ALTAIR

BASIC

REFERENCE MANUAL

altair™ 8800 BASIC
REFERENCE MANUAL

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PREFACE

The Altair BASIC language is a high-level programming language specifically designed for interactive computing systems. Its simple English-like instructions are easily understood and quickly learned and its interactive nature allows instant feedback of results and diagnostics. Despite its simplicity, however, Altair BASIC has evolved into a powerful language with provisions for editing and string processing as well as numerical computation.

The Altair BASIC interpreter reads the instructions of the BASIC language and directs the ALTAIR 8800 series microcomputer to execute them. Altair BASIC includes many useful diagnostic and editing features in all versions. The extended versions provide additional features including comprehensive file input/output procedures in the disk version.

This manual will explain the features of the BASIC language and the special provisions of the 4K, 8K, Extended and Disk Extended Altair BASIC interpreters, release 4.0. For quick reference, a table of Altair BASIC instructions, diagnostics and functions are provided in Section 6. A complete index is at the end of the manual. In addition to this reference manual, the programmer should have a good BASIC text book on hand. A list of some suggested texts is given in Appendix J.

CONTENTS

1. SOME INTRODUCTORY REMARKS

1-1 Introduction to this Manual.

a. Conventions. For the sake of simplicity, some conventions will be followed in discussing the features of the Altair BASIC language.

1. Words printed in capital letters must be written exactly as shown. These are mostly names of instructions and commands.
2. Items enclosed in angle brackets (<>) must be supplied as explained in the text. Items in square brackets ([]) are optional. Items in both kinds of brackets, [<W>], for example, are to be supplied if the optional feature is used. Items followed by dots (...) may be repeated or deleted as necessary.
3. Shift/ or Control/ followed by a letter means the character is typed by holding down the Shift or Control key and typing the indicated letter.
4. All indicated punctuation must be supplied.

b. Definitions. Some terms which will become important are as follows:

Alphanumeric character: all letters and numerals taken together are called alphanumeric characters.

Carriage Return: Refers both to the key on the terminal which causes the carriage, print head or cursor to move to the beginning of the next line and to the command that the carriage return key issues which terminates a BASIC line.

Command Level: After Altair BASIC prints OK, it is at the command level. This means it is ready to accept commands.

Commands and Statements: Instructions in Altair BASIC are loosely divided into two classes, Commands and Statements. Commands are instructions normally used only in direct mode (see Modes of Operation, section 1-2). Some commands, such as CONT, may only be used in direct mode since they have no meaning as program statements. Some commands, such as DELETE, are not normally used as program statements because they cause a return to command level. But most commands will find occasional use as program statements. Statements are instructions that are normally used in indirect mode. Some statements, such as DEF, may only be used in indirect mode.

Edit: The process of deleting, adding and substituting lines in a program and that of preparing data for output according to a predetermined format will both be referred to as "editing." The particular meaning in use will be clear from the context.

Integer Expression: An expression whose value is truncated to an integer. The components of the expression need not be of integer type.

Reserved Words: Some words are reserved by BASIC for use as statements and commands. These are called reserved words and they may not be used in variable or function names.

Special Characters: some characters appear differently on different terminals. Some of the most important of these are the following:

^ (caret) appears on some terminals as ↑ (up-arrow)
~ (tilde) does not appear on some terminals and prints as a blank
_ (underline) appears on some terminals as ← (back-arrow).

String Literal: A string of characters enclosed by quotation marks (") which is to be input or output exactly as it appears. The quotation marks are not part of the string literal, nor may a string literal contain quotation marks. (""HI, THERE""is not legal.)

Type: While the actual device used to enter information into the computer differs from system to system, this manual will use the word "type" to refer to the process of entry. The user types, the computer prints. Type also refers to the classifications of numbers and strings.

1-2 Modes of Operation.

Altair BASIC provides for operation of the computer in two different modes. In the direct mode, the statements or commands are executed as they are entered into the computer. Results of arithmetic and logical operations are displayed and stored for later use, but the instructions themselves are lost after execution. This mode is useful for debugging and for using Altair BASIC in a "calculator" mode for quick computations which do not justify the design and coding of complete programs.

In the indirect mode, the computer executes instructions from a program stored in memory. Program lines are entered into memory if they are preceded by a line number. Execution of the program is initiated by the RUN

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1-3 Formats.

a. Lines. The line is the fundamental unit of an Altair BASIC program. The format for an Altair BASIC line is as follows:

nnnnn <BASIC statement>[:<BASIC statement>...]

Each Altair BASIC line begins with a number. The number corresponds to the address of the line in memory and indicates the order in which the statements in the line will be executed in the program. It also provides for branching linkages and for editing. Line numbers must be in the range 0 to 65529. A good programming practice is to use an increment of 5 or 10 between successive line numbers to allow for insertions.

1) Line numbers may be generated automatically in the Extended and Disk versions of Altair BASIC by use of the AUTO and RENUM commands. The AUTO command provides for automatic insertion of line numbers when entering program lines. The format of the AUTO command is as follows:

AUTO[<initial line>[,[<increment>]]

Example;

```
AUTO 100,10
100 INPUT X,Y
110 PRINT SQR(X^2+Y^2)
120 ^C
OK
```

AUTO will number every input line until Control/C is typed. If the <initial line> is omitted, it is assumed to be 10 and an increment of 10 is assumed if <increment> is omitted. If the <initial line> is followed by a comma but no increment is specified, the increment last used in an AUTO statement is assumed.

If AUTO generates a line number that already exists in the program currently in memory, it prints the number followed by an asterisk. This is to warn the user that any input will replace the existing line.

2) The RENUM command allows program lines to be "spread out" so that a new line or lines may be inserted between existing lines. The format of the RENUM command is as follows:

RENUM [<NN>[<MM>[,<II>]]]

where NN is the new number of the first line to be resequenced. If omitted, NN is assumed to be 10. Lines less than MM will not be renumbered. If MM is omitted, the whole program will be resequenced. II is the increment between the lines to be resequenced. If II is omitted, it is assumed to be 10. Examples:

RENUM Renumbers the whole program to start at line 10 with an increment of 10 between the new line numbers.

RENUM 100,,100 Renumbers the whole program to start at line 100 with an increment of 100.

RENUM 6000,5000,1000 Renumbers the lines from 5000 up so they start at 6000 with an increment of 1000.

NOTE

RENUM cannot be used to change the order of program lines (for example, RENUM 15,30 when the program has three lines numbered 10, 20 and 30) nor to create line numbers greater than 65529. An ILLEGAL FUNCTION CALL error will result.

All line numbers appearing after a GOTO, GOSUB, THEN, ON...GOTO, ON...GOSUB and ERL<relational operator> will be properly changed by RENUM to reference the new line numbers. If a line number appears after one of the statements above but does not exist in the program, the message "UNDEFINED LINE XXXXX IN YYYYY" will be printed. This line reference (XXXXX) will not be changed by RENUM, but line number YYYYY may be changed.

3) In the Extended and Disk versions, the current line number may be designated by a period (.) anywhere a line number reference is required. This is particularly useful in the use of the EDIT command. See section 5-4.

4) Following the line number, one or more BASIC statements are written. The first word of a statement identifies the operations to be performed. The list of arguments which follows the identifying word serves several purposes. It can contain (or refer symbolically to) the

data which is to be operated upon by the statement. In some important instructions, the operation to be performed depends upon conditions or options specified in the list.

Each type of statement will be considered in detail in sections 2, 3 and 4.

More than one statement can be written on one line if they are separated by colons (:). Any number of statements can be joined this way provided that the line is no more than 72 characters long in the 4K and 8K versions, or 255 characters in the Extended and Disk versions. In the Extended and Disk versions, lines may be broken with the LINE FEED key. Example:

```
10Ø IF X<Y+37<line feed>
    THEN 5 <line feed>
    ELSE PRINT(X)<carriage return>
```

The line is shown broken into three lines, but it is input as one BASIC line.

b. REMarks. In many cases, a program can be more easily understood if it contains remarks and explanations as well as the statements of the program proper. In Altair BASIC, the REM statement allows such comments to be included without affecting execution of the program. The format of the REM statement is as follows:

```
REM <remarks>
```

A REM statement is not executed by BASIC, but branching statements may link into it. REM statements are terminated by the carriage return or the end of the line but not by a colon. Example:

```
10Ø REM DO THIS LOOP:FOR I=1TO1Ø        -the FOR statement
                                         will not be executed
101 FOR I=1 TO 1Ø: REM DO THIS LOOP     -this FOR statement will
                                         be executed.
```

In Extended and Disk versions, remarks may be added to the end of a program line separated from the rest of the line by a single quotation mark ('). Everything after the single quote will be ignored.

c. Errors. When the BASIC interpreter detects an error that will cause the program to be terminated, it prints an error message. The error message formats in Altair BASIC are as follows:

```
Direct statement     ?XX ERROR
```

Indirect statement ?XX ERROR IN nnnnn

XX is the error code or message (see section 6-5 for a list of error codes and messages) and nnnnn is the line number where the error occurred. Each statement has its own particular possible errors in addition to the general errors in syntax. These errors will be discussed in the description of the individual statements.

1-4 Editing - elementary provisions.

Editing features are provided in Altair BASIC so that mistakes can be corrected and features can be added and deleted without affecting the remainder of the program. If necessary, the whole program may be deleted. Extended and Disk Altair BASIC have expanded editing facilities which will be discussed in section 5.

a. Correcting single characters. If an incorrect character is detected in a line as it is being typed, it can be corrected immediately with the backarrow (underline on some terminals) or ,except in 4K, the RUBOUT key. Each stroke of the key deletes the immediately preceding character. If there is no preceding character, a carriage return is issued and a new line is begun. Once the unwanted characters are removed, they can be replaced simply by typing the rest of the line as desired.

When RUBOUT is typed, a backslash (\) is printed and then the character to be deleted. Each successive RUBOUT prints the next character to be deleted. Typing a new character prints another backslash and the new character. All characters between the backslashes are deleted.

Example:

```
100 X=\=X\Y=10
```

Typing two RUBOUTS deleted the '=' and 'X' which were subsequently replaced by Y= .

b. correcting lines. A line being typed may be deleted by typing an at-sign (@) instead of typing a carriage return. A carriage return is printed automatically after the line is deleted. Except in 4K, typing Control/U has the same effect.

In the Extended and Disk versions, typing Control/A instead of the carriage return will allow all the features of the EDIT command (except the A command) to be used on the

line currently being typed. See section 5-4.

c. correcting whole programs. The NEW command causes the entire current program and all variables to be deleted. NEW is generally used to clear memory space preparatory to entering a new program.

2. STATEMENTS AND EXPRESSIONS.

2-1. Expressions.

The simplest BASIC expressions are single constants, variables and function calls.

a. Constants. Altair BASIC accepts integers or floating point real numbers as constants. All but the 4K version of Altair BASIC accept string constants as well. See section 4-1. Some examples of acceptable numeric constants follow:

```
123
3.141
0.0436
1.25E+05
```

Data input from the terminal or numeric constants in a program may have any number of digits up to the length of a line (see section 1-3a). In 4K and 8K Altair BASIC, however, only the first 7 digits of a number are significant and the seventh digit is rounded up. Therefore, the command

```
PRINT 1.234567890123
```

produces the following output:

```
1.23457
OK
```

In Extended and Disk versions of Altair BASIC, double precision format allows 17 significant digits with the 17th digit rounded up.

The format of a printed number is determined by the following rules:

1. If the number is negative, a minus sign (-) is printed to the left of the number. If the number is positive, a space is printed.

2. If the absolute value of the number is an integer in the range 0 to 999999, it is printed as an integer.

3. If the absolute value of the number is greater than or equal to .01 and less than or equal to 999999, it is printed in fixed point notation with no exponent.

4. In Extended and Disk versions, fixed point values up to 9999999999999999 are possible.

5. If the number does not fall into categories 2, 3 or 4, scientific notation is used.

The formats of scientific notation are as follows:

```
SX.XXXXXESTT              single precision

SX.XXXXXXXXXXXXXXXDSTT    double precision
```

where S stands for the signs of the mantissa and the exponent (they need not be the same, of course), X for the digits of the mantissa and T for the digits of the exponent. E and D may be read "...times ten to the power...." Non-significant zeros are suppressed in the mantissa, but two digits are always printed in the exponent. The sign convention in rule 1 is followed for the mantissa. The exponent must be in the range -38 to +38. The largest number that may be represented in Altair BASIC is 1.70141E38, the smallest positive number is 2.9387E-38. The following are examples of numbers as input and as output by Altair BASIC:

```
Number              Altair BASIC Output

+1                   1
-1                  -1
6523                 6523
1E20                 1E20
-12.34567E-10       -1.23456E-09
1.234567E-7          1.23457E-07
1000000              1E+06
.1                   .1
.01                  .01
.000123              1.23E-04
-25.460             -25.46
```

The Extended and Disk versions of Altair BASIC allow numbers to be represented in integer, single precision or double precision form. The type of a number constant is determined according to the following rules:

1. A constant with more than 7 digits or a 'D' instead of 'E' in the exponent is double precision.

2. A constant outside the range -32768 to 32767 with 7 or fewer digits and a decimal point or with an 'E' exponent is single precision.

3. A constant in the range -32768 to 32767 and no decimal point is integer.

4. A constant followed by an exclamation point (!) is single precision; a constant followed by a pound sign (#) is double precision.

Two additional types of constants are allowed in Extended and Disk versions of Altair BASIC. Hexadecimal (base sixteen) constants may be explicitly designated by the symbol &H preceding the number. The constant may not contain any characters other than the digits Ø - 9 or letters A - F, or a SYNTAX ERROR will occur. Octal constants may be designated either by &O or just the & sign.

In all formats, a space is printed after the number. In all but the 4K version, Altair BASIC checks to see if the entire number will fit on the current line. If not, it issues a carriage return and prints the whole number on the next line.

b. Variables

1) A variable represents symbolically any number which is assigned to it. The value of a variable may be assigned explicitly by the programmer or may be assigned as the result of calculations in a program. Before a variable is assigned a value, its value is assumed to be zero. In 4K , a variable name consists of one or two characters. The first character is any letter. The second character must be a numeral. In other versions of Altair BASIC, the variable name may be any length, but any alphanumeric characters after the first two are ignored. The first character must be a letter. No reserved words may appear as variable names or within variable names. The following are examples of legal and illegal Altair BASIC variables:

Legal	Illegal
In 4K and 8K Altair BASIC:	
A	%A (first character must be alphabetic.)
Z1	Z1A (variable name is too long for 4K)
Other versions:	

TP	TO (variable names cannot be reserved words)
PSTG$	
COUNT	RGOTO (variable names cannot contain reserved words.)

In all but 4K Altair BASIC, a variable may also represent a string. Use of this feature is discussed in section 4.

2) Extended and Disk versions of Altair BASIC allow the use of Integer and Double Precision variables as well as Single Precision and Strings. The type of a variable may be explicitly declared in Extended and Disk versions of Altair BASIC by using one of the symbols in the table below as the last character of the variable name.

Type	Symbol
Strings (Ø to 255 characters)	$
Integers (-32768 to 32767)	%
Single Precision (up to 7 digits, exponent between -38 and +38)	!
Double Precision (up to 16 digits, exponent between -38 and +38)	#

Internally, BASIC handles all numbers in binary. Therefore, some 8 digit single precision and 17 digit double precision numbers may be handled correctly. If no type is explicitly declared, type is determined by the first letter of the variable name according to the type table. The table of types may be modified with the following statements.

```
DEFINT r        Integer
DEFSTR r        String
DEFSNG r        Single Precision
DEFDBL r        Double Precision
```

where r is a letter or range of letters to be designated. Examples:

```
15 DEFINT I-N   Variable names beginning with the letters I-N are to be of integer type.
2Ø DEFDBL D     Variable names beginning with D are to be of double precision type.
```

If no type definition statements are encountered, BASIC proceeds as if it had executed a DEFSNG A-Z statement.

3) Integer variables should be used wherever possible since they take the least amount of space in memory and integer arithmetic is much faster than single precision arithmetic.

Care must be exercised when single precision and double precision numbers are mixed. Since single precision numbers can have more significant digits than will be printed, a double precision variable set to a single precision value may not print the same as the single precision variable.

```
10 A=1.01                          single precision value
20 B#=A*10:C#=CDBL(A)*10#          convert to double precision
30 PRINTA;B#;C#;CDBL(A)            in various ways
RUN
 1.01   10.10000038146973   10.09999990463257   1.009999990463257
OK
```

In order to assure that double precision numbers will print the same as single precision, the VAL and STR$ functions should be used. For example:

```
10 A=1.01
20 B#=VAL(STR$(A)):C#=B#*10#
30 PRINT A;B#;C#
RUN
 1.01   1.01   10.1
OK
```

c. Array Variables. It is often advantageous to refer to several variables by the same name. In matrix calculations, for example, the computer handles each element of the matrix separately, but it is convenient for the programmer to refer to the whole matrix as a unit. For this purpose, Altair BASIC provides subscripted variables, or arrays. The form of an array variable is as follows:

VV(<subscript>[,<subscript>...])

where VV is a variable name and the subscripts are integer expressions. Subscripts may be enclosed in parentheses or square brackets. An array variable may have only one dimension in 4K, but in all other versions of Altair BASIC it may have as many dimensions as will fit on a single line. The smallest subscript is zero. Examples:

A(5)	The sixth element of array A. The first element is A(0).
ARRAY(I,2*J)	The address of this element in a two-dimensional array is determined by evaluating the expressions in parentheses at the time of the reference to the

array and truncating to integers. If I=3 and J=2.4, this refers to ARRAY(3,4).

The DIM statement allocates storage for array variables and sets all array elements to zero. The form of the DIM statement is as follows:

```
DIM VV(<subscript>[,<subscript>...])
```

where VV is a legal variable name. Subscript is an integer expression which specifies the largest possible subscript for that dimension. Each DIM statement may apply to more than one array variable. Some examples follow:

```
113 DIM A(3), D$(2,2,2)
114 DIM R2%(4), B(10)
115 DIM Q1(N), Z#(2+I)
```

Arrays may be dimensioned dynamically during program execution. At the time the DIM is executed, the expression within the parentheses is evaluated and the results truncated to integer.

If no DIM statement has been executed before an array variable is found in a program, BASIC assumes the variable to have a maximum subscript of 10 (11 elements) for each dimension in the reference. A BS or SUBSCRIPT OUT OF RANGE error message will be issued if an attempt is made to reference an array element which is outside the space allocated in its associated DIM statement. This can occur when the wrong number of dimensions is used in an array element reference. For example:

```
30 LET A(1,2,3)=X  when A has been dimensioned by
10 DIM A(2,2)
```

A DD or REDIMENSIONED ARRAY error occurs when a DIM statement for an array is found after that array has been dimensioned. This often occurs when a DIM statement appears after an array has been given its default dimension of 10.

d. Operators and Precedence. Altair BASIC provides a full range of arithmetic and (except in 4K) logical operators. The order of execution of operations in an expression is always according to their precedence as shown in the table below. The order can be specified explicitly by the use of parentheses in the normal algebraic fashion.

Table of Precedence

Operators are shown here in decreasing order of precedence. Operators listed in the same entry in the table have the same precedence and are executed in order from left to right in an expression.

1. Expressions enclosed in parentheses ()

2. ^ exponentiation (not in 4K). Any number to the zero power is 1. Zero to a negative power causes a /Ø or DIVISION BY ZERO error.

3. - negation, the unary minus operator

4. *,/ multiplication and division

5. \ integer division (available in Extended and Disk versions, see section 5-2)

6. MOD (available in Extended and Disk versions. See section 5-2)

7. +,- addition and subtraction

8. relational operators
   = equal
   <> not equal
   < less than
   > greater than
   <=,=< less than or equal to
   >=,=> greater than or equal to

(the logical operators below are not available in 4K)

9. NOT logical, bitwise negation

1Ø. AND logical, bitwise disjunction

11. OR logical, bitwise conjunction

(The logical operators below are available only in Extended and Disk versions.)

12. XOR logical, bitwise exclusive OR

13. EQV logical, bitwise equivalence

14. IMP logical, bitwise implication

In 4K Altair BASIC, relational operators may be used only once in an IF statement. In all other versions, relational

operators may be used in any expressions. Relational expressions have the value either of True (-1) or False (Ø).

e. Logical Operations. Logical operators may be used for bit manipulation and Boolean algebraic functions. The AND, OR, NOT, XOR, EQV and IMP operators convert their arguments into sixteen bit, signed, two's complement integers in the range -32768 to 32767. After the operations are performed, the result is returned in the same form and range. If the arguments are not in this range, an FC or ILLEGAL FUNCTION CALL error message will be printed and execution will be terminated. Truth tables for the logical operators appear below. The operations are performed bitwise, that is, corresponding bits of each argument are examined and the result computed one bit at a time. In binary operations, bit 7 is the most significant bit of a byte and bit Ø is the least significant.

