Calls: HASH, PRINTE, SYMCMP, SYMMOD
Called By: MAIN, POCMN, POEXT, PONAM
Pointers: SYMPTR
Temporaries: HSAV1, HSAV2, HSMBL



Flowchart of STOSYM routine. The use of square brackets as in [Y] indicates the contents at address Y.

LKPSYM

This routine is used to look up a symbol in the Symbol Table. On entry, DESCRA contains the address of the symbol to be looked up and DESCRC contains the length. This routine proceeds much as the STOSYM routine except that if the symbol is found the value of the flag byte is returned in register B.

If the symbol is not found in the Symbol Table then a return code of hexadecimal FF is returned in register B.

Calls: HASH, SYMCMP, SYMMOD
Called By: MAIN, NSEVL, POCMN, POENT, POEXT
Pointers: HKEYA, SYMPTR

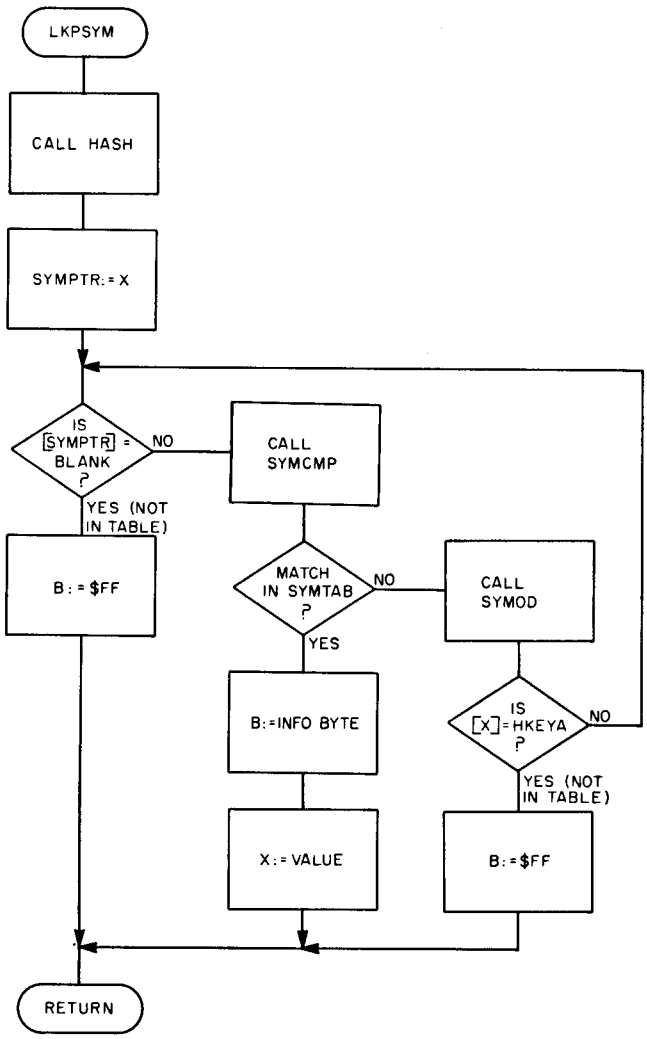
HASH

This routine is used to create a hashed code for accessing the Symbol Table (SYMTAB). On entry, DESCRA contains the address of the symbol to be hashed and DESCRC contains the length.

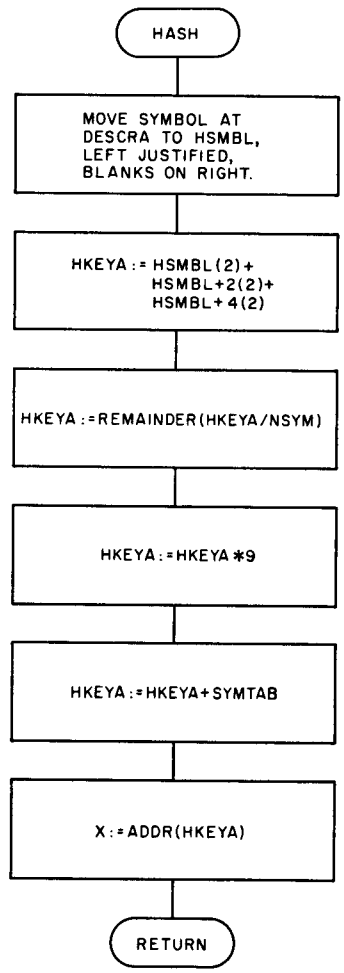
The hashed value is calculated by first folding over the six bytes of the symbol (spaces are added to the right of symbols less than six bytes long) into two bytes by adding the six bytes together in groups of two bytes. This value is divided by the maximum number of symbols that the Symbol Table can hold (NSYM). The remainder from this division is then multiplied by nine (the entry length) and the base address of the Symbol Table is added to produce a pseudo random address. This value is returned in the Index register.

Calls: ADD16, DIV16, MPY16
Called By: LKPSYM, STOSYM
Pointers: DESCRA, DESCRC, NSYM
Temporaries: HKEYA, HKEYB, HSAV1, HSAV2, HSMBL

Flowchart of LKPSYM routine. The use of square brackets as in [Y] indicates the contents at address Y.



Flowchart of HASH routine. ADDR(Y) indicates the address of item Y.



DELSYM

Sometimes it is necessary to delete an entry from the Symbol Table. This routine does the deletion but it can only delete the last entry that has been added to the Symbol Table. On entry, SYMPTR contains the location of the last symbol stored and this is the entry that is deleted.

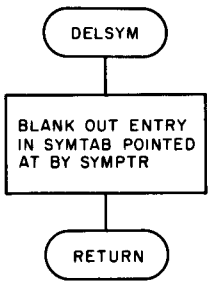
Calls: none
Called By: LBLCK
Pointers: SYMPTR

SYMCMP

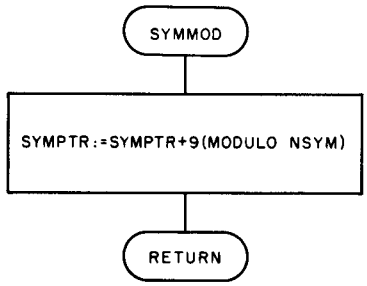
This routine is used to compare a symbol with an entry in the Symbol Table. On entry, the Index register points to the entry in the Symbol Table and HSMBL contains the symbol.

On return, the results of the comparison are reflected in the condition codes (see COMPAR).

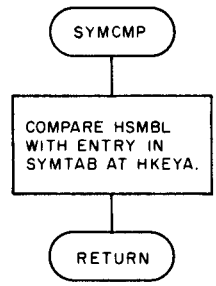
Calls: COMPAR
Called By: LKPSYM, STOSYM
Pointers: HSMBL, PCOUNT, PSTNG1, PSTNG2



Flowchart of DELSYM routine.



Flowchart of SYMMOD routine.



Flowchart of SYMCMP routine.

Input and Output Routines

These IO routines perform the details of formatting information from and to the particular medium used for the source and object code. These routines are independent of the particular serial medium used to store the code. The routines which are directly dependent on the type of medium are described in the section *Interfacing and Using the Assembler.*

OUTBNR

This routine stores the single ASCII character in register B into the output file.

The character may be an:

"R" – Relocatable
"N" – Entry
"X" – External
"M" – Common

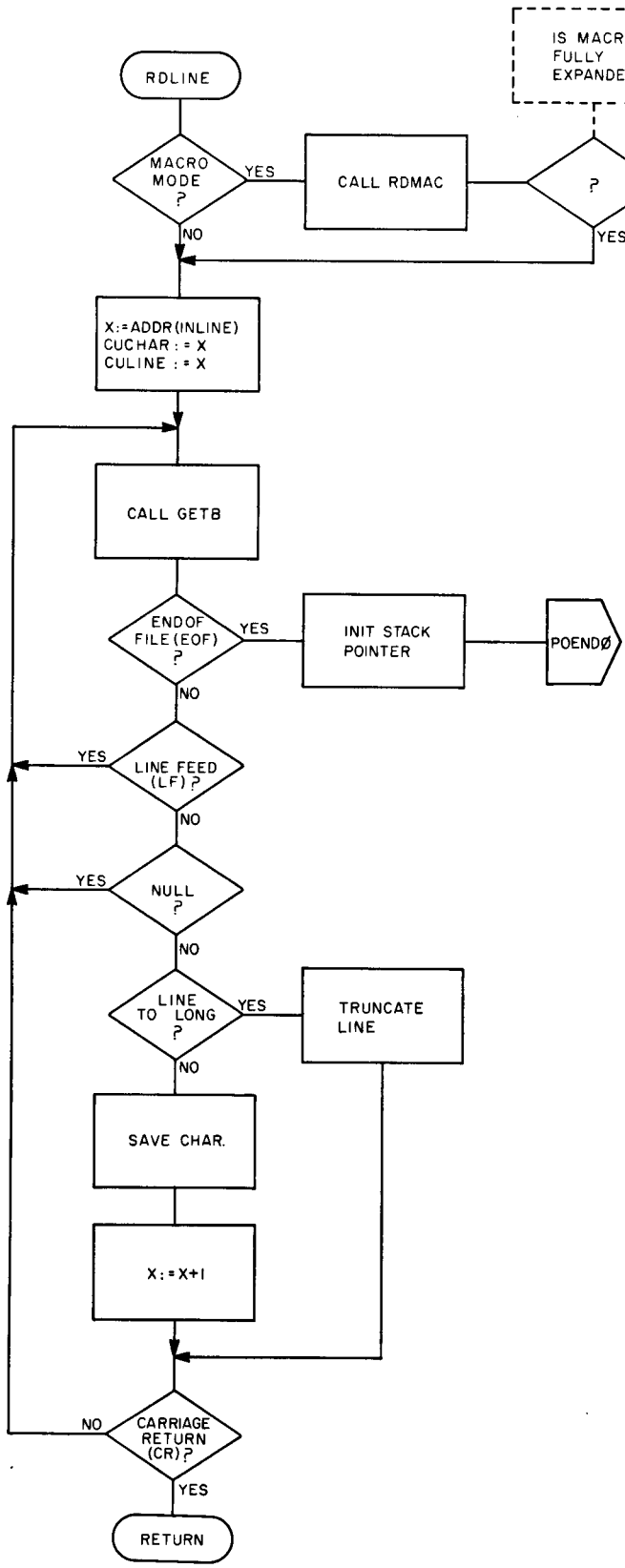
Calls: OUTB
Called By: POENT, POEXT, POFDB, PONAM
Flags: OPTNS

OUTBIN

This routine puts machine code into the output file. On entry, register B contains one byte of machine code. OUTBIN translates this byte into two bytes of ASCII hexadecimal characters and then calls OUTB to output the two bytes to the object file.

Calls: OUTB, OUTHL, OUTHR
Called By: ADDR9, LCNAB1, LCN2, LCN3, PBLOCK, POENT, POEXT, POFCB, POFCC, POFDB, PONAM, RMBOUT
Flags: OPTNS

Flowchart of RDLINE routine. ADDR(Y) indicates the address of item Y.



RDLINE

This routine extracts lines of source code from the input file. On exit from RDLINE, the Assembler global pointers CUCHAR and CULINE point to the input line that is to be processed next.

If the Macro flag MACFLG is set, RDLINE calls the routine RDMAC. This routine passes lines of source code from the expanded Macro back to RDLINE and RDLINE passes these lines to the rest of the Assembler, rather than lines from the input file.

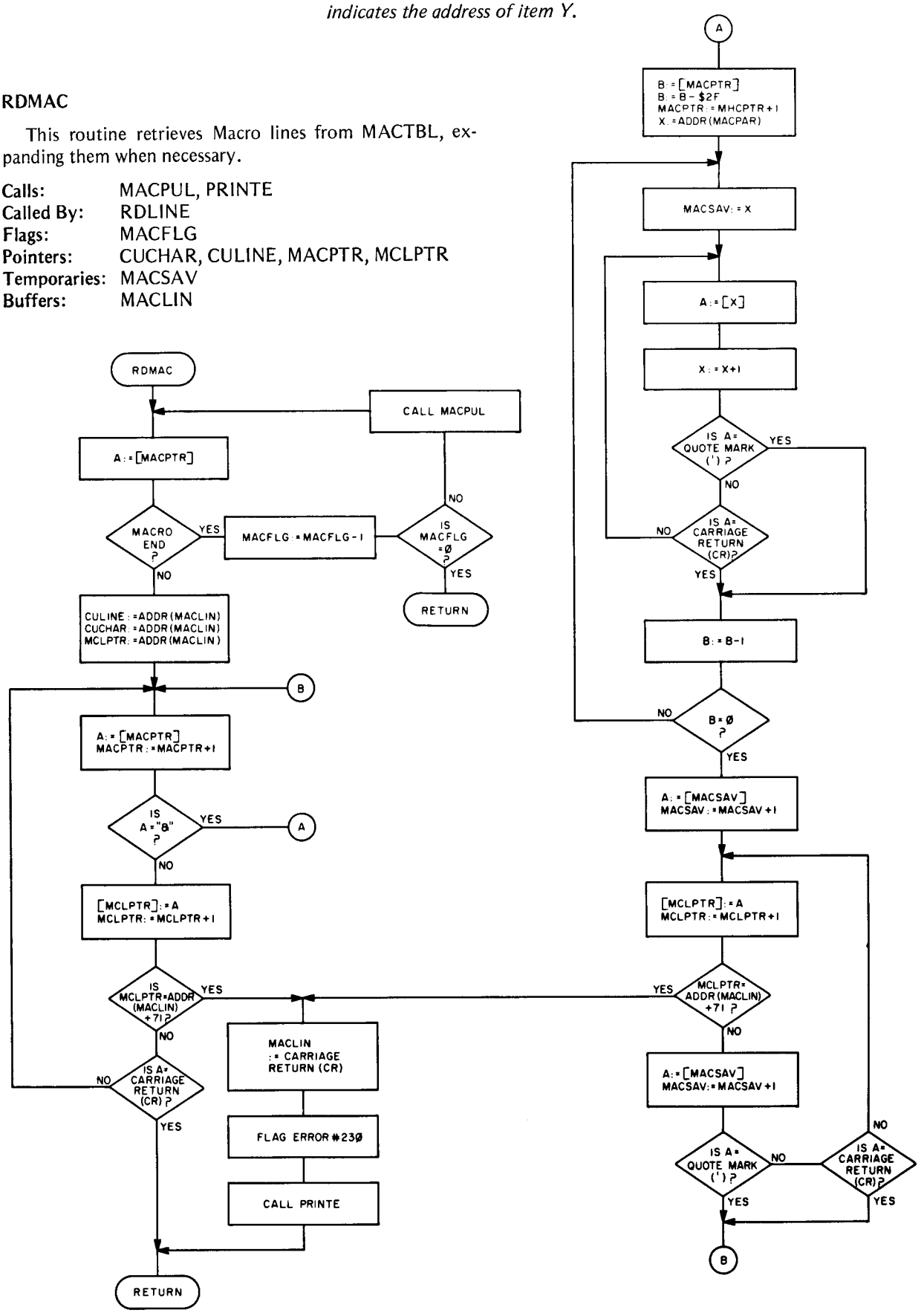
Calls:	GETB, RDMAC
Called By:	MAIN, POMAC
Flags:	MACFLG
Pointers:	CUCHAR, CULINE, INBUF

Flowchart of RDMAC routine. The use of square brackets as in [Y] indicates the contents at address Y. ADDR(Y) indicates the address of item Y.

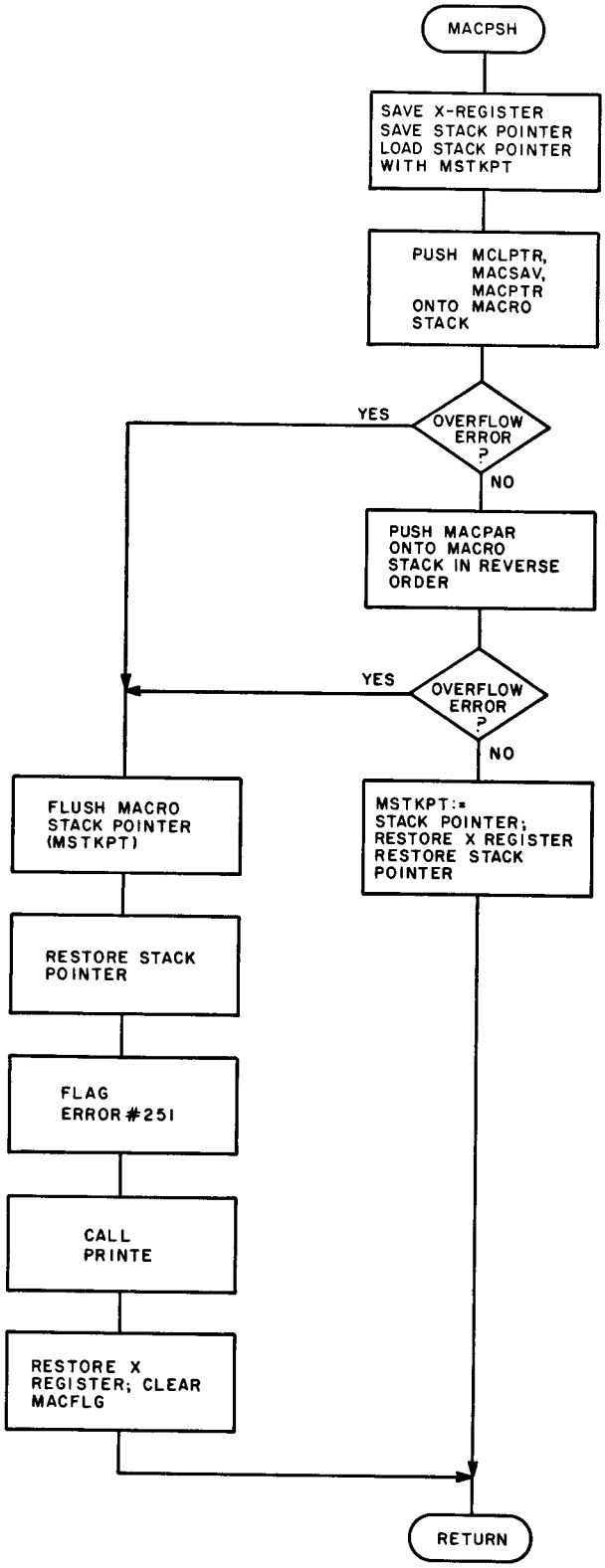
RDMAC

This routine retrieves Macro lines from MACTBL, expanding them when necessary.

Calls: MACPUL, PRINTE
Called By: RDLINE
Flags: MACFLG
Pointers: CUCHAR, CULINE, MACPTR, MCLPTR
Temporaries: MACSAV
Buffers: MACLIN



Flowchart of MACPSH routine.



MACPSH

This routine is used when a nested Macro is called. The state of the present or outer Macro being expanded is pushed onto the Macro Stack (MACSTK).

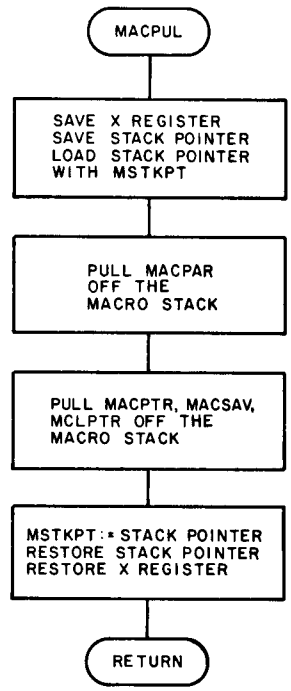
Calls:	PRINTE
Called By:	MAIN
Flags:	MACFLG
Pointers:	MACEND, MACPTR, MACSAV, MACSTK, MCLPTR, MSTKPT
Temporaries:	STKSAV, MXSAV1, MXSAV2
Buffers:	MACPAR

MACPUL

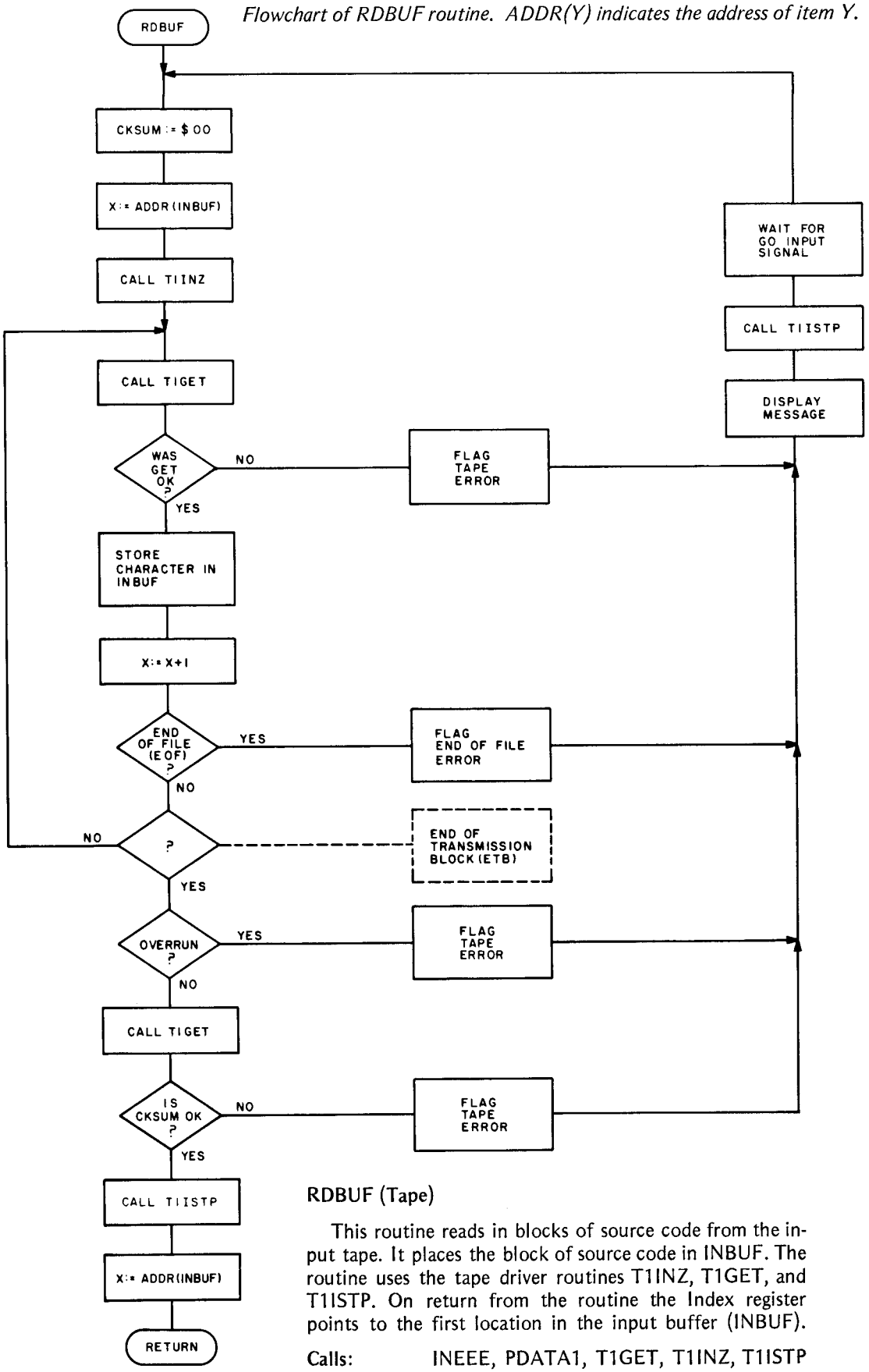
This routine is used to pull the state of a Macro previously pushed onto the Macro Stack. This is done when the inner Macro has been fully expanded.

Calls:	none
Called By:	RDMAC
Pointers:	MACPTR, MACSAV, MCLPTR, MSTKPT
Temporaries:	MXSAV1, STKSAV
Buffers:	MACPAR

Flowchart of MACPUL routine.



Flowchart of RDBUF routine. ADDR(Y) indicates the address of item Y.



RDBUF (Tape)

This routine reads in blocks of source code from the input tape. It places the block of source code in INBUF. The routine uses the tape driver routines T1INZ, T1GET, and T1ISTP. On return from the routine the Index register points to the first location in the input buffer (INBUF).

Calls: INEEE, PDATA1, T1GET, T1INZ, T1ISTP
Called By: GETB

Pseudo Instruction Processing

Following are the descriptions of the routines which process the set of pseudo instructions defined for this Assembler (see "Pseudo Instructions" in the section **The Source Language**).

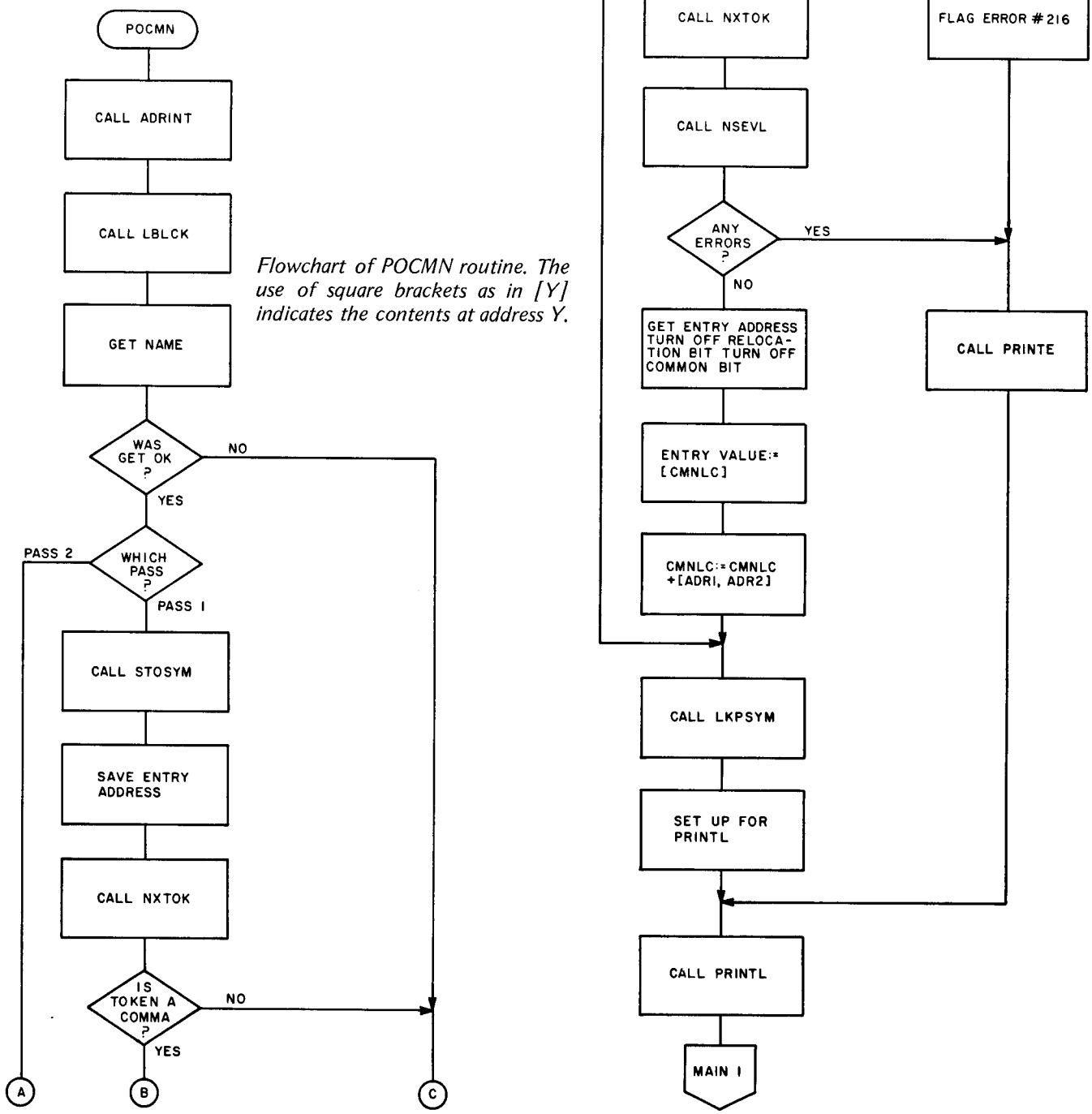
POCMN

This routine processes the CMN pseudo operation. In Pass 1, the name in the *operand* field is stored in the Symbol Table with: REL bit set equal to off (0), Common bit set equal to on (1), Value set equal to value of the Common Location Counter (CMNLC).

CMNLC is then incremented by the number of bytes allocated by the second operand.

In Pass 2 there is very little processing done by POCMN other than setting up flags for the listing line.

Calls: ADRINT, LBLCK, LKPSYM, NSEVL, NXTOK, PRINTE, PRINTL, STOSYM
Called By: MAIN
Flags: CMNFLG, MCOUNT, PASS, POP
Pointers: ADR1, ADR2, CMNLC, SYMPTR
Temporaries: CMNXS



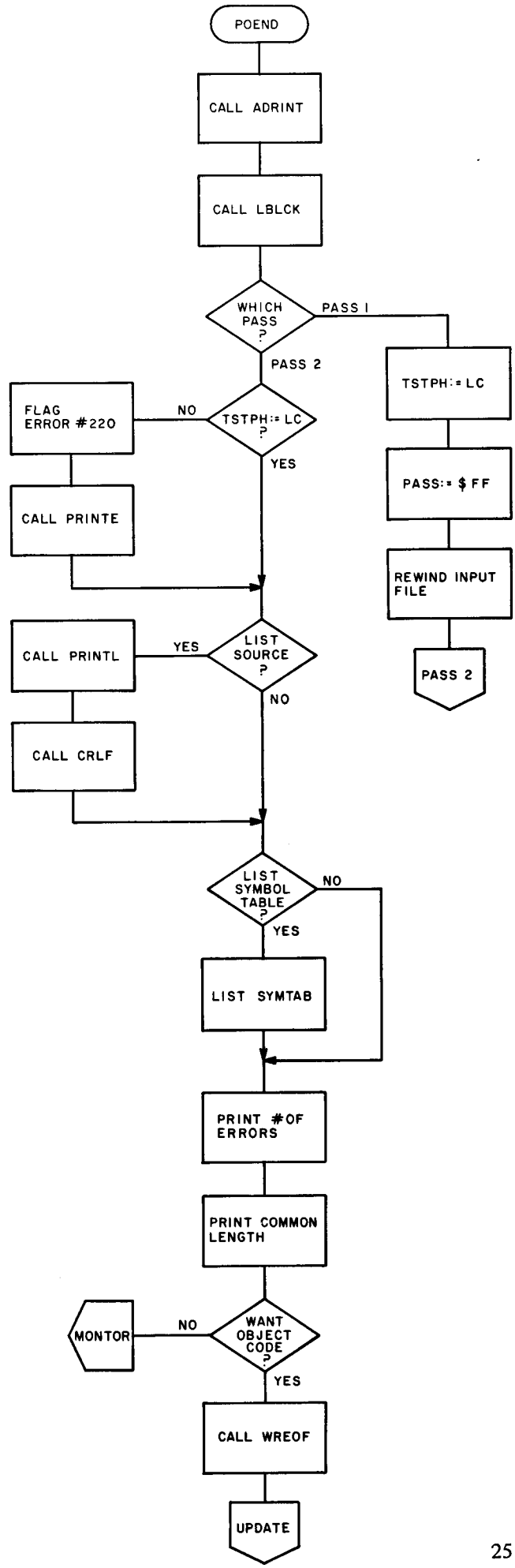
Flowchart of POCMN routine. The use of square brackets as in [Y] indicates the contents at address Y.

POEND

This routine processes the END pseudo operation. In Pass 1, POEND initializes the system global value TSTPH. TSTPH is used by the Assembler to check for phasing errors. A phasing error is one in which an instruction is at different locations during Pass 1 and Pass 2. This can occur, for example, if a Macro definition follows the call to that Macro.

During Pass 1 POEND also sets PASS to Pass 2, rewinds the input file, and then transfers control to PASS2. In Pass 2, POEND finishes up the assembly by printing the Symbol Table, if selected, printing the error count, closing the output file, and transferring control to the system monitor.

Calls:	ADRINT, COMPAR, CRLF, CVBTD, LBLCK, LINCK, OUTCHR, PDATA1, PRINTE, PRINTL, RESTR, WREOF
Called By:	MAIN
Flags:	OPTNS, PASS, SORTF
Pointers:	CBLOCK, CMNLC, CXS2, LC, PCOUNT, PSTING1, PSTING2, TSTPH, ZZZ
Temporaries:	ENDXS



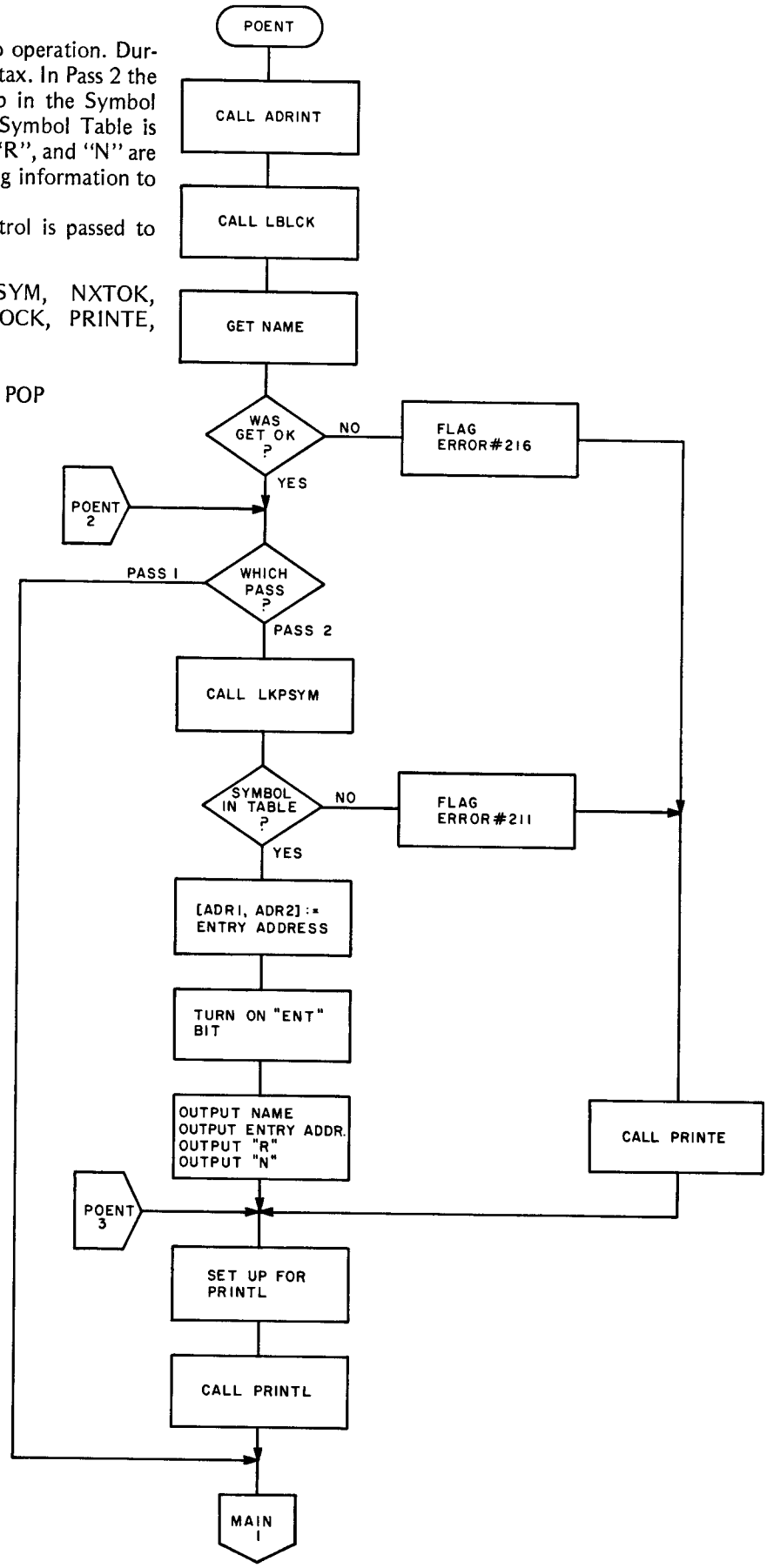
Flowchart of POEND routine.

POENT

This routine processes the ENT pseudo operation. During Pass 1 the statement is checked for syntax. In Pass 2 the symbol in the *operand* field is looked up in the Symbol Table. The ENT bit in the entry in the Symbol Table is then set. The symbol, the entry address, "R", and "N" are output to the output file, providing linking information to the Linking Loader.

Following Pass 1 or 2 processing control is passed to entry point MAIN1.

Calls: ADRINT, LBLCK, LKPSYM, NXTOK, OUTBIN, OUTBNR, PBLOCK, PRINTE, PRINTL
Called By: MAIN
Flags: ENTFLG, MCOUNT, PASS, POP
Pointers: ADR1, ADR2, SYMPTR



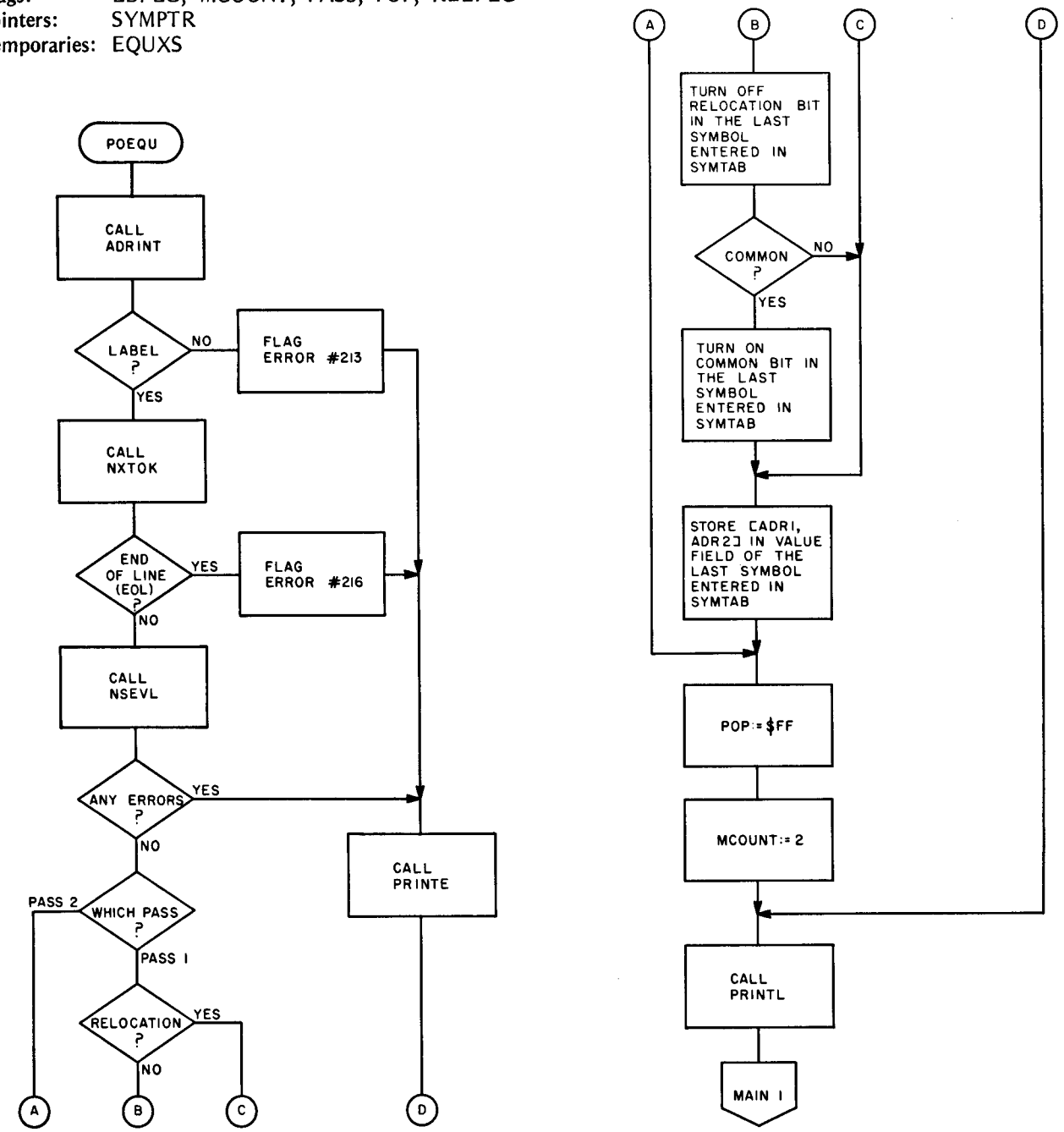
Flowchart of POENT routine. The use of square brackets as in [Y] indicates the contents at address Y.

POEQU

This routine processes the EQU pseudo instruction. In Pass 1 the operand is evaluated and stored in the Symbol Table entry associated with the label on the EQU statement. During Pass 2 there is no processing done other than printing the line of listing.

Following Pass 1 or 2 processing control is passed to entry point MAIN1 in the main loop.

Calls: ADRINT, NSEVL, NXTOK, PRINTE, PRINTL
Called By: MAIN
Flags: LBFLG, MCOUNT, PASS, POP, RELFLG
Pointers: SYMPTR
Temporaries: EQUXS



Flowchart of POEQU routine. The use of square brackets as in [Y] indicates the contents at address Y.

PBLOCK

This routine is used by the POENT and POEXT routines to output the Entry/External symbol to the output file.

Calls: OUTBIN
Called By: POENT, POEXT
Pointers: SYMPTR
Temporaries: PBXS

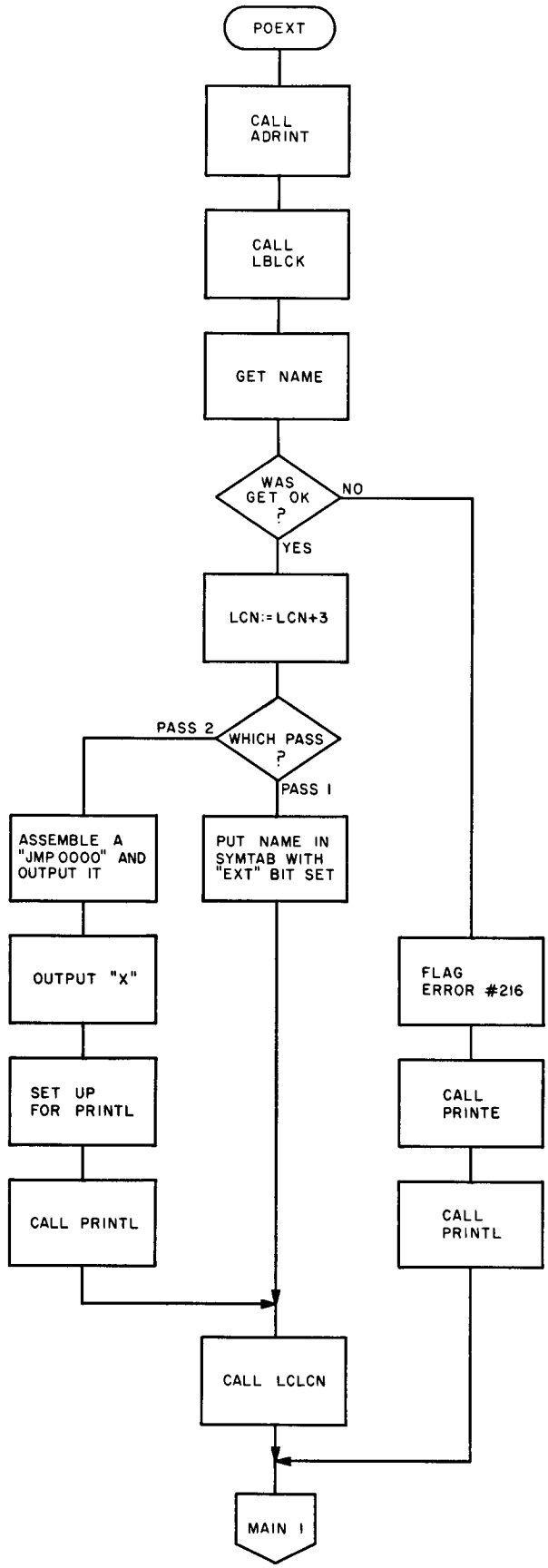
POEXT

This routine processes the EXT pseudo operation. In Pass 1 the symbol in the *operand* field of the statement is stored in the Symbol Table with the EXT bit set and a value equal to the current value of the location counter.

In Pass 2, a JMP symbol (3 bytes) is assembled and output to the output file, along with the EXT indicator "X". This provides linking information to the Linking Loader.

Following Pass 1 or 2 processing control is passed to entry point MAIN1.

Calls: ADRINT, LBLCK, LCLCN, LKPSYM, NXTOK, OUTBIN, OUTBNR, PBLOCK, PRINTE, PRINTL, STOSYM
Called By: MAIN
Flags: EXTFLG, MCOUNT, PASS
Pointers: ADR1, ADR2, LCN, OPCD, SYMPTR



Flowchart of POEXT routine.

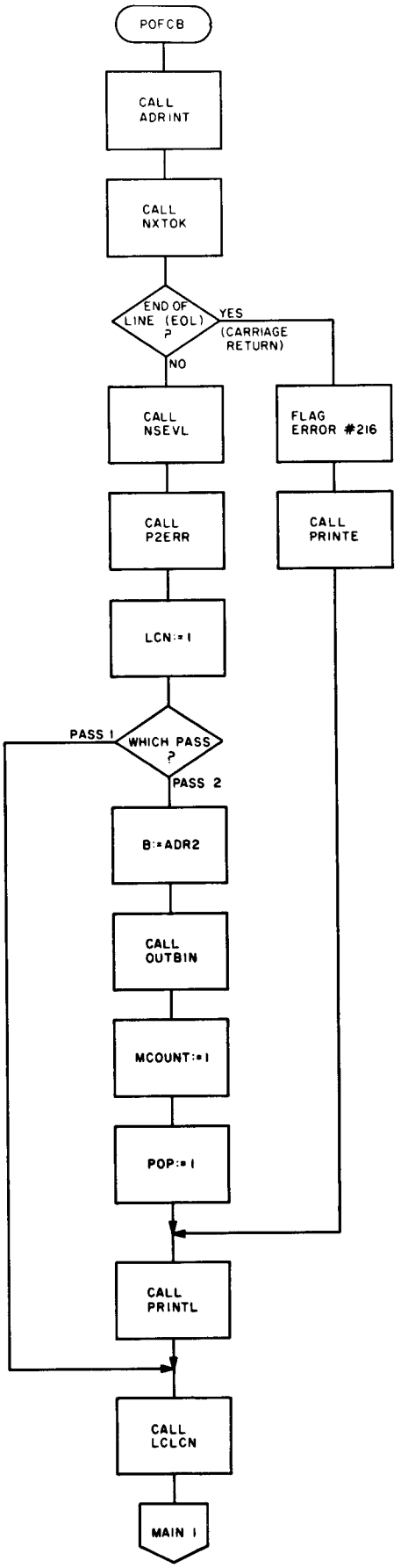
POFCB

This routine processes the FCB pseudo instruction. During Pass 1, POFCB simply increments the Location Counter (LC).

In Pass 2 the LC is incremented as in Pass 1, but the operand is evaluated and stored as a one byte value in the output buffer.

Following Pass 1 or 2 processing control is passed to entry point MAIN1 in the main loop.

Calls: ADRINT, LCLCN, NSEVL, NXTOK, OUTBIN, PRINTE, PRINTL
Called By: MAIN
Flags: MCOUNT, PASS, POP
Pointers: LCN



Flowchart of POFCB routine.

POFCC

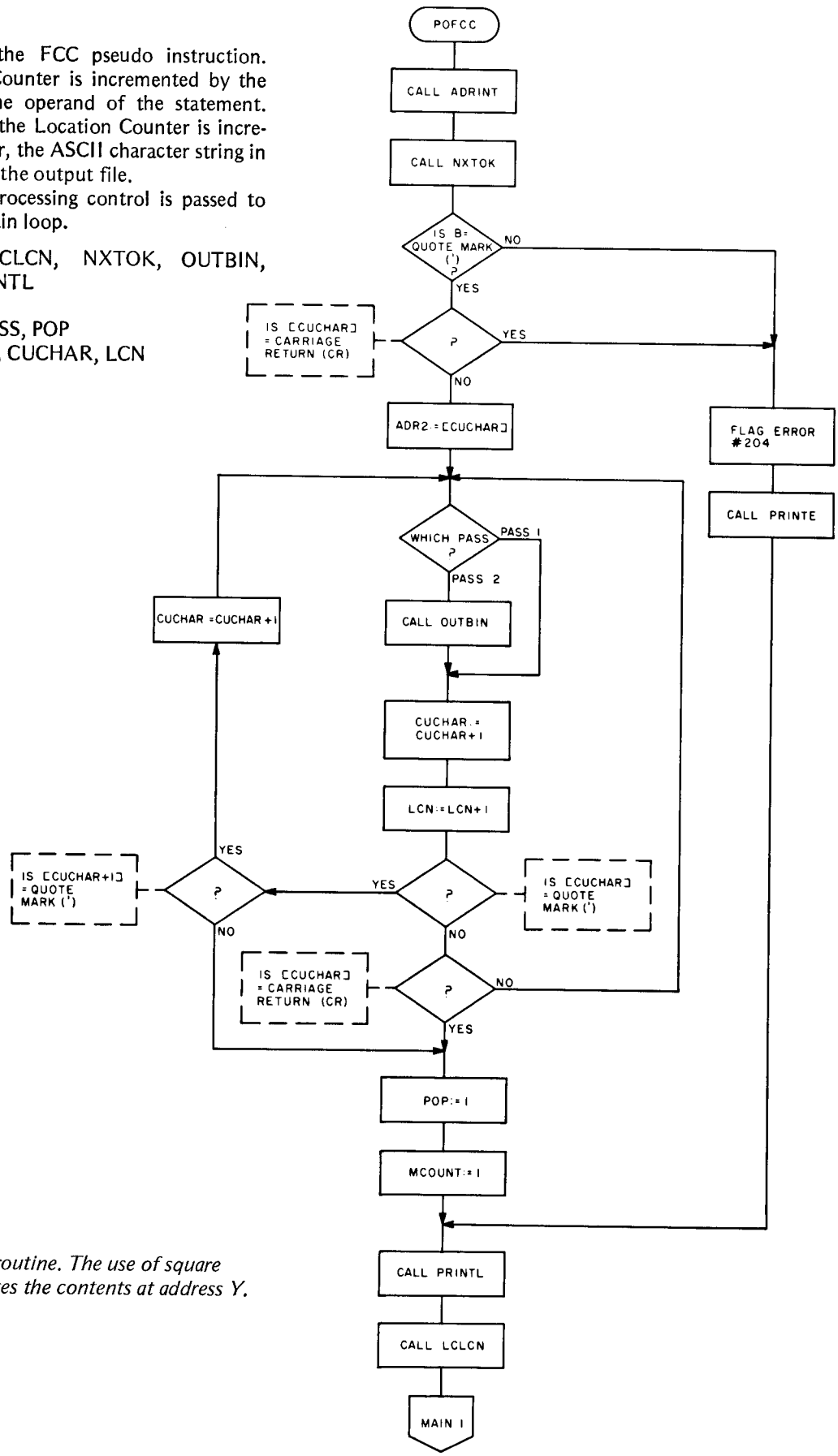
This routine processes the FCC pseudo instruction.

In Pass 1 the Location Counter is incremented by the number of characters in the operand of the statement.

When Pass 2 is executed the Location Counter is incremented as in Pass 1; however, the ASCII character string in the *operand* field is stored in the output file.

Following Pass 1 or 2 processing control is passed to entry point MAIN1 in the main loop.

Calls: ADRINT, LCLCN, NXTOK, OUTBIN, PRINTE, PRINTL
Called By: MAIN
Flags: MCOUNT, PASS, POP
Pointers: ADR1, ADR2, CUCHAR, LCN



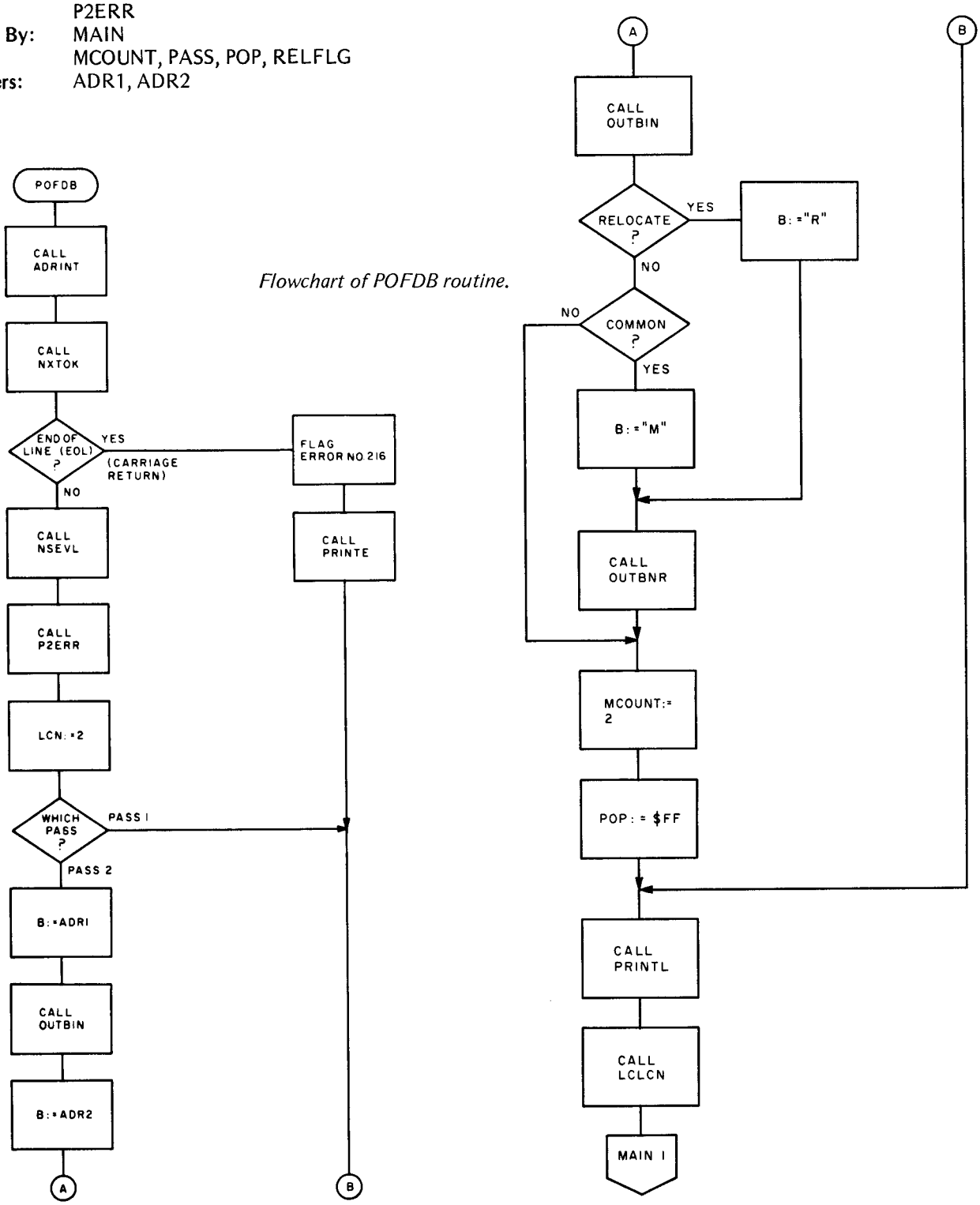
Flowchart of POFCC routine. The use of square breakets as in [Y] indicates the contents at address Y.

POFDB

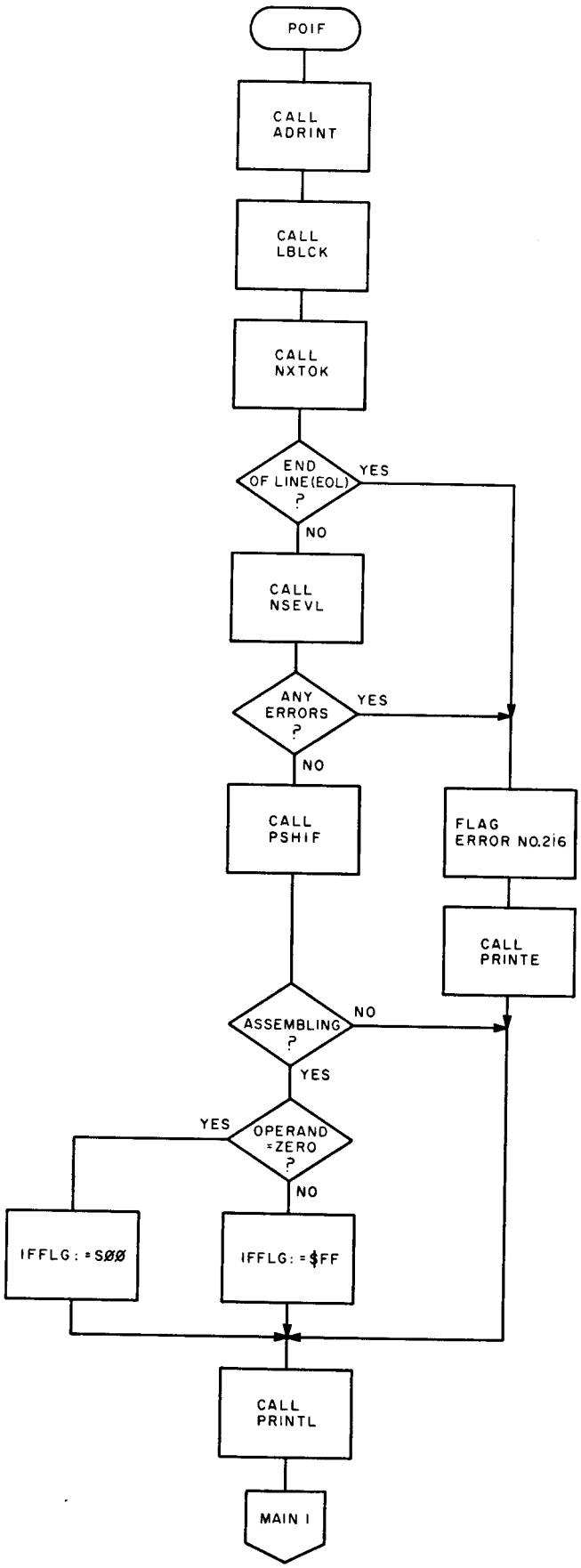
This routine processes the FDB pseudo operation. It is almost the same as routine POFCB, except that two byte values are used instead of one byte values.

Following Pass 1 or 2 processing control is passed to entry point MAIN1 in the main loop.

Calls: ADRINT, LCLCN, NSEVL, NXTOK, OUTBIN, OUTBNR, PRINTE, PRINTL, P2ERR
Called By: MAIN
Flags: MCOUNT, PASS, POP, RELFLG
Pointers: ADR1, ADR2



Flowchart of POFDB routine.



POIF

This routine processes the IF pseudo instruction. There is no distinction made between Pass 1 and 2.

The operand is evaluated and the present value of the flag IFFLG is stacked in IFSTK. Then depending on whether the operand value is 0 or not, IFFLG is set or cleared.

Cleared: Not assembling
Set: Assembling

Calls: ADRINT, LBLCK, NSEVL, NXTOK, PRINTE, PRINTL, PSHIF
Jumps: MAIN1
Called By: MAIN
Flags: IFFLG

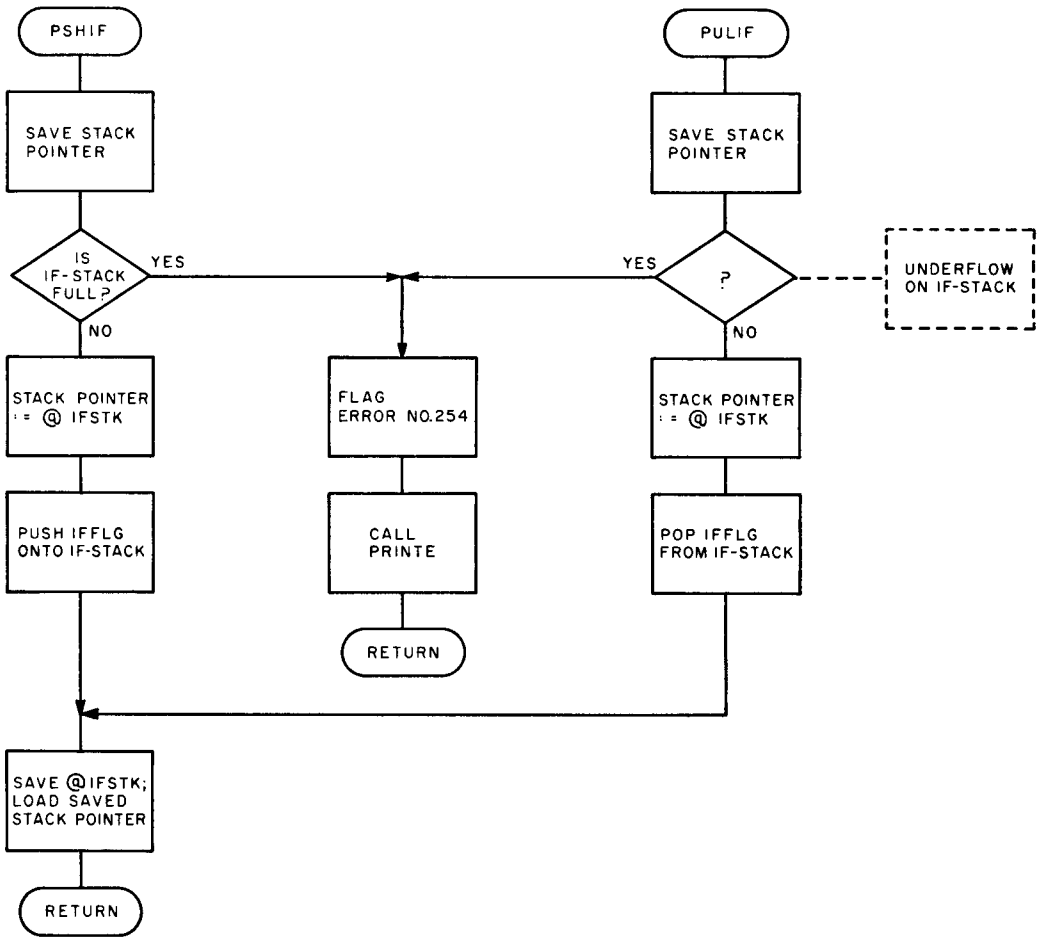
Flowchart of POIF routine.

PSHIF (PULIF)

This routine is used by the POIF and PONIF routines to either push or pull the present value of the IFFLG on (from) the IF stack (IFSTK).

Calls: PRINTE
Called By: POIF, PONIF
Entry Points: PULIF
Flags: IFFLG
Pointers: STKSAV, @IFSTK

Flowchart of PUSHIF and PULIF routines.

