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A PAPERBYTE™ BOOK

RA6800ML

AN M6800 RELOCATABLE MACRO ASSEMBLER

by Jack E. Hemenway

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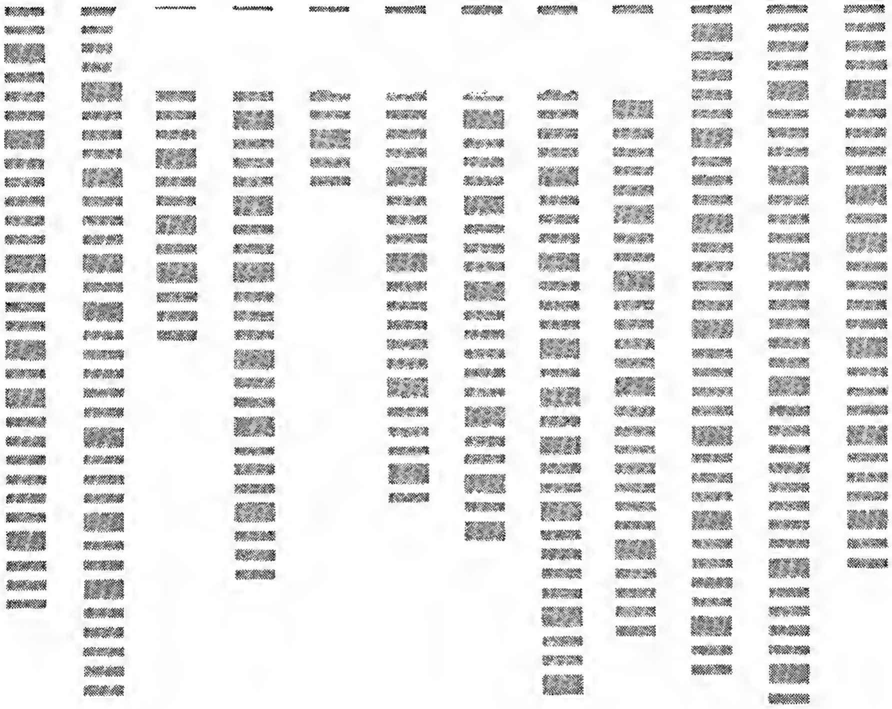

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To Begin With . . .

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" } "alphanumeric"
0 through 9 } "numeric" }
* (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 remaining 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:

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

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:

$$\#\left\{\begin{matrix}\text{number}\\ \text{symbol}\\ \text{expression}\\ \text{ASCII string}\end{matrix}\right\}$$

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:

$$\left\{\begin{matrix}\text{number}\\ \text{symbol}\\ \text{expression}\end{matrix}\right\}$$

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:

$$\left\{\begin{matrix}\text{number}\\ \text{symbol}\\ \text{expression}\end{matrix}\right\}$$

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 $\not{b}$ 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):

$$\left\{\begin{matrix}\text{ADC} & \text{ADD}\\ \text{AND} & \text{BIT}\\ \text{CMP} & \text{LDA}\\ \text{ORA} & \text{SBC}\\ \text{SUB} & \end{matrix}\right\}\not{b}\left\{\begin{matrix}\text{A}\\ \text{B}\end{matrix}\right\}\not{b}\quad\#\left\{\begin{matrix}\text{number}\\ \text{symbol}\\ \text{expression}\\ \text{ASCII string}\end{matrix}\right\}$$

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

$$\left\{\begin{matrix}\text{ADC} & \text{ADD} & \text{AND}\\ \text{BIT} & \text{CMP} & \text{LDA}\\ \text{ORA} & \text{SBC} & \text{SUB}\end{matrix}\right\}\not{b}\left\{\begin{matrix}\text{A}\\ \text{B}\end{matrix}\right\}\not{b}\left\{\begin{matrix}\text{number}\\ \text{symbol}\\ \text{expression}\end{matrix}\right\}$$

Indexed mode (two bytes):

$$\left\{\begin{matrix}\text{ADC} & \text{ADD} & \text{AND}\\ \text{BIT} & \text{CMP} & \text{LDA}\\ \text{ORA} & \text{SBC} & \text{SUB}\end{matrix}\right\}\not{b}\left\{\begin{matrix}\text{A}\\ \text{B}\end{matrix}\right\}\not{b}\left\{\begin{matrix}\text{number}\\ \text{symbol}\\ \text{expression}\end{matrix}\right\}\text{,X}$$

Address Type 2

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

$$\text{STA}\quad\not{b}\quad\left\{\begin{matrix}\text{A}\\ \text{B}\end{matrix}\right\}\quad\not{b}\left\{\begin{matrix}\text{number}\\ \text{symbol}\\ \text{expression}\end{matrix}\right\}$$

Indexed mode (two bytes):

$$\text{STA}\quad\not{b}\quad\left\{\begin{matrix}\text{A}\\ \text{B}\end{matrix}\right\}\quad\not{b}\left\{\begin{matrix}\text{number}\\ \text{symbol}\\ \text{expression}\end{matrix}\right\}\text{,X}$$

Address Type 3

Accumulator mode (one byte):

$$\left\{\begin{matrix} \text{ASL} & \text{ASR} & \text{CLR} & \text{COM} \\ \text{DEC} & \text{INC} & \text{LSR} & \text{NEG} \\ \text{ROL} & \text{ROR} & \text{TST} & \end{matrix}\right\} \not{b} \left\{\begin{matrix} \text{A} \\ \text{B} \end{matrix}\right\}$$

Extended mode (three bytes):

$$\left\{\begin{matrix} \text{ASL} & \text{ASR} & \text{CLR} & \text{COM} \\ \text{DEC} & \text{INC} & \text{LSR} & \text{NEG} \\ \text{ROL} & \text{ROR} & \text{TST} & \end{matrix}\right\} \not{b} \left\{\begin{matrix} \text{number} \\ \text{symbol} \\ \text{expression} \end{matrix}\right\}$$

Indexed mode (two bytes):

$$\left\{\begin{matrix} \text{ASL} & \text{ASR} & \text{CLR} & \text{COM} \\ \text{DEC} & \text{INC} & \text{LSR} & \text{NEG} \\ \text{ROL} & \text{ROR} & \text{TST} & \end{matrix}\right\} \not{b} \left\{\begin{matrix} \text{number} \\ \text{symbol} \\ \text{expression} \end{matrix}\right\} \text{,X}$$

Address Type 4

Accumulator mode (one byte):

$$\left\{\begin{matrix} \text{PSH} \\ \text{PUL} \end{matrix}\right\} \quad \not{b} \quad \left\{\begin{matrix} \text{A} \\ \text{B} \end{matrix}\right\}$$

Address Type 5

Immediate mode (three bytes):

$$\left\{\begin{matrix} \text{CPX} \\ \text{LDS} \\ \text{LDX} \end{matrix}\right\} \quad \not{b} \quad \# \left\{\begin{matrix} \text{number} \\ \text{symbol} \\ \text{expression} \\ \text{ASCII string} \end{matrix}\right\}$$

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

$$\left\{\begin{matrix} \text{CPX} \\ \text{LDS} \\ \text{LDX} \end{matrix}\right\} \quad \not{b} \quad \left\{\begin{matrix} \text{number} \\ \text{symbol} \\ \text{expression} \end{matrix}\right\}$$

Indexed mode (two bytes):

$$\left\{\begin{matrix} \text{CPX} \\ \text{LDS} \\ \text{LDX} \end{matrix}\right\} \quad \not{b} \quad \left\{\begin{matrix} \text{number} \\ \text{symbol} \\ \text{expression} \end{matrix}\right\} \quad \text{,X}$$

Address Type 6

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

$$\left\{\begin{matrix} \text{STX} \\ \text{STS} \end{matrix}\right\} \quad \not{b} \quad \left\{\begin{matrix} \text{number} \\ \text{symbol} \\ \text{expression} \end{matrix}\right\}$$

Indexed (two bytes):

$$\left\{\begin{matrix} \text{STX} \\ \text{STS} \end{matrix}\right\} \quad \not{b} \quad \left\{\begin{matrix} \text{number} \\ \text{symbol} \\ \text{expression} \end{matrix}\right\} \quad \text{,X}$$

Address Type 7

Extended mode (three bytes):

$$\left\{\begin{matrix} \text{JMP} \\ \text{JSR} \end{matrix}\right\} \quad \not{b} \quad \left\{\begin{matrix} \text{number} \\ \text{symbol} \\ \text{expression} \end{matrix}\right\}$$

Indexed mode (two bytes):

$$\left\{\begin{matrix} \text{JMP} \\ \text{JSR} \end{matrix}\right\} \quad \not{b} \quad \left\{\begin{matrix} \text{number} \\ \text{symbol} \\ \text{expression} \end{matrix}\right\} \quad \text{,X}$$

Address Type 8

Relative mode (two bytes):

$$\left\{\begin{matrix} \text{BCC} & \text{BCS} & \text{BEQ} & \text{BGE} & \text{BGT} \\ \text{BHI} & \text{BLE} & \text{BLT} & \text{BMI} & \text{BRA} \\ \text{BSR} & \text{BVC} & \text{BVS} & & \end{matrix}\right\} \not{b} \left\{\begin{matrix} \text{number} \\ \text{symbol} \\ \text{expression} \end{matrix}\right\}$$

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:

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

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:

ƀ ENT ƀ 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:

ƀ EXT ƀ 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 ƀ EQU ƀ $\left\{\begin{array}{l}\text{number}\\ \text{symbol}\\ \text{expression}\end{array}\right\}$

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] ƀ FCB ƀ $\left\{\begin{array}{l}\text{number}\\ \text{symbol}\\ \text{expression}\end{array}\right\}$

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] ƀ FCC ƀ 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] ƀ FDB ƀ $\left\{\begin{array}{l}\text{number}\\ \text{symbol}\\ \text{expression}\end{array}\right\}$

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:

b̸ IF b̸ $\left\{\begin{array}{l}\text{number}\\ \text{symbol}\\ \text{expression}\end{array}\right\}$

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 b̸ 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:

b̸ NAM b̸ 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] b̸ RMB b̸ $\left\{\begin{array}{l}\text{number}\\ \text{symbol}\\ \text{expression}\end{array}\right\}$

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

b̸ CMN b̸ symbol, $\left\{\begin{array}{l}\text{number}\\ \text{symbol}\\ \text{expression}\end{array}\right\}$.

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

b̸ ENT b̸ 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

b̸ EXT b̸ 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:

```
                                Sample reference followed by
Prototype:                      generated code:

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

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

```
                                Sample reference followed by
Prototype:                      generated code:

ADD16      MAC
           LDA  A  &0+1         ADD16 AAA,BBB,CCC
           LDA  B  &0           LDA  A  AAA+1
           ADD  A  &1+1         LDA  B  AAA
           ADC  B  &1           ADD  A  BBB+1
           STA  A  &2+1         ADC  B  BBB
           STA  A  &2           STA  A  CCC+1
           MEND                 STA  A  CCC
```

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

```
                                Sample reference followed by
Prototype:                      generated code:

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

To push the X register onto a stack:

```
                                Sample reference followed by
Prototype:                      generated code:

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

To pull the X register off of the stack:

```
                                Sample reference followed by
Prototype:                      generated code:

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

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

```
                                Sample reference followed by
Prototype:                      generated code:

PSHREG     MAC
           PSHX                 PSHREG
           PSH  A               PSHX
           PSH  B               DES
           MEND                 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):

```
                                Sample reference followed by
Prototype:                      generated code:

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

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

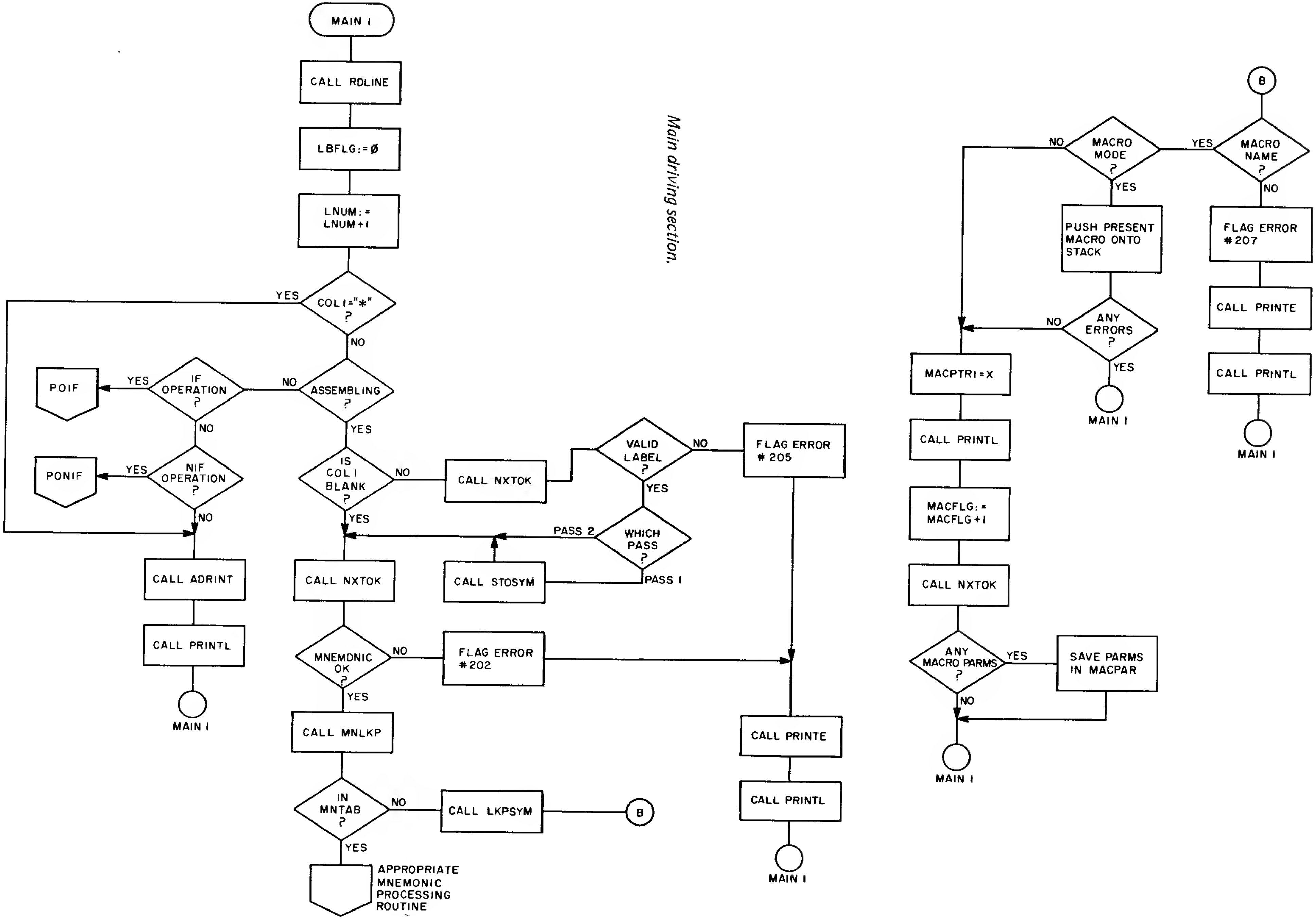
      NAM PROG2
      EXT SUB1     DEFINE SUB1 AS EXTERNAL
      EXT SUB2     DEFINE SUB2 AS EXTERNAL
*
      JSR SUB1     CALL SUB1 IN PROG1
      JSR SUB2     CALL SUB2 IN PROG2
        •
        •
      END
```

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: 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.

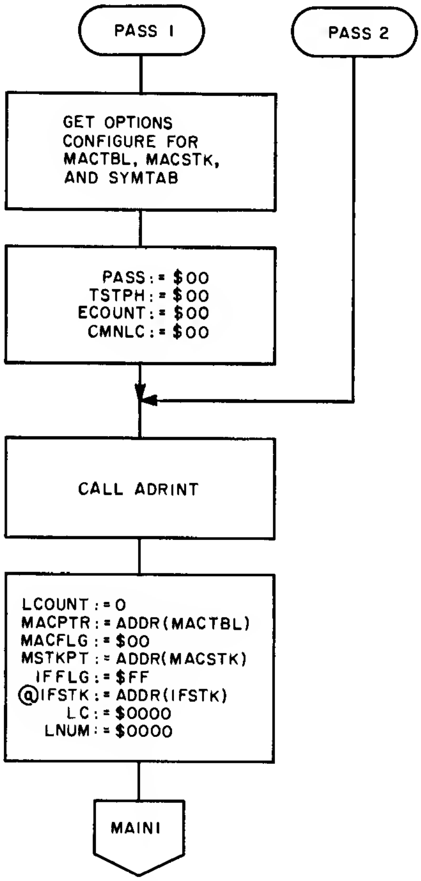
Pass 2 of Main

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.

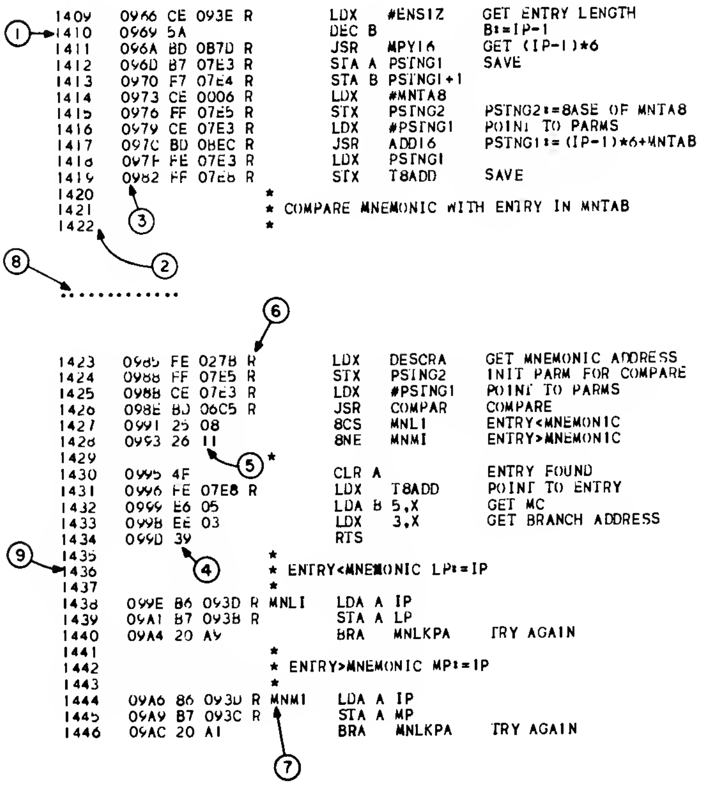
⑤ Columns 15 thru 18; the operand, either 2 or 4 hexadecimal characters. Column 19; blank.

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  PSTNG1     SAVE
1413   0970 F7 07E4 R        STA B  PSTNG1+1
1414   0973 CE 0006 R        LDX    #MNTA8
1415   0976 FF 07E5 R        STX    PSTNG2     PSTNG2:=8ASE OF MNTA8
1416   0979 CE 07E3 R        LDX    #PSTNG1    POINT TO PARMS
1417   097C BD 0BEC R        JSR    ADD16      PSTNG1:= (IP-1)*6+MNTAB
1418   097F FE 07E3 R        LDX    PSTNG1
1419   0982 FF 07E8 R        STX    T8ADD      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    #PSTNG1    POINT TO PARMS
1426   098E BD 06C5 R        JSR    COMPAR     COMPARE
1427   0991 25 08            8CS    MNL1       ENTRY<MNEMONIC
1428   0993 26 11            8NE    MNMI       ENTRY>MNEMONIC
1429                      *
1430   0995 4F               CLR A             ENTRY FOUND
1431   0996 FE 07E8 R        LDX    T8ADD      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 MNL1   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
```

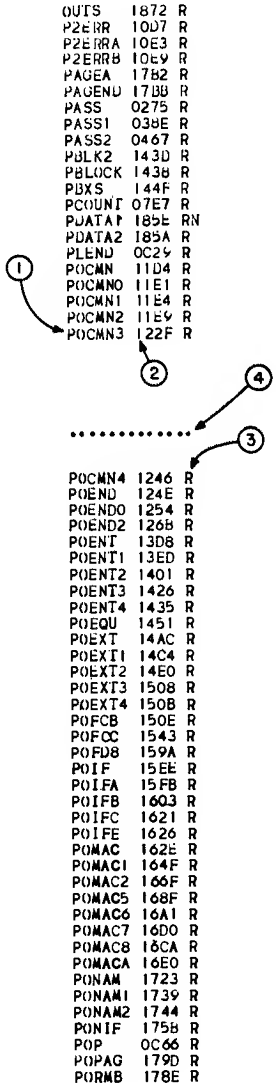
Listing 2: Symbol table listing format. A sample of the Assembler listing option showing the format of a symbol table listing.

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
POCMNO 11E1 R
POCMN1 11E4 R
POCMN2 11E9 R
POCMN3 122F R

.............

POCMN4 1246 R
POEND  124E R
POENDO 1254 R
POEND2 126B 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
POFD8  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  175B R
POP    0C66 R
POPAG  179D R
PORMB  178E 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

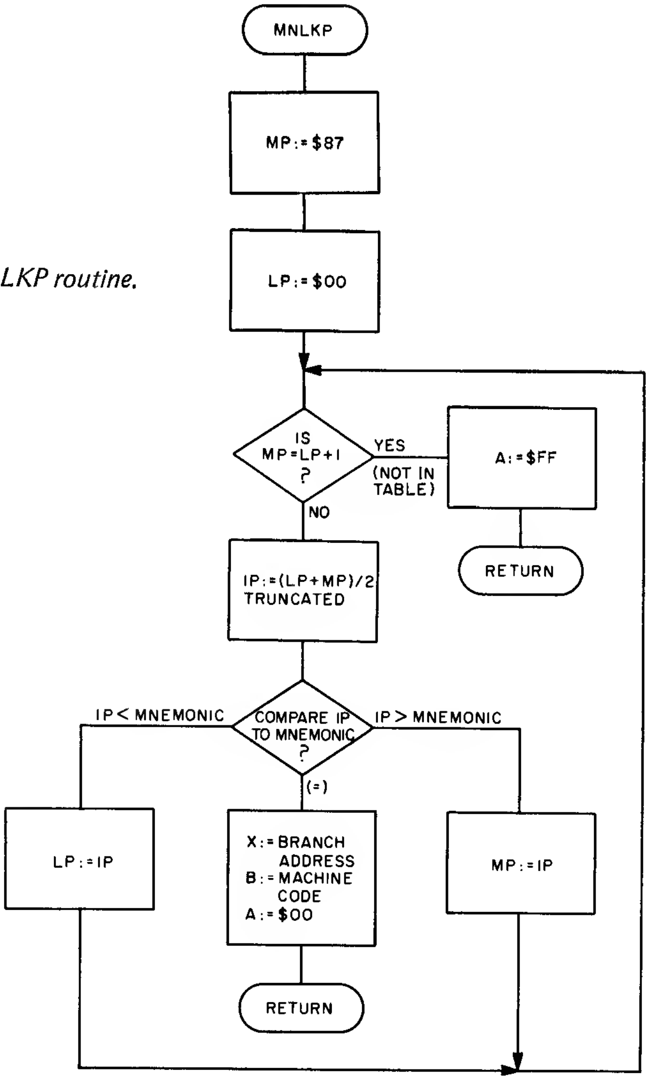
The following routines provide the table look-up, comparison, and insertion functions necessary for maintenance of the Mnemonic and Symbol Tables.

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.

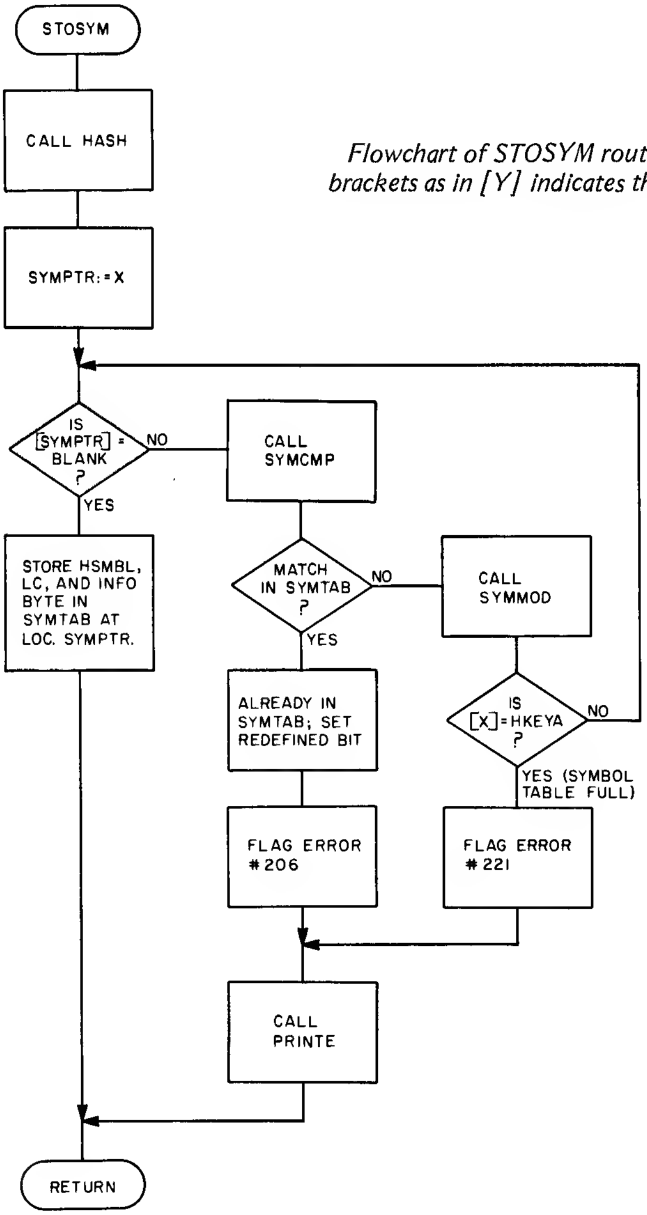
STOSYM

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

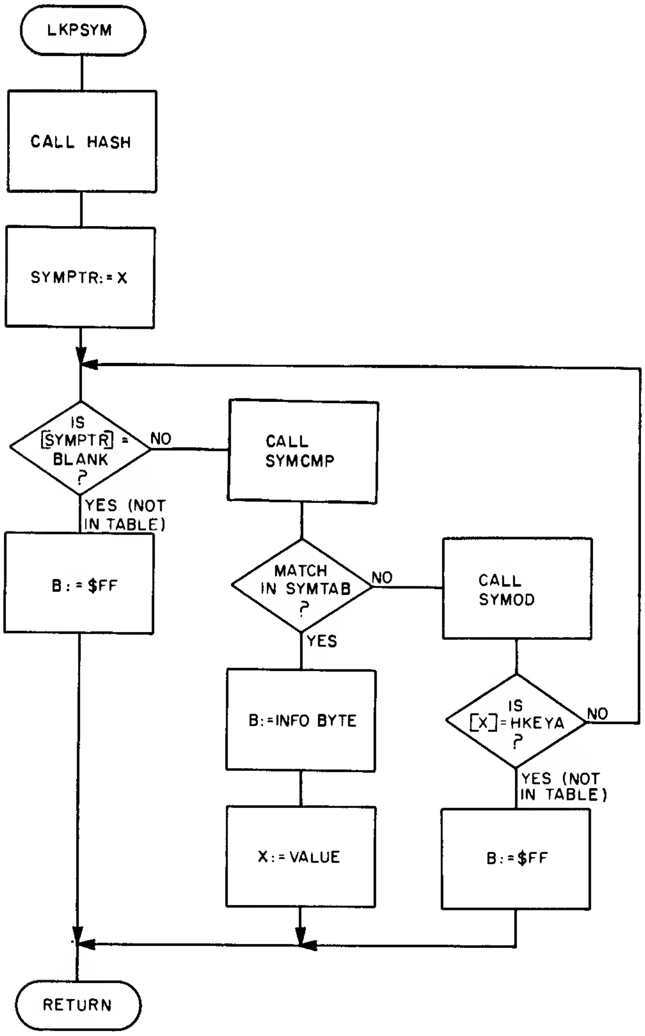
HASH

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.

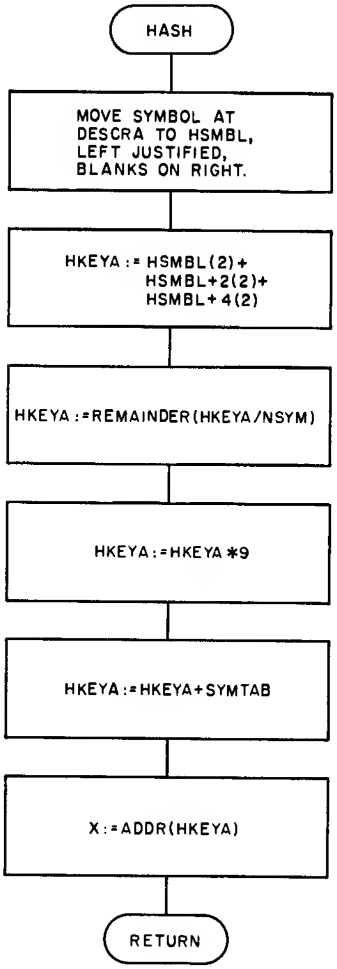
The hashed value is calculated by first folding over the six bytes of the symbol (spaces are added to the right of symbols less than six bytes long) into two bytes by adding the six bytes together in groups of two bytes. This value is divided by the maximum number of symbols that the Symbol Table can 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.


HASH
MOVE SYMBOL AT DESCRA TO HSMBL, LEFT JUSTIFIED, BLANKS ON RIGHT.
HKEYA := HSMBL(2)+ HSMBL+2(2)+ HSMBL+4(2)
HKEYA :=REMAINDER(HKEYA/NSYM)
HKEYA:=HKEYA *9
HKEYA:=HKEYA+SYMTAB
X:=ADDR(HKEYA)
RETURN

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.

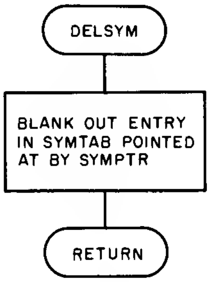
Calls:	none
Called By:	LBLCK
Pointers:	SYMPTR

SYMCMP

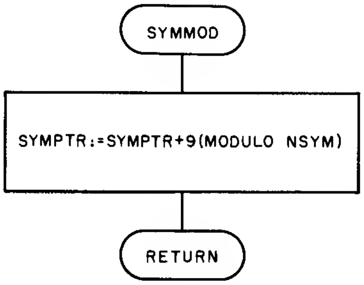
This routine is used to compare a symbol with an entry in the Symbol Table. On entry, the Index register points to the entry in the Symbol Table and HSMBL contains the symbol.

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

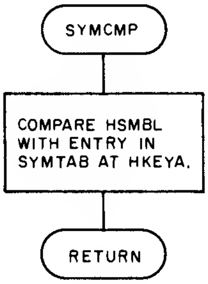
Calls:	COMPAR
Called By:	LKPSYM, STOSYM
Pointers:	HSMBL, PCOUNT, PSTNG1, PSTNG2



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

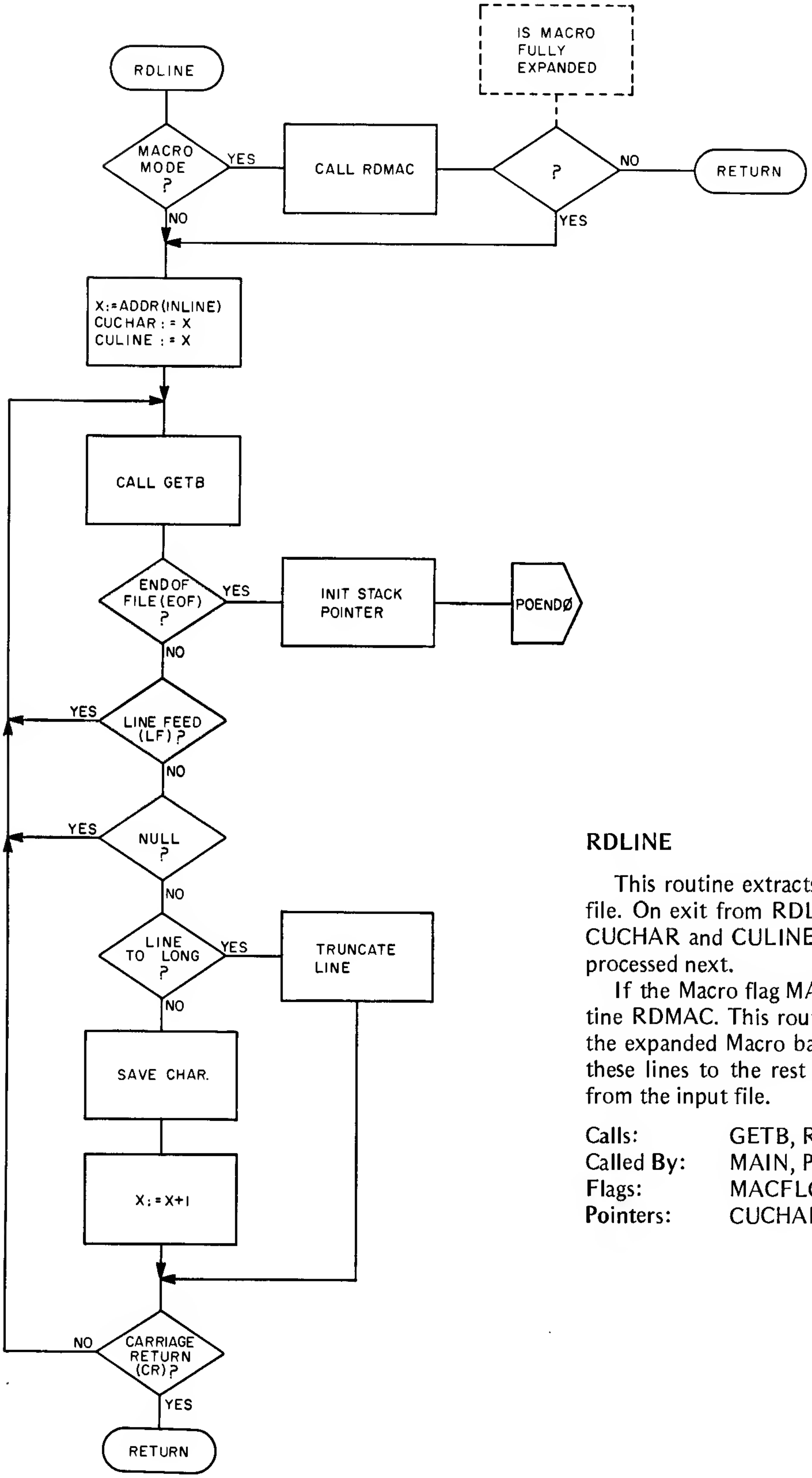
Calls:	OUTB
Called By:	POENT, POEXT, POFDB, PONAM
Flags:	OPTNS

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.