AND

X	Y	X AND Y
1	1	1
1	Ø	Ø
Ø	1	Ø
Ø	Ø	Ø

OR

X	Y	X OR Y
1	1	1
1	Ø	1
Ø	1	1
Ø	Ø	Ø

NOT

X	NOT X
1	Ø
Ø	1

XOR

X	Y	X XOR Y
1	1	Ø
1	Ø	1
Ø	1	1
Ø	Ø	Ø

EQV

X	Y	X EQV Y
1	1	1
1	Ø	Ø
Ø	1	Ø
Ø	Ø	1

IMP

X	Y	X IMP Y
1	1	1
1	Ø	Ø
Ø	1	1
Ø	Ø	1

Some examples will serve to show how the logical operations work:

63 AND 16=16	63=binary 111111 and 16=binary 10000, so 63 AND 16=16
15 AND 14=14	15= binary 1111 and 14=binary 1110, so 15 AND 14=binary 1110=14.
-1 AND 8=8	-1=binary 1111111111111111 and 8=binary 1000, so -1 AND 8=8.
4 OR 2=6	4=binary 100 and 2=binary 10 so 4 OR 2=binary 110=6.
10 OR 10=10	binary 1010 OR'd with itself is 1010=10.
-1 OR -2=-1	-1=binary 1111111111111111 and -2=1111111111111110, so -1 OR -2=-1.
NOT 0=-1	the bit complement of sixteen zeros is sixteen ones, which is the two's complement representation of -1.
NOT X=-(X+1)	the two's complement of any number is the bit complement plus one.

A typical use of logical operations is 'masking', testing a binary number for some predetermined pattern of bits. Such numbers might come from the computer's input ports and would then reflect the condition of some external device. Further applications of logical operations will be considered in the discussion of the IF statement.

f. The LET statement. The LET statement is used to assign a value to a variable. The form is as follows:

```
LET <VV>=<expression>
```

where VV is a variable name and the expression is any valid Altair BASIC arithmetic or, except in 4K, logical or string expression. Examples:

```
1000 LET V=X
110 LET I=I+1      the '=' sign heremeans 'is replaced
                   by ....'
```

The word LET in a LET statement is optional, so algebraic equations such as:

```
120 V=.5*(X+2)
```

are legal assignment statements.

A SN or SYNTAX ERROR message is printed when BASIC detects incorrect form, illegal characters in a line, incorrect punctuation or missing parentheses. An OV or OVERFLOW error occurs when the result of a calculation is

too large to be represented by Altair BASIC's number formats. All numbers must be within the range 1E-38 to 1.70141E38 or -1E-38 to -1.70141E38. An attempt to divide by zero results in the /Ø or DIVISION BY ZERO error message.

For a discussion of strings, string variables and string operations, see section 4.

2-2. Branching, Loops and Subroutines.

a. Branching. In addition to the sequential execution of program lines, BASIC provides for changing the order of execution. This provision is called branching and is the basis of programmed decision making and loops. The statements in Altair BASIC which provide for branching are the GOTO, IF...THEN and ON...GOTO statements.

1) GOTO is an unconditional branch. Its form is as follows:

GOTO<mmmmm>

After the GOTO statement is executed, execution continues at line number mmmmm.

2) IF...THEN is a conditional branch. Its form is as follows:

IF<expression>THEN<mmmmm>

where the expression is a valid arithmetic, relational or, except in 4K, logical expression and mmmmm is a line number. If the expression is evaluated as non-zero, BASIC continues at line mmmmm. Otherwise, execution resumes at the next line after the IF...THEN statement.

An alternate form of the IF...THEN statement is as follows:

IF<expression>THEN<statement>

where the statement is any Altair BASIC statement.
Examples:

```
1Ø IF A=1Ø THEN 4Ø       If the expression A=1Ø is
    true, BASIC branches to line 4Ø.  Otherwise,
    execution proceeds at the next line.
15 IF A<B+C OR X THEN 1ØØ  The expression after IF is
    evaluated and if the value of the expression is
    non-zero, the statement branches to line 1ØØ.
```

Otherwise, execution continues on the next line.

```
20 IF X THEN 25
```
If X is not zero, the statement branches to line 25.

```
30 IF X=Y THEN PRINT X
```
If the expression X=Y is true (its value is non-zero), the PRINT statement is executed. Otherwise, the PRINT statement is not executed. In either case, execution continues with the line after the IF...THEN statement.

```
35 IF X=Y+3 GOTO 39
```
Equivalent to the corresponding IF...THEN statement, except that GOTO must be followed by a line number and not by another statement.

Extended and Disk versions of Altair BASIC provide an expanded IF...THEN statement of the form

```
IF<expression>THEN<YY>ELSE<ZZ>
```

where YY and ZZ are valid line numbers or Altair BASIC statements. Examples:

```
IF X>Y THEN PRINT "GREATER" ELSE PRINT "NOT GREATER"
```

If the expression X>Y is true, the statement after THEN is executed; otherwise, the statement after ELSE is executed.

```
IF X=2*Y THEN 5 ELSE PRINT "ERROR"
```

If the expression X=2*Y is true, BASIC branches to line 5; otherwise, the PRINT statement is executed. Extended and Disk Altair BASIC allow a comma before THEN.

IF statements may be nested in the Extended and Disk versions. Nesting is limited only by the length of the line. Thus, for example:

```
IF X>Y THEN PRINT "GREATER" ELSE IF Y>X
        THEN PRINT "LESS THAN" ELSE PRINT "EQUAL"
```

and

```
IF X=Y THEN IF Y>Z THEN PRINT "X>Z" ELSE PRINT "Y<=Z"
    ELSE PRINT "X<>Y"
```

are legal statements. If a line does not contain the same number of ELSE and THEN clauses, each ELSE is matched with the closest unmatched THEN. Example:

```
IF A=B THEN IF B=C THEN PRINT "A=C" ELSE PRINT "A<>C"
```

will not print "A<>C" when A<>B.

3) ON...GOTO (not in 4K) provides for another type of conditional branch. Its form is as follows:

ON<expression>GOTO<list of line numbers>

After the value of the expression is truncated to an integer, say I, the statement causes BASIC to branch to the line whose number is Ith in the list. The statement may be followed by as many line numbers as will fit on one line. If I=Ø or is greater than the number of lines in the list, execution will continue at the next line after the ON...GOTO statement. I must not be less than zero or greater than 255, or an FC or ILLEGAL FUNCTION CALL error will result.

b. Loops. It is often desirable to perform the same calculations on different data or repetitively on the same data. For this purpose, Altair BASIC provides the FOR and NEXT statements. The form of the FOR statement is as follows:

FOR<variable>=<X>TO<Y>[STEP <Z>]

where X,Y and Z are expressions. When the FOR statement is encountered for the first time, the expressions are evaluated. The variable is set to the value of X which is called the initial value. BASIC then executes the statements which follow the FOR statement in the usual manner. When a NEXT statement is encountered, the step Z is added to the variable which is then tested against the final value Y. If Z, the step, is positive and the variable is less than or equal to the final value, or if the step is negative and the variable is greater than or equal to the final value, then BASIC branches back to the statement immediately following the FOR statement. Otherwise, execution proceeds with the statement following the NEXT. If the step is not specified, it is assumed to be 1. Examples:

```
1Ø FOR I=2 TO 11          The loop is executed 1Ø times with
                          the variable I taking on each in-
                          tegral value from 2 to 11.
2Ø FOR V=1 TO 9.3         This loop will execute 9 times un-
                          til V is greater than 9.3
3Ø FOR V=1Ø*N TO 3.4/Z STEP SQR(R)   The initial, final
                          and step expressions need not be
                          integral, but they will be eval-
                          uated only once, before loop-
                          ing begins.
4Ø FOR V=9 TO 1 STEP -1   This loop will be executed 9
                          times.
```

FOR...NEXT loops may be nested. That is, BASIC will execute

a FOR...NEXT loop within the context of another loop. An example of two nested loops follows:

```
100 FOR I=1 TO 10
120 FOR J=1 TO I
130 PRINT A(I,J)
140 NEXT J
150 NEXT I
```

Line 130 will print 1 element of A for I=1, 2 for I=2 and so on. If loops are nested, they must have different loop variable names. The NEXT statement for the inside loop variable (J in the example) must appear before that for the outside variable (I). Any number of levels of nesting is allowed up to the limit of available memory.

The NEXT statement is of the form:

NEXT[<variable>[,<variable>...]]

where each variable is the loop variable of a FOR loop for which the NEXT statement is the end point. In the 4K version, the only form allowed is NEXT with one variable. In all other versions, NEXT without a variable will match the most recent FOR statement. In the case of nested loops which have the same end point, a single NEXT statement may be used for all of them, except in 4K. The first variable in the list must be that of the most recent loop, the second of the next most recent, and so on. If BASIC encounters a NEXT statement before its corresponding FOR statement has been executed, an NF or NEXT WITHOUT FOR error message is issued and execution is terminated.

c. Subroutines. If the same operation or series of operations are to be performed in several places in a program, storage space requirements and programming time will be minimized by the use of subroutines. A subroutine is a series of statements which are executed in the normal fashion upon being branched to by a GOSUB statement. Execution of the subroutine is terminated by the RETURN statement which branches back to the statement after the most recent GOSUB. The format of the GOSUB statement is as follows:

GOSUB<line number>

where the line number is that of the first line of the subroutine. A subroutine may be called from more than one place in a program, and a subroutine may contain a call to another subroutine. Such subroutine nesting is limited only by available memory.

Except in the 4K version, subroutines may be branched to conditionally by use of the ON...GOSUB statement, whose form is as follows:

ON <expression> GOSUB <list of line numbers>

The execution is the same as ON...GOTO except that the line numbers are those of the first lines of subroutines. Execution continues at the next statement after the ON...GOSUB upon return from one of the subroutines.

d. OUT OF MEMORY errors. While nesting in loops, subroutines and branching is not limited by BASIC, memory size limitations restrict the size and complexity of programs. The OM or OUT OF MEMORY error message is issued when a program requires more memory than is available. See Appendix C for an explanation of the amount of memory required to run programs.

2-3. Input/Output

a. INPUT. The INPUT statement causes data input to be requested from the terminal. The format of the INPUT statement is as follows:

INPUT<list of variables>

The effect of the INPUT statement is to cause the values typed on the terminal to be assigned to the variables in the list. When an INPUT statement is executed, a question mark (?) is printed on the terminal signalling a request for information. The operator types the required numbers or strings (or, in 4K, expressions) separated by commas and types a carriage return. If the data entered is invalid (strings were entered when numbers were requested, etc.) BASIC prints 'REDO FROM START?' and waits for the correct data to be entered. If more data was requested by the INPUT statement than was typed, ?? is printed on the terminal and execution awaits the needed data. If more data was typed than was requested, the warning 'EXTRA IGNORED' is printed and execution proceeds. After all the requested data is input, execution continues normally at the statement following the INPUT. Except in 4K, an optional prompt string may be added to an INPUT statement.

INPUT["<prompt string>";]<variable list>

Execution of the statement causes the prompt string to be printed before the question mark. Then all operations proceed as above. The prompt string must be enclosed in double quotation marks (") and must be separated from the

variable list by a semicolon (;). Example:

```
100 INPUT "WHAT'S THE VALUE";X,Y
```

causes the following output:

```
WHAT'S THE VALUE?
```

The requested values of X and Y are typed after the ? Except in 4K, a carriage return in response to an INPUT statement will cause execution to continue with the values of the variables in the variable list unchanged. In 4K, a SN error results.

b. PRINT. The PRINT statement causes the terminal to print data. The simplest PRINT statement is:

```
PRINT
```

which prints a carriage return. The effect is to skip a line. The more usual PRINT statement has the following form:

```
PRINT<list of expressions>
```

which causes the values of the expressions in the list to be printed. String literals may be printed if they are enclosed in double quotation marks (").

The position of printing is determined by the punctuation used to separate the entries in the list. Altair BASIC divides the printing line into zones of 14 spaces each. A comma causes printing of the value of the next expression to begin at the beginning of the next 14 column zone. A semicolon (;) causes the next printing to begin immediately after the last value printed. If a comma or semicolon terminates the list of expressions, the next PRINT statement begins printing on the same line according to the conditions above. Otherwise, a carriage return is printed.

c. DATA, READ, RESTORE

1) the DATA statement. Numerical or string data needed in a program may be written into the program statements themselves, input from peripheral devices or read from DATA statements. The format of the DATA statement is as follows:

```
DATA<list>
```

where the entries in the list are numerical or string constants separated by commas. In 4K, expressions may also

appear in the list. The effect of the statement is to store the list of values in memory in coded form for access by the READ statement. Examples:

```
10 DATA 1,2,-1E3,.04
20 DATA " LOO", MITS
```

Leading and trailing spaces in string values are suppressed unless the string is enclosed by double quotation marks.

2) The READ statement. The data stored by DATA statements is accessed by READ statements which have the following form:

READ<list of variables>

where the entries in the list are variable names separated by commas. The effect of the READ statement is to assign the values in the DATA lists to the corresponding variables in the READ statement list. This is done one by one from left to right until the READ list is exhausted. If there are more names in the READ list than values in the DATA lists, an OD or OUT OF DATA error message is issued. If there are more values stored in DATA statements than are read by a READ statement, the next READ statement to be executed will begin with the next unread DATA list entry. A single READ statement may access more than one DATA statement, and more than one READ statement may access the data in a single DATA statement.

An SN or SYNTAX ERROR message can result from an improperly formatted DATA list. In 4K Altair BASIC, such an error message will refer to the READ statement which attempted to access the incorrect data. In other versions, the line number in the error message will refer to the actual line of the DATA statement in which the error occurred.

3) RESTORE statement. After the RESTORE statement is executed, the next piece of data accessed by a READ statement will be the first entry of the first DATA list in the program. This allows re-READing the data.

d. CSAVEing and CLOADing Arrays (8K cassette, Extended and Disk versions only). Numeric arrays may be saved on cassette or loaded from cassette using CSAVE* and CLOAD* The formats of the statements are:

CSAVE*<array name>

and

CLOAD*<array name>

The array is written out in binary with four octal 210 header bytes to indicate the start of data. These bytes are searched for when CLOADing the array. The number of bytes written is four plus:

8*<number of elements> for a double precision array
4*<number of elements> for a single precision array
2*<number of elements> for an integer array

When an array is written out or read in, the elements of the array are written out with the leftmost subscript varying most quickly, the next leftmost second, etc:

```
    DIM A(10)
CSAVE*A
```

writes out A(0),A(1),...A(10)

```
    DIM A(10,10)
CSAVE*A
```

writes out A(0,0), A(1,0)...A(10,0),A(10,1)...A(10,10)

Using this fact, it is possible to write out an array as a two dimensional array and read it back in as a single dimensional array, etc.

NOTE

Writing out a double precision array and reading it back in as a single precision or integer array is not recommended. Useless values will undoubtedly be returned.

e. Miscellaneous Input/Output

1) WAIT (not in 4K). The status of input ports can be monitored by the WAIT command which has the following format:

WAIT<I,J>[,<K>]

where I is the number of the port being monitored and J and K are integer expressions. The port status is exclusive ORd with K and the result is ANDed with J. Execution is

suspended until a non-zero value results. J picks the bits of port I to be tested and execution is suspended until those bits differ from the corresponding bits of K. Execution resumes at the next statement after the WAIT. If K is omitted, it is assumed to be zero. I, J and K must be in the range Ø to 255. Examples:

WAIT 2Ø,6	Execution stops until either bit 1 or bit 2 of port 2Ø are equal to 1. (Bit Ø is least significant bit, 7 is the most significant.) Execution resumes at the next statement.
WAIT 1Ø,255,7	Execution stops until any of the most significant 5 bits of port 1Ø are one or any of the least significant 3 bits are zero. Execution resumes at the next statement.

2) POKE, PEEK (not in 4K). Data may be entered into memory in binary form with the POKE statement whose format is as follows:

POKE <I,J>

where I and J are integer expressions. POKE stores the byte J into the location specified by the value of I. In 8K, I must be less than 32768. In Extended and Disk versions, I may be in the range Ø to 65536. J must be in the range Ø to 255. In 8K, data may be POKEd into memory above location 32768 by making I a negative number. In that case, I is computed by subtracting 65536 from the desired address. To POKE data into location 45ØØØ, for example, I is 45ØØØ-65536=-2Ø536. Care must be taken not to POKE data into the storage area occupied by Altair BASIC or the system may be POKEd to death, and BASIC will have to be loaded again.

The complementary function to POKE is PEEK. The format for a PEEK call is as follows:

PEEK(<I>)

where I is an integer expression specifying the address from which a byte is read. I is chosen in the same way as in the POKE statement. The value returned is an integer between Ø and 255. A major use of PEEK and POKE is to pass arguments and results to and from machine language subroutines.

3)OUT, INP (not in 4K). The format of the OUT statement is as follows:

```
OUT <I,J>
```

where I and J are integer expressions. OUT sends the byte signified by J to output port I. I and J must be in the range Ø to 255.

The INP function is called as follows:

```
INP(<I>)
```

INP reads a byte from port I where I is an integer expression in the range Ø to 255. Example:

```
2Ø IF INP(J)=16 THEN PRINT "ON"
```

3. FUNCTIONS

Altair BASIC allows functions to be referenced in mathematical function notation. The format of a function call is as follows:

```
<name>(<argument>[,<argument>...])
```

where the name is that of a previously defined function and the arguments are one or more expressions, separated by commas. Only one argument is allowed in 4K and 8K. Function calls may be components of expressions, so statements like

```
1Ø LET T=(F*SIN(T))/P  and
2Ø C=SQR(A^2+B^2+2*A*B*COS(T))
```

are legal.

3-1. Intrinsic Functions

Altair BASIC provides several frequently used functions which may be called from any program without further definition. A procedure is provided, however, whereby unneeded functions may be deleted to save memory space. See Appendix B. For a list of intrinsic functions, see section 6-3.

3-2. User-Defined Functions (not in 4K).

a. The DEF statement. The programmer may define functions which are not included in the list of intrinsic functions by means of the DEF statement. The form of the DEF statement is as follows:

DEF<function name>(<variable list>)=<expression>

where the function name must be FN followed by a legal variable name and the entries in the variable list are 'dummy' variable names. The dummy variables represent the argument variables or values in the function call. In 8K Altair BASIC, only one argument is allowed for a user-defined function, but in the Extended and Disk versions, any number of arguments is allowed. Any expression may appear on the right side of the equation, but it must be limited to one line. User-defined functions may be of any type in Extended and Disk versions, but user-defined string functions are not allowed in 8K If a type is specified for the function, the value of the expression is forced to that type before it is returned to the calling statement. Examples:

```
10 DEF FNAVE(V,W)=(V+W)/2
11 DEF FNCON$(V$,W$)=RIGHT$(V$+W$,5)  Returns the right
                        most 5 characters of the concat-
                        enation of V$ and W$.
12 DEF FNRAD(DEG)=3.14159/180*DEG  When called with the
                        measure of an angle in degrees,
                        returns the radian equivalent.
```

A function may be redefined by executing another DEF statement with the same name. A DEF statement must be executed before the function it defines may be called.

b. USR. The USR function allows calls to assembly language subroutines. See appendix E.

3-3. Errors.

An FC or ILLEGAL FUNCTION CALL error results when an improper call is made to a function. Some places this might occur are the following:

1. a negative array subscript. LET A(-1)=0, for example.
2. an array subscript that is too large (>32767)
3. negative or zero argument for LOG

4. Negative argument for SQR

5. A^B with A negative and B not an integer

6. a call to USR with no address patched for the machine language subroutine.

7. improper arguments to MID$, LEFT$,RIGHT$, INP, OUT, WAIT, PEEK, POKE, TAB, SPC, INSTR, STRING$, SPACE$ or ON...GOTO.

b. An attempt to call a user-defined function which has not previously appeared in a DEF statement will cause a UF or UNDEFINED USER FUNCTION error.

c. A TM or TYPE MISMATCH error will occur if a function which expects a string argument is given a numeric value or vice-versa.

4. STRINGS

In all Altair BASIC versions except 4K, expressions may either have numeric value or may be strings of characters. Altair BASIC provides a complete complement of statements and functions for manipulating string data. Many of the statements have already been discussed so only their particular application to strings will be treated in this section.

4-1. String Data.

A string is a list of alphanumeric characters which may be from Ø to 255 characters in length. Strings may be stated explicitly as constants or referred to symbolically by variables. String constants are delimited by quotation marks at the beginning and end. A string variable name ends with a dollar sign ($). Examples:

A$="ABCD"	Sets the variable A$ to the four character string "ABCD"
B9$="14A/56"	Sets the variable B9$ to the six character string "14A/56"
FOOFOO$="E$"	Sets the variable FOOFOO$ to the two character string "E$"

Strings input to an INPUT statement need not be surrounded

by quotation marks.