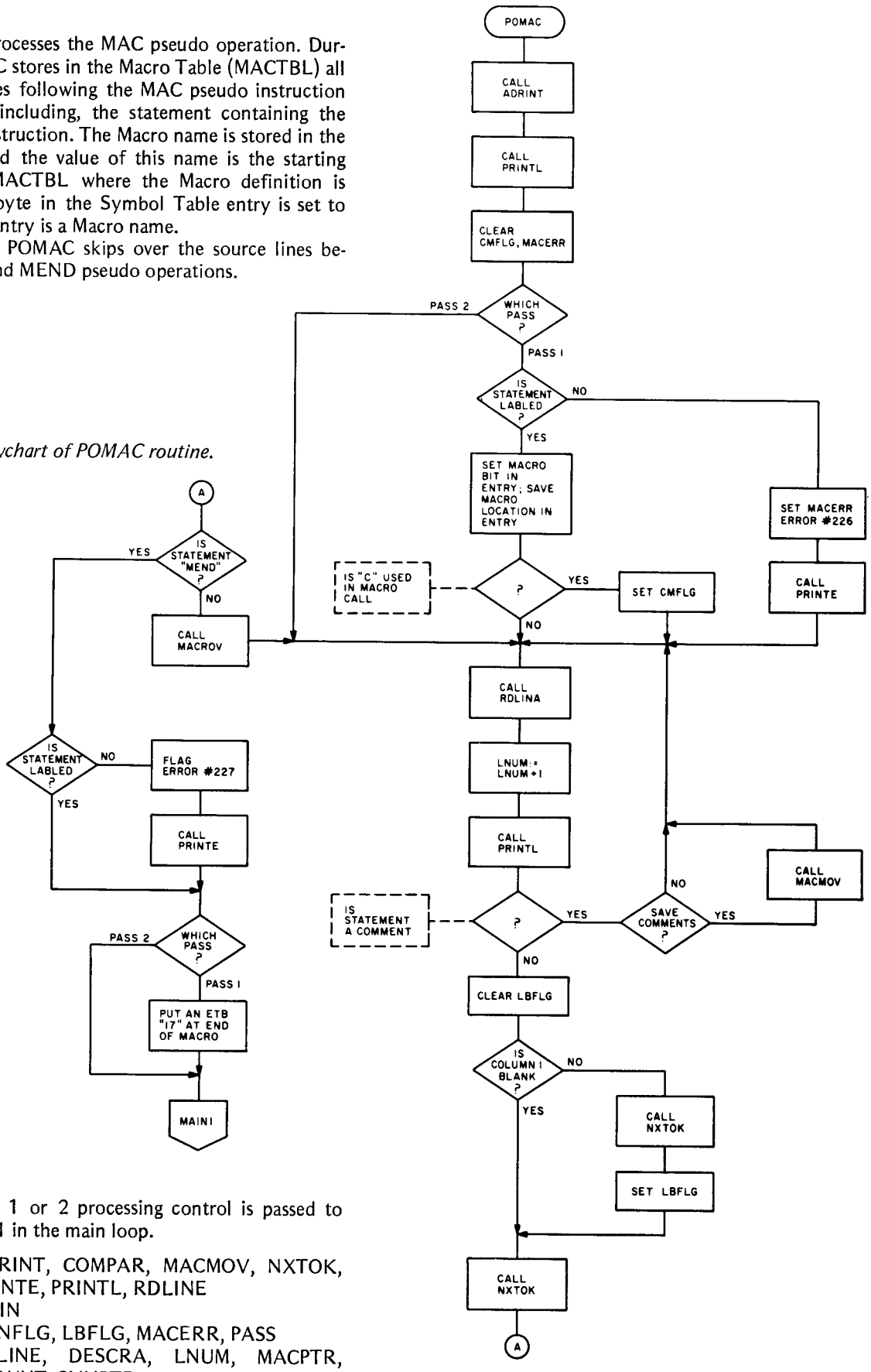


POMAC

This routine processes the MAC pseudo operation. During Pass 1 POMAC stores in the Macro Table (MACTBL) all of the source lines following the MAC pseudo instruction up to, but not including, the statement containing the MEND pseudo instruction. The Macro name is stored in the Symbol Table and the value of this name is the starting address in the MACTBL where the Macro definition is stored. The flag byte in the Symbol Table entry is set to indicate that the entry is a Macro name.

During Pass 2 POMAC skips over the source lines between the MAC and MEND pseudo operations.

Flowchart of POMAC routine.



Following Pass 1 or 2 processing control is passed to entry point MAIN1 in the main loop.

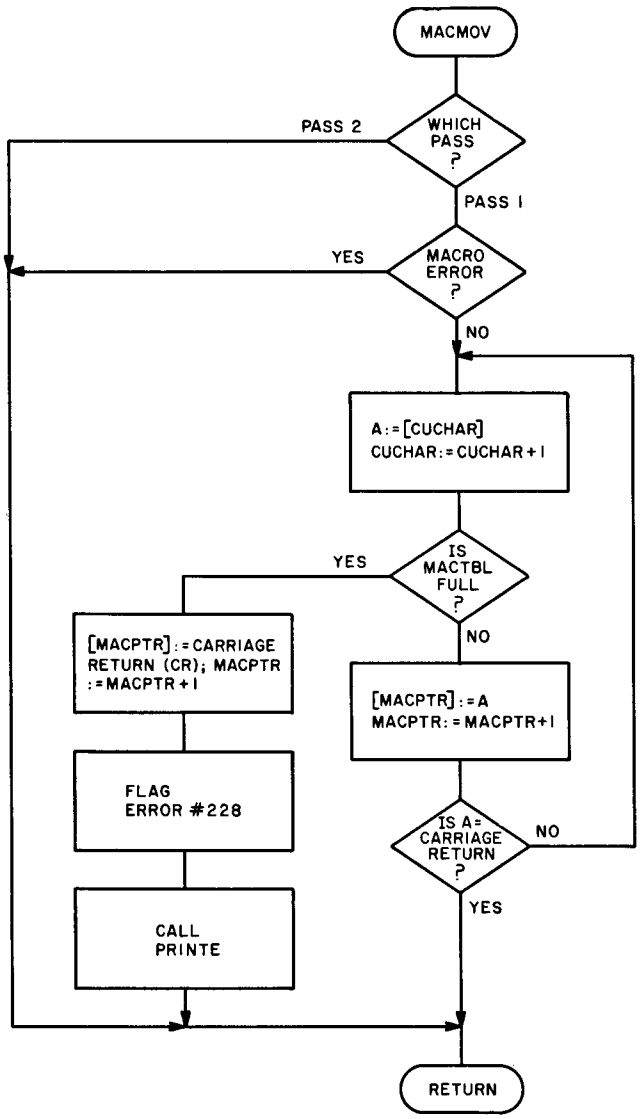
Calls:	ADRINT, COMPAR, MACMOV, NXTOK, PRINTE, PRINTL, RDLINE
Called By:	MAIN
Flags:	CMNFLG, LBFLG, MACERR, PASS
Pointers:	CULINE, DESCRA, LNUM, MACPTR, PCOUNT, SYMPTR

MACMOV

This routine is used by the POMAC routine to move a line from the Macro definition to the Macro Table.

Calls: PRINTE
Called By: POMAC
Flags: MACERR, PASS
Pointers: CULINE, MACPTR

Flowchart of MACMOV routine. The use of square brackets as in [Y] indicates the contents at address Y.

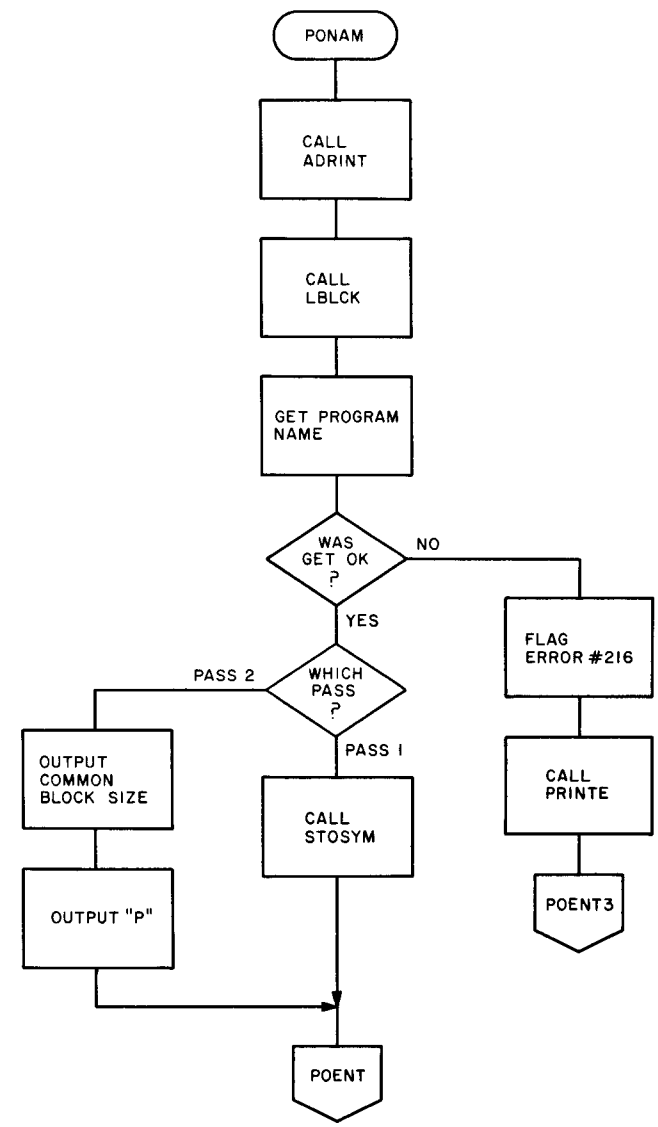


PONAM

This routine processes the NAM pseudo instruction. The operand name is passed to the Linking Loader as an Entry point followed by the size of the Common Block.

Calls: ADRINT, LBLCK, NXTOK, OUTBIN, OUTBNR, PRINTE, PRINTL
Jumps: POENT1, POENT3
Called By: MAIN
Flags: PASS
Pointers: CMNLC

Flowchart of PONAM routine.

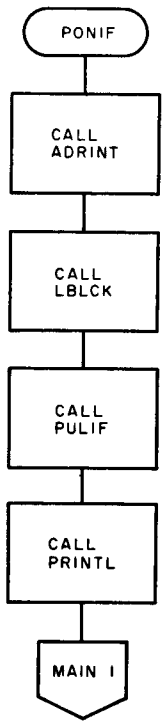


PONIF

This routine processes the NIF pseudo operation. There is no distinction between Pass 1 and Pass 2 processing.

The last value of the flag IFFLG is pulled off of the IFSTACK.

Calls: ADRINT, LBLCK, PRINTE, PULIF
Jumps: MAIN1
Called By: MAIN



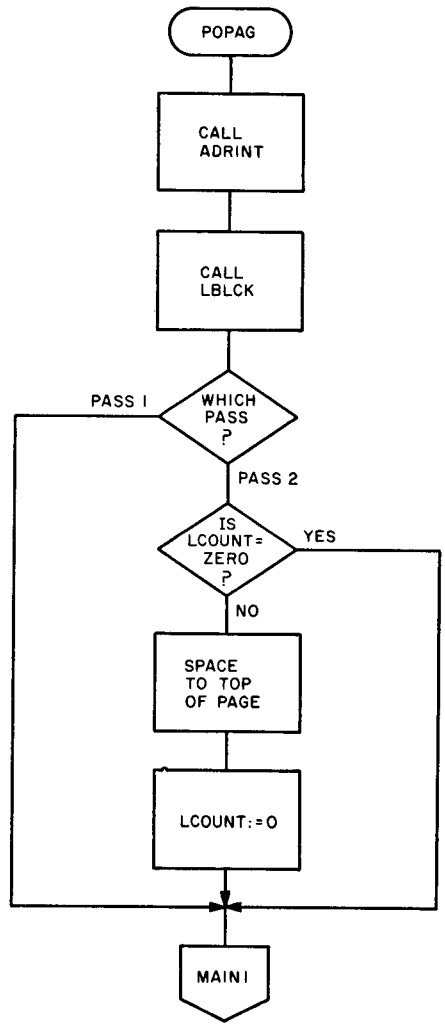
Flowchart of PONIF routine.

POPAG

This routine processes the PAG pseudo instruction. During Pass 2 this routine simply advances the listing on the system console (if the listing option has been selected) to the top of the next page.

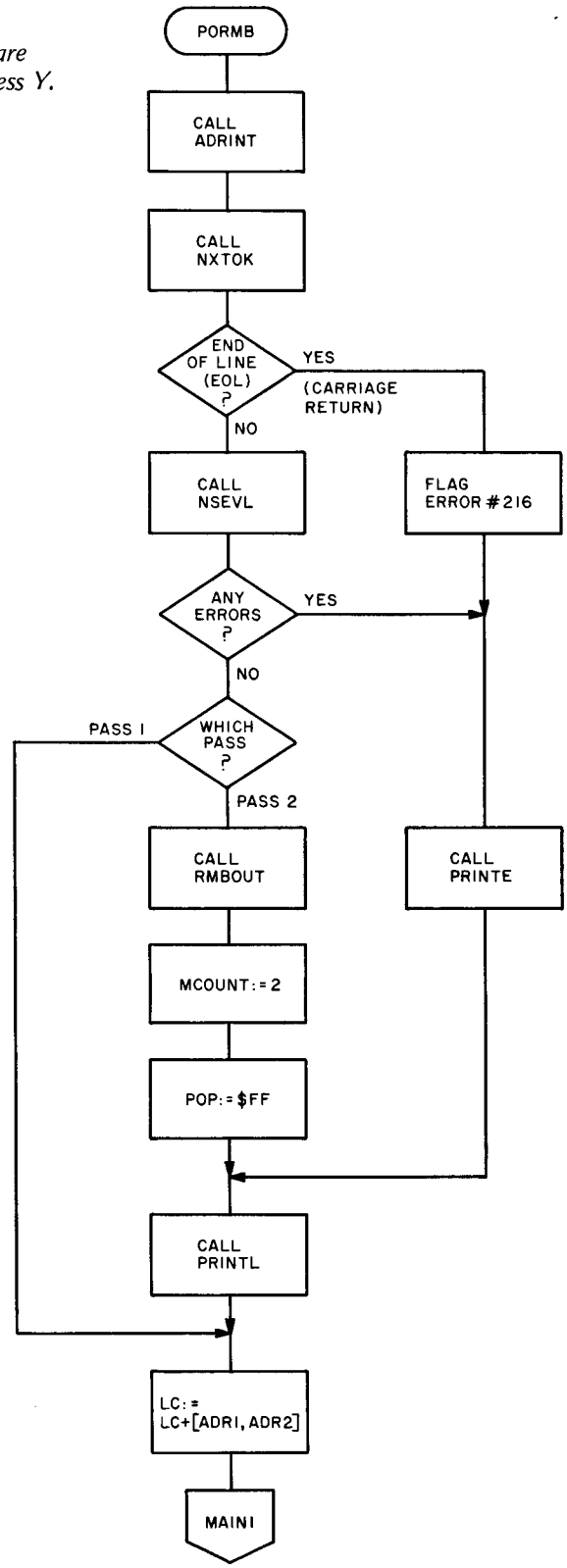
Following Pass 1 or 2 processing control is passed to entry point MAIN1 in the main loop.

Calls: ADRINT, LBLCK, OUTCHR
Called By: MAIN
Flags: PASS
Pointers: LCOUNT



Flowchart of POPAG routine.

Flowchart of PORMB routine. The use of square brackets as in [Y] indicates the contents at address Y.



PORMB

This routine processes the RMB pseudo instruction. During Pass 1 the operand is evaluated and the Location Counter (LC) is incremented by this value. In Pass 2 the Location Counter is incremented by the value of the operand, and that number of zeroes is stored in the output buffer.

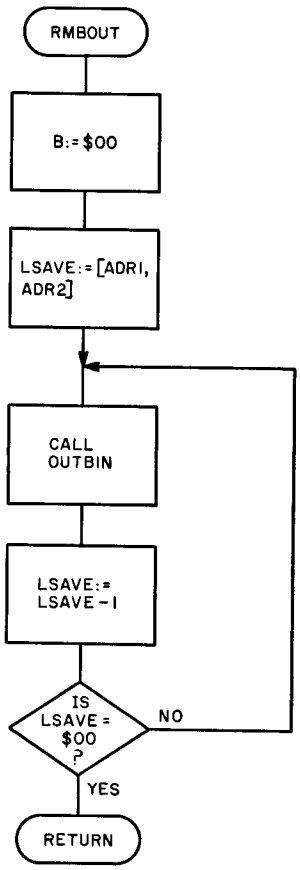
Following Pass 1 or 2 processing control is passed to entry point MAIN1 in the main loop.

Calls: ADRINT, NSEVL, NXTOK, PRINTE, PRINTL, RMBOUT
Called By: MAIN
Flags: MCOUNT, PASS, POP
Pointers: ADR1, ADR2, LC
Temporaries: LSAVE

RMBOUT

This routine is used by the PORMB routine to output zero bytes to the output file. On entry, (ADR1, ADR2) contains the number of bytes to be output.

Calls: OUTBIN
Called By: PORMB
Pointers: ADR1, ADR2
Temporaries: LSAVE

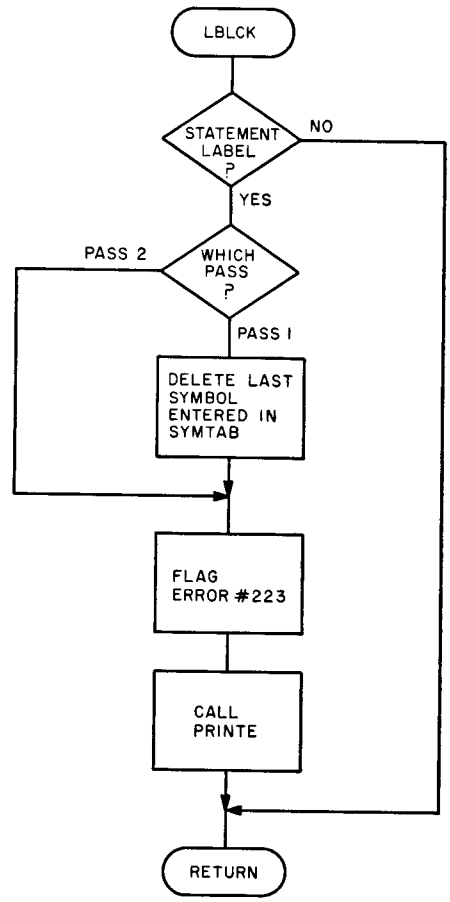


Flowchart of RMBOUT routine. The use of square brackets as in [Y] indicates the contents at address Y.

LBLCK

This routine is used by certain of the pseudo instruction processing routines to check to see if there is a label for that source line. If there is a label, it is deleted from the Symbol Table, and an error message printed.

Calls: DELSYM, PRINTE
Called By: POCMN, POEND, POENT, POEXT, PONAM, POPAG
Flags: LBFLG, PASS



Flowchart of LBLCK routine.

Opcode Processing Routines

The address processing routines all perform the same function and share common subroutines. The main function of an address processing routine is to scan the *operand* field of a statement and, based on the structure and values of the operands, generate the machine code for the instruction being processed. The processing routine also increments the Location Counter by the number of bytes the assembled instruction requires. Inherent, Relative and Accumulator addressing types require one byte. Indexed and Direct types require two bytes. Extended type instructions require three bytes, and Immediate types require either two or three bytes.

During Pass 1 no machine code is generated, but the *operand* field is scanned to detect errors and to calculate the number of bytes the instruction requires.

During Pass 2 the machine code is generated and stored in the output file.

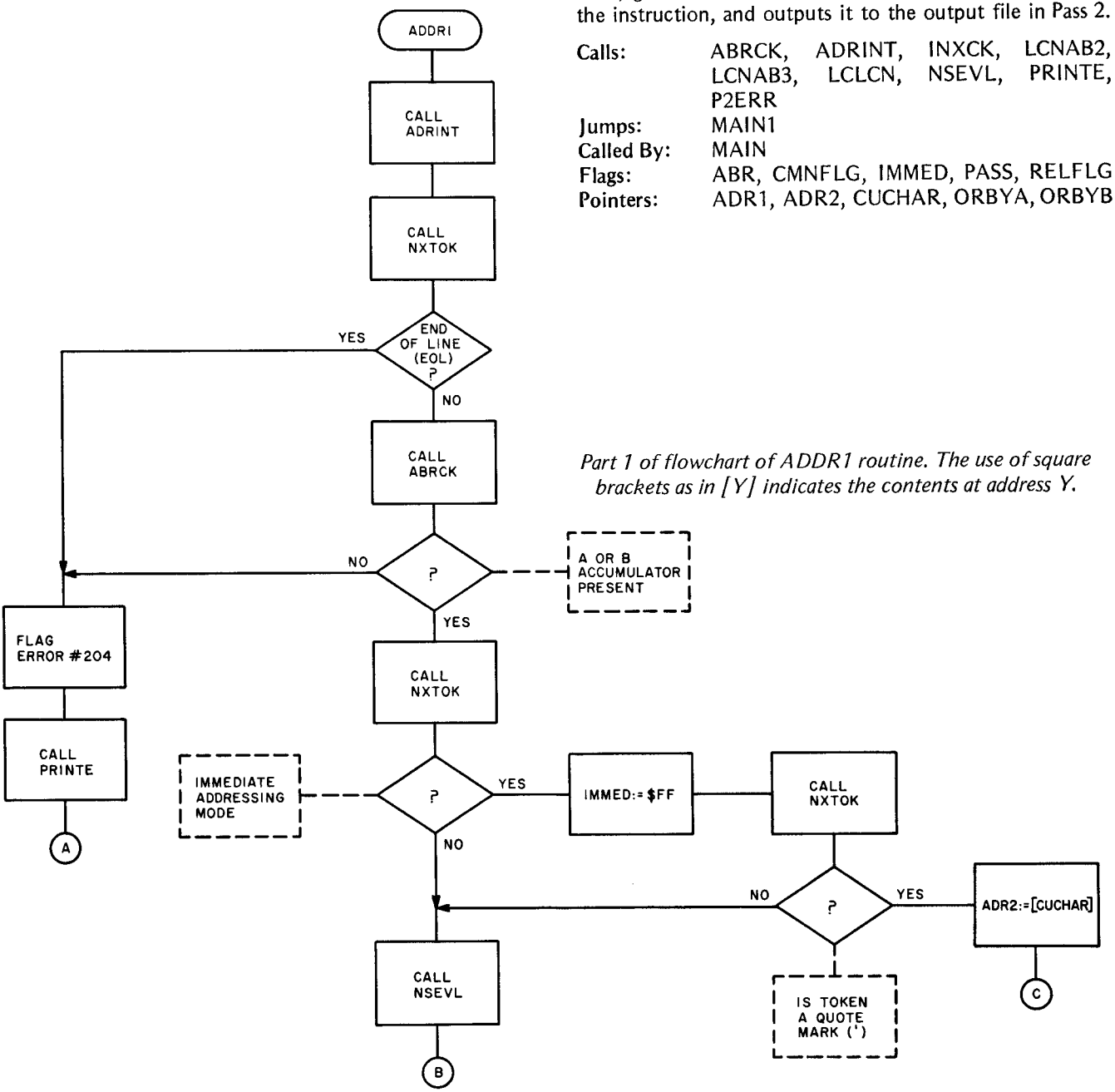
Following Pass 1 and 2 processing control is passed to entry point MAIN1 in the main loop.

ADDR1

This routine processes the following opcodes: ADC, ADD, AND, BIT, CMP, LDA, ORA, SBC, SUB. The operand structure may be Immediate (2 bytes), Direct (2 bytes), Extended (3 bytes), or Indexed (2 bytes).

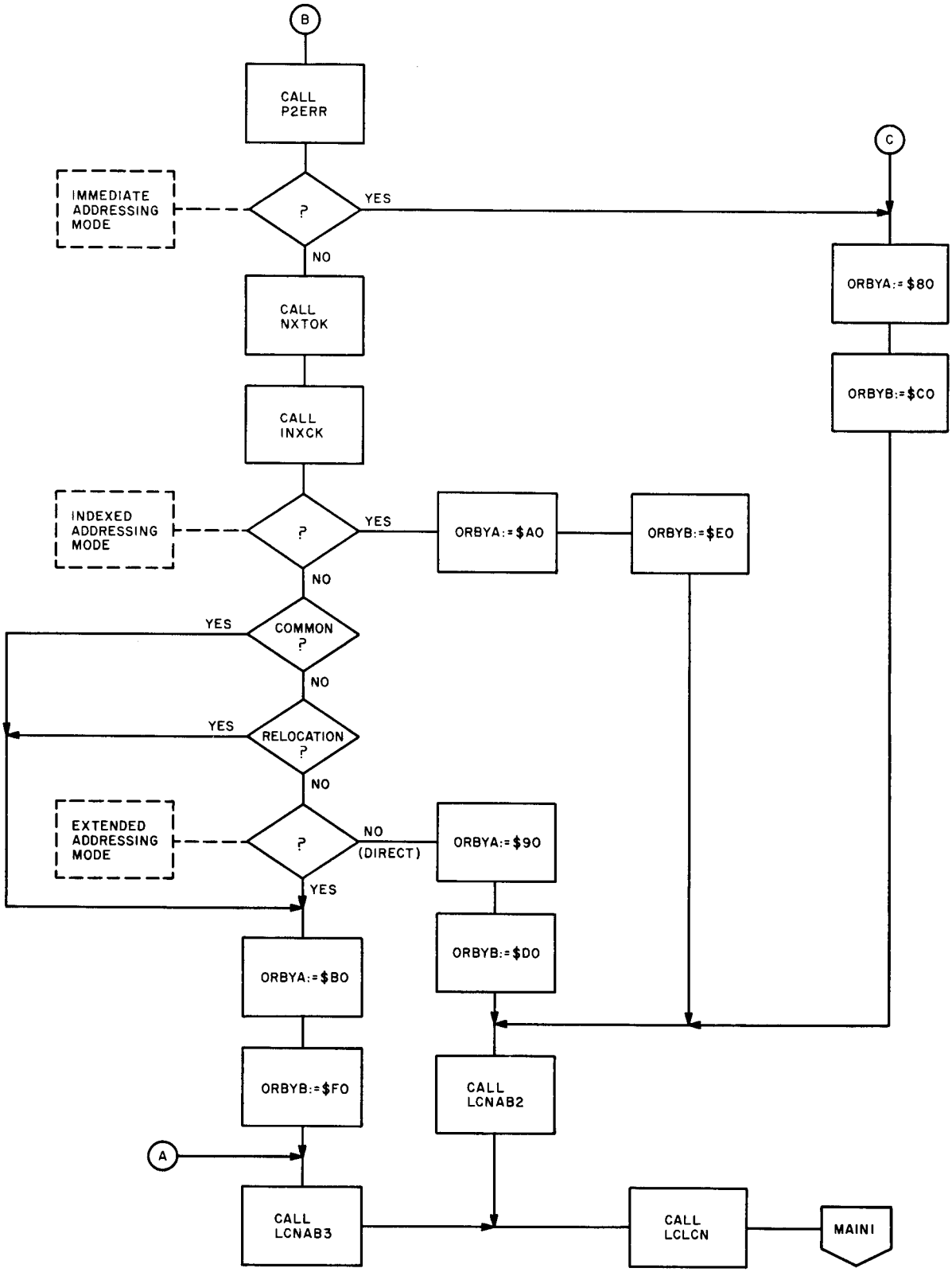
On entry, register B contains part of the opcode: depending on the *operand* field, ADDR1 completes the opcode, generates the machine code for the address part of the instruction, and outputs it to the output file in Pass 2.

Calls:	ABRCK, ADRINT, INXCK, LCNAB2, LCNAB3, LCLCN, NSEVL, PRINTE, P2ERR
Jumps:	MAIN1
Called By:	MAIN
Flags:	ABR, CMNFLG, IMMED, PASS, RELFLG
Pointers:	ADR1, ADR2, CUCHAR, ORBYA, ORBYB



Part 1 of flowchart of ADDR1 routine. The use of square brackets as in [Y] indicates the contents at address Y.

Part 2 of flowchart of ADDR1 routine.

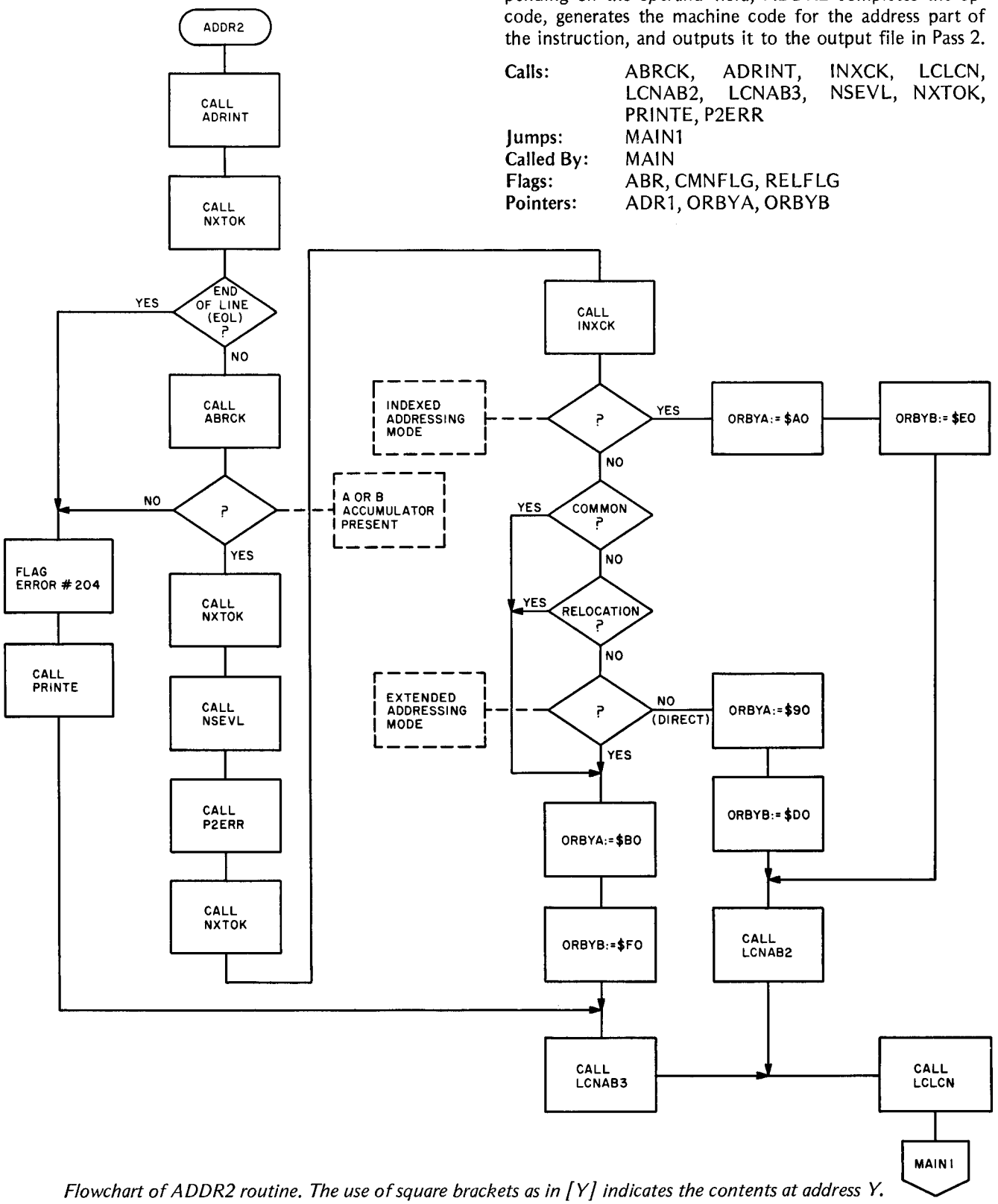


ADDR2

This routine processes the following opcode: STA. The operand structure may be Direct (2 bytes), Extended (3 bytes), or Indexed (2 bytes).

On entry, register B contains part of the opcode; depending on the *operand* field, ADDR2 completes the opcode, generates the machine code for the address part of the instruction, and outputs it to the output file in Pass 2.

Calls: ABRCK, ADRINT, INXCK, LCLCN, LCNAB2, LCNAB3, NSEVL, NXTOK, PRINTE, P2ERR
Jumps: MAIN1
Called By: MAIN
Flags: ABR, CMNFLG, RELFLG
Pointers: ADR1, ORBYA, ORBYB



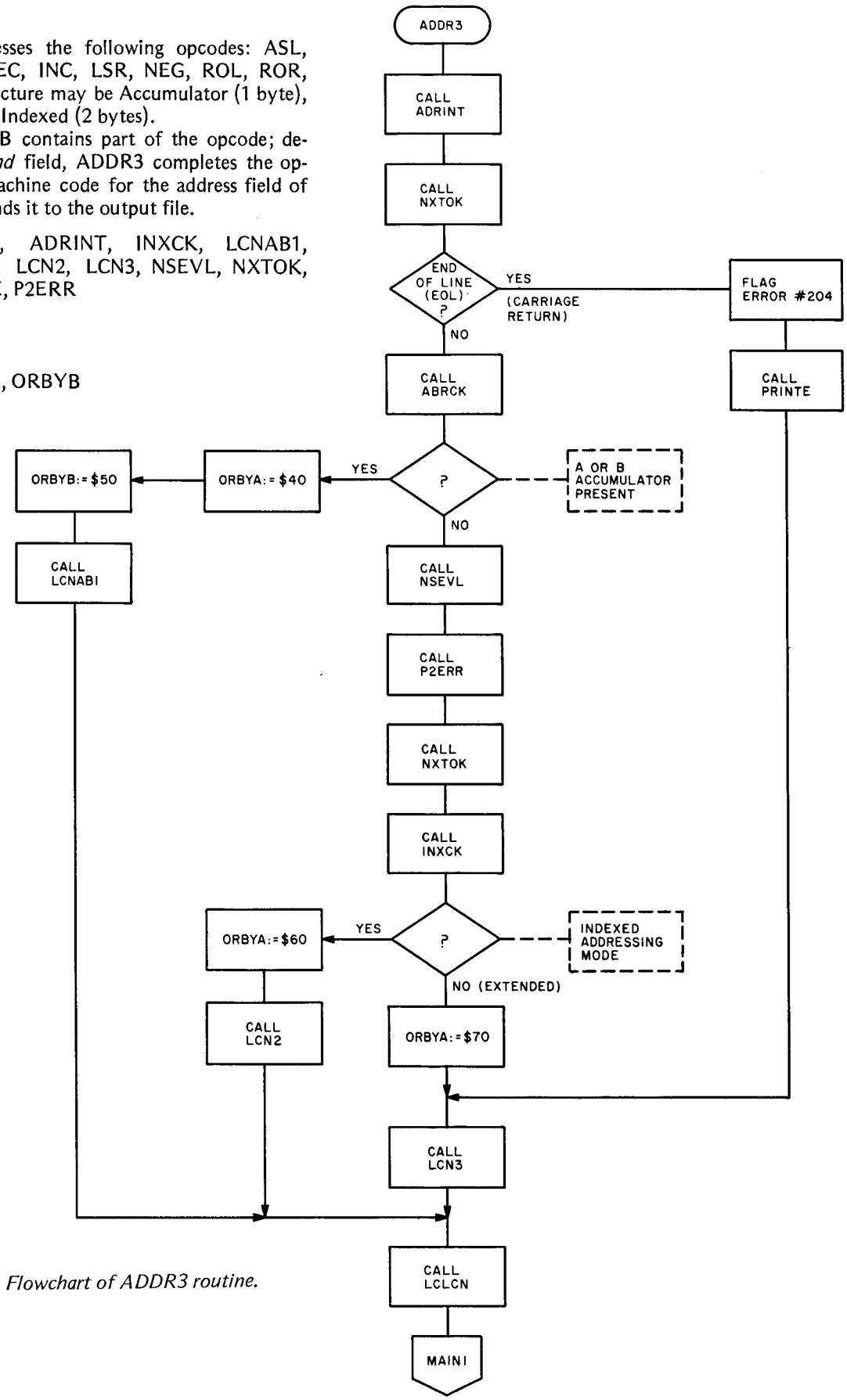
Flowchart of ADDR2 routine. The use of square brackets as in [Y] indicates the contents at address Y.

ADDR3

This routine processes the following opcodes: ASL, ASR, CLR, COM, DEC, INC, LSR, NEG, ROL, ROR, TST. The operand structure may be Accumulator (1 byte), Extended (3 bytes), or Indexed (2 bytes).

On entry, register B contains part of the opcode; depending on the *operand* field, ADDR3 completes the opcode, generates the machine code for the address field of the instruction, and sends it to the output file.

Calls: ABRCK, ADRINT, INXCK, LCNAB1, LCLCN, LCN2, LCN3, NSEVL, NXTOK, PRINTE, P2ERR
Jumps: MAIN1
Called By: MAIN
Flags: ABR
Pointers: ORBYA, ORBYB



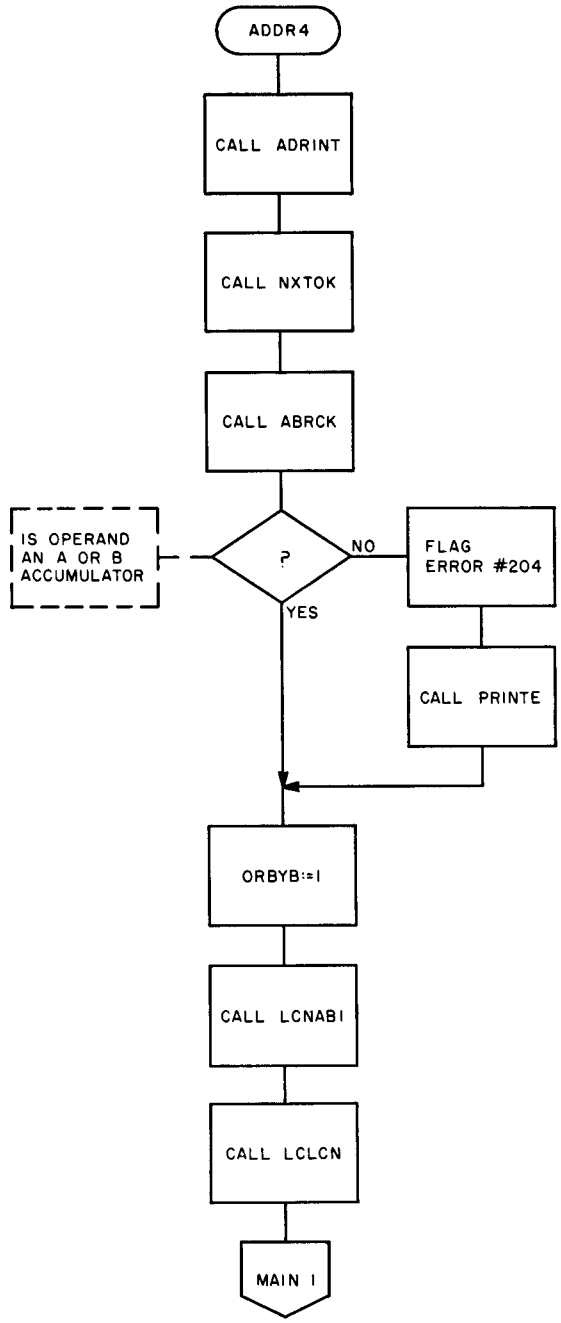
Flowchart of ADDR3 routine.

ADDR4

This routine processes the opcodes PSH and PUL. The operand structure is the Accumulator structure (1 byte).

On entry, register B contains the partial opcode. Depending on the Accumulator in the *operand* field, ADDR4 completes the opcode and outputs it to the output file in Pass 2.

Calls: ABRCK, ADRINT, LCLCN, LCNAB1, NXTOK, PRINTE
Jumps: MAIN1
Called By: MAIN
Flags: ABR
Pointers: ORBYA, ORBYB



Flowchart of ADDR4 routine.

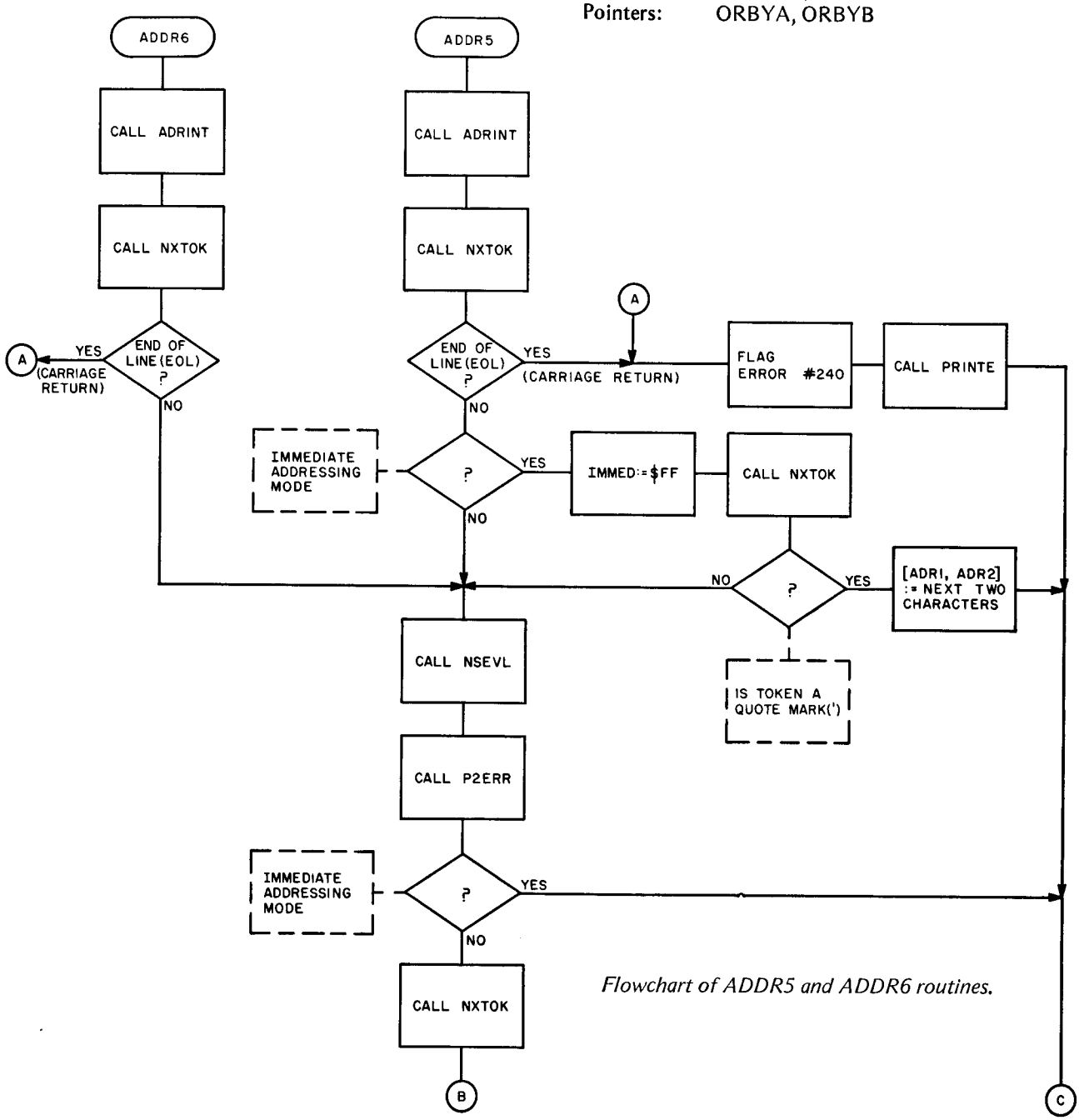
ADDR5

This routine processes the following opcodes: CPX, LDS, LDX.

The operand structure may be Immediate (3 bytes), Direct (2 bytes), Extended (3 bytes), or Indexed (2 bytes).

On entry, register B contains the partial opcode. Depending on the *operand* field, ADDR5 completes the opcode, generates the machine code for the address part of the instruction, and outputs it to the output file in Pass 2.

Calls: ADRINT, INXCK, LCLCN, LCN2, LCN3, NSEVL, NXTOK, PRINTE, P2ERR
Jumps: MAIN1
Called By: MAIN
Flags: CMNFLG, RELFLG
Pointers: ORBYA, ORBYB



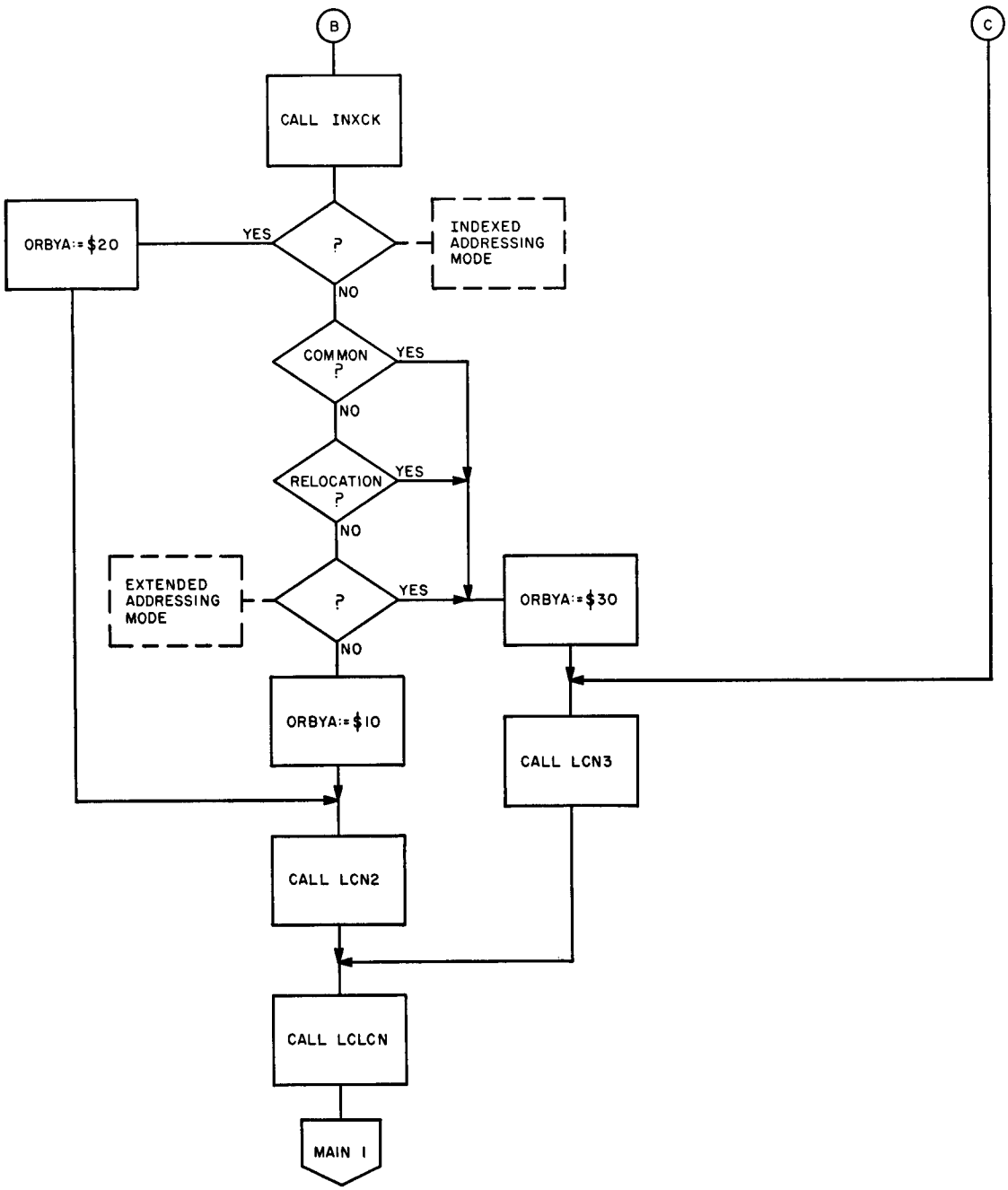
Flowchart of ADDR5 and ADDR6 routines.

ADDR6

This routine processes the following opcodes: STX, STS. The operand structure may be Direct (2 bytes), Extended (3 bytes), or Indexed (2 bytes).

On entry, register B contains the partial opcode. Depending on the *operand* field, ADDR6 completes the opcode, generates the machine code for the address part of the instruction, and outputs it to the output file in Pass 2.

Calls: ADRINT, NXTOK
Jumps: ADDR5A, ADDR5C
Called By: MAIN

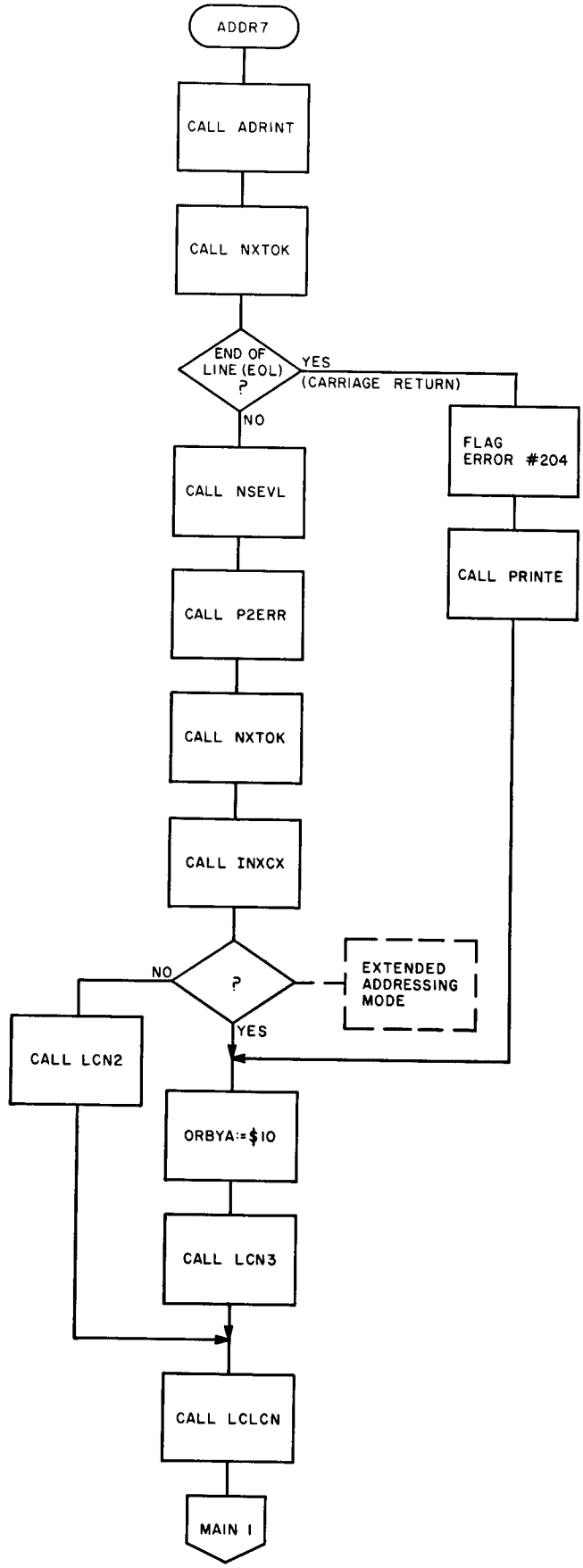


ADDR7

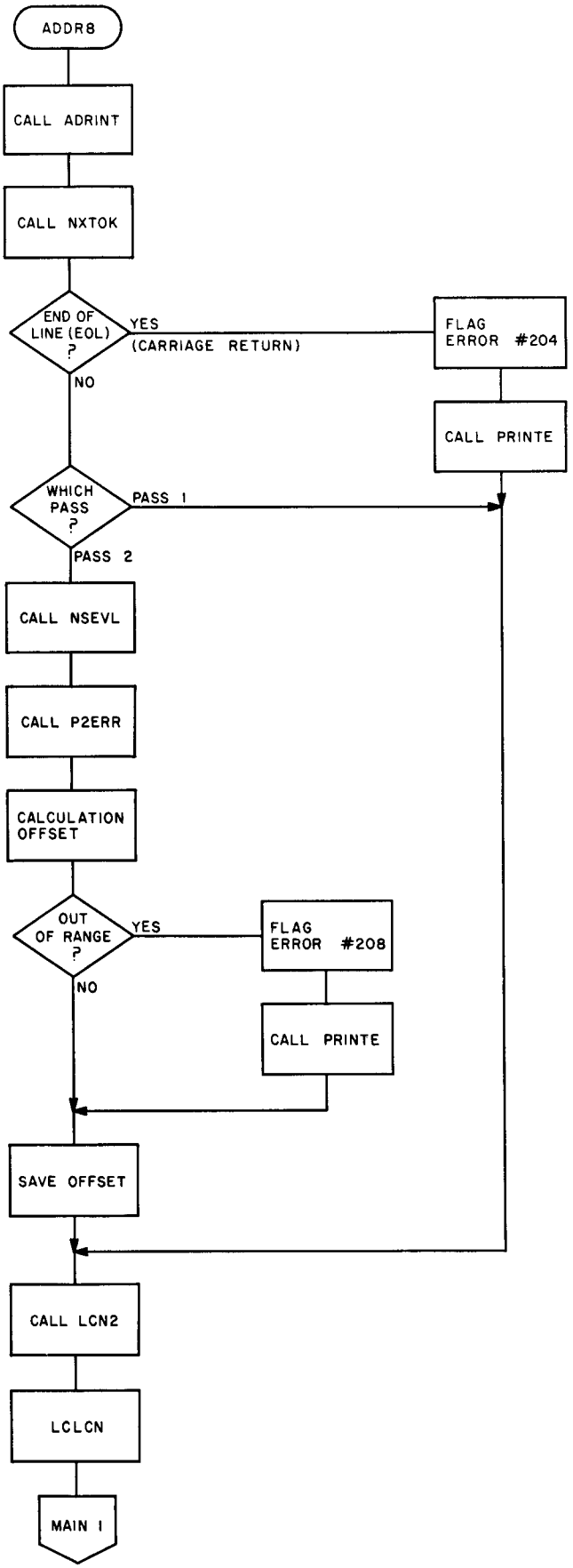
This routine processes the following opcodes: JMP, JSR. The operand structure may be Extended (3 bytes), or Indexed (2 bytes).

On entry, register B contains the partial opcode. Depending on the *operand* field, ADDR7 completes the opcode, generates the machine code for the address part of the instruction, and outputs it to the output file in Pass 2.

Calls: ADRINT, INXCK, LCLCN, LCN2, LCN3, NSEVL, NXTOK, PRINTE, P2ERR
Jumps: MAIN1
Called By: MAIN
Pointers: ORBYA



Flowchart of ADDR7 routine.



ADDR8

This routine processes the following opcodes: BCC, BCS, BEQ, BGE, BGT, BHI, BLE, BLT, BMI, BRA, BSR, BVC, BVS. The operand structure is the Relative (2 bytes).

On entry, register B contains the complete opcode. ADDR8 evaluates the *operand* field and calculates the relative offset that is to be the address part of the instruction and outputs it to the output buffer in Pass 2.

Calls:	ADRINT, LCLCN, LCN2, NSEVL, NXTOK, PRINTE, P2ERR
Jumps:	MAIN1
Called By:	MAIN
Flags:	PASS
Pointers:	ADR1, ADR2, LC
Temporaries:	LSAVE

Flowchart of ADDR8 routine.

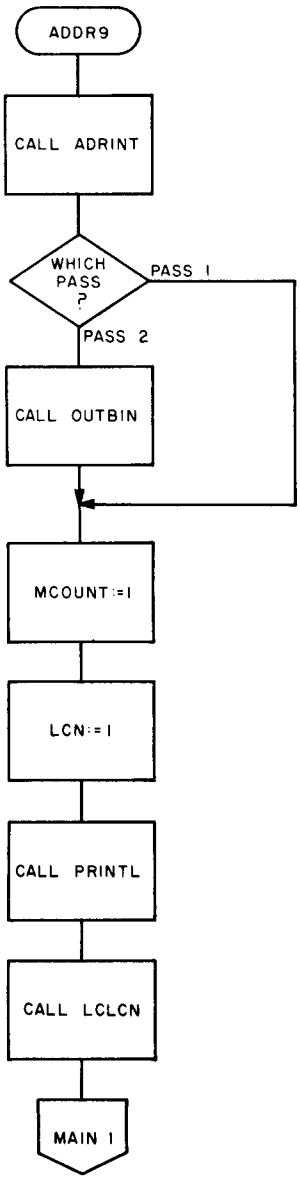
ADDR9

This routine processes the following opcodes: ABA, CBA, CLC, CLI, CLV, DAA, DES, DEX, INS, INX, NOP, RTI, RTS, SBA, SEC, SEI, SEV, SWI, TAB, TAP, TBA, TPA, TSX, TXS, WAI.

The operand structure does not exist as this is an Inherent type instruction. On entry register B contains the complete opcode, and the routine outputs this value to the output buffer in Pass 2.

Calls: ADRINT, LCLCN, OUTBIN, PRINTL
Jumps: MAIN1
Called By: MAIN
Flags: MCOUNT, PASS
Pointers: LCN

Flowchart of ADDR9 routine.



Address Processing Utility Routines

These utility routines are used by the opcode processing routines ADDR1 through ADDR9 for processing the various operands and instruction types.

ADRINT

This initializes flags and variables used in the opcode and pseudo operation processing routines.

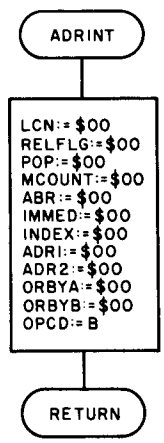
Calls: none
Called By: ADDR1 thru ADDR9, MAIN, POCMN, POEND, POENT, POEQU, POEXT, POFCB, POFCC, POFDB, POIF, POMAC, PONAM, PONIF, POPAG, PORMB
Flags: ABR, ADR1, ADR2, CMNFLG, ENTFLG, EXTFLG, IMMED, INDEX, LCN, MCOUNT, ORBYA, ORBYB, POP, RELFLG
Pointers: OPCD

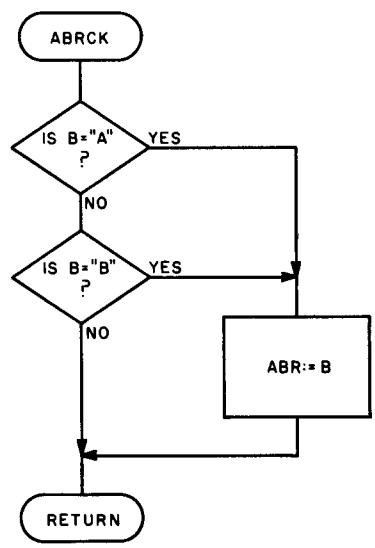
ABRCK

This checks to see what, if any, register is the first operand in the *operand* field of an instruction. The register is either A or B.

Calls: none
Called By: ADDR1 thru ADDR4
Flags: ABR

Flowchart of ADRINT routine.





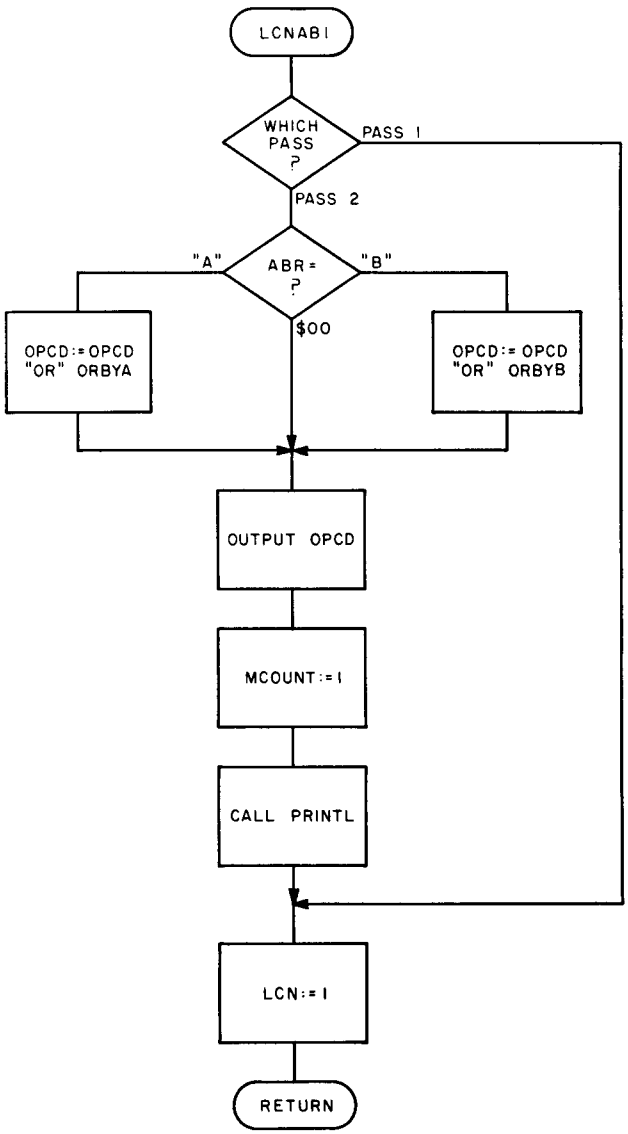
Flowchart of ABRCK routine.

LCNAB1

This does the finish up processing for one byte Accumulator type instructions.

Calls: OUTBIN, PRINTL
Called By: ADDR3, ADDR4
Flags: ABR, MCOUNT, PASS
Pointers: LCN, OPCD, ORBYA, ORBYB

Flowchart of LCNAB1 routine.

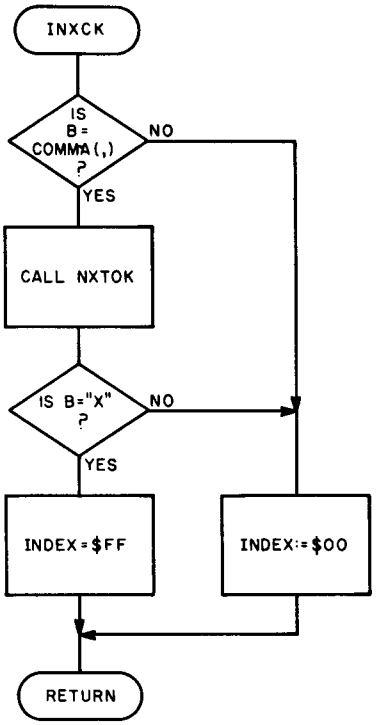


INXCK

This checks to see if an instruction is Indexed.

Calls: NXTOK, PRINTE
Called By: ADDR1, ADDR2, ADDR3, ADDR5, ADDR7
Flags: INDEX

Flowchart of INXCK routine.

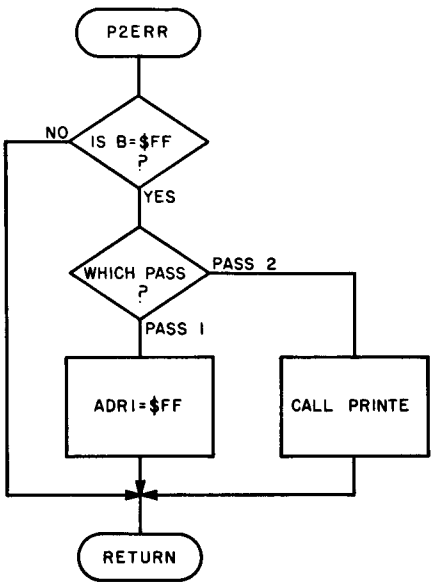


P2ERR

This prints Pass 2 errors. Some errors returned by the evaluation routine NSEVL are considered errors in Pass 2 but are not errors in Pass 1.

Calls: PRINTE
Called By: ADDR1, ADDR2, ADDR3, ADDR5, ADDR7, ADDR8, POFCB, POFDB
Flags: PASS
Pointers: ADR1, ADR2

Flowchart of P2ERR routine.