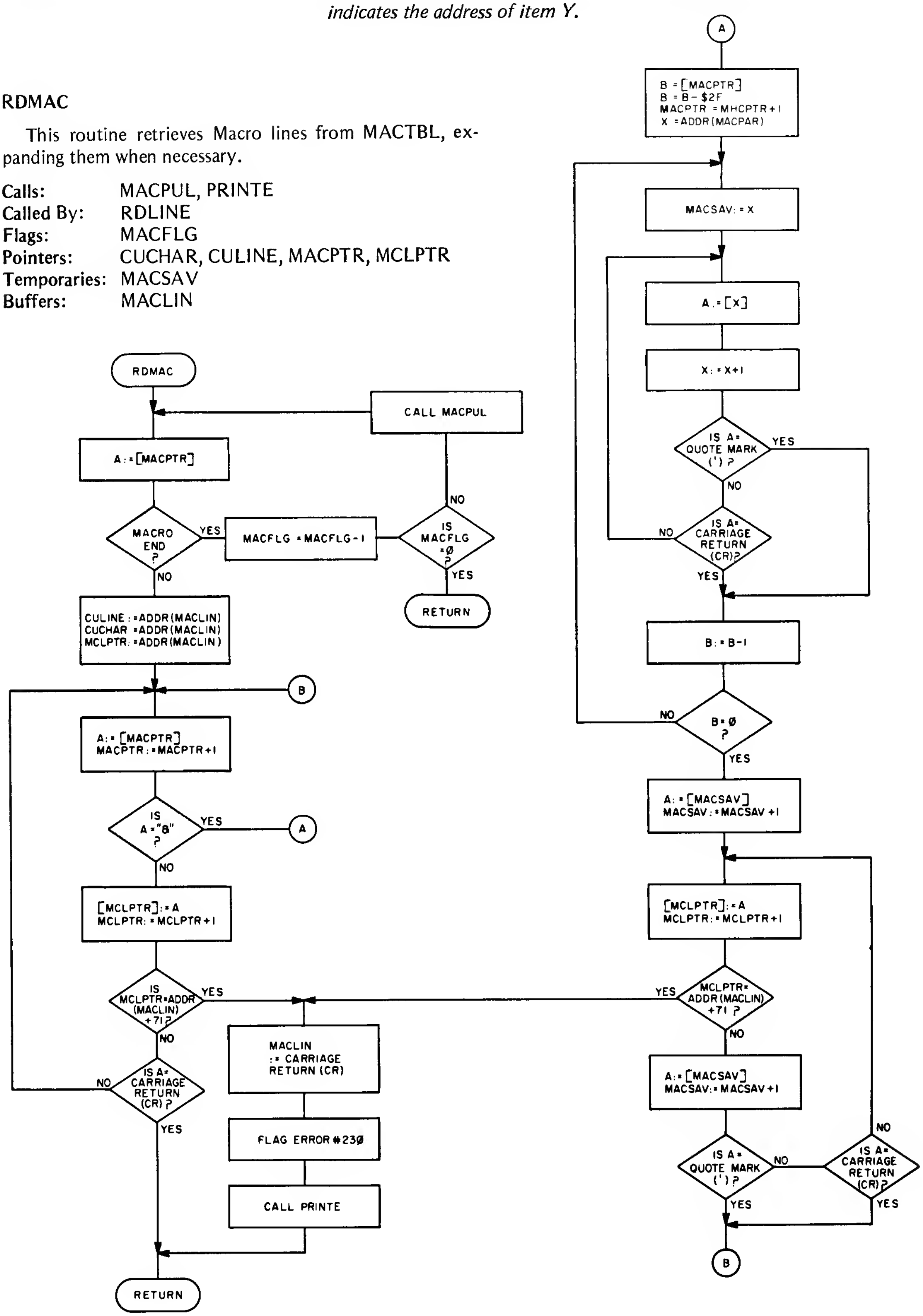
Calls:	GETB, RDMAC
Called By:	MAIN, POMAC
Flags:	MACFLG
Pointers:	CUCHAR, CULINE, INBUF

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.

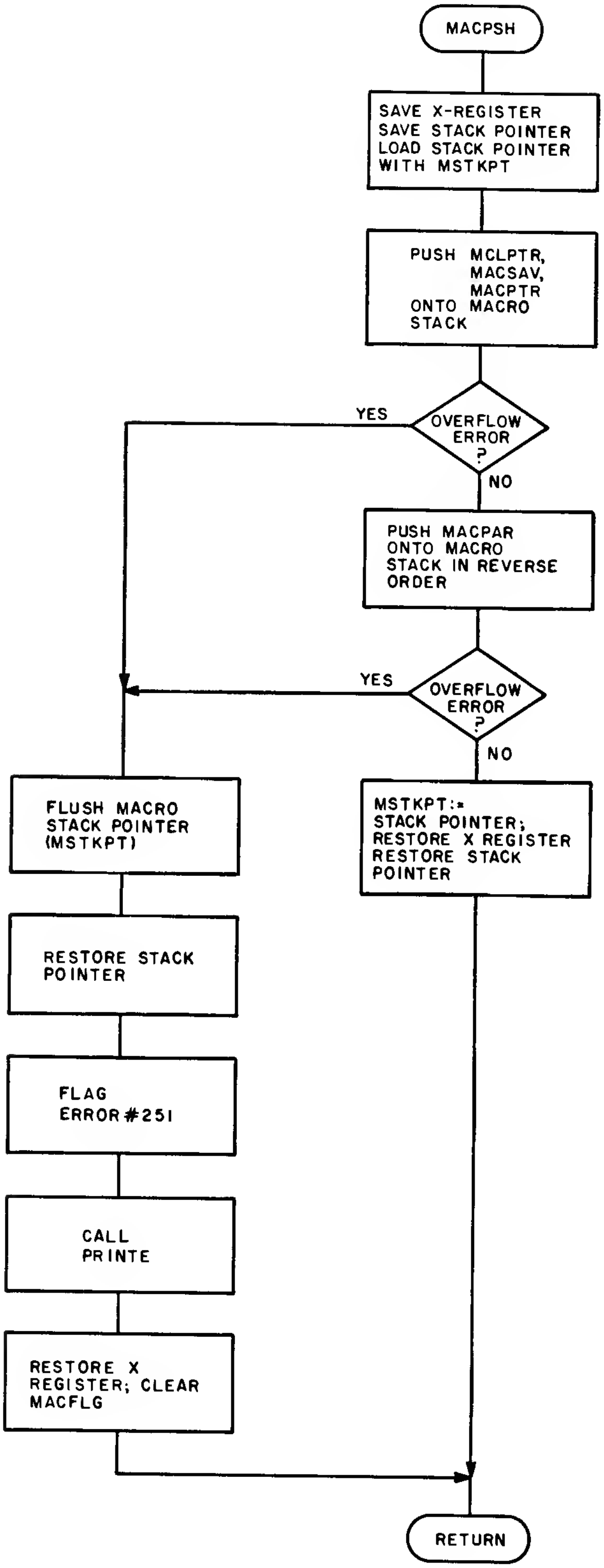
RDMAC

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
SAVE X-REGISTER SAVE STACK POINTER LOAD STACK POINTER WITH MSTKPT
PUSH MCLPTR, MACSAV, MACPTR ONTO MACRO STACK
OVERFLOW ERROR ?
YES
NO
PUSH MACPAR ONTO MACRO STACK IN REVERSE ORDER
OVERFLOW ERROR ?
YES
NO
FLUSH MACRO STACK POINTER (MSTKPT)
MSTKPT:= STACK POINTER; RESTORE X REGISTER RESTORE STACK POINTER
RESTORE STACK POINTER
FLAG ERROR #251
CALL PRINTE
RESTORE X REGISTER; CLEAR MACFLG
RETURN

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).

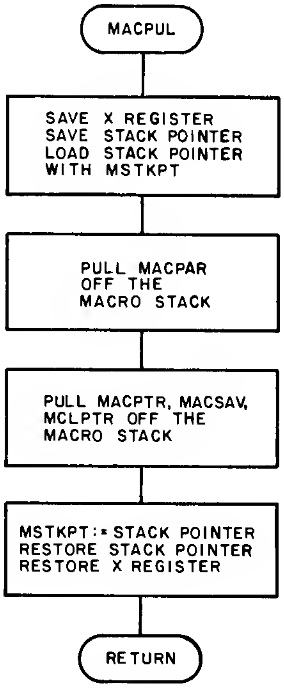
Calls:	PRINTE
Called By:	MAIN
Flags:	MACFLG
Pointers:	MACEND, MACPTR, MACSAV, MACSTK, MCLPTR, MSTKPT
Temporaries:	STKSAV, MXSAV1, MXSAV2
Buffers:	MACPAR

MACPUL

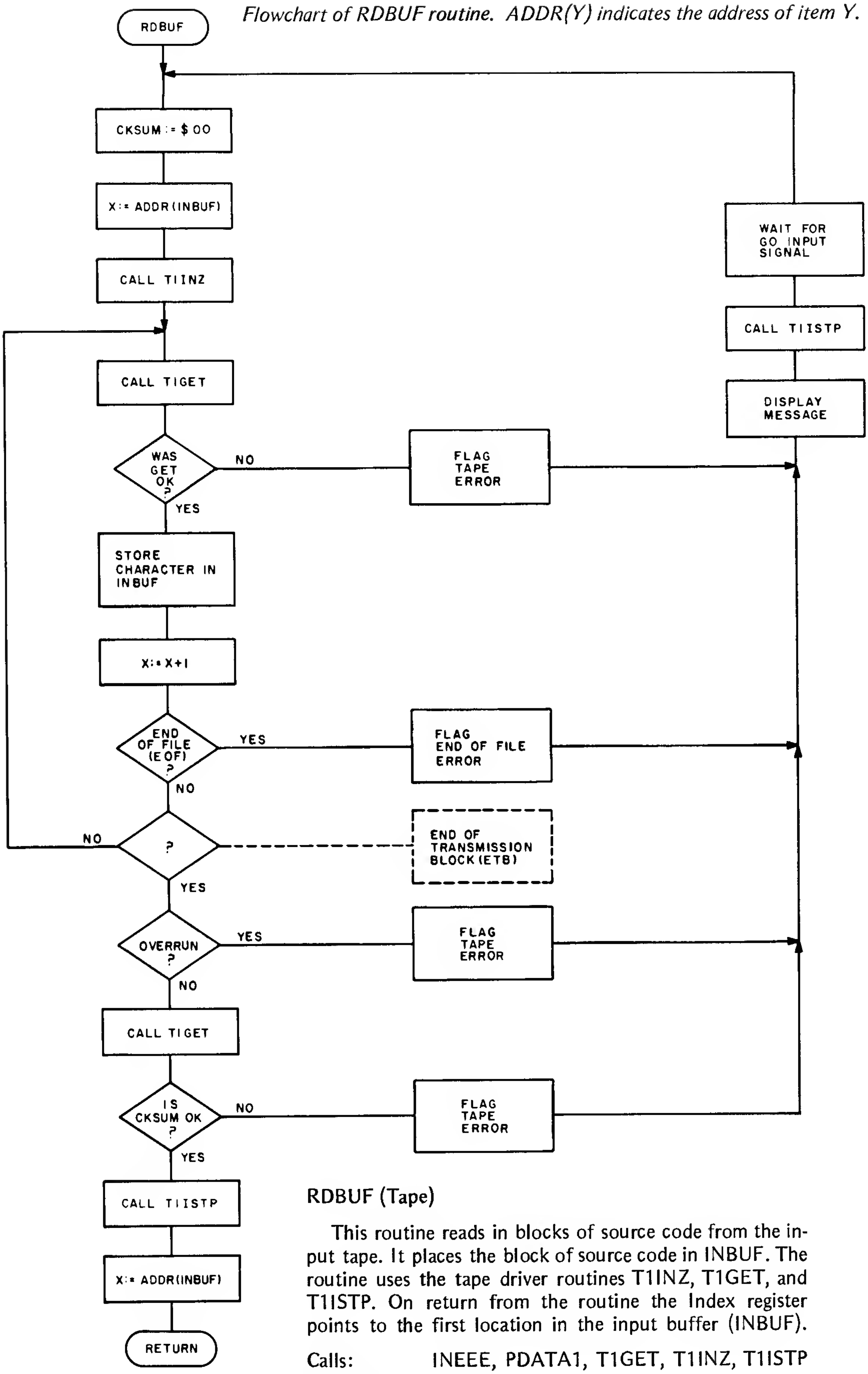
This routine is used to pull the state of a Macro previously pushed onto the Macro Stack. This is done when the inner Macro has been fully expanded.

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

Flowchart of MACPUL routine.


MACPUL
SAVE X REGISTER SAVE STACK POINTER LOAD STACK POINTER WITH MSTKPT
PULL MACPAR OFF THE MACRO STACK
PULL MACPTR, MACSAV, MCLPTR OFF THE MACRO STACK
MSTKPT:= STACK POINTER RESTORE STACK POINTER RESTORE X REGISTER
RETURN

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**).

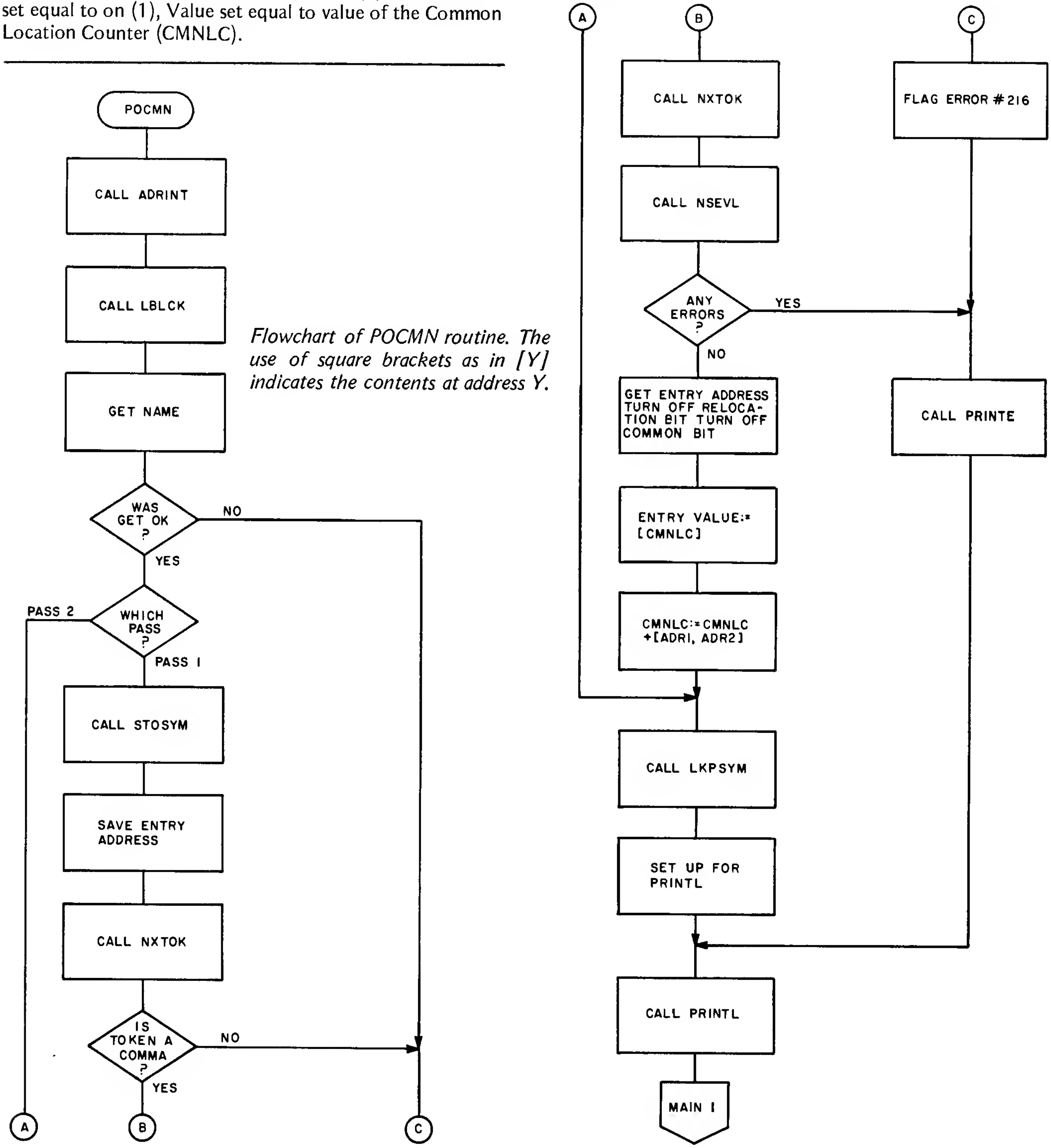
POCMN

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



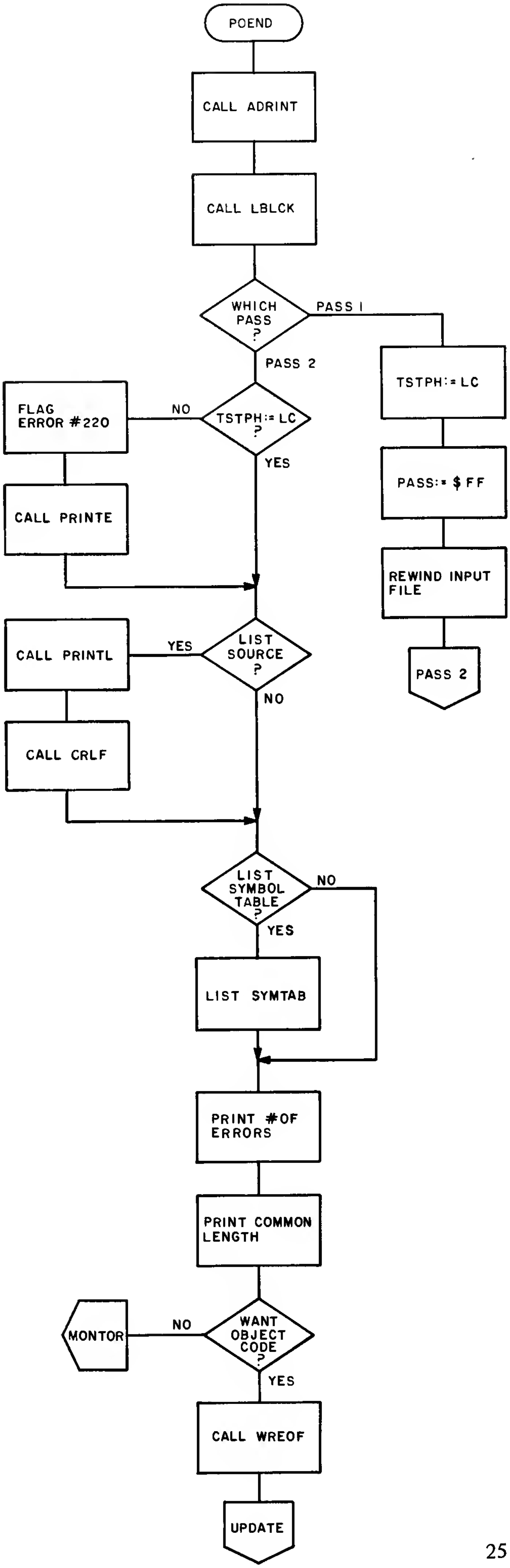
Flowchart of POCMN routine. The use of square brackets as in [Y] indicates the contents at address Y.

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



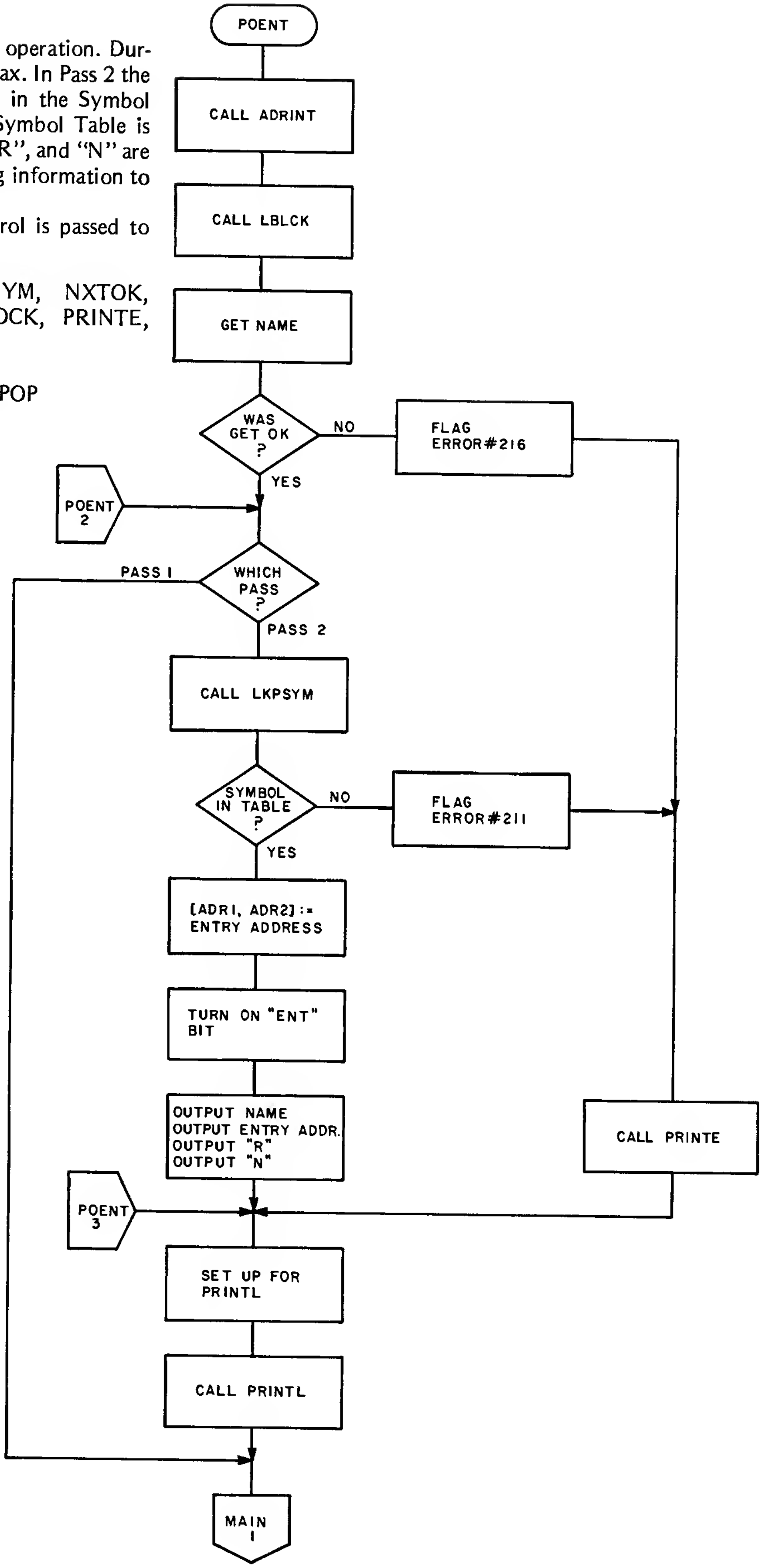
Flowchart of POEND routine.

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



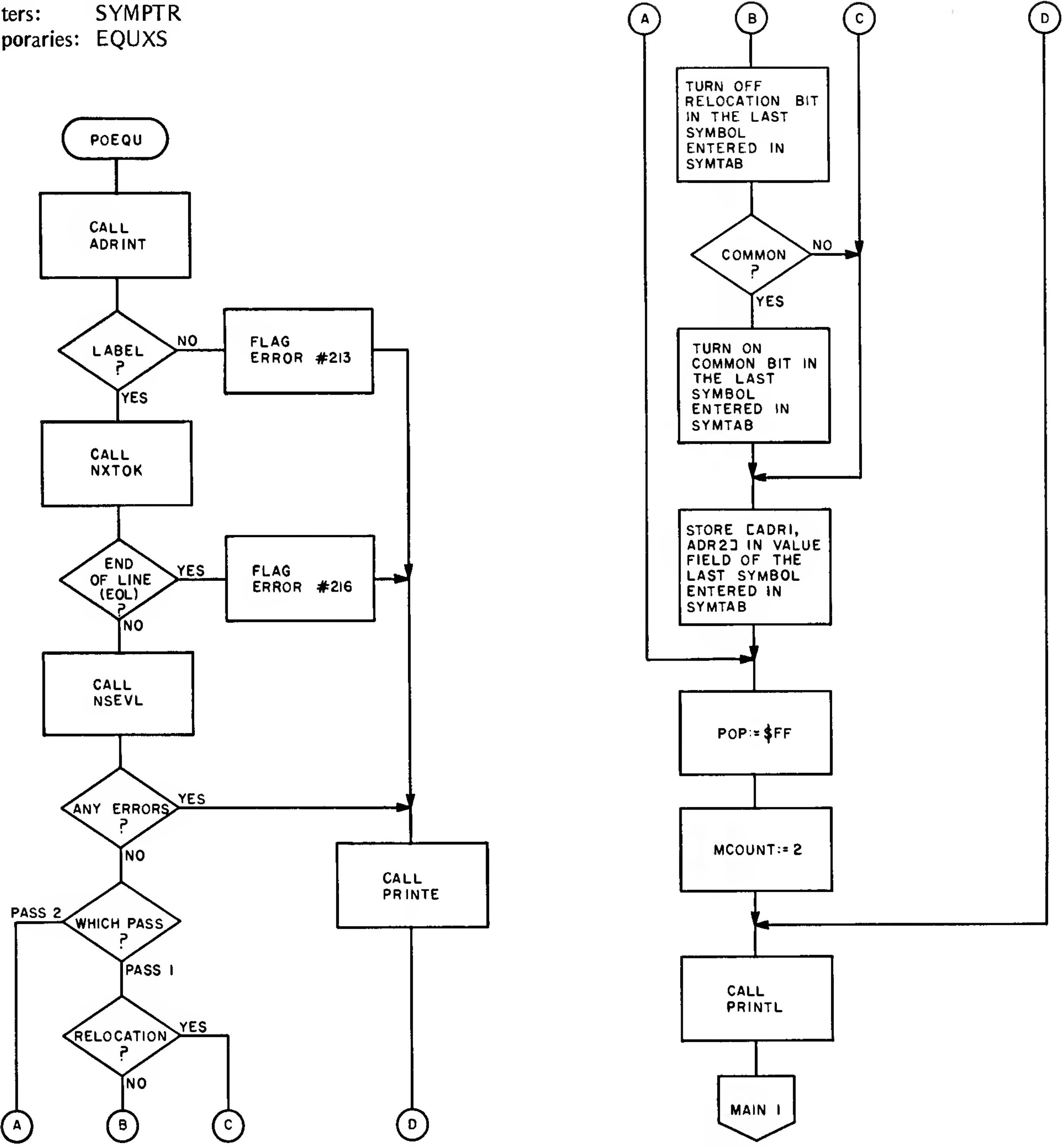
Flowchart of POENT routine. The use of square brackets as in [Y] indicates the contents at address Y.

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

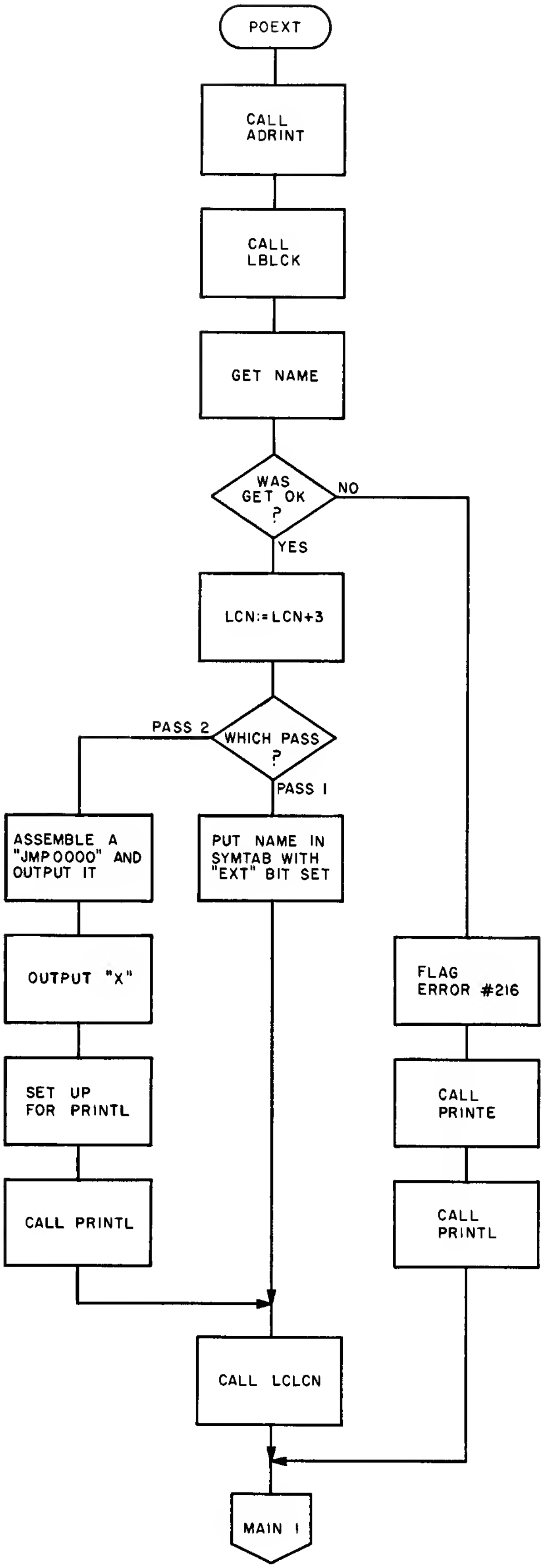
POEXT

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.

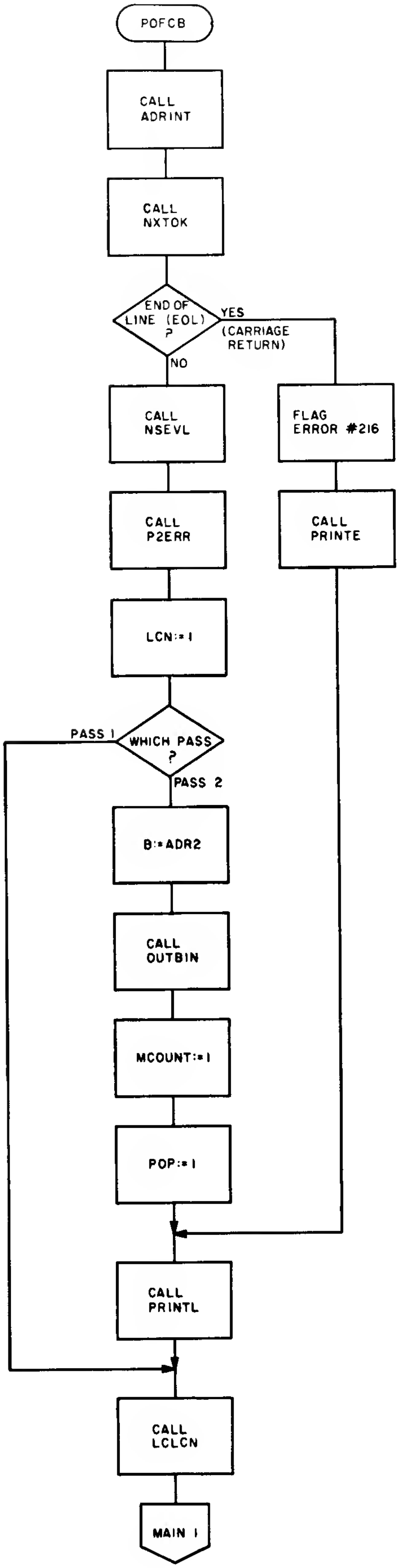
POFCB

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

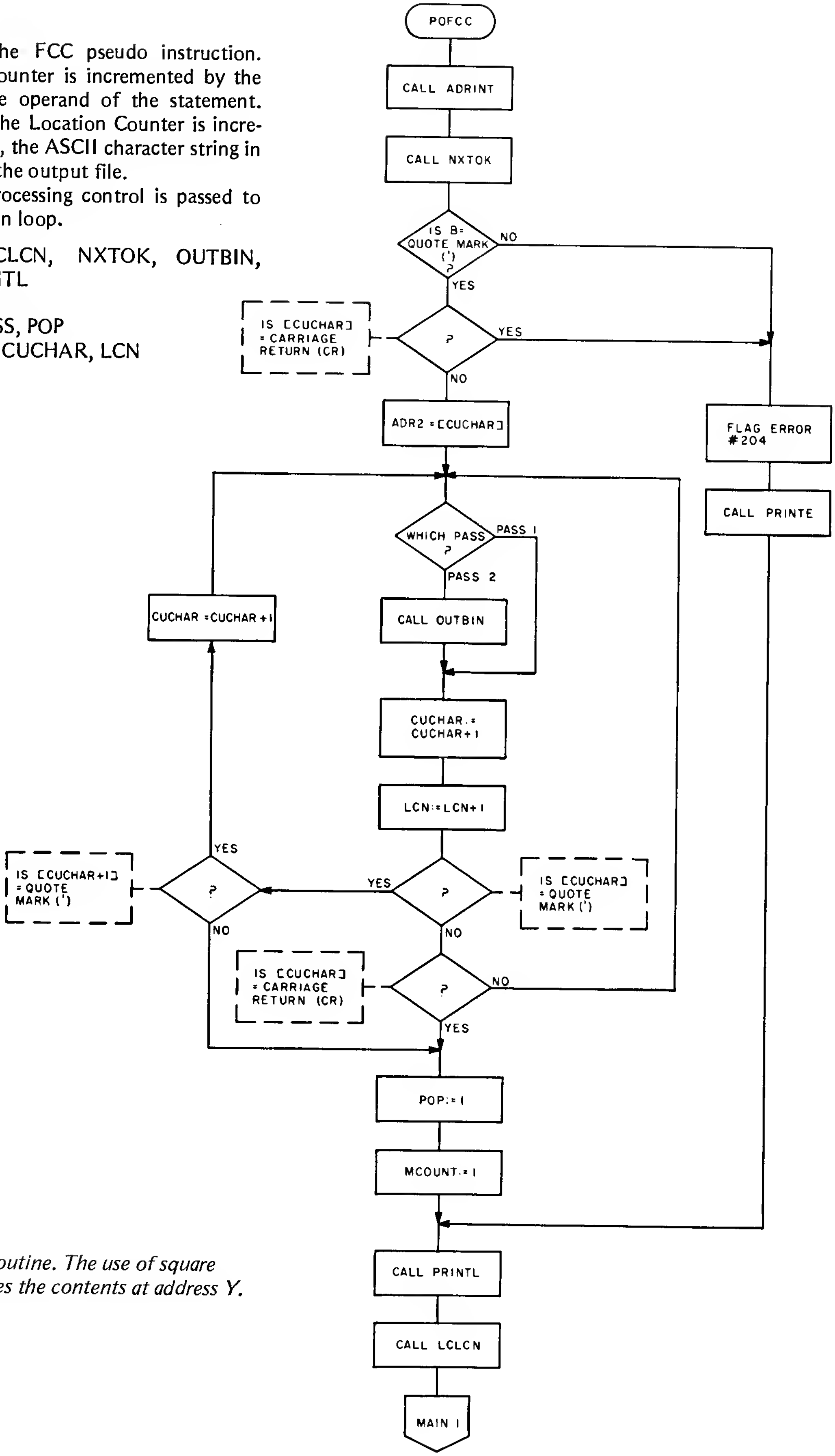


Flowchart of POFCB routine.