String arrays may be dimensioned exactly as any other kind of array by use of the DIM statement. Each element of a string array is a string which may be up to 255 characters long. The total number of string characters in use at any point in the execution of a program must not exceed the total allocation of string space or an OS or OUT OF STRING SPACE error will result. String space is allocated by the CLEAR command which is explained in section 6-2.

4-2. String operations.

a. Comparison Operators. The comparison operators for strings are the same as those for numbers:

= equal
<> not equal
< less than
> greater than
=<,<= less than or equal to
=>,>= greater than or equal to

Comparison is made character by character on the basis of ASCII codes until a difference is found. If, while comparison is proceeding, the end of one string is reached, the shorter string is considered to be smaller. ASCII codes may be found in Appendix B. Examples:

```
A<Z      ASCII A is Ø65, Z is Ø9Ø
1<A      ASCII 1 is Ø49
" A">"A"  Leading and trailing blanks are significant
            in string literals.
```

b. String Expressions. String expressions are composed of string literals, string variables and string function calls connected by the + or concatenation operator. The effect of the catenation operator is to add the string on the right side of the operator to the end of the string on the left. If the result of concatenation is a string more than 255 characters long, an LS or STRING TOO LONG error message will be issued and execution will be terminated.

c. Input/Output. The same statements used for input and output of normal numeric data may be used for string data, as well.

1) INPUT, PRINT. The INPUT and PRINT statements read and write strings on the terminal. Strings need not be enclosed in quotation marks, but if they are not, leading blanks will be ignored and the string will be terminated when the first comma or colon is encountered. Examples:

```
10 INPUT ZOO$,FOO$          Reads two strings
20 INPUT X$                 Reads one string and assigns
                            it to the variable X$.
30 PRINT X$,"HI, THERE"     Prints two strings, including
                            all spaces and punctuation
                            in the second.
```

2) DATA, READ. DATA and READ statements for string data are the same as for numeric data. For format conventions, see the explanation of INPUT and PRINT above.

4-3. String Functions.

The format for intrinsic string function calls is the same as that for numeric functions. For the list of string functions, see section 6-3. Special user-defined string functions are allowed in Extended and Disk versions and may be defined by the use of the DEF statement (see section 3-2). String function names must end with a dollar sign.

5. EXTENDED VERSIONS.

The Extended and Disk versions of Altair BASIC provide several statements, operators, functions and commands which are not available either in the 4K or 8K versions. For clarity, these features are grouped together in this section. Some modifications to existing 4K and 8K features, such as the IF...THEN...ELSE statement and number typing facilities, have been discussed in conjunction with the other versions. Check the index for references to those features.

5-1. Extended Statements

a. ERASE. The ERASE statement eliminates arrays from a program and allows their space in memory to be used for other purposes. The format of the ERASE statement is as follows:

ERASE<array variable list>

where the entries in the list are valid array variable names separated by commas. ERASE will only operate on arrays and not array elements. If a name appears in the list which is not used in the program, an ILLEGAL FUNCTION CALL error will occur. The arrays deleted in an ERASE statement may be dimensioned again, but the old values are lost. Example:

```
10 DIM A(5,5)      etc.
    .
    .
    .
60 ERASE A
70 DIM A(100)
```

b. LINE INPUT. It is often desirable to input a whole line to a string variable without use of quotation marks and other delimiters. LINE INPUT provides this facility. The format of the LINE INPUT statement is as follows:

LINE INPUT ["<prompt string>",];<string variable name>

The prompt string is a string literal that is printed on the terminal before input is accepted. A question mark is not printed unless it is contained in the prompt string. All input from the end of the prompt string to the carriage return is assigned to the string variable. A LINE INPUT may be escaped by typing Control/C. At that point, BASIC returns to command level and prints OK. Execution may be resumed at the LINE INPUT by typing CONT. LINE INPUT destroys the input buffer, so the command may not be edited by Control/A for re-execution.

c. SWAP. The SWAP statement allows the values of two variables to be exchanged. The format is as follows:

SWAP <variable,variable>

The value of the second variable is assigned to the first variable and vice-versa. Either or both of the variables may be elements of arrays. If one or both of the variables are non-array variables which have not had values assigned to them, an ILLEGAL FUNCTION CALL error will result. Both variables must be of the same type or a TYPE MISMATCH error will result. Example:

```
10 INPUT F$,L$
20 SWAP F$,L$
30 PRINT F$,L$
RUN
```

```
?FIRST,LAST              Data input
LAST          FIRST      Computer prints
```

d. TRON, TROFF. As a debugging aid, two statements are provided to trace the execution of program instructions. When the trace flag is turned on by the TRON statement, the number of each line in the program is printed as it is executed. The numbers appear enclosed in square brackets ([]). The function is disabled by execution of the TROFF statement. Example:

```
TRON                    executed in direct mode
OK                      printed by computer
10 PRINT 1:PRINT "A"    typed by programmer
20 STOP
RUN
[10] 1                  line numbers and output printed by
A                       computer.
[20]
BREAK IN 20
```

The NEW command will also turn off the trace flag.

e. IF...THEN...ELSE. See section 2-2.

f. DEFINT, DEFSNG, DEFDBL, DEFSTR. See section 2-1

g. CONSOLE, WIDTH. CONSOLE allows the console terminal to be switched from one I/O port to another. The format of the statement is:

CONSOLE <I/O port number>,<switch register setting>

The <I/O port number> is the hardware port number of the low order (status) port of the new I/O board. This value must be a numeric expression between 0 and 255 inclusive. If it is not in this range, an ILLEGAL FUNCTION CALL error will occur. The <switch register setting> is also a value between 0 and 255 inclusive which specifies the type of I/O port (SIO, PIO, 4PIO etc) being selected. Appropriate values of the <switch register setting> may be found in Appendix B in the table of sense switch settings or in the table below.

Table of values for <switch register setting>:

I/O Board	Sense Switch Setting
2SIO with 2 stop bits	0
2SIO with 1 stop bit	1
SIO	2
ACR	3
4PIO	4
PIO	5
HSR	6
non-standard terminal	14
no terminal	15

WIDTH Statement

The WIDTH statement sets the width in characters of the printing terminal line. The format of the WIDTH statement is as follows:

```
WIDTH <integer expression>
```

Example:

```
WIDTH 80
WIDTH 32
```

The <numeric formula> must have a value between 15 and 255 inclusive, or an ILLEGAL FUNCTION CALL error will occur.

h. Error Trapping. Extended and Disk Altair BASIC make it possible for the user to write error detection and handling routines which can attempt to recover from errors or provide more complete explanation of the cause of errors than the simple error messages. This facility has been added to Altair BASIC through the use of the ON ERROR GOTO, RESUME and ERROR statements and with the ERR and ERL variables.

1) Enabling Error Trapping. The ON ERROR GOTO statement specifies the line of the Altair BASIC program on which the error handling subroutine starts. The format is as follows:

```
ON ERROR GOTO <line number>
```

The ON ERROR GOTO statement should be executed before the user expects any errors to occur. Once an ON ERROR GOTO statement has been executed, all errors detected will cause BASIC to start execution of the specified error handling routine. If the <line number> specified in the ON ERROR GOTO statement does not exist, an UNDEFINED LINE error will occur.

Example:

```
10 ON ERROR GOTO 1000
```

2) Disabling the Error Routine. ON ERROR GOTO 0 disables trapping of errors so any subsequent error will cause BASIC to print an error message and stop program execution. If an ON ERROR GOTO 0 statement appears in an error trapping subroutine, it will cause BASIC to stop and print the error message which caused the trap. It is recommended that all error trapping subroutines execute an ON ERROR GOTO 0 subroutine if an error is encountered for which they have no recovery action.

NOTE

If an error occurs during the execution of an error trap routine, the system error message will be printed and execution will be terminated. Error trapping does not trap errors within the error trap routine.

3) The ERR and ERL Variables. When the error handling subroutine is entered, the variable ERR contains the error code for the error. The error codes and their meanings are listed below. See section 6-5 for a detailed discussion of each of the errors and error messages.

Code	Error
1	NEXT WITHOUT FOR
2	SYNTAX ERROR
3	RETURN WITHOUT GOSUB
4	OUT OF DATA
5	ILLEGAL FUNCTION CALL
6	OVERFLOW
7	OUT OF MEMORY
8	UNDEFINED LINE
9	SUBSCRIPT OUT OF RANGE

```
10    REDIMENSIONED ARRAY
11    DIVISION BY ZERO
12    ILLEGAL DIRECT
13    TYPE MISMATCH
14    OUT OF STRING SPACE
15    STRING TOO LONG
16    STRING FORMULA TOO COMPLEX
17    CAN'T CONTINUE
18    UNDEFINED USER FUNCTION
19    NO RESUME
20    MISSING OPERAND
21    RESUME WITHOUT ERROR
22    UNPRINTABLE ERROR
23    LINE BUFFER OVERFLOW
```

Disk Errors

```
50    FIELD OVERFLOW
51    INTERNAL ERROR
52    BAD FILE NUMBER
53    FILE NOT FOUND
54    BAD FILE MODE
55    FILE ALREADY OPEN
56    DISK NOT MOUNTED
57    DISK I/O ERROR
58    FILE ALREADY EXISTS
59    SET TO NON-DISK STRING
60    DISK ALREADY MOUNTED
61    DISK FULL
62    INPUT PAST END
63    BAD RECORD NUMBER
64    BAD FILE NAME
65    MODE-MISMATCH
66    DIRECT STATEMENT IN FILE
67    TOO MANY FILES
68    OUT OF RANDOM BLOCKS
```

The ERL variable contains the line number of the line where the error was detected. For instance, if the error occured in line 1000, ERL will be equal to 1000. If the statement which caused the error was a direct mode statement, ERL will be equal to 65535 decimal. To test if an error occurred in a direct statement, use

```
IF 65535=ERL THEN ...
```

In all other cases, use

```
IF ERL=<line number> THEN...
```

If the line number is on the left of the equation, it cannot be renumbered by RENUM (see section 1-1a).

4) Disk Error Values - The ERR function. The ERR function returns the parameters of a DISK I/O ERROR. ERR(Ø) returns the number of the disk, ERR(1) returns the track number (Ø-76) and ERR(2) returns the sector number (Ø-31). ERR(3) and ERR(4) contain the low and high order bytes, respectively, of the cumulative error count since BASIC was loaded.

NOTE

Neither ERL nor ERR may appear to the left of the = sign in a LET or assignment statement.

5) The RESUME statement. The RESUME statement is used to continue execution of the BASIC program after the error recovery procedure has been performed. The user has three options. The user may RESUME execution at the statement that caused the error, at the statement after the one that caused the error or at some other line. To RESUME execution at the statement which caused the error, the user should use:

```
RESUME
```

or

```
RESUME Ø
```

To RESUME execution at the statement immediately after the one which caused the error, the user should use:

```
RESUME NEXT
```

To RESUME execution at a line dfferent than the one where the error occurred, use:

```
RESUME <line number>
```

Where <line number> is not equal to zero.

6) Error Routine Example. The following example shows how a simple error trapping subroutine operates.

```
100 ON ERROR GOTO 500
200 INPUT "WHAT ARE THE NUMBERS TO DIVIDE";X,Y
210 Z=X/Y
220 PRINT "QUOTIENT IS";Z
230 GOTO 200
500 IF ERR=11 AND ERL=210 THEN 520
510 ON ERROR GOTO 0
520 PRINT "YOU CANT HAVE A DIVISOR OF ZERO!"
530 RESUME 200
```

7) The ERROR statement. In order to force branching to an error trapping routine, an ERROR statement has been provided. The primary use of the ERROR statement is to allow the user to define his own error codes which can then conveniently be handled by a centralized error trap routine as described above. The format of the ERROR statement is:

ERROR <integer expression>

When defining error codes, values should be picked which are greater than the ones used by Altair BASIC. Since more error messages may be added to Altair BASIC, user-defined error codes should be assigned the highest possible numbers to assure future compatibility. If the <numeric expression> used in an ERROR statement is less than zero or greater than 255 decimal, an ILLEGAL FUNCTION CALL error will occur. Of course, the ERROR statement may also be used to force SYNTAX or other standard Altair BASIC errors. Use of an ERROR statement to force printout of an error message for which no error text is defined will cause an UNPRINTABLE ERROR message to be printed out.

5-2. Extended Operators.

Two operators are provided that are exclusive to the Extended and Disk versions.

a. Integer Division. Integer division, denoted by \ (backslash), forces its arguments to integer form and truncates the quotient to an integer. More precisely:

A\B= FIX(INT(A)/INT(B))

Its precedence is just after multiplication and floating point divison. Integer division is approximately eight times as fast as standard floating point division.

b. Modulus Arithmetic - the MOD operator. A MOD B gives the 'remainder' as A is divided by B. More precisely:

```
A MOD B=INT(A)-(INT(B)*(A\B))
```

If B=Ø, a DIVISION BY ZERO error occurs. The precedence of MOD is just below that of integer division.

5-3. Extended Functions

a. Intrinsic Functions. Extended and Disk Altair BASIC provide several intrinsic functions which are not available in the other versions. For a list of these functions and a description of their use, see section 6-3.

b. The DEFUSR statement. Up to ten assembly language subroutines may be defined by means of the DEFUSR statement whose form is as follows:

```
DEFUSR[<digit Ø through 9>]=<integer expression>
```

Example:

```
DEFUSR1=&100000
DEFUSR2=31096
DEFUSR9=ADR
```

The of the <integer expression> is the starting address of the USR routine specified. When the USR subroutine is entered, the A register contains the type of the argument which was given to the USR function. This is also the length of the descriptor for that argument type:

Value in A	Meaning
2	Two byte signed two's complement integer.
3	String.
4	Single precision four byte floating point number.
8	Double precision floating point number.

When the USR subroutine is entered, the [H,L] register pair contains a pointer to the floating point accumulator (FAC). The [H,L] registers contain the address of FAC-3.
If the value in the FAC is a single precision floating point number, it is stored as follows:

FAC-3: Lowest 8 bits of mantissa.
FAC-2: Middle 8 bits of mantissa.
FAC-1: Highest 7 bits of mantissa with hidden (implied) leading one. Bit 7 is the sign of the number (Ø positive, 1 negative).

FAC: Exponent excess 200 octal. If the contents of FAC is 200, the exponent is 0. If contents of FAC is 0,the number is zero.

If the argument is double precision floating point, the FAC-7 to FAC-4 contain four more bytes of mantissa, low order byte in FAC-7, etc. If the argument is an integer, FAC-3 contains the low order byte and FAC-2 contains the high order byte of the signed two's complement value. If the argument is a string, [D,E] points to a string descriptor of the argument, whose form is:

Byte	Use
0	Length of string 0-255 decimal.
1-2	Sixteen bit address pointer to first byte of strings text in memory (Caution - may point into program text if argument is a string literal).

Normally, the value returned by a USR function will be the same type (integer, string, single or double precision floating point) as the argument which was passed to it. However, calling the MAKINT routine whose address is stored in location 6 will return the integer in [H,L] as the value of the function, forcing the value returned by the function to be integer. Execute the following sequence to return from the function:

```
        PUSH    H               ;SAVE VALUE TO BE RETURNED
        LHLD    6             ;GET ADDRESS OF MAKINT ROUTINE
        XTHL                    ;SAVE RETURN ON STACK &
                                  ;GET BACK [H,L]
        RET                     ;RETURN
```

The argument of the function may be forced to an integer, no matter what its type by calling the FRCINT routine whose address is located in location 4 to get the integer value of the argument in [H,L]:

```
        LXI     H,SUB1          ;GET ADDRESS OF SUBROUTINE
                                ;CONTINUATION
        PUSH    H               ;PLACE ON STACK
        LHLD    4               ;GET ADDRESS OF FRCINT
        PCHL                    ;CALL FRCINT

SUB1: .....
```

5-4. The EDIT Command.

The EDIT command allows modifications and additions to be made to existing program lines without having to retype the entire line each time. Commands typed in the EDIT mode are, as a rule, not echoed. That is, they usually do not appear on the terminal screen or printout as they are typed. Most commands may be preceded by an optional numeric repetition factor which may be used to repeat the command a number of times. This repetition factor should be in the range Ø to 255 (Ø is equivalent to 1). If the repetition factor is omitted, it is assumed to be 1. In the following examples, a lower case "n" before the command stands for the repetition factor. In the following description of the EDIT commands, the "cursor" refers to a pointer which is positioned at a character in the line being edited.

To EDIT a line, type EDIT followed by the number of the line and hit the carriage return. The line number of the line being EDITed will be printed followed by a space. The cursor will now be positioned to the left of the first character in the line.

NOTE

The best way of getting the "feel" of the EDIT command is to try EDITing a few lines yourself.

If a command not recognized as an EDIT command is entered, the computer prints a bell (control/G) and the command is ignored.

In the following examples, the lines labelled "computer prints" show the appearance of the line after each command.

a. Moving the Cursor. Typing a space moves the cursor to the right and causes the character passed over to be printed. A number preceding the space (n<space>) will cause the cursor to pass over and print out n characters. Typing a Rubout causes the immediately previous character to be printed effectively backspacing the cursor.

b. Inserting Characters

WARNINGS:

Character insertion is stopped by typing Escape (or Altmode on some terminals). Control/C will not interrupt the EDIT command while it is in Insert mode, but will be inserted into the edited line. Therefore, Control/C should not be used in the EDIT command.

It is possible using EDIT to create a line which, when listed with its line number, is longer than 72 characters. Punched paper tapes containing such lines will not read properly. However, such lines may be CSAVEd and CLOADed without error.

I Inserts new characters into the line being edited. Each character typed after the I is inserted at the current cursor position and printed on the terminal. Typing Escape (or Altmode on some terminals) stops character insertion. If an attempt is made to insert a character that will make the line longer than 255 characters, a Control/G (bell) is sent to the terminal and the character is not printed.

A backarrow (or Rubout) typed during an insert command (or-) will delete the character to the left of the cursor. Characters up to the beginning of the line may be deleted in this manner, and a backarrow will be echoed for each character deleted. However, if there are no characters to the left of the cursor, a bell is echoed instead of a backarrow. If a carriage return is typed during an insert command, it is as if an escape and then carriage return were typed. That is, all characters to the right of the cursor will be printed and the EDITed line will replace the original line.

X X is similar to I, except that all characters to the right of the cursor are printed, and the cursor moves to the end of the line. At this point, it will automatically enter the insert mode (see I command). X is most useful when new statements are to be added to the end of an existing line. For example:

```
User types          EDIT 50 (carriage return)
Computer prints     50
User types             X
Computer prints     50 X=X+1
User types                    :Y=Y+1(CR)
Computer prints     50 X=X+1:Y=Y+1
```

In the above example, the original line #50 was:

```
50      X=X+1
```

The new line #50 now reads:

```
50  X=X+1:Y=Y+1
```

H — H is the same as X, except that all characters to the right of the cursor are deleted (they will not be printed). The insert mode (see I command) will then automatically be entered. H is most useful when the last statements on a line are to be replaced with new ones.

c. Deleting Characters

D — nD deletes n characters to the right of the cursor. If n is ommitted, it defaults to 1. If there are less than n characters to the right of the cursor, characters will be deleted only to the end of the line. The cursor is positioned to the right of the last character deleted. The characters deleted are enclosed in backslashes (\). For example:

```
User types        20 X=X+1:REM JUST INCREMENT X
User types        EDIT 20 (carriage return)
Computer prints   20
User types           6D (carriage return)
Computer prints   20 \X=X+1:\REM JUST INCREMENT X
```

The new line #20 will no longer contain the characters which are enclosed by the backslashes.

d. Searching.

S — The nSy command searches for the nth occurrence of the character y in the line. N defaults to 1. The search skips over the first character to the right of the cursor and begins with the second character to the right of the cursor. All characters passed over during the search are printed. If the character is not found, the cursor will be at the end of the line. If it is found, the cursor will stop to the right of the character and all of the characters to its left will have been printed. For example

```
User types  :        50 REM INCREMENT X
User types  :        EDIT 50
```

```
Computer prints          50
User types  :              2SE
Computer prints          50 REM INCR
```

K nKy is equivalent to S except that all of the characters passed over during the search are deleted. The deleted characters are enclosed in backslashes. For example:

```
User types               10 TEST LINE
User types               EDIT 10
Computer prints          10
User types                  KL
Computer prints          10 \TEST \
```

e. Text Replacement.

C A character in a line may be changed by the use of the command Cy which changes the character to the right of the cursor to the character y. Y is printed on the terminal and the cursor is advanced one position. nCy may be used to change n characters in a line as they are typed in from the terminal. (See example below.) If an attempt is made to change a character which does not exist, the change mode will be exited. Example:

```
User types               10 FOR I=1 TO 100
User types               EDIT 10
Computer prints          10
User types                  2S1
Computer prints          10 FOR I=1 TO
User types                          3C256
Computer prints          10 FOR I=1 TO 256
```

f. Ending and Restarting

Carriage Return Terminates editing and prints the remainder of the line. The edited line replaces the original line.