LCN2

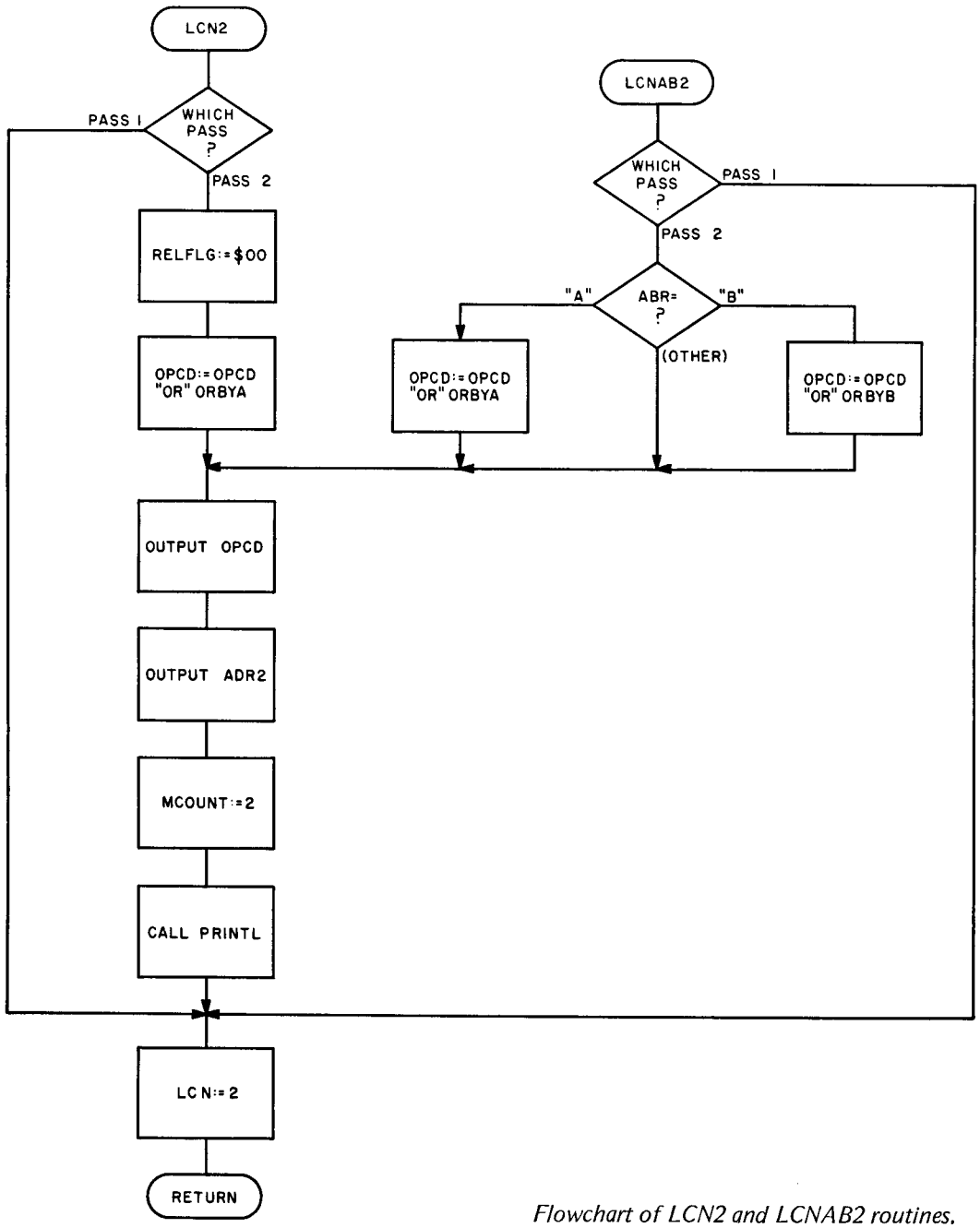
This does the finish up processing for two byte Indexed, Direct, and Immediate type instructions.

Calls: OUTBIN, PRINTL
Called By: ADDR3, ADDR5, ADDR7, ADDR8
Entry: LCN2A
Flags: CMNFLG, MCOUNT, PASS, RELFLG
Pointers: ADR2, LCN, OPCD, ORBYA, ORBYB

LCNAB2

This does the finish up processing for two byte register (A, B) Indexed, Direct, and Immediate type instructions.

Calls: none
Jumps: LCN2A
Called By: ADDR1, ADDR2
Flags: ABR, PASS
Pointers: OPCD, ORBYA, ORBYB



Flowchart of LCN2 and LCNAB2 routines.

LCN3

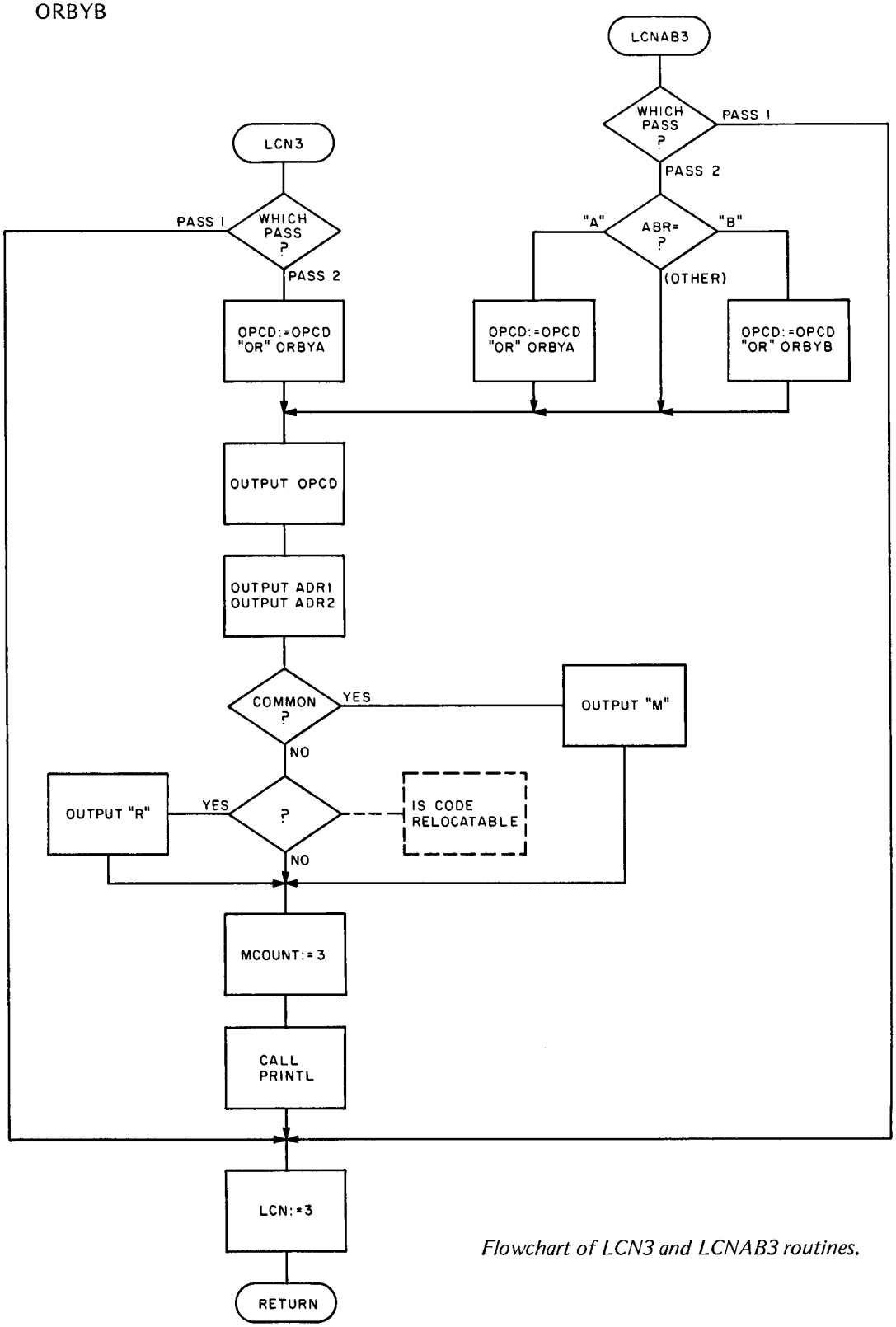
This does the finish up processing for the three byte Extended type instructions.

Calls: OUTBIN, PRINTL
Called By: ADDR3, ADDR5, ADDR7
Entry: LCN3A
Flags: CMNFLG, MCOUNT, PASS, RELFLG
Pointers: ADR1, ADR2, LCN, OPCD, ORBYA, ORBYB

LCNAB3

This does the finish up processing for the three byte register (A, B) Extended and Immediate type instructions.

Calls: none
Jumps: LCN3A
Called By: ADDR1, ADDR2
Flags: ABR, PASS
Pointers: OPCD, ORBYA, ORBYB



Flowchart of LCN3 and LCNAB3 routines.

LCLCN

This does the addition of LCN to LC (LC:=LC+LCN).

Calls: none
Called By: POEXT, POFCB, POFCC, POFDB, ADDR1 thru ADDR5, ADDR7 thru ADDR9
Pointers: LC, LCN

Lexical Analysis Routines

The lexical analysis routines described in this section are concerned with finding and classifying the individual tokens of an assembly language statement. A token is a non-blank string of contiguous characters, such as a label, an expression, or an operand.

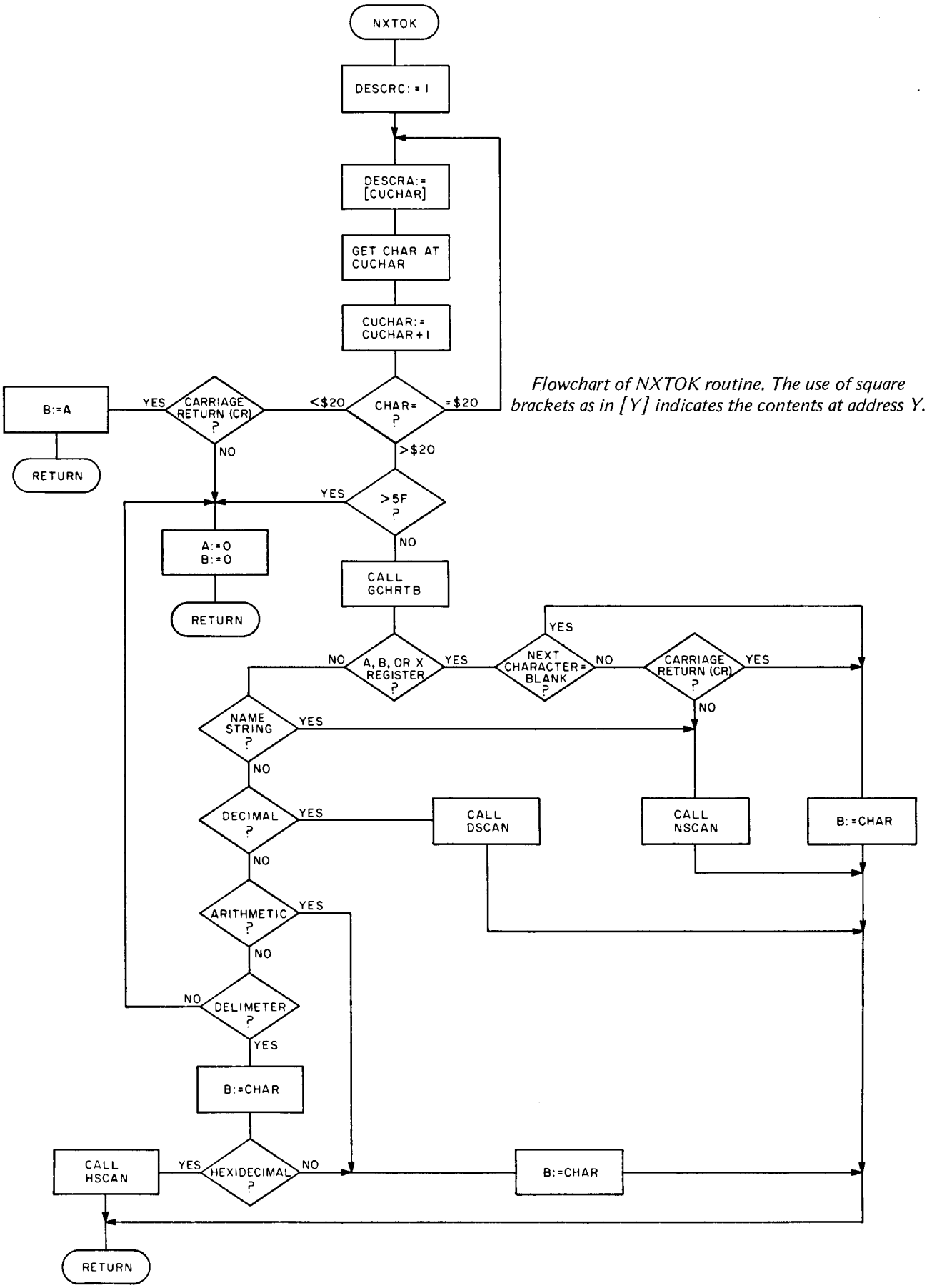
NXTOK

This routine extracts tokens from a line of source code. It scans a line of source code and returns the next token each time that it is called.

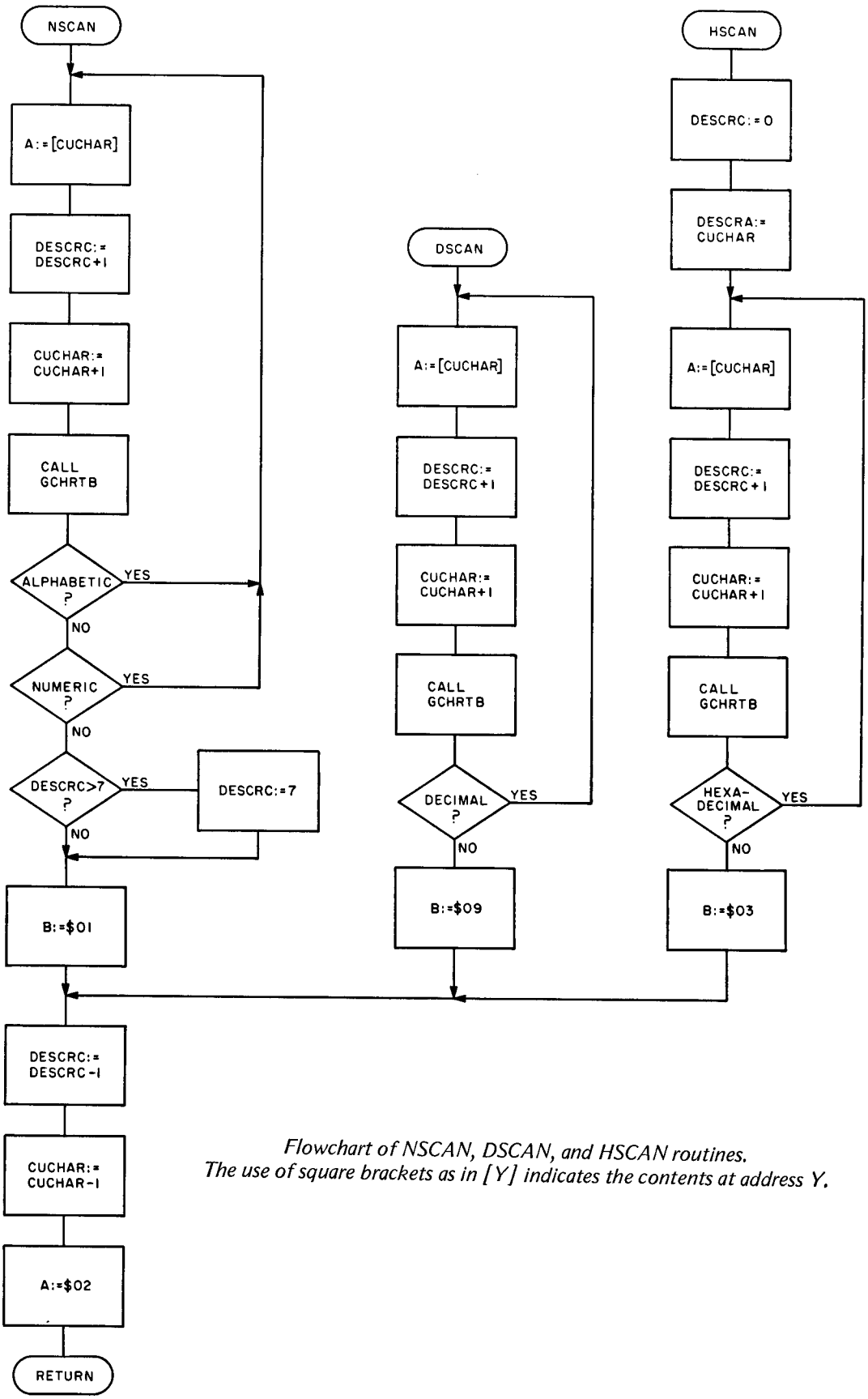
On entry, CUCHAR points to the next character in the line. NXTOK returns a token by placing the address of the token in DESCRA and the length of the token in DESCRC. The routine also returns the token type in register B and the token class in register A. If the token is unrecognizable, the routine returns with both the A and B registers cleared. The following tokens are recognized by NXTOK:

TOKEN	TYPE (B)	CLASS (A)	
NAME	01	02	Substrings
HEX	03	02	
DECIMAL	09	02	
#	23	04	Delimiters
,	2c	04	
'	27	04	
*	2A	24	Arithmetic
/	2F	24	
+	2B	24	
–	2D	24	
A	41	01	A,B,X registers
B	42	01	
X	58	01	
CR	0D	0D	End of Line
ERROR	00	00	Error

Calls: DSCAN, GCHRTB, HSCAN, NSCAN
Called By: ADDR1 thru ADDR8, INXCK, MAIN, NSEVL, POCMN, POENT, POEQU, POEXT, POFCB, POFCC, POFDB, POMAC, PONAM, PORMB
Pointers: CUCHAR, DESCRA, DESCRC



Flowchart of NXTOK routine. The use of square brackets as in [Y] indicates the contents at address Y.



Flowchart of NSCAN, DSCAN, and HSCAN routines.
The use of square brackets as in [Y] indicates the contents at address Y.

DSCAN

This routine scans substrings of decimal characters. On entry, CUCHAR points to the first character to be scanned. DSCAN continues to scan until it finds a non-decimal character. The address of the decimal substring is returned in DESCRA and the length of the substring is returned in DESCRC. The B register is loaded with a type code of 09.

Calls: GCHRTB
Jumps: ENDSCN
Called By: NXTOK
Pointers: CUCHAR, DESCRC

NSCAN

This routine scans substrings of alphanumeric characters. On entry, CUCHAR points to the first character to be scanned. NSCAN continues to scan until it finds a non-alphanumeric character. The address of the alphanumeric substring is returned in DESCRA and the length of the substring is returned in DESCRC. The B register is loaded with a type code of 01.

Calls: GCHRTB
Jumps: ENDSCN
Called By: NXTOK
Pointers: CUCHAR, DESCRC

HSCAN

This routine scans substrings of hexadecimal characters. On entry, CUCHAR points to the first character to be scanned. HSCAN continues to scan until it finds a non-hexadecimal character. The address of the substring is returned in DESCRA and the length of the substring in DESCRC. The B register is loaded with the type code 03.

Calls: GCHRTB
Called By: NXTOK
Pointers: CUCHAR, DESCRA, DESCRC

ENDSCN

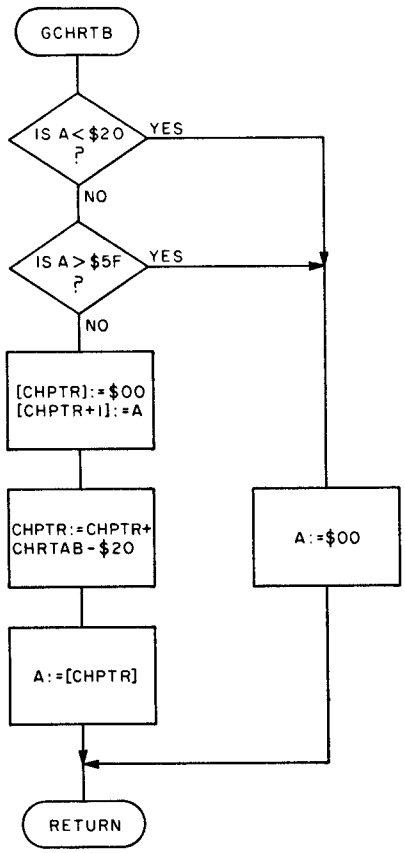
This is a common return for routines: DSCAN, NSCAN, and HSCAN.

GCHRTB

This routine retrieves the byte in CHRTAB that is Indexed by the value of the character in the A register.

On return, register A contains the value of the byte retrieved from CHRTAB.

Calls: ADD16
Called By: DSCAN, HSCAN, NSCAN, NXTOK
Pointers: CHPTR



Flowchart of GCHRTB routine. The use of square brackets as in [Y] indicates the contents at address Y.

Evaluation Routine

NSEVL

This routine evaluates numbers, symbols, and expressions composed of numbers, symbols and operators. A straight left to right evaluation is performed without regard to precedence of hierarchy of operators.

The relocation indicator flag (RELFLG) is set if the final result is relocatable. Generally, a result is considered relocatable if it contains an odd count of relocatable terms. This can produce meaningless results; for example, the addition of two relocatable terms is an absolute value, but unfortunately not very useful. However, the difference of two relocatable terms can be very useful as the length of a table.

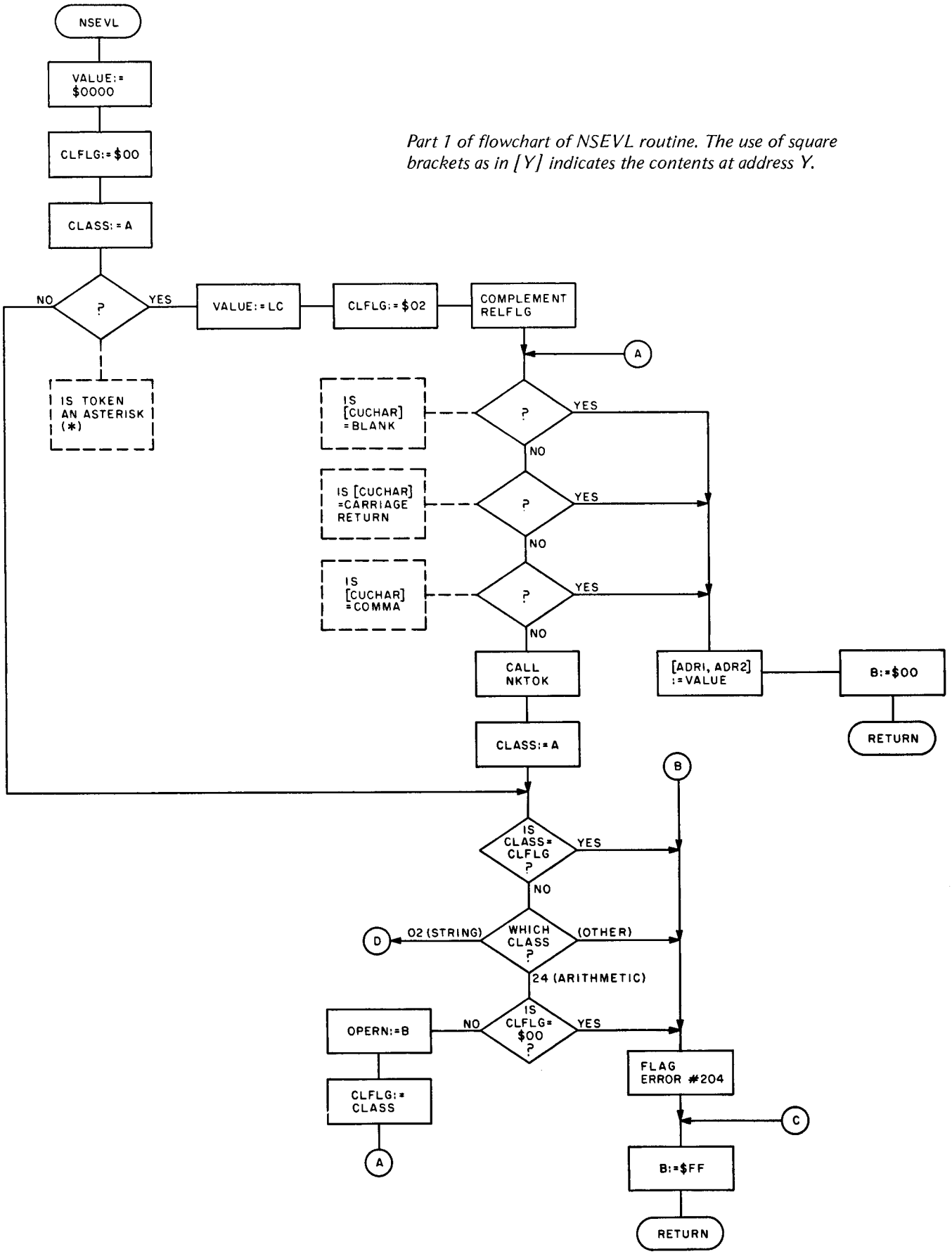
The Common flag is set if during the evaluation a symbol is found that is marked common in the Symbol Table.

On entry, the class code and the type code for the first token of the operand are in registers A and B, and the relocation flag is set to absolute (00).

NSEVL proceeds by scanning the *operand* field and performing the indicated operations and storing the intermediate results in variables VALUE and TEMP.

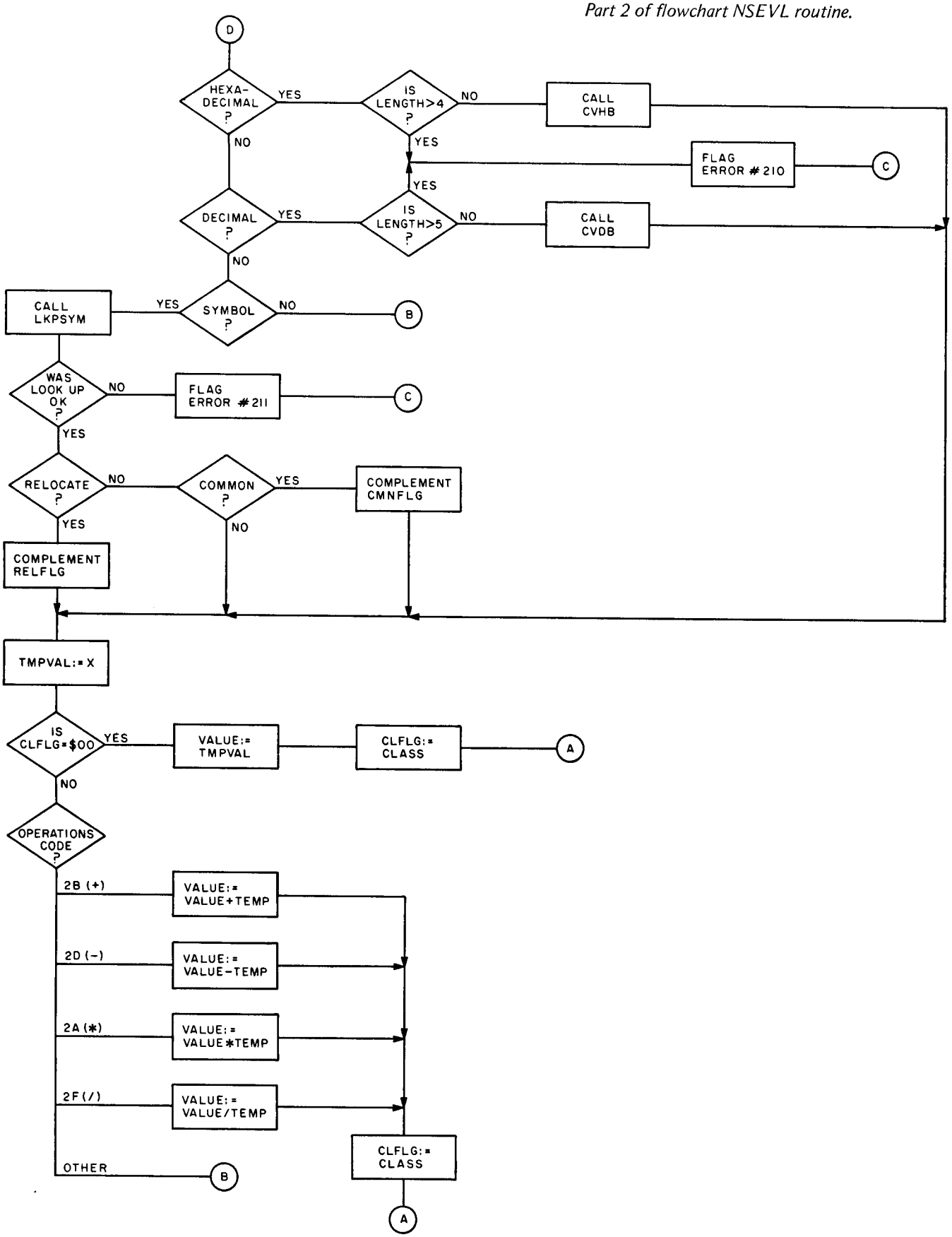
On return the final sixteen bit unsigned result is in variable (ADR1, ADR2), and the B register contains a 00 if there were no errors. If there were errors the error number is in the Index register as a four digit BCD number. The relocation flag (RELFLG) is equal to 00 if the result is an absolute value, and to FF if the result is relocatable.

Calls: ADD16, CVDB, CVHB, DIV16, LKPSYM, MPY16, NXTOK, SUB16
Called By: POCMN, POEQU, POFCB, POFDB, POIF, PORMB, ADDR1, ADDR2, ADDR3, ADDR5, ADDR7
Flags: CMNFLG, RELFLG
Pointers: CLASS, CLFLG, CUCHAR, DESRC



Part 1 of flowchart of NSEVL routine. The use of square brackets as in [Y] indicates the contents at address Y.

Part 2 of flowchart NSEVL routine.



Interfacing and Using the Assembler

IO Interface Conventions

There are obviously several different methods of reading in a source program, assembling it, and finally outputting the object code. The medium used could be memory only, input from and output to cassette tapes, input from and output to floppy disk, input from tape and output to disk, etc. Included in this section on interfacing are sample IO routines for tape to tape and disk to disk systems.

Looking at the listings of the IO tape and disk routines given in Appendices J and K, notice the various entry points (such as TABLES, OUTB, WREOF, etc.) declared at the beginning. (These same names are declared as External in the main program.) These are the names of the IO routines which the user must supply for his (her) own system. Note that some of the disk routines are supplied by the authors' ICOM Floppy Disk Operating System (FDOS), while for the tape version all of the routines had to be written from scratch. Again, this may or may not be similar to the user's situation depending on the user's system configuration and software. The routines supplied in the cassette tape example could serve as a basis for any routines needed by the user.

Finally, the user should be aware that the actual lengths of this assembler and all additional tables and routines as given throughout this book assume the use of the cassette tape IO routines given in Appendix J. This means that if the user supplies his (her) own routines, the lengths and capacities described elsewhere in this book may be affected.

Tape Driver Routines

The following routines are part of a sample tape driver package. They handle the IO functions for a dual cassette tape system.

T1INZ

This routine is used to initialize and start cassette Tape1 for an input operation.

Calls: TDELY
Called By: RDBUF

T1GET

This routine is used to read a character from the input tape, Tape1. The character is returned in register A. It checks for read errors and returns the error code in register B. If register B contains a 00 then there were no errors.

Calls: none
Called By: RDBUF

T1ISTP

This routine is used to stop Tape1 after an input operation.

Calls: none
Called By: RDBUF

T2OTZ

This routine is used to initialize and start cassette Tape2 for an output operation.

Calls: TDELY
Called By: WRITBF

T2OUT

This routine is used to output a character to Tape2. The character to be written is in register A.

Calls: none
Called By: WRITBF, T2OSTP

T2OSTP

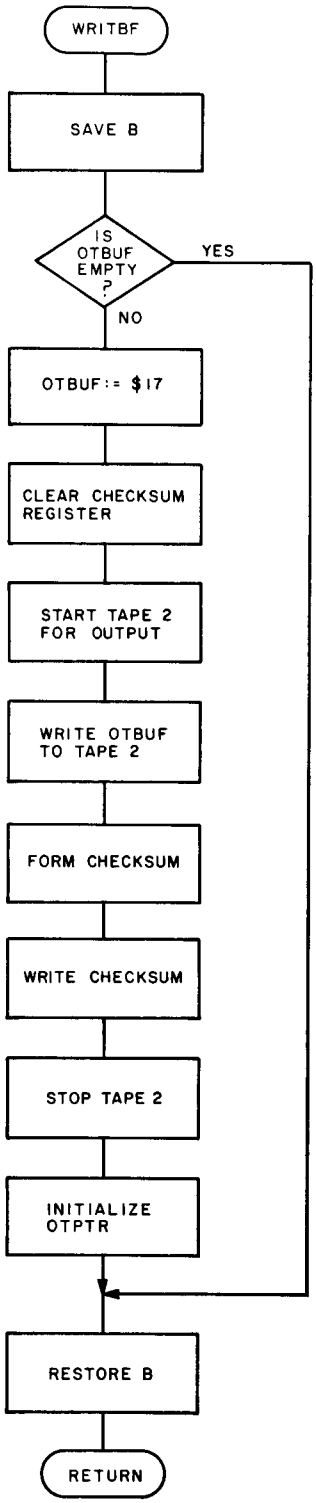
This routine is used to stop Tape2 after a write operation.

Calls: T2OUT
Called By: WRITBF

WRITBF (Tape)

This routine writes out blocks of object code to Tape2 from the output buffer. The variable OTPTR contains the address of the last byte to be written out when the routine is called and contains the address of the first byte in the output buffer when the routine returns.

Calls: T2OTZ, T2OSTP, T2OUT
Called By: OUTB, WREOF



Flowchart of WRITBF routine.

Disk Driver Routines

The disk drivers are all in the bootstrap Erasable Read Only Memory included in the ICOM Floppy Disk Operating System (FDOS).

RIX	– Read a byte from the disk. Byte in A register.
WRT	– Write a byte to the disk. Byte in A register. Carry flag set if End-Of-File.
UPDATE	– Close an output file.
FDOS	– Load FDOS system and pass control to it.

Assembler Loading and Execution

These instructions are written assuming two different ways to load and execute the Assembler, depending on whether the object code for the Assembler and the target program are on cassette tape or diskette. The main difference is the necessity of the ICOM Floppy Disk Operating System (FDOS) for the diskette. The procedures would be similar for any tape or disk system other than the two mentioned.

Cassette Tape Files

To load the Assembler from the cassette tape is easily accomplished if the object code for the Assembler is in absolute MIKBUG object code format. Using the MIKBUG "L" function loads the Assembler from tape. If the Assembler object code is in a relocatable format, then the Linking Loader must be utilized. For a discussion of how to do this, consult the PAPERBYTE™ book, *LINK68–Linking Loader for Motorola 6800.*

The Assembler executes as a two pass assembler, reading the input source from the cassette tape twice and, optionally, placing the generated object code onto a second cassette tape. The input source tape would go in the first cassette recorder; the object code tape, in the second tape machine.

Use the MIKBUG "M" function to set the entry point of the Assembler into locations A048 and A049 (hexadecimal). If the Assembler was loaded in absolute object code form, the entry point is hexadecimal 0100. (If the Linking Loader was used to load the Assembler, then the entry point is probably different. Again, consult PAPERBYTE™ book *LINK68–Linking Loader for Motorola 6800.* If the Assembler has been relocated, care should be taken so that enough room to contain the 16 K required by the Assembler is allowed for.) Note that using the "M" function merely sets up a jump address for the start of the Assembler. If MIKBUG is not being used as a monitor, this may be accomplished in other ways.

After this setup, using the MIKBUG "G" function begins execution of the Assembler, which starts by requesting a list of the options the user desires:

ENTER OPTIONS

The options possible are:

L	– Provides a printed listing as shown in listing 1, page 15.

S — Prints a sorted Symbol Table, as shown in listing 2, page 15;

M — All Macro expansions are printed, but only if the "L" option has also been chosen;

O — Object code is generated.

The options desired are entered, separated by commas, and the list is terminated with a carriage return.

Example: L, O

requests that the Assembler provide a printed listing and that object code is generated, but that no Symbol Table or Macro expansions be printed.

At this point the Assembler begins Pass 1, reading the source tape in cassette 1. When the Assembler encounters an END pseudo operation in the source code, it issues the message:

REWIND TAPE & TYPE CR

At this point the user rewinds the cassette tape which contains the source and resets the controls for another read operation. Pass 1 is complete.

Pass 2 of the Assembler produces the listings, writes the object code onto cassette 2, etc. When assembly is complete, control is returned to the system monitor.

If the Assembler encounters any tape errors in the input tape it issues the warning message:

READ ERROR

and stops the tape. The user should then reposition the tape at the beginning of the block that produced the error and type a carriage return. The Assembler then will attempt to reread the block.

If an End-Of-File mark is encountered by the Assembler it types the message:

EOF: REPOSITION TAPE AND TYPE CR .

Position the tape to the beginning of the next file and type a carriage return. Consult the section entitled **Source Tape Format** for an explanation of the use of multiple files.

Diskette Files

The Assembler is located on a diskette under the name "ASMM" and is loaded and executed using the ICOM Floppy Disk Operating System (FDOS) command "RUNGO".

Example:

RUNGO, ASMM, TEST1, TEST2

Here the input source file is TEST1 and the output object file is TEST2. Since an object file is optional, TEST2 could have been eliminated.

The Assembler requests a list of options with the statement:

ENTER OPTIONS:

The possible options are:

L — Provides a printed listing as shown in listing 1, page 15;

S — Prints a sorted Symbol Table as shown in listing 2, page 15;

M — All Macro expansions are printed, but only if the "L" option has also been chosen;

O — Object code is generated.

The options desired are entered, separated by commas, and the list is terminated with a carriage return.

Example: L,S,M

requests that a listing of the program, sorted Symbol Table, and all Macro expansions be printed, but no object code generated.

The Assembler then executes Pass 1 and Pass 2. Upon completion of the second pass, control is transferred back to the Floppy Disk Operating System.

Loading the Object Code

Loading relocatable object code generated by the Assembler is covered in detail in the companion PAPERBYTE™ publication *LINK68—Linking Loader for Motorola 6800.*

Source Tape Format

The input to the Assembler is on audio tape cassette(s) in variable length blocks. The maximum length is set by the size of the input buffer in the Assembler (512 bytes).

Each line of source code is written followed by an End-of-Statement mark (a carriage return). Immediately following the last line in a block is an End-Of-Block mark (EOB, 17 hexadecimal). This is followed by a checksum character. The checksum is calculated by taking the one's complement of the summation of all the preceding bytes including the EOB. Note that lines do not span blocks.

Following the last block on the tape there is an End-Of-File (EOF) block. This block contains only one character, the EOF character (04 hexadecimal).

Thus, a file is composed of a variable number of variable length blocks followed by an EOF block.

This provision has been made so as to allow the processing of different files on different tapes, or to allow the processing of a file that is longer than the capacity of one tape side.

The user might have a set of commonly used subroutines on one tape that is used in many different programs. So long as this subroutine tape has an EOF block at the end of it, the user may use this one tape each time a different program is assembled. That is, the code on this tape does not have to be copied onto the different program tapes.

Output Object Tape Format

The output object code (relocatable) is recorded on audio cassette tape in blocks. The maximum length is set by the size of the output buffer in the Assembler (512 bytes). The format is:

Bytes 1 thru n	Relocatable object code and information for the Linking Loader.
Byte n-1	End-Of-Block (EOB) (17 hexadecimal).
Byte n-2	Checksum character byte; it is the one's complement of the summation of bytes 1 thru n.

The last block on the tape is followed by an End-Of-File block. It contains only one byte, an EOF character (04 hexadecimal).

APPENDICES

Appendix A:

Error Messages

Number	Type
0202	Opcode or label error
0204	Syntax error
0205	Label error
0206	Redefined symbol
0207	Undefined opcode
0208	Relative branch error
0210	Byte overflow
0211	Undefined symbol
0213	EQU pseudo operation error
0216	Pseudo operation error
0220	Phasing error
0221	Symbol table overflow
0223	The pseudo operation cannot be labeled
0226	The MAC pseudo operation is unlabeled
0227	MEND pseudo operation cannot be labeled
0228	Macro table overflow
0230	Macro expansion line overflow
0251	Macro nesting error
0254	IF stack overflow/underflow (nesting error)

Appendix B:

Capacities

This appendix is a summary of the various capacities of tables and stacks used in the Assembler. Some of the values are calculated from other fixed components of the Assembler, but are nonetheless set in the code. By far the largest pieces of the Assembler's total 16 K size are the Assembler's actual code, the Macro Table, and the Symbol Table. Note that the Symbol Table length is variable (see "Tables" in **The Assembler,** depending on the lengths of the particular IO routines used by the user.

Assembler (overall)	16 K
Assembler (actual code)	6 K
Character Table (CHRTAB)	64 entries, one byte per entry
If Stack (IFSTK)	8 levels of nested ifs
Macro Stack (MACSTK)	maximum of 35 nested Macro calls if no parameters on calls, 4 levels if the maximum number of parameters (8) is used on each call
Macro Table (MACTBL)	2 K, free form
Mnemonic Table (MNTAB)	86 entries, 6 bytes per entry
Symbol Table (SYMTAB)	800 symbol entries, 9 bytes per entry

Appendix C

Notes from a User: Implementation of RA6800ML

by Walter Banks, University of Waterloo

Implementation of RA6800ML is accomplished by a bootstrap procedure which ultimately results in a macro assembler specifically tailored to a unique system. This is accomplished with the use of two absolute modules presented in Appendices D and F.

In normal use RA6800ML generates relocatable object modules which are linked together by LINK68 to form a load module of absolute code. The macro assembler itself is generated as a relocatable load module requiring linking with input and output drivers to form a usable load module. This has been overcome with the use of two absolute load modules found in Appendices D and F. The ASSEMBLER load module contains a copy of the Assembler, linked to location $0100 without any external references satisfied. The overlay modules contain external reference code for use with a standard MIKBUG-based system. This overlay is designed to facilitate easy initial implementation of RA6800ML and serve as a template for user developed software.

The macro assembler calls external routines through the use of a jump table which starts at location $034A. Subroutine calls within the macro assembler go through the jump table to the overlayed routines and control is returned to the macro assembler with an RTS.

The IO structure of RA6800ML assumes four separate data paths. INCH and OUTCH are input and output byte routines to the user console device. GETB and OUTB are communication paths from the macro assembler to mass storage devices such as disk, tape, or paper tape. They are used to load the source code for assembling and output relocatable code modules.

The jump table calls GETB which is a subroutine used to get data from a source code input stream. The overlay prompts users to load new tapes when end-of-tape is sensed.

The calls to OUTB are used to write out the relocatable object code to the output stream. In the simple implementation these are handled by the console output routine in MIKBUG.

The calls to MONTOR and UPDATE are used to return control to the user supervisor program. UPDATE expects the user routine to close all open files. MONTOR is a direct entry to the user supervisor.

INITIO calls a routine which initializes IO devices and drivers. It is not needed in the simple overlay; however, room is left for a subroutine jump to a new program.

WREOF writes an end-of-file ($04) to the output data stream.

A call to RESTR causes the input file to be reset at the start-of-file point. In the simple version presented here a message to rewind the tape is output and operator intervention is required.

An exception to the use of the jump table is the reference to TABLES. TABLES is used as a pointer to a data area of memory and is used only as a pointer. It must be noted that the first two locations in memory pointed to by TABLES must contain the address of TABLES+3.

Users can load a simple version of the Assembler by loading the Assembler absolute code module found in barcode form in Appendix E. The overlay package may be loaded on top of the Assembler and the combined code can be dumped to a convenient mass storage device such as a floppy disk or cassette tape. Future modifications can be made in two ways. First, the overlay package can be tailored to the unique requirements of a particular system. The absolute code may be dumped generating a new load module. Second, the whole package of Assembler and overlay can be linked from object files and a new load module generated.