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



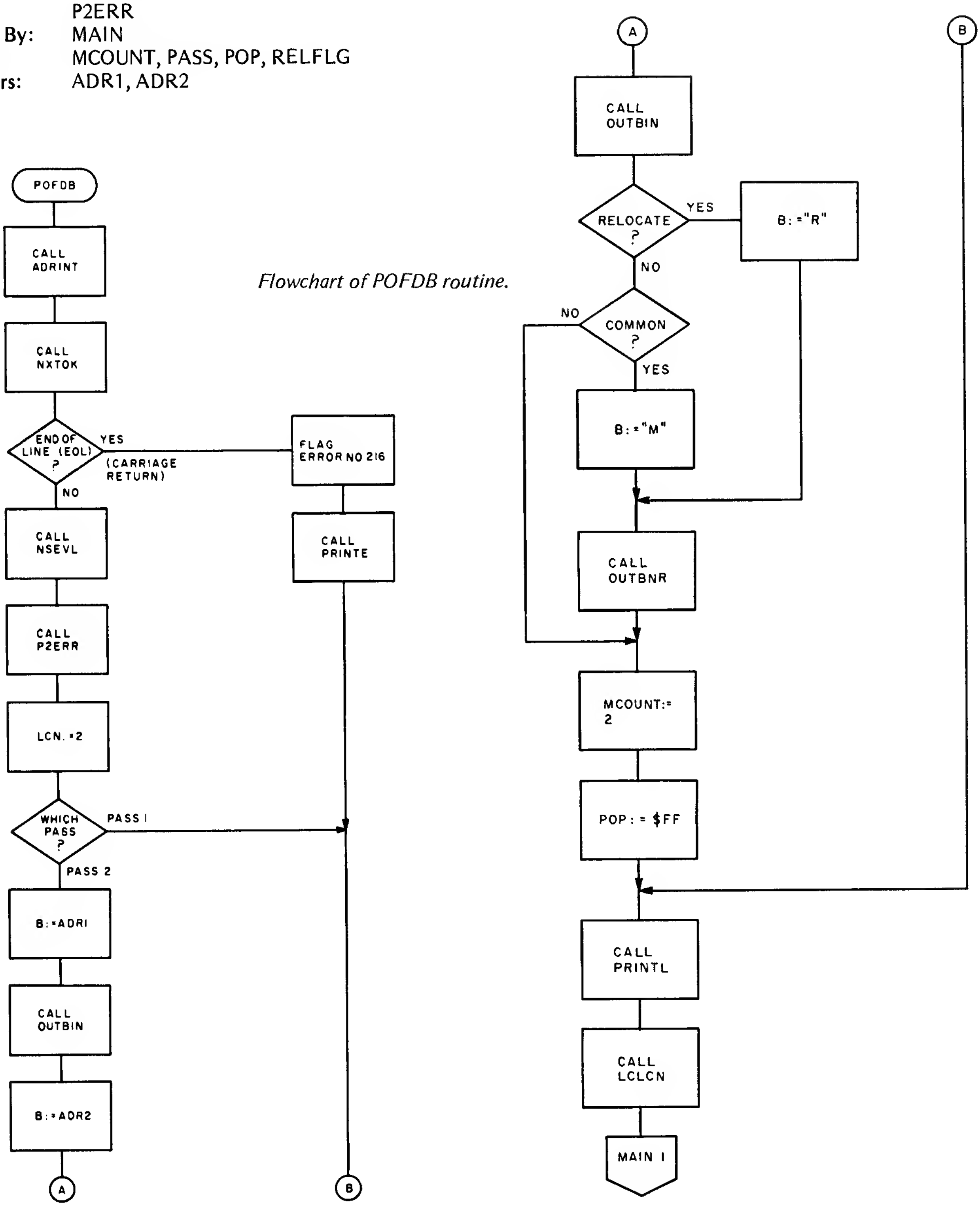
Flowchart of POFCC routine. The use of square breakets as in [Y] indicates the contents at address Y.

POFDB

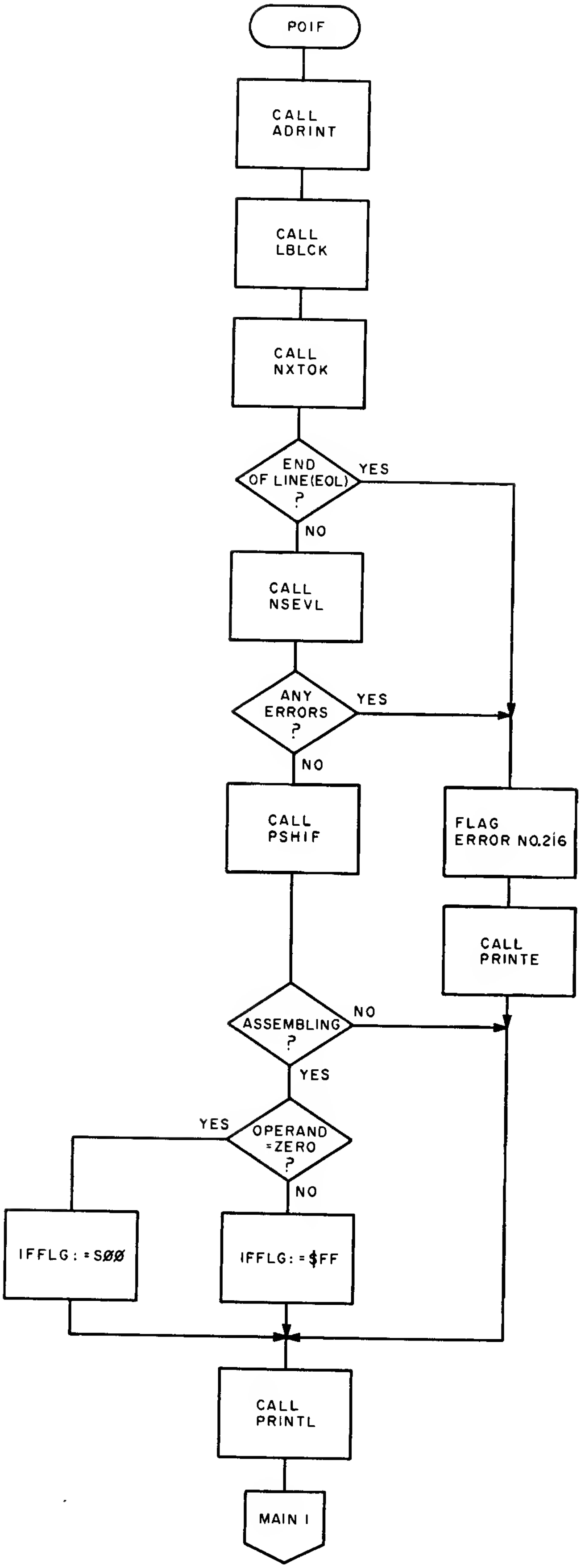
This routine processes the FDB pseudo operation. It is almost the same as routine POFCB, except that two byte values are used instead of one byte values.

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

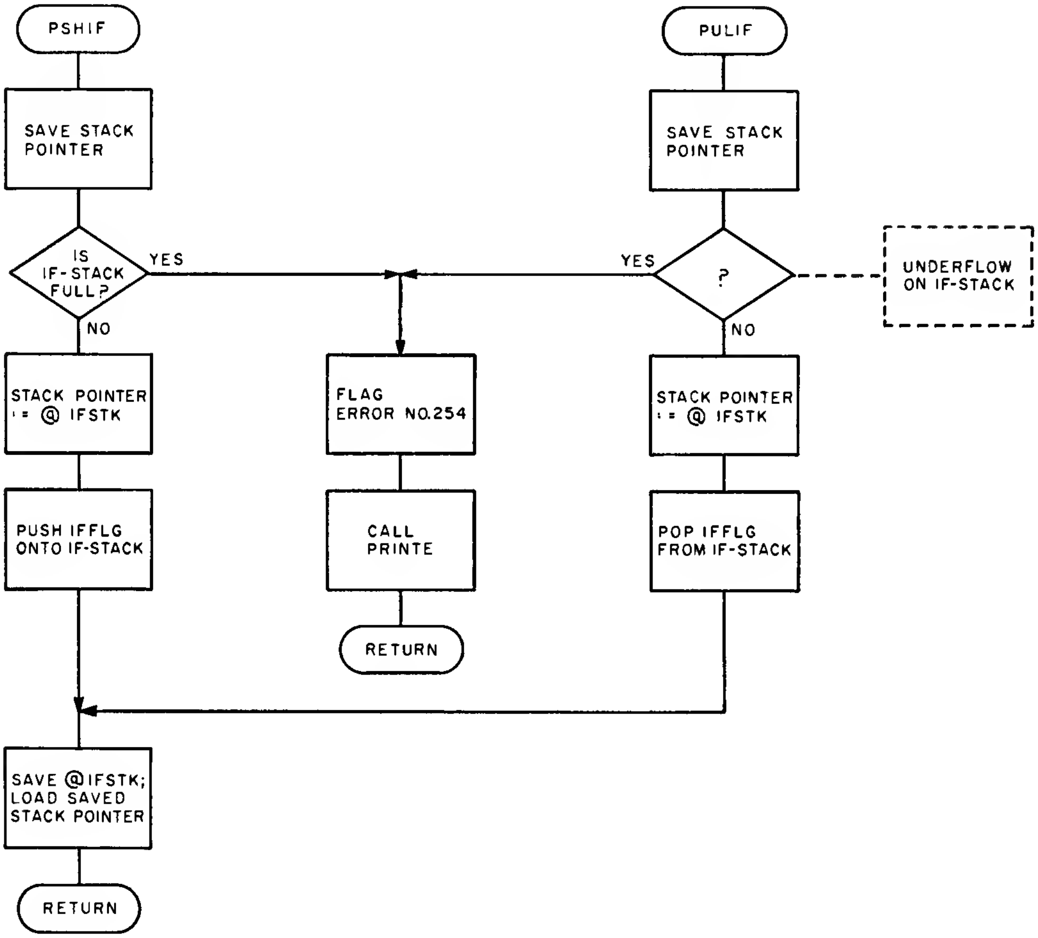
Flowchart of POIF routine.

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

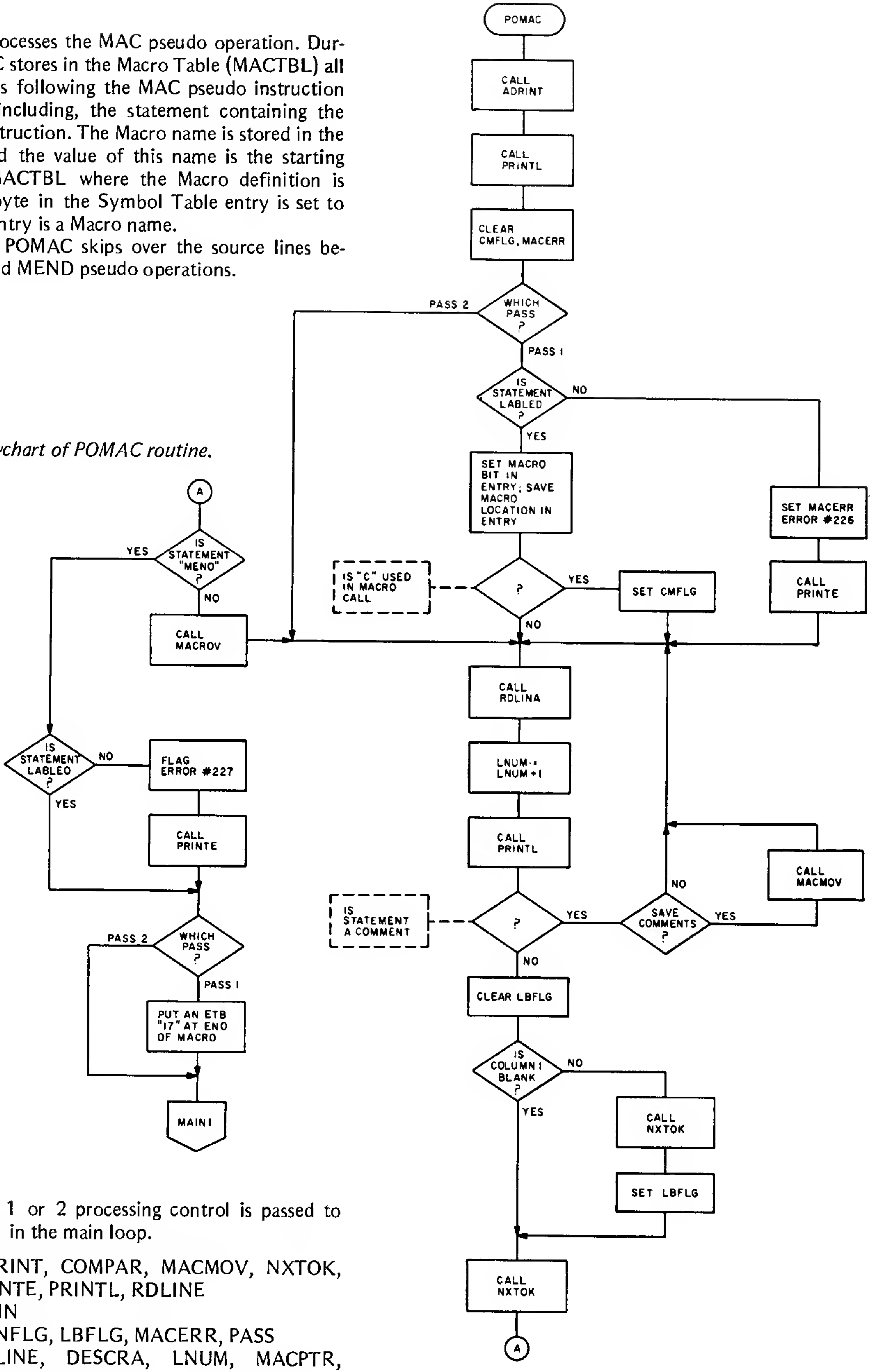
Flowchart of PUSHIF and PULIF routines.



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.

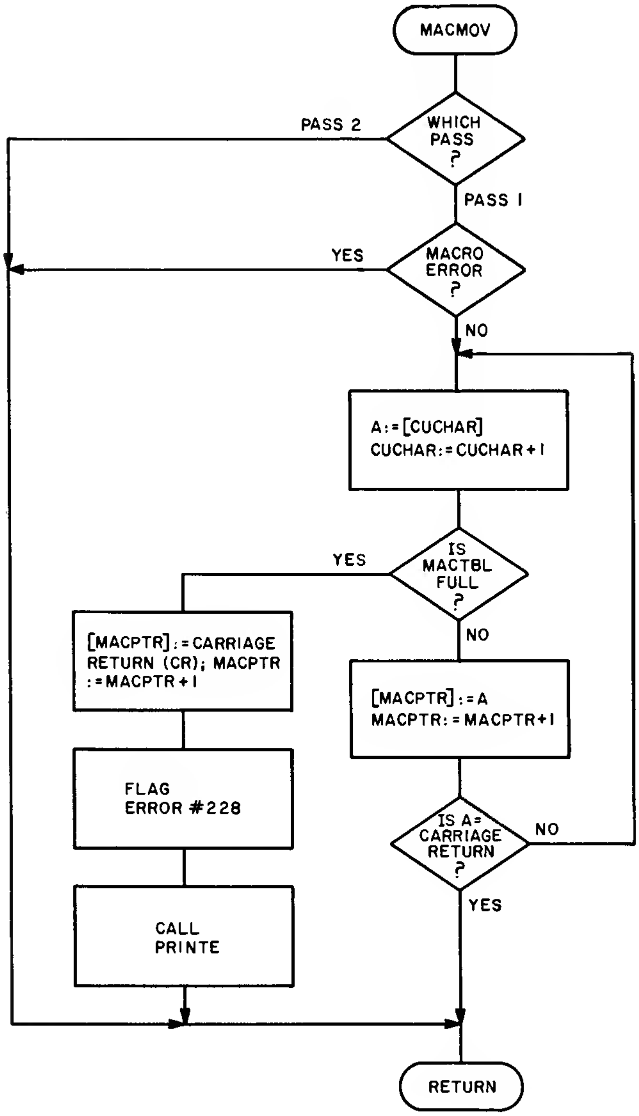
Calls:	ADRINT, COMPAR, MACMOV, NXTOK, PRINTE, PRINTL, RDLINE
Called By:	MAIN
Flags:	CMNFLG, LBFLG, MACERR, PASS
Pointers:	CULINE, DESCRA, LNUM, MACPTR, PCOUNT, SYMPTR

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.

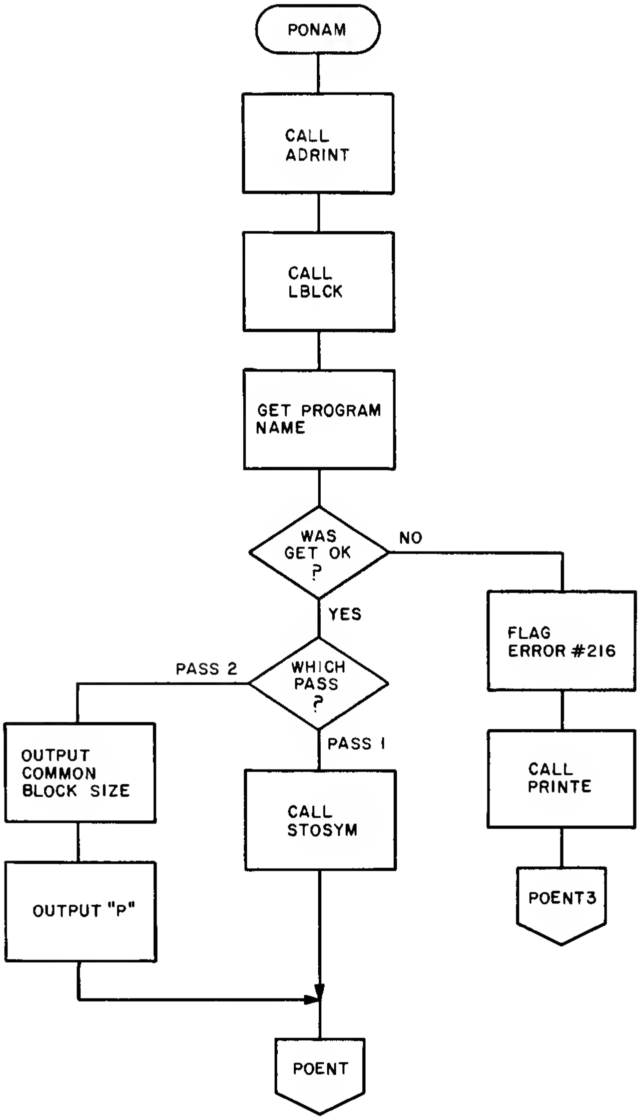


PONAM

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.

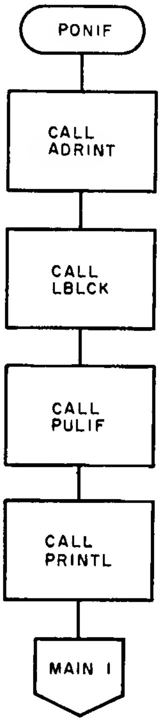


PONIF

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



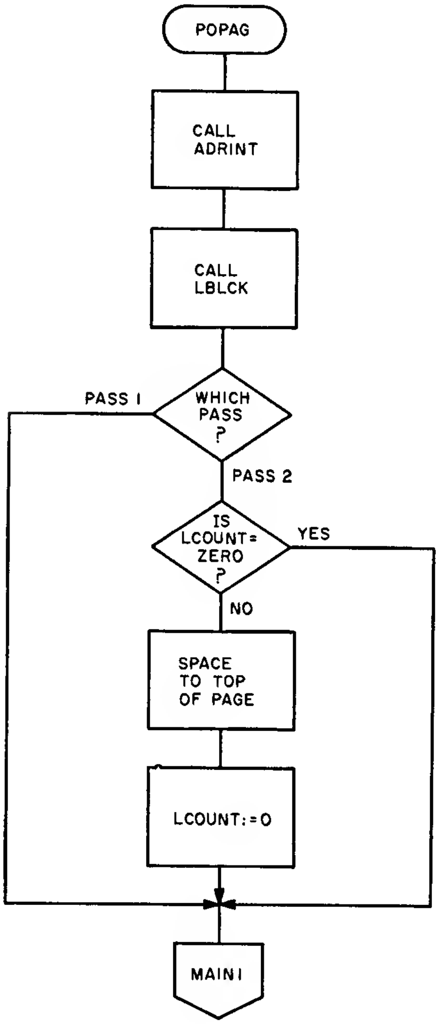
Flowchart of PONIF routine.

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.

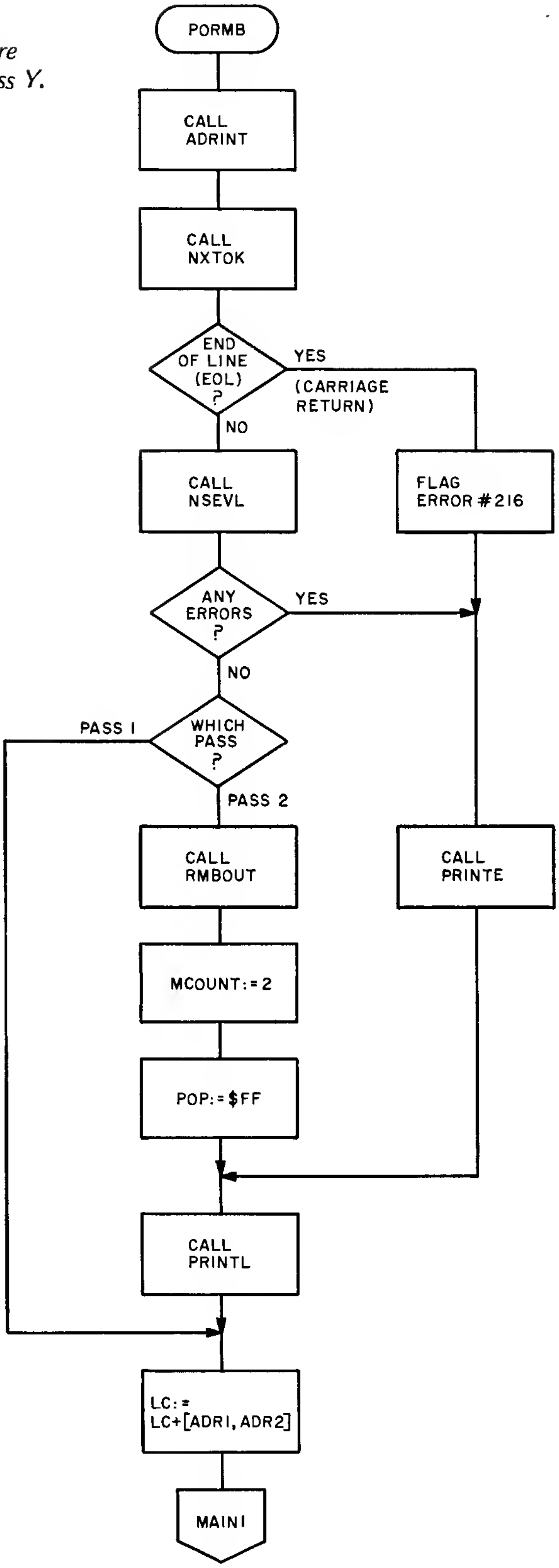
Flowchart of PORMB routine. The use of square brackets as in [Y] indicates the contents at address Y.

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.

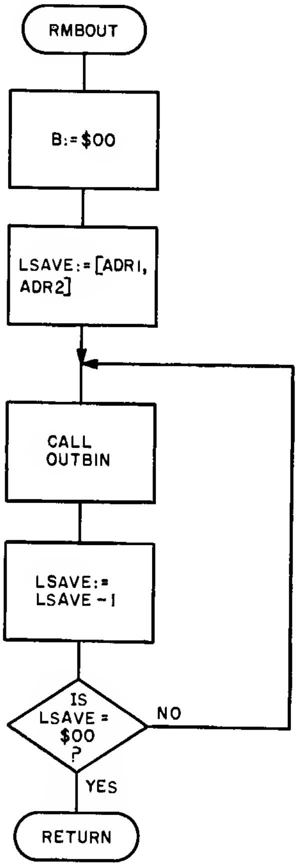
Calls:	ADRINT, NSEVL, NXTOK, PRINTE, PRINTL, RMBOUT
Called By:	MAIN
Flags:	MCOUNT, PASS, POP
Pointers:	ADR1, ADR2, LC
Temporaries:	LSAVE



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

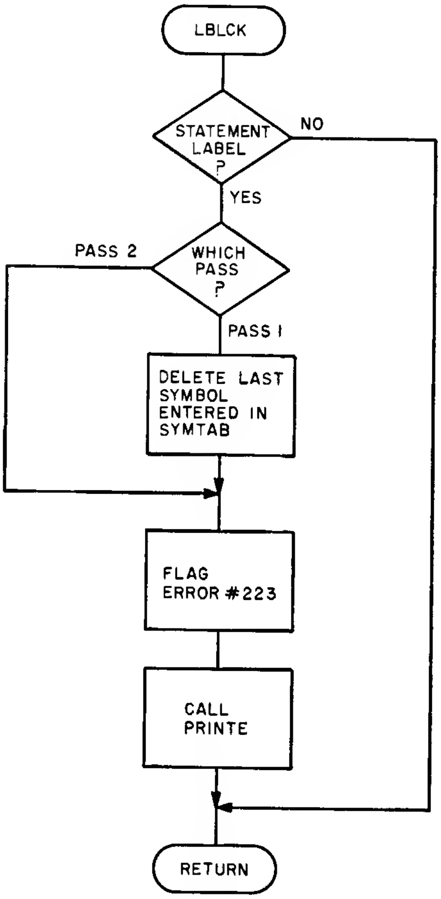


Flowchart of RMBOUT routine. The use of square brackets as in [Y] indicates the contents at address Y.

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.

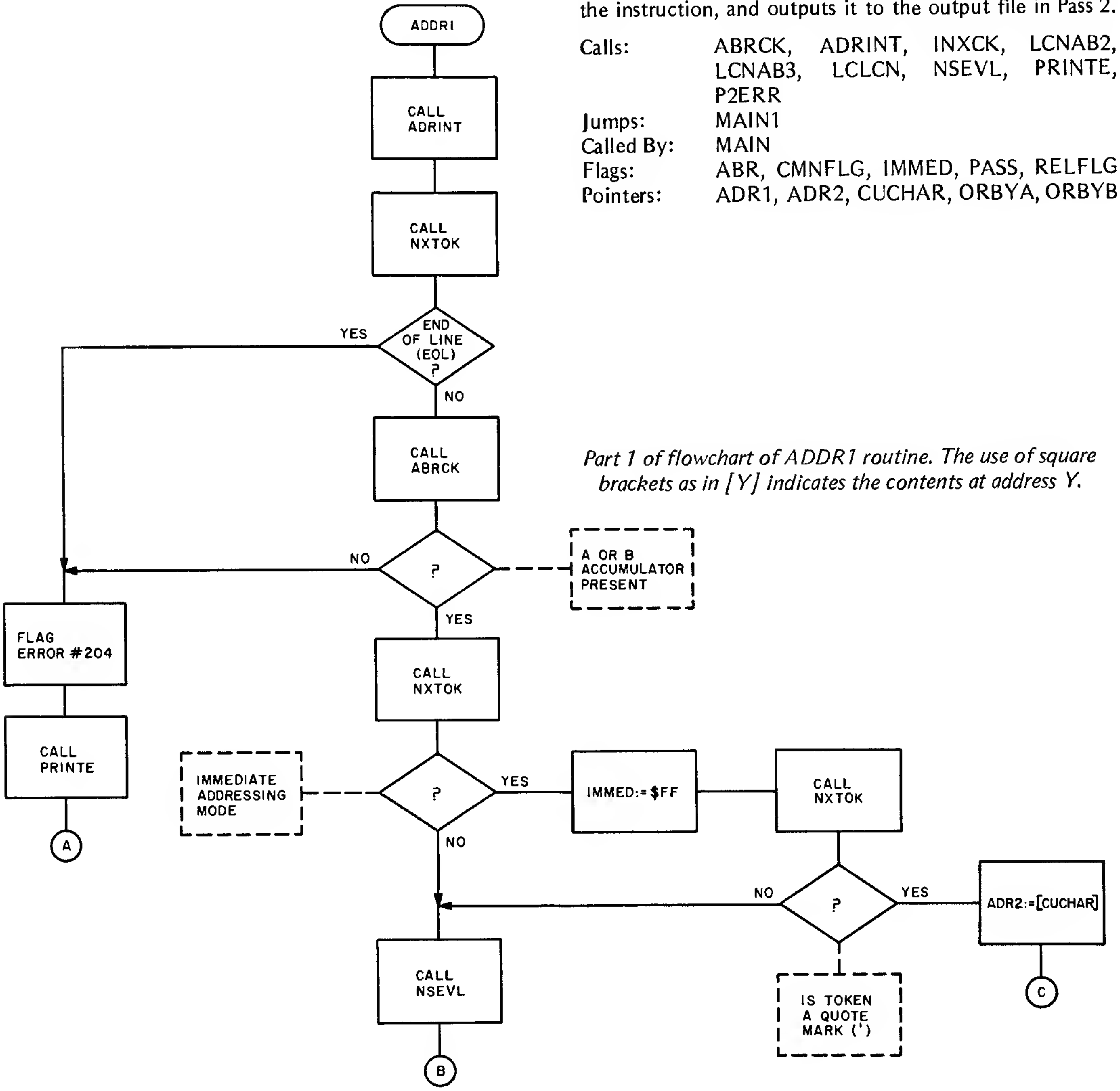
Following Pass 1 and 2 processing control is passed to entry point MAIN1 in the main loop.

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).

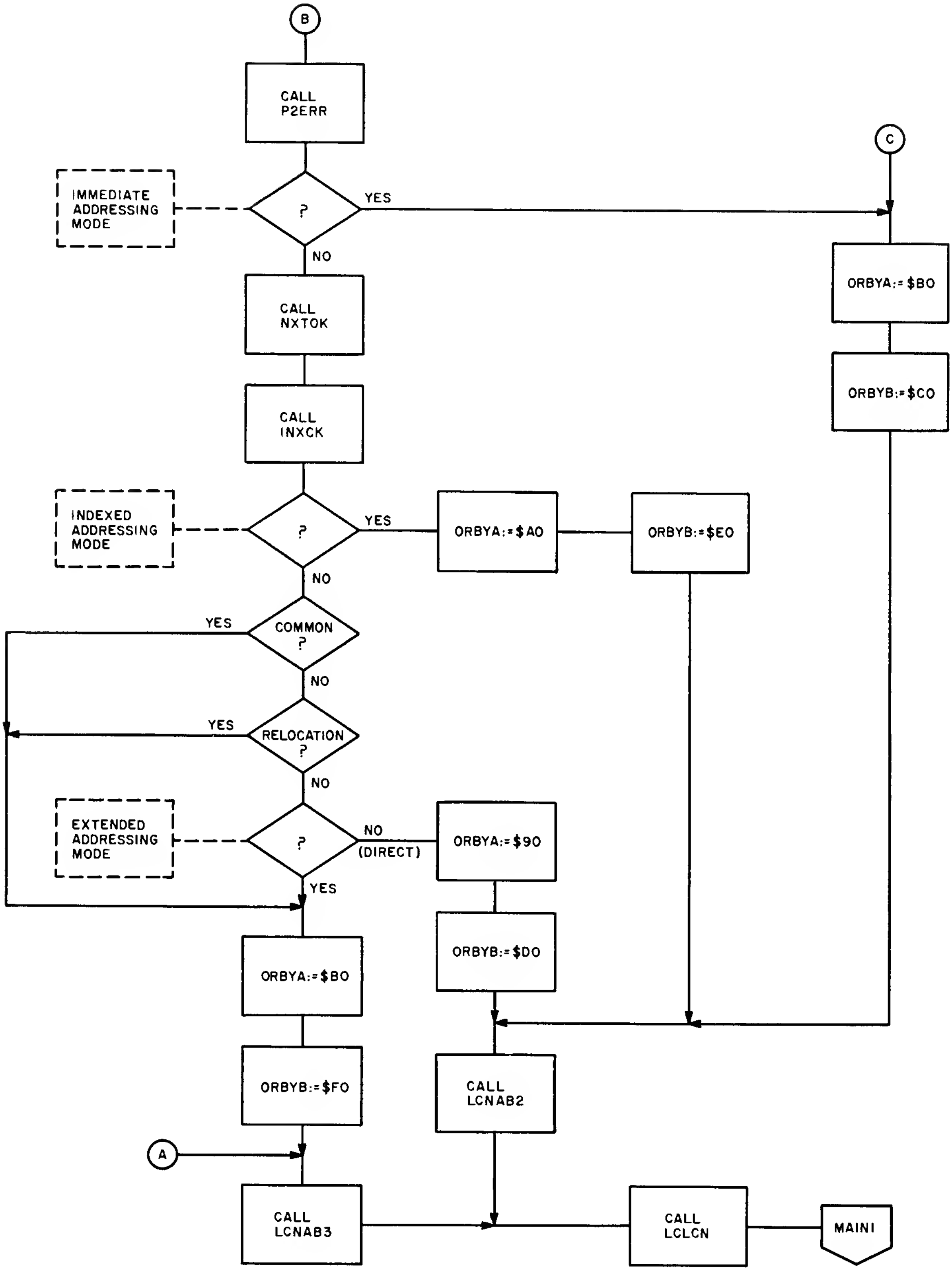
On entry, register B contains part of the opcode: depending on the *operand* field, ADDR1 completes the opcode, generates the machine code for the address part of the instruction, and outputs it to the output file in Pass 2.

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.