E E is the same as a carriage return, except the remainder of the line is not printed.

Q Q restores the original line and causes BASIC to return to command level. Changes do not take effect until an E or carriage return is typed, so Q allows the user to restore the original line without any changes which may have been made.

L L causes the remainder of the line to be printed, and then prints the line number and restarts editing at

the beginning of the line. The cursor will be positioned to the left of the first character in the line. L allows monitoring the effect of changes on a line. Example:

```
User types          50 REM INCREMENT X
User types          EDIT 50
Computer prints     50
User types             2SM
Computer prints     50 REM INCRE
User types                    L
Computer prints     50 REM INCREMENT X
                    50
```

A A causes the original line to be restored and editing to be restarted at the beginning of the line. For example:

```
User types          10 TEST LINE
User types          EDIT 10
Computer prints     10
User types             10D
Computer prints     10 \TEST LINE\
User types                       A
Computer prints     10 \TEST LINE\
                    10
```

In the above example, the user made a mistake when he deleted TEST LINE. Suppose that he wants to type "1D" instead of 10D. As a result of the A command, the original line 10 is reentered and is ready for further editing.

IMPORTANT

Whenever a SYNTAX ERROR is discovered during the execution of a source program , BASIC will automatically begin EDITing the line that caused the error as if an EDIT command had been typed. Example:

```
10 APPLE
RUN
SYNTAX ERROR IN 10
10
```

Complete editing of a line causes the line edited to be reinserted. Reinserting a line causes all variable values to be deleted. To preserve those values for examination, the EDIT command mode may be exited with the Q command after the line number is printed. If this is done, BASIC will return to command level and all variable values will be preserved.

The features of the EDIT command may be used on the line currently being typed. To do this, type Control/A instead of Carriage Return. The computer will respond with a carriage return, an exclamation point (!) and a space. The cursor will be positioned at the first character of the line. At this point, any of the EDIT subcommands except Control/A may be used to correct the line. Example:

```
User types          10 IF X GOTO #"/A
Computer prints     !
User types            S#            2C12
Computer prints     ! 10 IF X GOTO 12
```

The current line number may be designated by a period (.) in any command requiring a line number. Examples:

```
User types          10 FOR I= 1 TO 10
User types          EDIT .
Computer prints     10
```

5-5. PRINT USING statement.

The PRINT USING statement can be employed in situations where a specific output format is desired. This situation might be encountered in such applications as printing payroll checks or accounting reports. The general format for the PRINT USING statement is as follows:

PRINT USING <string>;<value list>

The <string> may be a string variable , string expression or a string constant which is a precise copy of the line to be printed. All of the characters in the string will be printed just as they appear, with the exception of the formatting characters. The <value list> is a list of the items to be printed. The string will be repeatedly scanned until: 1) the string ends and there are no values in the value list or, 2) a field is scanned in the string, but the value list is exhausted. The string is constructed according to the following rules:

a. String Fields.

! specifies a single character string field.
(The string itself is specified in the value list.)
\n spaces\ Specifies a string field consisting of 2+n characters. Backslashes with no spaces between them

would indicate a field of 2 characters width, one space between them would indicate a field 3 characters wide, etc.

In both cases above, if the string has more characters than the field width, the extra characters will be ignored. If the string has fewer characters than the field width, extra spaces will be printed to fill out the entire field. Trying to print a number in a string field will cause a TYPE MISMATCH error to occur. Example:

```
10 A$="ABCDE":B$="FGH"
20 PRINT USING "!";A$;B$
30 PRINT USING "\  \";B$;A$

(the above would print out)

AF
FGH ABCD
```

Note that where the "!" was used only the first letter of each string was printed. Where the backslashes enclosed two spaces, four letters from each string were printed (an extra space was printed for B$ which has only three characters). The extra characters in the first case and for A$ in the second case were ignored.

b. Numeric Fields. With the PRINT USING statement, numeric printouts may be altered to suit almost any application. Strings for formatting numeric fields are constructed from the following characters:

#	Numeric fields are specified by the # sign, each of which will represent a digit position. These digit positions are always filled. The numeric field will be right justified; that is, if the number printed is too small to fill all of the digit positions specified, leading spaces will be printed as necessary to fill the entire field.
.	The decimal point may be specified in any position in the field. Rounding is performed as necessary. If the field format specifies that a digit is to precede the decimal point, the digit will always be printed (as 0 if necessary).

The following program will help illustrate these rules:

```
10 INPUT A$,A
20 PRINT USING A$;A
30 GOTO 10
RUN
? ##,12
 12
? ###,12
  12
? #####,12
    12
?##.##,12
 12.00
? ###.,12
  12.
? #.###,.02
 0.020
?##.#,2.36
  2.4
?###,-12
  -12
?#.##,-.12
 -.12
?####,-12
  -12
```

\+ The + sign may be used at either the beginning or end of the numeric field. If the number is positive, the + sign will be printed at the specified end of the number. If the number is negative, a - sign will be printed at the specified end of the number.

\- The - sign, when used to the right of the numeric field designation, will force the minus sign to be printed to the right of the number if it is negative. If the number is positive, a space is printed.

** The ** placed at the beginning of a numeric field designation will cause any unused spaces in the leading portion of the number printed out to be filled with asterisks. The ** also specifies positions for 2 more digits. (Termed "asterisk fill")

$$ When the $$ is used at the beginning of a numeric field designation, a $ sign will be printed in the space immediately preceding the number printed. Note that $$ also specifies positions for two more digits, but that the $ itself takes up one of these spaces. Exponential format cannot be used with leading $ signs, nor can negative numbers be output

unless the sign is forced to be trailing.

$ The **$ used at the beginning of a numeric field designation causes both of the above (and $$) to be performed on the number being printed out. All of the previous conditions apply, except that **$ allows for 3 additional digit positions, one of which is the $ sign.

, A comma appearing to the left of the decimal point in a numeric field, designation will cause a comma to be printed to the left of every third digit to the left of the decimal point in the number being printed. The comma also specifies another digit position. A comma to the right of the decimal point in a numeric field designation is considered a part of the string itself and is treated as a printing character.

^^^^ (↑↑↑↑on some terminals) Exponential Format. If exponential format is desired in the printout, the numeric field designation should be followed by ^^^^ (allows space for E+XX). Any decimal point arrangement is allowed. The significant digits are left justified and the exponent is adjusted. Unless a leading + or a trailing + or - is used, one position to the left of the decimal point will be used to print a space or minus sign. Examples:

```
PRINT USING "[##^^^^]"; 13,17,-8
[ 1E+01][ 2E+01][-8E+00]
OK
PRINT USING "[.######^^^^-]; 12345,-123456
[.123450E+05 ][.123456E+06-]
OK
PRINT USING "[+.##^^^^]"; 123,-126
[+.12E+03][-.13E+03]
OK
```

% If the number to be printed out is larger than the specified numeric field, a % character will be printed followed by the number itself in standard Altair BASIC format. (The user will see the entire number.) If rounding a number causes it to exceed the specified field, the % character will be printed followed by the rounded number. If, for example, A=.999, then

```
PRINT USING ".##",A
```

will print

```
%1.00.
```

If the number of digits specified exceeds 24, an ILLEGAL FUNCTION CALL error will occur.

The following program will help illustrate the preceding rules.

```
Program: 10 INPUT A$,A
         20 PRINT USING A$;A
         30 GOTO 10
         RUN
```

The computer will start by typing a ?. The numeric field designator and value list are entered and the output is displayed as follows:

```
? +#,9
+9
? +#,10
%+10
? ##,-2
-2
? +#,-2
-2
? #,-2
%-2
? +.###,.02
+.020
? ####.#,100
 100.0
? ##+,2
 2+
? THIS IS A NUMBER ##,2
THIS IS A NUMBER 2
? BEFORE ## AFTER,12
BEFORE 12 AFTER
? ####,44444
%44444
? **##,1
***1
? **##,12
**12
? **##,123
*123
? **##,1234
1234
? **##,12345
%12345
? **,1
*1
? **,22
```

```
22
? **.##,12
12.00
? **####,1
*****1
(note: not floating $)
? $####.##,12.34
$  12.34
(note: floating $)
? $$####.##,12.56
 $12.56
? $$.##,1.23
$1.23
? $$.##,12.34
%$12.34
? $$###,0.23
   $0
? $$####.##,0
    $0.00
? **$###.##,1.23
****$1.23
? **$.##,1.23
*$1.23
? **$###,1
****$1
? #,6.9
 7
? #.#,6.99
 7.0
? ##-,2
 2
? ##-,-2
 2-
? ##+,2
 2+
? ##+,-2
 2-
? ##^^^^,2
 2E+00
? ##^^^^,12
 1E+01
? #####.###^^^^,2.45678
 2456.780E-03
? #.###^^^^,123
 0.123E+03
? #.##^^^^,-123
-.12E+03
? "#####,###.#",1234567.89
 1,234,570.0
```

Typing Control/C will stop the program.

5-6. Disk file operations.

As many as sixteen floppy disks may be connected to a single ALTAIR disk controller. These disks have been assigned the physical disk numbers 0 through 15. Users with one drive should address the drive at zero, and users with two drives should address them at zero and one, etc.

In the following descriptions, <disk number> is an integer expression whose value is the physical number of one of the disks in the system. If the <disk number> is omitted from a statement other than MOUNT or UNLOAD, the <disk number> defaults to 0. If the <disk number> is omitted from a MOUNT or UNLOAD statement, disks 0 through the highest disk number specified at initialization are affected.

a. Opening, Closing and Naming Files. To initialize disks for reading and writing, the the MOUNT command is issued as follows:

MOUNT [<disk number>[,<disk number>...]]

Example:

MOUNT 0

Mounts the disk on drive zero, and

MOUNT 0,1

Mounts the disks on drives zero and one. If there is already a disk MOUNTed on the specified drive(s) a DISK ALREADY MOUNTED message will be printed. Before removing a disk which has been used for reading and writing by Disk Altair BASIC, the user should give an UNLOAD command:

UNLOAD [<disk number>[,<disk number>...]]

UNLOAD closes all the files open on a disk, and marks the disk as not mounted. Before any further I/O is done on an UNLOADed disk, a MOUNT command must be given.

NOTE

MOUNT, UNLOAD or any other disk command may be used as a program statement.

All data and program files on the disk have an associated file name. This name is the result of evaluating a string

expression and must be one to eight characters in length. The first character of the file name cannot be a null (Ø) byte or a byte of 255 decimal. An attempt to use a null file name (zero characters in length) , a file name over 8 characters in length or containing a Ø or 255 in the first character position will cause a BAD FILE NAME error. Any other sequence of one to eight characters is acceptable.

Examples of valid file names:

```
ABC
abc          (Not the same as ABC)
filename
file.ext
12345678
INVNTORY
FILE##22
```

NOTE

Commands that require a file name will use <file name> in the appropriate position. Remember that a <file name> can be any string expression as long as the resulting string follows the rules given above.

b. The FILES Command. The FILES command is used to print out the names of the files residing on a particular disk. The format of the FILES command is:

FILES <disk number>

Example:

```
FILES            (prints directory of files on disk Ø)

STRTRK  PIP  CURFIT  CISASM
```

Execution of the FILES command may be interrupted by typing Control/C. A more complete listing of the information stored in a particular file may be obtained by running the PIP utility program (see Appendix I).

c. SAVEing and LOADing programs. Once a program has been written, it is often desirable to save it on a disk for use at a later time. This is accomplished by issuing a SAVE command:

SAVE <file name>[,<disk number>[,A]]

Example:

SAVE "TEST",Ø

or

SAVE "TEST"

would save the program TEST on disk zero. Whenever a program is SAVEd, any existing copy of the program previously SAVEd will be deleted, and the disk space used by the previous program is made available. See section 5-6d for a discussion of saving with the 'A' option.

The LOAD statement reads a file from disk and loads it into memory. The syntax of the LOAD statement is:

LOAD <file name>[,<disk number>[,R]]

Correspondingly:

LOAD "TEST",Ø or LOAD "TEST"

loads the program TEST from disk zero. If the file does not exist, a FILE NOT FOUND error will occur.

LOAD "TEST",Ø,R

OK

LOADs the program TEST from disk zero and runs it. The LOAD command with the "R" option may be used to chain or segment programs into small pieces if the whole program is too large to fit in the computer's memory. All variables and program lines are deleted by LOAD, but all data files are kept OPEN(see below) if the "R" option is used. Therefore, information may be passed between programs through the use of disk data files. If the "R" option is not used, all files are automatically CLOSEd (see below) by a LOAD.

Example:

```
NEW
1Ø PRINT "FOO1":LOAD "FOO2",Ø,R
SAVE "FOO1",Ø

OK
1Ø PRINT "FOO2":LOAD "FOO1",Ø,R
SAVE "FOO2",Ø
```

```
OK
RUN
FOO2
FOO1
FOO2
FOO1
...etc.
```

(Control/C may be used to stop execution at this point)

In this example, program FOO2 is RUN. FOO2 prints the message "FOO2" and then calls the program FOO1 on disk. FOO1 prints "FOO1" and calls the program FOO2 which prints "FOO2" and so on indefinitely.

RUN may also be used with a file name to load and run a program. The format of the command is as follows:

RUN<file name>[,<disk number>[,R]]

All files are closed unless ,R is specified after the disk number.

d. SAVEing and LOADing Program Files in ASCII. Often it is desirable to save a program in a form that allows the program text to be read as data by another program, such as a text editor or resequencing program. Unless otherwise specified, Altair BASIC saves its programs in a compressed binary format which takes a minimum of disk space and loads very quickly. To save a program in ASCII, specify the "A" option on the SAVE command:

```
SAVE "TEST",0,A

OK

LOAD "TEST",0

OK
```

Information in the file tells the LOAD command the format in which the file is to be loaded. The first character of an ASCII file is never 255, and a binary program file always starts with 255 (377 octal). Remember, loading an ASCII file is much slower than loading a binary file.

e. The MERGE Command. Sometimes it is very useful to put parts of two programs together to form a new program combining elements of both programs. The MERGE command is provided for this purpose. As soon as the MERGE command has been executed, BASIC returns to command level. Therefore it is more likely that MERGE would be used as a direct command than as a statement in a program. The format of the MERGE statement is as follows:

```
MERGE <file name>[,<disk number>]

Example:

MERGE "PRINTSUB",1
OK
```

The <file name> specified is merged into the program already in memory. The <file name> must specify an ASCII format saved program or a BAD FILE MODE error will occur. If there are lines in the program on disk which have the same line numbers as lines in the program in memory, the lines from the file on disk will replace the corresponding program lines in memory. It is as if the program lines of the file on disk were typed on the user terminal.

f. Deleting Disk Files. The KILL statement deletes a file from disk and returns disk space used by the file to free disk space. The format of the KILL statement is as follows:

```
KILL <file name>[,<disk number>]
```

If the file does not exist, a FILE NOT FOUND error will occur. If a KILL statement is given for a file that is currently OPEN (see below), a FILE ALREADY OPEN error occurs.

g. Renaming Files - the NAME Statement. The NAME statement is used to change the name of a file:

```
NAME <old file name> AS <new file name>[,<disk number>]

Example:

NAME "OLDFILE" AS "NEWFILE"
```

The <old file name> must exist, or a FILE NOT FOUND error will occur. A file with the same name as <new file name> must not exist or a FILE ALREADY EXISTS error will occur. After the NAME statement is executed, the file exists on the

same disk in the same area of disk space. Only the name is changed.

h. OPENing Data Files. Before a program can read or write data to a disk file, it must first OPEN the file on the appropriate disk in one of several modes. The general form of the OPEN statement is:

OPEN <mode>,[#]<file number>,<file name>[,<disk number>]

<mode> is a string expression whose first character is one of the following:

O	Specifies sequential output mode
I	Specifies sequential input mode
R	Specifies random Input/Output mode

A sequential file is a stream of characters that is read or written in order much like INPUT and PRINT statements read from and write to the terminal. Random files are divided into groups of 128 characters called records. The nth record of a file may be read or written at any time. Random files have other attributes that will be discussed later in more detail.

<file number> is an integer expression between one and fifteen. The number is associated with the file being OPENed and is used to refer to the file in later I/O operations.

Examples:

```
OPEN "O",2,"OUTPUT",Ø
OPEN "I",1,"INPUT"
```

The above two statements would open the file OUTPUT for sequential output and the file INPUT for sequential input on disk zero.

```
OPEN M$,N,F$,D
```

The above statement would open the file whose name was in the string F$ in mode M$ as file number N on disk D.

i. Sequential ASCII file I/O Sequential input and output files are the simplest form of disk input and output since they involve the use of the INPUT and PRINT statements

with a file that has been previously OPENed.

INPUT is used to read data from a disk file as follows:

INPUT #<file number>,<variable list>

where <file number> represents the number of the file that was OPENed for input and <variable list> is a list of the variables to be read, as in a normal INPUT statement. When data is read from a sequential input file using an INPUT statement, no question mark (?) is printed on the terminal. The format of data in the file should appear exactly as it would be typed to a standard INPUT statement to the terminal. When reading numeric values, leading spaces, carriage returns and line feeds are ignored. When a non-space, non-carriage return, non-line-feed character is found, it is assumed to be part of a number in Altair BASIC format. The number terminates on a space, a carriage return , line-feed or a comma.

When scanning for string items, leading blanks, carriage returns and line-feeds are also ignored. When a character which is not a leading blank, carriage return or line-feed is found, it is assumed to be the start of a string item.If this first character is a quotation mark (") the item is taken as being a quoted string, and all characters between the first double quote (") and a matching double quote are returned as characters in the string value. This means that a quoted string in a file may contain any characters except double quote. If the first character of a string item is not a quotation mark, then it is assumed to be an unquoted string constant. The string returned will terminate on a comma, carriage return or line feed. The string is immediately terminated after 255 characters have been read.

For both numeric and string items, if end of file (EOF) is reached when the item is being INPUT, the item is terminated regardless of whether or not a closing quote was seen.

Sequential I/O commands destroy the input buffer so they may not be edited by Control/A for re-execution.

Example of sequential I/O (numeric items):

```
500 OPEN "O",1,"FILE",0
510 PRINT #1,X,Y,Z
520 CLOSE #1
```

```
530 OPEN "I",1,"FILE",0
540 INPUT #1",X,Y,Z
```

Note that CLOSE is used so that a file which has just been written may be read. When FILE is re-OPENed, the data pointer for that file is set back to the beginning of the file so that the first INPUT on the file will read data from the start of the file.

2) PRINT and PRINT USING statements are used to write data into a sequential output file. Their formats are as follows:

```
PRINT #<file number>,<expression list>
```

or

```
PRINT #<file number>,
 USING <string expression>;<expression list>
```

Example of sequential I/O (quoted string items):

```
500 OPEN "O",1,"FILE"
510 PRINT #1,CHR$(34);X$;CHR$(34);
515 PRINT #1,CHR$(34);Y$;CHR$(34);CHR$(34);Z$;CHR$(34)
520 CLOSE 1
530 OPEN "I",1,"FILE",0
540 INPUT #1,X$,Y$,Z$
```

In this example, the strings being output (X$, Y$, Z$) are surrounded with double quotes through the use of the CHR$ function to generate the ASCII value for a double quote. This technique must be used if a string which is being output to a sequential data file contains commas, carriage returns, line-feeds or leading blanks that are significant. When leading blanks are not significant and there are no commas, carriage returns or line-feeds in the strings to be output, it is sufficient to insert commas between the strings being output as in the following example:

```
500 OPEN "O",1,"FILE"
510 PRINT #1,X$;",";Y$;",";Z$
520 CLOSE 1
530 OPEN "I",1,'FILE",0
540 INPUT #1,X$,Y$,Z$
```

3) CLOSE. The format of the CLOSE statement is as follows:

```
CLOSE [<file number>[,<file number>...]]
```

CLOSE is used to finish I/O to a particular Altair BASIC data file. After CLOSE has been executed for a file, the file may be reOPENed for input or output on the same or different <file number>. A CLOSE for a sequential output file writes the final buffer of output. A CLOSE to any OPEN file finishes the connection between the <file number> and the <file name> given in the OPEN for that file. It allows the <file number> to be used again in another OPEN statement.

A CLOSE with no argument CLOSEs all OPEN files.

NOTE

A FILE can be OPENed for sequential input or random access on more than one <file number> at a time but may be OPEN for output on only one <file number> at a time.

END and NEW always CLOSE all disk files automatically. STOP does not CLOSE disk files.

4) LINE INPUT. Often it is desirable to read a whole line of a file into a string without using quotes, commas or other characters as delimiters. This is especially true if certain fields of each line are being used to contain data items, or if a BASIC program saved in ASCII mode is being read as data by another program. The facility provided to perform this function is the LINE INPUT statement:

LINE INPUT #<file number>,<string variable>

A LINE INPUT from a data file will return all characters up to a carriage return in <string variable>. LINE INPUT then skips over the following carriage return/line-feed sequence so that a subsequent LINE INPUT from the file will return the next line.