APPENDIX D

RA6800ML Assembly Language Object Code in Absolute Hexadecimal Format

The listing below gives the absolute object code for the relocatable macro assembler RA6800ML in hexadecimal format. This listing can be used to manually enter the program or to verify entry of the program via the PAPERBYTE™ bar code representation given in Appendix E. Note that each line does not correspond directly to the variable length records of the bar codes, but uses a fixed length of 16 data bytes per line. The data is preceded by a 2 byte address field. Note that this program begins at hexadecimal 0100. Information on how to use this version of the Assembler to bootstrap RA6800ML for the first time is given in Appendix C, with Appendix F giving details of IO routines appropriate for the bootstrap process.

```
0100 8E A0 42 7E 04 8E 41 42 41 11 6A 1B 41 44 43 0F
0110 00 09 41 44 44 0F 00 0B 41 4E 44 0F 00 04 41 53
0120 4C 0F F9 08 41 53 52 0F F9 07 42 43 43 11 19 24
0130 42 43 53 11 19 25 42 45 51 11 19 27 42 47 45 11
0140 19 2C 42 47 54 11 19 2E 42 48 49 11 19 22 42 49
0150 54 0F 00 05 42 4C 45 11 19 2F 42 4C 53 11 19 23
0160 42 4C 54 11 19 2D 42 4D 49 11 19 2B 42 4E 45 11
0170 19 26 42 50 4C 11 19 2A 42 52 41 11 19 20 42 53
0180 52 11 19 8D 42 56 43 11 19 28 42 56 53 11 19 29
0190 43 42 41 11 6A 11 43 4C 43 11 6A 0C 43 4C 49 11
01A0 6A 0E 43 4C 52 0F F9 0F 43 4C 56 11 6A 0A 43 4D
01B0 4E 12 D4 FF 43 4D 50 0F 00 01 43 4F 4D 0F F9 03
01C0 43 50 58 10 68 8C 44 41 41 11 6A 19 44 45 43 0F
01D0 F9 0A 44 45 53 11 6A 34 44 45 58 11 6A 09 45 4E
01E0 44 13 4E FF 45 4E 54 14 D8 FF 45 4F 52 0F 00 08
01F0 45 51 55 15 51 FF 45 58 54 15 AC FF 46 43 42 16
0200 0E FF 46 43 43 16 43 FF 46 44 42 16 9A FF 49 46
0210 20 16 EE FF 49 4E 43 0F F9 0C 49 4E 53 11 6A 31
0220 49 4E 58 11 6A 08 4A 4D 50 10 E6 6E 4A 53 52 10
0230 E6 AD 4C 44 41 0F 00 06 4C 44 53 10 68 8E 4C 44
0240 58 10 68 CE 4C 53 52 0F F9 04 4D 41 43 17 2E FF
0250 4E 41 4D 18 23 FF 4E 45 47 0F F9 00 4E 49 46 18
0260 58 FF 4E 4F 50 11 6A 02 4F 52 41 0F 00 0A 50 41
0270 47 18 9D FF 50 53 48 10 48 36 50 55 4C 10 48 32
0280 52 4D 42 18 BE FF 52 4F 4C 0F F9 09 52 4F 52 0F
0290 F9 06 52 54 49 11 6A 3B 52 54 53 11 6A 39 53 42
02A0 41 11 6A 10 53 42 43 0F 00 02 53 45 43 11 6A 0D
02B0 53 45 49 11 6A 0F 53 45 56 11 6A 0B 53 54 41 0F
02C0 91 07 53 54 53 10 DA 8F 53 54 58 10 DA CF 53 55
02D0 42 0F 00 00 53 57 49 11 6A 3F 54 41 42 11 6A 16
02E0 54 41 50 11 6A 06 54 42 41 11 6A 17 54 50 41 11
02F0 6A 07 54 53 54 0F F9 0D 54 53 58 11 6A 30 54 58
0300 53 11 6A 35 57 41 49 11 6A 3E 00 00 00 04 04 04
0310 00 04 00 00 24 24 04 24 80 24 42 42 42 42 42 42
0320 42 42 42 42 00 00 00 00 00 00 80 83 83 82 82 82
0330 82 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80
0340 80 80 81 80 80 00 00 00 00 00 7E FF FF 7E FF FF
0350 7E FF FF 7E FF FF 7E FF FF 7E FF FF 7E FF FF 7E
0360 FF FF 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0370 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0380 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0390 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
03A0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
03B0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
03C0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
03D0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
03E0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
03F0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0400 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0410 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
```

```
0420 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0430 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0440 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0450 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0460 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0470 00 00 00 00 00 00 00 00 45 4E 54 45 52 20 4F 50
0480 54 49 4F 4E 53 3A 20 04 7E E1 AC 7E E1 D1 7F 03
0490 75 CE 04 78 BD 19 5E 7F 03 6E 73 03 6E BD 04 88
04A0 81 0D 27 26 81 4C 26 04 86 70 20 16 81 4F 26 04
04B0 86 B0 20 0E 81 53 26 04 86 D0 20 06 81 4D 26 DD
04C0 86 E0 B4 03 6E B7 03 6E 20 D3 BD 14 BE FE 03 4B
04D0 EE 00 FF 03 62 FF 08 E3 CE 08 00 FF 08 E5 CE 08
04E0 E3 BD 0C EC FE 08 E3 FF 03 64 CE 01 00 FF 08 E5
04F0 CE 08 E3 BD 0C EC FE 08 E3 FF 03 66 08 FF 03 68
0500 FF 08 E5 CE 3F FF FF 08 E3 CE 08 E3 BD 0C FD B6
0510 08 E3 F6 08 E4 CE 00 09 FF 08 E5 CE 08 E5 BD 0C
0520 A1 B7 03 6A F7 03 6B CE 00 09 FF 08 E3 CE 08 E3
0530 BD 0C 7D B7 08 E3 F7 08 E4 FE 03 68 FF 08 E5 CE
0540 08 E3 BD 0C EC FE 08 E3 FF 03 6C 86 20 FE 03 68
0550 A7 00 08 BC 03 6C 26 F8 CE 00 00 FF 03 71 FF 03
0560 88 CE 00 00 FF 04 13 BD 11 89 7F 03 87 FE 03 62
0570 FF 04 0D 7F 04 0C FE 03 66 FF 03 8A 86 FF B7 04
0580 77 CE 04 75 FF 04 75 CE 00 00 FF 03 73 FF 03 6F
0590 BD 06 68 7F 03 76 FE 03 6F 08 FF 03 6F FE 03 80
05A0 A6 00 81 2A 26 08 BD 11 89 BD 0D 0E 20 E2 7D 04
05B0 77 26 22 81 20 27 03 BD 07 F6 BD 07 F6 B6 03 7D
05C0 81 03 22 E2 BD 0A 40 8C 16 EE 27 07 8C 18 58 27
05D0 02 20 D3 6E 00 81 20 27 1D BD 07 F6 C1 01 27 0B
05E0 CE 02 05 BD 0E BB BD 0D 0E 20 A5 7C 03 76 7D 03
05F0 75 26 03 BD 08 F8 BD 07 F6 C1 01 27 0B CE 02 02
0600 BD 0E BB BD 0D 0E 20 88 BD 0A 40 81 00 27 2D BD
0610 09 57 C1 FF 27 28 C5 20 27 24 7D 04 0C 27 08 BD
0620 07 37 7D 04 0C 27 20 FF 04 0D BD 0D 0E 7C 04 0C
0630 BD 07 F6 C1 0D 26 13 F7 03 DA 20 0B 6E 00 CE 02
0640 07 BD 0E BB BD 0D 0E 7E 05 90 CE 03 DA FF 04 0F
0650 FE 03 7B A6 00 08 FF 03 7B FE 04 0F A7 00 08 FF
0660 04 0F 81 0D 26 EA 20 DF 7D 04 0C 27 09 BD 06 A5
0670 7D 04 0C 27 01 39 CE 04 15 FF 03 7E FF 03 80 BD
0680 03 53 24 06 8E A0 42 7E 13 54 81 0A 27 F1 81 00
0690 27 ED 8C 04 64 27 05 A7 00 08 20 04 C6 0D E7 00
06A0 81 0D 26 DB 39 FE 04 0D A6 00 81 17 26 0B 7A 04
06B0 0C 27 05 BD 07 9B 20 ED 39 CE 03 92 FF 03 80 FF
06C0 03 7E FF 04 11 FE 04 0D A6 00 08 FF 04 0D 81 26
06D0 27 13 FE 04 11 A7 00 08 FF 04 11 8C 03 D9 27 4B
06E0 81 0D 26 E1 39 E6 00 C0 2F 08 FF 04 0D CE 03 DA
06F0 FF 04 0F A6 00 08 81 2C 27 04 81 0D 26 F5 5A 26
0700 EF FE 04 0F A6 00 08 FF 04 0F FE 04 11 A7 00 08
0710 FF 04 11 8C 03 D9 27 13 FE 04 0F A6 00 08 FF 04
0720 0F 81 2C 27 A0 81 0D 26 E1 20 9A 86 0D A7 00 CE
0730 02 30 BD 0E BB 20 8E FF 03 8E BF 03 8C BE 03 8A
0740 CE 04 12 C6 06 A6 00 09 FF 03 90 30 09 BC 03 64
0750 27 33 FE 03 90 36 5A 26 EC CE 03 DA A6 00 81 0D
0760 27 03 08 20 F7 A6 00 FF 03 90 30 09 BC 03 64 27
0770 14 FE 03 90 36 09 8C 03 D9 26 EA BF 03 8A BE 03
0780 8C FE 03 8E 39 BE 03 66 BF 03 8A BE 03 8C CE 02
0790 51 BD 0E BB FE 03 8E 7F 04 0C 39 FF 03 8E BF 03
07A0 8C BE 03 8A CE 03 DA 32 A7 00 08 81 0D 26 F8 CE
07B0 04 0D C6 06 32 A7 00 08 5A 26 F9 BF 03 8A BE 03
07C0 8C FE 03 8E 39 36 37 E6 04 FF 07 F4 FE 07 F4 EE
07D0 00 A6 00 FE 07 F4 6C 01 26 02 6C 00 FE 07 F4 EE
07E0 02 A1 00 26 0C FE 07 F4 6C 03 26 02 6C 02 5A 26
```

```
07F0 DB 33 32 39 00 00 7F 03 7D 7C 03 7D FE 03 7E FF
0800 03 7B A6 00 08 FF 03 7E 81 20 27 F0 22 06 81 0D
0810 26 47 16 39 81 5F 23 02 20 3F BD 08 C3 85 01 27
0820 13 FE 03 7E E6 00 C1 20 27 04 C1 0D 26 0A FE 03
0830 7B E6 00 39 85 80 27 04 BD 08 73 39 85 40 27 04
0840 BD 08 5C 39 85 20 26 E6 85 04 27 0D FE 03 7B E6
0850 00 C1 24 26 D9 BD 08 98 39 4F 5F 39 FE 03 7E A6
0860 00 7C 03 7D 08 FF 03 7E BD 08 C3 85 40 26 ED C6
0870 09 20 43 FE 03 7E A6 00 7C 03 7D 08 FF 03 7E BD
0880 08 C3 85 80 26 ED 85 40 26 E9 C6 07 F1 03 7D 24
0890 03 F7 03 7D C6 01 20 1E 7F 03 7D FE 03 7E FF 03
08A0 7B FE 03 7E A6 00 7C 03 7D 08 FF 03 7E BD 08 C3
08B0 85 02 26 ED C6 03 7A 03 7D FE 03 7E 09 FF 03 7E
08C0 86 02 39 81 20 25 16 81 5F 22 12 7F 08 DF B7 08
08D0 E0 CE 08 DF BD 0C EC FE 08 DF A6 00 39 4F 39 00
08E0 00 02 EA 00 00 00 00 00 00 00 00 00 00 00 00 00
08F0 00 00 00 00 00 00 00 00 BD 09 B9 FF 03 82 A6 00
0900 81 20 26 2F FF 08 F6 CE 08 EA FF 08 F4 C6 06 FE
0910 08 F4 A6 00 08 FF 08 F4 FE 08 F6 A7 00 08 FF 08
0920 F6 5A 26 EB B6 03 73 A7 00 B6 03 74 A7 01 86 40
0930 A7 02 39 BD 09 7E 26 10 FE 03 82 86 80 AA 08 A7
0940 08 CE 02 06 BD 0E BB 39 BD 09 93 BC 08 F0 27 02
0950 20 AC CE 02 21 20 ED BD 09 B9 FF 03 82 A6 00 81
0960 20 26 03 C6 FF 39 BD 09 7E 26 08 FE 03 82 E6 08
0970 EE 06 39 BD 09 93 BC 08 F0 26 E2 C6 FF 39 FF 08
0980 E3 86 06 B7 08 E7 CE 08 EA FF 08 E5 CE 08 E3 BD
0990 07 C5 39 FE 03 82 08 08 08 08 08 08 08 08 08 BC
09A0 03 6C 26 03 FE 03 68 FF 03 82 39 FE 03 82 86 20
09B0 C6 09 A7 00 08 5A 26 FA 39 CE 20 20 FF 08 EA FF
09C0 08 EC FF 08 EE CE 08 EA FF 08 F6 FE 03 7B FF 08
09D0 F4 F6 03 7D FE 08 F4 A6 00 08 FF 08 F4 FE 08 F6
09E0 A7 00 08 FF 08 F6 5A 26 EB FE 08 EA FF 08 F0 FE
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0A00 F2 CE 08 F0 BD 0C EC B6 08 F0 F6 08 F1 FE 03 6A
0A10 FF 08 F2 CE 08 F2 BD 0C A1 FF 08 F0 4F C6 09 CE
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0A30 F2 CE 08 F0 BD 0C EC FE 08 F0 39 00 00 00 00 06
0A40 B6 03 7D B7 08 E7 86 57 B7 0A 3C 4F B7 0A 3B B6
0A50 0A 3B 4C B1 0A 3C 26 03 86 FF 39 F6 0A 3B FB 0A
0A60 3C 56 F7 0A 3D 4F CE 0A 3E 5A BD 0C 7D B7 08 E3
0A70 F7 08 E4 CE 01 06 FF 08 E5 CE 08 E3 BD 0C EC FE
0A80 08 E3 FF 08 E8 FE 03 7B FF 08 E5 CE 08 E3 BD 07
0A90 C5 25 0B 26 11 4F FE 08 E8 E6 05 EE 03 39 B6 0A
0AA0 3D B7 0A 3B 20 A9 B6 0A 3D B7 0A 3C 20 A1 00 00
0AB0 00 00 00 00 00 7F 0A AE 7F 0A AF 7F 0A B2 B7 0A
0AC0 B3 C1 2A 26 2D FE 03 73 FF 0A AE 86 02 B7 0A B2
0AD0 73 03 77 FE 03 7E A6 00 81 20 27 08 81 0D 27 04
0AE0 81 2C 26 08 FE 0A AE FF 0D 68 5F 39 BD 07 F6 B7
0AF0 0A B3 B1 0A B2 26 06 CE 02 04 5F 53 39 81 02 27
0B00 14 81 24 27 02 20 F0 7D 0A B2 27 EB F7 0A B4 B7
0B10 0A B2 7E 0A D3 C1 03 26 11 F6 03 7D C1 04 2F 05
0B20 CE 02 10 20 D5 BD 0B CE 20 3B C1 09 26 11 F6 03
0B30 7D C1 05 2F 05 CE 02 10 20 C0 BD 0C 2A 20 26 C1
0B40 01 27 03 7E 0A F7 BD 09 57 C5 80 26 12 C5 40 27
0B50 05 73 03 77 20 0F C5 10 27 03 73 03 78 20 06 CE
0B60 02 11 7E 0A FA FF 0A B0 7D 0A B2 26 0F FE 0A B0
0B70 FF 0A AE B6 0A B3 B7 0A B2 7E 0A D3 B6 0A B4 81
0B80 2B 26 08 CE 0A AE BD 0C EC 20 E8 81 2D 26 08 CE
0B90 0A AE BD 0C FD 20 DC 81 2A 26 15 B6 0A AE F6 0A
0BA0 AF CE 0A B0 BD 0C 7D B7 0A AE F7 0A AF 7E 0B 73
0BB0 81 2F 27 03 7E 0A F7 B6 0A AE F6 0A AF CE 0A B0
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0BD0 7B 7F 0B CC 7F 0B CD F6 03 7D 09 08 5A 26 FC F6
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0BF0 48 48 48 BA 0B CD B7 0B CD 5A 27 18 09 BD 0C 18
0C00 B7 0B CC 5A 27 0E 09 BD 0C 18 48 48 48 48 BA 0B
0C10 CC B7 0B CC FE 0B CC 39 A6 00 80 30 81 09 2F 02
0C20 80 07 39 00 00 00 00 00 00 00 7F 0C 23 7F 0C 24
0C30 7F 0C 26 7F 0C 27 7C 0C 27 FE 03 7B 09 F6 03 7D
0C40 F7 0C 25 08 5A 26 FC FF 0C 28 E6 00 C4 0F 4F CE
0C50 0C 26 BD 0C 7D FB 0C 24 B9 0C 23 B7 0C 23 F7 0C
0C60 24 4F C6 0A CE 0C 26 BD 0C 7D B7 0C 26 F7 0C 27
0C70 FE 0C 28 09 7A 0C 25 26 CE FE 0C 23 39 37 36 A6
0C80 01 36 A6 00 36 86 10 36 30 A6 03 58 49 68 02 69
0C90 01 24 04 EB 04 A9 03 6A 00 26 F0 31 31 31 31 31
0CA0 39 37 36 A6 00 E6 01 37 36 34 30 86 01 6D 01 2B
0CB0 0B 4C 68 02 69 01 2B 04 81 11 26 F5 A7 00 A6 03
0CC0 E6 04 6F 03 6F 04 E0 02 A2 01 24 07 EB 02 A9 01
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0CE0 A7 00 E7 01 EE 00 31 31 31 32 33 39 36 37 A6 01
0CF0 E6 00 AB 03 E9 02 A7 01 E7 00 33 32 39 36 37 A6
0D00 01 E6 00 A0 03 E2 02 A7 01 E7 00 33 32 39 B6 03
0D10 6E 85 80 26 14 7D 03 75 27 0F 7D 04 0C 27 04 85
0D20 10 26 06 BD 0D 2A BD 0D 71 39 37 F6 03 87 C1 00
0D30 26 03 BD 0D 44 7C 03 87 F6 03 87 C1 3C 26 03 7F
0D40 03 87 33 39 CE 0D 4B BD 19 5E 39 0D 0A 0D 0A 0D
0D50 0A 2E 2E 2E 2E 2E 2E 2E 2E 2E 2E 2E 2E 0D 0A
0D60 0D 0A 0D 0A 04 00 00 00 00 00 00 00 00 00 00 20
0D70 04 CE 0D 6A B6 03 6F F6 03 70 BD 0E 5C CE 0D 6B
0D80 BD 19 5E 7D 04 0C 27 05 86 2B BD 19 85 CE 0E 59
0D90 BD 19 5E 7D 0D 65 26 0D 7D 0D 66 26 08 CE 0E 56
0DA0 BD 19 5E 20 2B CE 03 73 BD 19 6E F6 0D 66 27 20
0DB0 C1 01 27 0E CE 0D 68 BD 19 6E CE 0E 58 BD 19 5E
0DC0 20 45 CE 0D 69 BD 19 70 CE 0E 56 BD 19 5E 20 37
0DD0 F6 0D 65 26 08 CE 0E 53 BD 19 5E 20 2A CE 0D 67
0DE0 BD 19 70 C1 01 26 08 CE 0E 56 BD 19 5E 20 18 C1
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0E00 06 CE 0D 68 BD 19 6E 7D 03 78 27 04 86 43 20 1D
0E10 7D 03 79 27 04 86 58 20 14 7D 03 7A 27 04 86 4E
0E20 20 0B 7D 03 77 27 04 86 52 20 02 86 20 BD 19 85
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0E40 81 0D 26 F4 86 0A BD 19 85 7F 0D 66 7F 0D 65 7F
0E50 03 77 39 20 20 20 20 20 20 20 20 04 FF 0E 9D CE
0E60 0E 92 7F 0E 9C E0 01 A2 00 25 05 7C 0E 9C 20 F5
0E70 EB 01 A9 00 36 FF 0E 9F FE 0E 9D B6 0E 9C 8B 30
0E80 A7 00 32 08 FF 0E 9D FE 0E 9F 08 08 8C 0E 9C 26
0E90 D1 39 27 10 03 E8 00 64 00 0A 00 01 00 00 00 00
0EA0 00 00 00 2A 2A 2A 2A 20 45 52 52 4F 52 23 20 00
0EB0 00 00 20 00 00 00 00 00 20 3A 04 36 37 FF 0E A1
0EC0 B6 0E A1 8B 30 B7 0E AF B6 0E A2 44 44 44 44 8B
0ED0 30 B7 0E B0 B6 0E A2 84 0F 8B 30 B7 0E B1 CE 0E
0EE0 B3 B6 03 6F F6 03 70 BD 0E 5C CE 0E A3 BD 19 5E
0EF0 BD 0E 35 33 32 FE 03 88 08 FF 03 88 FE 0E A1 39
0F00 BD 11 89 BD 07 F6 C1 0D 26 08 CE 02 04 BD 0E BB
0F10 20 5B BD 11 B7 F6 11 84 27 F0 BD 07 F6 C1 23 26
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0F80 F7 11 87 C6 E0 F7 11 88 BD 12 13 BD 12 C2 7E 05
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0FB0 B5 BD 11 D7 BD 07 F6 BD 11 C4 26 2A 7D 03 78 26
0FC0 0A 7D 03 77 26 05 F6 0D 68 27 0F C6 B0 F7 11 87
0FD0 C6 F0 F7 11 88 BD 12 5E 20 19 C6 90 F7 11 87 C6
0FE0 D0 F7 11 88 20 0A C6 A0 F7 11 87 C6 E0 F7 11 88
0FF0 BD 12 13 BD 12 C2 7E 05 90 BD 11 89 BD 07 F6 C1
1000 0D 26 08 CE 02 04 BD 0E BB 20 2A BD 11 B7 7D 11
1010 84 27 0F C6 40 F7 11 87 C6 50 F7 11 88 BD 11 EA
1020 20 20 BD 0A B5 BD 11 D7 BD 07 F6 BD 11 C4 26 0A
1030 C6 70 F7 11 87 BD 12 7C 20 08 C6 60 F7 11 87 BD
1040 12 31 BD 12 C2 7E 05 90 BD 11 89 BD 07 F6 BD 11
1050 B7 7D 11 84 26 06 CE 02 04 BD 0E BB 7C 11 88 BD
1060 11 EA BD 12 C2 7E 05 90 BD 11 89 BD 07 F6 C1 0D
1070 26 08 CE 02 40 BD 0E BB 20 46 C1 23 26 19 73 11
1080 85 BD 07 F6 C1 27 26 0F FE 03 7E A6 00 B7 0D 68
1090 A6 01 B7 0D 69 20 29 BD 0A B5 BD 11 D7 F6 11 85
10A0 27 02 20 1C BD 07 F6 BD 11 C4 26 20 7D 03 78 26
10B0 0A 7D 03 77 26 05 F6 0D 68 27 0A C6 30 F7 11 87
10C0 BD 12 7C 20 0F C6 10 F7 11 87 20 05 C6 20 F7 11
10D0 87 BD 12 31 BD 12 C2 7E 05 90 BD 11 89 BD 07 F6
10E0 C1 0D 26 B3 20 8C BD 11 89 BD 07 F6 C1 0D 26 08
10F0 CE 02 04 BD 0E BB 20 0E BD 0A B5 BD 11 D7 BD 07
1100 F6 BD 11 C4 26 0A C6 10 F7 11 87 BD 12 7C 20 03
1110 BD 12 31 BD 12 C2 7E 05 90 BD 11 89 BD 07 F6 C1
1120 0D 26 08 CE 02 04 BD 0E BB 20 36 7D 03 75 27 31
1130 BD 0A B5 BD 11 D7 FE 03 73 08 08 FF 03 85 B6 0D
1140 69 F6 0D 68 B0 03 86 F2 03 85 C1 FF 26 03 4D 2B
1150 0D C1 00 26 03 4D 2A 06 CE 02 08 BD 0E BB B7 0D
1160 69 BD 12 31 BD 12 C2 7E 05 90 BD 11 89 7D 03 75
1170 27 03 BD 19 2B 7C 0D 65 7C 03 84 BD 0D 0E BD 12
1180 C2 7E 05 90 00 00 00 00 00 7F 03 84 7F 03 77 7F
1190 03 78 7F 03 79 7F 03 7A 7F 0D 66 F7 0D 67 7F 0D
11A0 65 7F 11 84 7F 11 85 7F 11 86 7F 0D 68 7F 0D 69
11B0 7F 11 87 7F 11 88 39 C1 41 27 05 C1 42 27 01 39
11C0 F7 11 84 39 C1 2C 26 0B BD 07 F6 C1 58 26 04 73
11D0 11 86 39 7F 11 86 39 C1 FF 26 0E 7D 03 75 27 03
11E0 BD 0E BB 7F 0D 68 73 0D 68 39 7D 07 52 72 0F 62
11F0 0D 67 B6 11 84 27 0F 81 42 27 05 FA 11 87 20 03
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1220 81 42 27 05 FA 11 87 20 03 FA 11 88 F7 0D 67 20
1230 14 7D 03 75 27 21 7F 03 77 7F 03 78 F6 0D 67 FA
1240 11 87 F7 0D 67 BD 19 2B F6 0D 69 BD 19 2B 7C 0D
1250 65 7C 0D 65 BD 0D 0E 7C 03 84 7C 03 84 39 7D 03
1260 75 27 55 F6 0D 67 B6 11 84 27 1F 81 42 27 05 FA
1270 11 87 20 03 FA 11 88 F7 0D 67 20 0E 7D 03 75 27
1280 37 F6 0D 67 FA 11 87 F7 0D 67 BD 19 2B F6 0D 68
1290 BD 19 2B F6 0D 69 BD 19 2B 7D 03 78 27 04 C6 4D
12A0 20 07 7D 03 77 27 05 C6 52 BD 19 3F 7C 0D 65 7C
12B0 0D 65 7C 0D 65 BD 0D 0E 7C 03 84 7C 03 84 7C 03
12C0 84 39 B6 03 74 F6 03 73 BB 03 84 C9 00 B7 03 74
12D0 F7 03 73 39 BD 11 89 BD 19 17 BD 07 F6 C1 01 27
12E0 08 CE 02 16 BD 0E BB 20 5D 7D 03 75 26 41 BD 08
12F0 F8 FE 03 82 FF 13 4C BD 07 F6 C1 2C 26 E3 BD 07
1300 F6 BD 0A B5 C1 FF 27 DC FE 13 4C 86 BF A4 08 8A
1310 10 A7 08 B6 04 13 A7 06 B6 04 14 A7 07 B6 0D 69
1320 F6 0D 68 BB 04 14 F9 04 13 B7 04 14 F7 04 13 BD
1330 09 57 FE 03 82 EE 06 FF 0D 68 73 0D 66 73 03 78
1340 7C 0D 65 7C 0D 65 BD 0D 0E 7E 05 90 00 00 BD 11
1350 89 BD 19 17 7D 03 75 26 0F FE 03 73 FF 03 71 73
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1390 FF 14 D1 7F 14 D5 FE 03 68 20 09 08 08 08 08 08
13A0 08 08 08 08 BC 03 6C 26 0B 7D 14 D5 27 03 7E 13
13B0 EB 7E 14 4D E6 00 C1 20 27 E1 E6 08 C1 FF 27 DB
13C0 FF 14 D3 FF 08 E5 FE 14 D1 FF 08 E3 C6 06 F7 08
13D0 E7 CE 08 E3 BD 07 C5 22 05 FE 14 D3 20 BD FE 14
13E0 D3 FF 14 D1 C6 FF F7 14 D5 20 B0 BD 0D 2A C6 06
13F0 FE 14 D1 A6 00 BD 19 85 08 5A 26 F7 86 20 BD 19
1400 85 BD 19 6E FF 14 D6 E6 00 C5 40 27 05 86 52 BD
1410 19 85 C5 20 27 05 86 4D BD 19 85 C5 10 27 05 86
1420 43 BD 19 85 C5 08 27 05 86 58 BD 19 85 C5 04 27
1430 05 86 4E BD 19 85 E6 00 2A 06 CE 14 8A BD 19 5E
1440 FE 14 D6 C6 FF E7 00 BD 14 BE 7E 13 8D BD 14 BE
1450 BD 14 BE CE 14 A1 B6 03 88 F6 03 89 BD 0E 5C CE
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1490 49 4E 45 44 04 54 48 45 52 45 20 57 45 52 45 3A
14A0 20 00 00 00 00 00 20 45 52 52 4F 52 53 04 43 4F
14B0 4D 4D 4F 4E 20 4C 45 4E 47 54 48 3D 20 04 CE 14
14C0 C5 BD 19 5E 39 0D 0A 04 5B 5B 5B 5B 5B 5B 00 00
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15B0 19 17 BD 07 F6 C1 01 27 0B CE 02 16 BD 0E BB BD
15C0 0D 0E 20 47 7C 03 84 7C 03 84 7C 03 84 7D 03 75
15D0 26 0E BD 08 F8 FE 03 82 A6 08 8A 08 A7 08 20 28
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15F0 BD 19 3F 7F 0D 68 7F 0D 69 7C 0D 65 7C 0D 65 7C
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16A0 C1 0D 26 08 CE 02 16 BD 0E BB 20 39 BD 0A B5 BD
16B0 11 D7 7C 03 84 7C 03 84 7D 03 75 27 2B F6 0D 68
16C0 BD 19 2B F6 0D 69 BD 19 2B 7D 03 77 27 04 C6 52
16D0 20 07 7D 03 78 27 05 C6 4D BD 19 3F 7C 0D 65 7C
16E0 0D 65 73 0D 66 BD 0D 0E BD 12 C2 7E 05 90 BD 11
16F0 89 BD 19 17 BD 07 F6 C1 0D 26 08 CE 02 16 BD 0E
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1710 27 14 7D 0D 68 26 0A 7D 0D 69 26 05 7F 04 77 20
1720 05 86 FF B7 04 77 BD 0D 0E 7E 05 90 00 00 BD 11
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17A0 76 BD 07 F6 86 04 B7 08 E7 FE 03 7B FF 08 E3 CE
17B0 18 1F FF 08 E5 CE 08 E3 BD 07 C5 26 0D 7D 03 76
17C0 27 0E CE 02 27 BD 0E BB 20 06 BD 17 E3 7E 17 6F
17D0 7D 03 75 26 0B 86 17 FE 04 0D A7 00 08 FF 04 0D
17E0 7E 05 90 7D 03 75 26 36 7D 17 2D 26 31 FE 03 80
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1890 02 54 BD 0E BB 39 BF 04 75 BE 03 8C 39 BD 11 89
18A0 BD 19 17 7D 03 75 27 13 F6 03 87 27 0E C6 3C F0
18B0 03 87 BD 14 BE 5A 26 FA 7F 03 87 7E 05 90 BD 11
18C0 89 BD 07 F6 C1 0D 26 08 CE 02 16 BD 0E BB 20 18
18D0 BD 0A B5 C1 FF 27 F4 7D 03 75 27 0F BD 19 00 7C
18E0 0D 65 7C 0D 65 73 0D 66 BD 0D 0E B6 03 74 F6 03
18F0 73 BB 0D 69 F9 0D 68 B7 03 74 F7 03 73 7E 05 90
1900 5F FE 0D 68 FF 03 85 BD 19 2B FE 03 85 09 27 06
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1920 03 BD 09 AB CE 02 23 BD 0E BB 39 B6 03 6E 85 40
1930 26 0C 17 8D 16 BD 03 56 17 8D 14 BD 03 56 39 B6
1940 03 6E 85 40 26 F8 17 BD 03 56 39 44 44 44 44 84
1950 0F 8B 30 81 39 23 02 8B 07 39 BD 19 85 08 A6 00
1960 81 04 26 F6 39 A6 00 8D 0E A6 00 08 20 0D 8D F5
1970 8D F3 86 20 7E 19 85 44 44 44 44 84 0F 8B 30 81
1980 39 23 02 8B 07 36 BD 04 8B 32 81 0A 26 0E 36 37
1990 C6 08 86 00 BD 04 8B 5A 26 F8 33 32 39 DE DE DE
19A0 DE DE DE DE DE DE DE DE DE DE DE DE DE DE DE DE
19B0 DE
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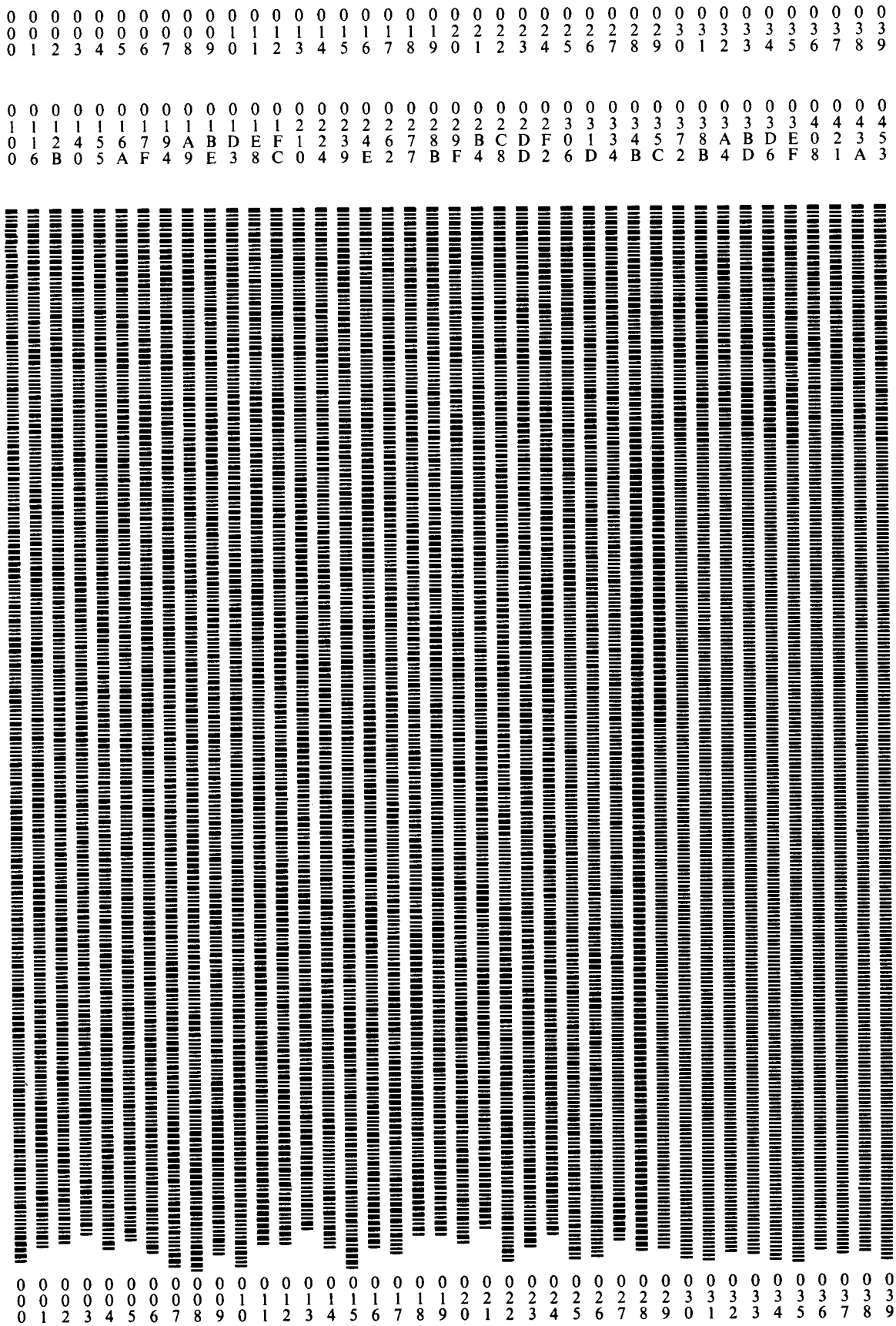
APPENDIX E

PAPERBYTE™ Bar Code Representation of RA6800ML in Absolute Format

Beginning on the following page is a complete machine readable representation (PAPERBYTE™ bar codes) of the object code for the Hemenway relocatable macro assembler RA6800ML. This object code was created by assembling the Assembler. See appendix G for a listing of the 6800 assembly language source code of the Assembler.

This representation uses the absolute loader format, in which each bar code frame (one line of bar codes running from top to bottom of the page) contains a 2 byte address followed by data which is loaded in ascending order starting at that address. A hexadecimal listing that can be used to verify the input from bar codes is given in Appendix D. For details on the frame format and absolute loader format used in this and other PAPERBYTE™ books, see PAPERBYTE publication *Bar Code Loader* by Ken Budnick. The book contains a brief history on bar codes, a general bar code loader algorithm with flowcharts, and complete program listings for 6800, 6502, and 8080 or Z-80 based systems.

Information on how to use this version of the Assembler to bootstrap RA6800ML for the first time is given in Appendix C, with Appendix F giving details of IO routines appropriate for the bootstrap process.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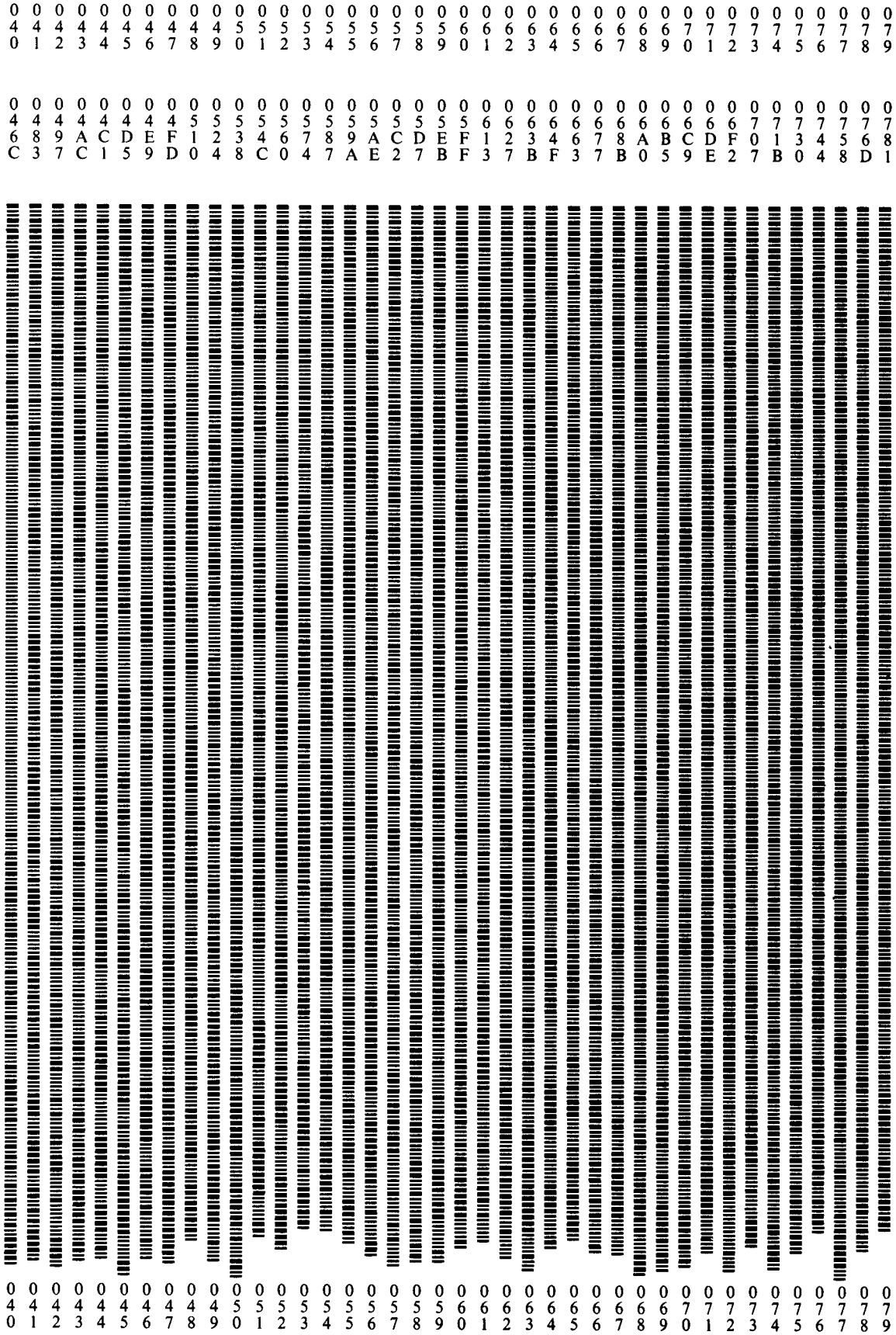
0100 0116 012B 0140 0155 016A 017F 0194 01A9 01BE 01D3 01E8 01FC 0210 0224 0239 024E 0262 0277 028B 029F 02B4 02C8 02DD 02F2 0306 031D 0334 034B 035C 0372 038B 03A4 03BD 03D6 03EF 0408 0421 043A 0453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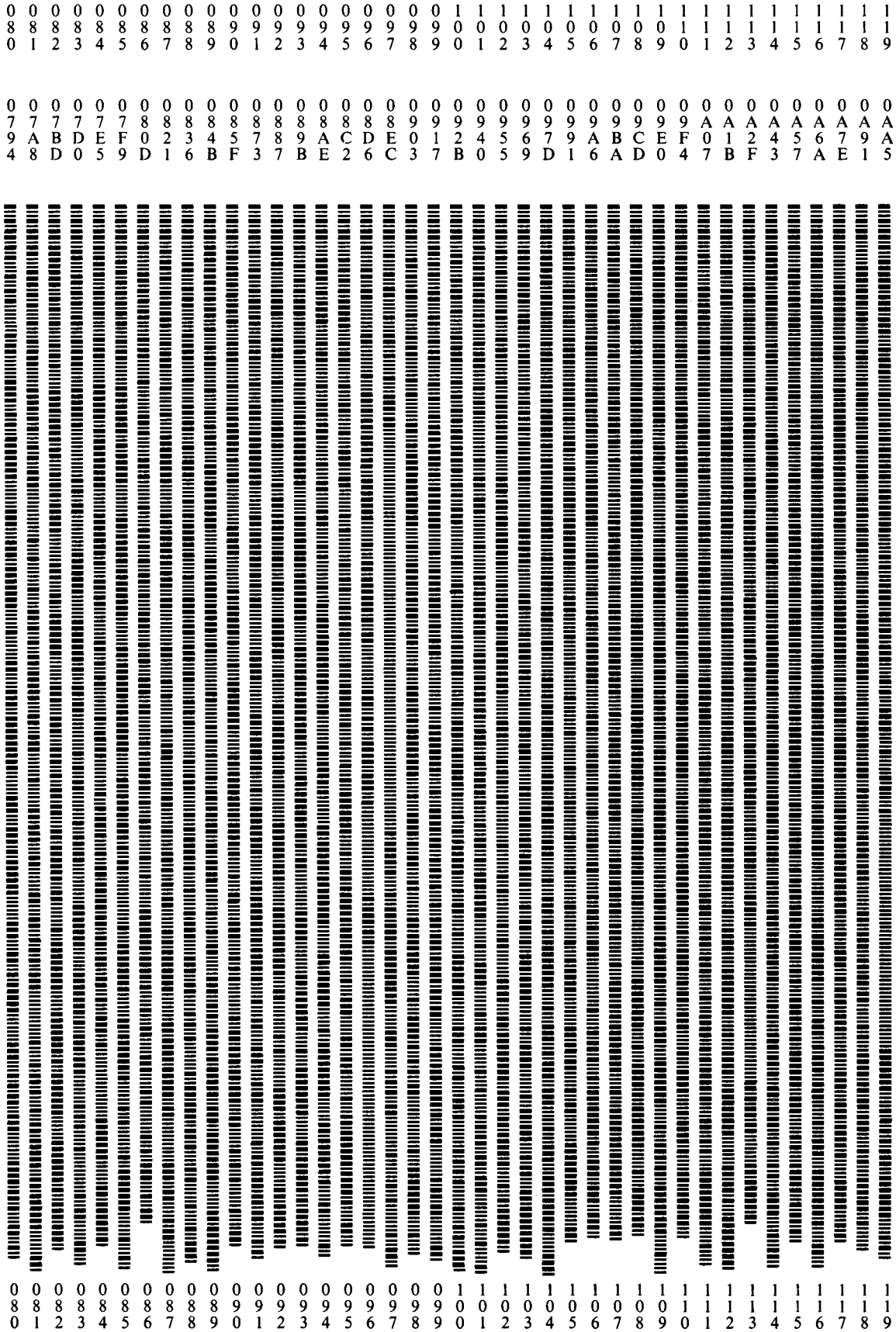
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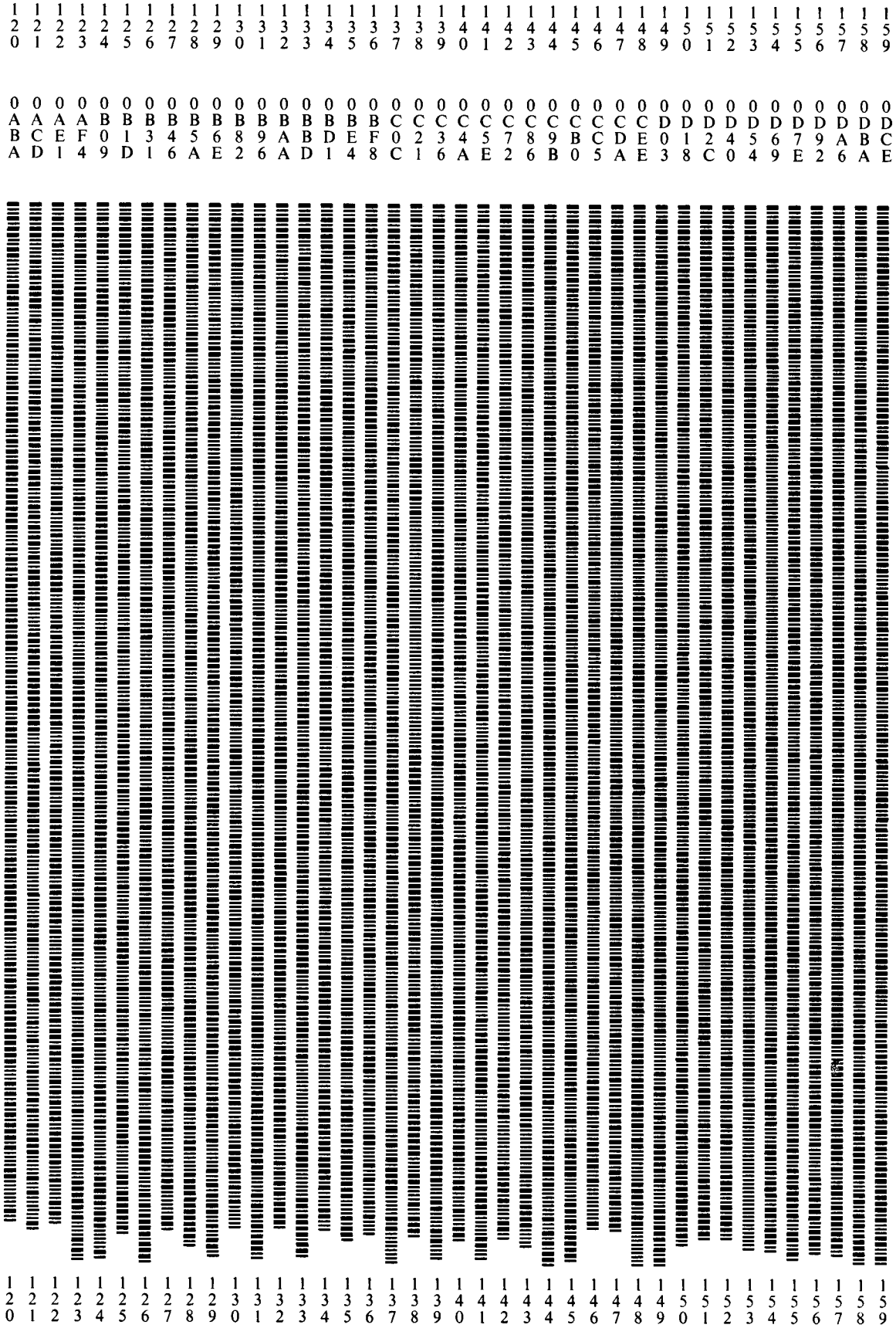
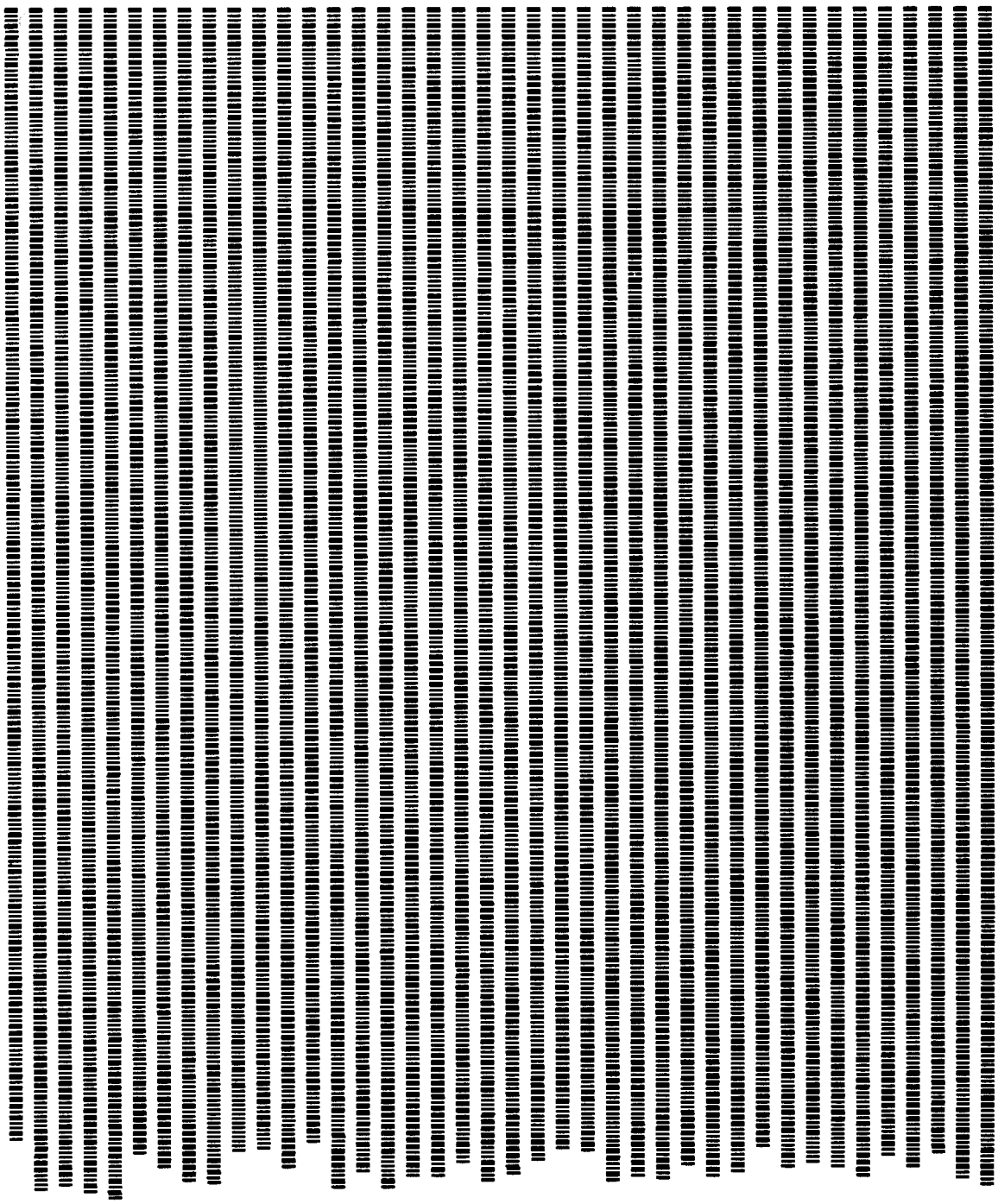
0794 07A8 07BD 07D0 07E5 07F9 080D 0821 0836 084B 085F 0873 0887 089B 08AE 08C2 08D6 08EC 0903 0917 092B 0940 0955 0969 097D 0991 09A6 09BA 09CD 09E0 09F4 0A07 0A1B 0A2F 0A43 0A57 0A6A 0A7E 0A91 0AA5
0800 0801 0802 0803 0804 0805 0806 0807 0808 0809 0890 0891 0892 0893 0894 0895 0896 0897 0898 0899 0900 0901 0902 0903 0904 0905 0906 0907 0908 0909 0910 0911 0912 0913 0914 0915 0916 0917 0918 0919

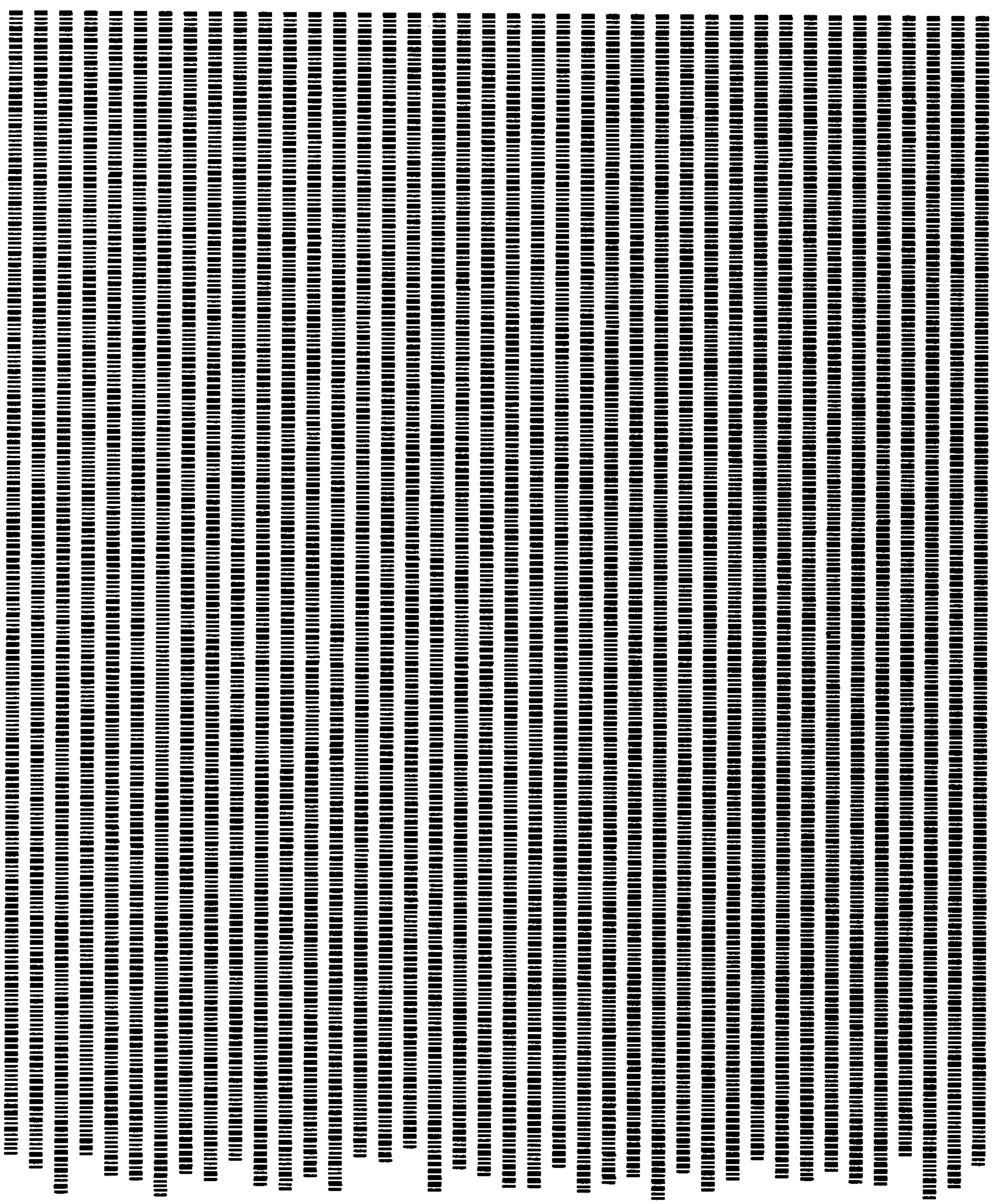

120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159
0ABA 0ACD 0AE1 0AF4 0B09 0B1D 0B31 0B46 0B5A 0B6E 0B82 0B96 0BAA 0BBD 0BD1 0BE4 0BF8 0C0C 0C21 0C36 0C4A 0C5E 0C72 0C86 0C9B 0CB0 0CC5 0CDA 0CEE 0D03 0D18 0D2C 0D40 0D54 0D69 0D7E 0D92 0DA6 0DBA 0DCE
120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159

160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199

0DE2 0DF6 0E0A 0E1F 0E34 0E49 0E5D 0E71 0E85 0E9A 0EB0 0EC5 0ED9 0EEC 0F00 0F14 0F28 0F3C 0F50 0F64 0F78 0F8C 0FA0 0FB3 0FC6 0FDA 0FEE 1002 1016 102A 103E 1051 1065 1079 108D 10A1 10B5 10C9 10DD 10F1

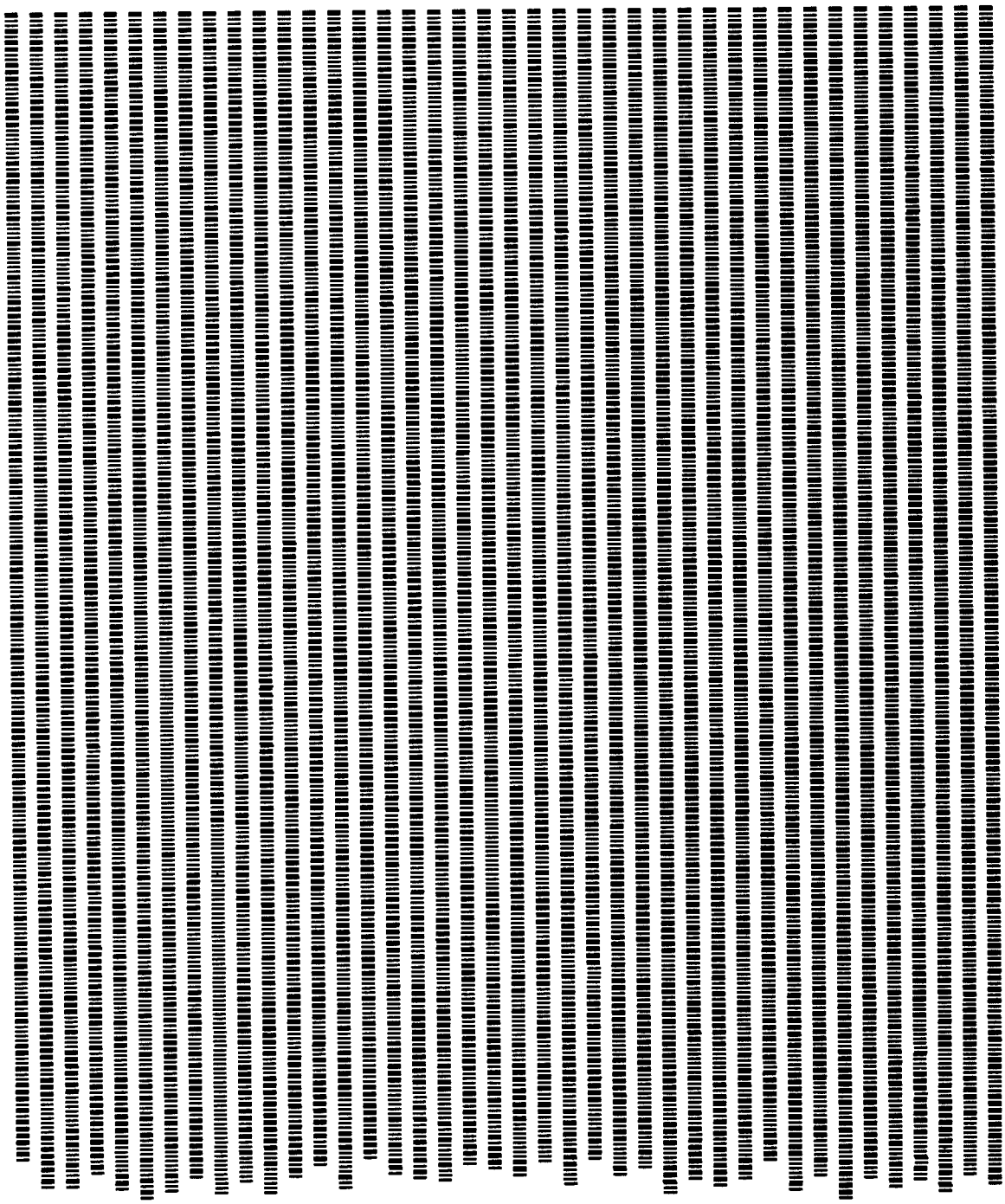


160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199

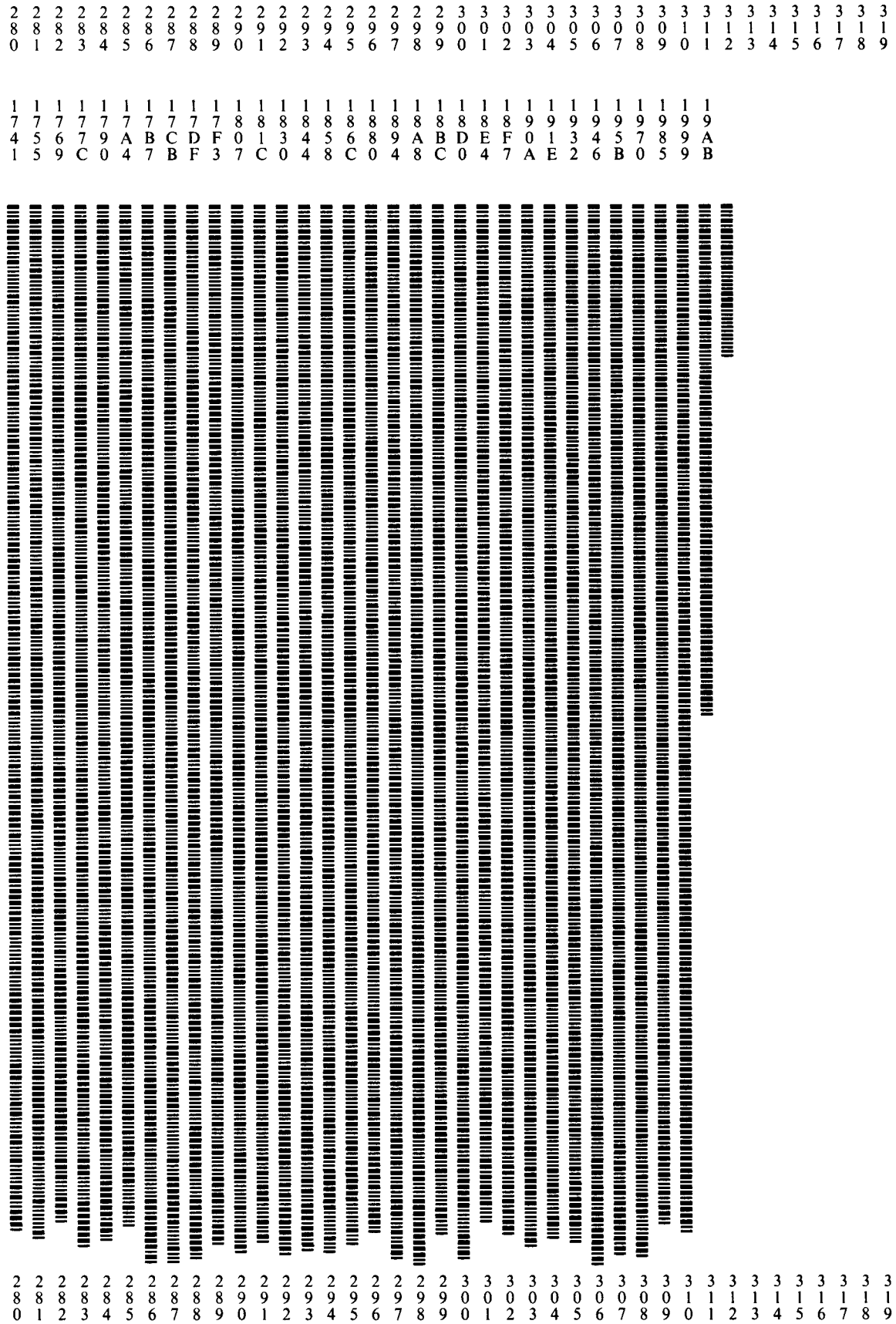

200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239
1105 1119 112D 1141 1155 1169 117D 1192 11A5 11B9 11CD 11E1 11F5 1209 121D 1231 1245 1257 126B 127F 1292 12A6 12BA 12CE 12E2 12F6 1309 131E 1332 1346 135A 136D 1381 1395 13AA 13BE 13D1 13E4 13F8 140C
200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239

240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279

1420 1434 1448 145C 146F 1483 1498 14AE 14C2 14D8 14EC 1500 1514 1527 153B 154E 1562 1576 158A 159E 15B2 15C6 15DA 15EE 1601 1615 1629 163D 1651 1665 1679 168D 16A1 16B5 16C9 16DD 16F1 1705 1719 172D



240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279


280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319
1741 1755 1769 177C 1790 17A4 17B7 17CB 17DF 17F3 1807 181C 1830 1844 1858 186C 1880 1894 18A8 18BC 18D0 18E4 18F7 190A 191E 1932 1946 195B 1970 1985 1999 19AB
280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319

APPENDIX F

Input and Output Routines for RA6800ML in Absolute Format with PAPERBYTE™ Bar Code Representation

These overlay modules contain external reference code to the relocatable macro assembler RA6800ML for use with a standard MIKBUG-based system. This overlay is designed to facilitate easy initial implementation of RA6800ML and serve as a template for user developed software. These routines can be used in conjunction with the version of RA6800ML given in Appendices D and E to bootstrap RA6800ML for the first time. Details of the bootstrap process are given in Appendix C. On page 93 is the machine readable representation (PAPERBYTE™ bar codes) of the object code of the IO routines listed below. The representation uses the absolute loader format, in which each bar code frame (one line of bars running from top to bottom of the page) contains a 2 byte address followed by data which is loaded in ascending order starting at that address. For details on the frame format and absolute loader format used in this and other PAPERBYTE™ books, see the PAPERBYTE publication *Bar Code Loader* by Ken Budnick. This book contains a brief history on bar codes, a general bar code loader algorithm with flowcharts, and complete program listings for 6800, 6502, and 8080 or Z-80 based systems.

```
00001                          NAM    ASSIO

00003        0100     START    EQU    $0100     START OF THE ASSEMBLER

00005        E1AC     INCH     EQU    $E1AC     INPUT CHAR (MIKBUG)
00006        E1D1     OUTCH    EQU    $E1D1     OUTPUT CHAR (MIKBUG)
00007        E1D1     OUTB     EQU    $E1D1     OUT DATA CHAR FROM ASSEMBLER
00008        E0E3     MONTOR   EQU    $E0E3     EXIT BACK TO MONITOR (MIKBUG)
00009        E0E3     UPDATE   EQU    $E0E3     CLOSE OUTPUT FILES ,EXIT

00011 034A                      ORG    START+$24A
00013 034A 7E 1A0E              JMP    TABLES    START OF SYMBOL TABLE
00014 034D 7E E0E3              JMP    UPDATE    CLOSE AN OUTPUT FILE
00015 0350 7E E0E3              JMP    MONTOR    MONITOR START ADDRESS
00016 0353 7E 19A4              JMP    GETB      READ A BYTE FROM RELOCATION
00017                    *                        INPUT STRING
00018 0356 7E E1D1              JMP    OUTB      WRITE A BYTE
00019 0359 7E 19C2              JMP    WREOF     WRITE EOF ON SAVE FILE
00020 035C 7E 19A0              JMP    INIT1O    INIT IO DEVICES
00021 035F 7E 19C8              JMP    RESTR     REWIND AN INPUT FILE

00023 0488                      ORG    START+$388

00025 0488 7E E1AC INEEE        JMP    INCH      INPUT CHAR TO ACC A
00026 048B 7E E1D1 OUTEEE       JMP    OUTCH     OUTPUT BYTE IN ACC A

00028        1961     PDATA1   EQU    START+$1861    PRINT CHAR STRING
00029        14BE     CRLF     EQU    START+$13BE    PRINT <CR> <LF>

00031 19A0                      ORG    START+$18A0    START AT THE END OF
00032                    *                             THE ASSEMBLER

00034 19A0 01          INIT1O   NOP                   INITIALIZE I/O DRIVERS
00035 19A1 01                   NOP
00036 19A2 01                   NOP
00037 19A3 39                   RTS

00039 19A4 FF 1A0C GETB         STX    DXSV      SAVE INDEX REGISTER
00040 19A7 BD 0488 GET1         JSR    INEEE     INPUT A DATA CHARACTER
00041 19AA 81 04                CMP A  #$04      IS IT END OF FILE
00042 19AC 26 0F                BNE    XIT       NO EXIT
00043 19AE CE 19F3              LDX    #EOF      YES PRINT EOF MESSAGE ON
00044                    *                        CONSOLE
00045 19B1 BD 1961              JSR    PDATA1
```

```
00046 19B4 BD 0488 RD6     JSR     INEEE     FOR CONSOLE RESPONSE
00047 19B7 81 0D           CMP A   #$0D       <CR> START READING NEXT TAPE
00048 19B9 27 EC           BEQ     GET1
00049 19BB 20 F7           BRA     RD6
00050 19BD FE 1A0C XIT     LDX     DXSV       RESTORE INDEX REGISTER
00051 19C0 0C              CLC                CLEAR   CARRY NOT EOF
00052 19C1 39              RTS
00054 19C2 96 04   WREOF   LDA A   4          LOAD ASCII EOF
00055 19C4 BD E1D1         JSR     OUTB       OUTPUT IT TO DATA STREAM
00056 19C7 39              RTS

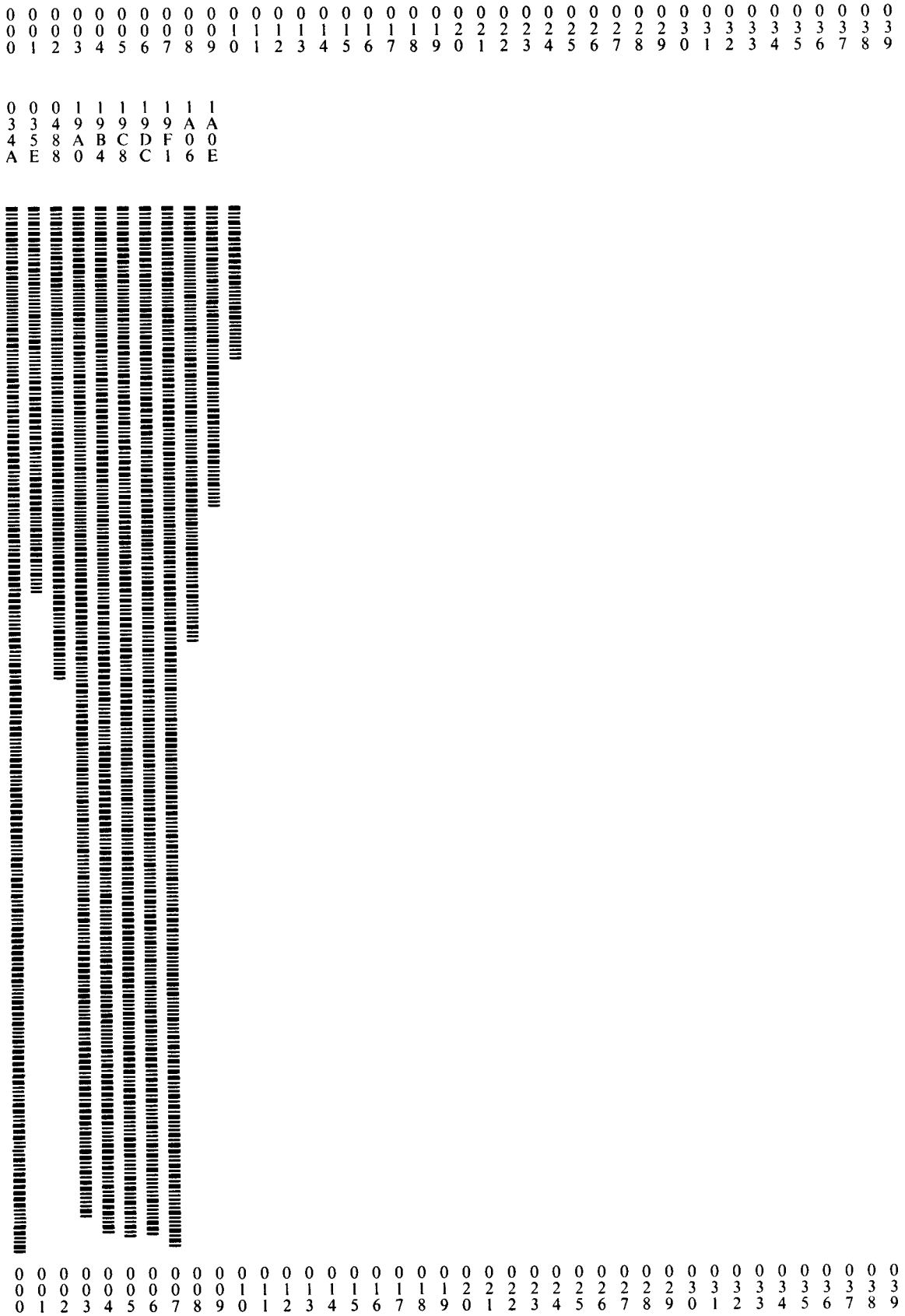
00058 19C8 CE 19D9 RESTR   LDX     #REWIND
00059 19CB BD 1961         JSR     PDATA1
00060 19CE BD 0488 BACK    JSR     INEEE
00061 19D1 81 0D           CMP A   #$0D       IS IT A CR?
00062 19D3 26 F9           BNE     BACK
00063 19D5 BD 14BE         JSR     CRLF
00064 19D8 39              RTS

00066 19D9 0D0A    REWIND  FDB     $0D0A
00067 19DB 524557          FCC     /REWIND TAPE TYPE CR/
      19DE 494E44
      19E1 205441
      19E4 504520
      19E7 414E44
      19EA 205459
      19ED 504520
      19F0 4352
00068 19F2 04              FCB     4
00069 19F3 454F46  EOF     FCC     /EOF: NEXT TAPE,TYPE CR/
      19F6 3A204E
      19F9 455854
      19FC 205441
      19FF 50452C
      1A02 545950
      1A05 452043
      1A08 52
00070 1A09 0D0A            FDB     $0D0A
00071 1A0B 04              FCB     4

00073 1A0C 0002    DXSV    RMB     2          SAVE SPACE FOR TEMP STORAGE OF
00074                      *                    THE INDEX REGISTER

00076 1A0E 1A10    TABLES  FDB     *+2        START OF SYMBOL TABLE

00078                      END
```


000 001 002 003 004 005 006 007 008 009 010 011 012 013 014 015 016 017 018 019 020 021 022 023 024 025 026 027 028 029 030 031 032 033 034 035 036 037 038 039
034A 035E 0488 190A0 190B4 190C8 190DC 190F1 1A016 1A0E

APPENDIX G

Assembly Language Source Listing of RA6800ML

This assembly was executed using the relocatable macro assembler RA6800ML. The object code in the assembly listing can be used without relocation if the program is loaded at location zero (hexadecimal) in memory. When creating a final object module for the Assembler, hand entered overlays for the Motorola MIKBUG monitor or the ICOM Floppy Disk Operating System IO routines will be necessary. The routines given in Appendices J and K can be used directly with their respective operating systems, or as guidelines for coding patches to interface other monitor programs.