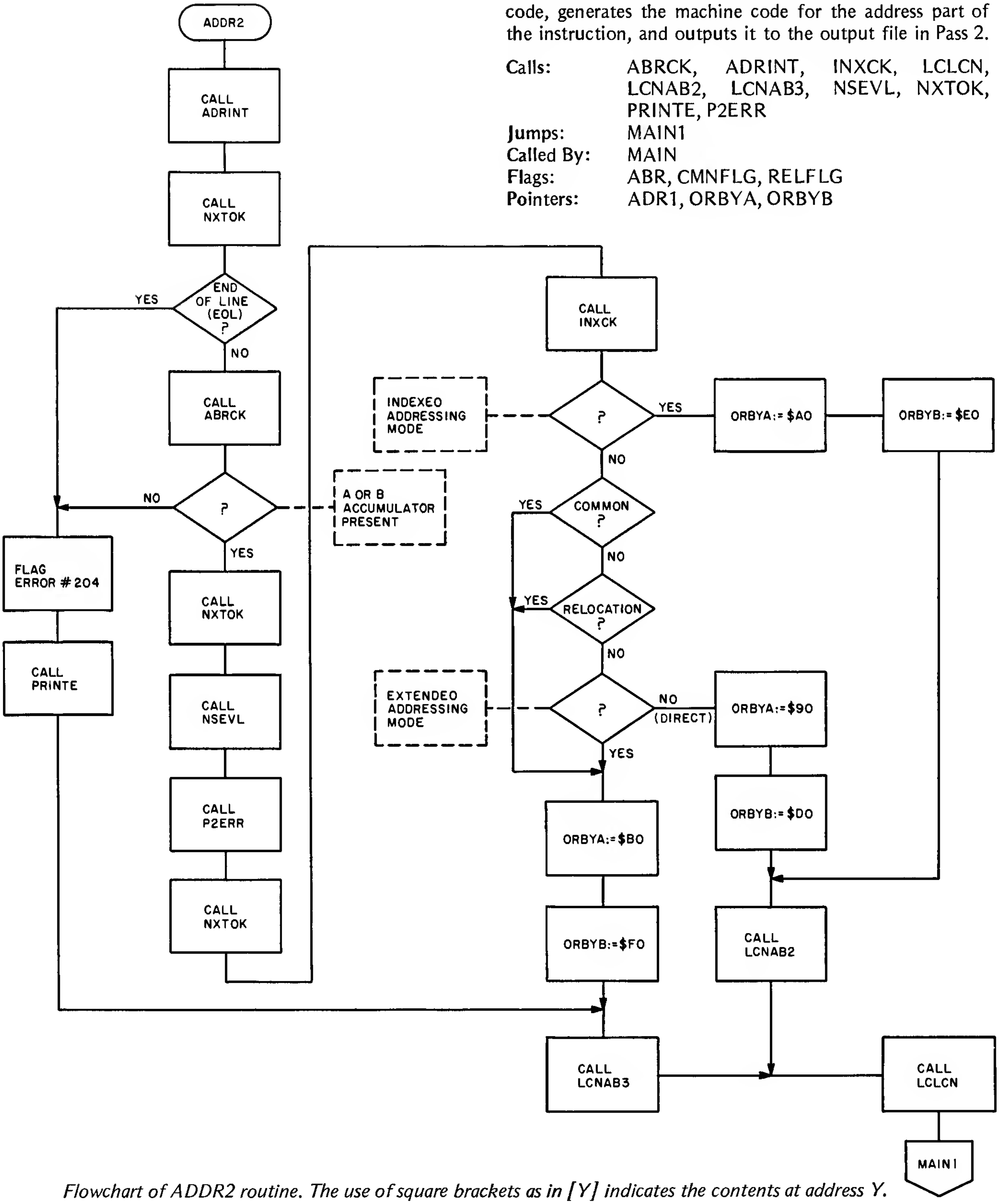


ADDR2

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



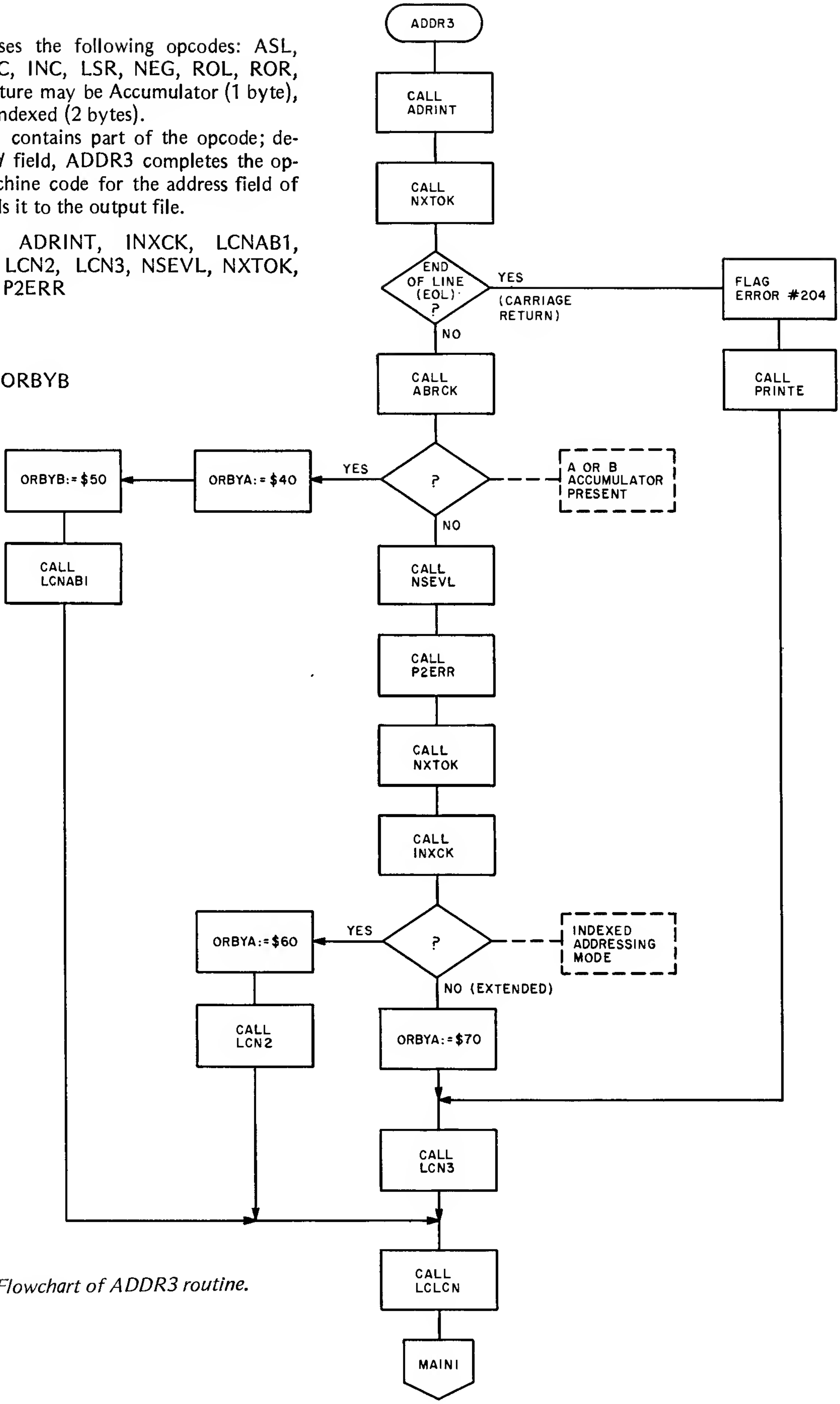
Flowchart of ADDR2 routine. The use of square brackets as in [Y] indicates the contents at address Y.

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



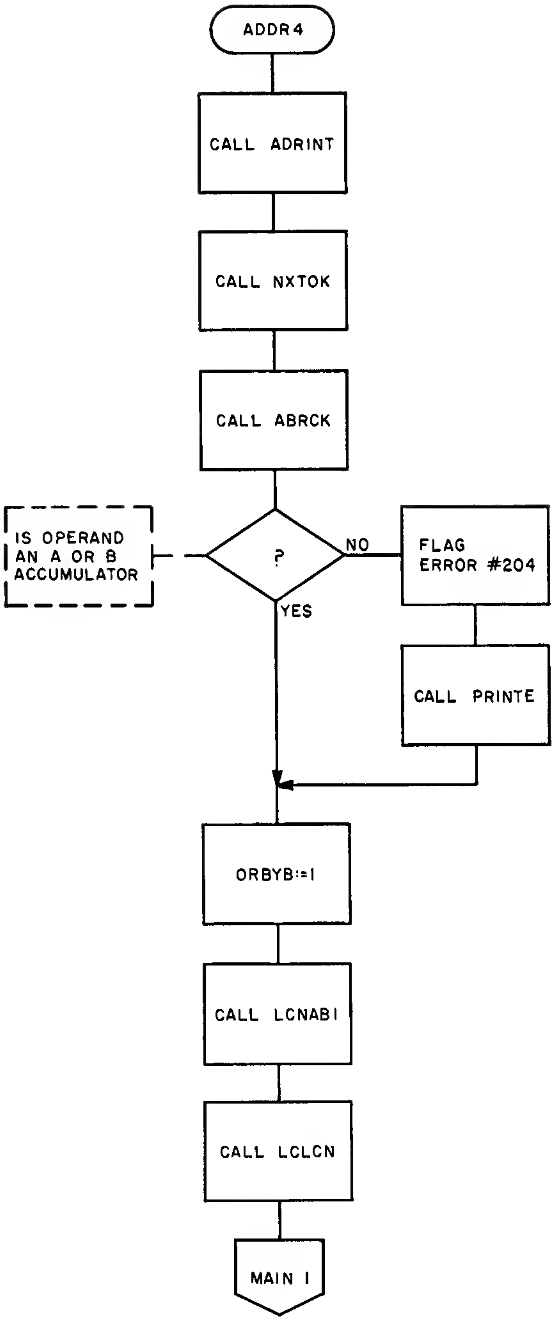
Flowchart of ADDR3 routine.

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.

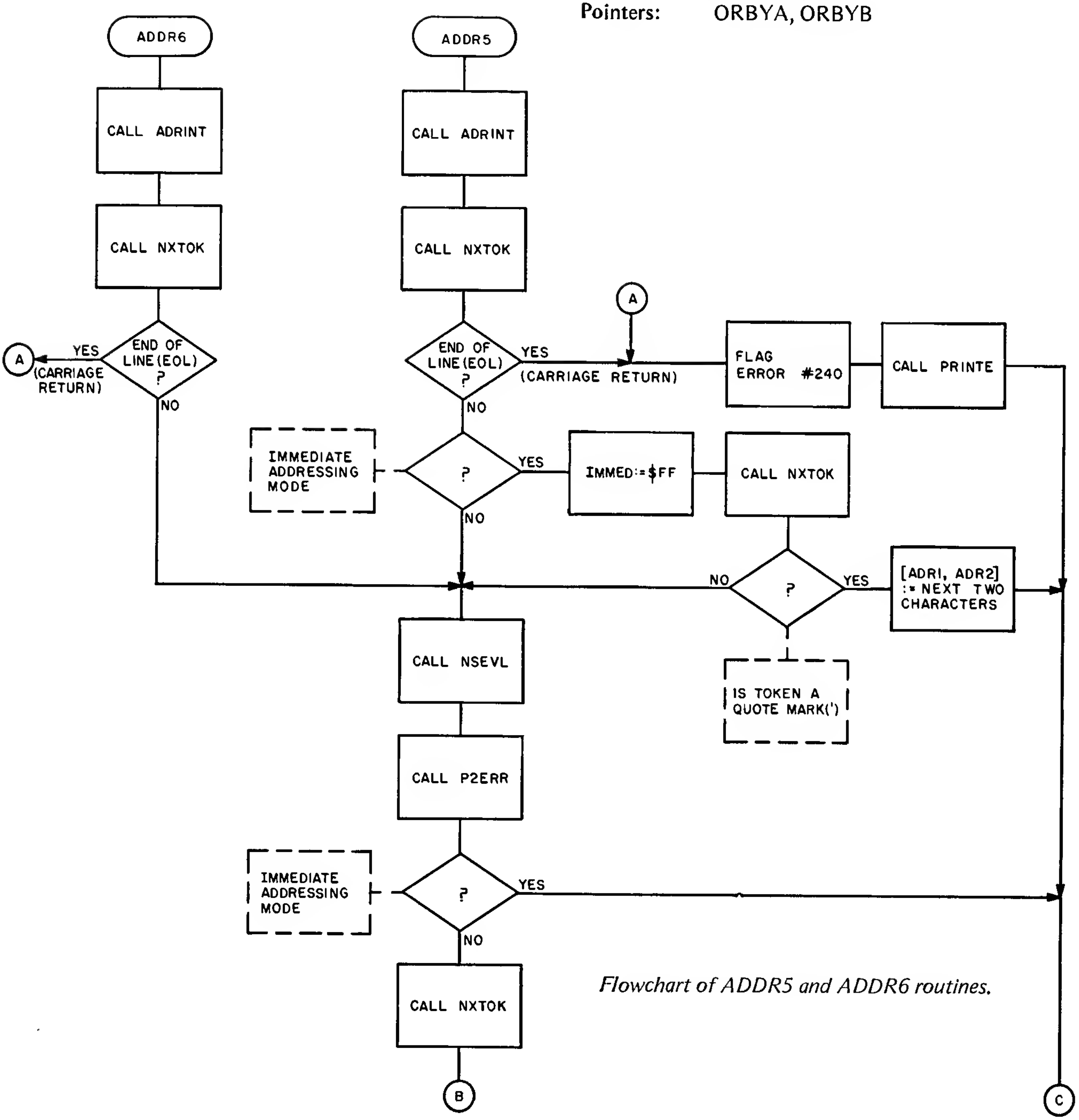
ADDR5

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



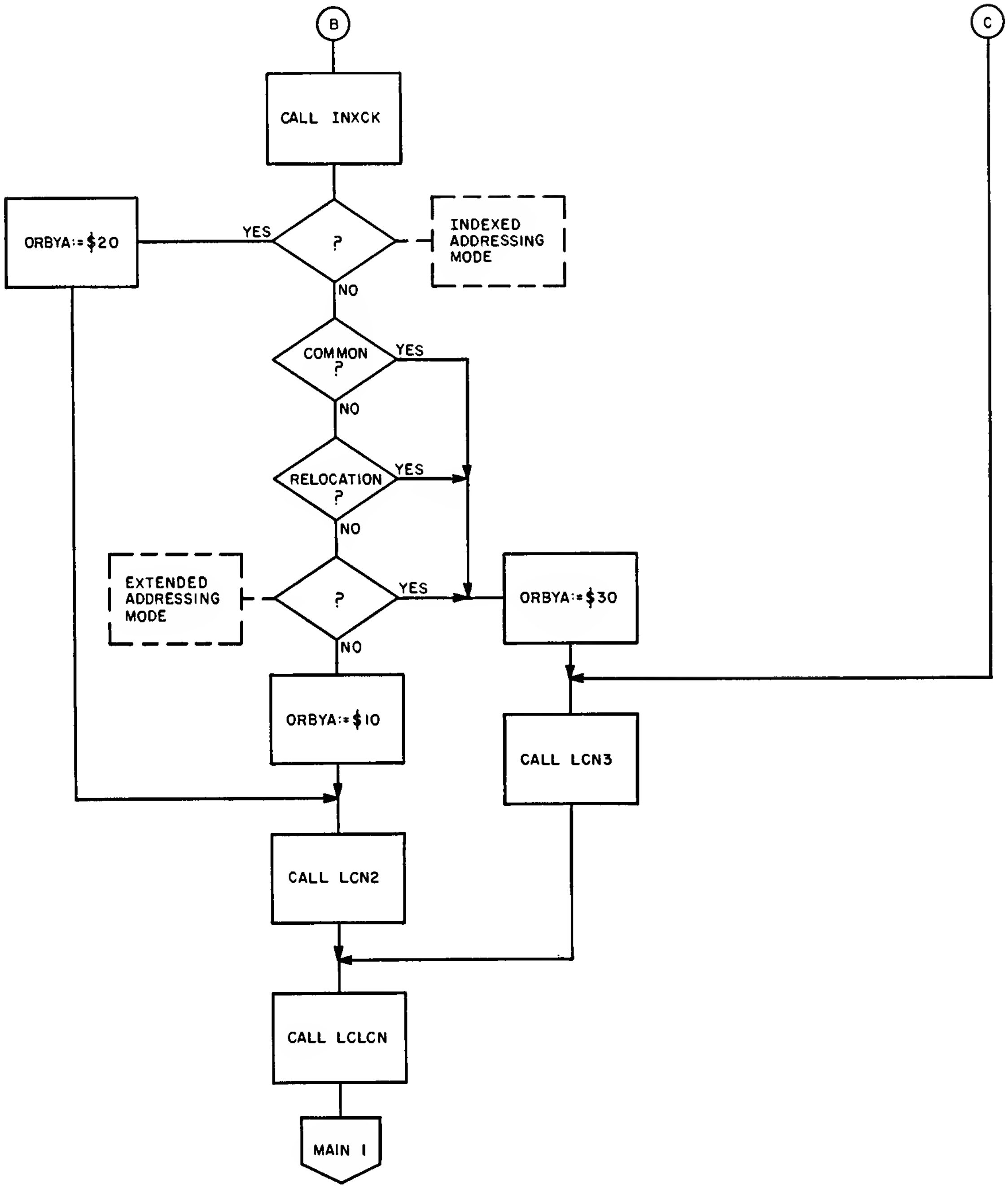
Flowchart of ADDR5 and ADDR6 routines.

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

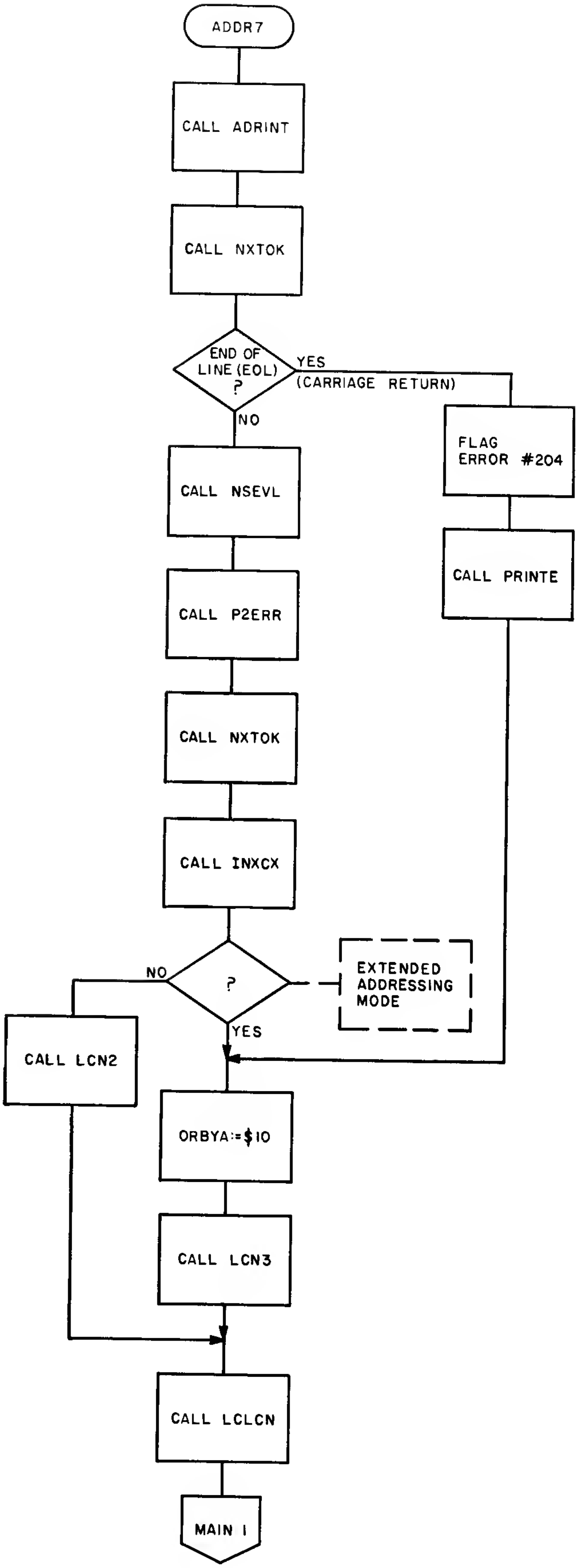


ADDR7

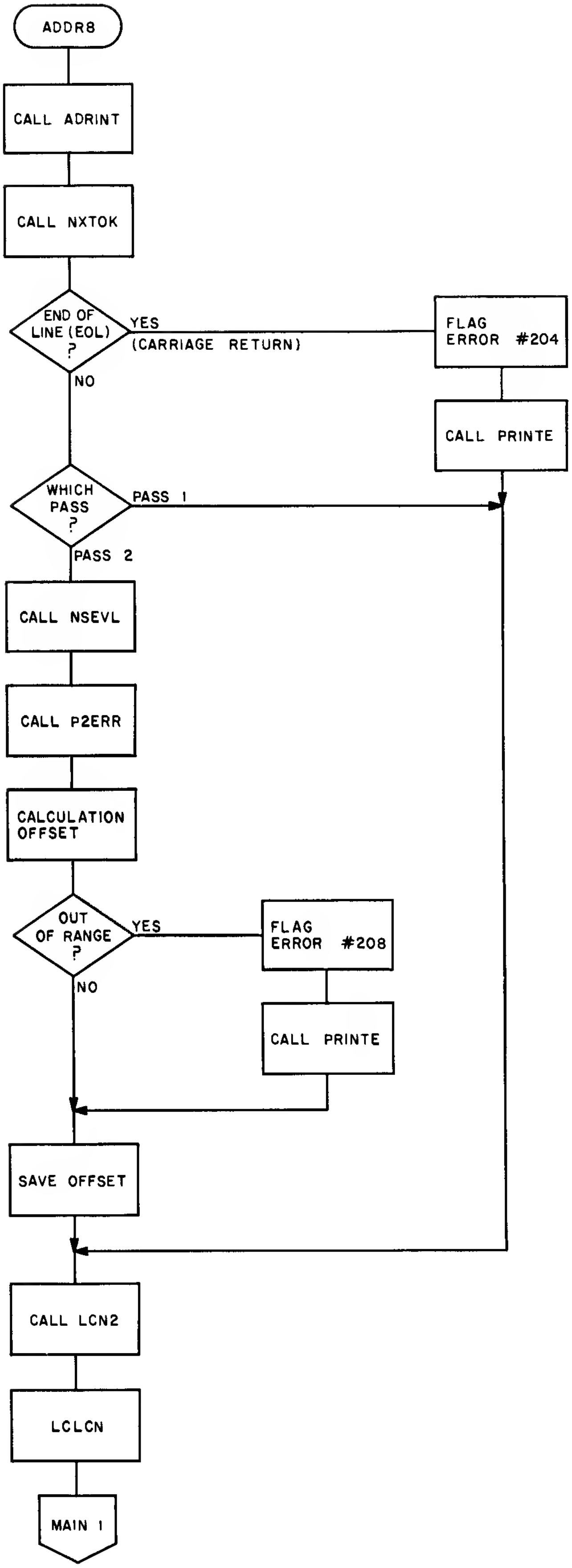
This routine processes the following opcodes: JMP, JSR. The operand structure may be Extended (3 bytes), or Indexed (2 bytes).

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.

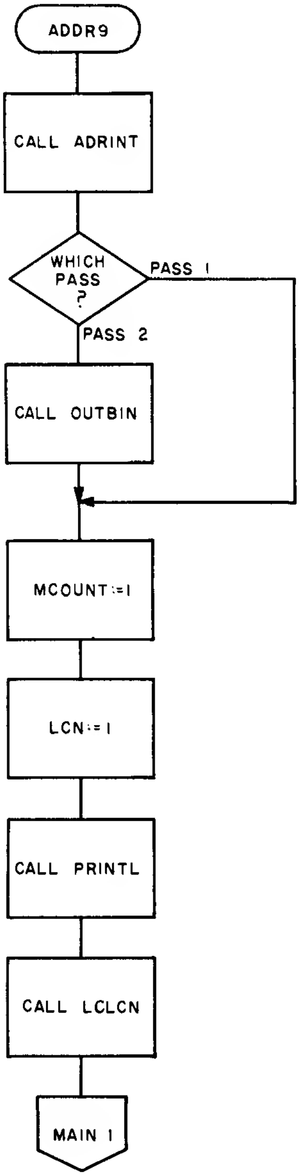
ADDR9

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.

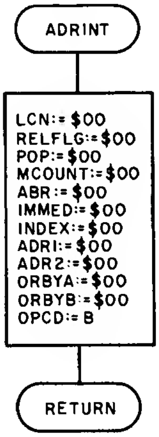
Calls:	none
Called By:	ADDR1 thru ADDR9, MAIN, POCMN, POEND, POENT, POEQU, POEXT, POFCB, POFCC, POFDB, POIF, POMAC, PONAM, PONIF, POPAG, PORMB
Flags:	ABR, ADR1, ADR2, CMNFLG, ENTFLG, EXTFLG, IMMED, INDEX, LCN, MCOUNT, ORBYA, ORBYB, POP, RELFLG
Pointers:	OPCD

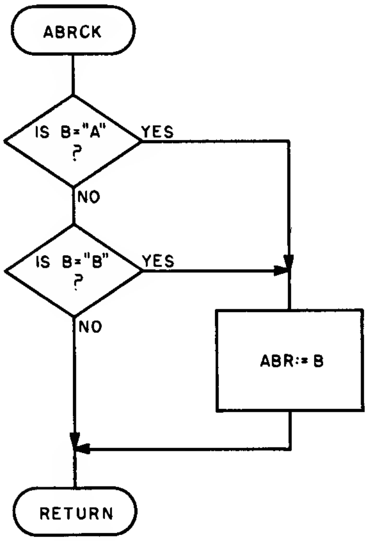
ABRCK

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.





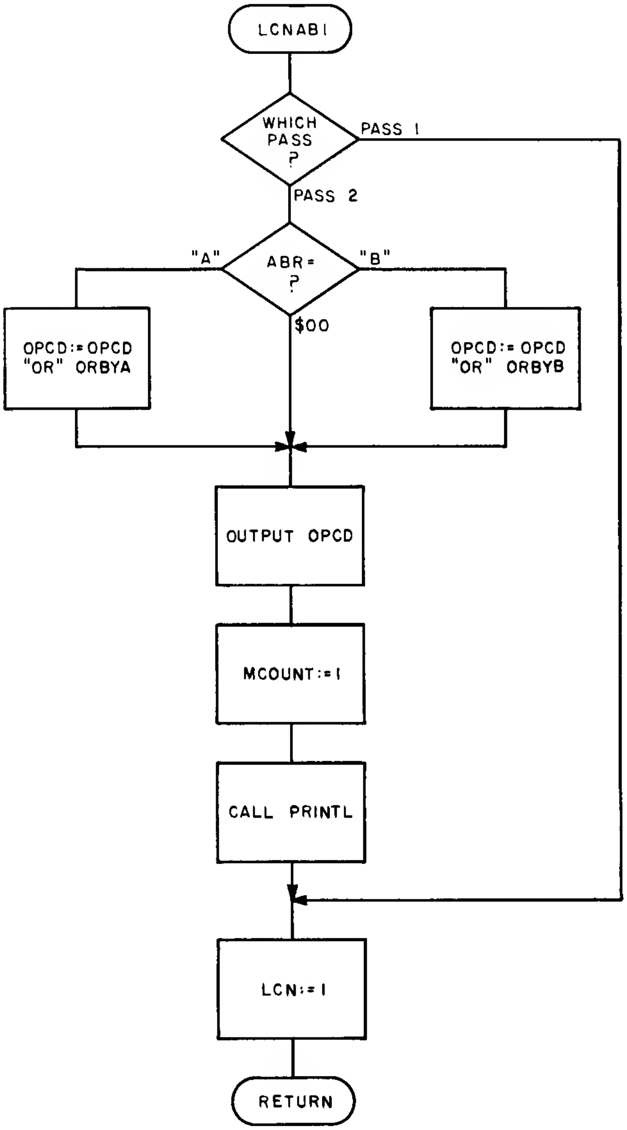
Flowchart of ABRCK routine.

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.

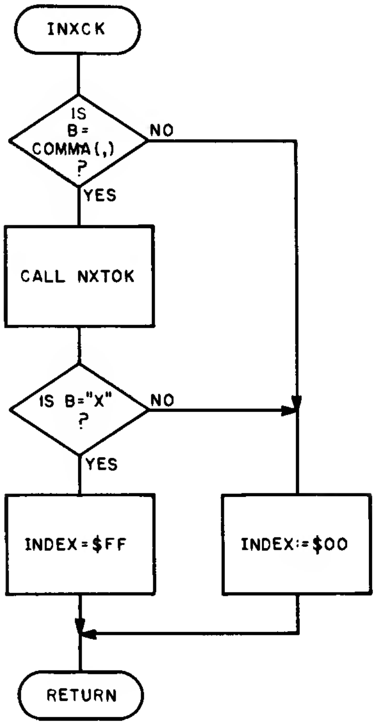


INXCK

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.

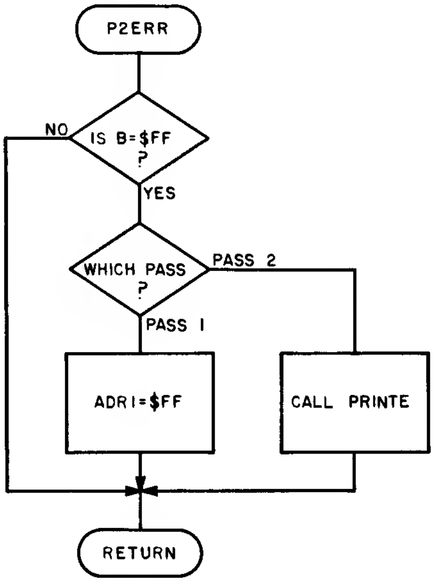


P2ERR

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

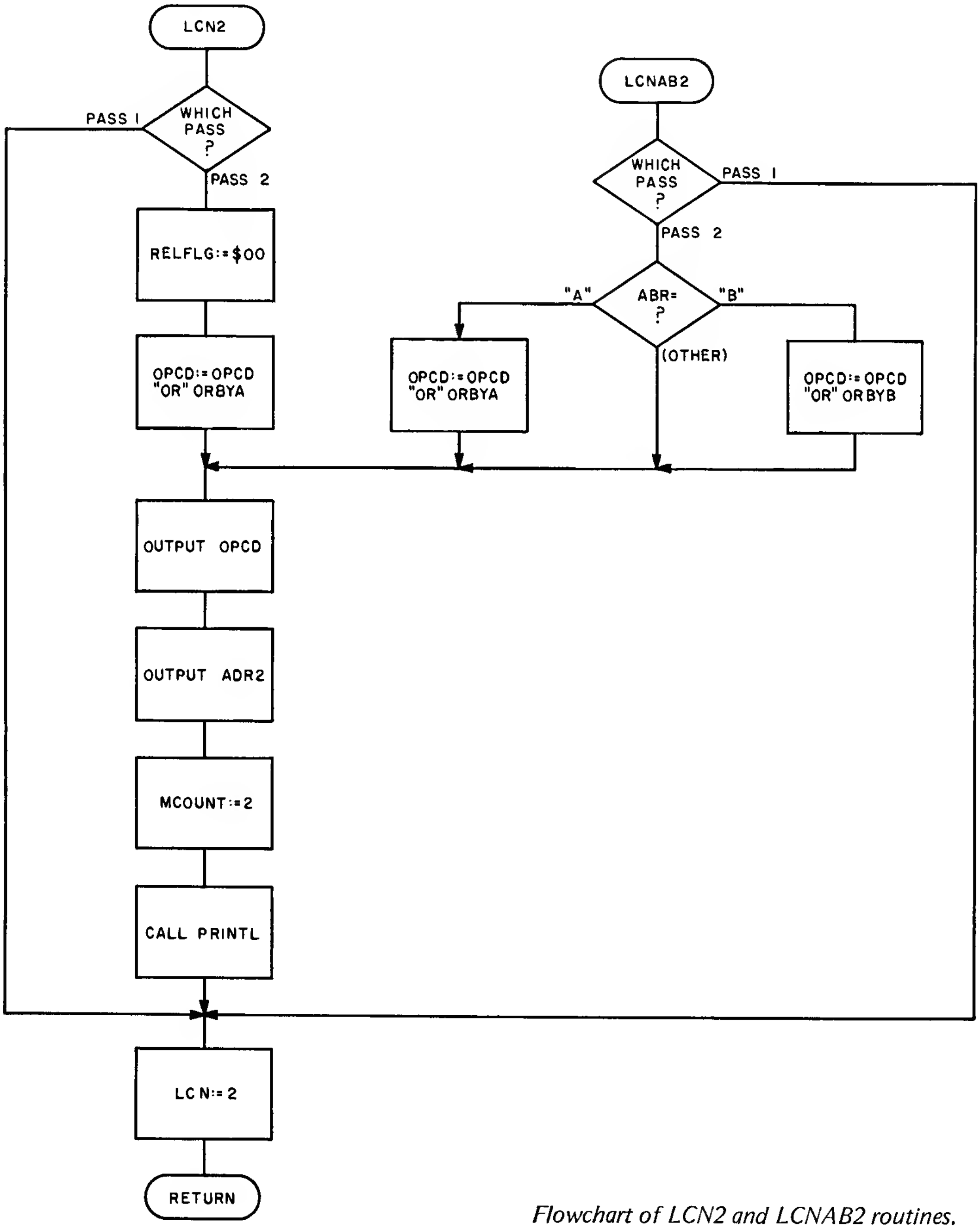
This does the finish up processing for two byte Indexed, Direct, and Immediate type instructions.

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

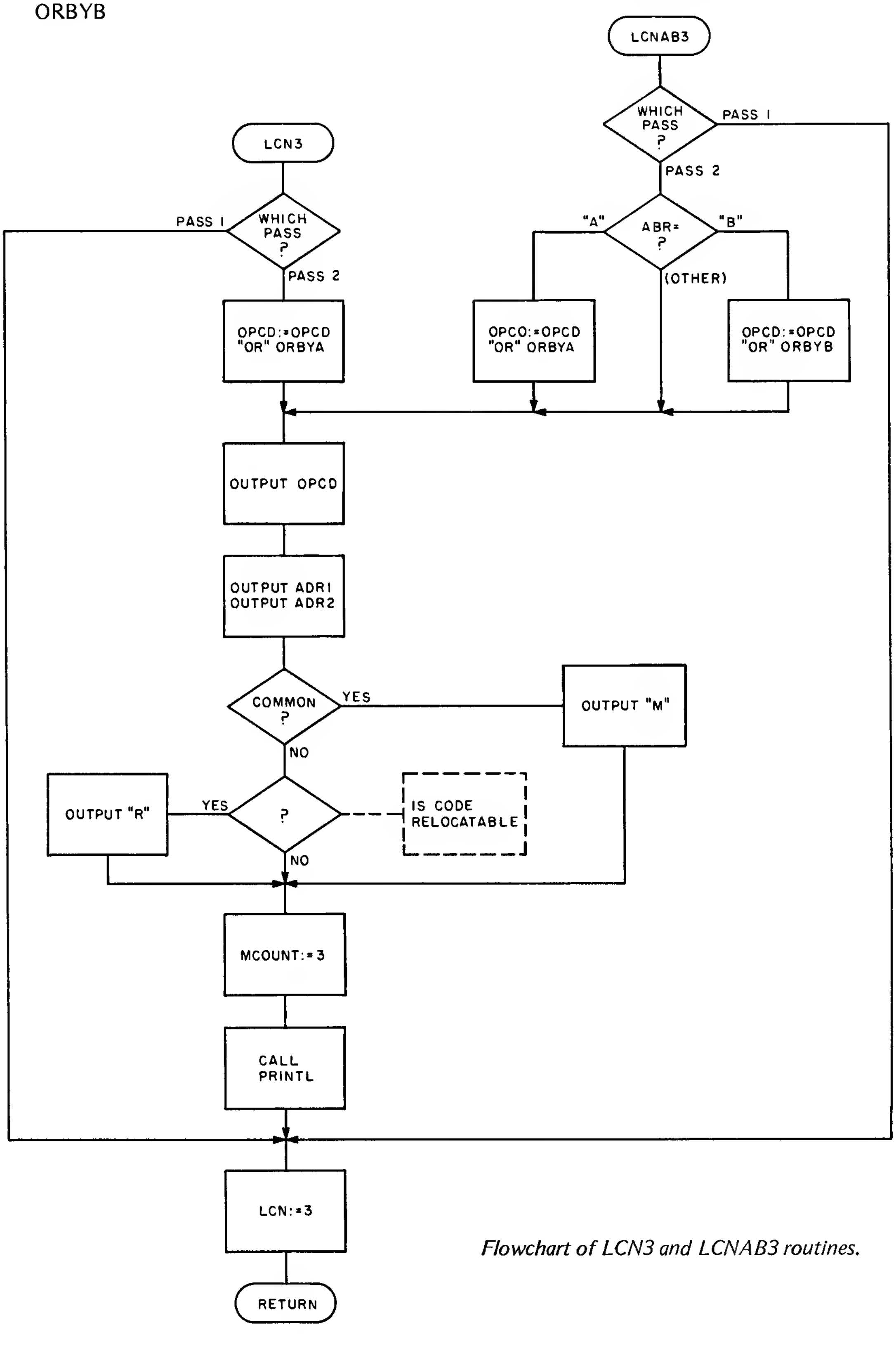
This does the finish up processing for the three byte Extended type instructions.