5) End of File (EOF) Detection. When reading a sequential data file with INPUT statements it is usually desirable to detect when there is no more data in the disk file. The mechanism for detecting this condition is the EOF function:

X=EOF(<file number>)

EOF returns TRUE (-1) when there is no more data in the file and FALSE (Ø) otherwise. If an attempt is made to INPUT

past the end of a data file, an INPUT PAST END error will occur.

Example:

```
100 OPEN "I",1,"DATA",0
110 I=0
120 IF EOF(1) THEN 160
130 INPUT #1,A(I)
140 I=I+1
150 GOTO 120
160 ......
```

In this example, numeric data from the sequential input file DATA is read into the array A. When end of file is detected, the IF statement at line 120 branches to line 160, and the variable I "points" one beyond the last element of A that was INPUT from the file.

The following is a program that will calculate the number of lines in a BASIC program file that has been SAVEd in ASCII mode:

```
10 INPUT "WHAT IS THE NAME OF THE PROGRAM";P$
20 OPEN "I",1,P$,0
30 I=0
40 IF EOF(1) THEN 70
50 I=I+1:LINE INPUT #1,L$
60 GOTO 40
70 PRINT "PROGRAM ";P$;" IS ";I;" LINES LONG"
80 END
```

This example uses the LINE INPUT statement to read each line of the program into the "dummy" string L$ which is used just to INPUT and ignore that part of the file.

6) Finding the Amount of Free Disk Space (DSKF). It is sometimes necessary to determine the amount of free disk space remaining on a particular disk before allocating (writing) a file. The DSKF function provides the user with the number of free groups left on a given disk, after the disk has been MOUNTed. A group is the fundamental unit of file allocation. That is, files are always allocated in groups of eight sectors at a time. Each sector contains 128 characters (bytes). Therefore, the minimum size for a file is 1024 bytes.

Syntax for the DSKF function:

DSKF(<disk number>)

Example:

```
PRINT DSKF(0)
200
```

The above example shows that there are 200*1024=204800 characters (bytes) that can still be stored on disk zero.

j. RANDOM FILE I/O. Previously, we have discussed how data may be PRINTed or INPUT from sequential data files. However, it is often desirable to access data in a random fashion, for instance to retrieve information on a particular part number or customer from a large data base stored on a floppy disk. If sequential files were used, the whole file would have to be scanned from the start until the particular item was found. Random files remove this restriction and allow a program to access any record from the first to the last in a speedy fashion. Also, random files transfer data from variables to the disk ouput records and vice versa in a much faster, more efficient fashion than sequential files. Random file I/O is more complex than sequential I/O, and it is recommended that beginners try sequential I/O first.

1) OPENing a FILE for Random I/O. Random I/O files are OPENed just like sequential files.

```
OPEN "R",1,"RANDOM",0
```

When a file is OPENed for random I/O, it is always OPEN for both input and output simultaneously.

2) CLOSING Random Files. Like sequential files, random files must be closed when I/O operations are finished. To CLOSE a random file, use the CLOSE command as described previously.

```
CLOSE <file number>[,<file number>...]
```

3) Reading and writing data to a random file - GET and PUT. Each random file has associated with it a "random buffer" of 128 bytes. When a GET or PUT operation is performed, data is transferred directly from the buffer to the data file or from the data file to the buffer. The syntax of GET and PUT is as follows:

PUT [#]<file number>[,<record number>]

GET [#]<file number>[,<record number>]

If <record number> is omitted from a GET or PUT statement, the record number that is one higher than the previous GET or PUT is read into the random buffer. Initially a GET or PUT without a record number will read or write the first record. The largest possible record number is 2046. If an attempt is made to GET a record which has never been PUT, all zeroes are read into the record, and no error occurs.

4) LOC and LOF. LOC is used to determine what the current record number is for random files. In other words, it returns the record number that will be used if a GET or PUT is executed with the <record number> parameter omitted.

LOC(<file number>)

```
PRINT LOC(1)
 15
```

LOC is also valid for sequential files, and gives the number of sectors (128 byte blocks) read or written since the OPEN statement was executed.

LOF is used to determine the last record number written to a random file:

LOF(<file number>)

```
PRINT LOF(2)
 200
```

An attempt to use LOF on a sequential file will cause a BAD FILE MODE error.

The value returned by LOF is always 5 MOD 8. That is , when the value LOF returns is divided by 8, the remainder is always 5. Therefore,the values returned by LOF are 5, 13, 21, 29 etc. This is due to the way random files are allocated.

NOTE

It is important to note that the value returned by LOF may be a record that has never been written in by a user program. This is because of the way random files are pre-extended.

5) Moving Data In and Out of the Random Buffer. So far we have described techniques for writing (PUT) and reading (GET) data from a file into its associated random buffer. Now we will describe how data from string variables is moved to and from the random buffer itself. This is accomplished through the use of the FIELD, LSET and RSET statements.

6) FIELD. The FIELD statement associates some or all of a file's random buffer with a particular string variable. Then, when the file buffer is read with GET or written with PUT, string variables which have been FIELDed into the buffer will automatically have their contents read or written. The format of the FIELD statement is:

FIELD [#] <file number> ,<field size> AS <string variable>[...]

<file number> is used to specify the file number of the file whose random buffer is being referenced. If the file is not a random file, a BAD FILE MODE error will occur. <field size> sets the length of the string in the random buffer. <string variable> is the string variable which is associated with a certain number of characters (bytes) in the buffer. Multiple fields may be associated with string variables in a given FIELD statement. Each successive string variable is assigned a successive field in the random buffer. Example:

```
FIELD 10 AS A$, 20 AS B$, 30 AS C$
```

The statement above would assign the first 10 characters of the random buffer to the string variable A$, the next 20 characters to B$ and the next 30 characters to the variable C$. It is important to note that the FIELD statement does not cause any data to be transferred to or from the random buffer. It only causes the string variables given as arguments to "point" into the random buffer.

Often, it is necessary to divide the random buffer into a number of sub-records to make more efficient use of disk space. For instance, it might be desirable to divide the 128 character record into two identical subrecords. To accomplish this a "dummy variable" would be placed in the FIELD statement to represent one of the subrecords. One of the following statements would be executed depending on whether the first or second subrecord were needed:

```
FIELD #1,64 AS D$, 20 AS NAME$,
      20 AS ADDRESSE$, 24 AS OCCUPATION$
```

or

```
- FIELD #1,20 AS NAME$, 20 AS ADDRESSE$,
      24 AS OCCUPATION$, 64 AS D$
```

where the dummy variable D$ is used to skip over one of the subrecords. Another way to do the same thing would be to set a variable I that would select the first or second subrecord.

```
FIELD #1,64*(I-1) AS D$,
 20 AS NAME$, 20 AS ADDRESS$, 24 AS OCCUPATION$
```

Here, if the variable I is one, I-1 *64 =0 characters will be skipped over, selecting the first subrecord. If I is two, 64 characters will be skipped over, selecting the second subrecord. Another technique that is very useful is to use a FOR...NEXT loop and an array to set up subrecords in the random buffer:

```
1000 FOR I=1 TO 16
1010 FIELD #1, (I-1)*8 AS D$, 4 AS A$(I),
     4 AS B$(I)
1020 NEXT I
```

In this example, we have divided the random buffer into 16 subrecords composed of two fields each. The first 4-character field is in A$(X) and the second 4-character field is in B$(X,) where X is the subrecord number.

NOTE

The FIELD statement may be executed any number of times on a given file. It does not cause any allocation of string space. The only space allocation that occurs is for the string variables mentioned in the FIELD statement. These string variables have a one byte count and two byte pointer set up which points into the random buffer for the specified file.

7) Using Numeric Values in Random Files: MKI$, MKS$, MKD$ and CVI, CVS, CVD. As we have seen, data is always stored in the random buffer through the use of string variables. In order to convert between strings and numbers and vice versa, a number of special functions have been provided.

To convert between numbers and strings:

MKI$(<integer value>)	Returns a two byte string (FC error if value is not >=-32768 and <=+32767. Fractional part is lost)
MKS$(<single precision value>)	Returns a four byte string
MKD$(<double precision value>)	Returns an eight byte string

To convert between strings and numbers:

CVI(<two byte string>)	Returns an integer value
CVS(<four byte string>)	Returns a single precision value
CVD(<eight byte string>)	Returns a double precision value

CVI, CVS, and CVD all give an ILLEGAL FUNCTION CALL error if the string given as the argument is shorter than required. If the string argument is longer than necessary, the extra characters are ignored. These functions are extremely fast, since they convert between Altair BASIC's internal representations of integers, single and double precision values and strings. Conventional sequential I/O must perform time-consuming character scanning algorithms when converting between numbers and strings.

8. LSET and RSET. When a GET operation is performed, all string variables which have been FIELDed into the random buffer for that file automatically have values assigned to them. The CVI, CVS and CVD functions may be used to convert any numeric fields in the record to their numeric values. When going the other way, i.e. inserting strings into the random buffer before performing a PUT statement, a problem arises. This is because of the way string assignments usually take place. For example:

```
LET A$=B$
```

When a LET statement is executed, B$ is copied into string space, A$ is pointed to the new string and the string length of A$ is modified. However, for assignments into the random buffers we do not want this to happen. Instead, we want the string being assigned to be stored where the string variable was FIELDed. In order to do this, two special assignment

statements have been provided, LSET and RSET:

LSET <string variable>=<string expression>

RSET <string variable>=<string expression>

Examples:

```
LSET A$=MKS$(V)
RSET B$="TEST"
LSET C$(I)=MKD$(D#)
```

The difference between LSET and RSET concerns what happens if the string value being assigned is shorter than the length specified for the string variable in the FIELD statement. LSET left justifies the string, adding blanks (octal 40, decimal 32) to pad out the right side of the string if it is too short. RSET right justifies the string, padding on the left. If the string value is too long, the extra characters at the end of the string are ignored.

NOTE

Do not use LSET or RSET on string variables which have not been mentioned in a FIELD statement, or a SET TO NON DISK STRING error will occur.

k. The DSKI$ and DSKO$ Primitives. Often it is necessary for the user to perform disk I/O operations directly without using any of the normal file structure features of Altair BASIC. To allow this, two special functions have been provided. These are the DSKI$ function and the DSKO$ statement. First we will give examples of how to perform simple disk I/O commands using Altair BASIC statements,

To Enable disk 0:

```
OUT 8,0
```

To Enable disk N:

```
OUT 8,N
```

TO step the disk head out one track:

```
WAIT 8,2,2:OUT 9,2
```

To step the disk head in one track:

```
WAIT 8,2,2:OUT 9,1
```

To test for track Ø:

```
IF (INP(8) AND 64)=Ø THEN <statements or line number>
```

The above will execute the statements or branch to the line number if the head is positioned at track Ø. This is the outermost track on the disk.

To read sector Y (Y may be any expression, minimum sector =Ø, maximum = 31):

```
A$=DSKI$(Y)
```

The statement

```
DSKO$ <string expression>,<sector expression>
```

writes the string expression on the sector specified. The high order bit (most signifigant) of the first character output will always be set to one when the string is written on the sector, and thus will always be one when the sector is read back in using DSKI$. A maximum of 137 characters are written; giving a string whose length exceeds 137 characters will cause an ILLEGAL FUNCTION CALL error. If the string argument is less than 137 characters in length, the end of the string will be padded with zeros to make a string of length 137.

7) Using Numeric Values in Random Files: MKI$, MKS$, MKD$ and CVI, CVS, CVD. As we have seen, data is always stored in the random buffer through the use of string variables. In order to convert between strings and numbers and vice versa, a number of special functions have been provided.