```
0000 0000    N          NAM   ASM     RESIDENT MACRO ASSEMBLER
                        *              (RELOCATING AND LINKING)
                        *              VERSION 1.0
                        *
                        * C COPYRIGHT 1977 JACK E. HEMENWAY
                        * BOSTON MASS. ALL RIGHTS RESERVED
                        *
                        *
0000 8E A042            LDS   #$A042
                        *
                        *
0003 7E 038E R          JMP   PASS1
                        *
                        *
                        *
                        * MNTAB MNEMONIC TABLE *
                        *
0006 41          MNTAB  FCC   'ABA'
0009 106A    R          FDB   ADDR9
000B 1B                 FCB   $1B
000C 41                 FCC   'ADC'
000F 0E00    R          FDB   ADDR1
0011 09                 FCB   $09
0012 41                 FCC   'ADD'
0015 0E00    R          FDB   ADDR1
0017 0B                 FCB   $0B
0018 41                 FCC   'AND'
001B 0E00    R          FDB   ADDR1
001D 04                 FCB   $04
001E 41                 FCC   'ASL'
0021 0EF9    R          FDB   ADDR3
0023 08                 FCB   $08
0024 41                 FCC   'ASR'
0027 0EF9    R          FDB   ADDR3
0029 07                 FCB   $07
002A 42                 FCC   'BCC'
002D 1019    R          FDB   ADDR8
002F 24                 FCB   $24
0030 42                 FCC   'BCS'
0033 1019    R          FDB   ADDR8
0035 25                 FCB   $25
0036 42                 FCC   'BEQ'
0039 1019    R          FDB   ADDR8
003B 27                 FCB   $27
003C 42                 FCC   'BGE'
003F 1019    R          FDB   ADDR8
0041 2C                 FCB   $2C
0042 42                 FCC   'BGT'
0045 1019    R          FDB   ADDR8
0047 2E                 FCB   $2E
0048 42                 FCC   'BHI'
004B 1019    R          FDB   ADDR8
004D 22                 FCB   $22
004E 42                 FCC   'BIT'
0051 0E00    R          FDB   ADDR1
0053 05                 FCB   $05
0054 42                 FCC   'BLE'
0057 1019    R          FDB   ADDR8
0059 2F                 FCB   $2F
005A 42                 FCC   'BLS'
005D 1019    R          FDB   ADDR8
005F 23                 FCB   $23
0060 42                 FCC   'BLT'
0063 1019    R          FDB   ADDR8
0065 2D                 FCB   $2D
0066 42                 FCC   'BMI'
0069 1019    R          FDB   ADDR8
006B 2B                 FCB   $2B
006C 42                 FCC   'BNE'
006F 1019    R          FDB   ADDR8
0071 26                 FCB   $26
0072 42                 FCC   'BPL'
0075 1019    R          FDB   ADDR8
0077 2A                 FCB   $2A
0078 42                 FCC   'BRA'
007B 1019    R          FDB   ADDR8
007D 20                 FCB   $20
007E 42                 FCC   'BSR'
0081 1019    R          FDB   ADDR8
0083 8D                 FCB   $8D
0084 42                 FCC   'BVC'
0087 1019    R          FDB   ADDR8
0089 28                 FCB   $28
008A 42                 FCC   'BVS'
008D 1019    R          FDB   ADDR8
008F 29                 FCB   $29
0090 43                 FCC   'CBA'
0093 106A    R          FDB   ADDR9
0095 11                 FCB   $11
0096 43                 FCC   'CLC'
0099 106A    R          FDB   ADDR9
009B 0C                 FCB   $0C
009C 43                 FCC   'CLI'
009F 106A    R          FDB   ADDR9
00A1 0E                 FCB   $0E
00A2 43                 FCC   'CLR'
00A5 0EF9    R          FDB   ADDR3
00A7 0F                 FCB   $0F
00A8 43                 FCC   'CLV'
00AB 106A    R          FDB   ADDR9
00AD 0A                 FCB   $0A
00AE 43                 FCC   'CMN'
00B1 11D4    R          FDB   POCMN
00B3 FF                 FCB   $FF
00B4 43                 FCC   'CMP'
00B7 0E00    R          FDB   ADDR1
00B9 01                 FCB   $01
00BA 43                 FCC   'COM'
00BD 0EF9    R          FDB   ADDR3
00BF 03                 FCB   $03
00C0 43                 FCC   'CPX'
00C3 0F68    R          FDB   ADDR5
00C5 8C                 FCB   $8C
00C6 44                 FCC   'DAA'
00C9 106A    R          FDB   ADDR9
00CB 19                 FCB   $19
00CC 44                 FCC   'DEC'
00CF 0EF9    R          FDB   ADDR3
00D1 0A                 FCB   $0A
00D2 44                 FCC   'DES'
00D5 106A    R          FDB   ADDR9
00D7 34                 FCB   $34
00D8 44                 FCC   'DEX'
00DB 106A    R          FDB   ADDR9
00DD 09                 FCB   $09
00DE 45                 FCC   'END'
00E1 124E    R          FDB   POEND
00E3 FF                 FCB   $FF
00E4 45                 FCC   'ENT'
00E7 13D8    R          FDB   POENT
00E9 FF                 FCB   $FF
00EA 45                 FCC   'EOR'
00ED 0E00    R          FDB   ADDR1
00EF 08                 FCB   $08
00F0 45                 FCC   'EQU'
00F3 1451    R          FDB   POEQU
00F5 FF                 FCB   $FF
00F6 45                 FCC   'EXT'
00F9 14AF    R          FDB   POEXT
00FB FF                 FCB   $FF
00FC 46                 FCC   'FCB'
00FF 1511    R          FDB   POFCB
0101 FF                 FCB   $FF
0102 46                 FCC   'FCC'
0105 1546    R          FDB   POFCC
0107 FF                 FCB   $FF
0108 46                 FCC   'FDB'
010B 159D    R          FDB   POFDB
010D FF                 FCB   $FF
010E 49                 FCC   'IF '
0111 15F1    R          FDB   POIF
0113 FF                 FCB   $FF
```

```
0114 49                FCC   'INC'
0117 0EF9      R       FDB   ADDR3
0119 0C                FCB   $0C
011A 49                FCC   'INS'
011D 106A      R       FDB   ADDR9
011F 31                FCB   $31
0120 49                FCC   'INX'
0123 106A      R       FDB   ADDR9
0125 08                FCB   $08
0126 4A                FCC   'JMP'
0129 0FE6      R       FDB   ADDR7
012B 6E                FCB   $6E
012C 4A                FCC   'JSR'
012F 0FE6      R       FDB   ADDR7
0131 AD                FCB   $AD
0132 4C                FCC   'LDA'
0135 0E00      R       FDB   ADDR1
0137 06                FCB   $06
0138 4C                FCC   'LDS'
013B 0F68      R       FDB   ADDR5
013D 8E                FCB   $8E
013E 4C                FCC   'LDX'
0141 0F68      R       FDB   ADDR5
0143 CE                FCB   $CE
0144 4C                FCC   'LSR'
0147 0EF9      R       FDB   ADDR3
0149 04                FCB   $04
014A 4D                FCC   'MAC'
014D 1631      R       FDB   POMAC
014F FF                FCB   $FF
0150 4E                FCC   'NAM'
0153 1726      R       FDB   PONAM
0155 FF                FCB   $FF
0156 4E                FCC   'NEG'
0159 0EF9      R       FDB   ADDR3
015B 00                FCB   $00
015C 4E                FCC   'NIF'
015F 175B      R       FDB   PONIF
0161 FF                FCB   $FF
0162 4E                FCC   'NOP'
0165 106A      R       FDB   ADDR9
0167 02                FCB   $02
0168 4F                FCC   'ORA'
016B 0E00      R       FDB   ADDR1
016D 0A                FCB   $0A
016E 50                FCC   'PAG'
0171 17A0      R       FDB   POPAG
0173 FF                FCB   $FF
0174 50                FCC   'PSH'
0177 0F48      R       FDB   ADDR4
0179 36                FCB   $36
017A 50                FCC   'PUL'
017D 0F48      R       FDB   ADDR4
017F 32                FCB   $32
0180 52                FCC   'RMB'
0183 17C1      R       FDB   PORMB
0185 FF                FCB   $FF
0186 52                FCC   'ROL'
0189 0EF9      R       FDB   ADDR3
018B 09                FCB   $09
018C 52                FCC   'ROR'
018F 0EF9      R       FDB   ADDR3
0191 06                FCB   $06
0192 52                FCC   'RTI'
0195 106A      R       FDB   ADDR9
0197 3B                FCB   $3B
0198 52                FCC   'RTS'
019B 106A      R       FDB   ADDR9
019D 39                FCB   $39
019E 53                FCC   'SBA'
01A1 106A      R       FDB   ADDR9
01A3 10                FCB   $10
01A4 53                FCC   'SBC'
01A7 0E00      R       FDB   ADDR1
01A9 02                FCB   $02
01AA 53                FCC   'SEC'
01AD 106A      R       FDB   ADDR9
01AF 0D                FCB   $0D
01B0 53                FCC   'SEI'
01B3 106A      R       FDB   ADDR9
01B5 0F                FCB   $0F
01B6 53                FCC   'SEV'
01B9 106A      R       FDB   ADDR9
01BB 0B                FCB   $0B
01BC 53                FCC   'STA'
01BF 0E91      R       FDB   ADDR2
01C1 07                FCB   $07
01C2 53                FCC   'STS'
01C5 0FDA      R       FDB   ADDR6
01C7 8F                FCB   $8F
01C8 53                FCC   'STX'
01CB 0FDA      R       FDB   ADDR6
01CD CF                FCB   $CF
01CE 53                FCC   'SUB'
01D1 0E00      R       FDB   ADDR1
01D3 00                FCB   $00
01D4 53                FCC   'SWI'
01D7 106A      R       FDB   ADDR9
01D9 3F                FCB   $3F
01DA 54                FCC   'TAB'
01DD 106A      R       FDB   ADDR9
01DF 16                FCB   $16
01E0 54                FCC   'TAP'
01E3 106A      R       FDB   ADDR9
01E5 06                FCB   $06
01E6 54                FCC   'TBA'
01E9 106A      R       FDB   ADDR9
01EB 17                FCB   $17
01EC 54                FCC   'TPA'
01EF 106A      R       FDB   ADDR9
01F1 07                FCB   $07
01F2 54                FCC   'TST'
01F5 0EF9      R       FDB   ADDR3
01F7 0D                FCB   $0D
01F8 54                FCC   'TSX'
01FB 106A      R       FDB   ADDR9
01FD 30                FCB   $30
01FE 54                FCC   'TXS'
0201 106A      R       FDB   ADDR9
0203 35                FCB   $35
0204 57                FCC   'WAI'
0207 106A      R       FDB   ADDR9
0209 3E                FCB   $3E

                * CHARACTER TABLE
                *
020A 00         CHRTAB FCB   $00   SPACE
020B 00                FCB   $00   !
020C 00                FCB   $00   "
020D 04                FCB   $04   #
020E 04                FCB   $04   $
020F 04                FCB   $04   %
0210 00                FCB   $00   &
0211 04                FCB   $04   '
0212 00                FCB   $00   (
0213 00                FCB   $00   )
0214 24                FCB   $24   *
0215 24                FCB   $24   +
0216 04                FCB   $04   ,
0217 24                FCB   $24   -
0218 80                FCB   $80   .
0219 24                FCB   $24   /
021A 42                FCB   $42   0
021B 42                FCB   $42   1
021C 42                FCB   $42   2
021D 42                FCB   $42   3
021E 42                FCB   $42   4
021F 42                FCB   $42   5
0220 42                FCB   $42   6
0221 42                FCB   $42   7
0222 42                FCB   $42   8
0223 42                FCB   $42   9
0224 00                FCB   $00   :
0225 00                FCB   $00   ;
0226 00                FCB   $00   <
0227 00                FCB   $00   =
0228 00                FCB   $00   >
0229 00                FCB   $00   ?
022A 80                FCB   $80   @
022B 83                FCB   $83   A
022C 83                FCB   $83   B
022D 82                FCB   $82   C
022E 82                FCB   $82   D
022F 82                FCB   $82   E
0230 82                FCB   $82   F
0231 80                FCB   $80   G
0232 80                FCB   $80   H
0233 80                FCB   $80   I
0234 80                FCB   $80   J
0235 80                FCB   $80   K
0236 80                FCB   $80   L
0237 80                FCB   $80   M
0238 80                FCB   $80   N
0239 80                FCB   $80   O
023A 80                FCB   $80   P
023B 80                FCB   $80   Q
023C 80                FCB   $80   R
023D 80                FCB   $80   S
023E 80                FCB   $80   T
023F 80                FCB   $80   U
0240 80                FCB   $80   V
0241 80                FCB   $80   W
0242 81                FCB   $81   X
0243 80                FCB   $80   Y
```

```
0244 80                 FCB  $80  Z
0245 00                 FCB  $00  [
0246 00                 FCB  $00  \
0247 00                 FCB  $00  ]
0248 00                 FCB  $00  CAROT
0249 00                 FCB  $00  UNDERLINE

                  * MAIN PROGRAM LOOP *
                  *
                  *
024A 7E 0000 X          EXT TABLES
024D 7E 0000 X          EXT UPDATE
0250 7E 0000 X          EXT MONTOR
0253 7E 0000 X          EXT GETB
0256 7E 0000 X          EXT OUTB
0259 7E 0000 X          EXT WREOF
025C 7E 0000 X          EXT INITIO
025F 7E 0000 X          EXT RESTR
                  *
0262 1861     N         ENT PDATA1
0262 0388     N         ENT INEEE
0262 13BE     N         ENT CRLF
                  *
0262 0002         MACTBL RMB 2 MACRO TABLE
0264 0002         MACEND RMB 2 MACRO TABLE END
0266 0002         MACSTK RMB 2 MACRO STACK
0268 0002         SYMTAB RMB 2 SYMBOL TABLE
026A 0002         NSYM   RMB 2 NUMBER OF SYMBOLS
026C 0002         SYMEND RMB 2 SYMTAB END
                  *
                  *
026E 0001         OPTNS  RMB  1  OPTIONS
026F 0002         LNUM   RMB  2  LINE NUMBER
0271 0002         TSTPH  RMB  2  PHASING ERROR CHECK LOC.
0273 0002         LC     RMB  2  LOCATION COUNTER
0275 0001         PASS   RMB  1  PASS: 0=1, FF=2
0276 0001         LBFLG  RMB  1  0=NO LABEL
0277 0001         RELFLG RMB  1  RELOCATION FLAG 00=NO,FF=YES
0278 0001         CMNFLG RMB  1  COMMON FLAG       "
0279 0001         EXTFLG RMB  1  EXTERNAL FLAG     "
027A 0001         ENTFLG RMB  1  ENTRY FLAG        "
027B 0002         DESCRA RMB  2  DESCRIPTOR ADDRESS
027D 0001         DESCRC RMB  1  DESCRIPTOR COUNT
027E 0002         CUCHAR RMB  2  CURRENT CHAR ADDRESS
0280 0002         CULINE RMB  2  CURRENT LINE ADDRESS
0282 0002         SYMPTR RMB  2  SYMTAB POINTER
0284 0001         LCN    RMB  1  # BYTES IN AN INSTRUCTION
0285 0002         LSAVE  RMB  2  LC SAVE LOCATION
0287 0001         LCOUNT RMB  1  # LINES ON A PAGE
0288 0002         ECOUNT RMB  2  ERROR COUNT
028A 0002         MSTKPT RMB  2  MACRO STACK POINTER
028C 0002         STKSAV RMB  2  MACRO STACK POINTER SAVE
028E 0002         MXSAV1 RMB  2  MACRO TEMP SAV
0290 0002         MXSAV2 RMB  2  MACRO TEMP SAV
0292 0048         MACLIN RMB  72 MACRO EXPANSION LINE AREA
02DA 0032         MACPAR RMB  50 MACRO PARAMETER AREA
030C 0001         MACFLG RMB  1  MACRO MODE: 00=NORMAL, FF=MACRO
030D 0002         MACPTR RMB  2  POINTER TO MACTABLE
030F 0002         MACSAV RMB  2  MACRO X-REG SAVE AREA
0311 0002         MCLPTR RMB  2  MACLIN POINTER
0313 0002         CMNLC  RMB  2  COMMON_BLOCK LC
0315 0050         INLINE RMB  80 INPUT LINE
0365 0010                RMB  16
0375 0375     R IFSTK  EQU  *  IF STACK
0375 0002         @IFSTK RMB  2  IF STACK POINTER
0377 0001         IFFLG  RMB  1  IF FLAG 00=NO ASSEMBLY: FF=ASSEMBLY
                  *
0378 45           OPTMSG FCC 'ENTER OPTIONS:
0387 04                  FCB 4
                  *
                  *
0388 7E E1AC      INEEE  JMP  $E1AC  INPUT A CHAR FROM TTY
038B 7E E1D1      OUTEEE JMP  $E1D1
                  *
                  *
                  *
                  *
                  * PASS 1 IS ENTRY POINT TO ASSEMBLER
                  *
                  *
038E 7F 0275 R PASS1  CLR   PASS       PASS:=1
0391 CE 0378 R OPIN   LDX #OPTMSG
0394 BD 1861 R        JSR PDATA1
                  *
0397 7F 026E R        CLR OPTNS
039A 73 026E R        COM OPTNS        NL,NO,NM,NS
                  *
039D BD 0388 R OPIN1  JSR INEEE        GET OPTION
03A0 81 0D            CMP A #$0D       CR ?
03A2 27 26            BEQ OPIN3        YES
                  *
03A4 81 4C            CMP A #'L        LIST?
```

```
03A6 26 04              BNE *+6         NO
                        *
03A8 86 70              LDA A #$70      YES
03AA 20 16              BRA OPIN2
                        *
03AC 81 4F              CMP A #'O       OBJECT?
03AE 26 04              BNE *+6         NO
                        *
03B0 86 B0              LDA A #$B0      YES
03B2 20 0E              BRA OPIN2
                        *
03B4 81 53              CMP A #'S       SYMBOL TABLE?
03B6 26 04              BNE *+6         NO
                        *
03B8 86 D0              LDA A #$D0      YES
03BA 20 06              BRA OPIN2
                        *
03BC 81 4D              CMP A #'M       MACRO EXPANSION LISTING?
03BE 26 DD              BNE OPIN1       NO
                        *
03C0 86 E0              LDA A #$E0      YES
                        *
03C2 B4 026E R OPIN2    AND A OPTNS     TURN OFF "NOT" BIT
03C5 B7 026E R          STA A OPTNS
03C8 20 D3              BRA OPIN1       GET ANOTHER OPTION
                        *
03CA BD 13BE R OPIN3    JSR CRLF
                        *
                        * CONFIGURE TABLES
                        *
03CD FE 024B R          LDX   TABLES+1
03D0 EE 00              LDX   0,X       GET START OF TABLES
03D2 FF 0262 R          STX   MACTBL    INIT MACTBL
                        *
03D5 FF 07E3 R          STX   PSTNG1
03D8 CE 0800            LDX   #$0800
03DB FF 07E5 R          STX   PSTNG2
03DE CE 07E3 R          LDX   #PSTNG1
03E1 BD 0BEC R          JSR   ADD16
03E4 FE 07E3 R          LDX   PSTNG1
03E7 FF 0264 R          STX   MACEND    INIT MACEND
                        *
03EA CE 0100            LDX   #$0100
03ED FF 07E5 R          STX   PSTNG2
03F0 CE 07E3 R          LDX   #PSTNG1
03F3 BD 0BEC R          JSR   ADD16
03F6 FE 07E3 R          LDX   PSTNG1
03F9 FF 0266 R          STX   MACSTK    INIT MACSTK
                        *
03FC 08                 INX
03FD FF 0268 R          STX   SYMTAB    INIT SYMTAB
                        *
0400 FF 07E5 R          STX   PSTNG2
0403 CE 3FFF R          LDX   #ASM+$3FFF 16K
0406 FF 07E3 R          STX   PSTNG1
0409 CE 07E3 R          LDX   #PSTNG1
040C BD 08FD R          JSR   SUB16
040F B6 07E3 R          LDA A PSTNG1
0412 F6 07E4 R          LDA B PSTNG1+1
0415 CE 0009            LDX   #0009
0418 FF 07E5 R          STX   PSTNG2
041B CE 07E5 R          LDX   #PSTNG2
041E BD 0BA1 R          JSR   DIV16
0421 B7 026A R          STA A NSYM
0424 F7 026B R          STA B NSYM+1    INIT NSYM
                        *
0427 CE 0009            LDX   #0009
042A FF 07E3 R          STX   PSTNG1
042D CE 07E3 R          LDX   #PSTNG1
0430 BD 0B7D R          JSR   MPY16
0433 B7 07E3 R          STA A PSTNG1
0436 F7 07E4 R          STA B PSTNG1+1
0439 FE 0268 R          LDX   SYMTAB
043C FF 07E5 R          STX   PSTNG2
043F CE 07E3 R          LDX   #PSTNG1
0442 BD 0BEC R          JSR   ADD16
0445 FE 07E3 R          LDX   PSTNG1
0448 FF 026C R          STX   SYMEND
                        *
                        *
044B 86 20              LDA A #$20      BLANKS TO SYMTAB
044D FE 0268 R          LDX   SYMTAB    POINT TO SYMTAB
0450 A7 00              STA A 0,X       BLANK LOCATION
0452 08                 INX             BUMP POINTER
0453 BC 026C R          CPX   SYMEND    ALL DONE ?
0456 26 F8              BNE   *-6       NO
                        *
0458 CE 0000            LDX   #$0000
045B FF 0271 R          STX   TSTPH     CLEAR TSTPH
045E FF 0288 R          STX   ECOUNT    CLEAR ECOUNT
0461 CE 0000            LDX   #$0000
0464 FF 0313 R          STX   CMNLC     INIT COMMON LC
                        *
```

```
0467 BD 1089 R PASS2  JSR   ADRINT    CLEAR FLAGS
046A 7F 0287 R        CLR   LCOUNT    LCOUNT:=0
046D FE 0262 R        LDX   MACTBL    INIT MACPTR
0470 FF 030D R        STX   MACPTR
0473 7F 030C R        CLR   MACFLG    MODE:= NON-MACRO
0476 FE 0266 R        LDX   MACSTK    INIT MACRO STACK POINTER
0479 FF 028A R        STX   MSTKPT
047C 86 FF            LDA A #$FF
047E B7 0377 R        STA A IFFLG     INIT TO ASSEMBLE
0481 CE 0375 R        LDX   #IFSTK
0484 FF 0375 R        STX   @IFSTK    INIT IFSTK
0487 CE 0000          LDX   #$0000
048A FF 0273 R        STX   LC        INIT LC
048D FF 026F R        STX   LNUM      INIT LNUM
                      *
                      * MAIN IS THE DRIVER SECTION OR TOP LEVEL
                      *      OF THE ASSEMBLER
                      *
0490 BD 0508 R MAIN1  JSR   RDLINE    GET A LINE OF SOURCE
0493 7F 0276 R        CLR   LBFLG     SET FLAG TO NO LABEL
0496 FE 026F R        LDX   LNUM
0499 08               INX
049A FF 026F R        STX   LNUM      BUMP LNUM
049D FE 0280 R        LDX   CULINE    POINT TO LINE
04A0 A6 00            LDA A 0,X       GET COL 1
04A2 81 2A            CMP A #$2A      COMMENT?
04A4 26 08            BNE   MAIN3     NO
                      *
04A6 BD 1089 R MAIN1A JSR   ADRINT    CLEAR PRINT FLAGS
04A9 BD 0C0E R        JSR   PRINTL    PRINT THE LINE
04AC 20 E2            BRA   MAIN1
                      *
04AE 7D 0377 R MAIN3  TST IFFLG       ASSEMBLING?
04B1 26 22            BNE MAIN3C      YES
                      *
04B3 81 20            CMP A #$20      COL 1 BLANK?
04B5 27 03            BEQ MAIN3A      YES
                      *
04B7 BD 06F6 R        JSR NXTOK       SCAN OVER LABEL
04BA BD 06F6 R MAIN3A JSR NXTOK       GET MNEMONIC
04BD B6 027D R        LDA A DESCRC    GET COUNT
04C0 81 03            CMP A #3        <= 3?
04C2 22 E2            BHI MAIN1A      NO
                      *
04C4 BD 0940 R        JSR MNLKP       SEARCH MNTAB
04C7 8C 15F1 R        CPX #POIF       IF ?
04CA 27 07            BEQ MAIN3B      YES
                      *
04CC 8C 175B R        CPX #PONIF      NIF?
04CF 27 02            BEQ MAIN3B      YES
                      *
04D1 20 D3            BRA MAIN1A      NEITHER
                      *
04D3 6E 00     MAIN3B JMP 0,X         GOT TO IF OR NIF PROCESSING ROUTINE
                      *
04D5 81 20     MAIN3C CMP A #$20      COL 1 BLANK?
04D7 27 1D            BEQ   MAIN5     YES
                      *
04D9 BD 06F6 R        JSR   NXTOK     GET LABEL
04DC C1 01            CMP B #$01      OK?
04DE 27 0B            BEQ   MAIN4     YES
                      *
04E0 CE 0205          LDX   #$0205    ERROR
04E3 BD 0DBB R        JSR   PRINTE
04E6 BD 0C0E R        JSR   PRINTL    PRINT LINE
04E9 20 A5            BRA   MAIN1
                      *
04EB 7C 0276 R MAIN4  INC   LBFLG     SET LABEL FLAG
04EE 7D 0275 R        TST   PASS      PASS?
04F1 26 03            BNE   MAIN5     PASS2
                      *
04F3 BD 07F8 R        JSR   STOSYM    STORE LABEL IN SYMTAB
                      *
04F6 BD 06F6 R MAIN5  JSR   NXTOK     GET MNEMONIC
04F9 C1 01            CMP B #$01      OK?
04FB 27 0B            BEQ   MAIN7     YES
                      *
04FD CE 0202   MAIN6  LDX   #$0202    ERROR
0500 BD 0DBB R        JSR   PRINTE
0503 BD 0C0E R        JSR   PRINTL    PRINT LINE
0506 20 88            BRA   MAIN1
                      *
0508 BD 0940 R MAIN7  JSR   MNLKP     SEARCH MNTAB
050B 81 00            CMP A #$00      IN MNTAB?
050D 27 2D            BEQ   MAIN9     YES
                      *
050F BD 0857 R        JSR   LKPSYM    MACRO NAME?
0512 C1 FF            CMP B #$FF      IN SYMTAB?
0514 27 28            BEQ   MAIN8     NO,ERROR
                      *
0516 C5 20            BIT B #$20      MACRO NAME?
```

```
0518 27 24           BEQ   MAIN8      NO,ERROR
                     *
                     *
051A 7D 030C R       TST   MACFLG     MACRO MODE?
051D 27 08           BEQ   MAIN7A     NO
                     *
                     * PUSH PRESENT MACRO ONTO MACSTACK
                     *
051F BD 0637 R       JSR MACPSH
0522 7D 030C R       TST MACFLG       ERRORS?
0525 27 20           BEQ MAIN13       YES
                     *
0527 FF 030D R MAIN7A STX   MACPTR    SAVE MACRO LOC IN MACTBL
052A BD 0C0E R       JSR   PRINTL
052D 7C 030C R       INC   MACFLG     MODE#=MACRO
                     *
0530 BD 06F6 R       JSR   NXTOK      PARMS?
0533 C1 0D           CMP B #$0D
0535 26 13           BNE   MAIN12     YES, SAVE THEM
                     *
0537 F7 02DA R       STA B MACPAR     NO, CR TO MACPAR
053A 20 0B           BRA   MAIN13
                     *
053C 6E 00     MAIN9 JMP   0,X        GO TO ROUTINE
                     *
053E CE 0207   MAIN8 LDX   #$0207     ERROR
0541 BD 0DBB R       JSR   PRINTE     PRINT IT
0544 BD 0C0E R MAIN10 JSR  PRINTL     PRINT LINE
0547 7E 0490 R MAIN13 JMP  MAIN1      PROCESS NEXT LINE
                     *
                     * MOVE PARMS ON MACRO CALL TO MACPAR
                     *
054A CE 02DA R MAIN12 LDX   #MACPAR
054D FF 030F R       STX   MACSAV     INIT POINTER
                     *
0550 FE 027B R MAIN11 LDX   DESCRA       POINT TO PARMS
0553 A6 00           LDA A 0,X           GET A CHAR
0555 08              INX
0556 FF 027B R       STX   DESCRA        SAVE POINTER
                     *
0559 FE 030F R       LDX   MACSAV        GET POINTER
055C A7 00           STA A 0,X           MOVE CHAR
055E 08              INX
055F FF 030F R       STX  MACSAV         SAVE POINTER
                     *
0562 81 0D           CMP A #$0D          EOL?
0564 26 EA           BNE   MAIN11        NO
                     *
0566 20 DF           BRA   MAIN13        YES

                     * GET A LINE OF SOURCE FROM INBUF *
                     * RETURNS ADDRESS OF LINE IN CULINE *
                     * CUCHAR#=ADDRESS OF FIRST CHARACTER*
                     *
0568 7D 030C R RDLINE TST   MACFLG  MACRO MODE?
056B 27 09           BEQ   RDLINA  NO
                     *
056D BD 05A5 R       JSR   RDMAC   EXPAND MACRO
                     *
0570 7D 030C R       TST   MACFLG  MACRO FULLY EXPANDED?
0573 27 01           BEQ   RDLINA  YES
                     *
0575 39              RTS
                     *
0576 CE 0315 R RDLINA LDX #INLINE
0579 FF 027E R       STX CUCHAR
057C FF 0280 R       STX CULINE
                     *
057F BD 0253 R RDL1  JSR GETB
0582 24 06           BCC RDL1A
                     *
0584 8E A042         LDS #$A042      FLUSH STACK, EOF
0587 7E 1254 R       JMP POENDO
                     *
058A 81 0A     RDL1A CMP A #$0A      LF?
058C 27 F1           BEQ RDL1        YES
                     *
058E 81 00           CMP A #$00      NULLS?
0590 27 ED           BEQ RDL1        YES
                     *
0592 8C 0364 R       CPX #INLINE+79  LINE TO LONG?
0595 27 05           BEQ RDL2        YES
                     *
0597 A7 00           STA A 0,X       STORE CHARACTER
0599 08              INX
059A 20 04           BRA RDL3
                     *
059C C6 0D     RDL2  LDA B #$0D      TRUNCATE LINE
059E E7 00           STA B 0,X
                     *
05A0 81 0D     RDL3  CMP A #$0D      CR?
05A2 26 DB           BNE RDL1        NO
                     *
```

```
05A4 39                 RTS
                  * RDMAC: EXPAND MACRO CALLS
                  *
05A5 FE 030D R RDMAC    LDX   MACPTR
05A8 A6 00              LDA A 0,X         GET CHAR
05AA 81 17              CMP A #$17        ETB?
05AC 26 0B              BNE   RDMAC1      NO
                  *
05AE 7A 030C R          DEC   MACFLG      DEC MODE COUNT
05B1 27 05              BEQ   RDMAC0      NO MORE MACROS
                  *
                  * PULL UP LAST MACRO STACKED
                  *
05B3 BD 069B R          JSR   MACPUL
05B6 20 ED              BRA   RDMAC
                  *
05B8 39           RDMAC0 RTS
                  *
05B9 CE 0292 R RDMAC1   LDX   #MACLIN     POINT TO MACRO EXPAND AREA
05BC FF 0280 R          STX   CULINE      INIT
05BF FF 027E R          STX   CUCHAR      INIT
05C2 FF 0311 R          STX   MCLPTR      INIT
                  *
05C5 FE 030D R RDMAC2   LDX   MACPTR      POINT TO MACRO DEF
05C8 A6 00              LDA A 0,X
05CA 08                 INX
                  *
05CB FF 030D R          STX   MACPTR
05CE 81 26              CMP A #'&         MACRO PARM?
05D0 27 13              BEQ   RDMAC3      YES
                  *
05D2 FE 0311 R          LDX   MCLPTR      POINT TO MACLIN
05D5 A7 00              STA A 0,X         MOVE CHAR TO MACLIN
05D7 08                 INX
05D8 FF 0311 R          STX   MCLPTR      SAVE POINTER
05DB 8C 02D9 R          CPX #MACLIN+71    OVERFLOW?
05DE 27 4B              BEQ RDMERR        YES
                  *
05E0 81 0D              CMP A #$0D        EOL?
05E2 26 E1              BNE   RDMAC2      NO
05E4 39                 RTS               ALL DONE
                  *
                  * SUBSTITUTE POSITIONAL PARMS
                  *
05E5 E6 00        RDMAC3 LDA B 0,X        GET POSITIONAL # OF PARM
05E7 C0 2F              SUB B #$2F        CONVERT TO BINARY
05E9 08                 INX               SKIP OVER POS#
05EA FF 030D R          STX   MACPTR
05ED CE 02DA R          LDX   #MACPAR     POINT TO PARMS FROM CALL
                  *
                  * SCAN OVER PARMS
                  *
05F0 FF 030F R RDMAC6   STX   MACSAV      SAVE
                  *
05F3 A6 00        RDMAC4 LDA A 0,X        GET A CHAR
05F5 08                 INX
05F6 81 2C              CMP A #',         END OF PARM?
05F8 27 04              BEQ   RDMAC7      YES
                  *
05FA 81 0D              CMP A #$0D        EOL?
05FC 26 F5              BNE   RDMAC4      NO
                  *
05FE 5A           RDMAC7 DEC B            FOUND PARM?
05FF 26 EF              BNE   RDMAC6      NO
                  *
0601 FE 030F R          LDX   MACSAV      POINT TO PARM
0604 A6 00              LDA A 0,X         FOUND PARM, GET CHAR
0606 08                 INX
0607 FF 030F R          STX   MACSAV      SAVE POINTER
                  *
060A FE 0311 R RDMAC5   LDX   MCLPTR      POINT TO MACLIN
060D A7 00              STA A 0,X         MOVE CHAR
060F 08                 INX
0610 FF 0311 R          STX MCLPTR        SAVE POINTER
0613 8C 02D9 R          CPX   #MACLIN+71  OVERFLOW?
0616 27 13              BEQ   RDMERR      YES
                  *
                  *
0618 FE 030F R          LDX   MACSAV      POINT TO MACPAR
061B A6 00              LDA A 0,X         GET NEXT CHAR
061D 08                 INX
061E FF 030F R          STX   MACSAV      SAVE
0621 81 2C              CMP A #',         END OF PARM?
0623 27 A0              BEQ   RDMAC2      YES
                  *
0625 81 0D              CMP A #$0D        EOL?
0627 26 E1              BNE   RDMAC5      NO
                  *
0629 20 9A              BRA   RDMAC2
                  *
062B 86 0D        RDMERR LDA A #$0D       END LINE
062D A7 00              STA A 0,X
```

```
062F CE 0230          LDX   #$0230    ERROR MESSAGE
0632 BD 0DBB R        JSR   PRINTE
0635 20 8E            BRA   RDMAC2
                    * PUSH A MACRO ONTO THE MACRO STACK
                    *
0637 FF 028E R MACPSH STX MXSAV1        SAVE X-REG
063A BF 028C R        STS STKSAV        SAVE STACK POINTER
063D BE 028A R        LDS MSTKPT        LOAD MACRO STACK POINTER
                    *
                    * PUSH MCLPTR,MACSAV,MACPTR ONTO STACK
                    *
0640 CE 0312 R        LDX #MCLPTR+1
0643 C6 06            LDA B #6
                    *
0645 A6 00      MPSH1 LDA A 0,X         GET A BYTE
0647 09               DEX
0648 FF 0290 R        STX MXSAV2        SAVE POINTER
064B 30               TSX               X=STKPTR+1
064C 09               DEX
064D BC 0264 R        CPX MACEND        END OF STACK?
0650 27 33            BEQ MPSH5         YES,ERROR
                    *
0652 FE 0290 R        LDX MXSAV2        RESTORE POINTER
0655 36               PSH A             PUSH A BYTE ONTO THE STACK
0656 5A               DEC B             ALL DONE?
0657 26 EC            BNE MPSH1         NO
                    *
                    * PUSH MACPAR IN REVERSE ORDER
                    *
0659 CE 02DA R        LDX #MACPAR
                    *
065C A6 00      MPSH2 LDA A 0,X         FIND EOL
065E 81 0D            CMP A #$0D        EOL?
0660 27 03            BEQ MPSH3         YES
                    *
0662 08               INX
0663 20 F7            BRA MPSH2
                    *
0665 A6 00      MPSH3 LDA A 0,X         GET A BYTE
0667 FF 0290 R        STX MXSAV2        SAVE PNTR
066A 30               TSX               X=STKPTR+1
066B 09               DEX
066C BC 0264 R        CPX MACEND        END OF STACK?
066F 27 14            BEQ MPSH5         YES,ERROR
                    *
0671 FE 0290 R        LDX MXSAV2        RESTORE POINTER
0674 36               PSH A             PUSH A BYTE ONTO THE STACK
0675 09               DEX               POINT TO NEXT LEFT CHAR
0676 8C 02D9 R        CPX #MACPAR-1     ALL DONE?
0679 26 EA            BNE MPSH3         NO
                    *
067B BF 028A R        STS MSTKPT        SAVE STACK POINTER
067E BE 028C R        LDS STKSAV        RESTORE STACK
0681 FE 028E R        LDX MXSAV1        RESTORE X-REG
0684 39               RTS
                    *
                    * MACRO NESTING OVERFLOW ERROR
                    *
0685 BE 0266 R MPSH5  LDS MACSTK        FLUSH STACK
0688 BF 028A R        STS MSTKPT
068B BE 028C R        LDS STKSAV
068E CE 0251          LDX #$0251        ERROR #
0691 BD 0DBB R        JSR PRINTE
0694 FE 028E R        LDX MXSAV1        RESTORE X-REG
0697 7F 030C R        CLR MACFLG        GET OUT OF MACRO MODE
069A 39               RTS
                    * PULL A MACRO FROM THE MACRO STACK
                    *
069B FF 028E R MACPUL STX MXSAV1        SAVE X-REG
069E BF 028C R        STS STKSAV        SAVE STACK POINTER
06A1 BE 028A R        LDS MSTKPT        LOAD MACRO STACK POINTER
                    *
                    * PULL MACPAR OFF OF THE MACRO STACK
                    *
06A4 CE 02DA R        LDX #MACPAR
                    *
06A7 32         MPUL1 PUL A             PULL A CHAR
06A8 A7 00            STA A 0,X         SAVE IN MACPAR
06AA 08               INX
06AB 81 0D            CMP A #$0D        EOL?
06AD 26 F8            BNE MPUL1         NO
                    *
                    * PULL MACPTR,MACSAV,MCLPTR
                    *
06AF CE 030D R        LDX #MACPTR
06B2 C6 06            LDA B #6
                    *
06B4 32         MPUL2 PUL A             PUL A CHAR
06B5 A7 00            STA A 0,X         SAVE
06B7 08               INX
06B8 5A               DEC B
06B9 26 F9            BNE MPUL2         NOT DONE
```

```
                    *
06BB BF 028A R              STS MSTKPT          SAVE MACRO STACK PNTR
06BE BE 028C R              LDS STKSAV          RESTORE STACK POINTER
06C1 FE 028E R              LDX MXSAV1          RESTORE X-REG
06C4 39                     RTS
                    * COMPARE TWO STRINGS *
                    * ON ENTRY (X) = A PARM LIST OF 5 BYTES :
                    *       A(STRING1)
                    *       A(STRING2)
                    *       COUNT OF # BYTES TO BE COMPARED
                    *
                    * ON RETURN IF CC Z IS SET THERE IS A MATCH
                    *       EXAMPLE:
                    *             LDX  #STRING1
                    *             JSR  COMPAR
                    *             BEQ  ------   MATCH
                    *
                    *    STRING1  RMB  2
                    *    STRING2  RMB  2
                    *    COUNT    RMB  1
                    *
                    *
06C5 36             COMPAR PSH A
06C6 37                    PSH B
06C7 E6 04                 LDA B 4,X        GET COUNT
06C9 FF 06F4 R             STX   XSAV       SAVE PARM POINTER
06CC FE 06F4 R CMP1        LDX   XSAV       GET PARM PTR
06CF EE 00                 LDX   0,X        GET A(STRING1)
06D1 A6 00                 LDA A 0,X        GET CHARACTER
06D3 FE 06F4 R             LDX   XSAV       GET PTR
06D6 6C 01                 INC   1,X        PTR SET TO NEXT
06D8 26 02                 BNE   CMP2       CHAR IN
06DA 6C 00                 INC   0,X        STRING1
06DC FE 06F4 R CMP2        LDX   XSAV       GET PARM PTR
06DF EE 02                 LDX   2,X        GET A(STRING2)
06E1 A1 00                 CMP A 0,X        COMPARE
06E3 26 0C                 BNE   CDONE      NOT EQUAL
06E5 FE 06F4 R             LDX   XSAV       GET PARM POINTER
06E8 6C 03                 INC   3,X        PTR SET TO NEXT
06EA 26 02                 BNE   CMP3       CHAR IN
06EC 6C 02                 INC   2,X        STRING2
06EE 5A             CMP3   DEC B            DECREMENT COUNT
06EF 26 DB                 BNE   CMP1       TRY AGAIN
06F1 33             CDONE  PUL B            DONE
06F2 32                    PUL A
06F3 39                    RTS
                    *
06F4 0002           XSAV   RMB   2          PARM PTR SAVE AREA
                    * NEXT TOKEN ROUTINE *
                    * SCANS A LINE OF SOURCE CODE AND RETURNS
                    * THE NEXT TOKEN,CLASS & RC IN REGS A,B
                    * THE ADDRESS OF THE TOKEN IS RETURNED IN
                    * DESCRA AND THE # OF BYTES IN THE TOKEN IS
                    * RETURNED IN DESCRC.
                    * THE RC AND CLASS ARE:
                    *
                    * TYPE:    RC (B)    CLASS (A)
                    *
                    * NAME      01          02  SUBSTRINGS
                    * HEX       03          02
                    * DECIMAL   09          02
                    *
                    * #         23          04  DELIMITERS
                    * ,         2C          04
                    * '         27          04
                    *
                    * *         2A          24  ARITHMETIC
                    * /         2F          24
                    * +         2B          24
                    * -         2D          24
                    *
                    * A         41          01  A,B,X REGS
                    * B         42          01
                    * X         58          01
                    *
                    * CR        0D          0D  EOL
                    *
                    * ERROR     00          00  ERRORS
                    *
                    *
06F6 7F 027D R NXTOK   CLR   DESCRC
06F9 7C 027D R         INC   DESCRC     DESCRC:=1
06FC FE 027E R NXTO    LDX   CUCHAR     POINT TO CURRENT CHAR
06FF FF 027B R         STX   DESCRA     INIT DESCRA
0702 A6 00             LDA A 0,X        GET CHAR
0704 08                INX
0705 FF 027E R         STX   CUCHAR     POINT TO NEXT CHAR
0708 81 20             CMP A #$20       LESS THAN 20 HEX?
070A 27 F0             BEQ   NXTO       BLANK,SKIP OVER
070C 22 06             BHI   NXTI       >20
                    *
070E 81 0D             CMP A #$0D       CR?
0710 26 47             BNE   NXTER      NO,UNRECOG. CHAR
```

```
0712 16                TAB             YES, SET RC
0713 39                RTS
                  *
0714 81 5F      NXT1   CMP A #$5F      >5F?
0716 23 02             BLS   NXT3      NO
0718 20 3F             BRA   NXTER     YES,UNRECOG. CHAR
                  *
071A BD 07C3 R NXT3    JSR   GCHRTB    GET BYTE FROM CHARTAB
071D 85 01             BIT A #$01      A,B,X REGS?
071F 27 13             BEQ   NXT4      NO
                  *
0721 FE 027E R         LDX   CUCHAR    YES,CHECK NEXT CHAR
0724 E6 00             LDA B 0,X
0726 C1 20             CMP B #$20      BLANK?
0728 27 04             BEQ   NXT3A     YES
072A C1 0D             CMP B #$0D      EOL?
072C 26 0A             BNE   NXT4A     NO GOT TO NSCAN
                  *
072E FE 027B R NXT3A   LDX   DESCRA    GET RC
0731 E6 00             LDA B 0,X
0733 39                RTS
                  *
0734 85 80      NXT4   BIT A #$80      NAME?
0736 27 04             BEQ   NXT5      NO
0738 BD 0773 R NXT4A   JSR   NSCAN     YES SCAN NAME STRING
073B 39                RTS
                  *
073C 85 40      NXT5   BIT A #$40      DECIMAL?
073E 27 04             BEQ   NXT6      NO
0740 BD 075C R         JSR   DSCAN     YES,SCAN DECIMAL STRING
0743 39                RTS
                  *
0744 85 20      NXT6   BIT A #$20      ARITHMETIC?
0746 26 E6             BNE   NXT3A     YES GET RC AND RTN
                  *
0748 85 04             BIT A #$04      DELIMITERS?
074A 27 0D             BEQ   NXTER     NO,UNRECOG. CHAR
074C FE 027B R         LDX   DESCRA    GET CHAR
074F E6 00             LDA B 0,X
0751 C1 24             CMP B #$24      $? (HEX)
0753 26 D9             BNE   NXT3A     NO,GET RC AND RTN
                  *
0755 BD 0798 R         JSR   HSCAN     YES,SCAN HEX STRING
0758 39                RTS
                  *
0759 4F         NXTER  CLR A           TROUBLE,SET RC,CLASS=00
075A 5F                CLR B
075B 39                RTS

                  * DSCAN SCAN DECIMAL STRING STOP AT
                  * FIRST NON-DECIMAL CHAR
                  *
075C FE 027E R DSCAN   LDX   CUCHAR    POINT TO NEXT CHAR
075F A6 00             LDA A 0,X       GET CHAR
0761 7C 027D R         INC   DESCRC    BUMP COUNT
0764 08                INX
0765 FF 027E R         STX   CUCHAR    POINT TO NEXT CHAR
0768 BD 07C3 R         JSR   GCHRTB    GET BYTE IN CHARTAB
076B 85 40             BIT A #$40      DECIMAL?
076D 26 ED             BNE   DSCAN     YES CONTINUE SCAN
076F C6 09             LDA B #$09
0771 20 43             BRA   ENDSCN    RETURN
                  *
                  *
                  * NSCAN SCAN NAME STRING STOP AT
                  * FIRST NON-ALPHANUMERIC CHAR
                  *
0773 FE 027E R NSCAN   LDX   CUCHAR    POINT TO NEXT CHAR
0776 A6 00             LDA A 0,X       GET CHAR
0778 7C 027D R         INC   DESCRC    BUMP COUNT
077B 08                INX
077C FF 027E R         STX   CUCHAR    POINT TO NEXT CHAR
077F BD 07C3 R         JSR   GCHRTB    GET BYTE IN CHARTAB
0782 85 80             BIT A #$80      ALPHA?
0784 26 ED             BNE   NSCAN     YES CONTINUE SCAN
0786 85 40             BIT A #$40      NUMERIC?
0788 26 E9             BNE   NSCAN     YES CONTINUE SCAN
078A C6 07             LDA B #$07      NAME TO LONG ?
078C F1 027D R         CMP B DESCRC
078F 24 03             BCC   NSCANA    NO
0791 F7 027D R         STA B DESCRC    YES,TRUNCATE
0794 C6 01      NSCANA LDA B #$01      LOAD RC
0796 20 1E             BRA   ENDSCN    RETURN
                  *
                  *
                  * HSCAN SCAN HEX STRING STOP AT
                  * FIRST NON-HEX CHAR
                  *
0798 7F 027D R HSCAN   CLR   DESCRC    DESCRC:=0
079B FE 027E R         LDX   CUCHAR    POINT TO NEXT CHAR
079E FF 027B R         STX   DESCRA    INIT DESCRA
07A1 FE 027E R HSCAN1  LDX   CUCHAR    POINT TO NEXT CHAR
```

```
07A4 A6 00          LDA A 0,X+      GET CHAR
07A6 7C 027D R      INC   DESCRC    BUMP COUNT
07A9 08             INX
07AA FF 027E R      STX   CUCHAR    POINT TO NEXT CHAR
07AD BD 07C3 R      JSR   GCHRTB    GET BYTE IN CHRTAB
07B0 85 02          BIT A #$02      HEX?
07B2 26 ED          BNE   HSCAN1    YES CONTINUE SCAN
07B4 C6 03          LDA B #$03
                    *
07B6 7A 027D R ENDSCN DEC   DESCRC  DESCRC:= CORRECT COUNT
07B9 FE 027E R      LDX   CUCHAR
07BC 09             DEX
07BD FF 027E R      STX   CUCHAR    CUCHAR:= CORRECT VALUE
07C0 86 02          LDA A #2        LOAD CLASS RC
07C2 39             RTS             ALL DONE

                    * GET BYTE IN CHRTAB INDEXED BY VALUE OF
                    * CHAR IN REG A
                    *
07C3 81 20      GCHRTB CMP A #$20   VALID CHAR ?
07C5 25 16          BCS   GCHRTR    NO < 20
07C7 81 5F          CMP A #$5F      VALID CHAR ?
07C9 22 12          BHI   GCHRTR    NO, > 5F
                    *
07CB 7F 07DF R      CLR   CHPTR     INIT PARM
07CE B7 07E0 R      STA A CHPTR+1   SAVE CHAR
07D1 CE 07DF R      LDX   #CHPTR    POINT TO PARM
07D4 BD 0BEC R      JSR   ADD16     ADD IN BASE OF CHARTAB
07D7 FE 07DF R      LDX   CHPTR     GET BYTE IN CHARTAB
07DA A6 00          LDA A 0,X
07DC 39             RTS
                    *
07DD 4F         GCHRTR CLR A
07DE 39             RTS
                    *
07DF 0002       CHPTR  RMB   2          PARM LIST
07E1 01EA    R          FDB   CHRTAB-$20

                    * TABLE MANIPULATION ROUTINES FOR TABLES
                    * SYMTAB AND MNTAB
                    *
                    * STORAGE LOCATIONS USED BY THE ROUTINES:
                    *
07E3 0002       PSTNG1 RMB   2          ADDRESS OF MNEMONIC
07E5 0002       PSTNG2 RMB   2          ADDRESS IN THE TABLE
07E7 0001       PCOUNT RMB   1          LENGTH OF MNEMONIC
07E8 0002       TBADD  RMB   2          TABLE POINTER
07EA 0006       HSMBL  RMB   6          SYMBOL TEMP LOC
07F0 0002       HKEYA  RMB   2          HASHED CODE
07F2 0002       HKEYB  RMB   2          TEMP LOC FOR HASHED CODE
07F4 0002       HSAV1  RMB   2          TEMP LOC FOR PTR
07F6 0002       HSAV2  RMB   2          TEMP LOC FOR PTR
                    *
                    *
                    * STORE A SYMBOL IN SYMTAB
                    * ON ENTRY DESCRA CONTAINS ADDRESS OF
                    * THE SYMBOL,AND DESCRC CONTAINS THE LENGTH
                    * A STANDARD HASH CODED METHOD IS USED
                    *
                    *
07F8 BD 08B9 R STOSYM JSR  HASH         GET HASHED KEY
07FB FF 0282 R      STX  SYMPTR     SAVE
                    *
                    * SEE IF LOC(HKEYA) IS EMPTY)
                    *
07FE A6 00      SYMA   LDA A 0,X        GET FIRST CHAR
0800 81 20          CMP A #$20      BLANK ?
0802 26 2F          BNE   SYMB      NO
                    *
                    * STORE SYMBOL IN SYMTAB
                    *
0804 FF 07F6 R      STX   HSAV2     SAVE TABLE PTR
0807 CE 07EA R      LDX   #HSMBL    POINT TO HSMBL
080A FF 07F4 R      STX   HSAV1     SAVE
080D C6 06          LDA B #6        LOAD SYMBOL LENGTH
                    *
                    * DO TRANSFER
                    *
080F FE 07F4 R SYM1    LDX   HSAV1      POINT TO HSYMBL
0812 A6 00          LDA A 0,X       GET CHAR
0814 08             INX
0815 FF 07F4 R      STX   HSAV1     POINT TO NEXT CHAR
0818 FE 07F6 R      LDX   HSAV2     POINT TO TABLE ENTRY
081B A7 00          STA A 0,X       STORE CHAR IN SYMTAB
081D 08             INX             *
081E FF 07F6 R      STX   HSAV2     POINT TO NEXT POSITION
0821 5A             DEC B           ALL DONE ?
0822 26 EB          BNE   SYM1      NO
                    *
                    * STORE LC, AND SET INFO BYTE
                    *
0824 B6 0273 R      LDA A LC        GET LC
```

```
0827 A7 00              STA A 0,X       STORE
0829 B6 0274 R          LDA A LC+1      GET LS BYTE OF LC
082C A7 01              STA A 1,X       STORE
082E 86 40              LDA A #$40      INFO BYTE:=RELOC,DEFINED
0830 A7 02              STA A 2,X
0832 39                 RTS             RETURN

                        *
                        * COMPARE HSMBL WITH ENTRY IN SYMTAB
                        *
0833 BD 087E R SYMB     JSR   SYMCMP    COMPARE
0836 26 10              BNE   SYMC      NO MATCH
                        *
                        * ERROR, SYMBOL ALREADY IN TABLE
                        *
0838 FE 0282 R          LDX   SYMPTR    GET ADDRESS OF ENTRY
083B 86 80              LDA A #$80
083D AA 05              ORA A 5,X       SET REDEFINED BIT
083F A7 05              STA A 5,X
0841 CE 0206            LDX   #$0206    LOAD ERROR#
0844 BD 0DBB R SYMB1    JSR   PRINTE    PRINT IT
0847 39                 RTS             RETURN
                        *
                        * FIND ANOTHER SLOT IN SYMTAB FOR SYMBOL
                        *
0848 BD 0893 R SYMC     JSR   SYMMOD    GET A(NEXT SLOT)
084B BC 07F0 R          CPX   HKEYA     CHECKED ALREADY ?
084E 27 02              BEQ   *+4       YES,TABLE IS FULL
                        *
0850 20 AC              BRA   SYMA      TRY AGAIN
                        *
0852 CE 0221            LDX   #$0221    LOAD ERROR#
0855 20 ED              BRA   SYMB1     PRINT IT & RETURN

                        * LOOK UP SYMBOL IN SYMTAB
                        * ON ENTRY DESCRA CONTAINS ADDRESS OF SYMBOL
                        * AND DESCRC CONTAINS THE LENGTH OF THE
                        * SYMBOL.
                        * ON RETURN:
                        *  B=VALUE OF INFO BYTE
                        *  B=FF SYMBOL NOT FOUND
                        *  X=VALUE OF SYMBOL
                        *
                        *
0857 BD 0889 R LKPSYM   JSR   HASH      GET KEY
085A FF 0282 R          STX   SYMPTR    SAVE
                        *
085D A6 00      LKPSM1  LDA A 0,X
085F 81 20              CMP A #$20      BLANK?
0861 26 03              BNE   LKPSM3    NO
                        *
                        * ENTRY NOT IN SYMTAB
                        *
0863 C6 FF      LKPSM2  LDA B #$FF      LOAD RC
0865 39                 RTS             RETURN
                        *
                        * COMPARE SYMBOL WITH ENTRY IN SYMTAB
                        *
0866 BD 087E R LKPSM3   JSR   SYMCMP    COMPARE
0869 26 08              BNE   LKPSM4    NO MATCH
                        *
                        * FOUND, EXTRACT INFO, AND VALUE
                        *
086B FE 0282 R          LDX   SYMPTR    POINT TO ENTRY
086E E6 05              LDA B 5,X       GET INFO BYTE
0870 EE 06              LDX   6,X       GET VALUE
0872 39                 RTS
                        *
                        * PROBE AGAIN FOR SYMBOL IN SYMTAB
                        *
0873 BD 0893 R LKPSM4   JSR   SYMMOD    GET NEXT KEY
0876 BC 07F0 R          CPX   HKEYA     ALREADY CHECKED?
0879 26 E2              BNE   LKPSM1    NO,TRY AGAIN
087B C6 FF              LDA B #$FF      SET RC
087D 39                 RTS

                        * ROUTINE TO COMPARE SYMBOL WITH ENTRY
                        *
087E FF 07E3 R SYMCMP   STX   PSTNG1    SAVE PTR TO ENTRY
0881 86 06              LDA A #6
0883 B7 07E7 R          STA A PCOUNT    PCOUNT:=L(SYMBOL)
0886 CE 07EA R          LDX   #HSMBL
0889 FF 07E5 R          STX   PSTNG2    POINT TO HSMBL
088C CE 07E3 R          LDX   #PSTNG1   POINT TO PARMS
088F BD 0CC5 R          JSR   COMPAR    COMPARE
0892 39                 RTS
                        *
                        *
                        * FIND NEXT SLOT IN SYMTAB
                        * SYMPTR:=SYMPTR+9 (MODULO NSYM)
                        *
0893 FE 0282 R SYMMOD   LDX   SYMPTR    GET A(CURRENT SLOT)
0896 08                 INX             SYMPTR:=SYMPTR+9
```

```
0897 08                 INX
0898 08                 INX
0899 08                 INX
089A 08                 INX
089B 08                 INX
089C 08                 INX
089D 08                 INX
089E 08                 INX
                *
                * BEYOND SYMTAB ?
                *
089F BC 026C R          CPX   SYMEND
08A2 26 03              BNE   *+5         NO
08A4 FE 0268 R          LDX   SYMTAB      POINT TO FIRST ENTRY
08A7 FF 0282 R          STX   SYMPTR      SAVE PTR TO ENTRY
08AA 39                 RTS
                * DELETE LAST SYMBOL ENTERED
                *
08AB FE 0282 R DELSYM   LDX   SYMPTR
08AE 86 20              LDA A #$20        LOAD BLANK
08B0 C6 09              LDA B #9          LOAD ENTRY LENGTH
                *
08B2 A7 00      DEL1    STA A 0,X         BLANK BYTE
08B4 08                 INX               POINT TO NEXT BYTE
08B5 5A                 DEC B             ALL DONE ?
08B6 26 FA              BNE   DEL1        NO
                *
08B8 39                 RTS               YES, RETURN
                * HASH SYMBOL TO PRODUCE A KEY
                *
                *
08B9 CE 2020    HASH    LDX   #$2020      BLANK HSMBL
08BC FF 07EA R          STX   HSMBL
08BF FF 07EC R          STX   HSMBL+2
08C2 FF 07EE R          STX   HSMBL+4
                *
                * MOVE SYMBOL TO HSMBL
                *
08C5 CE 07EA R          LDX   #HSMBL      POINT TO HSMBL
08C8 FF 07F6 R          STX   HSAV2       SAVE
08CB FE 027B R          LDX   DESCRA      POINT TO SYMBOL
08CE FF 07F4 R          STX   HSAV1       SAVE
08D1 F6 027D R          LDA B DESCRC      GET L(SYMBOL)
                *
08D4 FE 07F4 R HASH1    LDX   HSAV1       POINT TO SYMBOL
08D7 A6 00              LDA A 0,X         GET CHAR
08D9 08                 INX
08DA FF 07F4 R          STX   HSAV1       POINT TO NEXT CHAR
08DD FE 07F6 R          LDX   HSAV2       POINT TO HSYMBL
08E0 A7 00              STA A 0,X         STORE CHAR
08E2 08                 INX
08E3 FF 07F6 R          STX   HSAV2       POINT TO NEXT CHAR
08E6 5A                 DEC B             ALL DONE?
08E7 26 EB              BNE   HASH1       NO
                *
                * FOLD OVER HSMBL CREATING KEYA
                *
08E9 FE 07EA R          LDX   HSMBL       HKEYA*=HSMBL(2)
08EC FF 07F0 R          STX   HKEYA
08EF FE 07EC R          LDX   HSMBL+2
08F2 FF 07F2 R          STX   HKEYB
08F5 CE 07F0 R          LDX   #HKEYA
08F8 BD 0BEC R          JSR   ADD16             +HSMBL+2(2)
08FB FE 07EE R          LDX   HSMBL+4
08FE FF 07F2 R          STX   HKEYB
0901 CE 07F0 R          LDX   #HKEYA
0904 BD 0BEC R          JSR   ADD16             +HSMBL+4 (2)
                *
                * HKEYA*=REMAINDER OF HKEYA/NSYM
                *
0907 B6 07F0 R          LDA A HKEYA       LOAD VALUES*
090A F6 07F1 R          LDA B HKEYA+1
090D FE 026A R          LDX   NSYM
0910 FF 07F2 R          STX   HKEYB
0913 CE 07F2 R          LDX   #HKEYB      POINT TO NSYM
0916 BD 0BA1 R          JSR   DIV16
0919 FF 07F0 R          STX   HKEYA       SAVE REMAINDER
                *
                * HKEYA*=HKEYA*9
                *
091C 4F                 CLR A
091D C6 09              LDA B #9
091F CE 07F0 R          LDX   #HKEYA
0922 BD 0B7D R          JSR   MPY16
0925 B7 07F0 R          STA A HKEYA
0928 F7 07F1 R          STA B HKEYA+1
                *
                * ADD IN BASE ADDRESS OF SYMTAB
                *
092B FE 0268 R          LDX   SYMTAB
092E FF 07F2 R          STX   HKEYB
0931 CE 07F0 R          LDX   #HKEYA
```

```
0934 BD 0BEC R          JSR   ADD16
0937 FE 07F0 R          LDX   HKEYA
093A 39                 RTS

                * LOOK UP MNEMONIC IN MNTAB
                * ON ENTRY DESCRA POINTS TO MNEMONIC, AND
                * DESCRC CONTAINS THE LENGTH (3)
                * ON RETURN:
                *  REG A = 00  FOUND
                *  REG A = FF  NOT IN TABLE
                *  REG X = ADDRESS OF ROUTINE TO PROCESS
                *          THE OPCODE/PSEUDOP
                *  REG B = MACHINE CODE FOR OPCODES
                *        = FF FOR PSEUDOPS
                *
                *
                * THE ALGORITHM IS A BINARY SEARCH
                *
                * TEMPORARY LOCATIONS:
                *
093B 0001       LP      RMB   1   ONE BELOW LOWEST ENTRY
093C 0001       MP      RMB   1   ONE HIGHER THAN HIGHEST ENTRY
093D 0001       IP      RMB   1   CALCULATED PROBE VALUE
093E 0006       ENSIZ   FDB   6   LENGTH OF ENTRY IN MNTAB
                *
0940 B6 027D R MNLKP    LDA A DESCRC
0943 B7 07E7 R          STA A PCOUNT      INIT PCOUNT
0946 86 57              LDA A #CHRTAB-MNTAB/6+1   (# ENTRIES+1)
0948 B7 093C R          STA A MP          INIT MP
094B 4F                 CLR A
094C B7 093B R          STA A LP          INIT LP
                *
094F B6 093B R MNLKPA   LDA A LP
0952 4C                 INC A             A:=LP+1
0953 B1 093C R          CMP A MP          MP=LP+1 ?
0956 26 03              BNE   MNLKPB      NO
                *
0958 86 FF              LDA A #$FF        YES,ENTRY NOT IN TABLE
095A 39                 RTS
                *
                * IP:= (LP+MP)/2 TRUNCATED
                *
095B F6 093B R MNLKPB   LDA B LP
095E FB 093C R          ADD B MP          B:=LP+MP
0961 56                 ROR B             B:=B/2
0962 F7 093D R          STA B IP          SAVE IP
                *
                * GET 16 BIT ADDRESS OF ENTRY
                *
0965 4F                 CLR A
0966 CE 093E R          LDX   #ENSIZ      GET ENTRY LENGTH
0969 5A                 DEC B             B:=IP-1
096A BD 0B7D R          JSR   MPY16       GET (IP-1)*6
096D B7 07E3 R          STA A PSTNG1      SAVE
0970 F7 07E4 R          STA B PSTNG1+1
0973 CE 0006 R          LDX   #MNTAB
0976 FF 07E5 R          STX   PSTNG2      PSTNG2:=BASE OF MNTAB
0979 CE 07E3 R          LDX   #PSTNG1     POINT TO PARMS
097C BD 0BEC R          JSR   ADD16       PSTNG1:=(IP-1)*6+MNTAB
097F FE 07E3 R          LDX   PSTNG1
0982 FF 07E8 R          STX   TBADD       SAVE
                *
                * COMPARE MNEMONIC WITH ENTRY IN MNTAB
                *

0985 FE 027B R          LDX   DESCRA      GET MNEMONIC ADDRESS
0988 FF 07E5 R          STX   PSTNG2      INIT PARM FOR COMPARE
098B CE 07E3 R          LDX   #PSTNG1     POINT TO PARMS
098E BD 06C5 R          JSR   COMPAR      COMPARE
0991 25 0B              BCS   MNLI        ENTRY<MNEMONIC
0993 26 11              BNE   MNMI        ENTRY>MNEMONIC
                *
0995 4F                 CLR A             ENTRY FOUND
0996 FE 07E8 R          LDX   TBADD       POINT TO ENTRY
0999 E6 05              LDA B 5,X         GET MC
099B EE 03              LDX   3,X         GET BRANCH ADDRESS
099D 39                 RTS
                *
                * ENTRY<MNEMONIC LP:=IP
                *
099E B6 093D R MNLI     LDA A IP
09A1 B7 093B R          STA A LP
09A4 20 A9              BRA   MNLKPA      TRY AGAIN
                *
                * ENTRY>MNEMONIC MP:=IP
                *
09A6 B6 093D R MNMI     LDA A IP
09A9 B7 093C R          STA A MP
09AC 20 A1              BRA   MNLKPA      TRY AGAIN
                * EVALUATE NUMBERS,SYMBOLS AND EXPRESSIONS
                *
                *
09AE 0002       VALUE   RMB   2           TEMPORARY LOCS
```

```
09B0 0002       TMPVAL RMB   2
09B2 0001       CLFLG  RMB   1          CLASS OF PREVIOUS TOKEN
09B3 0001       CLASS  RMB   1          CLASS OF CURRENT TOKEN
09B4 0001       OPERN  RMB   1          ARITHMETIC OPERATOR
                *
09B5 7F 09AE R NSEVL   CLR   VALUE
09B8 7F 09AF R         CLR   VALUE+1    VALUE#=0
09BB 7F 09B2 R         CLR   CLFLG      CLFLG#=0
09BE B7 09B3 R         STA A CLASS      SAVE CLASS OF CURRENT TOKEN
09C1 C1 2A             CMP B #$2A       * ?
09C3 26 2D             BNE   NSVLC1     NO
                *
09C5 FE 0273 R         LDX   LC         YES
09C8 FF 09AE R         STX   VALUE      VALUE#=LC
09CB 86 02             LDA A #2
09CD B7 09B2 R         STA A CLFLG      CLFLG#=2
09D0 73 0277 R         COM   RELFLG     RELFLG#=RELOC
                *
09D3 FE 027E R NSVLA   LDX   CUCHAR
09D6 A6 00             LDA A 0,X        GET NEXT CHAR
09D8 81 20             CMP A #$20       BLANK?
09DA 27 08             BEQ   NSVLB      YES
09DC 81 0D             CMP A #$0D       EOL?
09DE 27 04             BEQ   NSVLB      YES
09E0 81 2C             CMP A #$2C       "," ?
09E2 26 08             BNE   NSVLC      NO
                *
09E4 FE 09AE R NSVLB   LDX   VALUE
09E7 FF 0C68 R         STX   ADR1       ADR1,2#=VALUE
09EA 5F                CLR B            RC#=00
09EB 39                RTS              ALL DONE
                *
09EC BD 06F6 R NSVLC   JSR   NXTOK      GET NEXT TOKEN
09EF B7 09B3 R         STA A CLASS      SAVE CLASS
09F2 B1 09B2 R NSVLC1  CMP A CLFLG      CLASS=CLFLG?
09F5 26 06             BNE   NSVLF      NO
                *
09F7 CE 0204   NSVLD   LDX   #$0204     ERROR
09FA 5F        NSVLE   CLR B
09FB 53                COM B            RC#=FF
09FC 39                RTS              RETURN
                *
09FD 81 02     NSVLF   CMP A #$02       STRING?
09FF 27 14             BEQ   NSVLH      YES
                *
0A01 81 24             CMP A #$24       ARITHMETIC OPERATOR?
0A03 27 02             BEQ   NSVLG      YES
                *
0A05 20 F0             BRA   NSVLD      ERROR
                *
0A07 7D 09B2 R NSVLG   TST   CLFLG      CLFLG=0?
0A0A 27 EB             BEQ   NSVLD      YES,ERROR
                *
0A0C F7 09B4 R         STA B OPERN      SAVE OPERATOR
0A0F B7 09B2 R         STA A CLFLG      CLFLG#=CLASS
0A12 7E 09D3 R         JMP   NSVLA      SCAN AGAIN
                *
0A15 C1 03     NSVLH   CMP B #$03       HEX STRING?
0A17 26 11             BNE   NSVLJ      NO
                *
0A19 F6 027D R         LDA B DESCRC     YES
0A1C C1 04             CMP B #4         > 4 ?
0A1E 2F 05             BLE   NSVLH1     NO
                *
0A20 CE 0210           LDX   #$0210     YES,ERROR
0A23 20 D5             BRA   NSVLE
                *
0A25 BD 0ACE R NSVLH1  JSR   CVHB       CONVERT
0A28 20 3B             BRA   NSVLM
                *
0A2A C1 09     NSVLJ   CMP B #9         DECIMAL?
0A2C 26 11             BNE   NSVLK      NO
                *
0A2E F6 027D R         LDA B DESCRC
0A31 C1 05             CMP B #5         > 5 ?
0A33 2F 05             BLE   NSVLJ1     NO
                *
0A35 CE 0210           LDX   #$0210     YES,ERROR
0A38 20 C0             BRA   NSVLE
                *
0A3A BD 0B2A R NSVLJ1  JSR   CVDB       CONVERT
0A3D 20 26             BRA   NSVLM
                *
0A3F C1 01     NSVLK   CMP B #$01       SYMBOL?
0A41 27 03             BEQ   NSVLL      YES
                *
0A43 7E 09F7 R         JMP   NSVLD      NO,ERROR
                *
0A46 BD 0857 R NSVLL   JSR   LKPSYM     LOOKUP SYMBOL
0A49 C5 80             BIT B #$80       REDEFINED ?
0A4B 26 12             BNE   NSVLLA     YES
```

```
                    *
0A4D C5 40          BIT B #$40      RELOC ?
0A4F 27 05          BEQ   *+7       NO
                    *
0A51 73 0277 R      COM   RELFLG    YES RELFLG:=RELOC
0A54 20 0F          BRA   NSVLM
                    *
0A56 C5 10          BIT B #$10      COMMON?
0A58 27 03          BEQ *+5         NO
                    *
0A5A 73 0278 R      COM CMNFLG      YES
0A5D 20 06          BRA NSVLM
                    *
0A5F CE 0211   NSVLLA LDX   #$0211   NO,ERROR
0A62 7E 09FA R      JMP   NSVLE
                    *
0A65 FF 09B0 R NSVLM  STX   TMPVAL   SAVE,CONVERTED VALUE
0A68 7D 09B2 R      TST   CLFLG     CLFLG=0 ?
0A6B 26 0F          BNE   NSVLP     NO
                    *
0A6D FE 09B0 R      LDX   TMPVAL    YES
0A70 FF 09AE R      STX   VALUE     VALUE:=TMPVAL
                    *
0A73 B6 09B3 R NSVLN  LDA A CLASS
0A76 B7 09B2 R      STA A CLFLG     CLFLG:=CLASS
0A79 7E 09D3 R      JMP   NSVLA     SCAN AGAIN
                    *
0A7C B6 09B4 R NSVLP  LDA A OPERN    GET LAST OPERATOR
0A7F 81 2B          CMP A #$2B      + ?
0A81 26 08          BNE   NSVLP1    NO
                    *
0A83 CE 09AE R      LDX   #VALUE
0A86 BD 0BEC R      JSR   ADD16     VALUE:=VALUE+TMPVAL
0A89 20 E8          BRA   NSVLN
                    *
0A8B 81 2D     NSVLP1 CMP A #$2D     - ?
0A8D 26 08          BNE   NSVLP2    NO
                    *
0A8F CE 09AE R      LDX   #VALUE    YES
0A92 BD 0BFD R      JSR   SUB16     VALUE:=VALUE-TMPVAL
0A95 20 DC          BRA   NSVLN
                    *
0A97 81 2A     NSVLP2 CMP A #$2A     * ?
0A99 26 15          BNE   NSVLP3    NO
                    *
0A9B B6 09AE R      LDA A VALUE
0A9E F6 09AF R      LDA B VALUE+1
0AA1 CE 09B0 R      LDX   #TMPVAL
0AA4 BD 0B7D R      JSR   MPY16     VALUE:=VALUE*TMPVAL
0AA7 B7 09AE R      STA A VALUE
0AAA F7 09AF R      STA B VALUE+1
0AAD 7E 0A73 R      JMP   NSVLN
                    *
0AB0 81 2F     NSVLP3 CMP A #$2F     / ?
0AB2 27 03          BEQ   NSVLP4    YES
                    *
0AB4 7E 09F7 R      JMP   NSVLD     NO, ERROR
                    *
0AB7 B6 09AE R NSVLP4 LDA A VALUE
0ABA F6 09AF R      LDA B VALUE+1
0ABD CE 09B0 R      LDX   #TMPVAL
0AC0 BD 0BA1 R      JSR   DIV16     VALUE:=VALUE/TMPVAL
0AC3 B7 09AE R      STA A VALUE
0AC6 F7 09AF R      STA B VALUE+1
0AC9 7E 0A73 R      JMP   NSVLN
                    * CVHB CONVERT HEX TO BINARY
                    *
                    * ON ENTRY DESCRA = ADDRESS OF STRING
                    *          DESCRC = # OF BYTES IN STRING
                    * ON RETURN [X]=VALUE
                    *
0ACC 0002      HVAL   RMB   2         TEMP STORAGE
                    *
0ACE FE 027B R CVHB   LDX   DESCRA    GET ADDRESS OF STRING
0AD1 7F 0ACC R      CLR   HVAL
0AD4 7F 0ACD R      CLR   HVAL+1
0AD7 F6 027D R      LDA B DESCRC    GET COUNT
0ADA 09             DEX             DECREMENT PTR TO STRING
0ADB 08        CVHB1  INX             POINT TO RIGHT MOST
0ADC 5A             DEC B           BYTE OF THE
0ADD 26 FC          BNE   CVHB1     STRING
                    *
0ADF F6 027D R      LDA B DESCRC    GET COUNT
0AE2 BD 0B18 R      JSR   CVHBS     CONVERT
0AE5 B7 0ACD R      STA A HVAL+1    SAVE
0AE8 5A             DEC B           DECREMENT COUNT
0AE9 27 29          BEQ   CVHBD     (1 HEX DIGIT)
0AEB 09             DEX             POINT TO NEXT LEFT BYTE
0AEC BD 0B18 R      JSR   CVHBS     CONVERT
0AEF 48             ASL A           SHIFT TO LEFT NIBBLE
0AF0 48             ASL A
0AF1 48             ASL A
```