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.

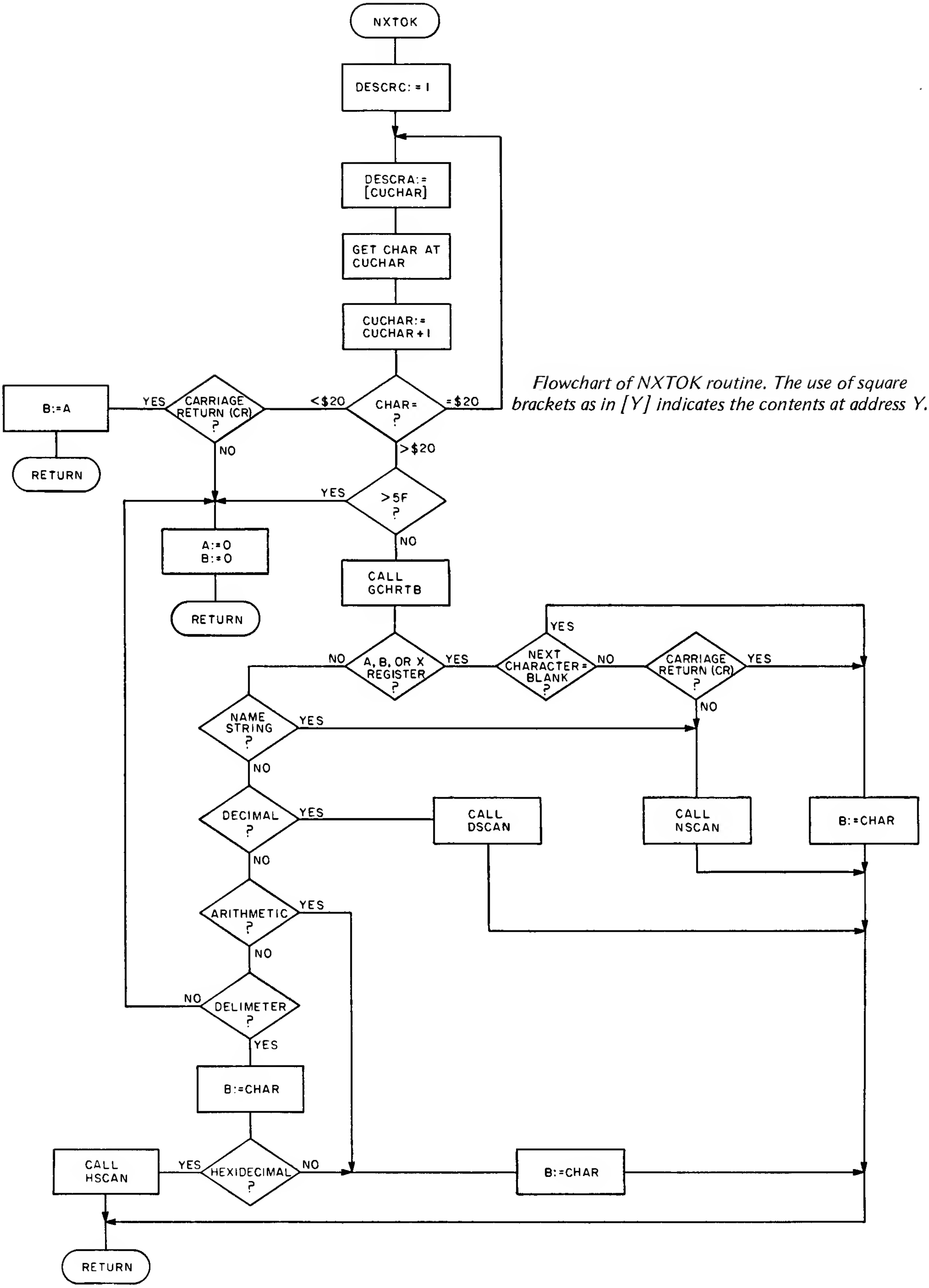
NXTOK

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.

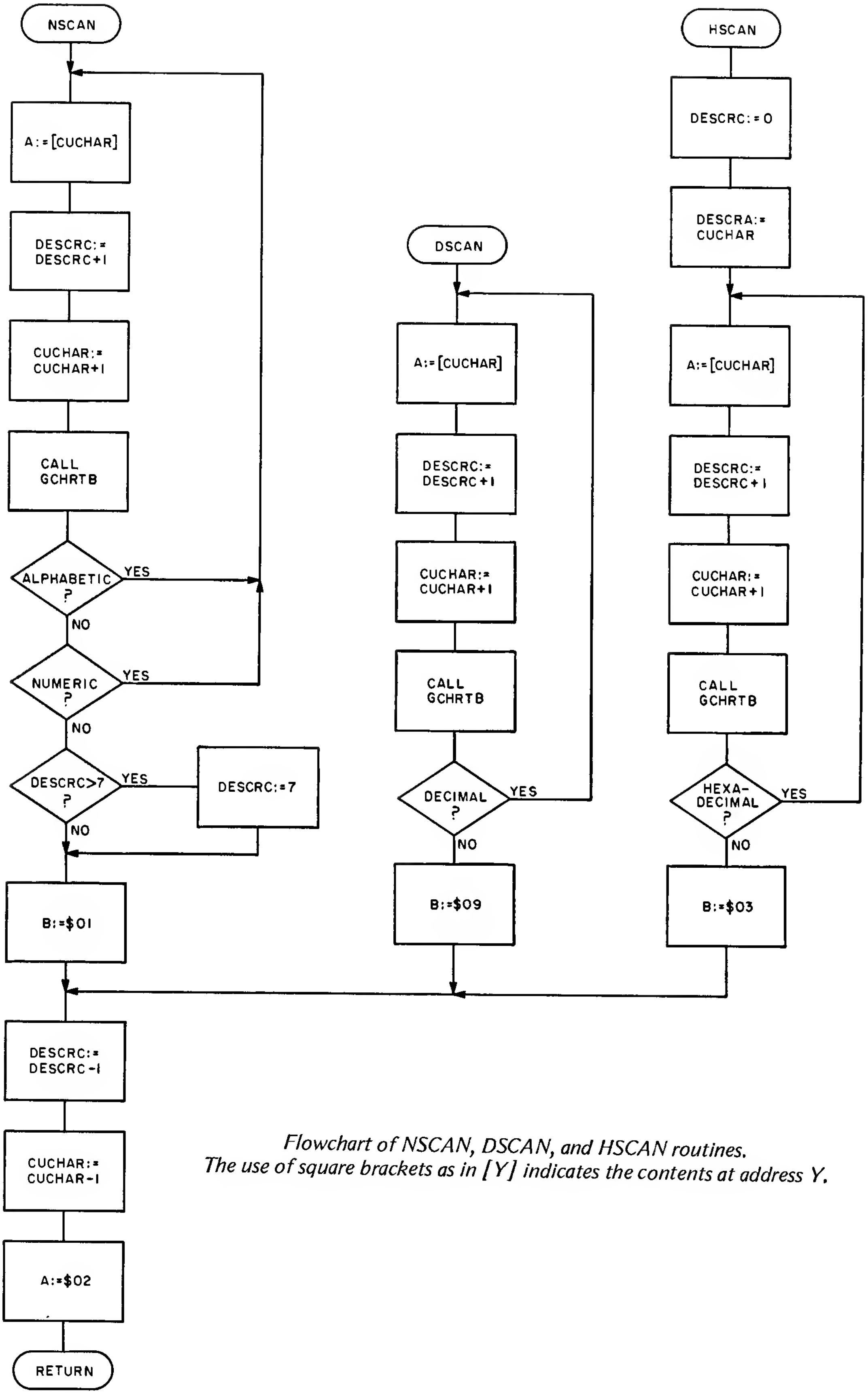
On entry, CUCHAR points to the next character in the line. NXTOK returns a token by placing the address of the token in DESCRA and the length of the token in DESCRC. The routine also returns the token type in register B and the token class in register A. If the token is unrecognizable, the routine returns 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

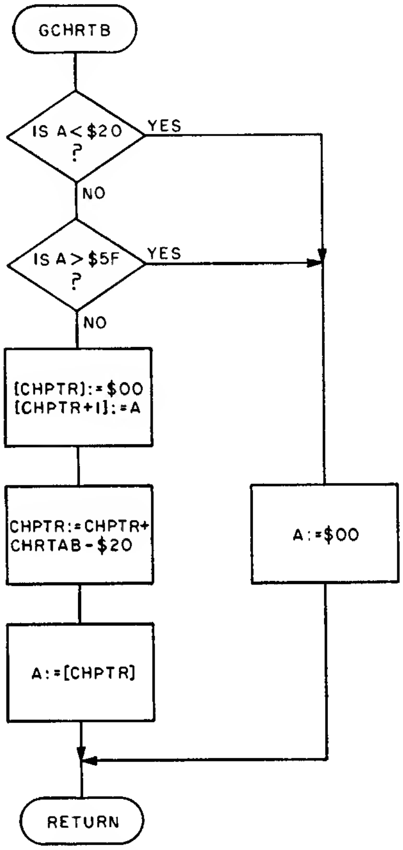
This is a common return for routines: DSCAN, NSCAN, and HSCAN.

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.

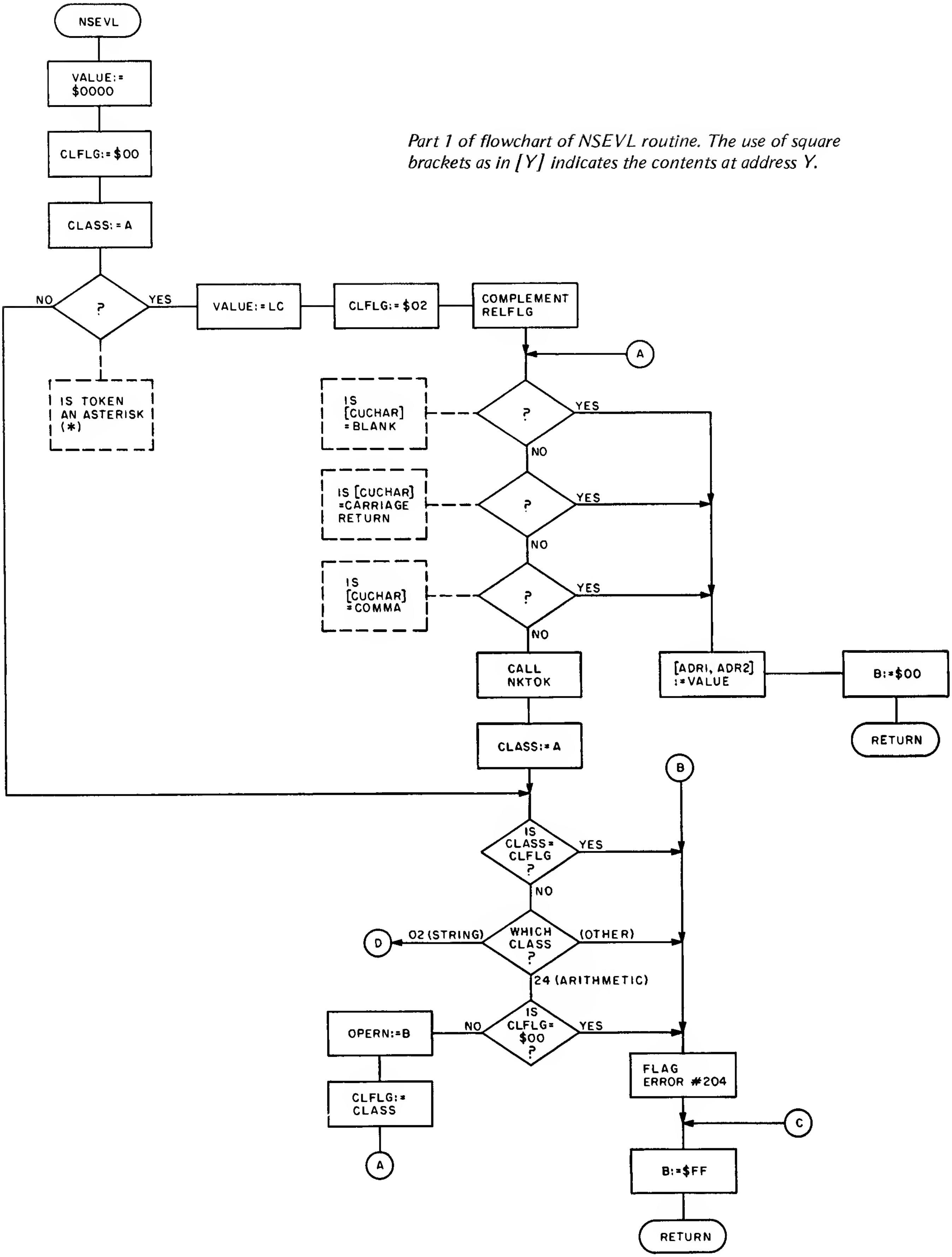
The Common flag is set if during the evaluation a symbol is found that is marked common in the Symbol Table.

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.

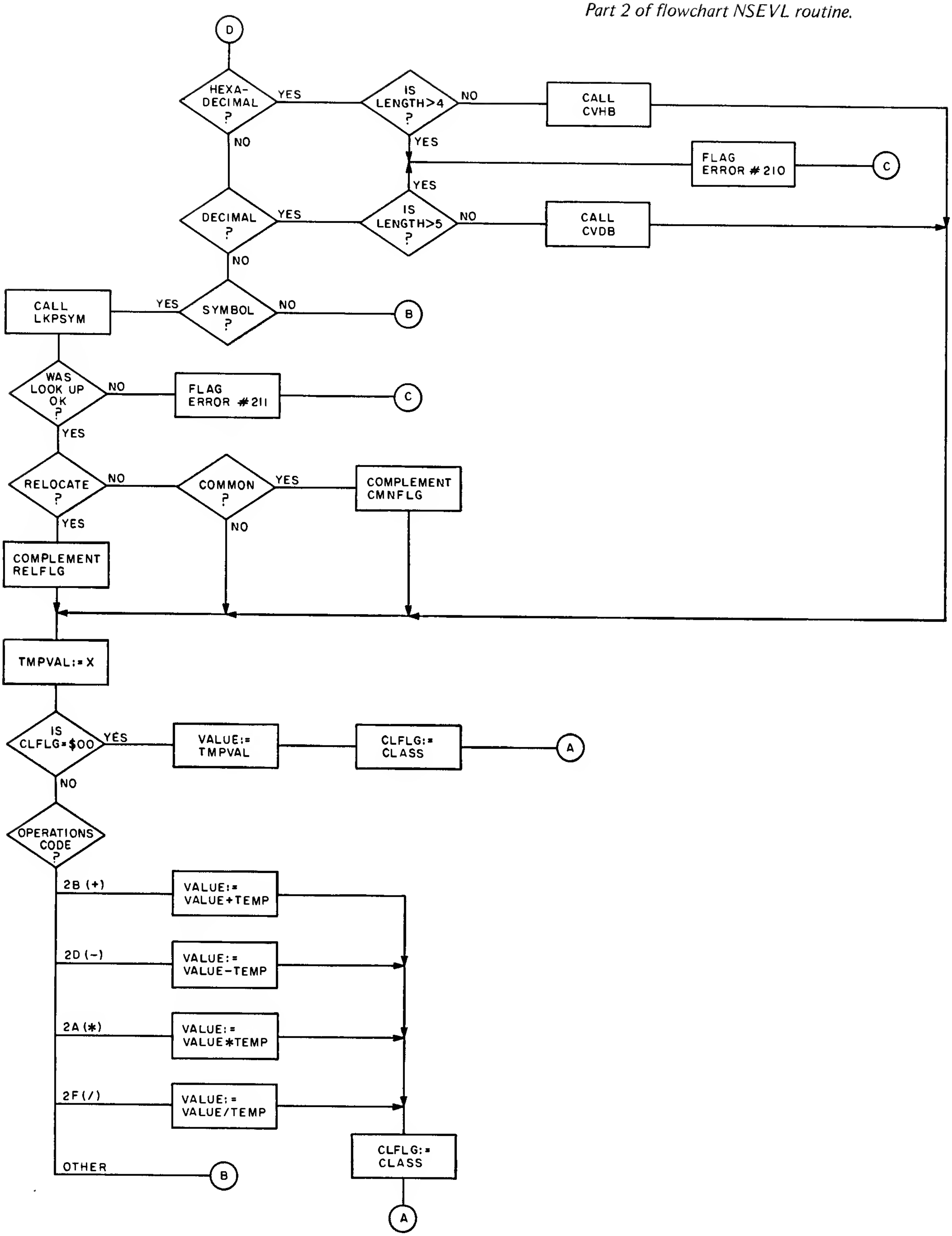
On return the final sixteen bit unsigned result is in variable (ADR1, ADR2), and the B register contains a 00 if there were no errors. If there were errors the error number is in the Index register as a four digit BCD number. The relocation flag (RELFLG) is equal to 00 if the result is an absolute value,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

T1STP

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

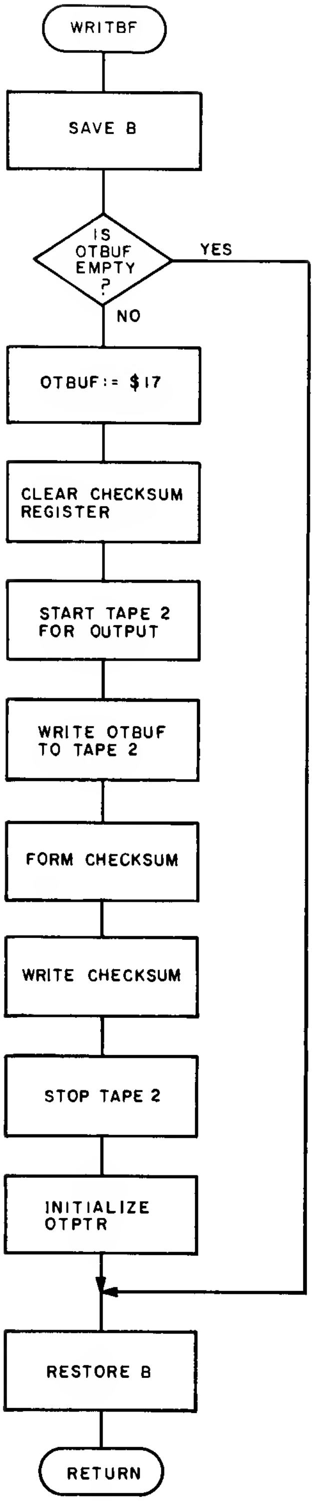
This routine is used to stop Tape2 after a write operation.

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^{TM} 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^{TM} 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^{TM} 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 founa 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^{TM} 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
09F0 08 EC FF 08 F2 CE 08 F0 BD 0C EC FE 08 EE FF 08
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
0A20 08 F0 BD 0C 7D B7 08 F0 F7 08 F1 FE 03 68 FF 08
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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0BC0 BD 0C A1 B7 0A AE F7 0A AF 7E 0B 73 00 00 FE 03
0BD0 7B 7F 0B CC 7F 0B CD F6 03 7D 09 08 5A 26 FC F6
0BE0 03 7D BD 0C 18 B7 0B CD 5A 27 29 09 BD 0C 18 48
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
0CD0 0C 20 01 0D 69 04 69 03 64 01 66 02 6A 00 26 E6
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 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
0DF0 02 26 0E CE 0D 69 BD 19 70 CE 0E 59 BD 19 5E 20
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
0E30 86 20 BD 19 85 FE 03 80 A6 00 36 BD 19 85 08 32
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
0F20 14 73 11 85 BD 07 F6 C1 27 26 0A FE 03 7E A6 00
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0F40 C6 80 F7 11 87 C6 C0 F7 11 88 20 3C BD 07 F6 BD
0F50 11 C4 26 2A 7D 03 78 26 0A 7D 03 77 26 05 F6 0D
0F60 68 27 0F C6 B0 F7 11 87 C6 F0 F7 11 88 BD 12 5E
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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
1200 FA 11 88 F7 0D 67 BD 19 2B 7C 0D 65 BD 0D 0E 7C
1210 03 84 39 7D 03 75 27 3F F6 0D 67 B6 11 84 27 25
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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1380 BD 14 BE B6 03 6E 85 20 27 03 7E 14 4D CE 14 C8
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
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1450 BD 14 BE CE 14 A1 B6 03 88 F6 03 89 BD 0E 5C CE
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1470 5E CE 04 13 BD 19 6E BD 14 BE B6 03 6E 85 40 26
1480 06 BD 03 59 7E 03 4D 7E 03 50 20 52 45 44 45 46
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
14D0 00 00 00 00 00 00 00 00 BD 11 89 BD 19 17 BD 07
14E0 F6 C1 01 27 08 CE 02 16 BD 0E BB 20 39 7D 03 75
14F0 27 43 BD 09 57 C1 FF 26 08 CE 02 11 BD 0E BB 20
1500 25 FF 0D 68 FE 03 82 A6 08 8A 04 A7 08 BD 15 38
1510 F6 0D 68 BD 19 2B F6 0D 69 BD 19 2B C6 52 BD 19
1520 3F C6 4E BD 19 3F 73 0D 66 73 03 7A 7C 0D 65 7C
1530 0D 65 BD 0D 0E 7E 05 90 FE 03 82 86 06 E6 00 36
1540 FF 15 4F BD 19 2B 32 FE 15 4F 08 4A 26 EF 39 00
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1560 02 13 BD 0E BB 20 3D BD 07 F6 C1 0D 26 05 CE 02
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1590 08 B6 0D 69 A7 07 B6 0D 68 A7 06 73 0D 66 7C 0D
15A0 65 7C 0D 65 BD 0D 0E 7E 05 90 00 00 BD 11 89 BD
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
15E0 C6 7E F7 0D 67 BD 19 2B BD 09 57 BD 15 38 C6 58
15F0 BD 19 3F 7F 0D 68 7F 0D 69 7C 0D 65 7C 0D 65 7C
1600 0D 65 73 03 79 BD 0D 0E BD 12 C2 7E 05 90 BD 11
1610 89 BD 07 F6 C1 0D 26 08 CE 02 16 BD 0E BB 20 1A
1620 BD 0A B5 BD 11 D7 7C 03 84 7D 03 75 27 0F F6 0D
1630 69 BD 19 2B 7C 0D 65 7C 0D 66 BD 0D 0E BD 12 C2
1640 7E 05 90 BD 11 89 BD 07 F6 C1 27 27 08 CE 02 04
1650 BD 0E BB 20 3C FE 03 7E E6 00 C1 0D 27 EF F7 0D
1660 69 7D 03 75 27 03 BD 19 2B FE 03 7E 08 FF 03 7E
1670 7C 03 84 E6 00 C1 27 27 06 C1 0D 26 E4 20 0C E6
1680 01 C1 27 26 06 08 FF 03 7E 20 D6 7C 0D 66 7C 0D
1690 65 BD 0D 0E BD 12 C2 7E 05 90 BD 11 89 BD 07 F6
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
1700 BB 20 23 BD 0A B5 C1 FF 27 F1 BD 18 67 7D 04 77
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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1730 89 BD 0D 0E 7F 17 2C 7F 17 2D 7D 03 75 26 30 7D
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1750 03 82 86 20 A7 08 B6 04 0D A7 06 B6 04 0E A7 07
1760 BD 07 F6 FE 03 7B A6 00 81 43 26 03 73 17 2C BD
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1780 00 81 2A 26 0A 7D 17 2C 27 E5 BD 17 E3 20 E0 7F
1790 03 76 FE 03 80 A6 00 81 20 27 06 BD 07 F6 73 03
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
17F0 FF 03 7E FE 03 7E A6 00 08 FF 03 7E FE 04 0D BC
1800 03 64 26 10 86 0D A7 00 08 FF 04 0D CE 02 28 BD
1810 0E BB 20 0A A7 00 08 FF 04 0D 81 0D 26 D5 39 4D
1820 45 4E 44 BD 11 89 BD 19 17 BD 07 F6 C1 01 27 09
1830 CE 02 16 BD 0E BB 7E 15 26 7D 03 75 26 06 BD 08
1840 F8 7E 14 ED F6 04 13 BD 19 2B F6 04 14 BD 19 2B
1850 C6 50 BD 19 3F 7E 14 ED BD 11 89 BD 19 17 BD 18
1860 7B BD 0D 0E 7E 05 90 BF 03 8C FE 04 75 8C 04 6D
1870 27 1D BE 04 75 B6 04 77 36 20 1B BF 03 8C FE 04
1880 75 8C 04 75 27 09 BE 04 75 32 B7 04 77 20 07 CE
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
1910 FF 03 85 5F 20 F1 39 7D 03 76 27 0E 7D 03 75 26
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

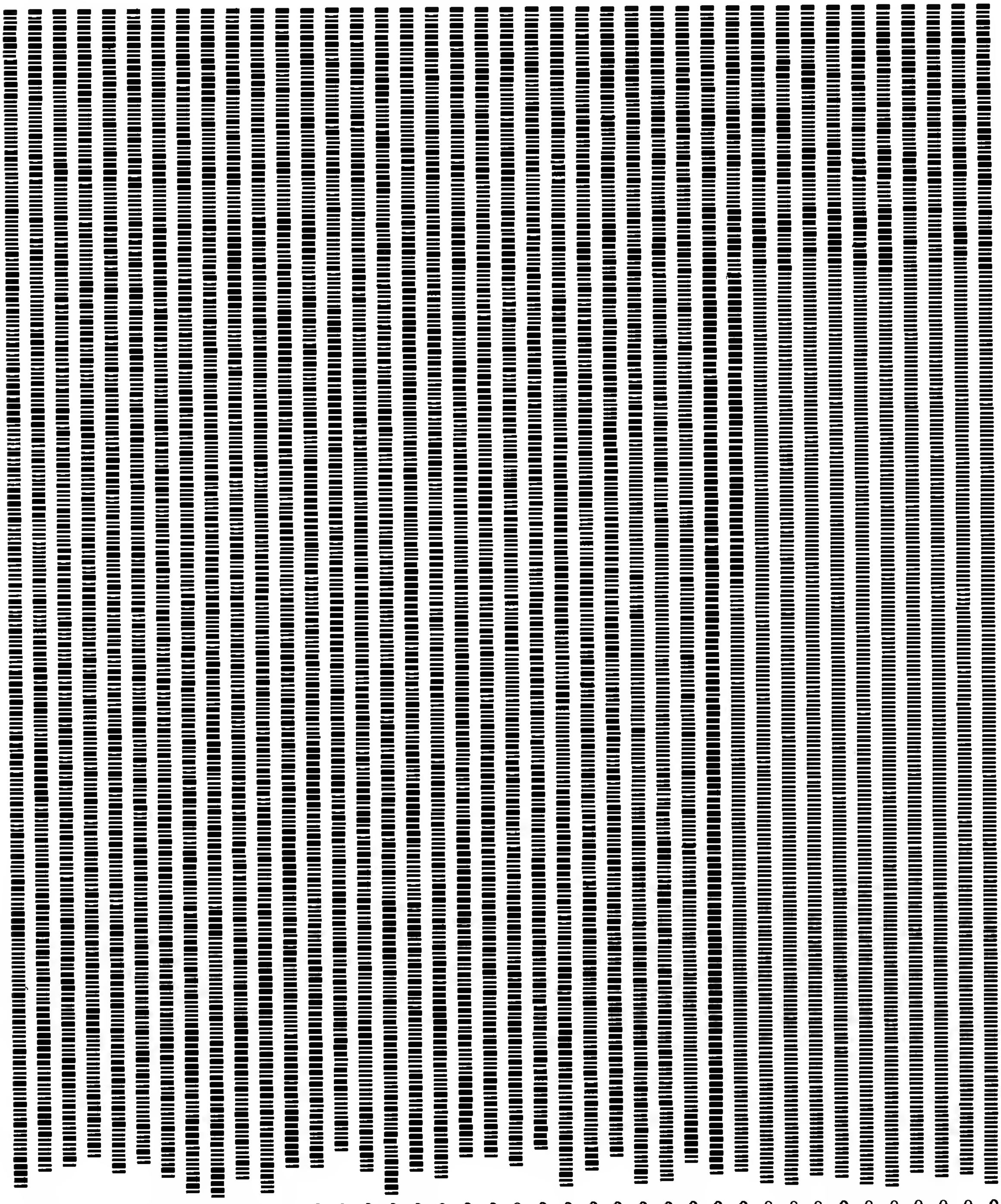
PAPERBYTE^{TM} Bar Code Representation of RA6800ML in Absolute Format

Beginning on the following page is a complete machine readable representation (PAPERBYTE^{TM} 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^{TM} 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.

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
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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0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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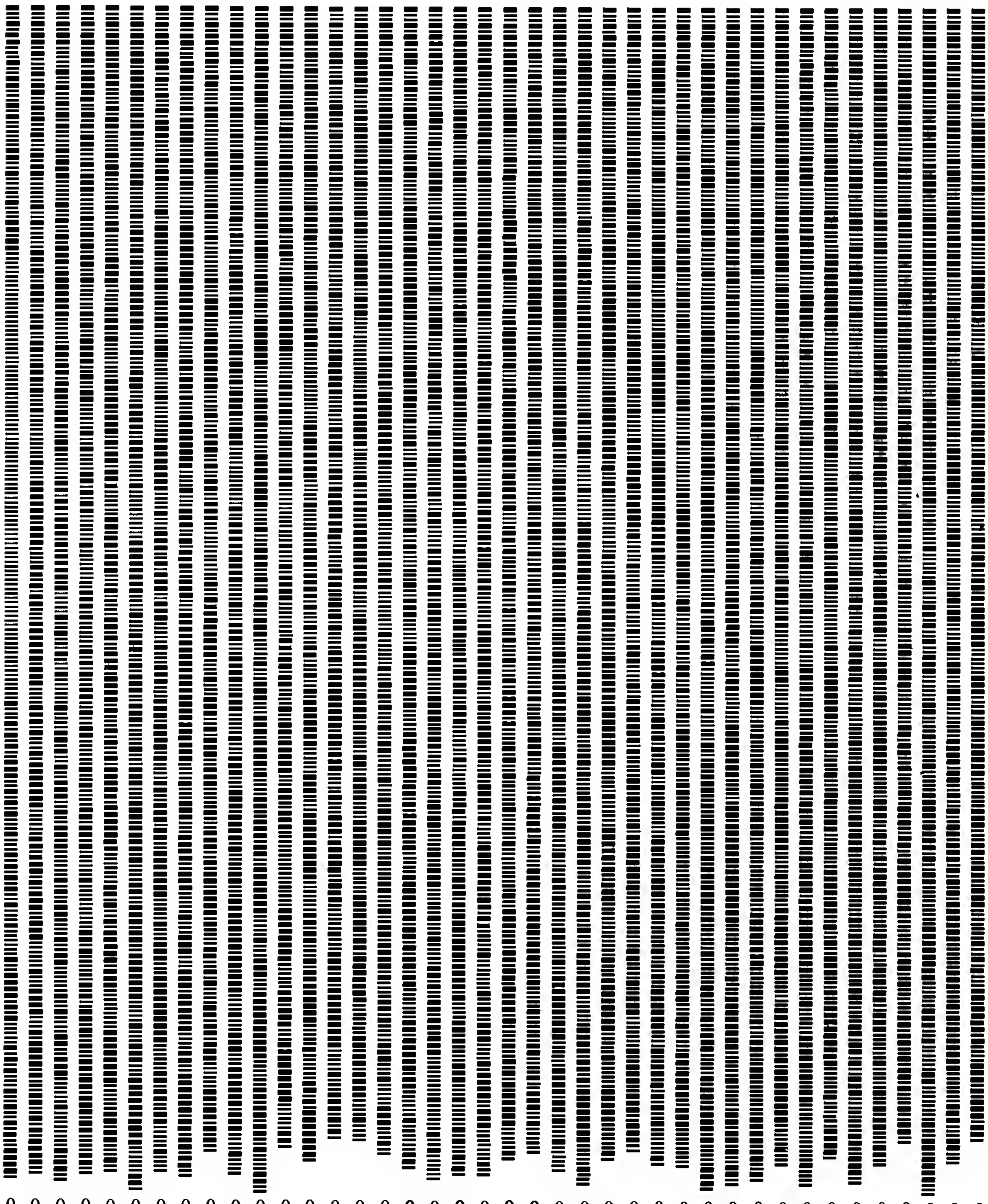
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
4 4 4 4 4 4 4 4 5 5 5 5 5 5 5 5 5 5 5 5 5 6 6 6 6 6 6 6 6 6 6 6 6 7 7 7 7 7 7 7
6 8 9 A C D E F 1 2 3 4 6 7 8 9 A C D E F 1 2 3 4 6 7 8 A B C D F 0 1 3 4 5 6 8
C 3 7 C 1 5 9 D 0 4 8 C 0 4 7 A E 2 7 B F 3 7 B F 3 7 B 0 5 9 E 2 7 B 0 4 8 D 1



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0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9