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```
LET A$=B$
```

When a LET statement is executed, B$ is copied into string space, A$ is pointed to the new string and the string length of A$ is modified. However, for assignments into the random buffers we do not want this to happen. Instead, we want the string being assigned to be stored where the string variable was FIELDed. In order to do this, two special assignment

6. LISTS AND DIRECTORIES

6-1. Commands.

Commands direct Altair BASIC to arrange memory and input/output facilities, to list and edit programs and to handle other housekeeping details in support of program execution. Altair BASIC accepts commands after it prints 'OK' and is at command level. The table below lists the commands in alphabetical order. The notation to the right of the command name indicates the versions to which it applies.

Command	Version(s)

CLEAR — All

Sets all program variables to zero.

CLEAR[<expression>] — 8K, Extended, Disk

Same as CLEAR but sets string space to the value of the expression. If no argument is given, string space will remain unchanged. When Altair BASIC is loaded, string space is set to 50 bytes in 8K and 200 bytes in extended.

CLOAD<string expression> — 8K(cassette), Extended, Disk

Causes the program on cassette tape designated by the first character of STRING expression> to be loaded into memory. A NEW command is issued before the program is loaded.

CLOAD?<string expression> — 8K(cassette), Extended, Disk

Compares the program in memory with the file on cassette with the same name. If they are the same, BASIC prints OK. If not, BASIC prints NO GOOD.

CLOAD*<array name> — 8K(cassette), Disk

Loads the specified array from cassette tape. May be used as a program statement

CONT — 8K, Extended, Disk

Continues program execution after a Control/C has been typed or a STOP or END statement has been executed. Execution resumes at the statement after the break occurred unless input from the terminal was interrupted. In that case,

execution resumes with the reprinting of the prompt (? or prompt string). CONT is useful in debugging, especially where an 'infinite loop' is suspected. An infinite loop is a series of statements from which there is no escape. Typing Control/C causes a break in execution and puts BASIC in command level. Direct mode statements can then be used to print intermediate values, change the values of variables, etc. Execution can be restarted by typing the CONT command, or by executing a direct mode GOTO statement, which causes execution to resume at the specified line number.

In 4K and 8K Altair BASIC, execution cannot be continued if a direct mode error has occured during the break. In all versions, execution cannot continue if the program was modified during the break.

CSAVE<string expression> 8K(cassette), Extended, Disk

Causes the program currently in memory to be saved on cassette tape under the name specified by the first character of <string expression>.

CSAVE*<array name> 8K(cassette), Disk

Causes the array named to be saved on cassette tape. May be used as a program statement.

DELETE<line number> Extended, Disk

Deletes the line in the current program with the specified number. If no such line exists, an ILLEGAL FUNCTION CALL error occurs.

DELETE-<line number> Extended, Disk

Deletes every line of the current program up to and including the specified line. If there is no such line, an ILLEGAL FUNCTION CALL error occurs.

DELETE<line number>-<line number> Extended, Disk

Deletes all lines of the current program from the first line number to the second inclusive. ILLEGAL FUNCTION CALL occurs if no line has the second number.

EDIT<line number> Extended, Disk

Allows editing of the line specified without affecting any other lines. The EDIT command has a powerful set of sub-commands which are discussed in detail in section 5-4.

LIST All

Lists the program currently in memory starting with the lowest numbered line. Listing is terminated either by the end of the program or by typing Control/C.

LIST[<line number>] All

In 4K and 8K, prints the current program beginning at the specified line. In Extended and Disk, prints the specified line if it exists.

LIST[<line number>][-<line number>] Extended, Disk

Allows several listing options.

1. If the second number is omitted, lists all lines with numbers greater than or equal to the number specified.

2. If the first number is omitted, lists all lines from the beginning of the program to the specified line, inclusive.

3. If both line numbers are used, lists all lines from the first number to the second, inclusive.

LLIST[<line number>][-<line number>] Extended, Disk

Same as list with the same options, except prints on the line printer.

NEW All

Deletes the current program and clears all variables. Used before entering a new program.

NULL<integer expression> 8K, Extended, Disk

Sets the number of nulls to be printed at the end of each line. For 10 character per second tape punches, <integer expression> should be >=3. For 30 cps punches, it should be >=3. When tapes are not being punched, <integer expression> should be 0 or 1 for Teletypes* and Teletype compatible CRT's. It should be 2 or 3 for 30 cps hard copy printers. The default value is 0. In the 4K version, the same affect may be achieved by patching location 46 octal to contain the number of nulls plus 1.

* Teletype is a registered trademark of the Teletype Corporation.

RUN[<line number>] All

Starts execution of the program currently in memory at the line specified. If the line number is omitted, execution begins at the lowest line number. Line number specification is not allowed in 4K.

6-2. Statements.

The following table of statements is listed in alpahabetical order. The notation in the Version column designates the versions to which each statement applies. In the table, X and Y stand for any expressions allowed in the version under consideration. I and J stand for expressions whose values are truncated to integers. V and W are any variable names. The format for a Altair BASIC line is as follows:

<nnnnn> <statement>[:<statement>...]

where nnnnn is the line number.

Name	Format	Version
CONSOLE	CONSOLE <I>,<J>	Extended, Disk

Allows terminal console device to be switched. I is the I/O port number which is the address of the low order channel of the new I/O board. J is the switch register setting (see section 5-1 for the list of settings). 0<=I,J<=255.

DATA	DATA<list>	All

Specifies data to be read by a READ statement. List elements can be numbers or, except in 4K, strings. 4K allows expressions. List elements are separated by commas.

DEF	DEF FNV(<W>)=<X>	8K, Extended, Disk

Defines a user-defined function. Function name is FN followed by a legal variable name. Extended and Disk versions allow user-defined string functions. Definitions are restricted to one line (72 characters in 4K and 8K, 255 characters in extended versions).

DEFUSR	DEFUSR[<digit>]=<X>	Extended, Disk

Defines starting address of assembly language subroutine. Up to ten subroutines are allowed.

DIM DIM <V>(<I>[,J...])[,...] All

Allocates space for array variables. In 4K, only one dimension is allowed per variable. More than one variable may be dimensioned by one DIM statement up to the limit of the line. The value of each expression gives the maximum subscript possible. The smallest subscript is Ø. Without a DIM statement, an array is assumed to have maximum subscript of 1Ø for each dimension referenced. For example, A(I,J) is assumed to have 121 elements, from A(Ø,Ø) to A(1Ø,1Ø) unless otherwise dimensioned in a DIM statement.

END END All

Terminates execution of a program. Closes all files in the Disk version.

ERASE ERASE<V>[,<W>...] Extended, Disk

Eliminates the arrays specified. The arrays may be redimensioned or the space made available for other uses.

ERROR ERROR<I> Extended, Disk

Forces error with code specified by the expression. Used primarily for user-defined error codes.

FOR FOR<V>=<X>TO<Y>[STEP<Z>] All

Allows repeated execution of the same statements. First execution sets V=X. Execution proceeds normally until NEXT is encountered. Z is added to V, then, IF Z<Ø and V>=Y, or if Z>Ø and V<=Y, BASIC branches back to the statement after FOR. Otherwise, execution continues with the statement after NEXT.

GOTO GOTO<nnnnn> All

Unconditional branch to line number

GOSUB GOSUB<nnnnn> All

Unconditional branch to subroutine beginning at line nnnnn.

IF...GOTO IF <X> GOTO<nnnnn> 8K, Extended, Disk

Same as IF...THEN except GOTO can only be followed by a line number and not another statement.

IF...THEN [ELSE] IF<X>THEN<X>[ELSE<Y>] All
or IF<X>THEN<statement>[:statement...]
[ELSE<statement>[:statement...]

If value of X<>Ø, branches to line number or statement after THEN. Otherwise, branches to the line number or statement(s) after ELSE. If ELSE is omitted, and the value of X=Ø, execution proceeds at the line after the IF...THEN. In 4K, X can only be a numeric expression. The ELSE clause is only allowed in Extended and Disk Altair BASIC.

INPUT INPUT<V>[,<W>...] All

Causes BASIC to request input from terminal. Values (or, in 4K, expressions) typed on the terminal are assigned to the variables in the list.

LET LET <V>=<X> All

Assigns the value of the expression to the variable. The word LET is optional.

LPRINT LPRINT X[,Y...] Extended, Disk

Same as PRINT, but prints on the line printer. Line feeds within strings are ignored. A carriage return is printed automatically after the 80th character on a line.

LPRINT USING LPRINT USING<string>;<list> Extended, Disk

Same as PRINT USING, but prints on the line printer. For a detailed description, see section 5-5.

MID$ MID$(<X$>,<I>[,<J>])=Y$ Extended, Disk

Part of the string X$ is replaced by Y$. Replacement starts with the Ith character of X$ and proceeds until Y$ is exhausted, the end of X$ is reached or J characters have been replaced, whichever comes first. If I is greater than LEN(X$), an ILLEGAL FUNCTION CALL error results.

NEXT NEXT [<V>,<W>...] All

Last statement of a FOR loop. V is the variable of the most recent loop, W of the next most recent and so on. Only one variable is allowed in 4K. Except in 4K, NEXT without a variable terminates the most recent FOR loop.

ON ERROR GOTO ON ERROR GOTO<line number> Extended, Disk

When an error occurs, branches to line specified. Sets variable ERR to error code and ERL to line number where the

error occured. See section 6-5 for a list of error codes. ON ERROR GOTO Ø (or without number) disables error trapping.

ON...GOTO ON<I>GOTO<list of line numbers> 8K, Ext., Disk

Branches to line whose number is Ith in the list. List elements are separated by commas. If I=Ø or > number of elements in the list, execution continues at next statement. If I<Ø or >255, an error results.

ON...GOSUB ON <I> GOSUB <list> 8K, Extended, Disk

Same as ON...GOTO except list elements are initial line numbers of subroutines.

OUT OUT<I>,<J> 8K, Extended, Disk

Sends byte J to port I. Ø<=I,J<=255.

POKE POKE<I>,<J> 8K, Extended, Disk

Stores byte J in memory location derived from I. Ø<=J<=255;-32768<I<65536. If I is negative, address is 65535+I, if I is positive, address=I.

PRINT PRINT<X>[,<Y>...] All

Causes values of expressions in the list to be printed on the terminal. Spacing is determined by punctuation.

Punctuation	Spacing - next printing begins:
,	at beginning of next 14 column zone
;	immediately
other or none	at beginning of next line

String literals may be printed if enclosed by (") marks. String expressions may be printed in all but 4K.

PRINT USING PRINT USING<string>;<list> Extended, Disk

Prints the values of the expressions in the list edited according to the string. The string is an expression which represents the line to be printed. The list contains the constants, variable names or expressions to be printed. List entries are separated by punctuation as in the PRINT statement. For a list of string characters and their functions, see section 5-5.

READ READ<V>[,<W>...] All

Assigns values in DATA statements to variables. Values are assigned in sequence starting with the first value in the

first DATA statement.

REM REM[<remark>] All

Allows insertion of remarks. Not executed, but may be branched into. In extended versions, remarks may be added to the end of a line preceded by a single quotation mark (').

RESTORE RESTORE All

Allows data from DATA statements to be reread. Next READ statement after RESTORE begins with first data of first data statement.

RESUME RESUME[<number>] Extended, Disk

Resumes program execution at the line specified after error trapping routine. If number is omitted or zero, resumes at statement where error occured. RESUME NEXT causes resumption at the statement following the statement where the error was made.

RETURN RETURN All

Terminates a subroutine. Branches to the statement after the most recent GOSUB.

STOP STOP All

Stops program execution. BASIC enters command level and, except in 4K, prints BREAK IN LINE nnnnn. Unlike END, STOP does not close files.

SWAP SWAP <V>,<W> Extended, Disk

Exchanges values of the variables named. Variables must be of the same type.

TROFF TROFF Extended, Disk

Turns off trace flag. The trace flag is turned on by TRON (see below). NEW also turns off the trace flag.

TRON TRON Extended, Disk

Turns on trace flag. Prints number of each line in square brackets as it is executed.

WAIT WAIT<I>,<J>[,<K>] 8K, Extended, Disk

Status of port I is XOR'd with K and AND'ed with J.

Continued execution awaits non-zero result. K defaults to Ø. Ø<=I,J,K<=255.

6-3. Intrinsic Functions.

Altair BASIC provides several commonly used algebraic and string functions which may be called from any program without further definition. If the functions are not required for a program, they may be deleted when BASIC is loaded to conserve memory space. The functions in the following table are listed in alphabetical order. The notation to the right of the Call Format is the versions in which the function is available. As usual, X and Y stand for expressions, I and J for integer expressions and X$ and Y$ for string expressions.

Function	Call Format	Version
ABS	ABS(X)	All

Returns absolute value of expression X. ABS(X)=X if X>=Ø, -X if X<Ø.

ASC	ASC(X$)	8K, Extended, Disk

Returns the ASCII code of the first character of the string X$. ASCII codes are in appendix A.

ATN	ATN(X)	8K, Extended, Disk

Returns arctangent(X). Result is in radians in range -pi/2 to pi/2.

The following functions are available in Extended and Disk:

CINT	CINT(X)	Converts X to integer.
CSNG	CSNG(X)	Converts X to single precision.
CDBL	CDBL(X)	Converts X to double precision.

If the argument is in the range -32768 to 32767, the CINT(X)=INT(X). Otherwise, CINT will produce an OVERFLOW error.

CHR$	CHR$(I)	8K, Extended, Disk

Returns a string whose one element has ASCII code I. ASCII

codes are in Appendix A.

COS COS(X) 8K, Extended, Disk

Returns cos(X). X is in radians.

ERL Extended, Disk

Returns the number of the line in which the last error occurred.

ERR Extended, Disk

Returns the error code of the last error.

ERR ERR(I) Disk

Returns parameters of disk errors. After a DISK I/O ERROR, ERR(Ø) returns number of the disk, ERR(1) returns the track number (Ø-76) , ERR(2) returns the sector number, ERR(3) and ERR(4) return the low and high order 8 bits of the cumulative count of disk errors respectively.

EXP EXP(X) 8K, Extended, Disk

Returns e to the power X. X must be <=87.3365.

FIX FIX(X) Extended, Disk

Returns the truncated integer part of X. FIX(X) is equivalent to SGN(X)*INT(ABS(X)). The major difference between FIX and INT is that FIX does not return the next lower number for negative X.

FRE FRE(Ø) 8K, Extended, Disk

Returns number of bytes in memory not being used by BASIC. If argument is a string, returns number of free bytes in string space.

HEX$ HEX$(X) Extended, Disk

Returns a string which represents the hexadecimal of the decimal argument.

INP INP(I) 8K, Extended, Disk

Reads a byte from port I.

INSTR INSTR([I,]X$,Y$) Extended, Disk

Searches for the first occurrence of string Y$ in X$ and

returns the position. Optional offset I sets position for starting the search. 0<=I<=255. If I>LEN(X$), if X$ is null or if Y$ cannot be found, INSTR returns 0. If Y$ is null INSTR returns I or 1. Strings may be string variable values, string expressions or string literals.

INT INT(X) All

Returns the largest integer <=X

LEFT$ LEFT$(X$,I) 8K, Extended, Disk

Returns leftmost I characters of string X$.

LEN LEN(X$) 8K, Extended, Disk

Returns length of string X$. Non-printing characters and blanks are counted.

LOG LOG(X) 8K, Extended, Disk

Returns natural log of X. X>0

LPOS LPOS(X) Extended, Disk

Returns the current position of the line printer print head within the line printer buffer. Does not necessarily give the physical position of the print head. The expression X must be given, but the value is ignored.

MID$ MID$(X$,I[,J]) 8K, Extended, Disk

Without J, returns rightmost characters from X$ beginning with the Ith character. If I>LEN(X$), MID$ returns the null string. 0<I<255. With 3 arguments, returns a string of length J of characters from X$ beginning with the Ith character. If J is greater than the number of characters in X$ to the right of I, MID$ returns the rest of the string. 0<=J<=255.

OCT$ OCT$(X) 8K, Extended, Disk

Returns a string which represents the octal value of the decimal argument.

RND RND(X) All

Returns a random number between 0 and 1. X<0 starts a new sequence of random numbers. X>0 gives the next random number in the sequence. X=0 gives the last number returned. In 8K, Extended and Disk, sequences started with the same negative number will be the same.

POS POS(I) 8K, Extended, Disk

Returns present column position of terminal's print head. Leftmost position =0.

RIGHT$ RIGHT$(X$,I) 8K, Extended, Disk

Returns rightmost I characters of string X$. If I=LEN(X$), returns X$.

SGN SGN(X) All

If X>0, returns 1, if X=0 returns 0, if X<0, returns -1. For example, ON SGN(X)+2 GOTO 100,200,300 branches to 100 if X is negative, 200 if X is 0 and 300 if X is positive.

SIN SIN(X) All

Returns the sine of the value of X in radians. COS(X)=SIN(X+3.14159/2).

SPACE$ SPACE$(I) 8K, Extended, Disk

Returns a string of spaces of length I.

SPC SPC(I) 8K, Extended, Disk

Prints I blanks on terminal. 0<=I<=255.

SQR SQR(X) All

Returns square root of X. X must be >=0

STR$ STR$(X) 8K, Extended, Disk

Returns string representation of value of X.

STRING$ STRING$(I,J) Extended, Disk

Returns a string of length I whose characters all have ASCII code J. See Appendix A for ASCII codes.

TAB TAB(I) All

Spaces to position I on the terminal. Space 0 is the leftmost space, 71 the rightmost. If the carriage is already beyond space I, TAB has no effect. 0<=I<=255. May only be used in PRINT and LPRINT statements.

TAN TAN(X) All

Returns tangent(X). X is in radians.

USR	USR(X)	All

Calls the user's machine language subroutine with argument X.

VAL	VAL(X$)	8K, Extended, Disk

Returns numerical value of string X$. If first character of X$ is not +,- or a digit, VAL(X$)=Ø.

VARPTR	VARPTR(V)	Extended, Disk

Returns the address of the variable given as the argument. If the variable has not been assigned a value during the execution of the program, an ILLEGAL FUNCTION CALL error will occur. The main use of the VARPTR function is to obtain the address of variable or array so it may be passed to an assembly language subroutine. Arrays are usually passed by specifying VARPTR(A[Ø]) so that the lowest addressed element of the array is returned.

NOTE

All simple variables should be assigned values in a program before calling VARPTR for any array. Otherwise, allocation of a new simple variable will cause the addresses of all arrays to change.

6-4. Special Characters

Altair BASIC recognizes several characters in the ASCII font as having special functions in carriage control, editing and program interruption. Characters such as Control/C, Control/S, etc. are typed by holding down the Control key and typing the designated letter. The special characters in the table are listed in the order of the versions to which they apply, starting with those common to all versions and ending with those that apply only to extended versions.

Typed as	Printed as

The following Special Characters are available in ALL versions.

@ @

Erases current line and executes carriage return.

(backarrow)

Erases last character typed. If there is no last character types a carriage return.

_ _(underline)

same as backarrow.

Carriage Return

Returns print head or curser to beginning of the next line.

Control/C ^C (in extended)

Interrupts execution of current program or list command. Takes effect after execution of the current statement or after listing the current line. BASIC goes to command level and types OK. CONT command resumes execution. See section 6-1.

: :

Separates statements in a line.

The following special characters are available in 8K, Extended and Disk versions only.

Control/O ^O (in extended)

Suppresses all output until an INPUT statement is encountered, another Control/O is typed, an error occurs or BASIC returns to command level.

? ?

equivalent to PRINT statement.

Rubout see explanation

Deletes previous character on an input line. First Rubout prints \ and the last character to be printed. Each successive Rubout prints the next character to the left. Typing a new character causes another \ and the new character to be printed. All characters between the backslashes are deleted.

Control/U ^U (in extended)

Same as @

Control/S

Causes program execution to pause until Control/Q or Control/C is typed.

Control/Q

Causes execution to resume after Control/S. Control/S and Control/Q have no effect if no program is being executed.

The following special characters are available in Extended and Disk versions only.

Control/A

Allows use of the EDIT command on the line currently being typed. Control/A is typed instead of Carriage Return. See section 5-4.

Control/I 1 to 8 spaces

Tab character. Causes print head or curser to move to the beginning of the next 8 column field. Fields begin at columns 1, 9, 17, etc. The tab character is especially useful for formatting lines broken with line feeds.

```
100<tab>FOR I=1 TO 10:<line feed>
<tab><tab>FOR J=1 TO 10:<line feed>
<tab><tab><tab>A(I,J)=0:<line feed>
<tab>NEXT J,I<carriage return>
```

lists as:

```
100     FOR I=1 TO 10:
                  FOR J=1 TO 10:
                           A(I,J)=0:
        NEXT J,I
```

Control/G bell

Rings terminal's bell

LINE FEED

Breaks a long line into shorter parts. The result is still one BASIC line.

.

Denotes the number of the current line. May be used wherever a line number is to be specified.

[,] [,]

Brackets are interchangable with parentheses as delimiters for array subscripts.

Lower Case Input

Lower case alphabetic characters are always echoed as lower case, but LIST, LLIST, PRINT and LPRINT will translate lower case to upper case if the lower case characters are not part of string literals, REM statements or single quote (') remarks.

6-5. Error Messages.

After an error occurs, BASIC returns to command level and types OK. Variable values and the program text remain intact, but the program cannot be continued by the CONT command. In 4K and 8K versions, all GOSUB and FOR context is lost. The program may be continued by direct mode GOTO, however. When an error occurs in a direct statement, no line number is printed. Format of error messages:

```
Direct Statement        ?XX ERROR
Indirect Statement      ?XX ERROR IN YYYYY
```

where XX is the error code and YYYYY is the line number where the error occurred. The following are the possible error codes and their meanings:

ERROR CODE	EXTENDED ERROR MESSAGE	NUMBER
The following error codes apply in ALL versions.		
BS	SUBSCRIPT OUT OF RANGE	9

An attempt was made to reference an array element which is outside the dimensions of the array. In the 8K and larger versions, this error can occur if the wrong number of dimensions are used in an array reference. For example:

```
LET A(1,1,1)=Z
```

.

Denotes the number of the current line. May be used wherever a line number is to be specified.

[,] [,]

Brackets are interchangable with parentheses as delimiters for array subscripts.

Lower Case Input

Lower case alphabetic characters are always echoed as lower case, but LIST, LLIST, PRINT and LPRINT will translate lower case to upper case if the lower case characters are not part of string literals, REM statements or single quote (') remarks.

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Direct Statement        ?XX ERROR
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The following error codes apply in ALL versions.		
BS	SUBSCRIPT OUT OF RANGE	9

An attempt was made to reference an array element which is outside the dimensions of the array. In the 8K and larger versions, this error can occur if the wrong number of dimensions are used in an array reference. For example:

```
LET A(1,1,1)=3
```

when A has already been dimensioned by DIM A(10,10)

DD REDIMENSIONED ARRAY 10

After an array was dimensioned, another dimension statement for the same array was encountered. This error often occurs if an array has been given the default dimension of 10 and later in the program a DIM statement is found for the same array.

FC ILLEGAL FUNCTION CALL 5

The parameter passed to a math or string function was out of range.. FC errors can occur due to:

1. a negative array subscript (LET A(-1)=0)
2. an unreasonably large array subscript (>32767)
3. LOG with negative or zero argument
4. SQR with negative argument
5. A^B with A negative and B not an integer
6. a call to USR before the address of a machine language subroutine has been entered.
7. calls to MID$, LEFT$, RIGHT$, INP, OUT, WAIT, PEEK, POKE, TAB, SPC, STRING$, SPACE$, INSTR or ON...GOTO with an improper argument.

ID ILLEGAL DIRECT 12

INPUT and DEF are illegal in the direct mode. In extended versions, however, INPUT is legal in direct.

NF NEXT WITHOUT FOR 1

The variable in a NEXT statement corresponds to no previously executed FOR statement.

OD OUT OF DATA 4

A READ statement was executed but all of the DATA statements in the program have already been read. The program tried to read too much data or insufficient data was included in the program.

OM OUT OF MEMORY 7

Program is too large, has too many variables, too many FOR loops, to many GOSUBs or too complicated expressions. See Appendix C.

OV OVERFLOW 6

The result of a calculation was too large to be represented in Altair BASIC's number format. If an underflow occurs, zero is given as the result and execution continues without any error message being printed.

SN SYNTAX ERROR 3

Missing parenthesis in an expression, illegal character in a line, incorrect punctuation, etc.

RG RETURN WITHOUT GOSUB 3

A RETURN statement was encountered before a previous GOSUB statement was executed.

UL UNDEFINED LINE 8

The line reference in a GOTO, GOSUB, IF...THEN...ELSE or DELETE was to a line which does not exist.

/Ø DIVISION BY ZERO 11

Can occur with integer division and MOD as well as floating point division. Ø to a negative power also causes a DIVISION BY ZERO error.

The following error messages apply to
8K, Extended and Disk versions only

CN CAN'T CONTINUE 17

Attempt to continue a program when none exists, an error occured, or after a modification was made to the program.

LS STRING TOO LONG 15

An attempt was made to create a string more than 255 characters long.

OS OUT OF STRING SPACE 14

String variables exceed amount of string space allocated for

them. Use the CLEAR command to allocate more string space or use smaller strings or fewer string variables.

ST STRING FORMULA TOO COMPLEX 16

A string expression was too long or too complex. Break it into two or more shorter ones.

TM TYPE MISMATCH 13

The left hand side of an assignment statement was a numeric variable and the right hand side was a string, or vice-versa; or a function which expected a string argument was given a numeric one or vice-versa.

UF UNDEFINED USER FUNCTION 18

Reference was made to a user defined function which had never been defined.

The following error messages are available in Extended and Disk versions only.

MISSING OPERAND 20

During evaluation of an expression, an operator was found with no operand following it.

NO RESUME 19

BASIC entered an error trapping routine, but the program ended before a RESUME statement was encountered.

RESUME WITHOUT ERROR 21

A RESUME statement was encountered, but no error trapping routine had been entered.

UNPRINTABLE ERROR 22

An error condition exists for which there is no error message available. Probably there is an ERROR statement with an undefined error code.

LINE BUFFER OVERFLOW 23

An attempt was made to input a program or data line which has too many characters to be held in the line buffer. Shorten the line or divide it into two or more parts.

Disk Altair BASIC Error Messages

FIELD OVERFLOW 50

An attempt was made to allocate more than 128 characters of string variables in a single FIELD statement.

INTERNAL ERROR 51

Internal error in Disk BASIC. Report conditions under which error occurred and all relevant data to MITS software department. This error can also be caused by certain kinds of disk I/O errors.

BAD FILE NUMBER 52

An attempt was made to use a file number which specifies a file that is not OPEN or that is greater than the number of files entered during the Disk Altair BASIC initialization dialog.

FILE NOT FOUND 53

Reference was made in a LOAD, KILL or OPEN statement to a file which did not exist on the disk specified.

BAD FILE MODE 54

An attempt was made to perform a PRINT to a random file, to OPEN a random file for sequential output, to perform a PUT or GET on a sequential file, to load a random file or to execute an OPEN statement where the file mode is not I, O, or R.

FILE ALREADY OPEN 55

A sequential output mode OPEN for a file was issued for a file that was already OPEN and had never been CLOSEd or a KILL statement was given for an OPEN file.

DISK NOT MOUNTED 56

An I/O operation was issued for a file that was not MOUNTed.

DISK I/O ERROR 57

An I/O error occured on disk X. A sector read (checksum) error occurred eighteen (18) consecutive times.

SET TO NON-DISK STRING 58

An LSET or RSET was given for a string variable which had not previously been mentioned in a FIELD statement.

DISK ALREADY MOUNTED 59

A MOUNT was issued for a DISK that was already MOUNTed but never UNLOADed.

DISK FULL 60

All disk storage is exhausted on the disk. . Delete some old disk files and try again.

INPUT PAST END 61

An INPUT statement was executed after all the data in a file had been INPUT. This will happen immediately if an INPUT is executed for a null (empty) file. Use of the EOF function to detect End Of File will avoid this error.

BAD RECORD NUMBER 62

In a PUT or GET statement, the record number is either greater than the allowable maximum (2046) or equal to zero.

BAD FILE NAME 63

A file name of Ø characters (null) or a file name whose first byte was Ø or 377 octal (255 decimal) or a file name with more than 8 characters was used as an argument to LOAD, SAVE, KILL or OPEN.

MODE-MISMATCH 64

Sequential OPEN for output was executed for a file that already existed on the disk as a random (R) mode file, or vice versa.

DIRECT STATEMENT IN FILE 65

A direct statement was encountered during a LOAD of a program in ASCII format. The LOAD is terminated.

TOO MANY FILES 66

A SAVE or OPEN (O or R) was executed which would create a new file on the disk, but all 255 directory entries were already full. Delete some files and try again.

OUT OF RANDOM BLOCKS 67

An attempt was made to have more random files OPEN at once than the number of random blocks that were allocated during initialization by the response to the "NUMBER OF RANDOM FILES?" question (see Appendix E).

FILE ALREADY EXISTS 68

The new file name specified in a NAME statement had the same name as another file that already existed on the disk. Try a different name.

FILE LINK ERROR 69

During the reading of a file, a sector was read which did not belong to the file.

6-6. Reserved Words.

Some words are reserved by the Altair BASIC interpreter for use as statements, commands, operators, etc. and thus may not be used for variable or function names. The reserved words are listed below in order of the versions for which they are reserved, starting with those reserved in all versions and ending with those reserved only in Disk Altair BASIC. Words reserved in larger versions may be used in smaller versions, although one may want to avoid all reserved words in the interest of compatibility. In addition to the words listed below, intrinsic function names are reserved words in all versions in which they are available.

RESERVED WORDS

Words reserved in all versions.

CLEAR	NEW
DATA	NEXT
DIM	PRINT
END	READ
FOR	REM
GOSUB	RETURN
GOTO	RUN
IF	STOP
INPUT	TO
LET	TAB
LIST	THEN
	USR

Words reserved in 8K, Extended and Disk versions. All the above plus:

```
AND             ON
CONT            OR
DEF             OUT
FN              POKE
NOT             SPC
NULL            WAIT
```

Words reserved in Extended and Disk versions. All the above plus:

```
AUTO              LINE
CONSOLE           kL              LLIST
DEFDBL            LPRINT
DEFINT            MOD
DEFSNG            RENUM
DEFSTR            RESUME
DELETE            SPACE$
EDIT              STRING$
ELSE              SWAP
                  TROFF
ERASE             TRON
ERL               VARPTR
ERR               WIDTH
IMP               XOR
INSTR
```

Words reserved in Disk. All the above plus:

```
CLOSE           LSET
DSKI$           MERGE
DSKO$           MOUNT
FIELD           NAME
FILES           OPEN
GET             PUT
KILL            RSET
LOAD              UNLOAD
```

APPENDIX A
ASCII CHARACTER CODES

DECIMAL	CHAR.	DECIMAL	CHAR.	DECIMAL	CHAR.
000	NUL	043	+	086	V
001	SOH	044	,	087	W
002	STX	045	-	088	X
003	ETX	046	.	089	Y
004	EOT	047	/	090	Z
005	ENQ	048	0	091	[
006	ACK	049	1	092	\
007	BEL	050	2	093	]
008	BS	051	3	094	^
009	HT	052	4	095	<
010	LF	053	5	096	'
011	VT	054	6	097	a
012	FF	055	7	098	b
013	CR	056	8	099	c
014	SO	057	9	100	d
015	SI	058	:	101	e
016	DLE	059	;	102	f
017	DC1	060	<	103	g
018	DC2	061	=	104	h
019	DC3	062	>	105	i
020	DC4	063	?	106	j
021	NAK	064	@	107	k
022	SYN	065	A	108	l
023	ETB	066	B	109	m
024	CAN	067	C	110	n
025	EM	068	D	111	o
026	SUB	069	E	112	p
027	ESCAPE	070	F	113	q
028	FS	071	G	114	r
029	GS	072	H	115	s
030	RS	073	I	116	t
031	US	074	J	117	u
032	SPACE	075	K	118	v
033	!	076	L	119	w
034	"	077	M	120	x
035	#	078	N	121	y
036	$	079	O	122	z
037	%	080	P	123	{
038	&	081	Q	124	|
039	'	082	R	125	
040	(	083	S	126	
041	)	084	T	127	DEL
042	*	085	U		

LF=Line Feed FF=Form Feed CR=Carriage Return DEL=Rubout

Using ASCII codes -- the CHR$ function.

CHR$(X) returns a string whose one character is that with ASCII code X. ASC(X$) converts the first character of a string to its ASCII decimal value.

One of the most common uses of CHR$ is to send a special character to the user's terminal. The most often used of these characters is the BEL (ASCII 7). Printing this character will cause a bell to ring on some terminals and a beep on many CRT's. This may be used as a preface to an error message, as a novelty, or just to wake up the user if he has fallen asleep. Example:

```
PRINT CHR$(7);
```

Another major use of special characters is on those CRT's that have cursor positioning and other special functions (such as turning on a hard copy printer). For example, on most CRT's a form feed (CHR$(12)) will cause the screen to erase and the cursor to "home" or move to the upper left corner.

Some CRT's give the user the capability of drawing graphs and curves in a special point-plotter mode. This feature may easily be taken advantage of through use of Altair BASIC's CHR$ function.

APPENDIX B
LOADING AND INITIALIZING BASIC

A. Loading BASIC from paper tape or cassette.

This appendix details the procedure for loading BASIC in 4K, 8K and Extended versions from paper tape or tape cassette. For instructions on loading Disk BASIC, see appendix E.

The programs below are entered into memory through the front panel switches. Rather than specify the switch positions as "up" and "down", it is convenient to denote the up position as 1 and the down position as Ø. Taken in groups of three, then, the switches can represent octal digits. To save space, the switch positions in the following loader program listings are shown in octal notation. The leftmost two switches in an 8 bit set are represented by the first digit, the next three by the second digit and the low-order three switches by the last digit.

For example, if we wish to enter octal 315 on the data switch register, the switches would have the following positions:

7	6	5	4	3	2	1	Ø
up	up	down	down	up	up	down	up
3			1			5	

For data entry, only the rightmost 8 switches of the 16 switches on the ALTAIR 88ØØ front panel switch register are used. All 16 switches would be used to enter a memory address.

The following is the procedure for loading BASIC from paper tape or cassette.

1. Turn the power switch on.
2. Raise the STOP switch and RESET switch simultaneously
3. Switch the terminal to LINE
4. Enter one of the following programs on the front panel switches. The 88-MBL Multi-Boot Loader PROM contains the necessary loader programs, so it is not necessary to enter a loader from the front panel if it is installed. Refer to the 88-MBL manual for more information.

a. loading from paper tape with the SIO board (REV 1)

Octal Address	Octal Data	
000	041	
001	302	
002	0xx	(17 for 4K, 37 for 8K, 77 for
003	061	Extended & Disk)
004	022	
005	000	
006	333	
007	000	
010	017	
011	330	
012	333	
013	001	
014	275	
015	310	
016	055	
017	167	
020	300	
021	351	
022	003	
023	000	

b. loading from cassette

Octal Address	Octal Data	
000	041	
001	302	
002	0xx	(17 for 4K, 37 for 8K, 77 for
003	061	Extended and Disk)
004	022	
005	000	
006	333	
007	006	
010	017	
011	330	
012	333	
013	007	
014	275	
015	310	
016	055	
017	167	
020	300	
021	351	
022	003	
023	000	

c. loading with the 88 PIO board

Octal Address	Octal Code	
000	041	
001	302	
002	0xx	(17 for 4K, 37 for 8K, 77 for
003	061	Extended and Disk)
004	023	
005	000	
006	333	
007	004	
010	346	
011	001	
012	310	
013	333	
014	005	
015	275	
016	310	
017	055	
020	167	
021	300	
022	351	
023	003	
024	000	

d. loading with the 2SIO board

Octal Address	Octal Data	
000	076	
001	003	
002	323	
003	020	
004	076	
005	021	(=2 stop bits, 025=1 stop bit)
006	323	
007	020	
010	041	
011	302	
012	0xx	(17for 4K, 37 for 8K, 77 for
013	061	Extended and Disk)
014	032	
015	000	
016	333	
017	020	
020	017	
021	320	
022	333	
023	021	
024	275	
025	310	
026	055	
027	167	

030	300
031	351
032	013
033	000

e. loading with the 4PIO board

Octal Address	Octal Data
000	257
001	323
002	040
003	323
004	041
005	076
006	054
007	323
010	040
011	041
012	302
013	0xx (17 for 4K, 37 for 8K, 77 for
014	061 Extended and Disk)
015	033
016	000
017	333
020	040
021	007
022	330
023	333
024	041
025	275
026	310
027	055
030	167
031	300
032	351
033	014
034	000

f. Loading with the High Speed Tape Reader

Octal Address	Octal Data
000	257
001	323
002	044
003	323
004	045
005	323
006	046
007	057
010	323

```
011     047
012     076
013     014
014     323
015     044
016     076
017     004
020     323
021     046
022     323
023     047
024     041
025     302
026     0xx  (17 for 4K, 37 for 8K, 77 for
027     061   Extended and Disk)
030     047
031     000
032     333
033     044
034     346
035     100
036     310
037     333
040     045
041     275
042     310
043     055
044     167
045     300
046     351
047     027
050     000
```

To enter these programs,

1. Put switches 0 to 15 in the down positions
2. Raise EXAMINE
3. Put the data for address zero in switches 0 through 7.
4. Raise DEPOSIT
5. Put the data for the next address in the switches
6. Depress DEPOSIT NEXT
7. Repeat steps 5 and 6 until the whole loader is toggled in

8. Put switches 0 through 15 in the down position

9. Raise EXAMINE

10. Check to see that the lights D0 through D7 show the data that should be in location 000. Light on =1, light off = 0. If the correct value is there, go to step 13, if not go to 11.

11. Put the correct value in the switches

12. Raise DEPOSIT

13. Depress EXAMINE NEXT

14. Repeat steps 10 through 13 to check the entire loader

15. If there were any mistakes, check the entire loader again to make sure they were corrected.

16. If a paper tape is being loaded, put it into the reader and make sure that it is positioned at the beginning of the leader. The leader is the section of tape at the beginning with 302 octal punched in each column. If an audio cassette is being loaded, put it in the cassette recorder and make sure it is fully rewound.

17. Lower switches 0 through 15

18. Raise EXAMINE

19. Enter the sense switch settings. See the table in section B.

20. If loading is through a SIOA, B or C or an 88PIO, turn on the tape reader and then depress RUN. If a cassette is being loaded, turn on the recorder, put it in PLAY mode and wait 15 seconds. Then press RUN on the computer. If loading is through a 4PIO, 2SIO or High Speed Tape Reader, depress RUN and then start the read device.

21. Wait for the tape to read. Paper tape takes about 25 minutes for Extended, 12 minutes for 8K and 6 minutes for 4K. Cassettes take about 8 minutes for Extended, 4 minutes for 8K and 2 minutes for 4K. Do not move any of the switches while the tape is being read.

22. If a loading error occurs, the loading procedure must start over from step 1. See section C below for error conditions.

23. When the tape is read, BASIC should start up and print MEMORY SIZE? See section D below for what to do next.

24. If BASIC will not load from cassette, the ACR module may need realignment. The Input Test Program described in the ACR Manual, pages 22 and 28 may be used to test the ACR.

B. Sense Switch Settings

Sense switches (switches A8 through A15) must be set before tape or cassette loading begins. The settings depend on the terminal and input interface boards in use. The low order (rightmost) four switches contain the load board setting and the high order four switches contain the terminal board setting. In the table below, the setting is given for each I/O board option. As above, the setting is an octal number which signifies the switch positions. The Terminal Switch and Load Switch columns show the switches that are raised for each of the load and terminal device options.

Device	Sense Switch Setting	Terminal Switches	Load Switches	Channels
2SIO (2 stop bits)	0	none	none	20, 21
2SIO (1 stop bit)	1	A12	A8	20, 21
SIO	2	A13	A9	0, 1
ACR	3	A13,A12	A9,A8	6, 7
4PIO	4	A14	A10	40, 41, 42, 43
PIO	5	A14,A12	A10,A8	4, 5
HSR	6	A14,A13	A10,A9	46, 47
non-standard terminal	14			
no terminal	15			

Examples:

Input from audio cassette through ACR and CRT terminal through 2SIO with 1 stop bit.

Switch	15	14	13	12	11	10	9	8
Position	0	0	0	1	0	0	1	1

Input from high speed paper tape reader, terminal through SIO.

Switch	15	14	13	12	11	10	9	8
Position	0	0	1	0	0	1	1	0

C. Error Detection

The checksum loader turns on the Interrupt Enable light on the front panel when a loading error occurs. The ASCII code of the error letter is stored in location 0. In addition, the error letter is sent out over all the terminal channels and so will appear on whatever terminal is connected to the terminal. The error letters are as follows:

C checksum error. Bad tape data.
M memory error. Data won't store properly. The address of the bad memory location is stored in locations 1 and 2.
O overlay error. Attempt was made to load data on top of the loader.
I invalid load device. Invalid setting on the sense switches.

D. Initialization Dialog

Upon starting, BASIC prints

MEMORY SIZE?

To this, the user responds by typing the number of bytes of memory to be used by BASIC and BASIC programs. Remember that the BASIC interpreter itself takes 3.4K in the 4K version, 6.2K in 8K and 14.6K in Extended. If the response is just a carriage return, BASIC will use all the memory it can find, starting at location zero up to the last byte of read/write memory. Then BASIC asks,

TERMINAL WIDTH?

to which the user responds with the width of the printing line of whatever output device is in use. Typing a carriage return sets the terminal width to 72. Extended and Disk Altair BASIC set the terminal width through the WIDTH command, so the TERMINAL WIDTH question is not asked at initialization and an initial width of 72 is assumed. In 4K, the response to MEMORY SIZE? and TERMINAL WIDTH? must be less than 6 digits.

At this point BASIC asks several questions about mathematical functions. The functions may be kept if needed or deleted to save space. 4K asks,

SIN? Answer Y to save SIN, SQR and RND
Answer N to delete SIN and see the

```
            next question
SQR?        Y keeps SQR and RND
            N deletes SQR, asks next question
RND?        Y keeps RND
            N deletes RND
```

8K and Extended BASIC ask,

```
WANT SIN-COS-TAN-ATN?      Y keeps all four
                           N deletes all four
                           A deletes only ATN
                           C (in extended) retains
                             CONSOLE function.  Any
                             other answer deletes
                             CONSOLE.
```

Now BASIC prints,

```
XXXX BYTES FREE

ALTAIR BASIC VERSION 4.0
[FOUR-K VERSION]
     or
[EIGHT-K VERSION]
     or
[EXTENDED VERSION]
OK
```

BASIC is now in command level and is ready for use.

E. Echo Routines.

The Altair input/output channels work in a full-duplex mode. This means that characters entered on an input/output terminal will not, as a rule, be printed as they are entered unless the computer is programmed to return them. The following echo programs may be used to test the input/output devices. To test an input-only device, dump the echoed characters on an output device or store them in memory for later examination. To test an output-only device, send the echo characters through the front panel switches or send a constant character. Be sure to check the ready-to-receive bit of the output terminal before attempting output. If the echo program works, but BASIC does not, make sure the load device's I/O board is strapped for 8 data bits and that the ready-to-recieve bit is set properly on the terminal device.

88-PIO

OCTAL ADDRESS	OCTAL CODE
001	004
002	346
003	001

004	312
005	000
006	000
007	333
010	005
011	323
012	005
013	303
014	000
015	000

2SIO

OCTAL ADDRESS	OCTAL CODE	
000	076	
001	003	
002	323	
003	020	(flag ch.)
004	076	
005	021	(=2 stop bits,
006	323	025=1 stop bit)
007	020	
010	333	
011	020	
012	017	
013	322	
014	010	
015	000	
016	333	
017	021	(data channel)
020	323	
021	021	
022	303	
023	010	
024	000	

4PIO

OCTAL ADDRESS	OCTAL CODE
000	257
001	323
002	040
003	323
004	041
005	323
006	042
007	057
010	323
011	043
012	076
013	054
014	323
015	040
016	323

017	042
020	333
021	040
022	346
023	200
024	312
025	020
026	000
027	333
030	042
031	346
032	200
033	312
034	027
035	000
036	333
037	041
040	323
041	043
042	303
043	020
044	000

APPENDIX C
SPACE AND SPEED HINTS

A. Space Allocation

The memory space required for a program depends, of course, on the number and kind of elements in the program. The following table contains information on the space required for the various program elements.

Element		Space Required
Variables		
numeric	integer	5 bytes
	single precision	7 bytes in Extended and Disk 6 bytes in 4K and 8K
	double precision	11 bytes
	string	6 bytes
Arrays		
integer	(# of elements)*	2 + 6 +(# of dimensions)*2 bytes
single precision		4+ 5
double precision		8
string		3
8K and 4K strings and floating pt.		6 + 5
Functions		
intrinsic		1 byte for the call (2 bytes in Extended and Disk)
user-defined		6 bytes for the definition
Reserved Words		1 byte each 2 bytes for ELSE in Extended and Disk
Other Characters		1 byte each
String Space		1 byte per character
Stack Space		
active FOR loop		17 bytes in Extended and Disk, 16 bytes in 4K and 8K
active GOSUB		5 bytes
parentheses		6 bytes each set
temporary result		12 bytes in Extended and Disk 10 bytes in 4K and 8K

BASIC itself takes about 3.4K in the 4K version, 6.2K in 8K, 14.6K in Extended and 20 K in Disk.

B. Space Hints

The space required to run a program may be significantly reduced without affecting exectuion by following a few of the following hints.

1. Use multiple statements per line. Each line has a 5 byte overhead for the line number, etc., so the fewer lines there are, the less storage is required.

2. Delete unnecessary spaces. Instead of writing

```
10 PRINT X, Y, Z
```

use

```
10 PRINTX,Y,Z
```

3. Delete REM statements to save 1 byte for REM and 1 byte for each character of the remark.

4. Use variables instead of costants, expecially when the same value is used several times. For example, using the constant 3.14159 ten times in a program uses 40 bytes more space than assigning

```
10 P=3.14159
```

once and using P ten times.

5. Using END as the last statement of a program is not necessary and takes one extra byte.

6. Reuse unneeded variables instead of defining new variables.

7. Use subroutines instead of writing the same code several times.

8. Use the smallest version of BASIC that will run the program.

9. Use the zero elements of arrays. Remember the array dimensioned by

```
100 DIM A(10)
```

has eleven elements, A(0) through A(10).

10. In Extended and Disk, use integer variables wherever possible.

C. Speed Hints

1. Deleting spaces and REM statements gives a small but significant decrease in execution time.

2. Variables are set up in a table in the order of their first appearance in the program. Later in the program, BASIC searches the table for the variable at each reference. Variables at the head of the table take less time to search for than those at the end. So, reuse variable names and keep the list of variables as short as possible.

3. In 8K, Extended and Disk use NEXT without the index variable.

4. 8K, Extended and Disk have faster floating point arithmetic than 4K. If space is not a limitation, use the larger versions.

5. The math functions in 8K, Extended and Disk are faster than those in 4K.

6. In the 4K and 8K versions, use variables instead of constants, especially in FOR loops and other code that must be executed repeatedly.

7. In Extended and Disk use integer variables wherever possible.

APPENDIX D
MATHEMATICAL FUNCTIONS

1. Derived Functions

The following functions, while not intrinsic to ALTAIR BASIC, can be calculated using the existing BASIC functions.

Function:	BASIC equivalent:
SECANT	SEC(X) = 1/COS(X)
COSECANT	CSC(X) = 1/SIN(X)
COTANGENT	COT(X) = 1/TAN(X)
INVERSE SINE	ARCSIN(X) = ATN(X/SQR(-X*X+1))
INVERSE COSINE	ARCCOS(X) = -ATN X(X/SQR(-X*X+1)) +1.5708
INVERSE SECANT	ARCSEC(X) = ATN(XSQR(X*X-1)) +SGN(SGN(X)-1)*1.5708
INVERSE COSECANT	ARCCSC(X) = ATN(1/SQR(X*X-1)) +(SGN(X)-1)*1.5708
INVERSE COTANGENT	ARCCOT(X) = ATN(X)+1.5708
HYPERBOLIC SINE	SINH(X) = (EXP(X)-EXP(-X))/2
HYPERBOLIC COSINE	COSH(X) = (EXP(X)+EXP(-X))/2
HYPERBOLIC TANGENT	TANH(X) = EXP(-X)/EXP(X)+EXP(-X)) *2+1
HYPERBOLIC SECANT	SECH(X) = 2/(EXP(X)+EXP(=X))
HYPERBOLIC COSECANT	CSCH(X) = 2/(EXP(X)-EXP(-X))
HYPERBOLIC COTANGENT	COTH(X) = EXP(-X)/(EXP(X)-EXP(-X)) *2+1
INVERSE HYPERBOLIC SINE	ARCSINH(X) = LOG(X+SQR(X*X+1))
INVERSE HYPERBOLIC COSINE	ARCCOSH(X) = LOG(X+SQR(X*X+-1))
INVERSE HYPERBOLIC TANGENT	ARCTANH(X) = LOG((1+X)/(1-X))/2
INVERSE HYPERBOLIC SECANT	ARCSECH(X) = LOG((SQR(-X*X+1)+1)/X)
INVERSE HYPERBOLIC COSECANT	ARCCSCH(X) = LOG((SGN(X)* SQR(X*X+1)+1)/X
INVERSE HYPERBOLIC COTANGENT	ARCCOTH(X) = LOG((X+1)/(X-1))/2

^&2. Simulated Math Functions.\&

The following subroutines are intended for 4K BASIC users

who want to use the transcendental functions not built into 4K BASIC. The corresponding routines for these functions in the 8K version are much faster and more accurate. The REM statements in these subroutines are given for documentation purposes only, and should not be typed in because they take up a large amount of memory. The following are the subroutine calls and their 8K equivalents:

8K EQUIVALENT	4K SUBROUTINE CALL
P9=X9^Y9	GOSUB 60030
L9=LOG(X9)	GOSUB 60090
E9=EXP(X9)	GOSUB 60160
C9=COS(X9)	GOSUB 60240
T9=TAN(X9)	GOSUB 60280
A9=ATN(X9)	GOSUB 60310

The unneeded subroutines should not be typed in. Please note which variables are used by each subroutine. Also note that TAN and COS require that the SIN function be retained when BASIC is loaded and initialized.