```
0AF2 48                 ASL A
0AF3 BA 0ACD R          ORA A HVAL+1    CONVERT TO BYTE
0AF6 B7 0ACD R          STA A HVAL+1    SAVE
0AF9 5A                 DEC B           DECREMENT COUNT
0AFA 27 18              BEQ   CVHBD     (2 HEX DIGITS)
0AFC 09                 DEX             POINT TO NEXT LEFT BYTE
0AFD BD 0B18 R          JSR   CVHBS     CONVERT
0B00 B7 0ACC R          STA A HVAL      SAVE
0B03 5A                 DEC B           DECREMENT COUNT
0B04 27 0E              BEQ   CVHBD     (3 HEX DIGITS)
                *
0B06 09                 DEX             POINT TO NEXT LEFT BYTE
0B07 BD 0B18 R          JSR   CVHBS     CONVERT
0B0A 48                 ASL A           SHIFT TO LEFT NIBBLE
0B0B 48                 ASL A
0B0C 48                 ASL A
0B0D 48                 ASL A
0B0E BA 0ACC R          ORA A HVAL      CONVERT TO BYTE
0B11 B7 0ACC R          STA A HVAL      SAVE
0B14 FE 0ACC R CVHBD    LDX   HVAL      GET FINAL VALUE
0B17 39                 RTS             RETURN
                *
                * ROUTINE TO CONVERT ASCII TO BINARY
                *
0B18 A6 00      CVHBS   LDA A 0,X       GET BYTE
0B1A 80 30              SUB A #$30      CONVERT
0B1C 81 09              CMP A #$09      0 - 9 ?
0B1E 2F 02              BLE   *+4       YES
0B20 80 07              SUB A #$07      NO, 10 - 15
0B22 39                 RTS

                * CVDB: CONVERT DECIMAL TO BINARY
                * ON ENTRY DESCRA = ADDRESS OF DECIMAL STRING
                *          DESCRC = # BYTES IN DECIMAL STRING
                * ON RETURN (X) = VALUE IN BINARY
                *
0B23 0002       DVAL    RMB   2         TEMP STORAGE FOR BINARY
0B25 0001       DCOUNT  RMB   1         DIGIT COUNT
0B26 0002       TENVL   RMB   2         POWER OF TEN
0B28 0002       DXSAV   RMB   2         TEMPORARY STORAGE FOR X
                *
0B2A 7F 0B23 R CVDB     CLR   DVAL      DVAL:=0
0B2D 7F 0B24 R          CLR   DVAL+1
0B30 7F 0B26 R          CLR   TENVL
0B33 7F 0B27 R          CLR   TENVL+1
0B36 7C 0B27 R          INC   TENVL+1   TENVL:=1
0B39 FE 027B R          LDX   DESCRA    POINT TO STRING
0B3C 09                 DEX
0B3D F6 027D R          LDA B DESCRC
0B40 F7 0B25 R          STA B DCOUNT    INIT DCOUNT
                *
0B43 08         CVDB1   INX             POINT TO
0B44 5A                 DEC B           LEAST SIGNIFICANT
0B45 26 FC              BNE   CVDB1     DIGIT
                *
0B47 FF 0B28 R CVDB2    STX   DXSAV     SAVE POINTER
0B4A E6 00              LDA B 0,X       GET DIGIT
0B4C C4 0F              AND B #$0F      CONVERT TO BCD
0B4E 4F                 CLR A           CLEAR ACCUMULATOR
0B4F CE 0B26 R          LDX   #TENVL    POINT TO POWER OF TEN
0B52 BD 0B7D R          JSR   MPY16     (A,B):=TENVL*DIGIT
0B55 FB 0B24 R          ADD B DVAL+1    DVAL:=DVAL+TENVL*DIGIT
0B58 B9 0B23 R          ADC A DVAL
0B5B B7 0B23 R          STA A DVAL
0B5E F7 0B24 R          STA B DVAL+1
0B61 4F                 CLR A
0B62 C6 0A              LDA B #$0A      B:=10
0B64 CE 0B26 R          LDX   #TENVL    POINT TO POWER OF TEN
0B67 BD 0B7D R          JSR   MPY16     TENVL:=TENVL*10
0B6A B7 0B26 R          STA A TENVL
0B6D F7 0B27 R          STA B TENVL+1
0B70 FE 0B28 R          LDX   DXSAV     RESTORE POINTER TO STRING
0B73 09                 DEX             POINT NEXT LEFT DIGIT
0B74 7A 0B25 R          DEC   DCOUNT    DONE?
0B77 26 CE              BNE   CVDB2     NO
0B79 FE 0B23 R          LDX   DVAL      GET FINAL VALUE
0B7C 39                 RTS             RETURN

                * MPY16 16 BIT MULTIPLY ROUTINE
                * (A,B):= (A,B)*(2 BYTES POINTED AT BY X REG)
                * USES 7 BYTES ON THE STACK
                *
0B7D 37         MPY16   PSH B           PUT VALUES ON TO THE STACK
0B7E 36                 PSH A
0B7F A6 01              LDA A 1,X
0B81 36                 PSH A
0B82 A6 00              LDA A 0,X
0B84 36                 PSH A
0B85 86 10              LDA A #16
0B87 36                 PSH A
0B88 30                 TSX             POINT TO DATA
0B89 A6 03              LDA A 3,X
                *
```

```
0B8B 58        MPY163 ASL B
0B8C 49               ROL A             FORM ANSWER
0B8D 68 02            ASL   2,X         SHIFT MULTIPLICAND
0B8F 69 01            ROL   1,X
0B91 24 04            BCC   MPY167
0B93 EB 04            ADD B 4,X         ADD MULTIPLIER
0B95 A9 03            ADC A 3,X
0B97 6A 00     MPY167 DEC   0,X
0B99 26 F0            BNE   MPY163      COUNT NOT ZERO
0B9B 31               INS
0B9C 31               INS
0B9D 31               INS
0B9E 31               INS
0B9F 31               INS
0BA0 39               RTS               ALL DONE
                * DIV16 16 BIT DIVIDE (UNSIGNED)
                * (A,B)=(A,B)/ (X),(X+1)
                * [X]=REMAINDER
                *
0BA1 37        DIV16  PSH B             DIVIDEND TO STACK
0BA2 36               PSH A
0BA3 A6 00            LDA A 0,X
0BA5 E6 01            LDA B 1,X
0BA7 37               PSH B             DIVISOR TO STACK
0BA8 36               PSH A
0BA9 34               DES               LEAVE ROOM FOR COUNT
0BAA 30               TSX               (X) PNTR TO STACKED DATA
0BAB 86 01            LDA A #1
0BAD 6D 01            TST   1,X
0BAF 2B 0B            BMI   DIV153
0BB1 4C        DIV151 INC A
0BB2 68 02            ASL   2,X
0BB4 69 01            ROL   1,X
0BB6 2B 04            BMI   DIV153
0BB8 81 11            CMP A #17
0BBA 26 F5            BNE   DIV151
0BBC A7 00     DIV153 STA A 0,X         SAVE COUNT
0BBE A6 03            LDA A 3,X
0BC0 E6 04            LDA B 4,X
0BC2 6F 03            CLR   3,X
0BC4 6F 04            CLR   4,X
0BC6 E0 02     DIV163 SUB B 2,X
0BC8 A2 01            SBC A 1,X
0BCA 24 07            BCC   DIV165      DIVISOR STILL OK
0BCC EB 02            ADD B 2,X         DIVISOR TOO LARGE
0BCE A9 01            ADC A 1,X         RESTORE
0BD0 0C               CLC
0BD1 20 01            BRA   DIV167
0BD3 0D        DIV165 SEC
0BD4 69 04     DIV167 ROL   4,X
0BD6 69 03            ROL   3,X
0BD8 64 01            LSR   1,X         ADJUST DIVISOR
0BDA 66 02            ROR   2,X
0BDC 6A 00            DEC   0,X
0BDE 26 E6            BNE   DIV163
                *
0BE0 A7 00            STA A 0,X         SAVE REMAINDER IN X
0BE2 E7 01            STA B 1,X
0BE4 EE 00            LDX   0,X
0BE6 31               INS               CLEAN UP STACK
0BE7 31               INS
0BE8 31               INS
0BE9 32               PUL A
0BEA 33               PUL B
0BEB 39               RTS
                * ADD16 16 BIT ADDITION
                * [X] POINTS:
                *          LOC(2),TEMP(2)
                * LOC(2):=LOC(2)+TEMP(2)
                *
0BEC 36        ADD16  PSH A
0BED 37               PSH B
0BEE A6 01            LDA A 1,X
0BF0 E6 00            LDA B 0,X
0BF2 AB 03            ADD A 3,X
0BF4 E9 02            ADC B 2,X
0BF6 A7 01            STA A 1,X
0BF8 E7 00            STA B 0,X
0BFA 33               PUL B
0BFB 32               PUL A
0BFC 39               RTS
                *
                *
                * SUB16 16 BIT SUBTRACTION
                * [X] POINTS:
                *          LOC(2),TEMP(2)
                * LOC(2):=LOC(2)-TEMP(2)
                *
0BFD 36        SUB16  PSH A
0BFE 37               PSH B
0BFF A6 01            LDA A 1,X
0C01 E6 00            LDA B 0,X
```

```
0C03 A0 03            SUB A 3,X
0C05 E2 02            SBC B 2,X
0C07 A7 01            STA A 1,X
0C09 E7 00            STA B 0,X
0C0B 33               PUL B
0C0C 32               PUL A
0C0D 39               RTS
                    * PRINTL PRINT A LINE ON THE TTY
                    *
0C0E B6 026E R PRINTL LDA A OPINS      GET OPTIONS
0C11 85 80            BIT A #$80       LIST?
0C13 26 14            BNE   PLEND      NO
0C15 7D 0275 R        TST   PASS       PASS?
0C18 27 0F            BEQ   PLEND      PASS1
0C1A 7D 030C R        TST   MACFLG     MACRO FLAG SET?
0C1D 27 04            BEQ   PRINT1     NO
                    *
0C1F 85 10            BIT A #$10       PRINT MACROS?
0C21 26 06            BNE   PLEND      NO
                    *
0C23 BD 0C2A R PRINT1 JSR   LINCK      CHECK LINE #
0C26 BD 0C71 R        JSR   OUTL       PRINT A LINE
0C29 39        PLEND  RTS              ALL DONE
                    *
                    *
                    * LINE CHECK FOR TOP OF PAGE ETC.
                    *
0C2A 37        LINCK  PSH B
0C2B F6 0287 R        LDA B LCOUNT
0C2E C1 00            CMP B #$00       END OF PAGE?
0C30 26 03            BNE   LINCKA     NO
0C32 BD 0C44 R        JSR   SPACER     YES SPACE TO TOP OF PAGE
0C35 7C 0287 R LINCKA INC   LCOUNT     BUMP LCOUNT
0C38 F6 0287 R        LDA B LCOUNT
0C3B C1 3C            CMP B #$3C       LCOUNT=60?
0C3D 26 03            BNE   LINCKB     NO
0C3F 7F 0287 R        CLR   LCOUNT     YES,SET FOR TOP OF PAGE
0C42 33        LINCKB PUL B
0C43 39               RTS
                    *
                    * SPACE TO TOP OF PAGE AND PRINT PAGE MARK
                    *
0C44 CE 0C4B R SPACER LDX   #HEADR     POINT TO DATA
0C47 BD 1861 R        JSR   PDATA1     PRINT ON TTY
0C4A 39               RTS
                    *
0C4B 0D0A      HEADR  FDB   $0D0A  CRLF
0C4D 0D0A             FDB   $0D0A
0C4F 0D0A             FDB   $0D0A
0C51 2E               FCC   '.............'
0C5E 0D0A             FDB   $0D0A
0C60 0D0A             FDB   $0D0A
0C62 0D0A             FDB   $0D0A
0C64 04               FCB   $04  EOT
                    * PRINT A FORMATTED LINE OF LISTING ON THE TTY
                    *
                    *
0C65 0001      MCOUNT RMB   1          # BYTES OF MACHINE CODE
0C66 0001      POP    RMB   1          PSEUDOP10=NO11,2 BYTES
0C67 0001      OPCD   RMB   1          OPCODE IN HEX
0C68 0001      ADR1   RMB   1          INSTRUCTION ADDRESS
0C69 0001      ADR2   RMB   1
0C6A 0005      LINEN  RMB   5          LINENUM IN ASCII
0C6F 2004             FDB    $2004    EOT
                    *
                    *
0C71 CE 0C6A R OUTL   LDX   #LINEN     LOAD PARMS
0C74 B6 026F R        LDA A LNUM       LOAD LINNUM (BINARY)
0C77 F6 0270 R        LDA B LNUM+1
0C7A BD 0D5C R        JSR   CVBTD      CONVERT TO DECIMAL (ASCII
0C7D CE 0C6B R        LDX   #LINEN+1   POINT TO DECIMAL LINE#
0C80 BD 1861 R        JSR   PDATA1     PRINT LINE#
                    *
0C83 7D 030C R        TST   MACFLG     MACRO LINE?
0C86 27 05            BEQ   *+7        NO
                    *
0C88 86 2B            LDA A #'+
0C8A BD 1888 R        JSR   OUTCHR
                    *
0C8D CE 0D59 R        LDX   #BLANK6
0C90 BD 1861 R        JSR   PDATA1     PRINT 2 BLANKS
                    *
0C93 7D 0C65 R        TST   MCOUNT     PRINT LC ?
0C96 26 0D            BNE   OUTLA      YES
0C98 7D 0C66 R        TST   POP        PRINT LC?
0C9B 26 08            BNE   OUTLA      YES
                    *
0C9D CE 0D56 R        LDX   #BLANK3    NO,PRINT BLANKS (5)
0CA0 BD 1861 R        JSR   PDATA1
0CA3 20 2B            BRA   OUTL2
                    *
0CA5 CE 0273 R OUTLA  LDX   #LC        POINT TO LC
0CA8 BD 1871 R        JSR   OUT4HS     PRINT IN HEX,SPACE
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0CAB F6 0C66 R          LDA B POP       PSEUDOP?
0CAE 27 20              BEQ   OUTL2     NO
0CB0 C1 01              CMP B #$01      1 BYTE?
0CB2 27 0E              BEQ   OUTL1     YES
0CB4 CE 0C68 R          LDX   #ADR1     POINT TO ADR1,ADR2
0CB7 BD 1871 R          JSR   OUT4HS    PRINT 2 BYTES 4 HEX,SPACE
0CBA CE 0D58 R          LDX   #BLANK5   POINT TO BLANKS
0CBD BD 1861 R          JSR   PDATA1    PRINT BLANKS
0CC0 20 45              BRA   OUTL6
                *
0CC2 CE 0C69 R OUTL1    LDX   #ADR2     POINT TO ADR2
0CC5 BD 1873 R          JSR   OUT2HS    PRINT 1 BYTE 2 HEX,SPACE
0CC8 CE 0D56 R          LDX   #BLANK3   POINT TO BLANKS
0CCB BD 1861 R          JSR   PDATA1    PRINT BLANKS
0CCE 20 37              BRA   OUTL6
0CD0 F6 0C65 R OUTL2    LDA B MCOUNT    PRINT NOTHING?
0CD3 26 08              BNE   OUTL3     NO
0CD5 CE 0D53 R          LDX   #BLANK    PRINT JUST 8 BLANKS
0CD8 BD 1861 R          JSR   PDATA1
0CDB 20 2A              BRA   OUTL6
                *
0CDD CE 0C67 R OUTL3    LDX   #OPCD
0CE0 BD 1873 R          JSR   OUT2HS    PRINT OPCODE(HEX),SPACE
0CE3 C1 01              CMP B #$01      ONLY OPCODE?
0CE5 26 08              BNE   OUTL4     NO
0CE7 CE 0D56 R          LDX   #BLANK3   PRINT BLANKS
0CEA BD 1861 R          JSR   PDATA1
0CED 20 18              BRA   OUTL6
                *
0CEF C1 02      OUTL4   CMP B #$02      1 BYTE ADDRESS?
0CF1 26 0E              BNE   OUTL5     NO,2 BYTES
0CF3 CE 0C69 R          LDX   #ADR2     POINT TO ADR2
0CF6 BD 1873 R          JSR   OUT2HS    PRINT 1 BYTE ADDRESS,SPACE
0CF9 CE 0D59 R          LDX   #BLANK6   PRINT BLANKS
0CFC BD 1861 R          JSR   PDATA1
0CFF 20 06              BRA   OUTL6
                *
0D01 CE 0C68 R OUTL5    LDX   #ADR1     POINT TO ADR1,ADR2
0D04 BD 1871 R          JSR   OUT4HS    PRINT 2 BYTE ADDRESS,SPACE
                *
0D07 7D 0278 R OUTL6    TST CMNFLG      COMMON?
0D0A 27 04              BEQ *+6         NO
                *
0D0C 86 43              LDA A #'C
0D0E 20 1D              BRA OUTL6B
                *
0D10 7D 0279 R          TST EXTFLG      EXTERNAL?
0D13 27 04              BEQ *+6         NO
                *
0D15 86 58              LDA A #'X
0D17 20 14              BRA OUTL6B
                *
0D19 7D 027A R          TST ENTFLG      ENTRY?
0D1C 27 04              BEQ *+6         NO
                *
0D1E 86 4E              LDA A #'N
0D20 20 0B              BRA OUTL6B
                *
0D22 7D 0277 R          TST RELFLG      RELOCATABLE?
0D25 27 04              BEQ *+6         NO
                *
0D27 86 52              LDA A #'R
0D29 20 02              BRA OUTL6B
                *
                *
0D2B 86 20      OUTL6A  LDA A #$20      LOAD SPACE
0D2D BD 1888 R OUTL6B   JSR   OUTCHR    PRINT (A)
0D30 86 20              LDA A #$20      LOAD SPACE
0D32 BD 1888 R          JSR   OUTCHR    PRINT SPACE
0D35 FE 0280 R OUTL7A   LDX   CULINE    POINT TO LINE
0D38 A6 00      OUTL7   LDA A 0,X       GET CHAR
0D3A 36                 PSH A           SAVE A
0D3B BD 1888 R          JSR   OUTCHR    PRINT CHAR
0D3E 08                 INX             BUMP POINTER
0D3F 32                 PUL A           RESTORE A
0D40 81 0D              CMP A #$0D      CR?
0D42 26 F4              BNE   OUTL7     NO
0D44 86 0A              LDA A #$0A      YES
0D46 BD 1888 R          JSR   OUTCHR    PRINT LF
0D49 7F 0C66 R          CLR   POP
0D4C 7F 0C65 R          CLR   MCOUNT
0D4F 7F 0277 R          CLR   RELFLG
0D52 39                 RTS
                *
0D53 20         BLANK   FCB   $20       BLANKS:
0D54 20                 FCB   $20
0D55 20                 FCB   $20
0D56 20         BLANK3  FCB   $20
0D57 20                 FCB   $20
0D58 20         BLANK5  FCB   $20
0D59 20         BLANK6  FCB   $20
0D5A 20                 FCB   $20
```

```
0D5B 04                 FCB   $04        EOT
                    * CONVERT BINARY 16 BITS TO 5 DECIMAL CHARS
                    * ON ENTRY (A,B) = 16 BIT BINARY VALUE
                    * [X] = ADDRESS OF 5 BYTE STRING FOR DECIMAL
                    * (ASCII) CONVERTED VALUE.
                    *
0D5C FF 0D9D R CVBTD  STX   SAVEX     SAVE DATA PTR
0D5F CE 0D92 R        LDX   #KIOK     LOAD PTR TO CONSTANTS
0D62 7F 0D9C R CVDEC1 CLR   SAVEA     INIT DEC CHAR
0D65 E0 01     CVDEC2 SUB B 1,X
0D67 A2 00            SBC A 0,X
0D69 25 05            BCS   CVDEC5    OVERFLOW
0D6B 7C 0D9C R        INC   SAVEA     BUMP CHAR BEING BUILT
0D6E 20 F5            BRA   CVDEC2
                    *
0D70 EB 01     CVDEC5 ADD B 1,X       RESTORE PARTIAL RESULT
0D72 A9 00            ADC A 0,X
0D74 36               PSH A
0D75 FF 0D9F R        STX   SAVEX1
0D78 FE 0D9D R        LDX   SAVEX     LOAD STORE CHAR PTR
0D7B B6 0D9C R        LDA A SAVEA
0D7E 8B 30            ADD A #$30      MAKE ASCII CHAR
0D80 A7 00            STA A 0,X
0D82 32               PUL A
0D83 08               INX
0D84 FF 0D9D R        STX   SAVEX
0D87 FE 0D9F R        LDX   SAVEX1    LOAD PTR TO CONSTANTS
0D8A 08               INX
0D8B 08               INX
0D8C 8C 0D9C R        CPX   #KIOK+10
0D8F 26 D1            BNE   CVDEC1
0D91 39               RTS
                    *
                    * CONSTANTS
0D92 2710      KIOK   FDB   10000
0D94 03E8             FDB   1000
0D96 0064             FDB   100
0D98 000A             FDB   10
0D9A 0001             FDB   1
                    *
                    * TEMPORARY STORAGE
                    *
0D9C 0001      SAVEA  RMB   1
0D9D 0002      SAVEX  RMB   2          STORE DATA PTR
0D9F 0002      SAVEX1 RMB   2          PTR TO CONSTANTS
                    *
                    * PRINT ERROR MESSAGES ROUTINE *
                    * ON ENTRY [X] = ERROR# IN BCD *
                    *
                    *
0DA1 0002      ERNUM  RMB   2          ERROR # IN BCD
0DA3 2A        ERMSA  FCC   '**** ERROR# '
0DAF 0003      ERMSB  RMB   3          ERROR # IN ASCII
0DB2 20               FCB   $20       BLANK
0DB3 0005      ERMSC  RMB   5          ERROR# IN ASCII
0DB8 20               FCB   $20       BLANK
0DB9 3A               FCC   ':'
0DBA 04               FCB   $04       EOT
                    *
0DBB 36        PRINTE PSH   A
0DBC 37               PSH   B
0DBD FF 0DA1 R        STX   ERNUM     SAVE ERROR #
0DC0 B6 0DA1 R        LDA A ERNUM     GET ERROR #
0DC3 8B 30            ADD A #$30      CONVERT TO ASCII
0DC5 B7 0DAF R        STA A ERMSB     SAVE
0DC8 B6 0DA2 R        LDA A ERNUM+1   GET ERROR #
0DCB 44               LSR A           SHIFT TO RIGHT NIBBLE
0DCC 44               LSR A
0DCD 44               LSR A
0DCE 44               LSR A
0DCF 8B 30            ADD A #$30      CONVERT TO ASCII
0DD1 B7 0DB0 R        STA A ERMSB+1   SAVE
0DD4 B6 0DA2 R        LDA A ERNUM+1   GET ERROR#
0DD7 84 0F            AND A #$0F      MASK OUT LEFT NIBBLE
0DD9 8B 30            ADD A #$30      CONVERT TO ASCII
0DDB B7 0DB1 R        STA A ERMSB+2   SAVE
0DDE CE 0DB3 R        LDX   #ERMSC    POINT TO LNUM AREA
0DE1 B6 020F R        LDA A LNUM
0DE4 F6 0270 R        LDA B LNUM+1
0DE7 BD 0D5C R        JSR   CVBTD     CONVERT LNUM TO DECIMAL
0DEA CE 0DA3 R        LDX   #ERMSA    PRINT MESSAGE
0DED BD 1B61 R        JSR   PDATA1
0DF0 BD 0D3B R        JSR   OUTL7A    PRINT LAST PART OF LINE
0DF3 33               PUL B
0DF4 32               PUL A
0DF5 FE 0288 R        LDX   ECOUNT    BUMP ECOUNT
0DF8 08               INX
0DF9 FF 0288 R        STX   ECOUNT
0DFC FE 0DA1 R        LDX   ERNUM
0DFF 39               RTS
                    *          **ADDRESS TYPE 1**
                    *
                    * [ADC ADD AND BIT CMP EOR LDA ORA SBC SUB]
```

```
                    *
                    * IMMEDIATE (2 BYTES):
                    *   CCC A #NUMBER       CCC B #NUMBER
                    *   CCC A #SYMBOL       CCC B #SYMBOL
                    *   CCC A #EXPRESSION   CCC B #EXPRESSION
                    *   CCC A #'C           CCC B #'C
                    *
                    * DIRECT (2 BYTES) OR EXTENDED(3 BYTES):
                    *   CCC A NUMBER        CCC B NUMBER
                    *   CCC A SYMBOL        CCC B SYMBOL
                    *   CCC A EXPRESSION    CCC B EXPRESSION
                    *
                    * INDEXED (2 BYTES):
                    *   CCC A NUMBER,X      CCC B NUMBER,X
                    *   CCC A SYMBOL,X      CCC B SYMBOL,X
                    *   CCC A EXPRESSION,X  CCC B EXPRESSION,X
                    *
                    *
0E00 BD 1089 R ADDR1  JSR   ADRINT    INIT ADDRESS FIELD VALUES
0E03 BD 06F6 R        JSR   NXTOK     GET NEXT TOKEN
0E06 C1 0D            CMP B #$0D      EOL?
0E08 26 08            BNE   ADDR1B    NO
                    *
0E0A CE 0204    ADDR1A LDX  #$0204    ERROR
0E0D BD 0D8B R        JSR   PRINTE    PRINT
0E10 20 5B            BRA   ADDR1E    RETURN
                    *
0E12 BD 10B7 R ADDR1B JSR   ABRCK     CHECK FOR REGISTER A OR B
0E15 F6 10B4 R        LDA B ABR       NEITHER?
0E18 27 F0            BEQ   ADDR1A    YES ERROR
0E1A BD 06F6 R        JSR   NXTOK     GET NEXT TOKEN
0E1D C1 23            CMP B #$23      IMMED. MODE?
0E1F 26 14            BNE   ADDR1C    NO
0E21 73 10B5 R        COM   IMMED     SET IMMEDIATE FLAG
0E24 BD 06F6 R        JSR   NXTOK     GET NEXT TOKEN
0E27 C1 27            CMP B #$27      "'" ?
0E29 26 0A            BNE   ADDR1C    NO
                    *
0E2B FE 027E R        LDX   CUCHAR    GET NEXT CHAR
0E2E A6 00            LDA A 0,X
0E30 B7 0C69 R        STA A ADR2
0E33 20 0B            BRA   ADDR1K
                    *
0E35 BD 09B5 R ADDR1C JSR   NSEVL     EVALUATE OPERAND
0E38 BD 10D7 R        JSR   P2ERR     PRINT PASS 2 ERRORS
0E3B F6 10B5 R        LDA B IMMED     IMMEDIATE MODE?
0E3E 27 0C            BEQ   ADDR1D    NO
0E40 C6 80      ADDR1K LDA B #$80     IMMEDIATE FORM A
0E42 F7 1087 R        STA B ORBYA     NIBBLE
0E45 C6 C0            LDA B #$C0      OF
0E47 F7 1088 R        STA B ORBYB     MACHINE CODE
0E4A 20 3C            BRA   ADDR1H
                    *
0E4C BD 06F6 R ADDR1D JSR   NXTOK     GET NEXT TOKEN
0E4F BD 10C4 R        JSR   INXCK     INDEXED?
0E52 26 2A            BNE   ADDR1G    YES
                    *
0E54 7D 0278 R        TST   CMNFLG    COMMON?
0E57 26 0A            BNE   ADDR1L    YES
                    *
0E59 7D 0277 R        TST   RELFLG    RELOC ?
0E5C 26 05            BNE   ADDR1L    YES
                    *
0E5E F6 0C68 R        LDA B ADR1      DIRECT?
0E61 27 0F            BEQ   ADDR1F    YES
                    *
0E63 C6 B0      ADDR1L LDA B #$B0     EXTENDED,FORM A
0E65 F7 1087 R        STA B ORBYA     NIBBLE
0E68 C6 F0            LDA B #$F0      OF
0E6A F7 1088 R        STA B ORBYB     MACHINE CODE
                    *
0E6D BD 115E R ADDR1E JSR   LCNAB3    FORM MACHINE CODE
0E70 20 19            BRA   ADDR1J
                    *
0E72 C6 90      ADDR1F LDA B #$90     DIRECT,FORM A
0E74 F7 1087 R        STA B ORBYA     NIBBLE
0E77 C6 D0            LDA B #$D0      OF
0E79 F7 1088 R        STA B ORBYB     MACHINE CODE
0E7C 20 0A            BRA   ADDR1H
                    *
0E7E C6 A0      ADDR1G LDA B #$A0     INDEXED,FORM A
0E80 F7 1087 R        STA B ORBYA     NIBBLE OF
0E83 C6 E0            LDA B #$E0      OF
0E85 F7 1088 R        STA B ORBYB     MACHINE CODE
                    *
0E88 BD 1113 R ADDR1H JSR   LCNAB2    FORM MACHINE CODE
0E8B BD 11C2 R ADDR1J JSR   LCLCN     LC#=LC+LCN
0E8E 7E 0490 R        JMP   MAIN1     RETURN TO MAIN LOOP
                    *         **ADDRESS TYPE 2**
                    *
                    * [STA]
                    *
                    * DIRECT (2 BYTES) OR EXTENDED(3 BYTES)
```

```
                    *   CCC A NUMBER          CCC B NUMBER
                    *   CCC A SYMBOL          CCC B SYMBOL
                    *   CCC A EXPRESSION      CCC B EXPRESSION
                    *
                    * INDEXED(2 BYTES):
                    *   CCC A NUMBER,X        CCC B NUMBER,X
                    *   CCC A SYMBOL,X        CCC B SYMBOL,X
                    *   CCC A EXPRESSION,X    CCC B EXPRESSION,X
                    *
                    *
0E91 BD 1089 R ADDR2  JSR   ADRINT    INIT ADDRESS FIELD FLAGS
0E94 BD 06F6 R        JSR   NXTOK     GET NEXT TOKEN
0E97 C1 0D            CMP B #$0D      EOL?
0E99 26 08            BNE   ADDR2B    NO
                    *
0E9B CE 0204    ADDR2A LDX  #$0204    ERROR
0E9E BD 0DBB R         JSR  PRINTE    PRINT
0EA1 20 32             BRA  ADDR2E    RETURN
                    *
0EA3 BD 10B7 R ADDR2B JSR   ABRCK     CHECK FOR REGISTER A OR B
0EA6 F6 1084 R        LDA B ABR       NEITHER?
0EA9 27 F0            BEQ   ADDR2A    YES ERROR
0EAB BD 06F6 R        JSR   NXTOK     GET NEXT TOKEN
0EAE BD 0985 R        JSR   NSEVL     EVALUATE OPERAND
0EB1 BD 10D7 R        JSR   P2ERR     PRINT PASS 2 ERRORS
0EB4 BD 06F6 R        JSR   NXTOK     GET NEXT TOKEN
0EB7 BD 10C4 R        JSR   INXCK     INDEXED?
0EBA 26 2A            BNE   ADDR2G    YES
                    *
0EBC 7D 0278 R        TST   CMNFLG    COMMON?
0EBF 26 0A            BNE   ADDR2K    YES
                    *
0EC1 7D 0277 R        TST   RELFLG    RELOC ?
0EC4 26 05            BNE   ADDR2K    YES
                    *
0EC6 F6 0C68 R        LDA B ADR1      DIRECT?
0EC9 27 0F            BEQ   ADDR2F    YES
                    *
0ECB C6 B0      ADDR2K LDA B #$B0     EXTENDED,FORM A
0ECD F7 1087 R         STA B ORBYA    NIBBLE
0ED0 C6 F0             LDA B #$F0     OF
0ED2 F7 1088 R         STA B ORBYB    MACHINE CODE
                    *
0ED5 BD 115E R ADDR2E JSR   LCNAB3    FORM MACHINE CODE
0ED8 20 19            BRA   ADDR2J
                    *
0EDA C6 90      ADDR2F LDA B #$90     DIRECT,FORM A
0EDC F7 1087 R         STA B ORBYA    NIBBLE
0EDF C6 D0             LDA B #$D0     OF
0EE1 F7 1088 R         STA B ORBYB    MACHINE CODE
0EE4 20 0A             BRA   ADDR2H
                    *
0EE6 C6 A0      ADDR2G LDA B #$A0     INDEXED,FORM A
0EE8 F7 1087 R         STA B ORBYA    NIBBLE
0EEB C6 E0             LDA B #$E0     OF
0EED F7 1088 R         STA B ORBYB    MACHINE CODE
                    *
0EF0 BD 1113 R ADDR2H JSR   LCNAB2    FORM MACHINE CODE
0EF3 BD 11C2 R ADDR2J JSR   LCLCN     LC#=LC+LCN
0EF6 7E 0490 R        JMP   MAIN1     RETURN TO MAIN LOOP
                    *         **ADDRESS TYPE 3**
                    *
                    * (ASL ASR CLR COM DEC INC LSR NEG ROL ROR TST)
                    *
                    * ACCUMULATOR(1 BYTE):
                    *   CCC A
                    *   CCC B
                    *
                    * EXTENDED (3 BYTES):
                    *   CCC NUMBER
                    *   CCC SYMBOL
                    *   CCC EXPRESSION
                    *
                    * INDEXED(2 BYTES)
                    *   CCC NUMBER,X
                    *   CCC SYMBOL,X
                    *   CCC EXPRESSION,X
                    *
                    *
0EF9 BD 1089 R ADDR3  JSR   ADRINT    INIT ADDRESS FIELD FLAGS
0EFC BD 06F6 R        JSR   NXTOK     GET NEXT TOKEN
0EFF C1 0D            CMP B #$0D      EOL?
0F01 26 08            BNE   ADDR3B    NO
                    *
0F03 CE 0204           LDX  #$0204    ERROR
0F06 BD 0DBB R         JSR  PRINTE    PRINT
0F09 20 2A             BRA  ADDR3D    RETURN
                    *
0F0B BD 10B7 R ADDR3B JSR   ABRCK     CHECK FOR REGISTER A OR B
0F0E 7D 1084 R        TST   ABR       NEITHER?
0F11 27 0F            BEQ   ADDR3C    YES
```

```
                    *
0F13 C6 40          *       LDA B #$40      ACCUMULATOR,FORM A
0F15 F7 1087 R      *       STA B ORBYA     NIBBLE
0F18 C6 50          *       LDA B #$50      OF
0F1A F7 1088 R      *       STA B ORBYB     MACHINE CODE
0F1D BD 10EA R      *       JSR   LCNABI    FORM MACHINE CODE
0F20 20 20          *       BRA   ADDR3F
                    *
0F22 BD 0985 R ADDR3C JSR   NSEVL       EVALUATE OPERAND
0F25 BD 10D7 R      *       JSR   P2ERR     PRINT PASS 2 ERRORS
0F28 BD 06F6 R      *       JSR   NXTOK     GET NEXT TOKEN
0F2B BD 10C4 R      *       JSR   INXCK     INDEXED?
0F2E 26 0A          *       BNE   ADDR3E    YES
                    *
0F30 C6 70          *       LDA B #$70      EXTENDED,FORM A
0F32 F7 1087 R      *       STA B ORBYA     NIBBLE OF MACHINE CODE
                    *
0F35 BD 117C R ADDR3D JSR   LCN3        FORM MACHINE CODE
0F38 20 08          *       BRA   ADDR3F
                    *
0F3A C6 60          ADDR3E LDA B #$60       INDEXED,FORM A
0F3C F7 1087 R      *       STA B ORBYA     NIBBLE OF MACHINE CODE
0F3F BD 1131 R      *       JSR   LCN2      FORM MACHINE CODE
                    *
0F42 BD 11C2 R ADDR3F JSR   LCLCN       LC=LC+LCN
0F45 7E 0490 R      *       JMP   MAIN1     RETURN TO MAIN LOOP
                    *         **ADDRESS TYPE 4**
                    *
                    * [PSH PUL]
                    *
                    * ACCUMULATOR(1 BYTE):
                    *   PSH A
                    *   PSH B
                    *   PUL A
                    *   PUL B
                    *
                    *
0F48 BD 1089 R ADDR4  JSR   ADRINT      INIT ADDRESS FIELD FLAGS
0F4B BD 06F6 R      *       JSR   NXTOK     GET NEXT TOKEN
0F4E BD 1087 R      *       JSR   ABRCK     CHECK FOR A,B REGS
0F51 7D 1084 R      *       TST   ABR       NEITHER ?
0F54 26 06          *       BNE   ADDR4A    NO
                    *
0F56 CE 0204        *       LDX   #$0204    ERROR
0F59 BD 0DBB R      *       JSR   PRINTE
                    *
0F5C 7C 1088 R ADDR4A INC   ORBYB       ORBYB=01
0F5F BD 10EA R      *       JSR   LCNABI    FORM MC
0F62 BD 11C2 R      *       JSR   LCLCN     LC=LC+LCN
0F65 7E 0490 R      *       JMP   MAIN1     RETURN TO MAIN LOOP
                    *         **ADDRESS TYPE 5**
                    *
                    * [CPX LDS LDX]
                    *
                    * IMMEDIATE(3 BYTES):
                    *   CCC  #NUMBER
                    *   CCC  #SYMBOL
                    *   CCC  #EXPRESSION
                    *   CCC  #'CC
                    *
                    * DIRECT(2 BYTES) OR EXTENDED(3 BYTES):
                    *   CCC  NUMBER
                    *   CCC  SYMBOL
                    *   CCC  EXPRESSION
                    *
                    * INDEXED(2 BYTES)
                    *   CCC  NUMBER,X
                    *   CCC  SYMBOL,X
                    *   CCC  EXPRESSION,X
                    *
                    *
0F68 BD 1089 R ADDR5  JSR   ADRINT      INIT ADDRESS FIELD FLAGS
0F6B BD 06F6 R      *       JSR   NXTOK     GET NEXT TOKEN
0F6E C1 0D          *       CMP B #$0D      EOL?
0F70 26 08          *       BNE   ADDR5B    NO
                    *
0F72 CE 0240        ADDR5A LDX   #$0240      ERROR
0F75 BD 0DBB R      *       JSR   PRINTE    PRINT
0F78 20 46          *       BRA   ADDR5E    RETURN
                    *
0F7A C1 23          ADDR5B CMP B #$23       IMMEDIATE?
0F7C 26 19          *       BNE   ADDR5C    NO
0F7E 73 1085 R      *       COM   IMMED     SET IMMEDIATE FLAG
0F81 BD 06F6 R      *       JSR   NXTOK     GET NEXT TOKEN
0F84 C1 27          *       CMP B #$27      "'" ?
0F86 26 0F          *       BNE   ADDR5C    NO
                    *
0F88 FE 027E R      *       LDX   CUCHAR    YES, GET NEXT TWO CHARS
0F8B A6 00          *       LDA A 0,X
0F8D B7 0C68 R      *       STA A ADR1
0F90 A6 01          *       LDA A 1,X
0F92 B7 0C69 R      *       STA A ADR2
```

```
0F95 20 29            BRA   ADDR5E
                      *
0F97 BD 0985 R ADDR5C JSR   NSEVL     EVALUATE OPERAND
0F9A BD 10D7 R        JSR   P2ERR     PRINT PASS 2 ERRORS
0F9D F6 1085 R        LDA B IMMED     IMMEDIATE?
0FA0 27 02            BEQ   ADDR5D    NO
0FA2 20 1C            BRA   ADDR5E    YES
                      *
0FA4 BD 06F6 R ADDR5D JSR   NXTOK     GET NEXT TOKEN
0FA7 BD 10C4 R        JSR   INXCK     INDEXED?
0FAA 26 20            BNE   ADDR5G    YES
                      *
0FAC 7D 0278 R        TST   CMNFLG    COMMON?
0FAF 26 0A            BNE   ADDR5K    YES
                      *
0FB1 7D 0277 R        TST   RELFLG    RELOC ?
0FB4 26 05            BNE   ADDR5K    YES
                      *
0FB6 F6 0C08 R        LDA B ADR1      DIRECT?
0FB9 27 0A            BEQ   ADDR5F    YES
                      *
0FBB C6 30      ADDR5K LDA B #$30     EXTENDED,FORM A
0FBD F7 1087 R        STA B ORBYA     NIBBLE OF MACHINE CODE
0FC0 BD 117C R ADDR5E JSR   LCN3      FORM MACHINE CODE
0FC3 20 0F            BRA   ADDR5J
                      *
0FC5 C6 10      ADDR5F LDA B #$10     DIRECT,FORM A
0FC7 F7 1087 R        STA B ORBYA     NIBBLE OF MACHINE CODE
0FCA 20 05            BRA   ADDR5H
                      *
0FCC C6 20      ADDR5G LDA B #$20     INDEXED,FORM A
0FCE F7 1087 R        STA B ORBYA     NIBBLE OF MC
                      *
0FD1 BD 1131 R ADDR5H JSR   LCN2      FORM MC
0FD4 BD 11C2 R ADDR5J JSR   LCLCN     LC:=LC+LCN
0FD7 7E 0490 R        JMP   MAIN1     RETURN TO MAIN LOOP
                      *       **ADDRESS TYPE 6**
                      *
                      * [STX,STS]
                      *
                      * DIRECT(2 BYTES) OR EXTENDED(3 BYTES):
                      *   CCC  NUMBER
                      *   CCC  SYMBOL
                      *   CCC  EXPRESSION
                      *
                      * INDEXED(2 BYTES)
                      *   CCC  NUMBER,X
                      *   CCC  SYMBOL,X
                      *   CCC  EXPRESSION,X
                      *
0FDA BD 1089 R ADDR6  JSR   ADRINT    INIT ADDRESS FIELD FLAGS
0FDD BD 06F6 R        JSR   NXTOK     GET NEXT TOKEN
0FE0 C1 0D            CMP B #$0D      EOL?
0FE2 26 B3            BNE   ADDR5C    NO
0FE4 20 8C            BRA   ADDR5A    YES,ERROR
                      *       **ADDRESS TYPE 7**
                      * [JMP JSR]
                      *
                      *
                      * INDEXED(2 BYTES):
                      *   CCC  NUMBER,X
                      *   CCC  SYMBOL,X
                      *   CCC  EXPRESION,X
                      *
                      *
0FE6 BD 1089 R ADDR7  JSR   ADRINT    INIT ADDRESS FIELD FLAGS
0FE9 BD 06F6 R        JSR   NXTOK     GET NEXT TOKEN
0FEC C1 0D            CMP B #$0D      EOL?
0FEE 26 08            BNE   ADDR7A    NO
                      *
0FF0 CE 0204          LDX   #$0204    ERROR
0FF3 BD 0DBB R        JSR   PRINTE    PRINT
0FF6 20 0E            BRA   ADDR7B
                      *
0FF8 BD 0985 R ADDR7A JSR   NSEVL     EVALUATE OPERAND
0FFB BD 10D7 R        JSR   P2ERR     PRINT PASS 2 ERRORS
0FFE BD 06F6 R        JSR   NXTOK     GET NEXT TOKEN
1001 BD 10C4 R        JSR   INXCK     INDEXED?
1004 26 0A            BNE   ADDR7C    YES
                      *
1006 C6 10      ADDR7B LDA B #$10     EXTENDED,FORM A NIBBLE
1008 F7 1087 R        STA B ORBYA     OF MC
100B BD 117C R        JSR   LCN3      FORM MACHINE CODE
100E 20 03            BRA   ADDR7D
                      *
1010 BD 1131 R ADDR7C JSR   LCN2      FORM MACHINE CODE
1013 BD 11C2 R ADDR7D JSR   LCLCN     LC:=LC+LCN
1016 7E 0490 R        JMP   MAIN1     RETURN TO MAIN LOOP
                      *         **ADDRESS TYPE 8**
                      *
                      * [BCC BCS BEQ BGE BGT BHI BLE BLS
```

```
                    *  BLT BMI BNE BPL BRA BSR BVC BVS]
                    *
                    * RELATIVE(2 BYTES):
                    *   CCC  NUMBER
                    *   CCC  SYMBOL
                    *   CCC  EXPRESSION
                    *
                    *
1019 BD 1089 R ADDR8  JSR   ADRINT   INIT ADDRESS FIELD FLAGS
101C BD 06F6 R        JSR   NXTOK    GET NEXT TOKEN
101F C1 0D            CMP B #$0D     EOL?
1021 26 08            BNE   ADDR8A   NO
                    *
1023 CE 0204          LDX   #$0204   ERROR
1026 BD 0DBB R        JSR   PRINTE   PRINT
1029 20 36            BRA   ADDR8D
                    *
102B 7D 0275 R ADDR8A TST   PASS     PASS ?
102E 27 31            BEQ   ADDR8D   PASS1
                    *
1030 BD 09B5 R        JSR   NSEVL    PASS 2 EVAL OPERAND
1033 BD 10D7 R        JSR   P2ERR    PRINT PASS 2 ERRORS
1036 FE 0273 R        LDX   LC       LSAVE:=LC+2
1039 08               INX
103A 08               INX
103B FF 0285 R        STX   LSAVE
103E B6 0C69 R        LDA A ADR2     CALCULATE OFFSET
1041 F6 0C68 R        LDA B ADR1
1044 B0 0286 R        SUB A LSAVE+1
1047 F2 0285 R        SBC B LSAVE
                    *
104A C1 FF            CMP B #$FF     CHECK FOR OUT OF RANGE
104C 26 03            BNE   ADDR8E
104E 4D               TST A          NEGATIVE? (FF - 80)
104F 2B 0D            BMI   ADDR8C   OK
                    *
1051 C1 00      ADDR8E CMP B #$00
1053 26 03            BNE   ADDR8F   OUT OF RANGE
1055 4D               TST A          POSITIVE? (00 - 7F)
1056 2A 06            BPL   ADDR8C   OK
                    *
1058 CE 0208    ADDR8F LDX   #$0208   ERROR
105B BD 0DBB R     .  JSR   PRINTE   PRINT
                    *
105E B7 0C69 R ADDR8C STA A ADR2     SAVE OFFSET
1061 BD 1131 R ADDR8D JSR   LCN2     FORM MC
1064 BD 11C2 R        JSR   LCLCN    LC:=LC+LCN
1067 7E 0490 R        JMP   MAIN1    RETURN TO MAIN LOOP

                    *         *ADDRESS TYPE ***
                    *
                    * [ABA CBA CLC CLI CLV DES DEX INS
                    *  INX NOP RTI RTS SBA SEC SEI SEV
                    *  SWI TAB TAP TBA TPA TSX TXS WAI]
                    *
                    * INHERENT(1 BYTE):
                    * CCC
                    *
                    *
106A BD 1089 R ADDR9  JSR   ADRINT   INIT ADDRESS FIELD FLAGS
106D 7D 0275 R        TST   PASS     PASS ?
1070 27 05            BEQ   ADDR9A   PASS 1
                    *
1072 BD 1B2E R        JSR   OUTBIN   OUTPUT MC
                    *
1075 7C 0C65 R ADDR9A INC   MCOUNT   MCOUNT:=1
1078 7C 0234 R        INC   LCN      LCN:=1
107B BD 0C0E R        JSR   PRINTL
107E BD 11C2 R        JSR   LCLCN    LC:=LC+LCN
1081 7E 0490 R        JMP   MAIN1    RETURN TO MAIN LOOP

                    * ROUTINES USED TO INIT AND CHECK ADDRESS FIELD
                    * FLAGS,MC FORMS AND LISTING FLAGS.
                    *
1084 0001       ABR     RMB   1        REG A OR B FLAG
1085 0001       IMMED   RMB   1        IMMEDIATE MODE FLAG
1086 0001       INDEX   RMB   1        INDEX MODE FLAG
1087 0001       ORBYA   RMB   1        FORM FOR A NIBBLE OF MC
1088 0001       ORBYB   RMB   1        FORM FOR A NIBBLE OF MC
                    *
1089 7F 0234 R ADRINT CLR   LCN
108C 7F 0277 R        CLR   RELFLG
108F 7F 027B R        CLR   CMNFLG
1092 7F 0279 R        CLR   EXTFLG
1095 7F 027A R        CLR   ENTFLG
1098 7F 0C66 R        CLR   POP
109B F7 0C67 R        STA B OPCD     SAVE OPCODE
109E 7F 0C65 R        CLR   MCOUNT
10A1 7F 1084 R        CLR   ABR
10A4 7F 1085 R        CLR   IMMED
10A7 7F 1086 R        CLR   INDEX
10AA 7F 0C68 R        CLR   ADR1
10AD 7F 0C69 R        CLR   ADR2
```

```
10B0 7F 10B7 R        CLR   ORBYA
10B3 7F 10B8 R        CLR   ORBYB
10B6 39               RTS
                *
                *
                * CHECK FOR PRESENCE OF A OR B REG
                *
10B7 C1 41      ABRCK CMP B #$41      "A" ?
10B9 27 05            BEQ   ABRCKA    YES
10BB C1 42            CMP B #$42      "B" ?
10BD 27 01            BEQ   ABRCKA    YES
10BF 39               RTS             NEITHER, RETURN
                *
10C0 F7 10B4 R ABRCKA STA B ABR       SAVE REG
10C3 39               RTS
                *
                *
                *
                * CHECK FOR INDEXED MODE
                *
10C4 C1 2C      INXCK CMP B #$2C      "," ?
10C6 26 0B            BNE   INXCKR    NO
10C8 BD 06F6 R        JSR   NXTOK     GET NEXT TOKEN
10CB C1 58            CMP B #$58      "X" ?
10CD 26 04            BNE   INXCKR    NO
10CF 73 10B6 R        COM   INDEX     INDEX#=FF
10D2 39               RTS
                *
10D3 7F 10B6 R INXCKR CLR   INDEX
10D6 39               RTS
                *
                *
                * CHECK FOR PASS 2 ERRORS
                *
10D7 C1 FF      P2ERR CMP B #$FF      ERROR (FROM NSEVL)?
10D9 26 0E            BNE   P2ERRB    NO
                *
10DB 7D 0275 R        TST   PASS      YES,PASS?
10DE 27 03            BEQ   P2ERRA    PASS1
10E0 BD 0DBB R        JSR   PRINTE    PASS 2,PRINT ERROR
10E3 7F 0C68 R P2ERRA CLR   ADR1
10E6 73 0C68 R        COM   ADR1      ADR1#=FF (TO KILL DIRECT)
10E9 39         P2ERRB RTS
                * ROUTINES TO FINISH UP ADDRESS TYPE PROCESSING
                * THESE ROUTINES DO THE FOLLOWING#
                *   PASS 1
                *      A. LCN#= # OF BYTES IN THE INSTRUCTION
                *   PASS 2
                *      A. FORM COMPLETE OPCODE
                *      B. OUTPUT MACHINE CODE GENERATED
                *      C. PRINT A LINE OF LISTING
                *      D. LCN#= # OF BYTES IN THE INSTRUCTION
                *
                * LCNAB1 1 BYTE ACCUMULATOR INSTRUCTIONS
                *
10EA 7D 0275 R LCNAB1 TST   PASS      PASS?
10ED 27 20            BEQ   LNAB1S    PASS 1
                *
10EF F6 0C67 R        LDA B OPCD      PASS 2,LOAD PARTIAL OPCODE
                * EXTENDED (3 BYTES)#
                *   CCC  NUMBER
                *   CCC  SYMBOL
                *   CCC  EXPRESSION
10F2 B6 1084 R        LDA A ABR       A OR B ?
10F5 27 0F            BEQ   LNAB1C    NEITHER
                *
10F7 81 42            CMP A #$42      "B" ?
10F9 27 05            BEQ   LNAB1B    YES
10FB FA 10B7 R        ORA B ORBYA     A FORM COMPLETE OPCODE
10FE 20 03            BRA   LNAB1C
                *
1100 FA 10B8 R LNAB1B ORA B ORBYB     B FORM COMPLETE OPCODE
1103 F7 0C67 R LNAB1C STA B OPCD      SAVE
1106 BD 1B2E R LNAB1O JSR   OUTBIN    OUTPUT OPCODE
1109 7C 0C65 R        INC   MCOUNT    MCOUNT#=1
110C BD 0C0E R        JSR   PRINTL    PRINT A LINE OF LISTING
110F 7C 02B4 R LNAB1S INC   LCN       LCN=1
1112 39               RTS             RETURN
                *
                *
                * LCNAB2 2 BYTE REGISTER (A,B)#INDEXED,
                *  DIRECT, AND IMMEDIATE TYPE INSTRUCTIONS
                *
1113 7D 0275 R LCNAB2 TST   PASS      PASS ?
1116 27 3F            BEQ   LCN2B     PASS 1
                *
1118 F6 0C67 R        LDA B OPCD      PASS 2,GET PARTIAL OPCODE
111B B6 10B4 R        LDA A ABR       A OR B ?
111E 27 25            BEQ   LCN2A     NEITHER
                *
1120 81 42            CMP A #$42      B ?
1122 27 05            BEQ   LNB2      YES
```

```
1124 FA 1087 R          ORA B ORBYA     A, FORM COMPLETE OPCODE
1127 20 03              BRA   LNAB2S
                *
1129 FA 1088 R LNB2     ORA B ORBYB     B, FORM COMPLETE OPCODE
112C F7 0C67 R LNAB2S   STA B OPCD      SAVE
112F 20 14              BRA   LCN2A     FINISH UP
                *
                *
                * LCN2 2 BYTE INDEXED,DIRECT,AND IMMEDIATE TYPE
                *  INSTRUCTIONS
                *
1131 7D 0275 R LCN2     TST   PASS      PASS ?
1134 27 21              BEQ   LCN2B     PASS 1
                *
1136 7F 0277 R          CLR   RELFLG
1139 7F 0278 R          CLR   CMNFLG
113C F6 0C67 R          LDA B OPCD      PASS 2,GET PARTIAL OPCODE
113F FA 1087 R          ORA B ORBYA     FORM COMPLETE OPCODE
1142 F7 0C67 R          STA B OPCD      SAVE
                *
1145 BD 182E R LCN2A    JSR   OUTBIN    OUTPUT OPCODE
1148 F6 0C69 R          LDA B ADR2      GET ADDRESS PART OF MC
114B BD 182E R          JSR   OUTBIN    OUTPUT IT
114E 7C 0C65 R          INC   MCOUNT    MCOUNT:=2
1151 7C 0C65 R          INC   MCOUNT
1154 BD 0C0E R          JSR   PRINTL    PRINT A LINE OF LISTING
                *
1157 7C 0284 R LCN2B    INC   LCN       LCN:=2
115A 7C 0284 R          INC   LCN
115D 39                 RTS             RETURN
                *
                *
                * LCNAB3 3 BYTE REGISTER(A,B):EXTENDED TYPE
                *   INSTRUCTIONS
                *
115E 7D 0275 R LCNAB3   TST   PASS      PASS ?
1161 27 55              BEQ   LCN3B     PASS 1
                *
1163 F6 0C67 R          LDA B OPCD      PASS 2 GET PARTIAL OPCODE
1166 B6 1084 R          LDA A ABR       A OR B ?
1169 27 1F              BEQ   LCN3A     NEITHER
116B 81 42              CMP A #$42      B ?
116D 27 05              BEQ   LNB3      YES
116F FA 1087 R          ORA B ORBYA     A, FORM COMPLETE OPCODE
1172 20 03              BRA   LNAB3S
                *
1174 FA 1088 R LNB3     ORA B ORBYB     B, FORM COMPLETE OPCODE
1177 F7 0C67 R LNAB3S   STA B OPCD      SAVE
117A 20 0E              BRA   LCN3A     FINISH UP
                *
                *
                * LCN3 3 BYTE EXTENDED AND IMMEDIATE TYPE
                *  INSTRUCTIONS
                *
117C 7D 0275 R LCN3     TST   PASS      PASS ?
117F 27 37              BEQ   LCN3B     PASS 1
                *
1181 F6 0C67 R          LDA B OPCD      GET PARTIAL OPCODE
1184 FA 1087 R          ORA B ORBYA     FORM COMPLETE OPCODE
1187 F7 0C67 R          STA B OPCD      SAVE
                *
118A BD 182E R LCN3A    JSR   OUTBIN    OUTPUT OPCODE
118D F6 0C66 R          LDA B ADR1      OUTPUT THE REST OF THE MC
1190 BD 182E R          JSR   OUTBIN
1193 F6 0C69 R          LDA B ADR2
1196 BD 182E R          JSR   OUTBIN
                *
1199 7D 0278 R          TST   CMNFLG    COMMON?
119C 27 04              BEQ *+6         NO
                *
119E C6 4D              LDA B #'M       "COMMON"
11A0 20 07              BRA LCN3C
                *
11A2 7D 0277 R          TST   RELFLG    RELOC ?
11A5 27 05              BEQ   *+7       NO
                *
11A7 C6 52              LDA B #$52      LOAD "R"
11A9 BD 1842 R LCN3C    JSR   OUTBNR
                *
11AC 7C 0C65 R          INC   MCOUNT    MCOUNT:=3
11AF 7C 0C65 R          INC   MCOUNT
11B2 7C 0C65 R          INC   MCOUNT
11B5 BD 0C0E R          JSR   PRINTL    PRINT A LINE OF LISTING
                *
11B8 7C 0284 R LCN3B    INC   LCN       LCN:=3
11BB 7C 0284 R          INC   LCN
11BE 7C 0284 R          INC   LCN
11C1 39                 RTS             RETURN
                *
                *
                * LCLCN LC:=LC+LCN
                *
```

```
11C2 B6 0274 R LCLCN  LDA A LC+1
11C5 F6 0273 R        LDA B LC
11C8 BB 02d4 R        ADD A LCN       ADD LCN
11CB C9 00            ADC B #$00
11CD B7 0274 R        STA A LC+1      SAVE LC
11D0 F7 0273 R        STA B LC
11D3 39               RTS             RETURN
                    * POCMN: ALLOCATE COMMON STORAGE AREAS
                    *
11D4 BD 1039 R POCMN  JSR ADRINT
11D7 BD 181A R        JSR LBLCK
                    *
11DA BD 06F6 R        JSR NXTOK       GET SYMBOL NAME
11DD C1 01            CMP B #1        OK?
11DF 27 08            BEQ POCMN2      YES
                    *
11E1 CE 0216  POCMNO  LDX #$0216      ERROR
11E4 BD 0DBB R POCMN1 JSR PRINTE
11E7 20 55            BRA POCMN4
                    *
11E9 7D 0275 R POCMN2 TST PASS        PASS ?
11EC 26 41            BNE POCMN3      PASS 2
                    *
11EE BD 07F8 R        JSR STOSYM      ENTER NAME IN SYMTAB
11F1 FE 0282 R        LDX SYMPTR
11F4 FF 124C R        STX CMNXS       SAVE ENTRY ADDRESS
                    *
11F7 BD 06F6 R        JSR NXTOK       GET DELIM.
11FA C1 2C            CMP B #$2C      "," ?
11FC 26 E3            BNE POCMNO      NO
                    *
11FE BD 06F6 R        JSR NXTOK       POINT TO OPERAND
1201 BD 0985 R        JSR NSEVL       GET VALUE
1204 C1 FF            CMP B #$FF      OK?
1206 27 DC            BEQ POCMN1      NO
                    *
1208 FE 124C R        LDX CMNXS       POINT TO ENTRY
120b 86 BF            LDA A #$BF
120D A4 08            AND A 8,X       TURN OFF REL BIT
120F 8A 10            ORA A #$10      TURN ON COMMON BIT
1211 A7 08            STA A 8,X
                    *
1213 B6 0313 R        LDA A CMNLC     GET COMMON LC
1216 A7 06            STA A 6,X       STORE IN ENTRY
1218 B6 0314 R        LDA A CMNLC+1
121B A7 07            STA A 7,X
                    *
                    * CMNLC:=CMNLC+[ADR1,ADR2]
                    *
121D B6 0C69 R        LDA A ADR2
1220 F6 0C68 R        LDA B ADR1
1223 BB 0314 R        ADD A CMNLC+1
1226 F9 0313 R        ADC B CMNLC
1229 B7 0314 R        STA A CMNLC+1
122C F7 0313 R        STA B CMNLC
                    *
122F BD 0857 R POCMN3 JSR LKPSYM      LOOK UP SYMBOL
1232 FE 0282 R        LDX SYMPTR      POINT TO ENTRY
1235 EE 06            LDX 6,X         GET COMMON ADDRESS
1237 FF 0C68 R        STX ADR1        SET UP FOR PRINTL
123A 73 0C66 R        COM POP
123D 73 0278 R        COM CMNFLG
1240 7C 0C65 R        INC MCOUNT
1243 7C 0C65 R        INC MCOUNT
                    *
1246 BD 0C0E R POCMN4 JSR PRINTL
1249 7E 0490 R        JMP MAIN1

                    *
124C 0002       CMNXS  RMB 2
                    * POEND: PROCESS END PSEUDOP
                    *
124E BD 1039 R POEND  JSR   ADRINT    INIT FLAGS
1251 BD 181A R        JSR   LBLCK     CHECK FOR A LABEL
1254 7D 0275 R POEND0 TST   PASS      PASS ?
1257 26 0F            BNE   POEND2    PASS2
                    *
1259 FE 0273 R        LDX   LC        PASS1
125C FF 0271 R        STX   TSTPH     TSTPH:=LC
125F 73 0275 R        COM   PASS      PASS:=PASS2
                    *
1262 BD 025F R        JSR   RESTR     REWIND INPUT FILE
                    *
1265 7E 0467 R        JMP   PASS2     EXECUTE PASS2
                    *
1268 FE 0271 R POEND2 LDX TSTPH       PHASING ERRORS?
126b BC 0273 R        CPX   LC
126E 27 06            BEQ   ENDP2     NO
                    *
1270 CE 0220          LDX   #$0220
1273 BD 0DBB R        JSR   PRINTE    PRINT ERROR
                    *
```