080	0794
081	07A8
082	07BD
083	07D0
084	07E5
085	07F9
086	080D
087	0821
088	0836
089	084B
090	085F
091	0873
092	0887
093	089B
094	08AE
095	08C2
096	08D6
097	08EC
098	0903
099	0917
100	092B
101	0940
102	0955
103	0969
104	097D
105	0991
106	09A6
107	09BA
108	09CD
109	09E0
110	09F4
111	0A07
112	0A1B
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114	0A43
115	0A57
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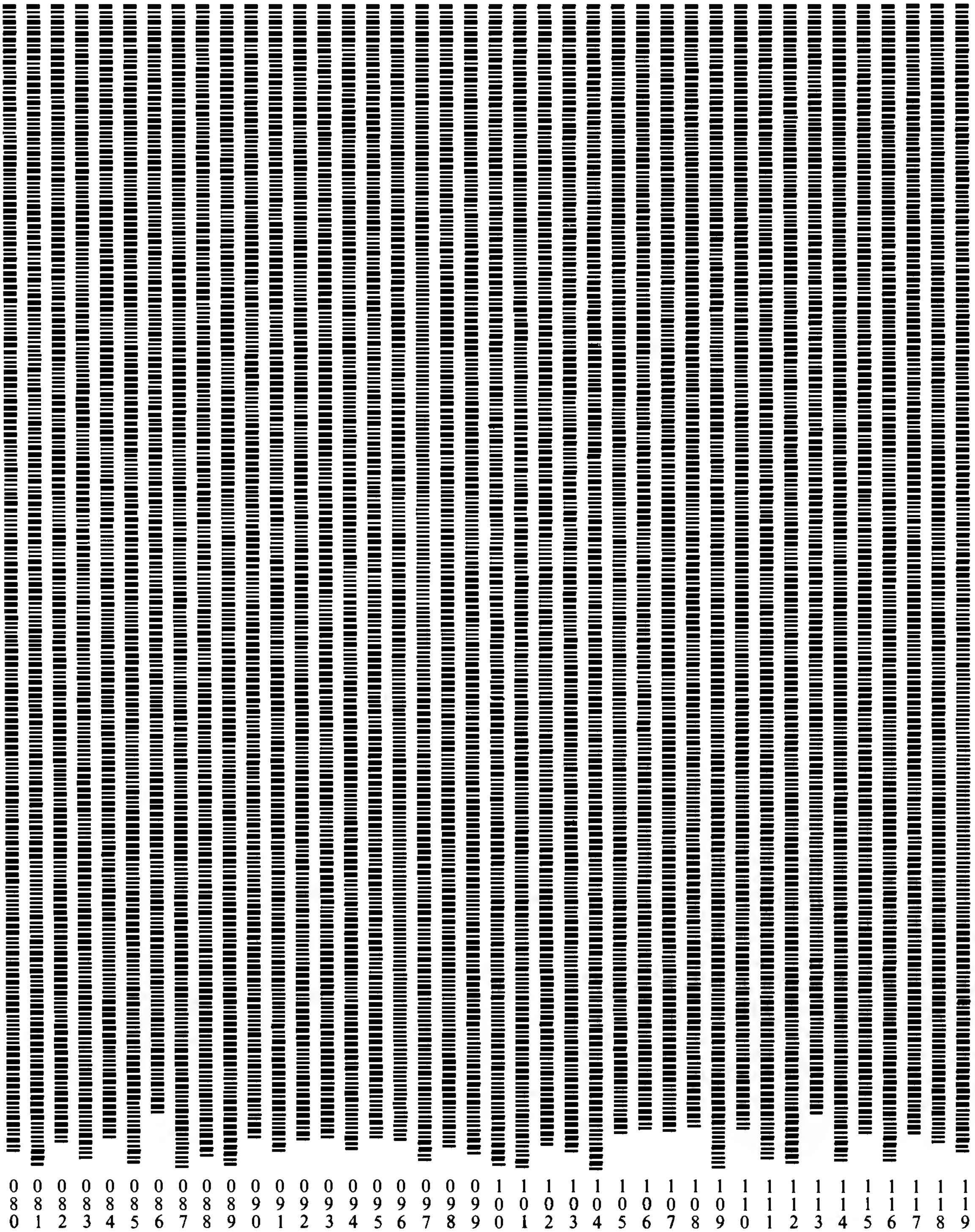
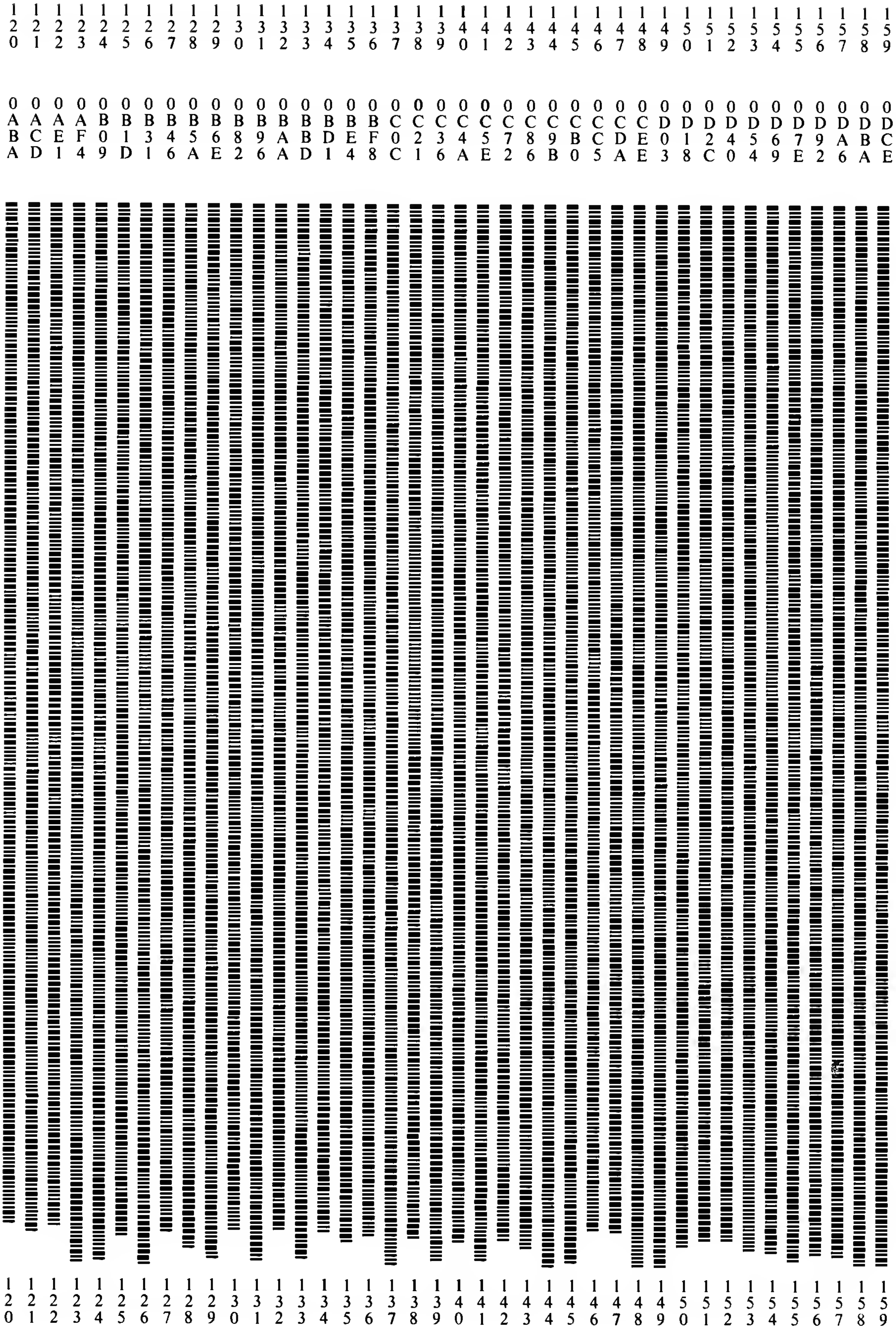
117	0A7E
118	0A91
119	0AA5

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122 0AE1
123 0AF4
124 0B09
125 0B1D
126 0B31
127 0B46
128 0B5A
129 0B6E
130 0B82
131 0B96
132 0BAA
133 0BBD
134 0BD1
135 0BE4
136 0BF8
137 0C0C
138 0C21
139 0C36
140 0C4A
141 0C5E
142 0C72
143 0C86
144 0C9B
145 0CB0
146 0CC5
147 0CDA
148 0CEE
149 0D03
150 0D18
151 0D2C
152 0D40
153 0D54
154 0D69
155 0D7E
156 0D92
157 0DA6
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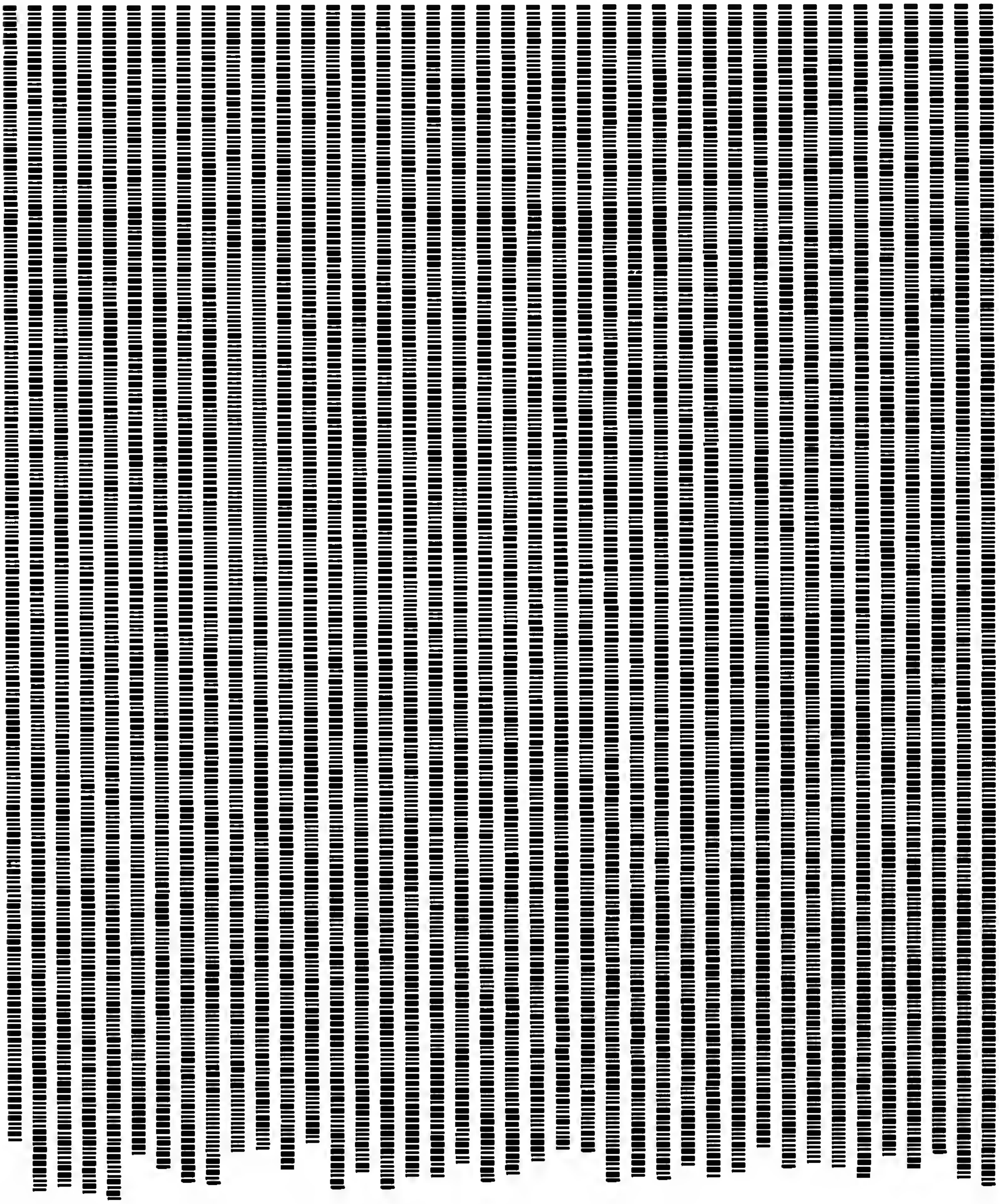
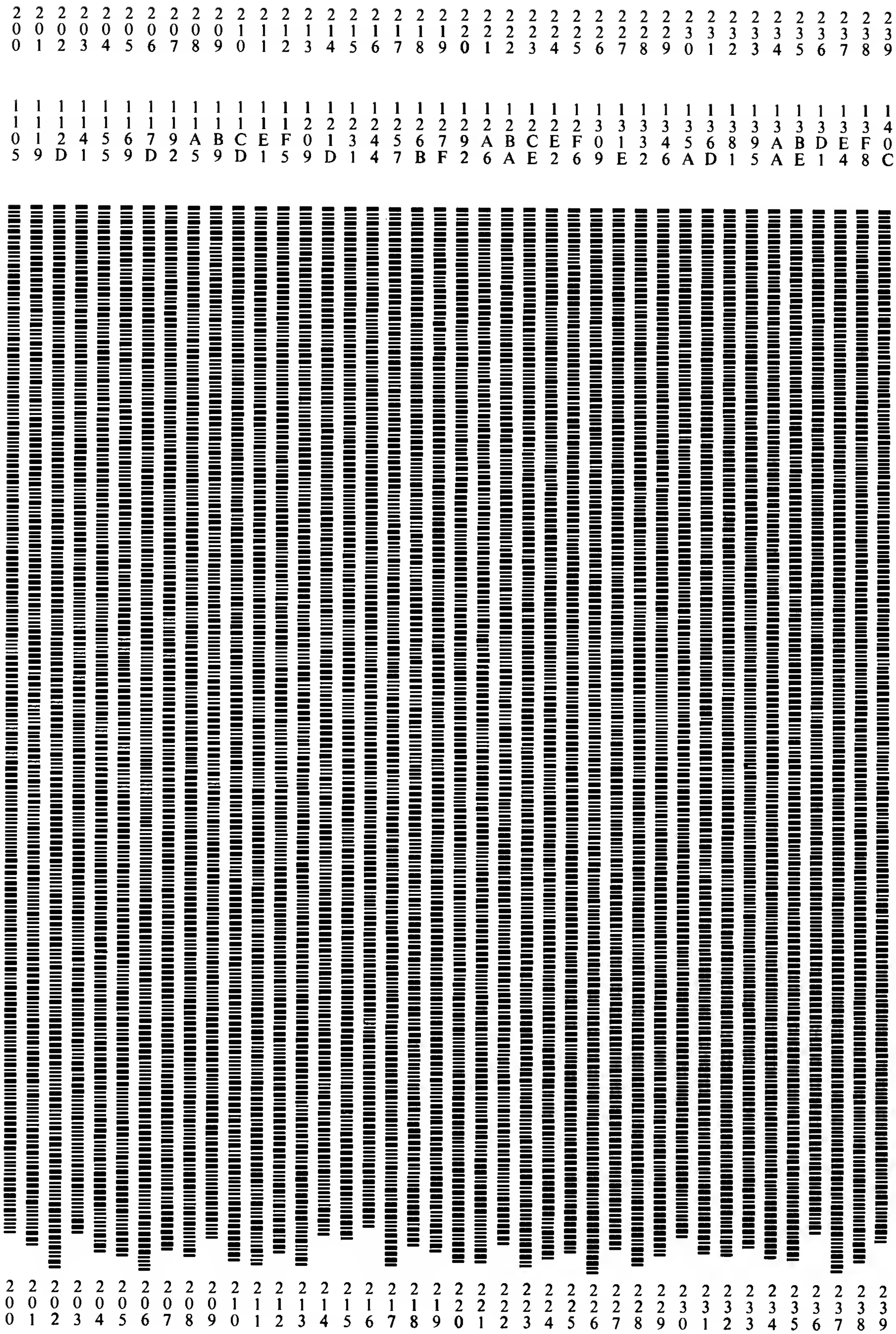
1161	0DF6
1162	0E0A
1163	0E1F
1164	0E34
1165	0E49
1166	0E5D
1167	0E71
1168	0E85
1169	0E9A
1170	0EB0
1171	0EC5
1172	0ED9
1173	0EEC
1174	0F00
1175	0F14
1176	0F28
1177	0F3C
1178	0F50
1179	0F64
1180	0F78
1181	0F8C
1182	0FA0
1183	0FB3
1184	0FC6
1185	0FDA
1186	0FEE
1187	1002
1188	1016
1189	102A
1190	103E
1191	1051
1192	1065
1193	1079
1194	108D
1195	10A1
1196	10B5
1197	10C9
1198	10DD
1199	10F1



1160 1161 1162 1163 1164 1165 1166 1167 1168 1169 1170 1171 1172 1173 1174 1175' 1176 1177 1178 1179 1180 1181 1182 1183 1184 1185 1186 1187 1188 1189 1190 1191 1192 1193 1194 1195 1196 1197 1198 1199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126B
127F
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12A6
12BA
12CE
12E2
12F6
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135A
136D
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13AA
13BE
13D1
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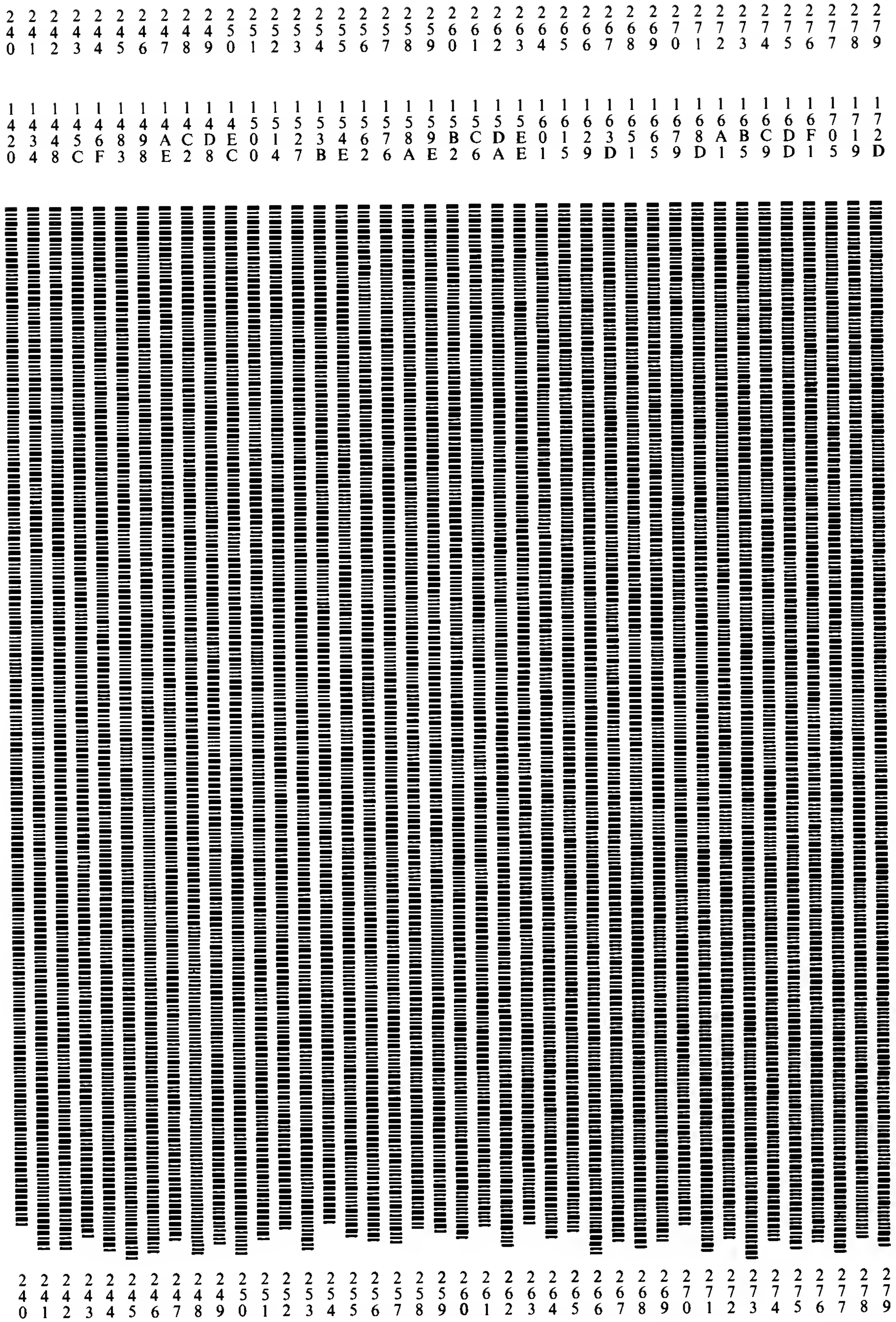
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14AE
14C2
14D8
14EC
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153B
154E
1562
1576
158A
159E
15B2
15C6
15DA
15EE
1601
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163D
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168D
16A1
16B5
16C9
16DD
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172D
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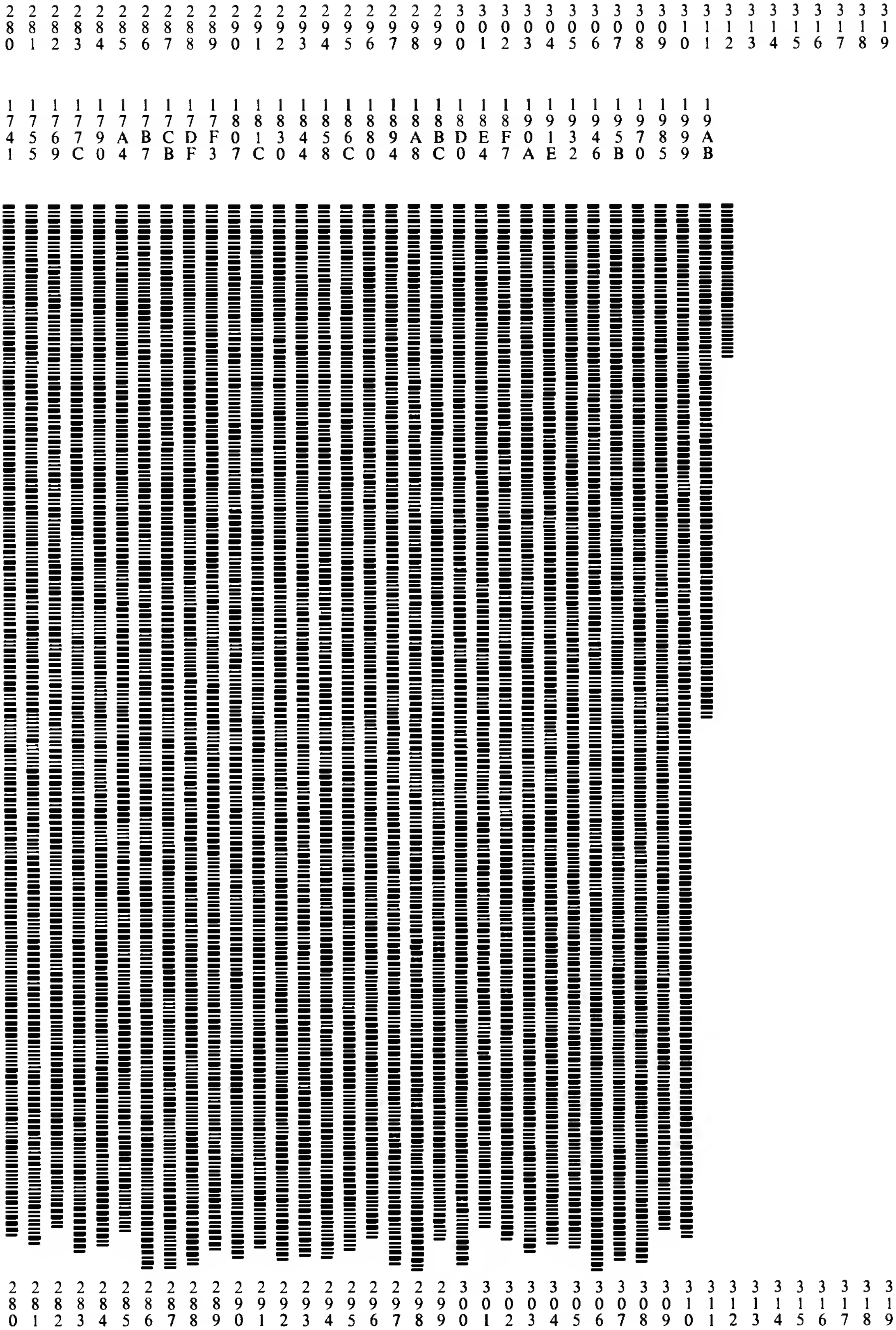

280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319
1741 1759 1769 177C 1790 17A4 17B7 17CB 17DF 17F3 1807 181C 1830 1844 1858 186C 1880 1894 18A8 18BC 18D0 18E4 18F7 190A 191E 1932 1946 195B 1970 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^{TM} 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^{TM} 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^{TM} 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.

```
                              NAM    ASSIO

           0100     START     EQU    $0100      START OF THE ASSEMBLER

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

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

 0488                         ORG    START+$388

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

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

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

 19A0 01            INITIO    NOP                 INITIALIZE I/O DRIVERS
 19A1 01                      NOP
 19A2 01                      NOP
 19A3 39                      RTS

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

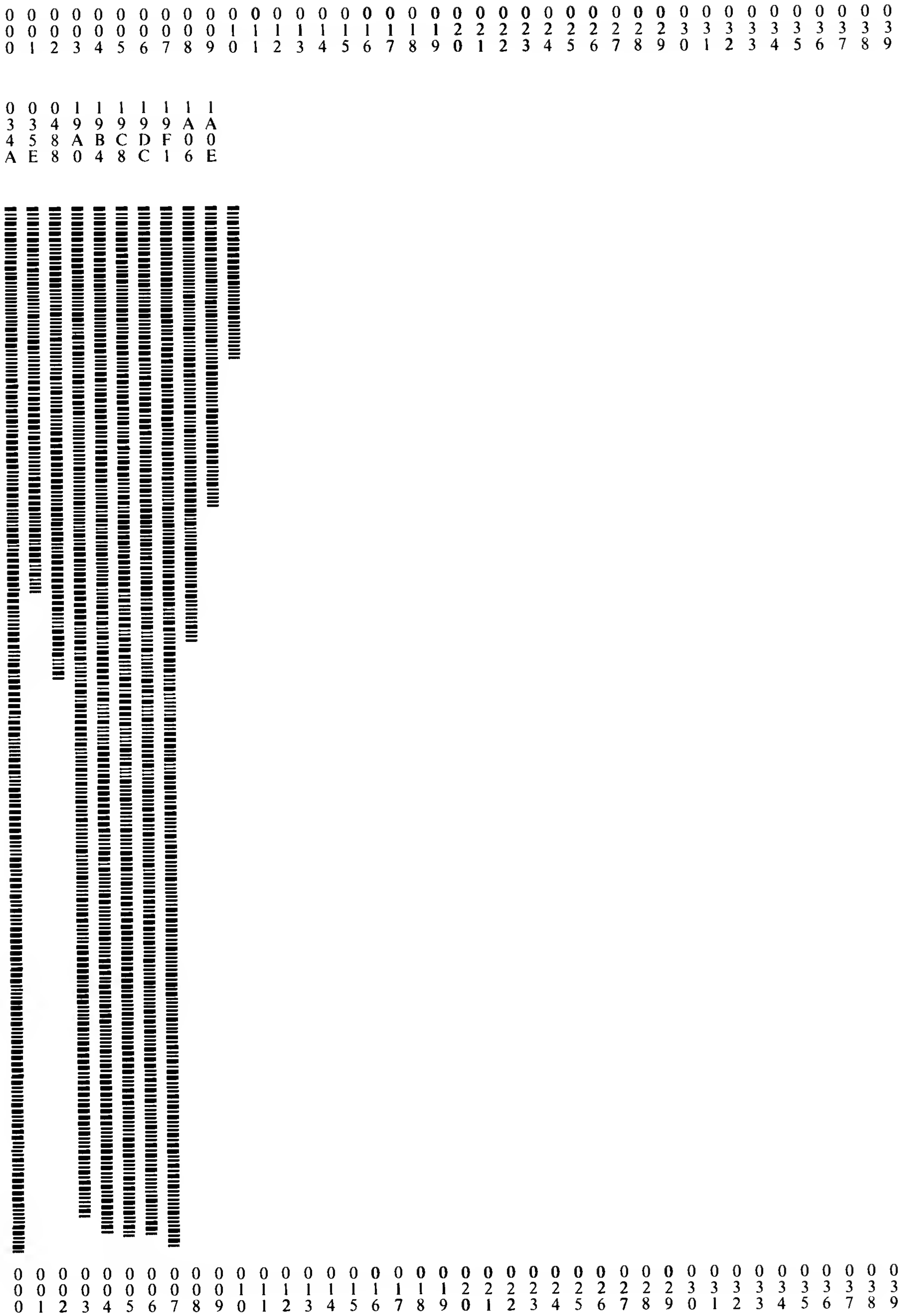
00058 19C8 CE 19D9 RESTR  LDX    #REWIND
00059 19CB BD 1961        JSR    PDATA1
00060 19CE BD 0488 BACK   JSR    INEEE
00061 19D1 81 0D          CMP A  #$0D      IS IT A CR?
00062 19D3 26 F9          BNE    BACK
00063 19D5 BD 14BE        JSR    CRLF
00064 19D8 39             RTS

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 19A0 19B4 19C8 19DC 19F1 1A06 1A0E
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

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 0F0A     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 138E 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 02B8 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   NXT1        >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 #$0D       EOL?
072C 26 0A              BNE   NXT4A      NO GOT TO NSCAN
                *
072E FE 027B R   NXT3A  LDX   DESCRA     GET RC
0731 E6 00              LDA B 0,X
0733 39                 RTS
                *
0734 85 B0       NXT4   BIT A #$B0       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 0889 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 08            ORA A 8,X     SET REDEFINED BIT
083F A7 08            STA A 8,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 08            LDA B 8,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 06C5 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 B6 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 8
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 06             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
```

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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 0B2B 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
                *
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```
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 MACHINF CODE
0C66 0001      POP    RMB   1            PSEUDOP:O=NO:1,2 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 026F 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 1861 R         JSR    PDATA1
0DF0 BD 0D35 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 00BB 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 1084 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 1085 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 08             BRA    ADDR1K
                         *
0E35 BD 09B5 R ADDR1C JSR    NSEVL       EVALUATE OPERAND
0E38 BD 10D7 R         JSR    P2ERR       PRINT PASS 2 ERRORS
0E3B F6 1085 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 09B5 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   LCNAB1      FORM MACHINE CODE
0F20 20 20                BRA   ADDR3F
                    *
0F22 BD 09B5 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 10B7 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   LCNAB1      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 09B5 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 09B5 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 020B   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 9**
                    *
                    * (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 03            BEQ    ADDR9A    PASS 1
                    *
1072 BD 102E R        JSR    OUTBIN    OUTPUT MC
                    *
1075 7C 0C65 R ADDR9A INC    MCOUNT    MCOUNT:=1
1078 7C 0284 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 0284 R ADRINT CLR    LCN
108C 7F 0277 R        CLR    RELFLG
108F 7F 0276 R        CLR    CMNFLG
1092 7F 0279 R        CLR    EXIFLG
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 1087 R        CLR    ORBYA
10B3 7F 1088 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 1084 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 #$58       "X" ?
10CD 26 04             BNE   INXCKR     NO
10CF 73 1086 R         COM   INDEX      INDEX:=FF
10D2 39                RTS
                *
10D3 7F 1086 R  INXCKR CLR   INDEX
10D6 39                RTS
                *
                *
                * CHECK FOR PASS 2 ERRORS
                *
10D7 C1 FF      P2ERR  CMP B #$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 0DB6 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   LNAB10     NEITHER
                *
10F7 81 42             CMP A #$42       "B" ?
10F9 27 05             BEQ   LNAB1B     YES
10FB FA 1087 R         ORA B ORBYA      A FORM COMPLETE OPCODE
10FE 20 03             BRA   LNAB1C
                *
1100 FA 1088 R  LNAB1B ORA B ORBYB      B FORM COMPLETE OPCODE
1103 F7 0C67 R  LNAB1C STA B OPCD       SAVE
1106 BD 182E R  LNAB10 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 0284 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 1084 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 0C68 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 0284 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 5D            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 POENDO 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 8D 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 8D 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            8IT 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            8IT 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 005C 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 5B        ZZZ      FCC '[[[[[['
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 1089 R POENT    JSR ADRINT      INIT
```

```
13DB BD 181A R        JSR LBLCK     CHECK FOR A LABEL
                    *
13DE BD 06F6 R        JSR NXTOK     GET ENTRY NAME
13E1 C1 01            CMP B #1      OK?
13E3 27 08            BEQ POENT1    YES
                    *
13E5 CE 0216          LDX #$0216    NO, ERROR
13E8 BD 0DBB R        JSR PRINTE
13EB 20 39            BRA POENT3
                    *
13ED 7D 0275 R POENT1 TST PASS      PASS?
13F0 27 43            BEQ POENT4    PASS 1
                    *
13F2 BD 0857 R        JSR LKPSYM    GET ENTRY ADDRESS
13F5 C1 FF            CMP B #$FF    IN SYMTAB?
13F7 26 08            BNE POENT2    YES
                    *
13F9 CE 0211          LDX #$0211    NO,ERROR
13FC BD 0DBB 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 1089 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 0DBB R EQUA   JSR    PRINTE    PRINT ERROR
1465 20 40            BRA    EQUE
                    *
1467 BD 06F6 R EQUB   JSR    NXTOK     GET NEXT TOKEN
146A C1 0D            CMP B  #$0D      EOL?
146C 26 05            BNE    EQUC      NO
                    *
146E CE 0216          LDX    #$0216    ERROR
1471 20 EF            BRA    EQUA
                    *
1473 BD 0985 R EQUC   JSR    NSEVL     EVALUATE OPERAND
1476 C1 FF            CMP B  #$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 1069 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 1039 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 28            BEQ   FDBD      PASS1
               *
15C0 F6 0C68 R        LDA 8 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 FD8C   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 06F6 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
```

```
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 POENT1       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 MAIN1
               *
               *
               * 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    MAIN1     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    #$0216    ERROR
17CE BD 0DBB R RMBA    JSR    PRINTE    PRINT
17D1 20 18             BRA    RMBC      FINISH UP
               *
17D3 BD 09B5 R RMBB    JSR    NSEVL     EVALUATE OPERAND
17D6 C1 FF             CMP B  #$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 86 0274 R RMBD    LDA A  LC+1      LC:=LC+ADR1,ADR2
17F1 F6 0273 R         LDA B  LC
17F4 B8 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            8RA   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      LA8EL?
181D 27 0E            8EQ   LBLCK2     NO
               *
181F 7D 0275 R        TST   PASS       PASS?
1822 26 03            BNE   L8LCK1     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
1B31 85 40            BIT A #$40        OUTPUT?
1833 26 0C            BNE OUTRET        NO
               *
1B35 17               T8A
1836 8D 16            BSR   OUTHL      CONVERT LEFT NIRBLE
1838 BD 0256 R        JSR OUTB
183B 17               TBA
183C BD 14            BSR   OUTHR      CONVERT RIGHT NI8BLE
183E BD 0256 R        JSR OUTB
1841 39        OUTRET RTS
               *
               *
1842 B6 026E R OUTBNR LDA A OPTNS
1845 85 40            8IT A #$40          OUTPUT?
1B47 26 F8            8NE OUTRET          NO
               *
1849 17               T8A
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 8D 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              8NE PDATA2
1867 39                 RTS
                 *
1868 A6 00       OUT2H  LDA A 0,X
186A 8D 0E       OUT2HA 8SR OUTHLL
186C A6 00              LDA A 0,X
186E 08                 INX
186F 20 0D              BRA OUTHRR
                 *
1B71 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
1BBO BB 30              ADD A #$30
1882 B1 39              CMP A #$39
1884 23 02              BLS OUTCHR
                 *
1886 8B 07              ADD A #$07
                 *
188B 36          OUTCHR PSH A
1889 BD 038B R          JSR OUTEEE
1B8C 32                 PUL A
188D 81 0A              CMP A #$0A   LF?
188F 26 0E              BNE OUTCHE   NO
                 *
1B91 36                 PSH A
1892 37                 PSH B
1893 C6 08              LDA 8 #B
                 *
1895 86 00       OUTCHL LDA A #$00
1897 BD 038B R          JSR OUTEEE
189A 5A                 DEC B
189B 26 F8              BNE OUTCHL
                 *
1B9D 33                 PUL B
189E 32                 PUL A
1B9F 39          OUTCHE RTS
                 *
                        END
```

```
@IFSTK  0375 R
ABR     1084 R
ABRCK   10B7 R
ABRCKA  10C0 R
ADD16   0BEC R
ADDR1   0E00 R
ADDR1A  0E0A R
ADDR1B  0E12 R
ADDR1C  0E35 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
ADDR2J  0EF3 R
ADDR2K  0ECB R
ADDR3   0EF9 R
ADDR3B  0F0B R
ADDR3C  0F22 R
ADDR3D  0F35 R
ADDR3E  0F3A R
ADDR3F  0F42 R
ADDR4   0F48 R
ADDR4A  0F5C R
ADDR5   0F68 R
ADDR5A  0F72 R
ADDR5B  0F7A R
ADDR5C  0F97 R
ADDR5D  0FA4 R
ADDR5E  0FC0 R
ADDR5F  0FC5 R
ADDR5G  0FCC R
ADDR5H  0FD1 R
ADDR5J  0FD4 R
ADDR5K  0FBB R
ADDR6   0FDA R
ADDR7   0FE6 R
ADDR7A  0FFB 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  1058 R
ADDR9   106A R
ADDR9A  1075 R
ADR1    0C66 R
ADR2    0C69 R
ADRINT  1089 R
ASM     0000 RN
BLANK   0D53 R
BLANK3  0D56 R
BLANK5  0D58 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  0278 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   0ADB R
CVHBD   0B14 R
CVHBS   0B18 R
CXS2    13D3 R
DCOUNT  0B25 R
DEL1    0BB2 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   0B28 R
ECOUNT  0288 R
ENDMA   1395 R
ENDMB   13A1 R
ENDP2   1276 R
ENDP3   1283 R
ENDP4   12F3 R
ENDP5   1340 R
ENDP6   134D R
ENDP6A  1381 R
ENDP7   1387 R
ENDSCN  07B6 R
ENDXS   13D6 R
ENSIZ   093E R
ENTFLG  027A R
EQUA    1462 R
EQUB    1467 R
EQUC    1473 R
EQUD    149E R
EQUE    14A7 R
EQUF    1492 R
EQUXS   14AD R
ERMSA   0DA3 R
ERMSB   0DAF R
ERMSC   0DB3 R
ERNUM   0DA1 R
EXTFLG  0279 R
FCBA    1518 R
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    08B9 R
HASH1   0BD4 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
INXCKL  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   11C2 R
```

```
LCN     0284 R
LCN2    1131 R
LCN2A   1145 R
LCN2B   1157 R
LCN3    117C R
LCN3A   118A R
LCN3B   1186 R
LCN3C   11A9 R
LCNAB1  10EA R
LCNAB2  1113 R
LCNAB3  115E R
LCOUNT  0287 R
LINCK   0C2A R
LINCKA  0C35 R
LINCKB  0C42 R
LINEN   0C6A R
LKPSM1  085D R
LKPSM2  0863 R
LKPSM3  0B66 R
LKPSM4  0B73 R
LKPSYM  0857 R
LNAB1B  1100 R
LNAB1C  1103 R
LNAB1D  1106 R
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
MAIN11  0550 R
MAIN12  054A R
MAIN13  0547 R
MAIN1A  04A6 R
MAIN3   04AE R
MAIN3A  04BA R
MAIN3B  04D3 R
MAIN3C  04D5 R
MAIN4   04EB R
MAIN5   04F6 R
MAIN6   04FD R
MAIN7   0508 R
MAIN7A  0527 R
MAIN8   053E R
MAIN9   053C R
MCLPTR  0311 R
MCOUNT  0C65 R
MCRLF   13C5 R
MEND    1722 R
MNLI    099E R
MNLKP   0940 R
MNLKPA  094F R
MNLKPB  095B R
MNMI    09A6 R
MNTAB   0006 R
MONTOR  0250 RX
MP      093C R
MPSH1   0645 R
MPSH2   065C R
MPSH3   0665 R
MPSH5   0685 R
MPUL1   06A7 R
MPUL2   06B4 R
MPY16   0B7D R
MPY163  0B8B R
MPY167  0B97 R
MSTKPT  028A R
MXSAV1  028E R
MXSAV2  0290 R
NSCAN   0773 R
NSCANA  0794 R
NSEVL   09B5 R
NSVLA   09D3 R
```

```
NSVLB   09E4 R
NSVLC   09EC R
NSVLC1  09F2 R
NSVLD   09F7 R
NSVLE   09FA R
NSVLF   09FD R
NSVLG   0A07 R
NSVLH   0A15 R
NSVLH1  0A25 R
NSVLJ   0A2A R
NSVLJ1  0A3A R
NSVLK   0A3F R
NSVLL   0A46 R
NSVLLA  0A5F R
NSVLM   0A65 R
NSVLN   0A73 R
NSVLP   0A7C R
NSVLP1  0A8B R
NSVLP2  0A97 R
NSVLP3  0AB0 R
NSVLP4  0AB7 R
NSYM    026A R
NXT0    06FC R
NXT1    0714 R
NXT3    071A R
NXT3A   072E R
NXT4    0734 R
NXT4A   0738 R
NXT5    073C R
NXT6    0744 R
NXTER   0759 R
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   1868 R
OUT2HA  1B6A R
OUT2HS  1B73 R
OUT4HS  1871 R
OUTB    0256 RX
OUTBIN  182E R
OUTBNR  1B42 R
OUTCHE  1B9F R
OUTCHL  1895 R
OUTCHR  1888 R
OUTEEE  033B R
OUTHL   184E R
OUTHLL  187A R
OUTHR   1852 R
OUTHRR  1B7E 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   0D38 R
OUTL7A  0D35 R
OUTLA   0CA5 R
OUTRET  1B41 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   0467 R
PBLK2   143D R
PBLOCK  1438 R
PBXS    144F R
PCOUNT  07E7 R
PDATA1  1B61 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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POEND   124E R          RDMAC0  05B8 R
POEND0  1254 R          RDMAC1  05B9 R
POEND2  1268 R          RDMAC2  05C5 R
POENT   13D8 R          RDMAC3  05E5 R
POENT1  13ED R          RDMAC4  05F3 R
POENT2  1401 R          RDMAC5  060A R
POENT3  1426 R          RDMAC6  05F0 R
POENT4  1435 R          RDMAC7  05FE R
POEQU   1451 R          RDMERR  062B R
POEXT   14AF R          REDEF   133A R
POEXT1  14C7 R          RELFLG  0277 R
POEXT2  14E3 R          RESTR   025F RX
POEXT3  150B R          RMBA    17CE R
POEXT4  150E R          RMBB    17D3 R
POFCB   1511 R          RMBC    17EB R
POFCC   1546 R          RMBD    17EE R
POFDB   159D R          RMBOTA  180A R
POIF    15F1 R          RMBOTB  1819 R
POIFA   15FE R          RMBOUT  1803 R
POIFB   1606 R          SAVEA   0D9C R
POIFC   1624 R          SAVEX   0D9D R
POIFE   1629 R          SAVEX1  0D9F R
POMAC   1631 R          SORT1   128D R
POMAC1  1652 R          SORT2   129B R
POMAC2  1672 R          SORT2A  12B4 R
POMAC5  1692 R          SORT3   12A4 R
POMAC6  16A4 R          SORT4   12DE R
POMAC7  16D3 R          SORT5   12EB R
POMAC8  16CD R          SORTF   13D5 R
POMACA  16E3 R          SPACER  0C44 R
PONAM   1726 R          STKSAV  028C R
PONAM1  173C R          STOSYM  07F8 R
PONAM2  1747 R          SUB16   0BFD R
PONIF   175B R          SYM1    080F R
POP     0C66 R          SYMA    07FE R
POPAG   17A0 R          SYMB    0833 R
PORMB   17C1 R          SYMB1   0844 R
PRINT1  0C23 R          SYMC    0848 R
PRINTE  0DBB R          SYMCMP  087E R
PRINTL  0C0E R          SYMEND  026C R
PSHIF   176A R          SYMMOD  0893 R
PSPLCM  1799 R          SYMPTR  0282 R
PSPLER  1792 R          SYMTAB  0268 R
PSTNG1  07E3 R          TABLES  024A RX
PSTNG2  07E5 R          TBADD   07E8 R
PULIF   177E R          TENVL   0B26 R
RDL1    057F R          TMPVAL  09B0 R
RDL1A   058A R          TSTPH  ,0271 R
RDL2    059C R          UPDATE  024D RX
RDL3    05A0 R          VALUE   09AE R
RDLINA  0576 R          WREOF   0259 RX
RDLINE  0568 R          XSAV    06F4 R
RDMAC   05A5 R          ZZZ     13C8 R
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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^{TM} 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

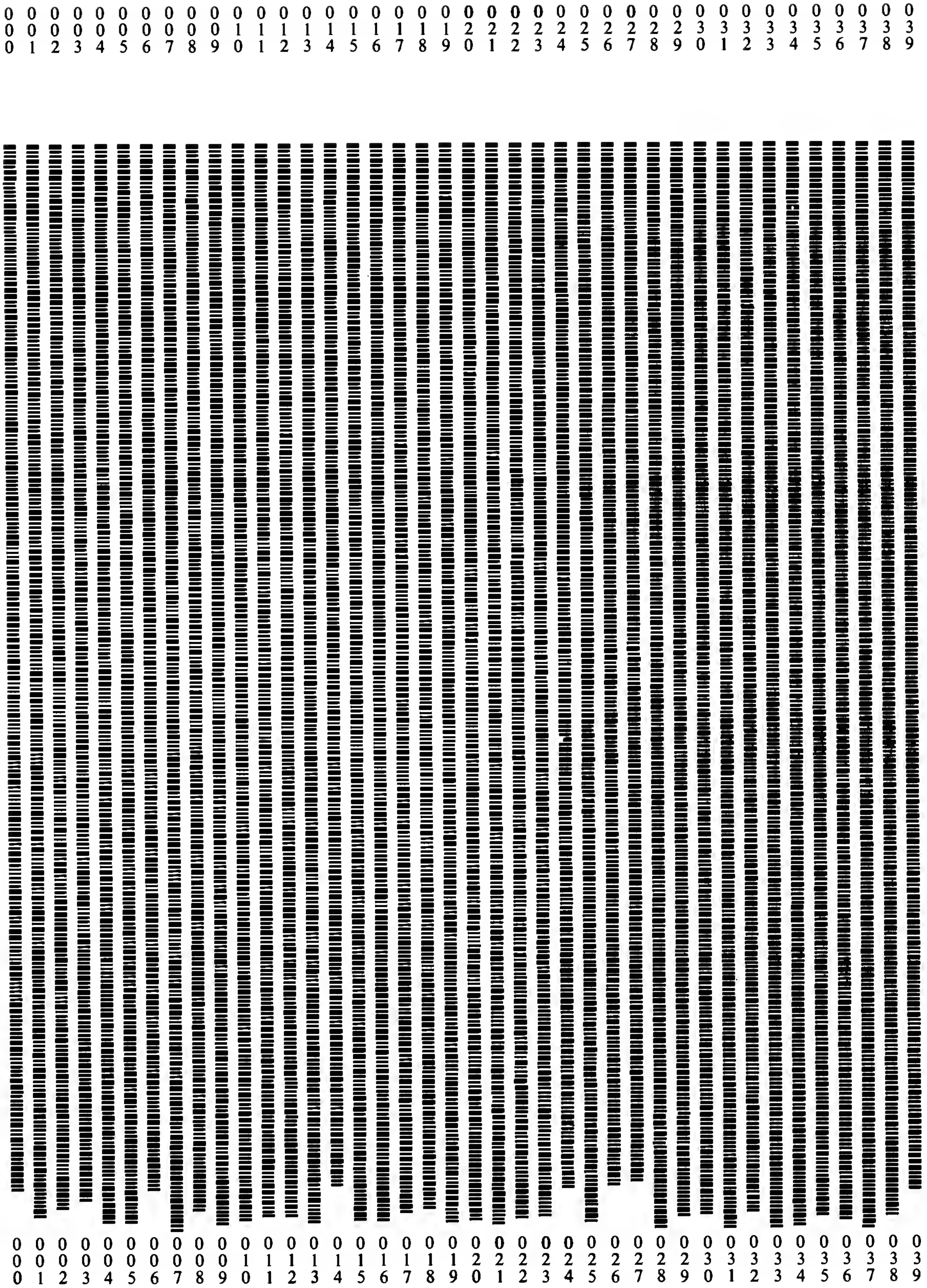
PAPERBYTE^{TM} Bar Code Representation of Relocatable Format Object Code for RA6800ML

Beginning on the following page is a complete machine readable representation (PAPERBYTE^{TM} 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^{TM} 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^{TM} 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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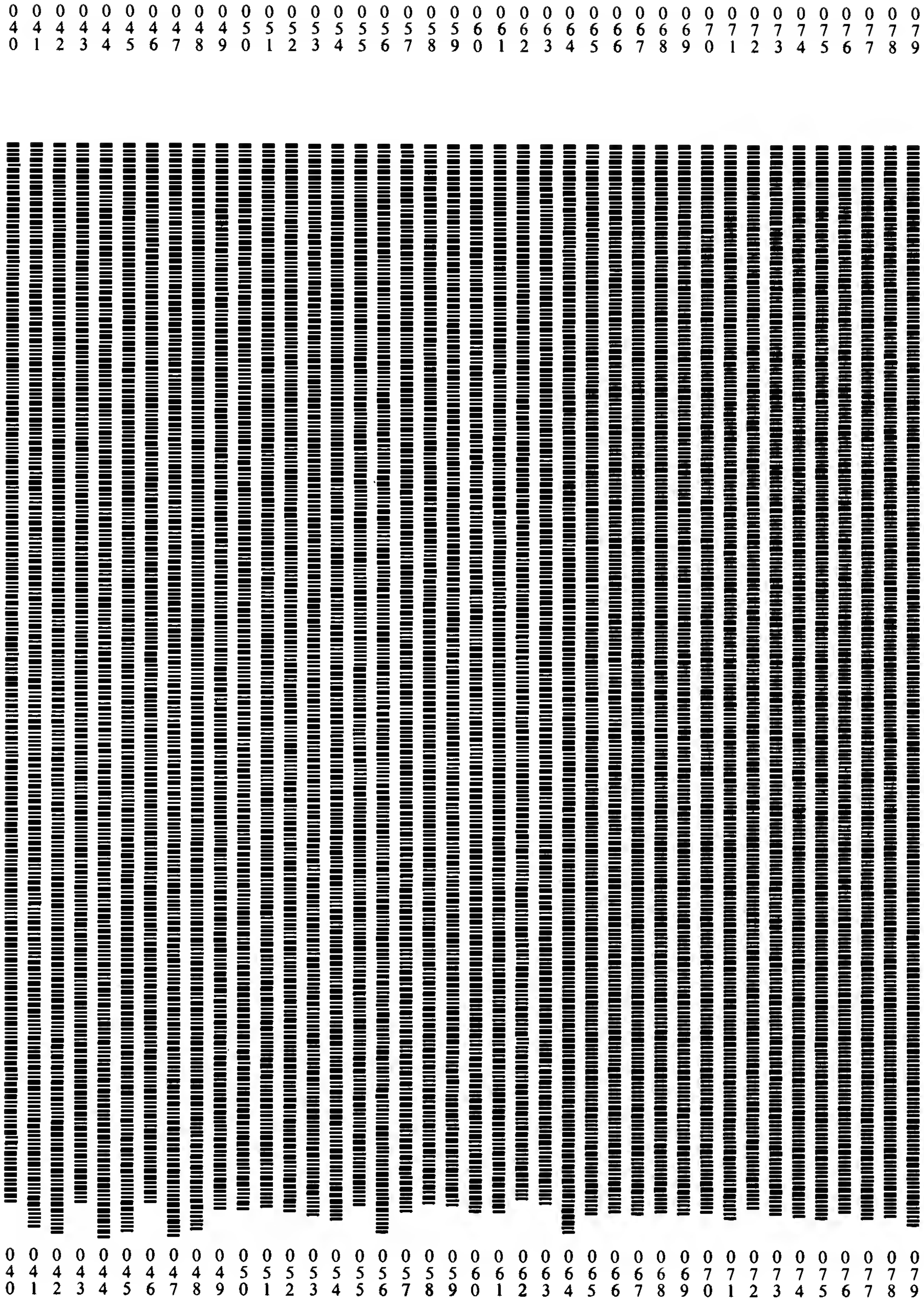
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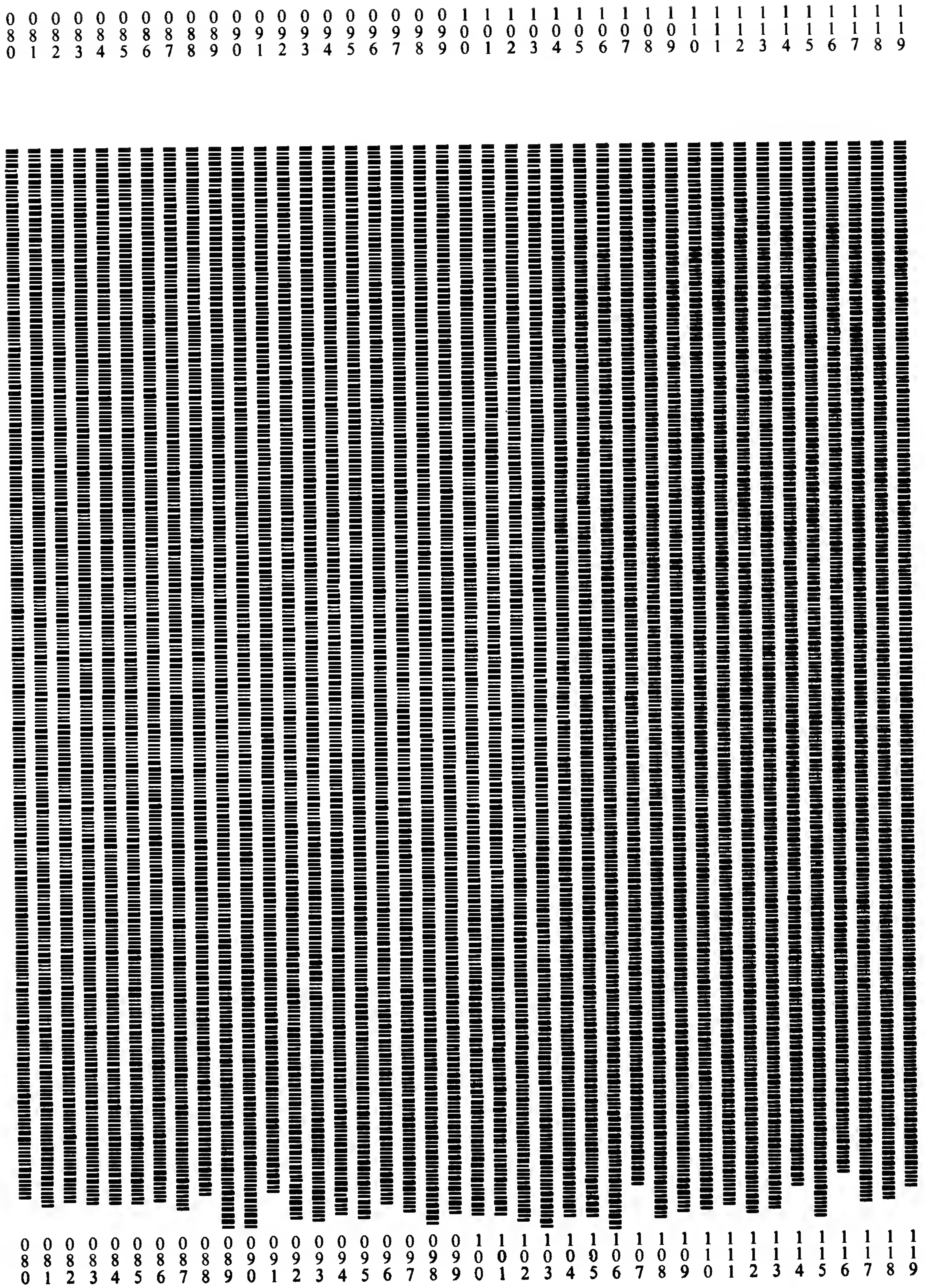
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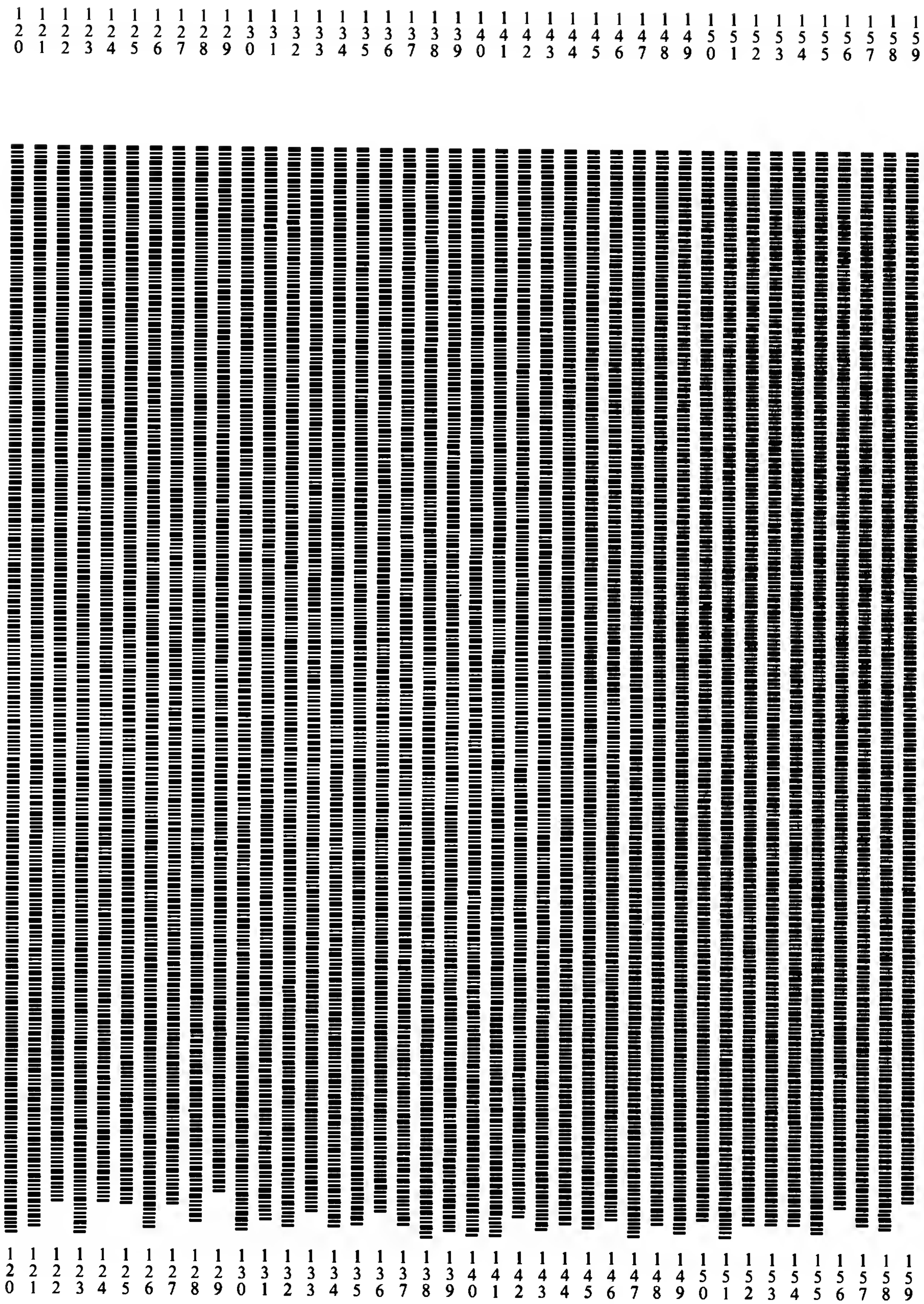
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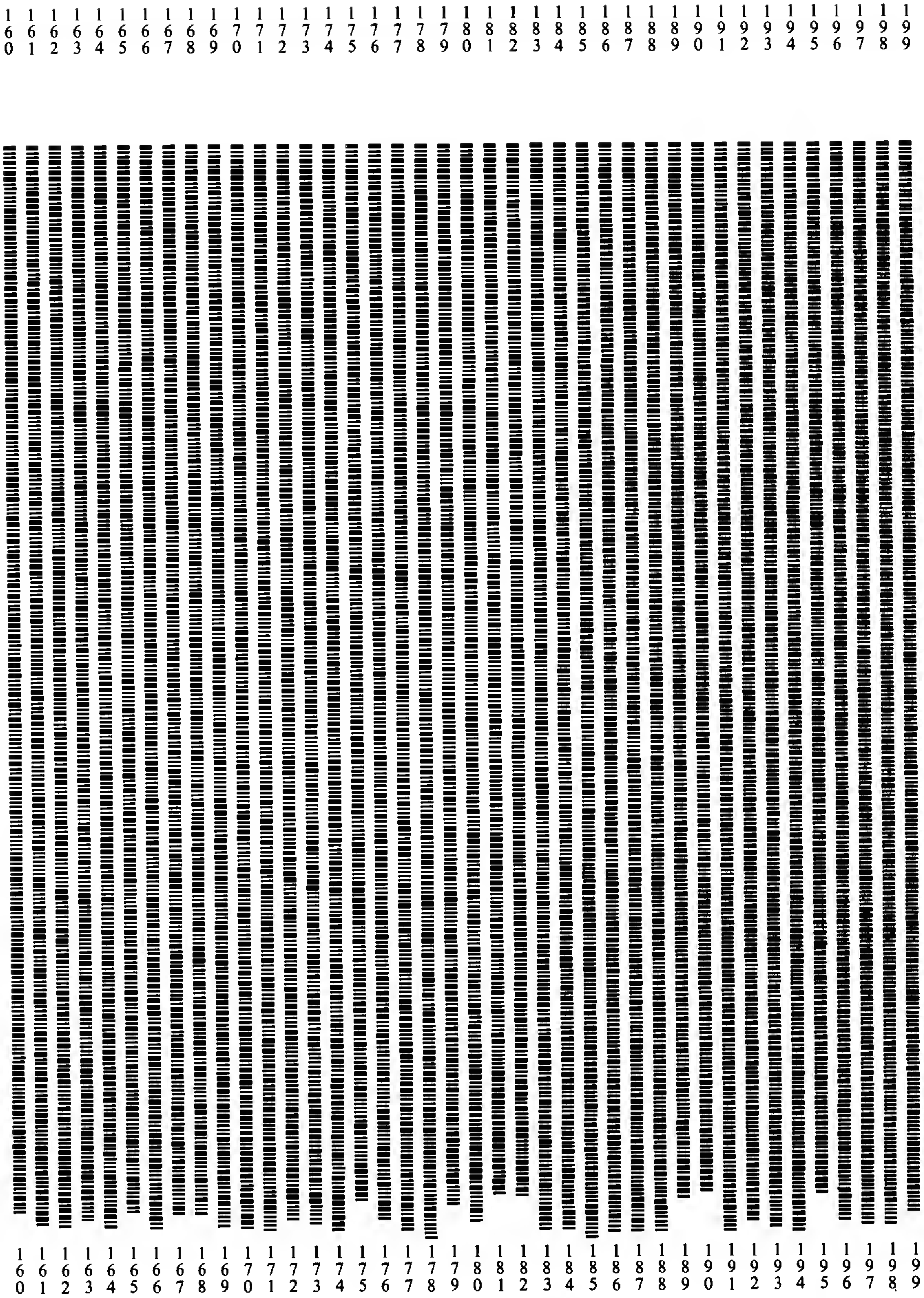
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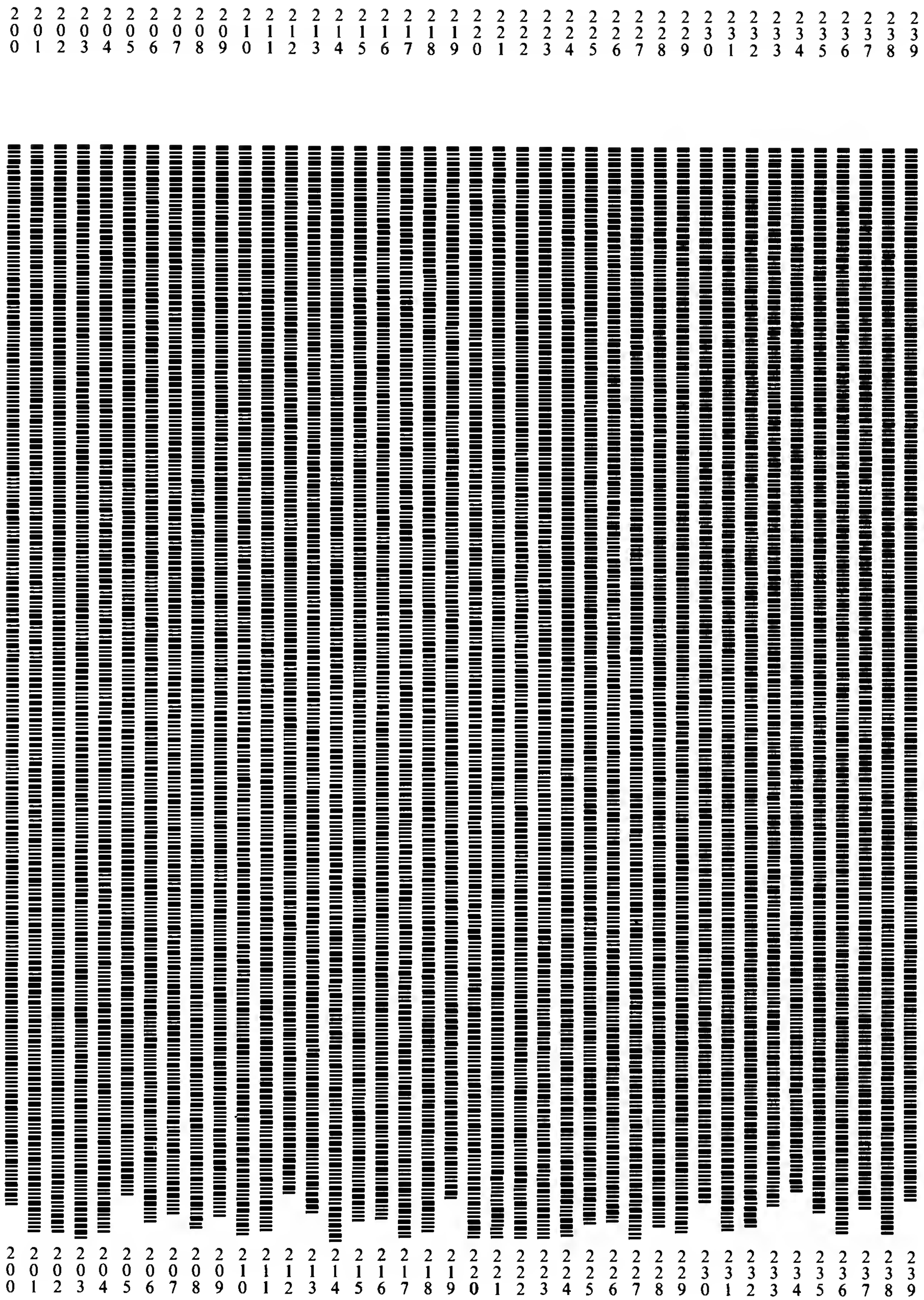
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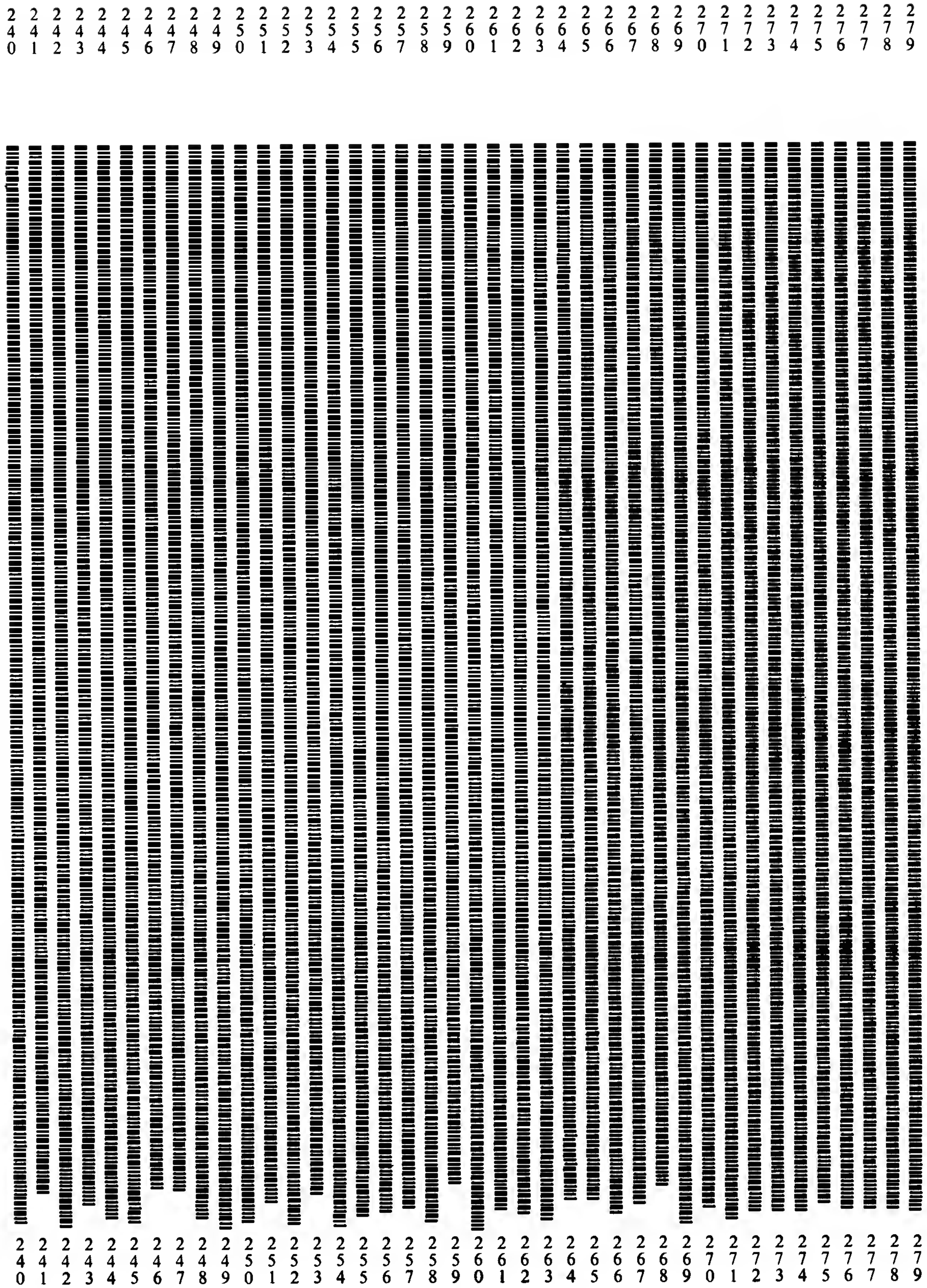
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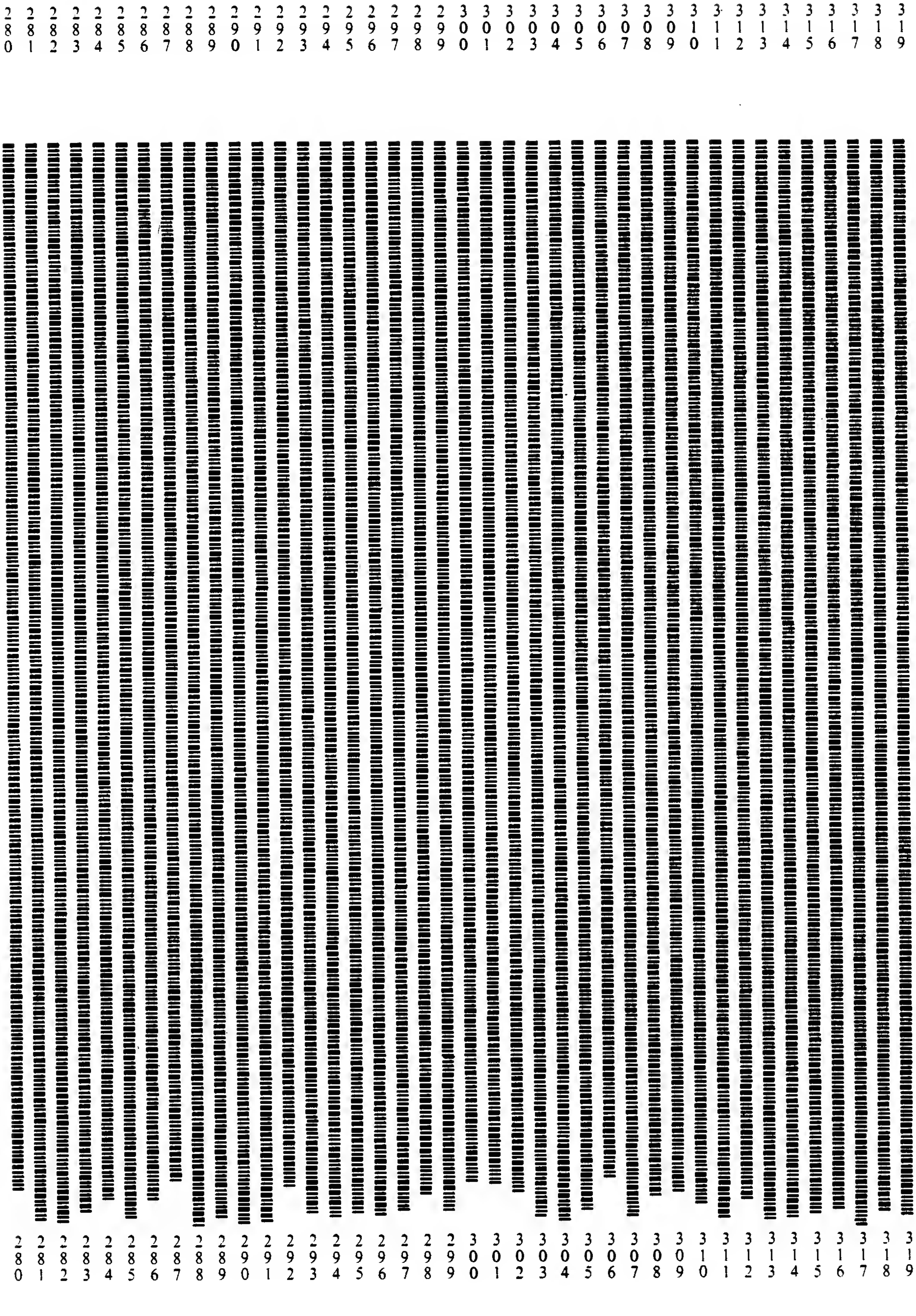