```
1276 B6 026E R ENDP2  LDA A OPTNS
1279 85 80            BIT A #$80      LISTING?
127B 26 06            BNE   ENDP3     NO
                *
127D BD 0C0E R        JSR   PRINTL
1280 BD 13BE R        JSR CRLF
                *
1283 B6 026E R ENDP3  LDA A OPTNS
1286 85 20            BIT A #$20      LIST SYMTAB?
1288 27 03            BEQ SORT1       YES
                *
128A 7E 134D R        JMP ENDP6       NO
                *
128D CE 13C8 R SORT1  LDX #ZZZ        INIT SORT
1290 FF 13D1 R        STX CBLOCK
1293 7F 13D5 R        CLR SORTF       CLEAR SORT FLAG
1296 FE 0268 R        LDX SYMTAB      POINT TO TABLE
1299 20 09            BRA SORT3
                *
129B 08         SORT2 INX
129C 08               INX
129D 08               INX
129E 08               INX
129F 08               INX
12A0 08               INX
12A1 08               INX
12A2 08               INX
12A3 08               INX
                *
12A4 BC 026C R SORT3  CPX SYMEND      AT TABLE END?
12A7 26 0B            BNE SORT2A      NO
                *
12A9 7D 13D5 R        TST SORTF       FOUND AN ENTRY?
12AC 27 03            BEQ *+5
                *
12AE 7E 12EB R        JMP SORT5       PRINT ENTRY
12B1 7E 134D R        JMP ENDP6       ALL DONE
                *
12B4 E6 00      SORT2A LDA B 0,X
12B6 C1 20            CMP B #$20      BLANK?
12B8 27 E1            BEQ SORT2       YES, GET NEXT ENTRY
                *
12BA E6 08            LDA B 8,X
12BC C1 FF            CMP B #$FF      USED ENTRY?
12BE 27 DB            BEQ SORT2       YES
                *
                * COMPARE ENTRY AT CBLOCK WITH NEW ENTRY
                *
12C0 FF 13D3 R        STX CXS2        SET UP FOR COMPARISON
12C3 FF 07E5 R        STX PSTNG2
12C6 FE 13D1 R        LDX CBLOCK
12C9 FF 07E3 R        STX PSTNG1
12CC C6 06            LDA B #6
12CE F7 07E7 R        STA B PCOUNT
12D1 CE 07E3 R        LDX #PSTNG1
12D4 BD 06C5 R        JSR COMPAR
12D7 22 05            BHI SORT4       NEED SWITCH
                *
12D9 FE 13D3 R        LDX CXS2
12DC 20 BD            BRA SORT2
                *
12DE FE 13D3 R SORT4  LDX CXS2        NEW CBLOCK PTRS
12E1 FF 13D1 R        STX CBLOCK
12E4 C6 FF            LDA B #$FF
12E6 F7 13D5 R        STA B SORTF     SET SORT FLAG
12E9 20 B0            BRA SORT2
                *
12EB BD 0C2A R SORT5  JSR LINCK
12EE C6 06            LDA B #6
12F0 FE 13D1 R        LDX CBLOCK
                *
12F3 A6 00      ENDP4 LDA A 0,X       GET CHAR
12F5 BD 1888 R        JSR   OUTCHR    PRINT
12F8 08               INX             POINT TO NEXT CHAR
12F9 5A               DEC B           DECREMENT COUNT
12FA 26 F7            BNE   ENDP4     NOT DONE
                *
12FC 86 20            LDA A #$20      PRINT BLANK
12FE BD 1888 R        JSR   OUTCHR
1301 BD 1871 R        JSR   OUT4HS    PRINT 4 HEX LOCATION
1304 FF 13D6 R        STX ENDXS
1307 E6 00            LDA B 0,X
1309 C5 40            BIT B #$40      RELOC ?
130B 27 05            BEQ   *+7       NO
                *
130D 86 52            LDA A #$52      LOAD "R"
130F BD 1888 R        JSR   OUTCHR    PRINT IT
                *
1312 C5 20            BIT B #$20      MACRO NAME?
1314 27 05            BEQ   *+7       NO
                *
1316 86 4D            LDA A #'M       LOAD M
```

```
1318 BD 1888 R          JSR   OUTCHR     PRINT IT
                        *
131B C5 10              BIT B #$10       COMMON?
131D 27 05              BEQ *+7          NO
                        *
131F 86 43              LDA A #'C
1321 BD 1888 R          JSR OUTCHR
                        *
1324 C5 08              BIT B #$08       EXTERNAL?
1326 27 05              BEQ *+7          NO
                        *
1328 86 58              LDA A #'X
132A BD 1888 R          JSR OUTCHR
                        *
132D C5 04              BIT B #$04       ENTRY?
132F 27 05              BEQ *+7
                        *
1331 86 4E              LDA A #'N
1333 BD 1888 R          JSR OUTCHR
                        *
1336 E6 00              LDA B 0,X        REDEFINED?
1338 2A 06              BPL   ENDP5      NO
                        *
133A CE 138A R          LDX   #REDEF     PRINT ERROR MESSAGE
133D BD 1861 R          JSR   PDATA1
                        *
1340 FE 13D6 R ENDP5    LDX ENDXS
1343 C6 FF              LDA B #$FF       SET DONE
1345 E7 00              STA B 0,X
1347 BD 13BE R          JSR CRLF
134A 7E 128D R          JMP SORT1
                        *
                        *
134D BD 13BE R ENDP6    JSR CRLF
1350 BD 13BE R          JSR CRLF
1353 CE 13A1 R          LDX   #ENDMB     PRINT # OF ERRORS MSG
1356 B6 0288 R          LDA A ECOUNT
1359 F6 0289 R          LDA B ECOUNT+1
135C BD 0D5C R          JSR   CVBTD      CONVERT TO ASCII
135F CE 1395 R          LDX   #ENDMA
1362 BD 1861 R          JSR   PDATA1     PRINT IT
                        *
1365 BD 13BE R          JSR CRLF
1368 BD 13BE R          JSR CRLF
                        *
136B CE 13AE R          LDX #CMSG        COMMON AREA MESSAGE
136E BD 1861 R          JSR PDATA1
                        *
1371 CE 0313 R          LDX #CMNLC       POINT TO COMMON LENGTH
1374 BD 1871 R          JSR OUT4HS
1377 BD 13BE R          JSR CRLF
                        *
137A B6 026E R          LDA A OPTNS
137D 85 40              BIT A #$40       OBJECT?
137F 26 06              BNE ENDP7        NO
                        *
1381 BD 0259 R ENDP6A   JSR WREOF        WRITE EOF NULLS
1384 7E 024D R          JMP UPDATE       CLOSE FILE AND EXIT TO MONTOR
                        *
1387 7E 0250 R ENDP7    JMP MONTOR
                        *
138A 20        REDEF    FCC   ' REDEFINED'
1394 04                 FCB   $04        EOT
                        *
1395 54        ENDMA    FCC   'THERE WERE: '
13A1 0005      ENDMB    RMB   5
13A6 20                 FCC   ' ERRORS'
13AD 04                 FCB   4
                        *
13AE 43        CMSG     FCC 'COMMON LENGTH= '
13BD 04                 FCB 4
                        *
                        *
13BE CE 13C5 R CRLF     LDX #MCRLF
13C1 BD 1861 R          JSR PDATA1
13C4 39                 RTS
                        *
                        *
13C5 0D0A      MCRLF    FDB   $0D0A      CR,LF
13C7 04                 FCB   $04        EOT
                        *
13C8 58        ZZZ      FCC 'XXXXXX'
13CE 0000               FDB 0000
13D0 00                 FCB 0
13D1 0002      CBLOCK   RMB 2
13D3 0002      CXS2     RMB 2
13D5 0001      SORTF    RMB 1
13D6 0002      ENDXS    RMB 2
                        * POENT: PROCESS "ENTRY" PSEUDOP
                        *        DEFINES AN ENTRY POINT FOR
                        *        REFERENCE BY OTHER MODULES.
                        *
13D8 BD 1D69 R POENT    JSR ADRINT       INIT
```

```
13D5 BD 161A R          JSR LBLCK       CHECK FOR A LABEL
                        *
13D8 BD 00F6 R          JSR NXTOK       GET ENTRY NAME
13E1 C1 01              CMP B #1        OK?
13E3 27 08              BEQ POENT1      YES
                        *
13E5 CE 0216            LDX #$0216      NO, ERROR
13E8 BD 0D3B R          JSR PRINTE
13EB 20 39              BRA POENT3
                        *
13ED 7D 0275 R POENT1   TST PASS        PASS?
13F0 27 43              BEQ POENT4      PASS 1
                        *
13F2 BD 0857 R          JSR LKPSYM      GET ENTRY ADDRESS
13F5 C1 FF              CMP B #$FF      IN SYMTAB?
13F7 26 08              BNE POENT2      YES
                        *
13F9 CE 0211            LDX #$0211      NO,ERROR
13FC BD 0D3B R          JSR PRINTE
13FF 20 25              BRA POENT3
                        *
1401 FF 0C68 R POENT2   STX ADR1        SAVE ENTRY ADDRESS
1404 FE 0282 R          LDX SYMPTR      POINT TO ENTRY
1407 A6 08              LDA A 8,X       GET INFO BYTE
1409 8A 04              ORA A #$04      TURN ON ENT BIT
140B A7 08              STA A 8,X
                        *
140D BD 1438 R          JSR PBLOCK      OUTPUT LABEL
1410 F6 0C68 R          LDA B ADR1      OUTPUT ENTRY ADDRESS
1413 BD 182E R          JSR OUTBIN
1416 F6 0C69 R          LDA B ADR2
1419 BD 182E R          JSR OUTBIN
141C C6 52              LDA B #'R       "RELOCATABLE"
141E BD 1842 R          JSR OUTBNR
1421 C6 4E              LDA B #'N       "ENT"
1423 BD 1842 R          JSR OUTBNR
                        *
1426 73 0C66 R POENT3   COM POP
1429 73 027A R          COM ENTFLG
142C 7C 0C65 R          INC MCOUNT
142F 7C 0C65 R          INC MCOUNT
1432 BD 0C0E R          JSR PRINTL
1435 7E 0490 R POENT4   JMP MAIN1       ALL DONE
                        *
                        *
                        * PBLOCK: ROUTINE TO WRITE LOADER ENTRY SYMBOL ON TAPE
                        *
1438 FE 0282 R PBLOCK   LDX SYMPTR      PT TO ENTRY SYMBOL
143B 86 06              LDA A #6        LENGTH
                        *
143D E6 00      PBLK2   LDA B 0,X       GET A CHAR
143F 36                 PSH A
1440 FF 144F R          STX PBXS
1443 BD 182E R          JSR OUTBIN
1446 32                 PUL A
1447 FE 144F R          LDX PBXS
144A 08                 INX
144B 4A                 DEC A           ALL DONE?
144C 26 EF              BNE PBLK2       NO
                        *
144E 39                 RTS
                        *
144F 0002       PBXS    RMB 2
                        * POEQU: PROCESS EQU PSEUDOP
                        *
1451 BD 1039 R POEQU    JSR   ADRINT    INIT ADDRESS FIELD FLAGS
1454 FE 0282 R          LDX   SYMPTR
1457 FF 14AD R          STX   EQUXS     SAVE SYMPTR
145A 7D 0276 R          TST   LBFLG     LABEL?
145D 26 08              BNE   EQUB       YES
                        *
145F CE 0213            LDX   #$0213    NO, ERROR
1462 BD 0D3B R EQUA     JSR   PRINTE    PRINT ERROR
1465 20 40              BRA   EQUE
                        *
1467 BD 00F6 R EQUB     JSR   NXTOK     GET NEXT TOKEN
146A C1 0D              CMP B #$0D      EOL?
146C 26 05              BNE   EQUC      NO
                        *
146E CE 0216            LDX   #$0216    ERROR
1471 20 EF              BRA   EQUA
                        *
1473 BD 09B5 R EQUC     JSR   NSEVL     EVALUATE OPERAND
1476 C1 FF              CMP B #$FF      ERRORS?
1478 27 E8              BEQ   EQUA      YES
                        *
147A 7D 0275 R          TST   PASS      PASS?
147D 26 1F              BNE   EQUD      PASS2
                        *
147F FE 14AD R          LDX   EQUXS
1482 A6 08              LDA A 8,X       GET INFO BYTE
1484 7D 0277 R          TST   RELFLG    RELOC ?
1487 26 09              BNE   EQUF      YES
```

```
                        *
1489 84 BF              AND A #$BF      NO, TURN OFF IN INFO BYTE
                        *
148B 7D 0278 R          TST   CMNFLG    COMMON?
148E 27 02              BEQ   EQUF       NO
                        *
1490 8A 10              ORA A #$10      YES TURN ON IN INFO BYTE
                        *
1492 A7 08      EQUF    STA A 8,X
1494 B6 0C69 R          LDA A ADR2      STORE VALUE
1497 A7 07              STA A 7,X
1499 B6 0C68 R          LDA A ADR1
149C A7 06              STA A 6,X
                        *
149E 73 0C66 R EQUD     COM   POP       SET PSEUDOP FLAG
14A1 7C 0C65 R          INC   MCOUNT    MCOUNT:=2
14A4 7C 0C65 R          INC   MCOUNT
                        *
14A7 BD 0C0E R EQUE     JSR   PRINTL    PRINT A LINE OF LISTING
14AA 7E 0490 R          JMP   MAIN1     RETURN TO MAIN LOOP
                        *
14AD 0002       EQUXS   RMB   2         SAVE AREA
                        * POEXT: PROCESS "EXTERNAL" PSEUDOP
                        *         MAKE EXTERNALLY-DEFINED SUBROUTINE
                        *         AVAILABLE TO MODULE
                        *
14AF BD 1089 R POEXT    JSR ADRINT      INIT
14B2 BD 161A R          JSR LBLCK       CHECK FOR A LABEL
                        *
14B5 BD 06F6 R          JSR NXTOK       GET EXTERNAL ENTRY NAME
14B8 C1 01              CMP B #1        OK?
14BA 27 0B              BEQ POEXT1      YES
                        *
14BC CE 0216            LDX #$0216      NO, ERROR
14BF BD 0DBB R          JSR PRINTE
14C2 BD 0C0E R          JSR PRINTL
14C5 20 47              BRA POEXT4
                        *
14C7 7C 0284 R POEXT1   INC LCN
14CA 7C 0284 R          INC LCN
14CD 7C 0284 R          INC LCN
                        *
14D0 7D 0275 R          TST PASS        PASS?
14D3 26 0E              BNE POEXT2      PASS 2
                        *
14D5 BD 07F8 R          JSR STOSYM      PUT NAME IN SYMBOL TABLE
14D8 FE 0282 R          LDX SYMPTR
14DB A6 08              LDA A 8,X
14DD 8A 08              ORA A #$08      SET EXT BIT
14DF A7 08              STA A 8,X
14E1 20 28              BRA POEXT3
                        *
14E3 C6 7E      POEXT2  LDA B #$7E      "JMP"
14E5 F7 0C67 R          STA B OPCD
14E8 BD 182E R          JSR OUTBIN
14EB BD 0857 R          JSR LKPSYM      SET UP ENTRY NAME
14EE BD 1438 R          JSR PBLOCK      OUTPUT NAME
14F1 C6 58              LDA B #'X       "EXT"
14F3 BD 1842 R          JSR OUTBNR
14F6 7F 0C68 R          CLR ADR1
14F9 7F 0C69 R          CLR ADR2
14FC 7C 0C65 R          INC MCOUNT
14FF 7C 0C65 R          INC MCOUNT
1502 7C 0C65 R          INC MCOUNT
1505 73 0279 R          COM EXTFLG
1508 BD 0C0E R          JSR PRINTL
                        *
150B BD 11C2 R POEXT3   JSR LCLCN
150E 7E 0490 R POEXT4   JMP MAIN1       ALL DONE
                        * POFCB: PROCESS FCB PSEUDOP
                        *
1511 BD 1089 R POFCB    JSR   ADRINT    INIT ADDRESS FIELD FLAGS
1514 BD 06F6 R          JSR   NXTOK     GET NEXT TOKEN
1517 C1 0D              CMP B #$0D      EOL?
1519 26 08              BNE   FCBB      NO
                        *
151B CE 0216    FCBA    LDX   #$0216    ERROR
151E BD 0DBB R          JSR   PRINTE    PRINT
1521 20 1A              BRA   FCBC      FINISH UP
                        *
1523 BD 09B5 R FCBB     JSR   NSEVL     EVALUATE OPERAND
1526 BD 10D7 R          JSR   P2ERR     PRINT PASS  ERRORS
1529 7C 0284 R          INC   LCN       LCN:=1
152C 7D 0275 R          TST   PASS      PASS?
152F 27 0F              BEQ   FCBD      PASS1
                        *
1531 F6 0C69 R          LDA B ADR2      PASS2, OUTPUT MC
1534 BD 182E R          JSR   OUTBIN
1537 7C 0C65 R          INC   MCOUNT    MCOUNT:=1
153A 7C 0C66 R          INC   POP       POP:=1
                        *
153D BD 0C0E R FCBC     JSR   PRINTL    PRINT A LINE OF LISTING
```

```
1540 BD 11C2 R FCBD   JSR   LCLCN     LC:=LC+LCN
1543 7E 0490 R        JMP   MAIN1     RETURN TO MAIN LOOP
                  * POFCC: PROCESS FCC PSEUDOP
                  *
1546 BD 1089 R POFCC  JSR   ADRINT    INIT ADDRESS FIELD FLAGS
1549 BD 06F6 R        JSR   NXTOK     GET NEXT TOKEN
154C C1 27            CMP B #$27      QUOTE ?
154E 27 08            BEQ   FCCB      YES
                  *
1550 CE 0204   FCCA   LDX   #$0204    ERROR
1553 BD 0DBB R        JSR   PRINTE    PRINT
1556 20 3C            BRA   FCCG      FINISH UP
                  *
1558 FE 027E R FCCB   LDX   CUCHAR    GET CURRENT CHAR
155B E6 00            LDA B 0,X
155D C1 0D            CMP B #$0D      EOL ?
155F 27 EF            BEQ   FCCA      YES
1561 F7 0C69 R        STA B ADR2      NO,SAVE CHAR
                  *
1564 7D 0275 R FCCC   TST   PASS      PASS ?
1567 27 03            BEQ   FCCD      PASS1
1569 BD 182E R        JSR   OUTBIN    OUTPUT MC
156C FE 027E R FCCD   LDX   CUCHAR    CUCHAR:=CUCHAR+1
156F 08               INX
1570 FF 027E R        STX   CUCHAR
1573 7C 0284 R        INC   LCN       LCN:=LCN+1
1576 E6 00            LDA B 0,X       GET CHAR
1578 C1 27            CMP B #$27      QUOTE?
157A 27 06            BEQ   FCCE      YES
                  *
157C C1 0D            CMP B #$0D      EOL?
157E 26 E4            BNE   FCCC      NO
1580 20 0C            BRA   FCCF      YES
                  *
1582 E6 01     FCCE   LDA B 1,X       GET NEXT CHAR
1584 C1 27            CMP B #$27      TWO QUOTES ?
1586 26 06            BNE   FCCF      NO
1588 08               INX
1589 FF 027E R        STX   CUCHAR    CUCHAR:=CUCHAR+1
158C 20 D6            BRA   FCCC
                  *
158E 7C 0C66 R FCCF   INC   POP       POP:=1
1591 7C 0C65 R        INC   MCOUNT    MCOUNT:=1
                  *
1594 BD 0C0E R FCCG   JSR   PRINTL    PRINT LINE OF LISTING
1597 BD 11C2 R        JSR   LCLCN     LC:=LC+LCN
159A 7E 0490 R        JMP   MAIN1     RETURN TO MAIN LOOP
                  * POFDB: PROCESS FDB PSEUDOP
                  *
159D BD 1089 R POFDB  JSR   ADRINT    INIT ADDRESS FIELD FLAGS
15A0 BD 06F6 R        JSR   NXTOK     GET NEXT TOKEN
15A3 C1 0D            CMP B #$0D      EOL?
15A5 26 08            BNE   FDBB      NO
                  *
15A7 CE 0216   FDBA   LDX   #$0216    ERROR
15AA BD 0DBB R        JSR   PRINTE    PRINT
15AD 20 39            BRA   FDBC      FINISH UP
                  *
15AF BD 09B5 R FDBB   JSR   NSEVL     EVALUATE OPERAND
15B2 BD 10D7 R        JSR   P2ERR     PRINT PASS 2 ERRORS
                  *
15B5 7C 0284 R        INC   LCN       LCN:=2
15B8 7C 0284 R        INC   LCN
15BB 7D 0275 R        TST   PASS      PASS?
15BE 27 2B            BEQ   FDBD      PASS1
                  *
15C0 F6 0C68 R        LDA B ADR1      OUTPUT MC
15C3 BD 182E R        JSR   OUTBIN
15C6 F6 0C69 R        LDA B ADR2
15C9 BD 182E R        JSR   OUTBIN
15CC 7D 0277 R        TST   RELFLG    RELOC ?
15CF 27 04            BEQ   FDCF      NO
                  *
15D1 C6 52            LDA B #'R       YES
15D3 20 07            BRA   FDCG
                  *
15D5 7D 0278 R FDCF   TST CMNFLG       COMMON?
15D8 27 05            BEQ FDCE        NO
                  *
15DA C6 4D            LDA B #'M       YES
                  *
15DC BD 1842 R FDCG   JSR   OUTBNR    OUTPUT "R" OR "M"
15DF 7C 0C65 R FDCE   INC   MCOUNT    MCOUNT:=2
15E2 7C 0C65 R        INC   MCOUNT
15E5 73 0C66 R        COM   POP       POP:=FF
                  *
15E8 BD 0C0E R FDBC   JSR   PRINTL     PRINT A LINE OF LISTING
15EB BD 11C2 R FDBD   JSR   LCLCN     LC:=LC+LCN
15EE 7E 0490 R        JMP   MAIN1     RETURN TO MAIN LOOP
                  * PROCESS THE IF PSEUDOP
                  *
```