Corrected page 155 for RA6800ML

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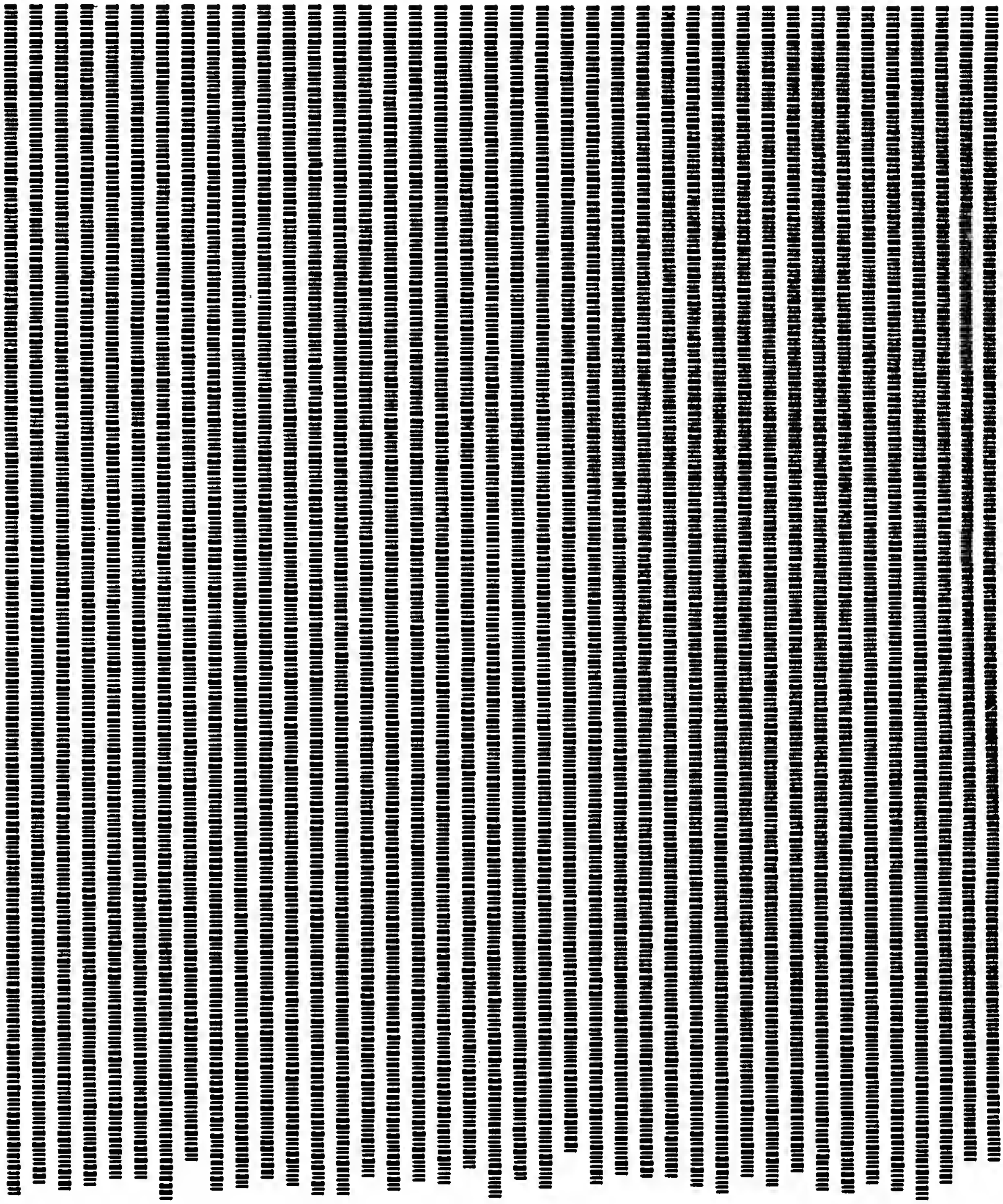

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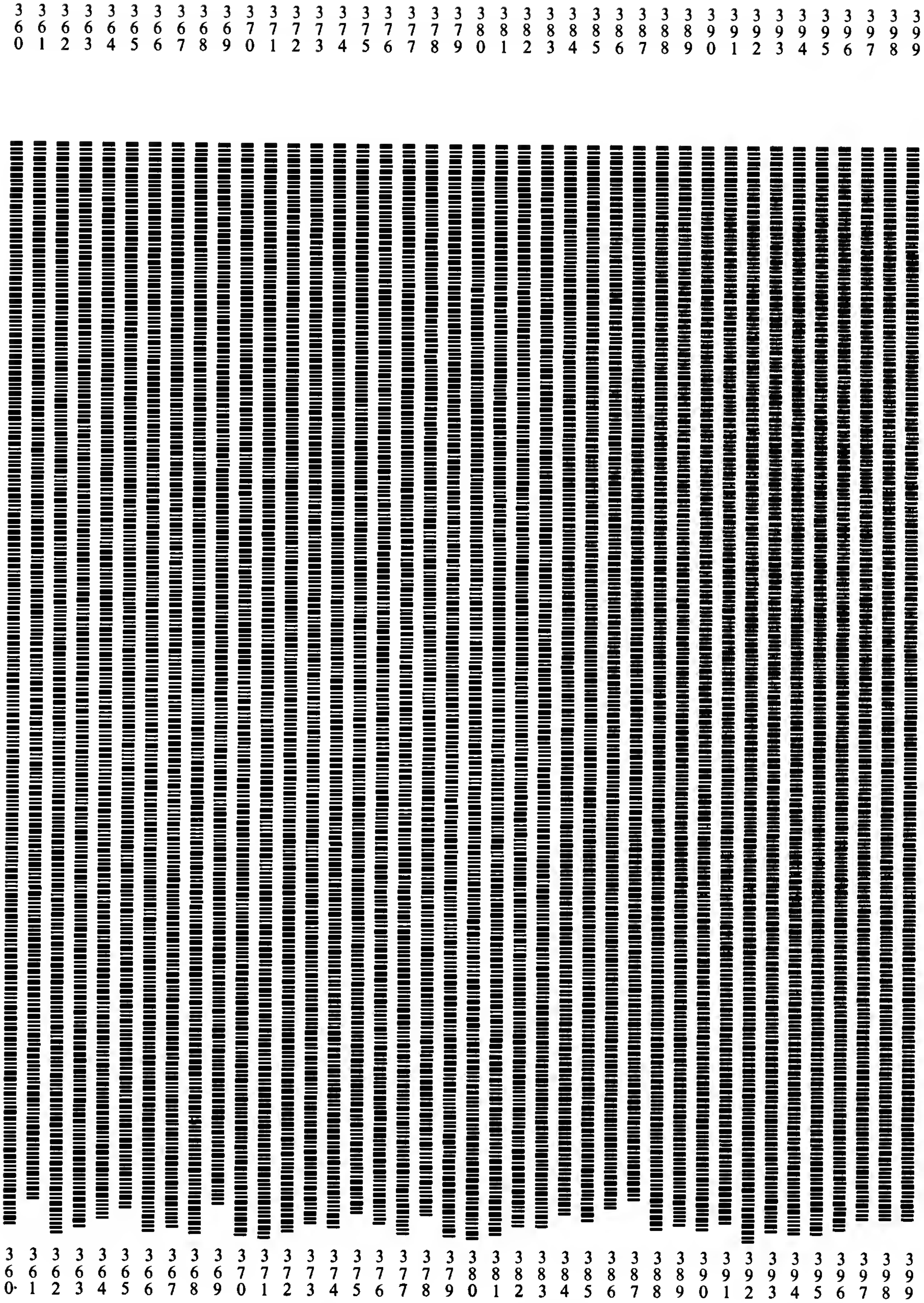
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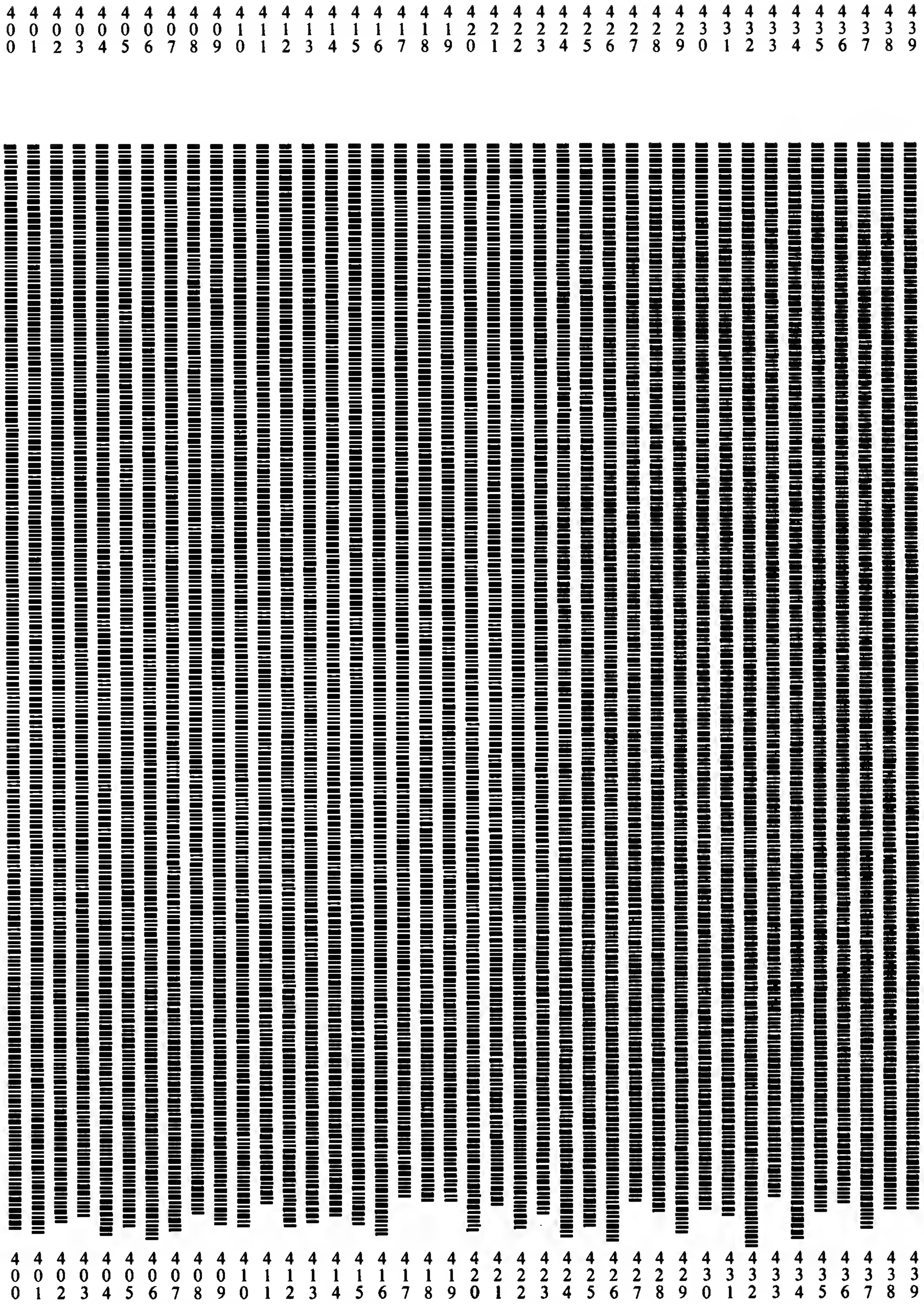
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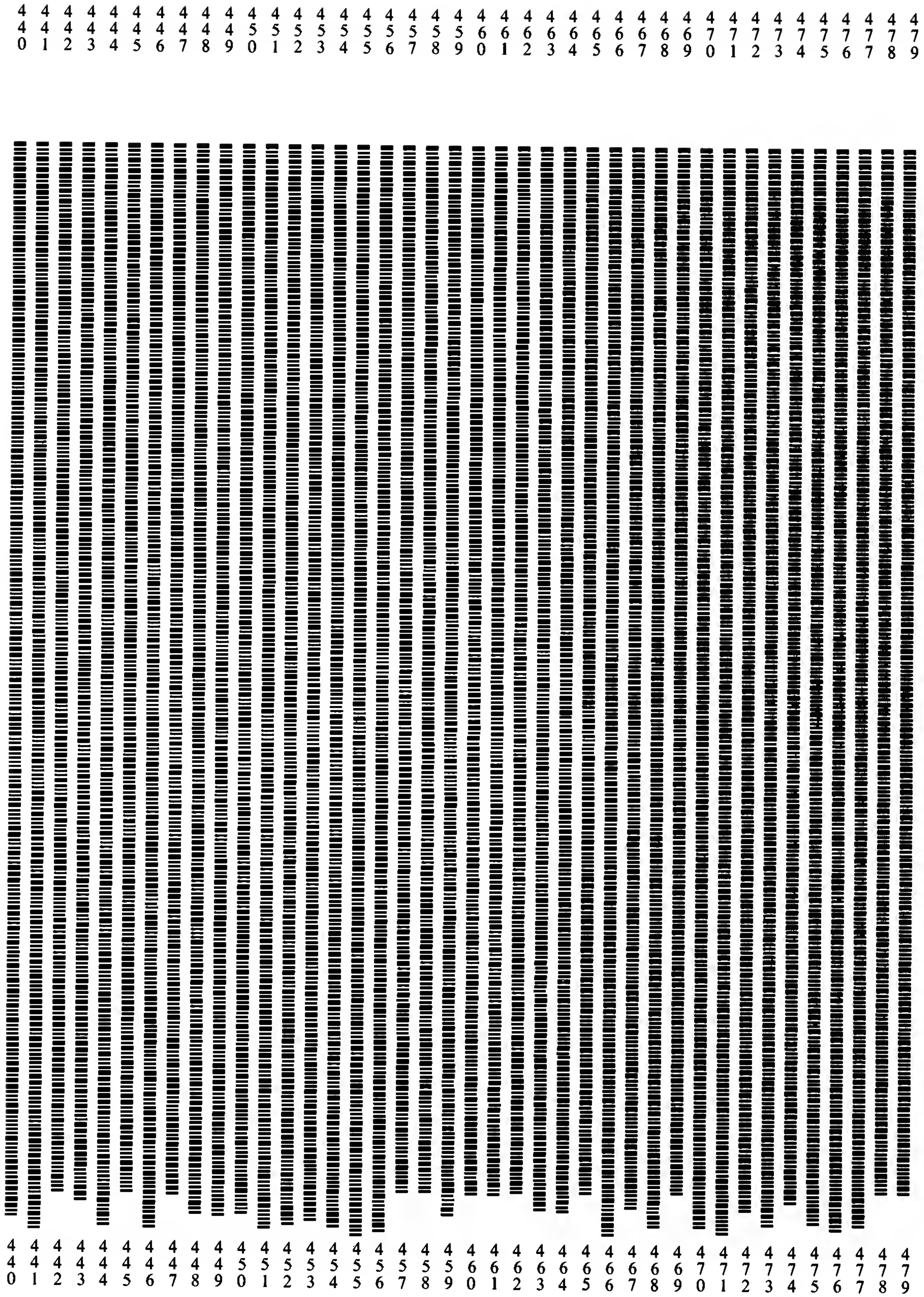
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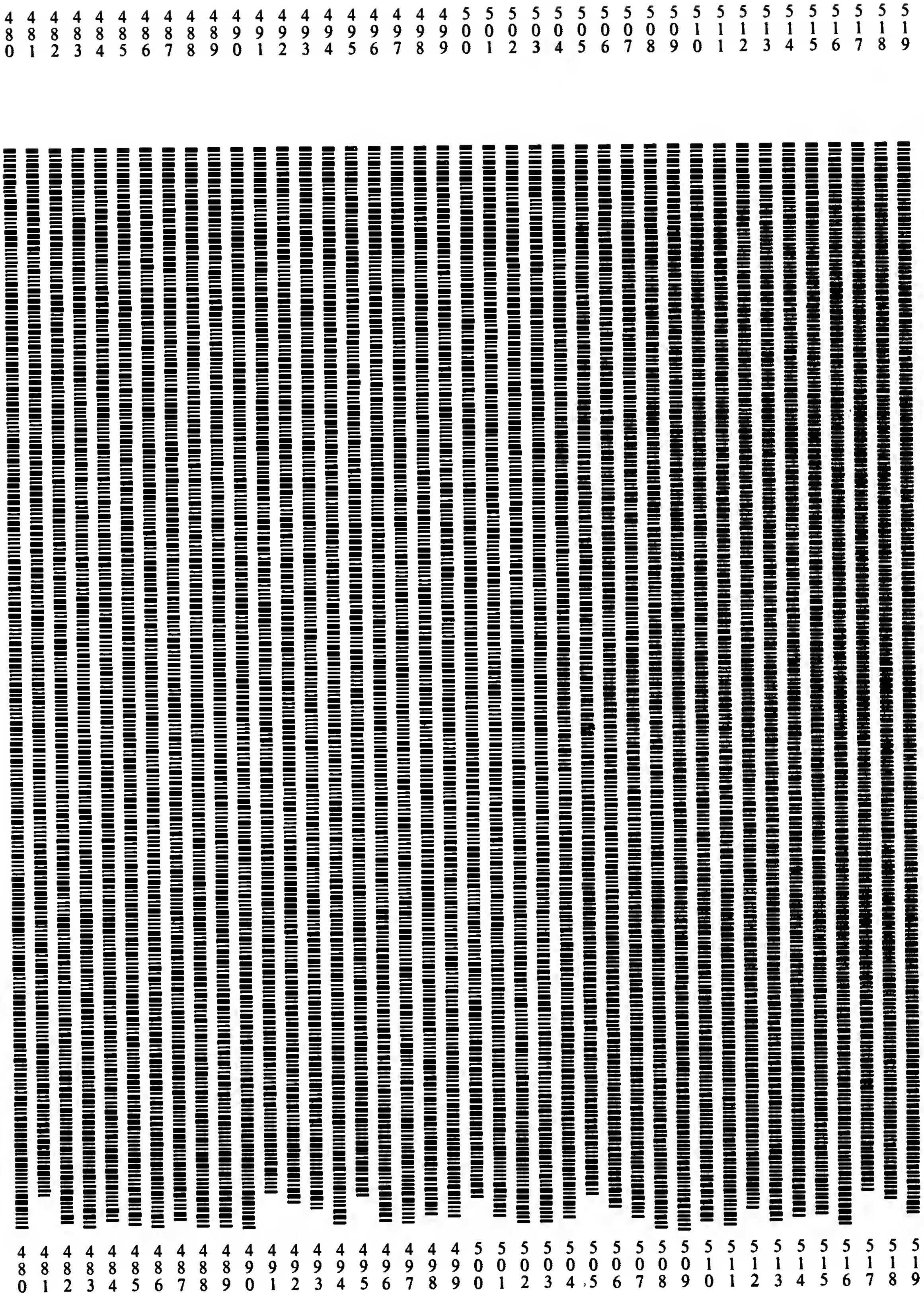
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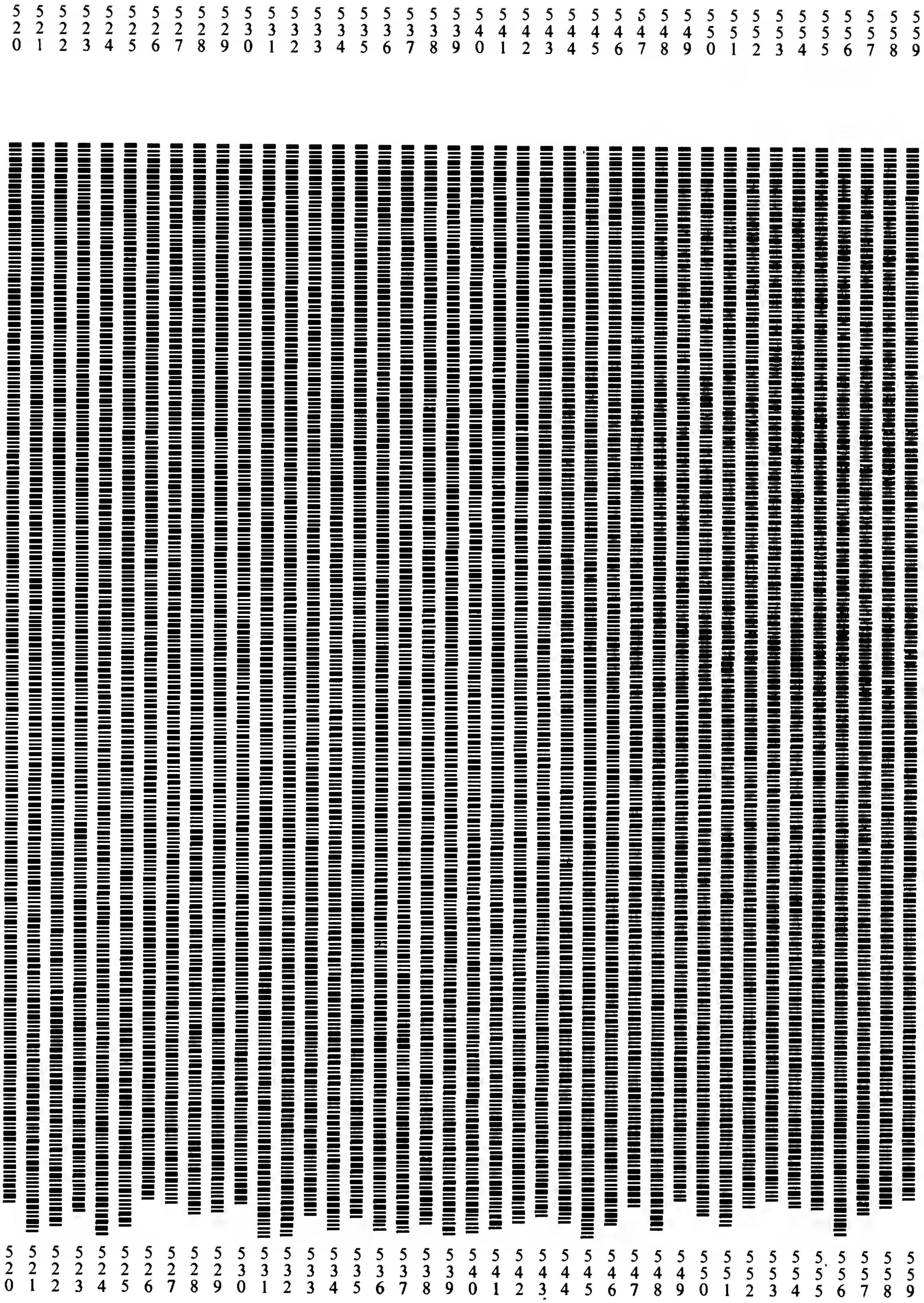
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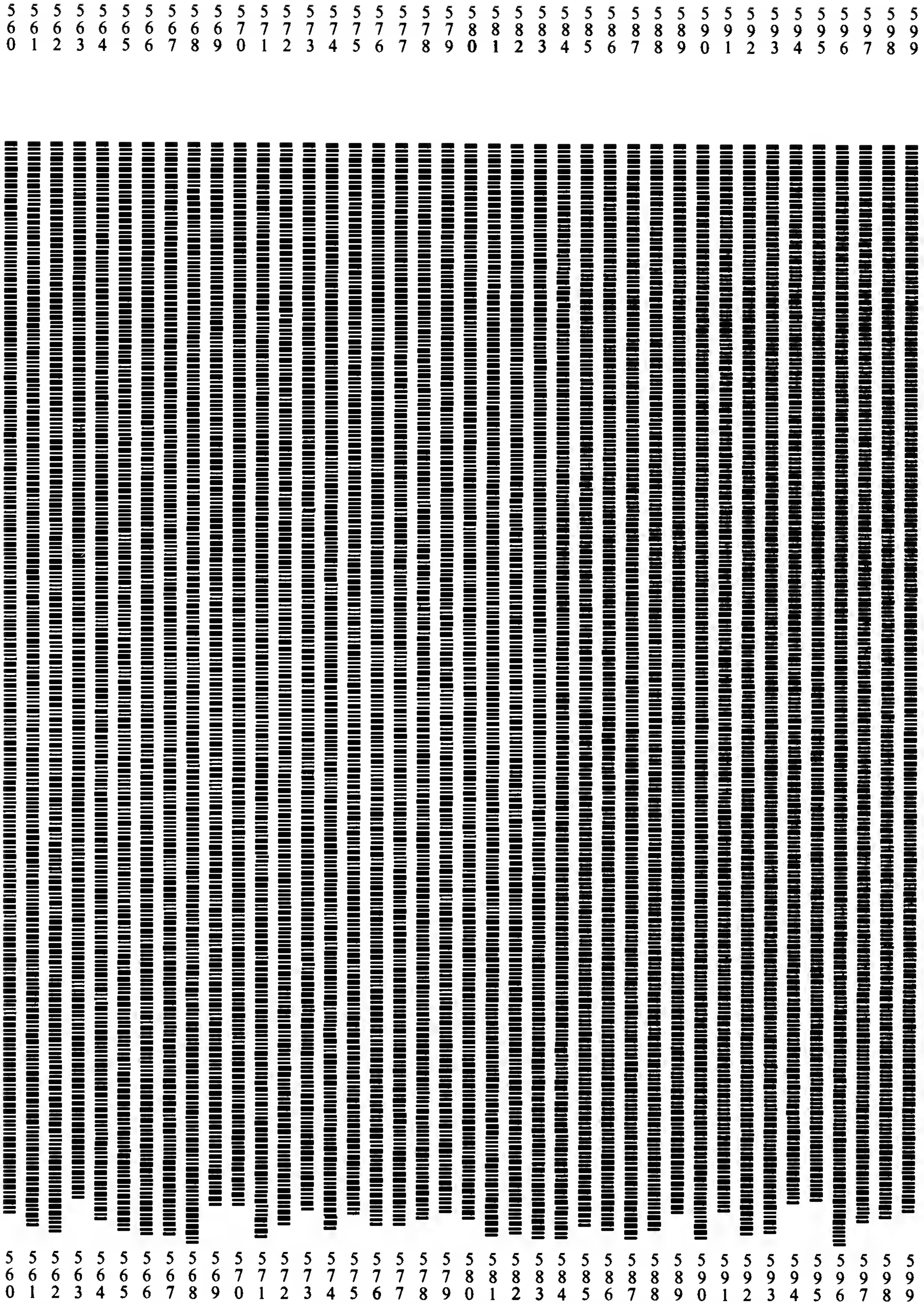
520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559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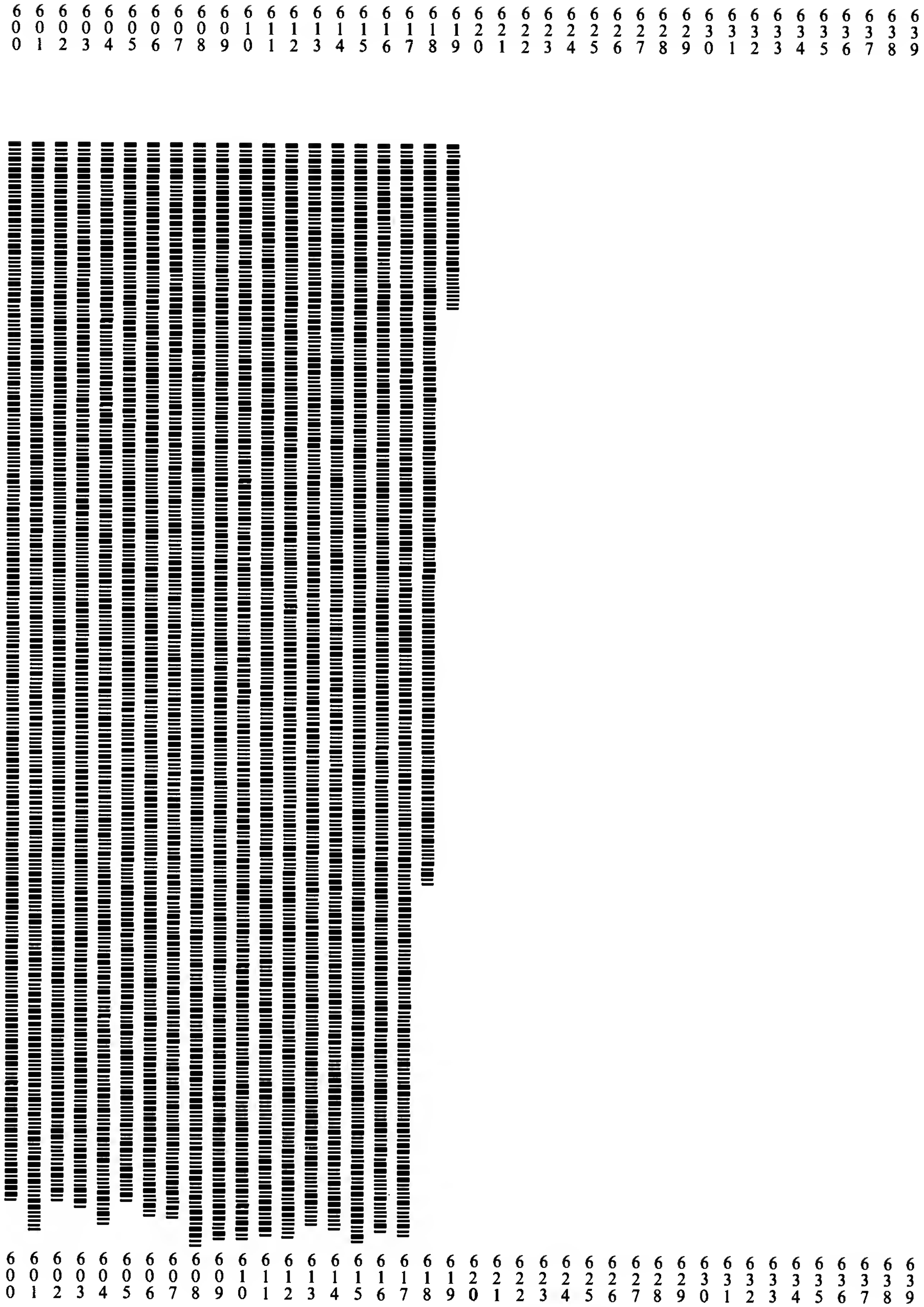
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APPENDIX J

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         DXSV   RMB 2
                  *
                  * GET A BYTE RETURN IN A REGISTER
                  *
0016 FF 0014 R GETB   STX DXSV
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 DXSV
0030 0C               CLC
0031 39               RTS
                  *
                  *
                  * OUTPUT BYTE IN A REGISTER
                  *
0032 FF 0014 R OUTB   STX DXSV
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 DXSV
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 WRIT8F
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 BC 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     OONE ?
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 T1INZ  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   OELAY 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
               *
               * REAO A BYTE
               *
0181 F6 B010   T1GET  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?
01BA 27 01            BEQ *+3      NO
               *
018C 39               RTS          YES
               *
018D B6 B011          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 REAO
               *
0199 36        T1ISTP PSH A
019A B6 17            LDA A #$17
019C B7 8010          STA A TP1ST
019F 32               PUL A
01A0 39               RTS
               *
               * START TAPE FOR OUTPUT
               *
01A1 37        T2OTZ  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 #$5J    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        T2OUT  PSH B
01BD F6 8014   T2OUTA LDA B TP2ST     GET STATUS
01C0 C5 02            BIT B #$02      READY?
01C2 27 F9            BEQ T2OUTA      NO
               *
01C4 B7 8015          STA A TP2DAT    YES, WRITE BYTE
01C7 33               PUL B
01C8 39               RTS
               *
               * STOP TAPE AFTER A WRITE
               *
```

```
01C9 4F          T2OSTP CLR A          WRITE PAD CHARS
01CA BD 01BC R          JSR T2OUT
01CD BD 01BC R          JSR T2OUT
01D0 BD 01BC R          JSR T2OUT
01D3 86 17              LDA A #$17
01D5 B7 8014            STA A TP2ST
010B 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
OXSV    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
T1GET   01B1 R
T1INZ   015E R
T1ISTP  0199 R
T2OSTP  01C9 R
T2OTZ   01A1 R
T2OUT   01BC R
T2OUTA  01BD R
TABLES  01E1 RN
TAPERR  0102 R
TDELY   01D9 R
TDELY1  01DA R
TDRIVE  0000 RN
TP1DAT  8011
TP1ST   8010
TP2DAT  B015
TP2ST   8014
TXSV    015C R
UPDATE  0009 RN
WREOF   0088 RN
WRITBF  0129 R
WRTBFA  013D R
WRTBFB  014C R
WRTBFC  0154 R

THERE WERE: 00000 ERRORS

COMMON LENGTH= 0000

ICOM FOOS-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    MONITOR 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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A Note About Bar Codes . . .

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.

BYTE BOOKS™

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