```
15F1 BD 1089 R POIF   JSR ADRINT
15F4 BD 181A R        JSR LBLCK
15F7 BD 06F6 R        JSR NXTOK
15FA C1 0D            CMP B #$0D      EOL?
15FC 26 08            BNE POIFB       NO
                      *
15FE CE 0216  POIFA   LDX #$0216
1601 BD 0DBB R        JSR PRINTE
1604 20 23            BRA POIFE
                      *
1606 BD 09B5 R POIFB  JSR NSEVL       EVALUATE OPERAND
1609 C1 FF            CMP B #$FF      ERRORS?
160B 27 F1            BEQ POIFA       YES
                      *
160D BD 176A R        JSR PSHIF       STACK PRESENT IFFLG
1610 7D 0377 R        TST IFFLG       ASSEMBLING?
1613 27 14            BEQ POIFE       NO
                      *
1615 7D 0C68 R        TST ADR1        =0?
1618 26 0A            BNE POIFC       NO
                      *
161A 7D 0C69 R        TST ADR2        =0?
161D 26 05            BNE POIFC       NO
                      *
161F 7F 0377 R        CLR IFFLG       TURN OFF ASSEMBLING
1622 20 05            BRA POIFE
                      *
1624 86 FF    POIFC   LDA A #$FF      TURN ON ASSEMBLING
1626 B7 0377 R        STA A IFFLG
                      *
1629 BD 0C0E R POIFE  JSR PRINTL
162C 7E 0490 R        JMP MAIN1
                      * PROCESS THE MAC PSEUDOP
                      *
162F 0001     CMFLG   RMB 1           COMMENT FLAG 0=NO,FF=YES
1630 0001     MACERR  RMB 1           MAC ERROR 0=NO,FF=YES
                      *
1631 BD 1089 R POMAC  JSR   ADRINT     INIT FLAGS
1634 BD 0C0E R        JSR   PRINTL
1637 7F 162F R        CLR   CMFLG
163A 7F 1630 R        CLR   MACERR
163D 7D 0275 R        TST   PASS        PASS?
1640 26 30            BNE   POMAC2      PASS2
                      *
1642 7D 0276 R        TST   LBFLG       LABELED?
1645 26 0B            BNE   POMAC1      YES,OK
                      *
1647 73 1630 R        COM   MACERR      SET ERROR FLAG
164A CE 0226          LDX   #$0226      ERROR
164D BD 0DBB R        JSR   PRINTE
1650 20 20            BRA   POMAC2
                      *
1652 FE 0282 R POMAC1 LDX   SYMPTR      PT TO LABEL
1655 86 20            LDA A #$20
1657 A7 08            STA A 8,X         SET MACRO FLAG IN SYMTAB
1659 B6 030D R        LDA A MACPTR
165C A7 06            STA A 6,X         SAVE MACRO LOC
165E B6 030E R        LDA A MACPTR+1
1661 A7 07            STA A 7,X
                      *
1663 BD 06F6 R        JSR   NXTOK       CHECK FOR "C"
1666 FE 027B R        LDX   DESCRA
1669 A6 00            LDA A 0,X
166B 81 43            CMP A #'C         "C"?
166D 26 03            BNE   *+5         NO
                      *
166F 73 162F R        COM   CMFLG       YES,SAVE COMMENTS
                      *
1672 BD 0576 R POMAC2 JSR   RDLINA      GET NEXT LINE
1675 FE 026F R        LDX   LNUM
1678 08               INX
1679 FF 026F R        STX   LNUM
167C BD 0C0E R        JSR   PRINTL
167F FE 0280 R        LDX   CULINE      PT TO LINE
1682 A6 00            LDA A 0,X         GET FIRST CHAR
1684 81 2A            CMP A #'*         COMMENT?
1686 26 0A            BNE   POMAC5      NO
                      *
1688 7D 162F R        TST   CMFLG       SAVE COMMENTS?
168B 27 E5            BEQ   POMAC2      NO
                      *
168D BD 16E6 R        JSR   MACMOV      YES, SAVE
                      *
1690 20 E0            BRA   POMAC2
                      *
1692 7F 0276 R POMAC5 CLR   LBFLG       CLEAR LABEL FLAG
1695 FE 0280 R        LDX   CULINE      PT TO LINE
1698 A6 00            LDA A 0,X         GET CHAR
169A 81 20            CMP A #$20        BLANK?
169C 27 06            BEQ   POMAC6      YES
                      *
169E BD 06F6 R        JSR   NXTOK       GET LABEL
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16A1 73 0276 R          COM   LBFLG      SET LABEL FLAG
                        *
16A4 BD 00F6 R POMAC6   JSR   NXTOK      GET MNEMONIC
16A7 86 04              LDA A #4         SET FOR COMPARE
16A9 B7 07E7 R          STA A PCOUNT
16AC FE 027B R          LDX   DESCRA
16AF FF 07E3 R          STX   PSTNG1
16B2 CE 1722 R          LDX   #MEND
16B5 FF 07E5 R          STX   PSTNG2
16B8 CE 07E3 R          LDX   #PSTNG1    POINT TO PARMS
16BB BD 06C5 R          JSR   COMPAR     COMPARE
16BE 26 0D              BNE   POMAC8     MEND NOT FOUND
                        *
16C0 7D 0276 R          TST   LBFLG      LABELED?
16C3 27 0E              BEQ   POMAC7     YES
                        *
16C5 CE 0227            LDX   #$0227     ERROR
16C8 BD 0DBB R          JSR   PRINTE
16CB 20 06              BRA   POMAC7
                        *
16CD BD 16E6 R POMAC8   JSR   MACMOV     PUT INTO MACTBL
16D0 7E 1672 R          JMP   POMAC2
                        *
16D3 7D 0275 R POMAC7   TST   PASS       PASS?
16D6 26 0B              BNE   POMACA     PASS2
                        *
16D8 86 17              LDA A #$17       ETB TO END OF MACRO
16DA FE 030D R          LDX   MACPTR
16DD A7 00              STA A 0,X
16DF 08                 INX
16E0 FF 030D R          STX   MACPTR
                        *
16E3 7E 0490 R POMACA   JMP   MAIN1      ALL DONE
                        *
                        * MOVE MACRO TO MACTBL
                        *
16E6 7D 0275 R MACMOV   TST   PASS       PASS?
16E9 26 36              BNE   MACMVE     PASS2
                        *
16EB 7D 1630 R          TST   MACERR     ERROR?
16EE 26 31              BNE   MACMVE     YES
                        *
16F0 FE 0280 R          LDX   CULINE
16F3 FF 027E R          STX   CUCHAR
                        *
16F6 FE 027E R MACLOP   LDX   CUCHAR     GET CHAR FOM INBUF
16F9 A6 00              LDA A 0,X
16FB 08                 INX
16FC FF 027E R          STX   CUCHAR
16FF FE 030D R          LDX   MACPTR     POINT TO MACTBL
1702 BC 0264 R          CPX   MACEND     FULL?
1705 26 10              BNE   MACMV1     NO
                        *
1707 86 0D              LDA A #$0D       CR TO MACTBL
1709 A7 00              STA A 0,X
170B 08                 INX
170C FF 030D R          STX   MACPTR
                        *
170F CE 0228            LDX   #$0228     ERROR
1712 BD 0DBB R          JSR   PRINTE
1715 20 0A              BRA   MACMVE
                        *
1717 A7 00      MACMV1  STA A 0,X        STORE CHAR IN MACTBL
1719 08                 INX
171A FF 030D R          STX   MACPTR
171D 81 0D              CMP A #$0D       EOL?
171F 26 D5              BNE   MACLOP     NO
                        *
1721 39         MACMVE  RTS              ALL DONE
                        *
1722 4D         MEND    FCC   /MEND/
                        * PONAM: PROCESS NAM PSEUDOP
                        *
1726 BD 1089 R PONAM    JSR ADRINT
1729 BD 181A R          JSR LBLCK
                        *
172C BD 06F6 R          JSR NXTOK        GET PROGRAM NAME
172F C1 01              CMP B #1         OK ?
1731 27 09              BEQ PONAM1       YES
                        *
1733 CE 0216            LDX #$0216       ERROR
1736 BD 0DBB R          JSR PRINTE
1739 7E 1426 R          JMP POENT3
                        *
173C 7D 0275 R PONAM1   TST PASS         PASS?
173F 26 06              BNE PONAM2       PASS 2
                        *
1741 BD 07F8 R          JSR STOSYM       SAVE NAME IN SYMTAB
1744 7E 13ED R          JMP POENT1
                        *
1747 F6 0313 R PONAM2   LDA B CMNLC       OUTPUT COMMON BLOCK SIZE
174A BD 182E R          JSR OUTBIN
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174D F6 0314 R          LDA B CMNLC+1
1750 BD 182E R          JSR OUTBIN
                        *
1753 C6 50              LDA B #'P       "PROGRAM"
1755 BD 1842 R          JSR OUTBNR
                        *
1758 7E 13ED R          JMP POENTI      PROCESS AS ENTRY NAME
                      * PONIF: PROCESS NIF PSEUDOP
                        *
175B BD 1089 R PONIF    JSR ADRINT
175E BD 181A R          JSR LBLCK
1761 BD 177E R          JSR PULIF       GET LAST IFFLG
1764 BD 0C0E R          JSR PRINTL
1767 7E 0490 R          JMP MAINI
                        *
                        *
                      * PSHIF: PUSH THE CURRENT IFFLG ONTO THE IFSTACK
                        *
176A BF 028C R PSHIF    STS STKSAV      SAVE STACK POINTER
176D FE 0375 R          LDX @IFSTK      LOAD IF STACK POINTER
1770 8C 036D R          CPX #IFSTK-8    FULL?
1773 27 1D              BEQ PSPLER      YES
                        *
1775 BE 0375 R          LDS @IFSTK      LOAD STACK POINTER
1778 B6 0377 R          LDA A IFFLG
177B 36                 PSH A           STACK IFFLG
177C 20 1B              BRA PSPLCM
                        *
                      * PULIF: PULL LAST IFFLG OFF OF THE IFSTACK
                        *
177E BF 028C R PULIF    STS STKSAV      SAVE STACK POINTER
1781 FE 0375 R          LDX @IFSTK      LOAD IF STACK POINTER
1784 8C 0375 R          CPX #IFSTK      UNDERFLOW?
1787 27 09              BEQ PSPLER      YES
                        *
1789 BE 0375 R          LDS @IFSTK      LOAD STACK POINTER
178C 32                 PUL A           POP LAST IFFLG
178D B7 0377 R          STA A IFFLG
1790 20 07              BRA PSPLCM
                        *
1792 CE 0254  PSPLER    LDX #$0254
1795 BD 0DBB R          JSR PRINTE
1798 39                 RTS
                        *
1799 BF 0375 R PSPLCM   STS @IFSTK
179C BE 028C R          LDS STKSAV
179F 39                 RTS
                      * POPAG: PROCESS PAG PSEUDOP
                        *
17A0 BD 1089 R POPAG    JSR   ADRINT    INIT FLAGS
17A3 BD 181A R          JSR   LBLCK     CHECK FOR LABEL
17A6 7D 0275 R          TST   PASS      PASS ?
17A9 27 13              BEQ   PAGEND    PASS 1
                        *
17AB F6 0287 R          LDA B LCOUNT    LCOUNT=0?
17AE 27 0E              BEQ   PAGEND    YES
                        *
17B0 C6 3C              LDA B #$3C      B:=60
17B2 F0 0287 R          SUB B LCOUNT    B:=60-LCOUNT
                        *
17B5 BD 13BE R PAGEA    JSR CRLF
17B8 5A                 DEC B           TO
17B9 26 FA              BNE   PAGEA     TOP OF PAGE
17BB 7F 0287 R          CLR   LCOUNT    LCOUNT:=0
17BE 7E 0490 R PAGEND   JMP   MAINI     RETURN TO MAIN LOOP
                      * PORMB: PROCESS RMB PSEUDOP
                        *
17C1 BD 1089 R PORMB    JSR   ADRINT    INIT ADDRESS FIELD FLAGS
17C4 BD 05F6 R          JSR   NXTOK     GET NEXT TOKEN
17C7 C1 0D              CMP B #$0D      EOL?
17C9 26 08              BNE   RMBB       NO
                        *
17CB CE 0216            LDX   #$0216    ERROR
17CE BD 0DBB R RMBA     JSR   PRINTE    PRINT
17D1 20 1B              BRA   RMBC      FINISH UP
                        *
17D3 BD 0985 R RMBB     JSR   NSEVL     EVALUATE OPERAND
17D6 C1 FF              CMP B #$FF      ERRORS?
17D8 27 F4              BEQ   RMBA      YES
                        *
17DA 7D 0275 R          TST   PASS      PASS?
17DD 27 0F              BEQ   RMBD      PASS1
                        *
17DF BD 1803 R          JSR   RMBOUT    OUTPUT MC
17E2 7C 0C65 R          INC   MCOUNT    MCOUNT:=2
17E5 7C 0C65 R          INC   MCOUNT
17E8 73 0C66 R          COM   POP       SET PSEUDOP FLAG
                        *
17EB BD 0C0E R RMBC     JSR   PRINTL    PRINT A LINE OF LISTING
17EE B6 0274 R RMBD     LDA A LC+1      LC:=LC+ADR1,ADR2
17F1 F6 0273 R          LDA B LC
17F4 BB 0C69 R          ADD A ADR2
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17F7 F9 0C68 R          ADC B ADR1
17FA B7 0274 R          STA A LC+1
17FD F7 0273 R          STA B LC
1800 7E 0490 R          JMP   MAIN1     RETURN TO MAIN LOOP
                        *
                        *
1803 5F         RMBOUT  CLR B           LOAD 00
1804 FE 0C68 R          LDX   ADR1      LSAVE:=#BYTES FROM RMB
1807 FF 0285 R          STX   LSAVE
                        *
180A BD 182E R  RMBOTA  JSR   OUTBIN    OUTPUT MC
180D FE 0285 R          LDX   LSAVE
1810 09                 DEX
1811 27 06              BEQ   RMBOTB    DONE
                        *
1813 FF 0285 R          STX   LSAVE
1816 5F                 CLR B
1817 20 F1              BRA   RMBOTA    DO AGAIN
                        *
1819 39         RMBOTB  RTS             RETURN
                        * LBLCK: CHECK FOR A AN ILLEGAL LABEL ON A
                        *         PSEUDOP. IF THERE IS ONE DELETE IT,
                        *         AND PRINT AN ERROR MESSAGE.
                        *
181A 7D 0276 R  LBLCK   TST   LBFLG     LABEL?
181D 27 0E              BEQ   LBLCK2    NO
                        *
181F 7D 0275 R          TST   PASS      PASS?
1822 26 03              BNE   LBLCK1    PASS2
                        *
1824 BD 08AB R          JSR   DELSYM    PASS1 DELETE LAST SYMBOL
                        *
1827 CE 0223    LBLCK1  LDX   #$0223    ERROR
182A BD 0DBB R          JSR   PRINTE    PRINT
                        *
182D 39         LBLCK2  RTS             RETURN
                        * OUTBIN: OUTPUT A BYTE AS TWO HEX ASCII CHARACTERS
                        * OUTBNR: OUTPUT "R", "N", OR "X"
                        *
182E B6 026E R  OUTBIN  LDA A OPTNS
1831 85 40              BIT A #$40      OUTPUT?
1833 26 0C              BNE OUTRET      NO
                        *
1835 17                 TBA
1836 8D 16              BSR   OUTHL     CONVERT LEFT NIBBLE
1838 BD 0256 R          JSR OUTB
183B 17                 TBA
183C 8D 14              BSR   OUTHR     CONVERT RIGHT NIBBLE
183E BD 0256 R          JSR OUTB
1841 39         OUTRET  RTS
                        *
                        *
1842 B6 026E R  OUTBNR  LDA A OPTNS
1845 85 40              BIT A #$40      OUTPUT?
1847 26 F8              BNE OUTRET      NO
                        *
1849 17                 TBA
184A BD 0256 R          JSR OUTB
184D 39                 RTS
                        *
                        *
184E 44         OUTHL   LSR A
184F 44                 LSR A
1850 44                 LSR A
1851 44                 LSR A
1852 84 0F      OUTHR   AND A #$0F
1854 8B 30              ADD A #$30
1856 81 39              CMP A #$39
1858 23 02              BLS   *+4
185A 8B 07              ADD A #$07
185C 39                 RTS
                        * ASSORTED I/O ROUTINES
                        *
185D BD 1888 R  PDATA2  JSR OUTCHR
1860 08                 INX
1861 A6 00      PDATA1  LDA A 0,X
1863 81 04              CMP A #4
1865 26 F6              BNE PDATA2
1867 39                 RTS
                        *
1868 A6 00      OUT2H   LDA A 0,X
186A BD 0E      OUT2HA  BSR OUTHLL
186C A6 00              LDA A 0,X
186E 08                 INX
186F 20 0D              BRA OUTHRR
                        *
1871 8D F5      OUT4HS  BSR OUT2H
1873 8D F3      OUT2HS  BSR OUT2H
1875 86 20      OUTS    LDA A #$20
1877 7E 1888 R          JMP OUTCHR
                        *
187A 44         OUTHLL  LSR A
187B 44                 LSR A
187C 44                 LSR A
187D 44                 LSR A
                        *
187E 84 0F      OUTHRR  AND A #$0F
1880 8B 30              ADD A #$30
1882 81 39              CMP A #$39
1884 23 02              BLS OUTCHR
                        *
1886 8B 07              ADD A #$07
                        *
1888 36         OUTCHR  PSH A
1889 BD 038B R          JSR OUTEEE
188C 32                 PUL A
188D 81 0A              CMP A #$0A      LF?
188F 26 0E              BNE OUTCHE      NO
                        *
1891 36                 PSH A
1892 37                 PSH B
1893 C6 08              LDA B #8
                        *
1895 86 00      OUTCHL  LDA A #$00
1897 BD 038B R          JSR OUTEEE
189A 5A                 DEC B
189B 26 F8              BNE OUTCHL
                        *
189D 33                 PUL B
189E 32                 PUL A
189F 39         OUTCHE  RTS
                        *
                        END
```

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@IFSTK 0375 R
ABR    10d4 R
ABRCK  10B7 R
ABRCKA 10C0 R
ADD16  0bEC R
ADDR1  0E00 R
ADDR1A 0E0A R
ADDR1B 0E12 R
ADDR1C 0E3b R
ADDR1D 0E4C R
ADDR1E 0E6D R
ADDR1F 0E72 R
ADDR1G 0E7E R
ADDR1H 0E88 R
ADDR1J 0E8b R
ADDR1K 0E40 R
ADDR1L 0E63 R
ADDR2  0E91 R
ADDR2A 0E9B R
ADDR2B 0EA3 R
ADDR2E 0ED5 R
ADDR2F 0EDA R
ADDR2G 0EE6 R
ADDR2H 0EF0 R
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ADDR4A 0F5C R
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ADDR5K 0FBB R
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ADDR7  0FE6 R
ADDR7A 0FF8 R
ADDR7B 1006 R
ADDR7C 1010 R
ADDR7D 1013 R
ADDR8  1019 R
ADDR8A 102B R
ADDR8C 105E R
ADDR8D 1061 R
ADDR8E 1051 R
ADDR8F 105d R
ADDR9  106A R
ADDR9A 1075 R
ADR1   0C6d R
ADR2   0C69 R
ADRINT 1089 R
ASM    0000 RN
BLANK  0D53 R
BLANK3 0D5d R
BLANK5 0D5d R
BLANK6 0D59 R
CBLOCK 13D1 R
CDONE  06F1 R
CHPTR  07DF R
CHRTAB 020A R
CLASS  09B3 R
CLFLG  09B2 R
CMFLG  162F R
CMNFLG 027d R
CMNLC  0313 R
CMNXS  124C R
CMP1   06CC R
CMP2   06DC R
CMP3   06EE R
CMSG   13AE R
COMPAR 06C5 R
CRLF   13BE RN
CUCHAR 027E R
CULINE 0280 R
CVBTD  0D5C R
CVDB   0B2A R
CVDB1  0B43 R
CVDB2  0B47 R
CVDEC1 0D62 R
CVDEC2 0D65 R
CVDEC5 0D70 R
CVHB   0ACE R
CVHB1  0AJB R
CVHBD  0B14 R
CVHBS  0B1B R
CXS2   13D3 R
DCOUNT 0B25 R
DEL1   08B2 R
DELSYM 08AB R
DESCRA 027B R
DESCRC 027D R
DIV151 0BB1 R
DIV153 0BBC R
DIV16  0BA1 R
DIV163 0BC6 R
DIV165 0BD3 R
DIV167 0BD4 R
DSCAN  075C R
DVAL   0B23 R
DXSAV  0B2B R
ECOUNT 0286 R
ENDMA  1395 R
ENDMB  13A1 R
ENDP2  1276 R
ENDP3  1283 R
ENDP4  12F3 R
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ENDP7  13B7 R
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ENDXS  13D6 R
ENSIZ  093E R
ENTFLG 027A R
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EQUD   149E R
EQUE   14A7 R
EQUF   1492 R
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ERMSA  0DA3 R
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ERMSC  0DB3 R
ERNUM  0DA1 R
EXTFLG 0279 R
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FCBB   1523 R
FCBC   153D R
FCBD   1540 R
FCCA   1550 R
FCCB   1558 R
FCCC   1564 R
FCCD   156C R
FCCE   1582 R
FCCF   158E R
FCCG   1594 R
FDBA   15A7 R
FDBB   15AF R
FDBC   15E8 R
FDBD   15EB R
FDCE   15DF R
FDCF   15D5 R
FDCG   15DC R
GCHRTB 07C3 R
GCHRTR 07DD R
GETB   0253 RX
HASH   0889 R
HASH1  08D4 R
HEADR  0C4B R
HKEYA  07F0 R
HKEYB  07F2 R
HSAV1  07F4 R
HSAV2  07F6 R
HSCAN  0798 R
HSCAN1 07A1 R
HSMBL  07EA R
HVAL   0ACC R
IFFLG  0377 R
IFSTK  0375 R
IMMED  1085 R
INDEX  1086 R
INEEE  0388 RN
INITIO 025C RX
INLINE 0315 R
INXCK  10C4 R
INXCKR 10D3 R
IP     093D R
KIOK   0D92 R
LBFLG  0276 R
LBLCK  181A R
LBLCK1 1827 R
LBLCK2 182D R
LC     0273 R
LCLCN  1FC2 R
LCN    0284 R
LCN2   1131 R
LCN2A  1145 R
LCN2B  1157 R
LCN3   117C R
LCN3A  116A R
LCN3B  11B6 R
LCN3C  11A9 R
LCNAB1 10EA R
LCNAB2 1113 R
LCNAB3 115E R
LCOUNT 0287 R
LINCK  0C2A R
LINCKA 0C3b R
LINCKB 0C42 R
LINEN  0C6A R
LKPSM1 085D R
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LNAB1B 1100 R
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LNAB1S 110F R
LNAB2S 112C R
LNAB3S 1177 R
LNB2   1129 R
LNB3   1174 R
LNUM   026F R
LP     093B R
LSAVE  0285 R
MACEND 0264 R
MACERR 1630 R
MACFLG 030C R
MACLIN 0292 R
MACLOP 16F6 R
MACMOV 16E6 R
MACMV1 1717 R
MACMVE 1721 R
MACPAR 02DA R
MACPSH 0637 R
MACPTR 030D R
MACPUL 069B R
MACSAV 030F R
MACSTK 0266 R
MACTBL 0262 R
MAIN1  0490 R
MAIN10 0544 R
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MAIN9  053C R
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MNLKPB 095B R
MNMI   09A6 R
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MP     093C R
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MPSH3  0665 R
MPSH5  0685 R
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MPUL2  06B4 R
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MXSAV2 0290 R
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NXT5   073C R
NXT6   0744 R
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NXTOK  06F6 R
OPCD   0C67 R
OPERN  09B4 R
OPIN   0391 R
OPIN1  039D R
OPIN2  03C2 R
OPIN3  03CA R
OPTMSG 0378 R
OPTNS  026E R
ORBYA  1087 R
ORBYB  1088 R
OUT2H  1668 R
OUT2HA 166A R
OUT2HS 1873 R
OUT4HS 1871 R
OUTB   02b6 RX
OUTBIN 182E R
OUTBNR 1842 R
OUTCHE 189F R
OUTCHL 1895 R
OUTCHR 1886 R
OUTEEE 033B R
OUTHL  184E R
OUTHLL 187A R
OUTHR  1852 R
OUTHRR 187E R
OUTL   0C71 R
OUTL1  0CC2 R
OUTL2  0CD0 R
OUTL3  0CDD R
OUTL4  0CEF R
OUTL5  0D01 R
OUTL6  0D07 R
OUTL6A 0D2B R
OUTL6B 0D2D R
OUTL7  0D3d R
OUTL7A 0D35 R
OUTLA  0CA5 R
OUTRET 1841 R
OUTS   1875 R
P2ERR  10D7 R
P2ERRA 10E3 R
P2ERRB 10E9 R
PAGEA  17B5 R
PAGEND 17BE R
PASS   0275 R
PASS1  038E R
PASS2  0407 R
PBLK2  143D R
PBLOCK 1438 R
PBXS   144F R
PCOUNT 07E7 R
PDATA1 1861 RN
PDATA2 185D R
PLEND  0C29 R
POCMN  11D4 R
POCMN0 11E1 R
POCMN1 11E4 R
POCMN2 11E9 R
POCMN3 122F R
POCMN4 1246 R
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POEND0  1254 R
POEND2  1266 R
POENT   13D8 R
POENT1  13ED R
POENT2  1401 R
POENT3  1426 R
POENT4  1435 R
POEQU   1451 R
POEXT   14AF R
POEXT1  14C7 R
POEXT2  14E3 R
POEXT3  150B R
POEXT4  150E R
POFCB   1511 R
POFCC   1546 R
POFDB   159D R
POIF    15F1 R
POIFA   15FE R
POIFB   1606 R
POIFC   1624 R
POIFE   1629 R
POMAC   1631 R
POMAC1  1652 R
POMAC2  1672 R
POMAC5  1692 R
POMAC6  16A4 R
POMAC7  16D3 R
POMAC8  16CD R
POMACA  16E3 R
PONAM   1726 R
PONAM1  173C R
PONAM2  1747 R
PONIF   175B R
POP     0C66 R
POPAG   17A0 R
PORMB   17C1 R
PRINT1  0C23 R
PRINTE  0DBB R
PRINTL  0C0E R
PSHIF   176A R
PSPLCM  1799 R
PSPLER  1792 R
PSTNG1  07E3 R
PSTNG2  07E5 R
PULIF   177E R
RDL1    057F R
RDL1A   058A R
RDL2    059C R
RDL3    05A0 R
RDLINA  0576 R
RDLINE  0568 R
RDMAC   05A5 R
RDMAC0  05B8 R
RDMAC1  05B9 R
RDMAC2  05C5 R
RDMAC3  05E5 R
RDMAC4  05F3 R
RDMAC5  060A R
RDMAC6  05F0 R
RDMAC7  05FE R
RDMERR  062B R
REDEF   133A R
RELFLG  0277 R
RESTR   025F RX
RMBA    17CE R
RMBB    17D3 R
RMBC    17EB R
RMBD    17EE R
RMBOTA  180A R
RMBOTB  1819 R
RMBOUT  1803 R
SAVEA   0D9C R
SAVEX   0D9D R
SAVEX1  0D9F R
SORT1   128D R
SORT2   129B R
SORT2A  12B4 R
SORT3   12A4 R
SORT4   12DE R
SORT5   12EB R
SORTF   13D5 R
SPACER  0C44 R
STKSAV  028C R
STOSYM  07F8 R
SUB16   08FD R
SYM1    080F R
SYMA    07FE R
SYMB    0833 R
SYMB1   0844 R
SYMC    0848 R
SYMCMP  087E R
SYMEND  026C R
SYMMOD  0893 R
SYMPTR  0282 R
SYMTAB  0268 R
TABLES  024A RX
TBADD   07E8 R
TENVL   0826 R
TMPVAL  09B0 R
TSTPH   0271 R
UPDATE  024D RX
VALUE   09AE R
WREOF   0259 RX
XSAV    06F4 R
ZZZ     13C8 R
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PRINT,ASMD*1

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APPENDIX H

ASCII Text Listing of the Relocatable Format Object Code for RA6800ML

The listing below gives the relocatable format object code of the relocatable macro assembler RA6800ML in ASCII text form. This listing can be used to either enter the program by hand or to verify the entry of the program via the bar codes given in Appendix I. Note that the ends of lines in this verification listing *do not* represent line feed or carriage return codes within the machine readable text.

The relocatable file of the macro assembler can be run through the relocatable linking loader LINK68, available as the PAPERBYTE™ publication *LINK68: Linking Loader for the Motorola M6800* by Robert Grappel and Jack Hemenway (ISBN 0-931718-09-0), in order to reposition RA6800ML at an arbitrary, more convenient address if low memory is not the ideal location in the user's system. This form of the Assembler object code will not be needed by users who can employ the absolute object code version of RA6800ML given in Appendices D or E without further relocation.

Appendix G gives an assembly language source listing for RA6800ML.

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APPENDIX I

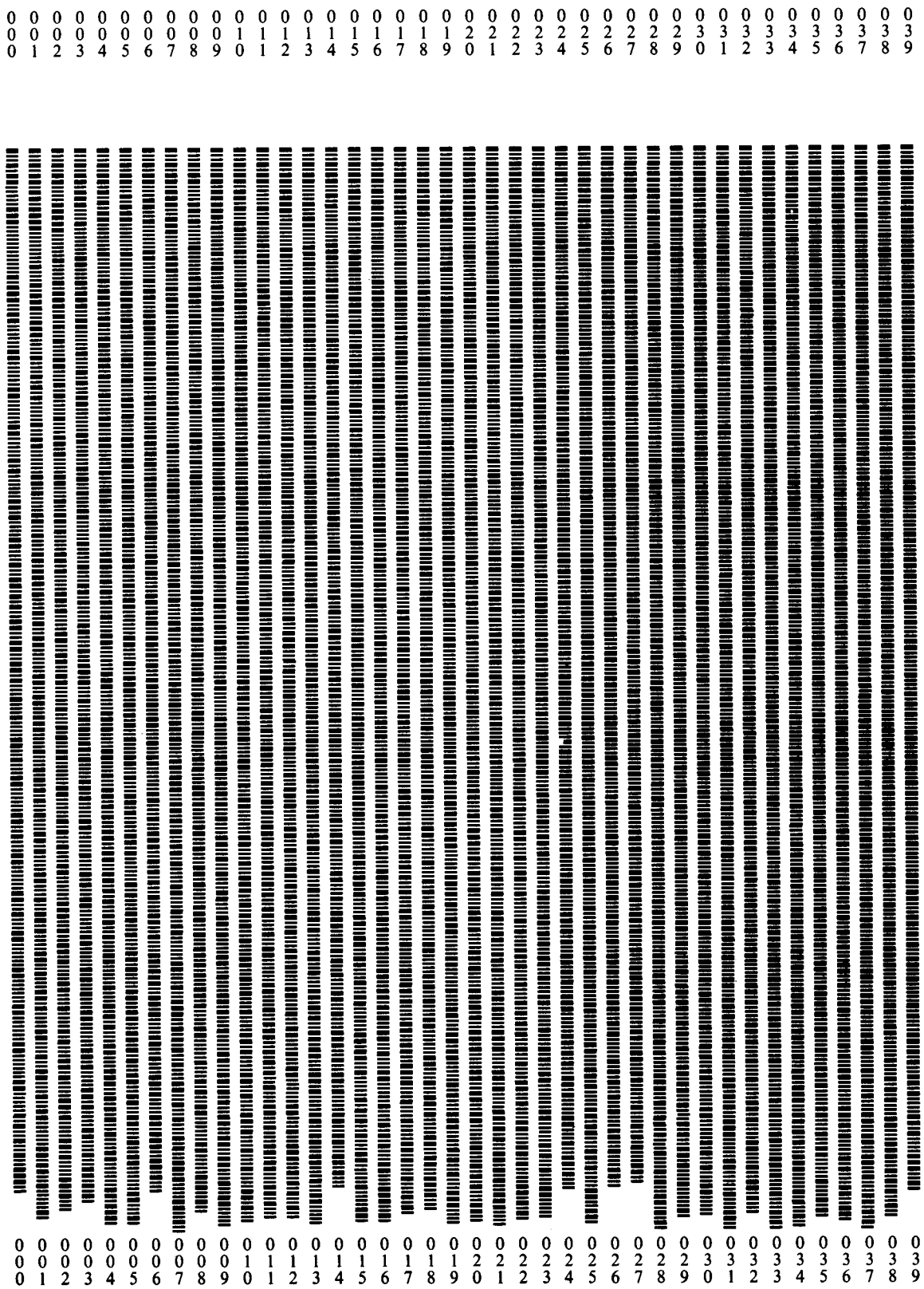
PAPERBYTE™ Bar Code Representation of Relocatable Format Object Code for RA6800ML

Beginning on the following page is a complete machine readable representation (PAPERBYTE™ bar codes) of the relocatable object code for the relocatable macro assembler RA6800ML. The format is that of an ASCII text string without carriage return or line feed conventions. Appendix H is a direct listing of this file using fixed length lines to make it fit the confines of a printed page.

This representation uses the bar code text format, in which each bar code frame (one line of bar codes running from top to bottom of the page) contains a segment of the ASCII relocatable format object text. The text must be loaded into memory and then saved on the user's mass storage device. For details on the text format used in this and other PAPERBYTE™ books, see the PAPERBYTE publication *Bar Code Loader* by Ken Budnick. The book contains a brief history on bar codes, a general bar code loader algorithm with flowcharts, and complete program listing for 6800, 6502, and 8080 or Z-80 based systems.

The relocatable file of the macro assembler can be run through the relocatable linking loader LINK68, available as the PAPERBYTE™ publication *LINK68: Linking Loader for the Motorola M6800* by Robert Grappel and Jack Hemenway (IBSN 0-931718-09-0), in order to reposition RA6800ML at an arbitrary, more convenient address if low memory is not the ideal location in the user's system. This form of the Assembler object code will not be needed by users who can employ the absolute object code version of RA6800ML given in Appendices D or E without further relocation.

Appendix G gives an assembly language source listing for RA6800ML.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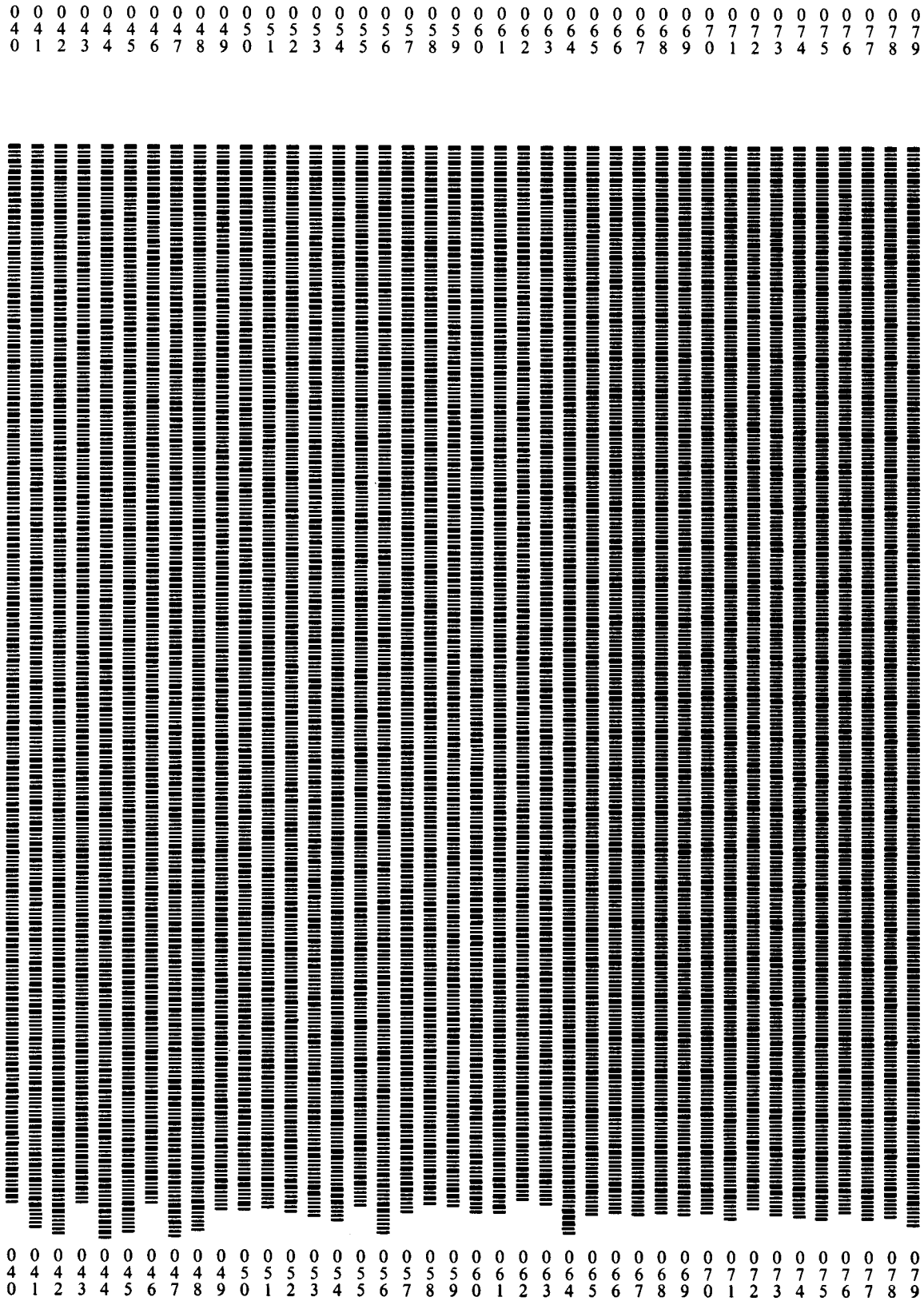
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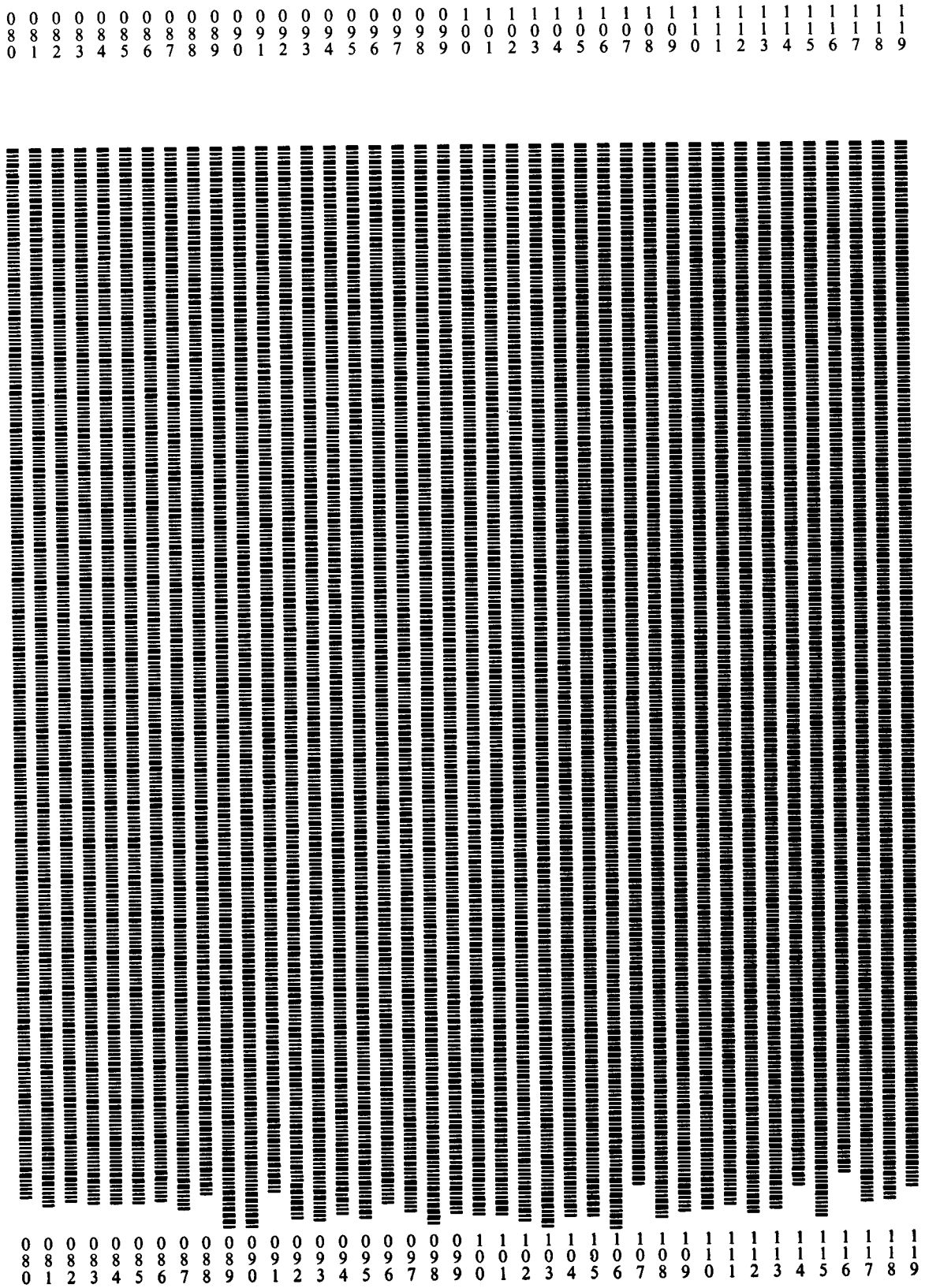
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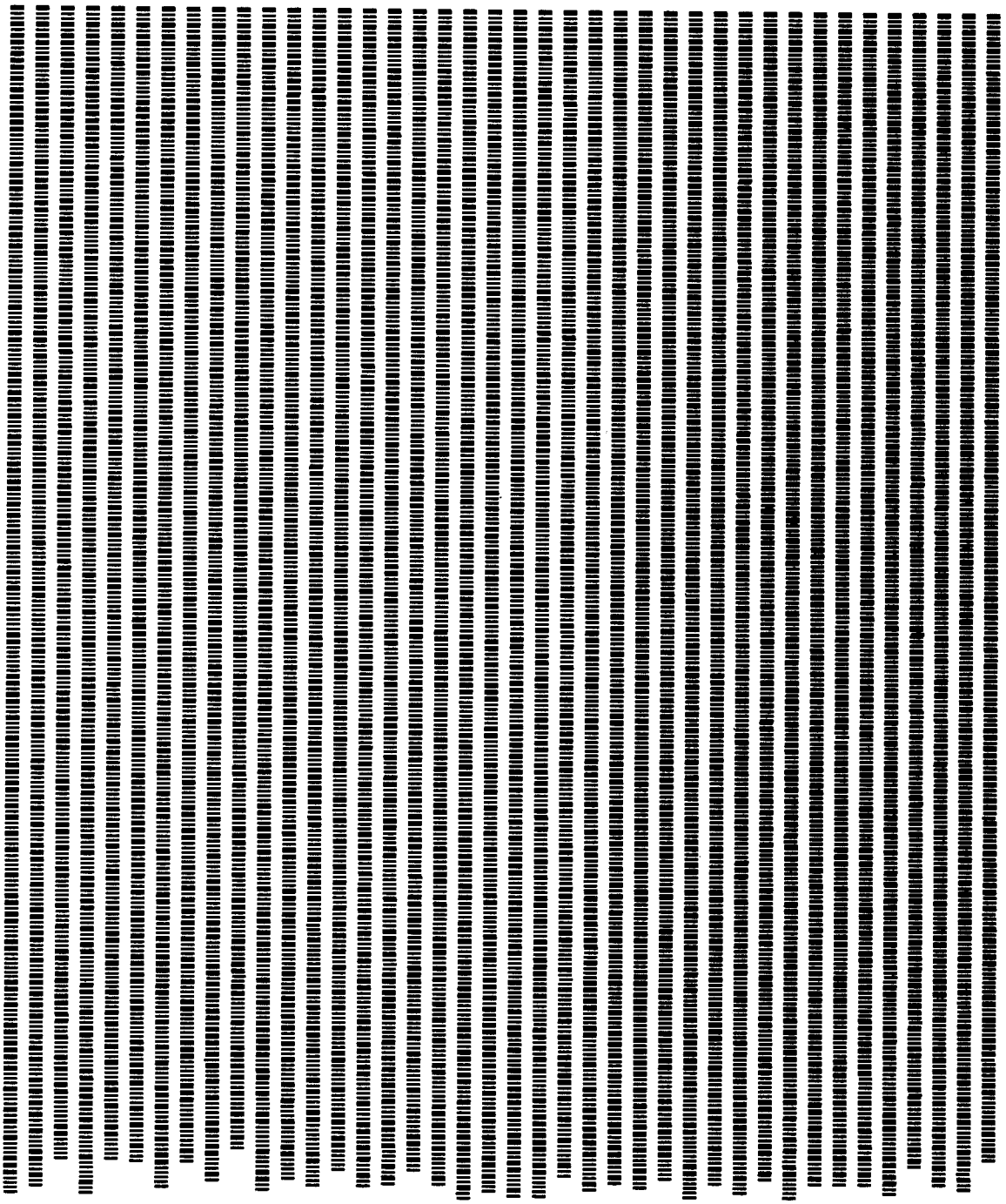

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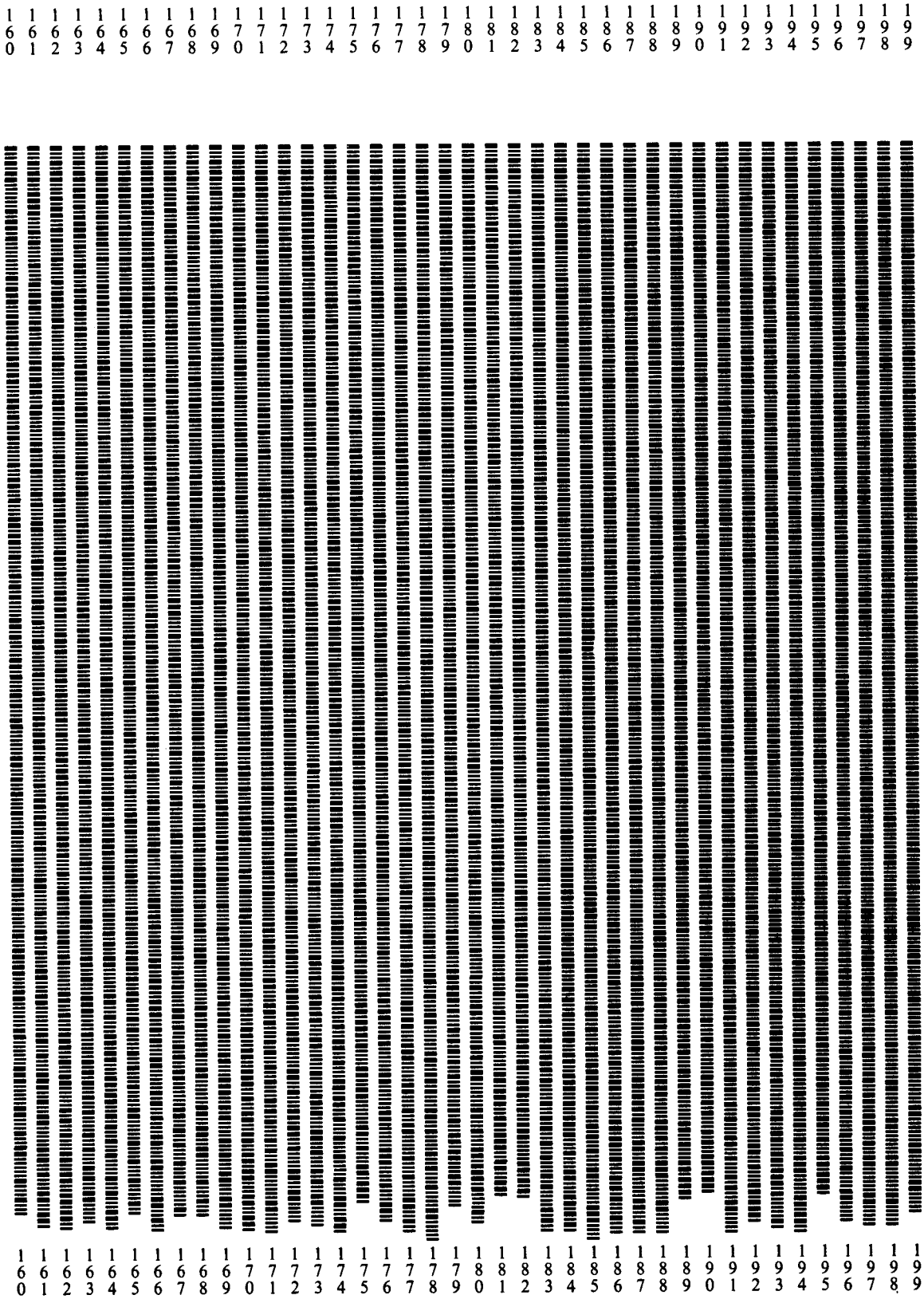
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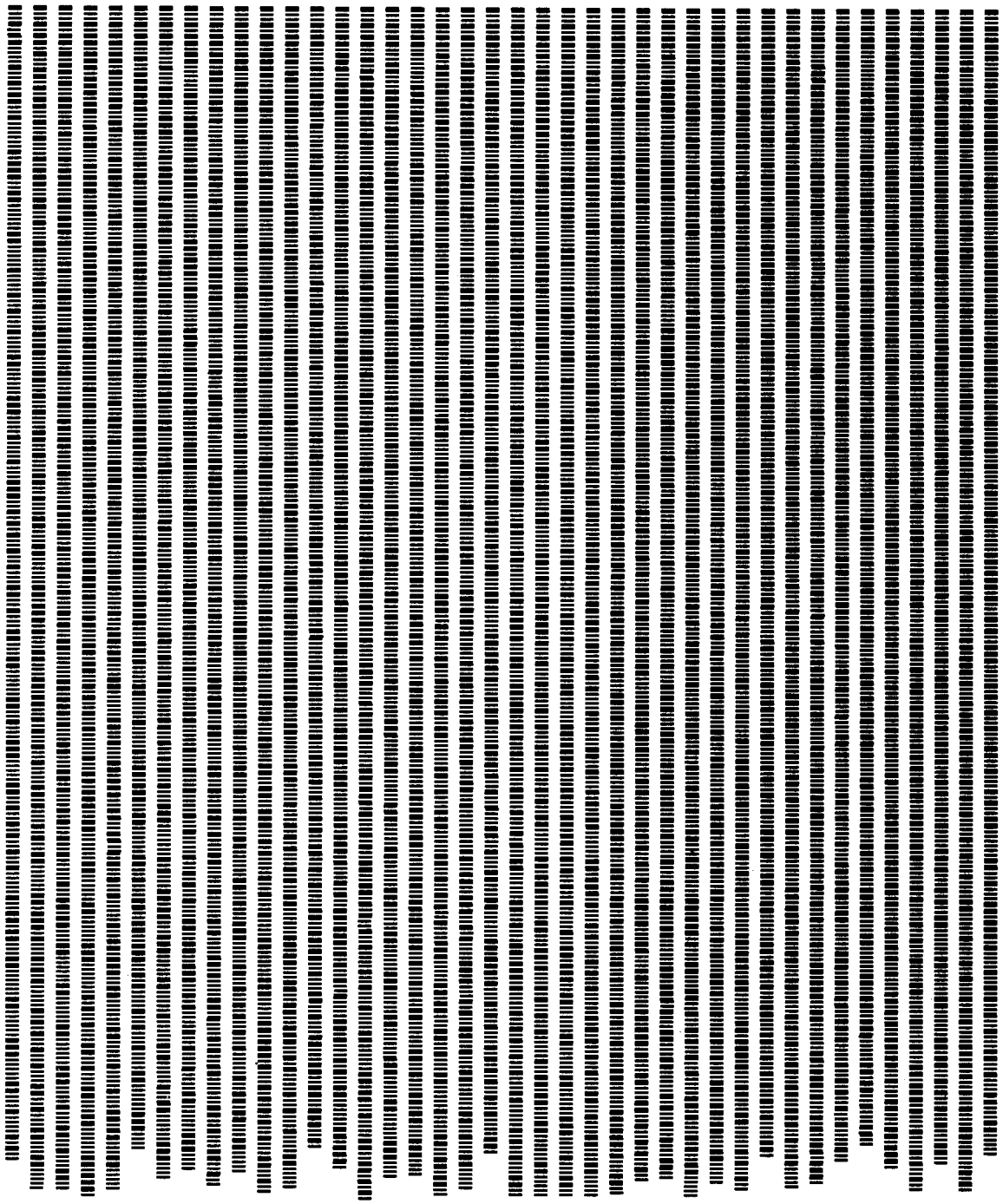
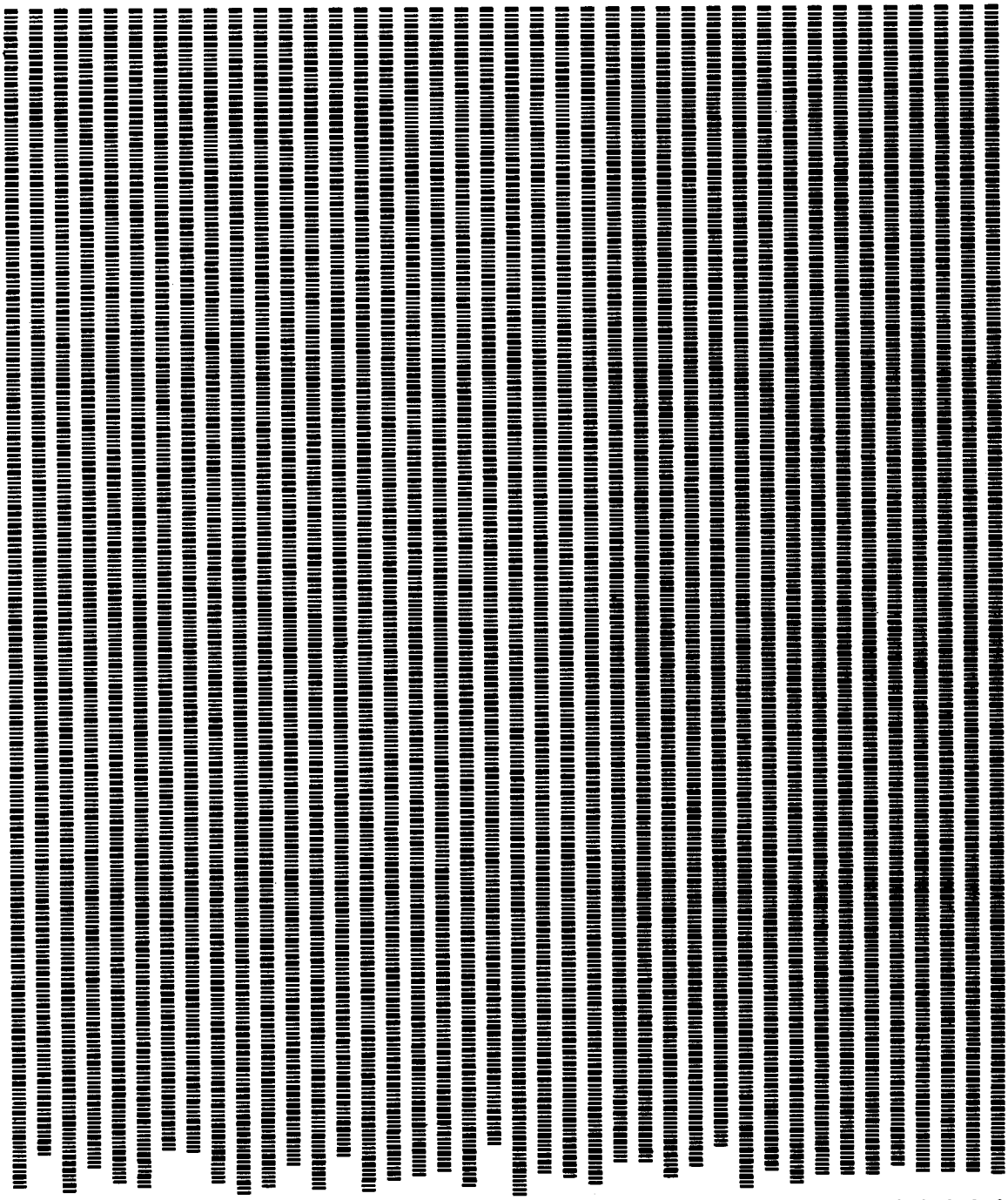
200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239



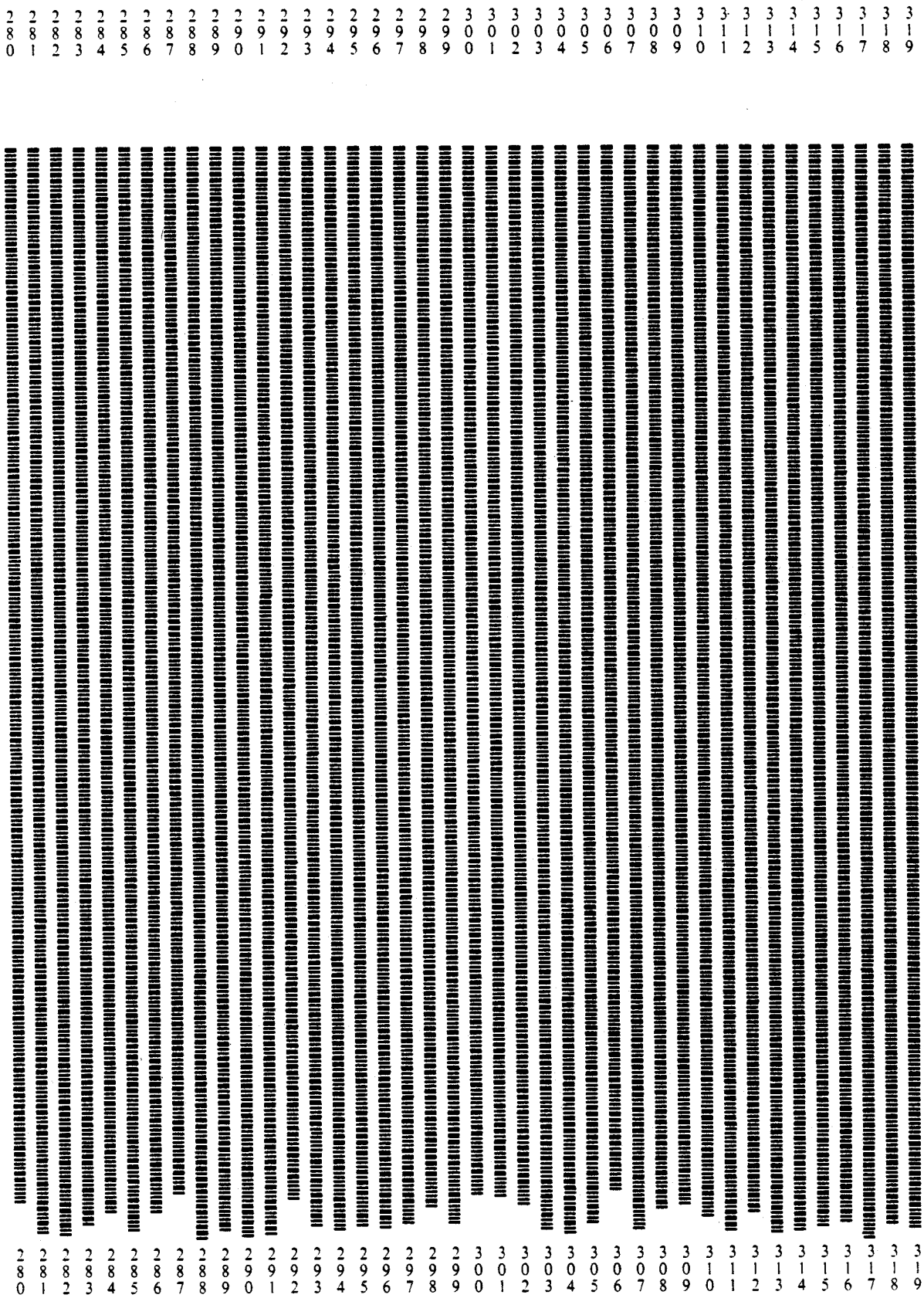
200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239

240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279

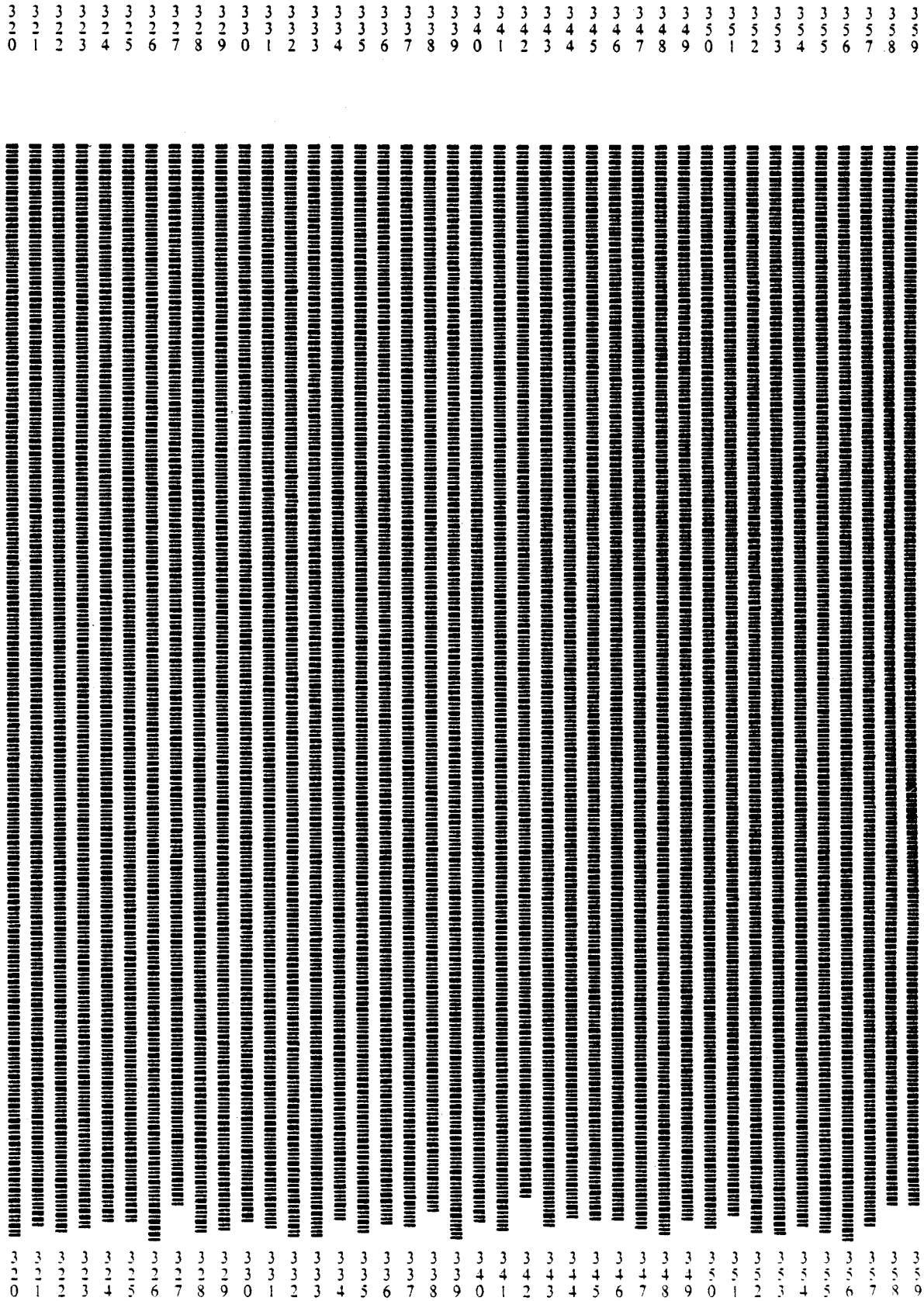


240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279

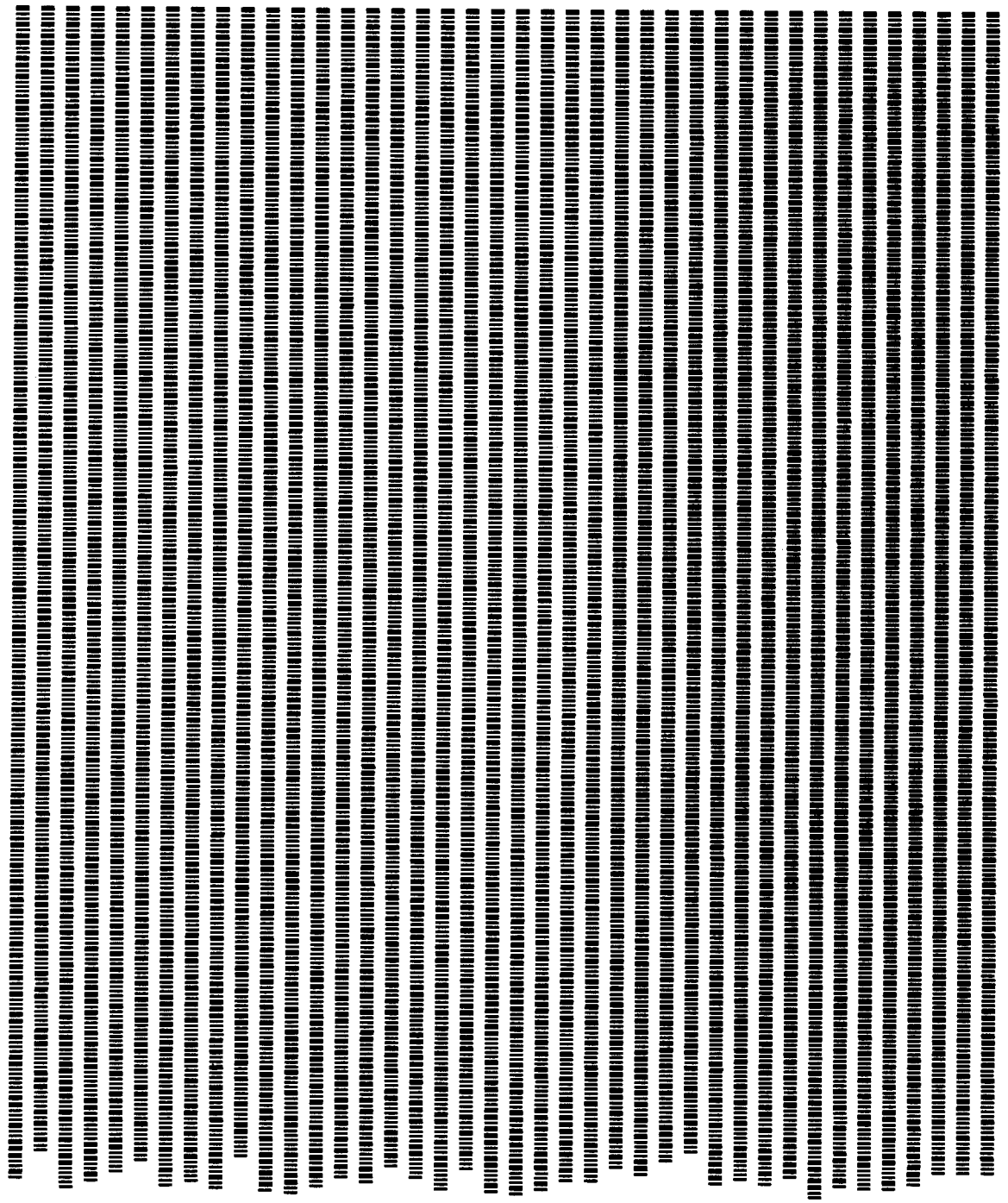
Corrected page 154 for **RA6800ML**



Corrected page 155 for **RA6800ML**

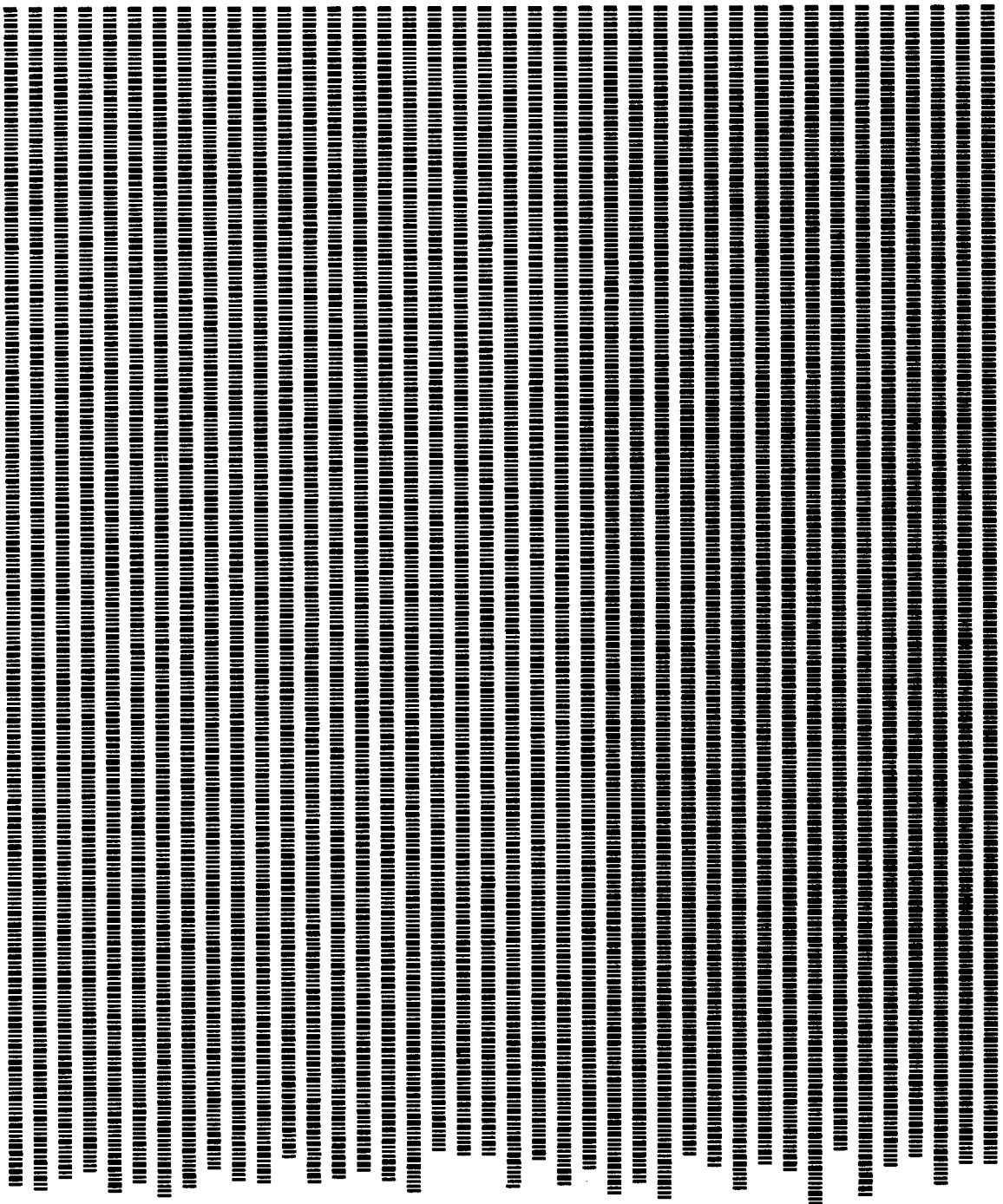


360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399

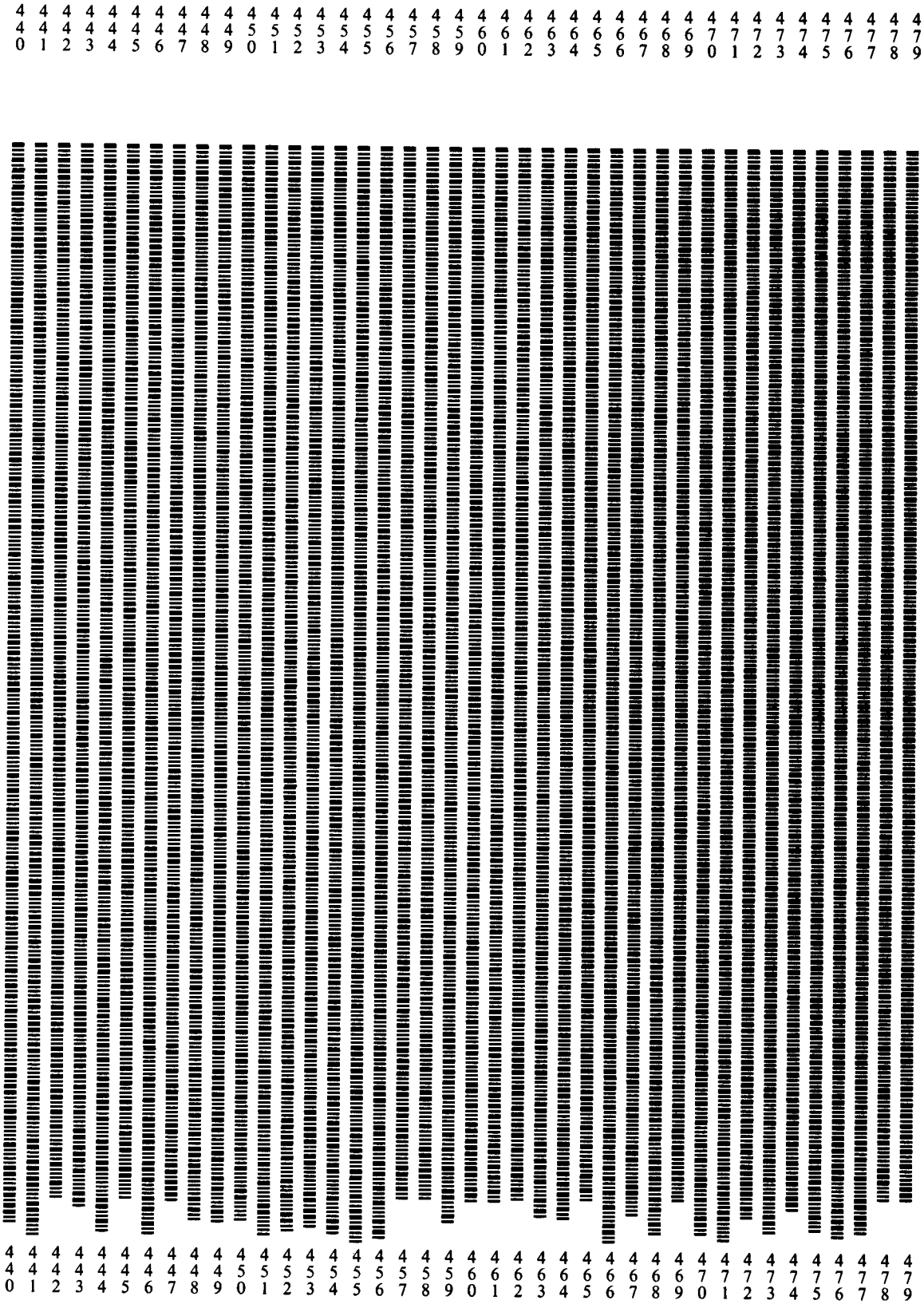


360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399

400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439



400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439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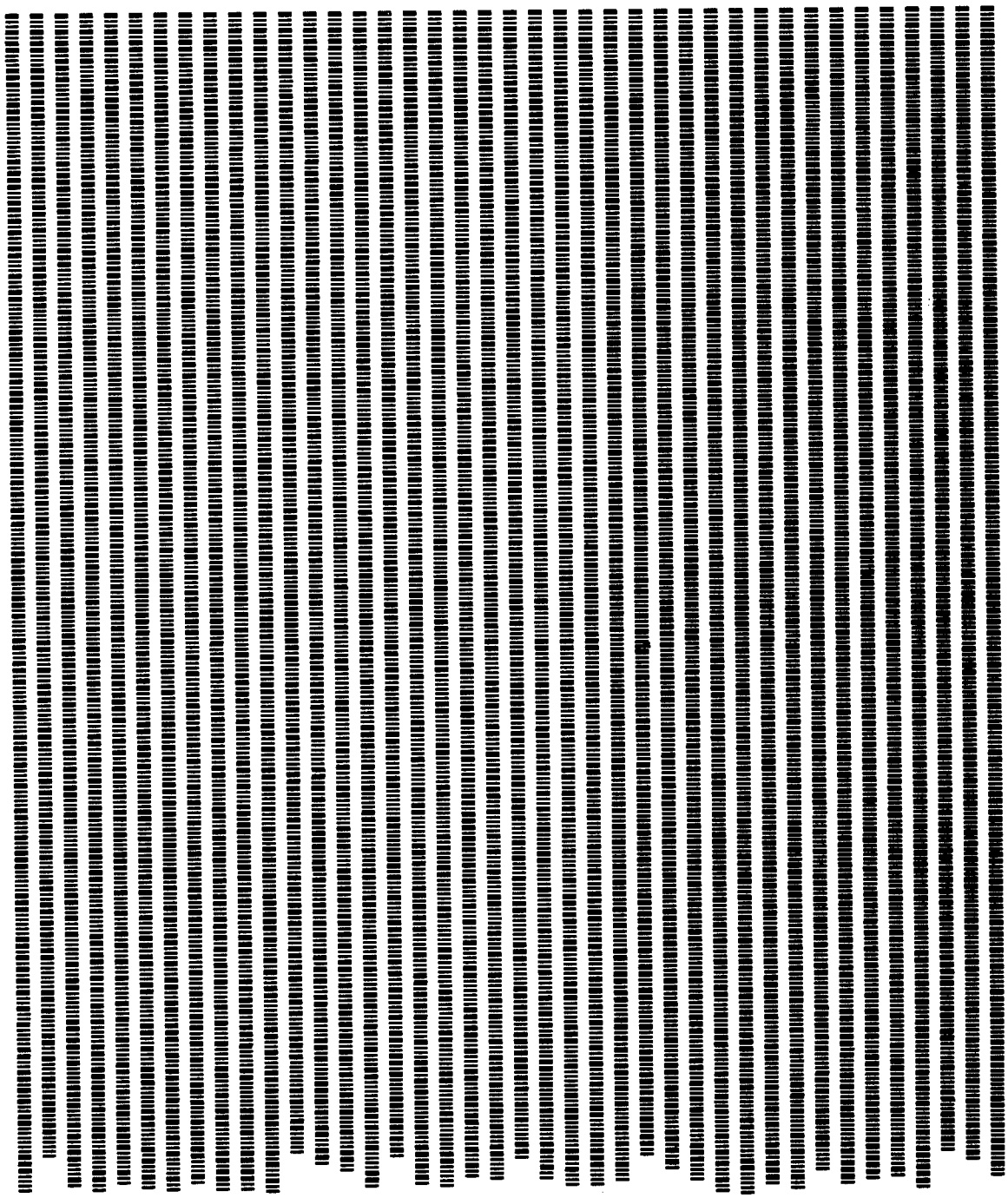
480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519



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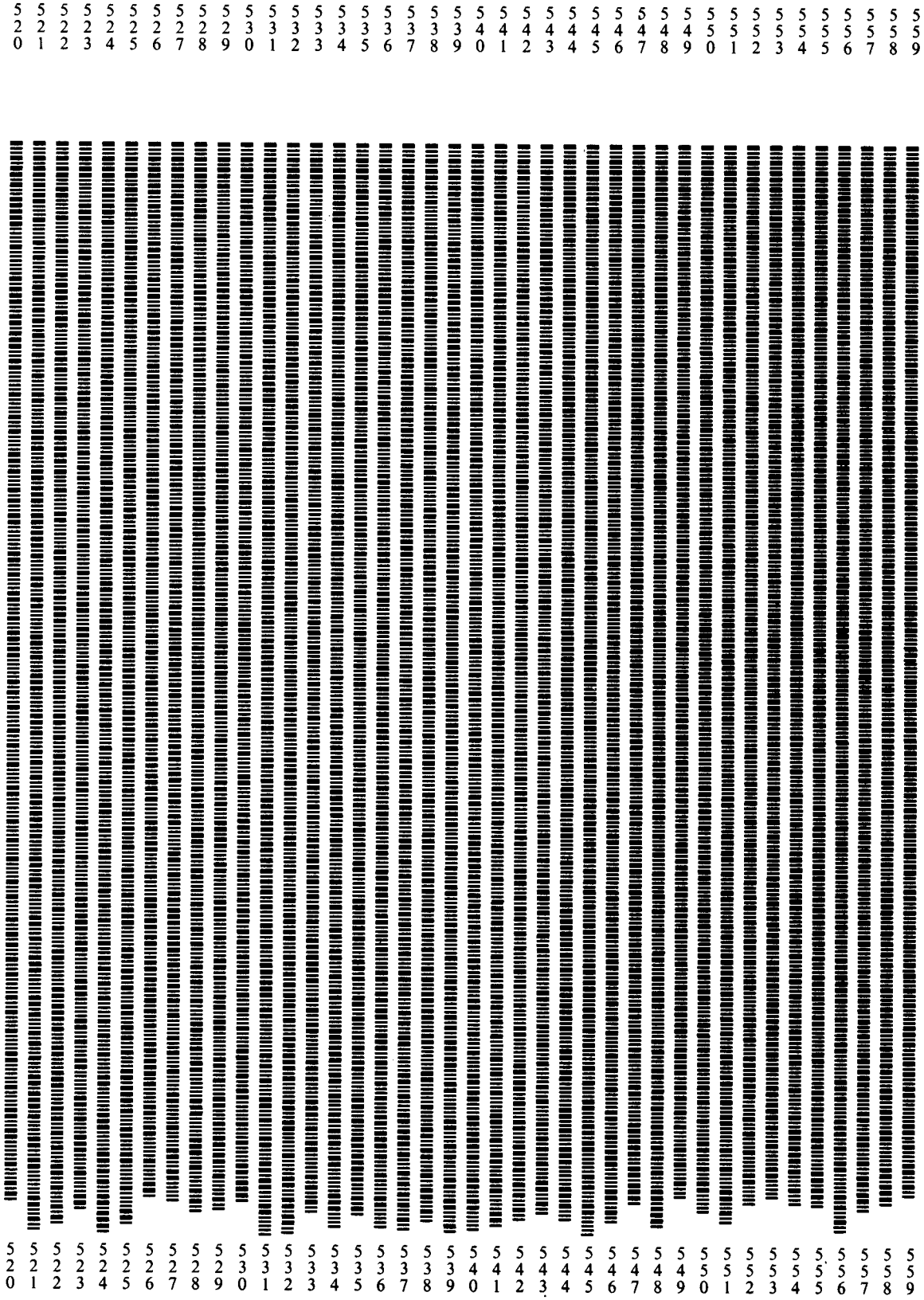
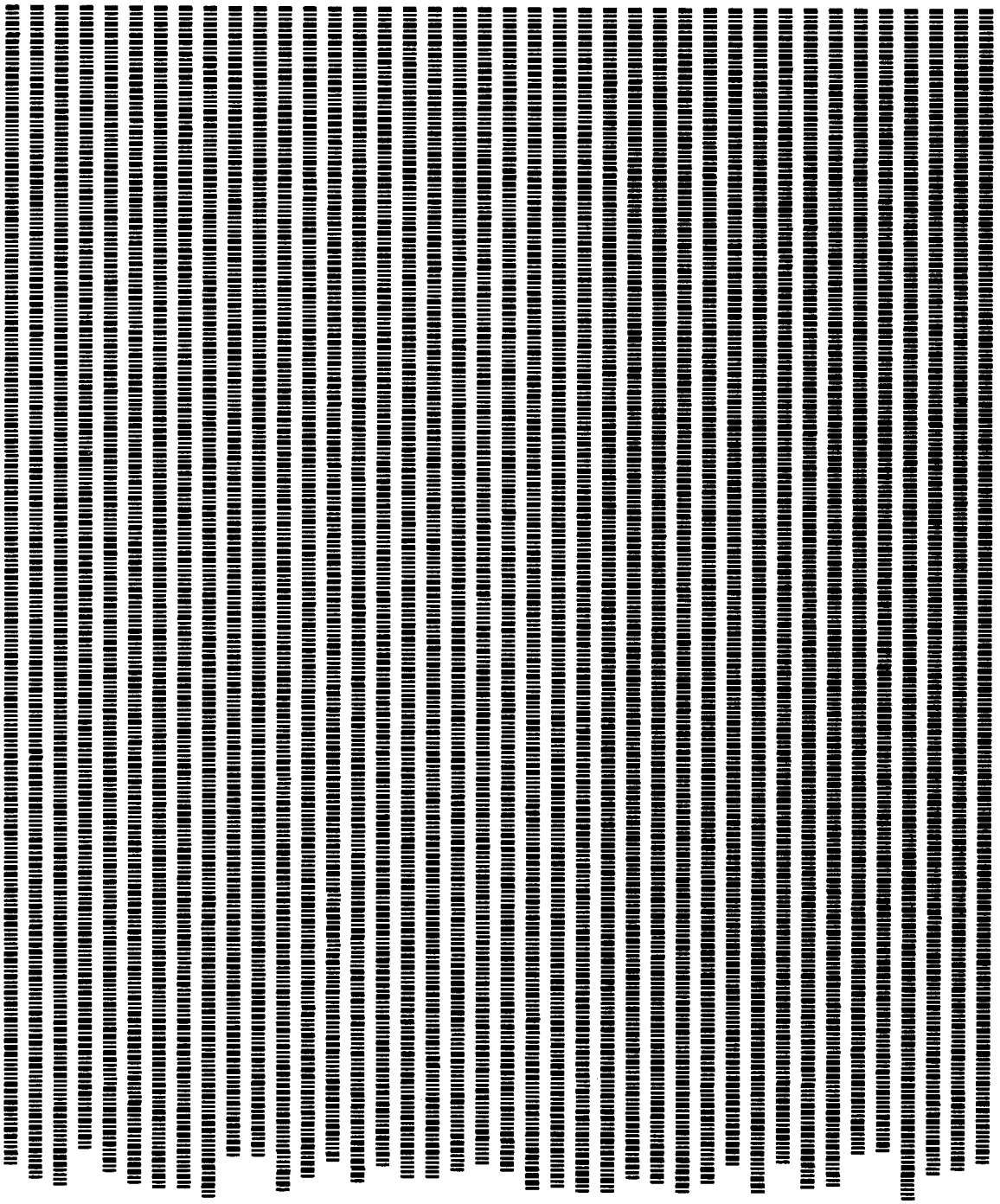
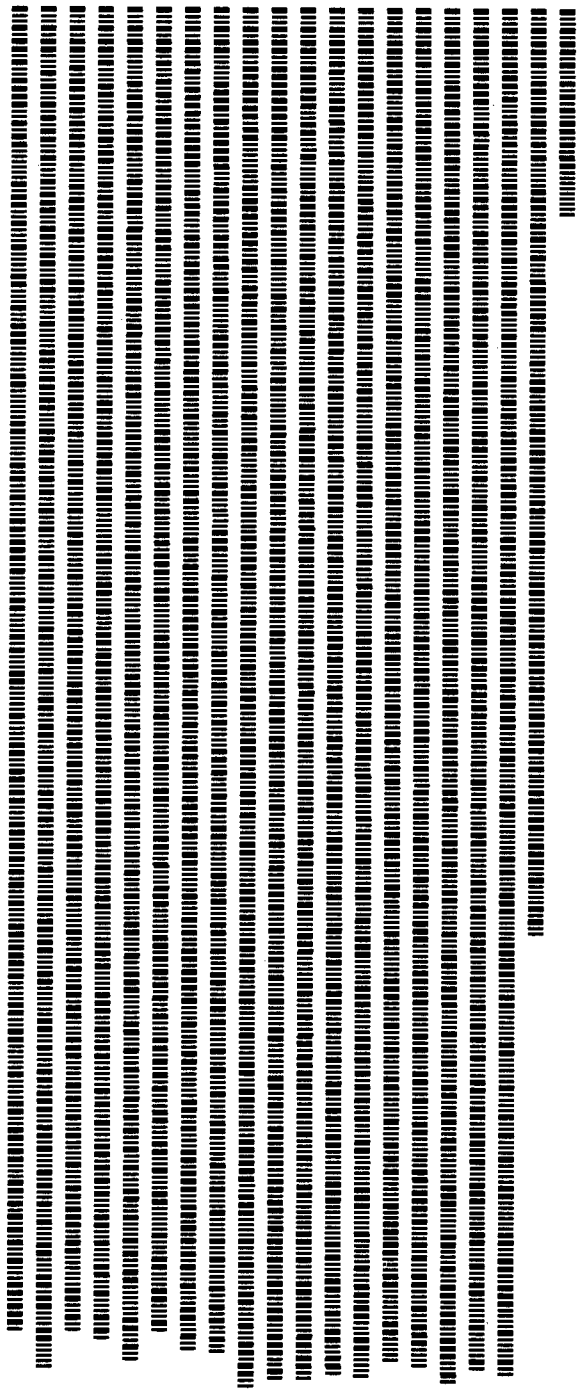

520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559

560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599



560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599

600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639



600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639

APPENDIX J

Cassette Tape IO Listing

```
0000 0000    N          NAM TDRIVERS
                        *
                        *       TAPE DRIVERS FOR RA6800ML ASSEMBLER
                        *       COPYRIGHT 1977 JACK E. HEMENWAY
                        *       BOSTON MASS. 02111 ALL RIGHTS RESERVED
                        *
                        *
                        * ROUTINES IN THE ASSEMBLER
                        *
0000 7E 0000 X          EXT PDATA1
0003 7E 0000 X          EXT INEEE
0006 7E 0000 X          EXT CRLF
                        *
                        * ENTRY POINTS IN DRIVER
                        *
0009 01E1    N          ENT TABLES
0009 0009    N          ENT UPDATE
0009 000C    N          ENT MONTOR
0009 0016    N          ENT GETB
0009 0032    N          ENT OUTB
0009 0088    N          ENT WREOF
0009 004E    N          ENT INITIO
0009 005F    N          ENT RESTR
                        *
                        * LOCATIONS IN MIKBUG
                        *
0009 7E E0E3   UPDATE JMP $E0E3
000C 7E E0E3   MONTOR JMP $E0E3
                        *
000F 0001      CKSUM  RMB 1
0010 0002      INPTR  RMB 2
0012 0002      OTPTR  RMB 2
0014 0002      IXSV   RMB 2
                        *
                        * GET A BYTE RETURN IN A REGISTER
                        *
0016 FF 0014 R GETB   STX IXSV
0019 FE 0010 R        LDX INPTR
001C A6 00            LDA A 0,X       GET A CHAR
001E 81 17            CMP A #$17      ETB ?
0020 26 05            BNE GETB1       NO
                        *
0022 37               PSH B
0023 BD 009A R        JSR RDBUF       READ ANOTHER BLOCK
0026 33               PUL B
                        *
0027 A6 00      GETB1 LDA A 0,X       GET CHAR
0029 08               INX
002A FF 0010 R        STX INPTR
002D FE 0014 R        LDX IXSV
0030 0C               CLC
0031 39               RTS
                        *
                        *
                        * OUTPUT BYTE IN A REGISTER
                        *
0032 FF 0014 R OUTB   STX IXSV
0035 FE 0012 R        LDX OTPTR
0038 8C 05E0 R        CPX #OTBUF+$1FD  FULL?
003B 26 07            BNE OUTB1       NO
                        *
003D 36               PSH A
003E 37               PSH B
003F BD 0129 R        JSR WRITBF
0042 32               PUL A
0043 33               PUL B
                        *
0044 A7 00      OUTB1 STA A 0,X       SAVE CHAR
0046 08               INX
0047 FF 0012 R        STX OTPTR
004A FE 0014 R        LDX IXSV
004D 39               RTS
                        *
                        *
004E CE 01E3 R INITIO LDX #INBUF
0051 FF 0010 R        STX INPTR
0054 86 17            LDA A #$17
0056 A7 00            STA A 0,X
                        *
0058 CE 03E3 R        LDX #OTBUF
005B FF 0012 R        STX OTPTR
005E 39               RTS
                        *
                        * PROMPT TO REWIND TAPE
```

```
                    *
005F CE 0070 R RESTR  LDX #REWIND
0062 BD 0000 R        JSR PDATA1
0065 BD 0003 R        JSR INEEE
0068 81 0D            CMP A #$0D      CR ?
006A 26 F9            BNE *-5
                    *
006C BD 0006 R        JSR CRLF
006F 39               RTS
                    *
0070 52       REWIND  FCC 'REWIND TAPE AND TYPE CR'
0087 04               FCB 4
                    *
                    * CLOSE OUTPUT FILE
                    *
0088 BD 0129 R WREOF  JSR WRITBF
008B FE 0012 R        LDX OTPTR
008E 86 04            LDA A #4
0090 A7 00            STA A 0,X
0092 08               INX
0093 FF 0012 R        STX OTPTR
0096 BD 0129 R        JSR WRITBF
0099 39               RTS

                    * READ IN A BLOCK FROM TAPE 1 *
                    *
009A 7F 000F R RDBUF  CLR   CKSUM
009D CE 01E3 R        LDX   #INBUF    POINT TO INBUF
00A0 BD 015E R        JSR   T1INZ     START TAPE 1
00A3 BD 0181 R RD1    JSR   T1GET     GET CHAR
00A6 5D               TST B           OK ?
00A7 26 18            BNE   RD2       NO
                    *
00A9 A7 00            STA A 0,X       PUT IN INBUF
00AB 08               INX             BUMP POINTER
00AC 81 04            CMP A #$04      EOF?
00AE 27 1D            BEQ   RD4       YES
00B0 81 17            CMP A #$17      ETB?
00B2 26 EF            BNE   RD1       NO
00B4 8C 03E2 R        CPX   #INBUF+$1FF OVERRUN ?
00B7 27 08            BEQ   RD2       YES
00B9 BD 0181 R        JSR   T1GET     GET CKSUM BYTE
00BC 7C 000F R        INC   CKSUM     OK ?
00BF 27 05            BEQ   RD3       YES
                    *
00C1 CE 0102 R RD2    LDX   #TAPERR   BAD
00C4 20 0A            BRA   RD5       FINISH UP
                    *
00C6 BD 0199 R RD3    JSR   T1ISTP    STOP TAPE 1
00C9 CE 01E3 R        LDX   #INBUF    INIT INPTR
00CC 39               RTS
                    *
00CD CE 00E0 R RD4    LDX   #EOF      EOF MSG
00D0 BD 0199 R RD5    JSR   T1ISTP    STOP TAPE
00D3 BD 0000 R        JSR   PDATA1    PRINT MESSAGE
00D6 BD 0003 R        JSR   INEEE     WAIT FOR "GO"
00D9 81 0D            CMP A #$0D      CR ?
00DB 26 F9            BNE   *-5       NO
00DD 7E 009A R        JMP   RDBUF     TRY AGAIN
                    *
00E0 45       EOF     FCC   'EOF:REPOSITION TAPE AND TYPE CR'
00FF 0D0A             FDB   $0D0A     CR,LF
0101 04               FCB   4         EOT
                    *
0102 54       TAPERR  FCC   'TAPE ERROR:BACK UP A BLOCK & TYPE CR'
0126 0D0A             FDB   $0D0A     CR,LF
0128 04               FCB   $04       EOT

                    * WRITBF: WRITE OUT OTBUF TO TAPE2
                    *
0129 37       WRITBF  PSH B
012A FE 0012 R        LDX   OTPTR
012D 8C 03E3 R        CPX   #OTBUF    EMPTY
0130 27 22            BEQ   WRTBFC    YES
                    *
0132 86 17            LDA A #$17      LOAD ETB
0134 A7 00            STA A 0,X       PUT INTO OTBUF
0136 CE 03E3 R        LDX   #OTBUF    POINT TO OTBUF
0139 5F               CLR B           CLR CKSUM REG
013A BD 01A1 R        JSR   T2OTZ     START TAPE
                    *
013D A6 00    WRTBFA  LDA A 0,X       GET CHAR
013F EB 00            ADD B 0,X       ADD TO CKSUM
0141 BD 01BC R        JSR   T2OUT
0144 BC 0012 R        CPX   OTPTR     DONE ?
0147 27 03            BEQ   WRTBFB
                    *
0149 08               INX             NO
014A 20 F1            BRA   WRTBFA    DO AGAIN
                    *
014C 53       WRTBFB  COM B           FORM CKSUM
014D 17               TBA             BYTE
014E BD 01BC R        JSR   T2OUT
0151 BD 01C9 R        JSR   T2OSTP    STOP TAPE
```

```
                    *
0154 CE 03E3 R WRTBFC LDX   #OTBUF
0157 FF 0012 R        STX   OTPTR     INIT OTPTR
015A 33               PUL   B
015B 39               RTS
                    * TAPE DRIVERS:
                    *
                    *
015C 8010       TP1ST  EQU $8010
015C 8011       TP1DAT EQU $8011
015C 8014       TP2ST  EQU $8014
015C 8015       TP2DAT EQU $8015
015C 0002       TXSV   RMB 2
                    *
                    *
                    * START TAPE FOR A READ:
                    *
015E FF 015C R TTINZ  STX TXSV
0161 36               PSH A
0162 86 17            LDA A #$17    MASTER RESET, RTS:=0
0164 B7 8010          STA A TP1ST
                    *
0167 86 5D            LDA A #$5D    RTS:=1
0169 B7 8010          STA A TP1ST
                    *
016C CE 0280          LDX #$0280    DELAY 1 SEC
016F BD 01D9 R        JSR TDELY
                    *
0172 86 57            LDA A #$57    MASTER RESET
0174 B7 8010          STA A TP1ST
0177 86 5D            LDA A #$5D    RTS:=1
0179 B7 8010          STA A TP1ST
017C 32               PUL A
017D FE 015C R        LDX TXSV
0180 39               RTS
                    *
                    * READ A BYTE
                    *
0181 F6 8010   TTGET  LDA B TP1ST  GET STATUS
0184 C5 01            BIT B #$01   RDRF?
0186 27 F9            BEQ *-5      NO
                    *
0188 C5 70            BIT B #$70   ERRORS?
018A 27 01            BEQ *+3      NO
                    *
018C 39               RTS          YES
                    *
018D B6 8011          LDA A TP1DAT GET BYTE
0190 16               TAB
0191 FB 000F R        ADD B CKSUM  FORM CHECKSUM
0194 F7 000F R        STA B CKSUM
0197 5F               CLR B
0198 39               RTS
                    *
                    * STOP TAPE AFTER A READ
                    *
0199 36        TTISTP PSH A
019A 86 17            LDA A #$17
019C B7 8010          STA A TP1ST
019F 32               PUL A
01A0 39               RTS
                    *
                    * START TAPE FOR OUTPUT
                    *
01A1 37        T20TZ  PSH B
01A2 36               PSH A
01A3 FF 015C R        STX TXSV
01A6 C6 17            LDA B #$17    MASTER RESET
01A8 F7 8014          STA B TP2ST
01AB C6 5D            LDA B #$5D    RTS:=1
01AD F7 8014          STA B TP2ST
                    *
01B0 CE 0500          LDX #$0500    DELAY 2 SECS.
01B3 BD 01D9 R        JSR TDELY
                    *
01B6 32               PUL A
01B7 33               PUL B
01B8 FE 015C R        LDX TXSV
01BB 39               RTS
                    *
                    * WRITE A BYTE TO TAPE
                    *
01BC 37        T20UT  PSH B
01BD F6 8014   T20UTA LDA B TP2ST   GET STATUS
01C0 C5 02            BIT B #$02    READY?
01C2 27 F9            BEQ T20UTA    NO
                    *
01C4 B7 8015          STA A TP2DAT  YES, WRITE BYTE
01C7 33               PUL B
01C8 39               RTS
                    *
                    * STOP TAPE AFTER A WRITE
                    *
01C9 4F        T20STP CLR A          WRITE PAD CHARS
01CA BD 01BC R        JSR T20UT
01CD BD 01BC R        JSR T20UT
01D0 BD 01BC R        JSR T20UT
01D3 86 17            LDA A #$17
01D5 B7 8014          STA A TP2ST
01D8 39               RTS
                    *
                    *
01D9 4F        TDELY  CLR A
01DA 4C        TDELY1 INC A
01DB 26 FD            BNE TDELY1
                    *
01DD 09               DEX
01DE 26 FA            BNE TDELY1
01E0 39               RTS
                    *
                    *
                    *
01E1 05E4    R TABLES FDB **$0403
01E3 01E3    R INBUF  EQU *
01E3 03E3    R OTBUF  EQU **$200
                    *
                         END
```

```
CKSUM   000F R
CRLF    0006 RX
DXSV    0014 R
EOF     00E0 R
GETB    0016 RN
GETB1   0027 R
INBUF   01E3 R
INEEE   0003 RX
INITIO  004E RN
INPTR   0010 R
MONTOR  000C RN
OTBUF   03E3 R
OTPTR   0012 R
OUTB    0032 RN
OUTB1   0044 R
PDATA1  0000 RX
RD1     00A3 R
RD2     00C1 R
RD3     00C6 R
RD4     00CD R
RD5     00D0 R
RDBUF   009A R
RESTR   005F RN
REWIND  0070 R
TTGET   0181 R
TTINZ   015E R
TTISTP  0199 R
T20STP  01C9 R
T20TZ   01A1 R
T20UT   01BC R
T20UTA  01BD R
TABLES  01E1 RN
TAPERR  0102 R
TDELY   01D9 R
TDELY1  01DA R
TDRIVE  0000 RN
TP1DAT  8011
TP1ST   8010
TP2DAT  8015
TP2ST   8014
TXSV    015C R
UPDATE  0009 RN
WREOF   0088 RN
WRITBF  012A R
WRTBFA  013D R
WRTBFB  014C R
WRTBFC  0154 R

THERE WERE: 00000 ERRORS

COMMON LENGTH= 0000

ICOM FDOS-II/6800-0.1

!
```

Appendix K

ICOM Floppy Disk IO Listing

```
0000 0000    N          NAM DDRV
                        *
                        *       DISK DRIVERS FOR RA6800ML ASSEMBLER
                        *       COPYRIGHT 1977 JACK E. HEMENWAY
                        *       BOSTON MASS. 02111 ALL RIGHTS RESERVED
                        *
                        * ENTRY POINTS IN DRIVER
                        *
0000 002C    N          ENT TABLES
0000 0003    N          ENT UPDATE
0000 0006    N          ENT MONTOR
0000 000B    N          ENT GETB
0000 0017    N          ENT OUTB
0000 0023    N          ENT WREOF
0000 002B    N          ENT INITIO
0000 0000    N          ENT RESTR
                        *
                        * LOCATIONS IN PROM BOOTSTRAP FDOS
                        *
0000 7E E838            RESTR  JMP $E838
0003 7E E820            UPDATE JMP $E820
0006 7E E800            MONTOR JMP $E800
0009 000D               OCNTR  EQU $000D
0009 E929               RIX    EQU $E929
0009 E9AA               WRT    EQU $E9AA
0009 0002               DXSV   RMB 2
                        *
                        *
                        * GET A BYTE RETURN IN A REGISTER
                        * CARRY FLAG SET IF EOF
                        *
000B 37                 GETB   PSH B
000C FF 0009 R                 STX DXSV
000F BD E929                   JSR RIX
0012 FE 0009 R                 LDX DXSV
0015 33                        PUL B
0016 39                        RTS
                        *
                        * OUTPUT BYTE IN A REGISTER
                        *
0017 37                 OUTB   PSH B
0018 FF 0009 R                 STX DXSV
001B BD E9AA                   JSR WRT
001E FE 0009 R                 LDX DXSV
0021 33                        PUL B
0022 39                        RTS
                        *
                        * WRITE NULLS TO LAST SECTOR
                        *
0023 4F                 WREOF  CLR A
0024 BD E9AA                   JSR WRT
0027 91 0D                     CMP A OCNTR
0029 26 F8                     BNE WREOF
                        *
002B 39                 INITIO RTS   DUMMY INIT
                        *
                        * START OF ASSEMBLER TABLES
                        *
002C 002E    R TABLES   FDB *+2
                        *
                                     END

     DDRV    0000 RN
     DXSV    0009 R
     GETB    000B RN
     INITIO  002B RN
     MONTOR  0006 RN
     OCNTR   000D
     OUTB    0017 RN
     RESTR   0000 RN
     RIX     E929
     TABLES  002C RN
     UPDATE  0003 RN
     WREOF   0023 RN
     WRT     E9AA

     THERE WERE: 00000 ERRORS

     COMMON LENGTH= 0000

     ICOM FDOS-II/6800-0.1

     !
```

Index

NOTE: The page numbers in **bold** type face indicate either the definition or the primary reference to the item. The numbers in *italics* indicate the line number in the source code listing.

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Bar codes are the newest form of machine readable data representation. They are used in all PAPERBYTE™ software products in BYTE magazine articles and self contained book publications and combine efficiency of space, low cost, and ease of data entry with the need for mass produced machine readable representations of software. Bar codes were originally used for product identification in inventory control and supermarket checkout applications. Today, because of their direct binary representation of data, they are an ideal computer compatible communications medium. In the application of bar codes to software distribution (such as PAPERBYTE books and articles), the use of a simple but reliable optical scanning wand and an appropriate program provides a convenient means for the user to acquire software.

Our intent in making PAPERBYTE software available in bar code form is to provide a method of conveying machine readable information from documentation to the memories and mass storage of a user's system on a one time basis. We suggest that the user of software obtained in this manner should locally record the data on the mass storage devices of his system after the data has been scanned from the printed page. The PAPERBYTE bar code representations provide a standardized means of obtaining the data, but they cannot be compared to the convenience of local mass storage devices such as floppy disks, digital cassettes or audio cassettes. Thus if repeated use of the software obtained from bar code is anticipated, we recommend that the user make a copy on some form of magnetic medium.

Bar Code Loader by Ken Budnik, the first in the PAPERBYTE series of software books, provides a brief history of bar codes, a look at the PAPERBYTE bar code format including flowcharts, a general bar code loader algorithm and well documented programs with complete implementation and checkout procedures for 6800, 6502 and 8080/Z-80 based systems.

RA6800ML:

AN M6800 RELOCATABLE MACRO ASSEMBLER is a two pass assembler for the Motorola 6800 microprocessor. It is designed to run on a minimum system of 16 K bytes of memory, a system console (such as a Teletype terminal), a system monitor (for instance, the Motorola MIKBUG read only memory program or the ICOM Floppy Disk Operating System), and some form of mass file storage (dual cassette recorders or a floppy disk).

The Assembler can produce a program listing, a sorted Symbol Table listing, and relocatable object code. The object code is loaded and linked with other modules using the Linking Loader LINK 68. (Refer to PAPERBYTE™ publication LINK 68: AN M6800 LINKING LOADER for details).

Included in this book: a complete description of the 6800 assembly language and its components, including outlines of the instruction and address formats, pseudo instructions, and macro facilities; details on interfacing and using the Assembler; error messages generated by the Assembler; the Assembler and sample IO driver source code listings; and the PAPERBYTE™ bar code representation of the Assembler's relocatable object file.

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