```
60000 REM EXPONENTIATION: P9=X9^Y9
60010 REM NEED: EXP, LOG
60020 REM VARIABLES USED: A9,B9,C9,E9,L9,P9,X9,Y9
60030 REM P9 =1 : E9=0 : IF Y9=0 THEN RETURN
60040 IF X9<0 THEN IF INT(Y9)=Y9 THEN P9=1-2*Y9+4*INT(Y9/2)
      : X9=-X9
60050 IF X9<>0 THEN GOSUB 60090 : X9=Y9*L9 : GOSUB 60160
60060 P9=P9*E9 : RETURN
60070 REM NATURAL LOGARITHM: L9=LOG(X9)
60080 REM VARIABLES USED: A9,B9,C9,E9,L9,X9
60090 E9=0 : IF X9<=0 THEN PRINT "LOG FC ERROR"; : STOP
60100 A9=1: B9=2: C9=.5: REM THIS WILL SPEED THE FOLLOWING
60110 IF X9>=A9 THEN X9=C9*X9 : E9=E9+A9 : GOTO 60100
60120 X9=(X9-.707107)/(X9+.7077107) : L9=X9*X9
60130 L9=(((.598979*L9+.961471)*L9+2.88539)*X9+E9-.5)*
      .693147
60135 RETURN
60140 REM EXPONENTIAL : E9=EXP(X9)
60150 REM VARIABLES USED: A9,E9,L9,X9
60160 L9=INT(1.4427*X9)+1 : IF L9<127 THEN 60180
60170 IF X9>0 THEN PRINT "EXP OV ERROR"; : STOP
60175 E9=0 : RETURN
60180 E9=.693147*L9-X9 : A9=1.32988E-3-1.41316E-4*E9
60190 A9=((A9*E9-8.30136E-3)*E9+4.16574E-2)*E9
60195 E9=((A9-.166665)*E9-1)*E9+1 : A9=2
60197 IF L9<=0 THEN A9=.5 : L9=-L9 : IF L9=0 THEN RETURN
60200 FOR X9=1 TO L9 : E9=A9*E9 : NEXT X9 : RETURN
60210 REM COSINE: C9=COS(X9)
60220 REM N.B. SIN MUST BE RETAINED AT LOAD-TIME
60230 REM VARIABLES USED: C9,X9
```

```
60240 C9=SIN(X9+1.5708) : RETURN
60250 REM TANGENT: T9=TAN(X9)
60260 REM NEEDS COS. (SIN MUST BE RETAINED AT LOAD-TIME)
60270 REM VARIABLES USED: C9,T9,X9
60280 GOSUB 60240 : T9=SIN(X9)/C9  : RETURN
60290 REM ARCTANGENT : A9=ATN(X9)
60300 REM VARIABLES USED: A9,B9,C9,T9,X9
60310 T9=SGN(X9): X9=ABS(X9):C9=0: IF X>1 THEN C9-1: X9=1/X9
60320 A9=X9*X9 : B9=((2.86623E-3*A9-1.61657E-2)*A9
         +4.29096E-2)*A9
60330 B9=((((B9-7.5289E-2)*A9+.106563)*A9-.1142089)*A9+.199936)*A9
60340 A9=((B9-.333332)*A9+1)*X9 : IF C9=1 THEN A9=1.5708-A9
```

APPENDIX E
BASIC AND ASSEMBLY LANGUAGE

All versions of Altair BASIC have provisions for interfacing with assembly language routines. The USR function allows Altair BASIC programs to call assembly language subroutines in the same manner as BASIC functions.

The first step in setting up a machine language subroutine for an Altair BASIC program is to set aside memory space. When BASIC asks, MEMORY SIZE? during initialization, the response should be the size of memory available, minus the amount needed for the assembly language routine. BASIC uses all the bytes it can find from location zero up, so only the topmost locations in memory can be used for user supplied routines. If the answer to the MEMORY SIZE? question is too small, BASIC will ask the question again until it gets all the memory it needs. See Appendix C.

The assembly language routine may be loaded into memory from the front panel switches or from a BASIC program by means of the POKE statement.

The starting address of the assembly language routine goes in USRLOC, a two byte location in memory which varies from version to version. USRLOC for 4K and 8K Altair BASIC version 4.0 is 111 decimal. In Extended and Disk, USRLOC need not be known explicitly since it is defined automatically by DEFUSR. See section 5-3b. The function USR calls the routine whose address is in USRLOC. Initially, USRLOC contains the address of ILLFUN, the routine which gives the FC or ILLEGAL FUNCTION CALL error, which is what happens if USR is called with no assembly language routine having been loaded.

When USR is called, the stack pointer is set up for 8 levels (16 bytes) of stack storage. If more stack space is needed, BASICs stack can be saved and a new stack set up for use by the assembly language routine. BASIC's stack must be restored, however, before returning from the user routine.

All memory and all the registers can be changed by a user's assembly language routine. Of course, memory locations within BASIC ought not to be changed, nor should more bytes be popped off the stack than were put on it.

USR is called with a single argument. The assembly language routine can retrieve this argument by calling the routine whose address is in locations 4 and 5 decimal. The

low-order byte of the address is in 4 and the high-order in 5. In 4K and 8K, this routine (DEINT) stores the argument in the register pair [D,E]. In Extended, the argument is passed in pair [H,L]. The argument is truncated to integer in 4K and 8K, and if it is not in the range -32768 to 32767, an FC error occurs. In extended, the register pair [H,L] contains a pointer to the Floating Point Accumulator where the argument is stored (see section 5-3b. for more information).

To pass a result back from an assembly language routine, load the value in register pair [A,B] in 4K and 8K, or [H,L] in Extended. This value must be a signed, 16 bit integer as defined above. Then call the routine whose address is in locations 6 and 7. If this routine is not called, USR(X) returns X. To return to BASIC, then, the assembly language routine executes a RET instruction.

Assembly language routines can be written to handle interrupts. Locations 56, 57 and 58 are used to hold a JMP instruction to a user supplied interrupt handling routine. Location 56 initially holds a RET, so it must be set up by the user or an interrupt will have no effect.

All interrupt handling routines should save the stack, registers A-L and the PSW. They should also reenable interrupts before returning since an interrupt automatically disables all further interrupts once it is received.

There is only one way to call an assembly language routine in 4K and 8K, but this does not limit the programmer to only one assembly language routine. The argument of USR can be used to designate which routine is being called. In 8K, additional arguments can be passed through the use of POKE and values may be passed back by PEEK.

In Extended and Disk BASIC, up to ten routines may be called with the USRØ - USR9 functions. For more information on this feature, see section 5-3b.

APPENDIX F
USING THE ACR INTERFACE

NOTE

The cassette features , CLOAD and CSAVE , are only present in 8K Altair BASICs which are distributed on cassette, and in Extended and Disk versions. 8K BASIC on paper tape will give the user about 250 additional bytes of free memory, but it will not recognize the CLOAD or CSAVE commands.

Programs may be saved on cassette tape by means of the CSAVE command. CSAVE may be used in either direct or indirect mode, and its format is as follows:

CSAVE <string expression>

The program currently in memory is saved on cassette under the name specified by the first character of the STRING expression>. CSAVE writes through channel 7 when the Write Buffer Empty bit (bit 7) of channel 6 is low. After CSAVE is completed, BASIC always returns to command level. Programs are written on tape in BASIC's internal representation. Variable values are not saved on tape, although an indirect mode CSAVE does not affect the variable values of the program currently in memory. The number of nulls (see NULL command) has no affect on the operation of CSAVE. Before using CSAVE, turn on the cassette recorder, make sure the tape is in the proper position and put the recorder in RECORD mode.

Programs may be loaded from cassette tape by means of the CLOAD command, which has the same format as CSAVE. The effect of CLOAD is to execute a NEW command, clearing memory and all variable values, and loading the specified file into memory. When done reading and loading, BASIC returns to command level. CLOAD reads a byte from channel 7 when the Read Data Ready bit (bit 0) in channel 6 is low. Reading continues until 3 consecutive zeros are read. BASIC will not return to command level after a CLOAD if it could not find the requested file or if the file was found but did not end with 3 zeros. In that case, the computer will continue to search until it is stopped and restarted at location 0.

In the 8K cassette and Extended versions of ALTAIR BASIC, data may be read and written with the CSAVE* and CLOAD* commands. The formats are as follows:

CSAVE*<array variable name>

and

CLOAD*<array variable name>

See section 2-4d for a discussion of CSAVE* and CLOAD* for array data.

CLOAD?<string expression> compares the program currently in memory with the specified file on cassette. If the two files match, BASIC prints OK. If not, BASIC prints NO GOOD.

Data may also be read from and written on cassette in the paper tape version of 8K Altair BASIC. To write data, execute a WAIT 6,128 statement to check for the Write Buffer Empty bit and then write with an OUT 7,<byte> statement. To read, execute a WAIT 6,1 to check for Read Data Ready and then read with an INP(7). The end of a block of data may be conveniently designated by a special character. Data should be stored in array form since there is no time during reading and writing for computation.

APPENDIX G
CONVERTING BASIC PROGRAMS NOT WRITTEN FOR THE ALTAIR COMPUTER

Though implementations of BASIC on different computers are in many ways similar, there are some incompatibilities between ALTAIR BASIC and the BASIC used on other computers.

1) Strings.

A number of BASICs require the length of strings to be declared before they are used. All dimension statements of this type should be removed from the program. In some of these BASICs, a declaration of the form DIM A$(I,J) declares a string array of J elements each of which has a length I. Convert DIM statements of this type to equivalent ones in Altair BASIC: DIM A$(J). Altair BASIC uses " + " for string concatenation, not " , " or " &." ALTAIR BASIC uses LEFT$, RIGHT$ and MID$ to take substrings of strings. Some other BASICs use A$(I) to access the Ith character of the string A$, and A$(I,J) to take a substring of A$ from character position I to character position J. Convert as follows:

OLD	NEW
A$(I)	MID$(A$,I,1)
A$(I,J)	MID$(A$,I,J-I+1)

This assumes that the reference to a subscript of A$ is in an expression or is on the right side of an assignment. If the reference to A$ is on the left hand side of an assignment, and X$ is the string expression used to replace characters in A$, convert as follows :

In 4K and 8K

OLD	NEW
A$(I)=X$	A$=LEFT$(A$,I-1)+X$+MID$(A$,I+1)
A$(I,J)=X$	A$=LEFT$(A$,I-1)+X$+MID$(A$,J+1)

Extended and Disk

OLD	NEW
A$(I)=X$	MID$(A$,1,1)=X$
A$(I,J)=X$	MID$(A$,I,J-I+1)=X$

2) Multiple assignments.

Some BASICs allow statements of the form:

```
500 LET B=C=0
```

This statement would set the variables B and C to zero. In 8K Altair BASIC this has an entirely different effect. All the " = " signs to the right of the first one would be interpreted as logical comparison operators. This would set the variable B to -1 if C equaled 0. If C did not equal 0, B would be set to 0. The easiest way to convert statements like this one is to rewrite them as follows.

```
500 C=0:B=C
```

3) Some BASICs use " \ " instead of " : " to delimit multiple statements on a line. Change each " \ " to " : " in the program.

4) Paper tapes punched by other BASICs may have no nulls at the end of each line, instead of the three per line recommended for use with Altair BASIC. To get around this, try to use the tape feed control on the Teletype to stop the tape from reading as soon as Altair BASIC prints a carriage return at the end of the line. Wait a moment, and then continue feeding in the tape. When reading has finished, be sure to punch a new tape in Altair BASIC's format.

A program for converting tapes to Altair BASIC's format was published in MITS Computer Notes, November 1976, p. 25.

5) Programs which use the MAT functions available in some BASICs will have to be re-written using FOR...NEXT loops to perform the appropriate operations.

APPENDIX H
DISK INFORMATION

Format of Altair Floppy Disk

Track Allocation:

Tracks	Use
0-5	Disk BASIC memory image.
6-69	Space for either random or sequential files.
70	Directory track. See below.
71-76	Space for sequential files only.

Format of DISK BASIC Memory Image (Tracks 0-5):

BASIC is loaded starting at track 0 sector 0 then track 0 sector 1, etc. Each sector contains 128 bytes of BASIC. The first 128 bytes are loaded first, second 128 second, etc.

Sector format (Tracks 0-5):

Byte	Use
0	Track Number+128 decimal.
1-2	Sixteen bit address of the next higher byte of memory than the highest memory location saved on this sector.
3-130	128 bytes of BASIC.
131	255 decimal stop byte.
132	Checksum - sum of bytes 3-130 with no carry in 8 bits.

Sector format (Tracks 6-76):

Byte	Use
0	Most Significant Bit always on. Contains track number plus 200 octal.
1	Sector number * 17 MOD 32.
2	File number in directory. Zero file number means that the sector is not part of any file. If the sector is the first file of a group of 8 sectors 0 means the whole group of 8 sectors is free.

3	Number of data bytes written (Ø to 128) . Always 128 for random files. (Except for the random file index blocks in which case this byte indicates how many groups are allocated to the file.)
4	Checksum. The sum of all the data on the sector except for the track number, the sector number and the terminating 255 byte.
5,6	Pointer to the next group of data. This is set up for random files and sequential files, and is even valid in the middle of a group. If it is zero it means there is no more data in the file. The track is the first byte and the sector number is the second byte.
7-134	Data
135	A 255 (octal 377) to make sure the right number of data bytes were read.
136	Unused.

Directory Track (7Ø) Format:

Each sector of the directory (which is all of track 7Ø) is composed of up to 8 file name slots, 16 bytes per slot. Each slot can contain a file name (8 bytes), a link to the start of file data (2 bytes), and a byte which specifies the mode of a file (Random=4, Sequential=2). The remaining 5 bytes are not currently used. Any slot which has the first filename byte equal to zero contains a file which has been deleted. If the first byte of a slot is a 255 , it is the last slot currently in use in the directory. Slots beyond the "stopper" are garbage. File numbers are calculated by multiplying the sector number of the directory track the file is in by 16 and adding the position of the slot in the sector (Ø-8) plus 1.

NOTE

The ith logical sector on a track is actually mapped to the i*17 MOD 32 physical sector to improve latency in BASIC I/O operations.

Format of Random Files

Each random file starts with two random index blocks. The "number of data bytes" field in the first block indicates how many groups are currently allocated to this random file. The next 256 bytes in the two random index blocks give the location of each group in the random file in order of their position in the file. The upper two bits give the group number , and the lower six bits give the track number - 6.

Assembly Code to Read and Write a Sector

The following code has been provided to help users write their own assembly language subroutines to read and write data on the floppy disk. It is assumed that the disk being used has already been enabled and positioned to the correct track. Two data bytes are always read or written at a time so that the CPU can keep up with the data rate (32 microseconds/byte) of the floppy disk. After two bytes are read or written, the CPU re-synchronizes with the next 'byte ready' status from the floppy disk controller.

```
; CALL WITH NUMBER OF DATA BYTES TO WRITE IN [A]
; AND POINTER TO DATA BUFFER IN [H,L]
; ALL REGS DESTROYED.

DSKO: MOV     C,A             ;SAVE # OF BYTES IN C
      MVI     A,136           ;CALCULATE NUMBER OF ZEROS TO WRITE
      SUB     C               ;SUBTRACT THE NUMBER OF DATA BYTES
      MOV     B,A             ;NUMBER OF ZEROS+1
      CALL    SECGET          ;LATENCY
      MVI     A,128           ;ENABLE WRITE WITHOUT SPECIAL CURRENT
      OUT     9
;
; CALL WITH [B]=NUMBER OF ZEROS [C]=NUMBER OF DATA BYTES
; AND [H,L] POINTING AT OUTPUT DATA
;
OHLDSK:       MVI     D,1             ;SETUP A MASK (READY TO WRITE)
      MVI     A,128           ;HIGH BIT (D7) ALWAYS ON IN FIRST BYTE
      ORA     M               ;OR ON DATA BYTE
      MOV     E,A             ;SAVE FOR LATER
      INX     H               ;INCREMENT BUFFER POINTER
NOTYTD:       IN      8               ;GET WRITE DATA READY STATUS
      ANA     D               ;TEST STATUS BIT
      JNZ     NOTYTD          ;NOT READY TO WRITE, WAIT
      ADD     E               ;ADD BYTE WE WANT TO SEND TO ZERO
      OUT     10              ;SEND THE BYTE
      MOV     A,M             ;GET NEXT BYTE TO SEND
      INX     H               ;MOVE BUFFER POINTER AHEAD
      MOV     E,M             ;GET NEXT DATA BYTE
      INX     H               ;MOVE BUFFER POINTER AHEAD AGAIN
      DCR     C               ;DECREMENT COUNT OF CHARS TO SEND
      JZ      ZRLOP           ;IF DONE, QUIT & GO TO ZRLOP
      DCR     C               ;DECREMENT COUNT OF CHARS AGAIN
      OUT     10              ;SEND THIS BYTE
      JNZ     NOTYTD          ;STILL MORE CHARS, DO THEM.
ZRLOP:        IN      8               ;GET READY TO WRITE
      ANA     D               ;IS IT READY
      JNZ     ZRLOP           ;IF NOT, LOOP
      OUT     10              ;KEEP SENDING FINAL BYTE
      DCR     B               ;DECREMENT COUNT OF BYTES TO SEND
```

```
        JNZ     ZRLOP           ;KEEP WAITING
        EI                      ;RE-ENABLE INTERRUPTS
        MVI     A,8             ;UNLOAD HEAD
        OUT     9               ;SEND COMMAND
        RET                     ;DONE

; DISK INPUT ROUTINE. ENTER WITH POINTER
; OF 137 BYTE BUFFER IN [H,L]. ALL REGS DESTROYED.
DSKI:   CALL    SECGET          ;POINT TO RIGHT SECTOR
        MVI     C,137           ;GET # OF CHARS TO READ
READOK: IN      8                       ;GET DISK STATUS
        ORA     A               ;READY TO READ BYTE
        JM      READOK
        IN      1Ø              ;READ THE STUFF
        MOV     M,A             ;SAVE IN BUFFER
        INX     H               ;BUMP DESTINATION POINTER
        DCR     C               ;LESS CHARS
        JZ      RETDO           ;IF OUT OF CHARS, RETURN
        DCR     C               ;DECREMENT COUNT OF CHARS
        NOP                     ;DELAY INTO NEXT BYTE
        IN      1Ø              ;GET NEXT BYTE
        MOV     M,A             ;SAVE BYTE IN BUFFER
        INX     H               ;MOVE BUFFER POINTER
        JNZ     READOK          ;IF CHARS STILL LEFT, LOOP BACK
RETDO:  EI                              ;RE-ENABLE INTERRUPTS
        MVI     A,8             ;UNLOAD HEAD
        OUT     9               ;SEND COMMAND
        RET

SECGET: MVI     A,4                     ;LOAD THE HEAD
        OUT     9
        DI                      ;DISABLE INTERRUPTS
SECLP2: IN      9                       ;GET SECTOR INFO
        RAR                     ;FIX UP SECTOR #
        JC      SECLP2          ;IF NOT, KEEP WAITING
        ANI     31              ;GET SECTOR #
        CMP     E               ;IS IT THE ONE WE WANTED
        JNZ     SECLP2          ;TRY TO FIND IT
        RET
```

The Disk PROM Bootstrap Loader

The Disk bootstrap loader PROM must be installed in the highest position on the PROM board and the PROM board must be strapped at the proper address. The proper position is the PROM IC socket on the opposite side of the board from the black finned heat sink. The black dot or '1' on the PROM should be in the upper left corner. The address jumpers on the PROM board must be in the '1' position.

To use the Disk bootstrap loader, turn the computer's power on. Raise RESET and STOP simultaneously. Lower RESET and then STOP. EXAMINE location 177400 (address switches A15-A8 up, rest down) and then set the sense switches for the terminal I/O board as explained in Appendix B. Depress the RUN switch. BASIC should print (or display):

MEMORY SIZE?

For the rest of the initialization procedure, see below.

Using the Cassette and Paper Tape Bootstraps

If the Disk Bootstrap PROM is not in use, a paper tape or cassette program must be loaded which then reads in BASIC from the disk. This is done by following the procedure below:

1. Key in the applicable paper tape or cassette bootstrap loader from the listings in Appendix B. Make location 2=116 octal. Set the sense switches for the terminal

2. Start the paper tape or cassette (labeled DISK LOADER) reading, and then start the computer as in the instructions for loading BASIC from paper tape from cassette as given in Appendix B.

BASIC should respond:

MEMORY SIZE?

For the rest of the initialization procdure, see below.

Disk Initialization Dialog

The initialization dialog has been expanded to allow the user to select the proper amount of memory needed to use the disk(s) on the system. After the the MEMORY SIZE question is answered, BASIC will ask:

HIGHEST DISK NUMBER?

The user should answer with the highest physical disk address in the system or with carriage return to default to 0. Each additional disk uses 40 bytes of memory.

Example:

HIGHEST DISK NUMBER? 1

BASIC next asks how many files are to be OPEN at one time in the program. This number includes both random and sequential files. If the user types carriage return, the default is zero. Each file allocated requires 138 bytes for buffer space. Example:

HOW MANY FILES? 2

Finally, BASIC asks how many random files are to be OPEN at one time. The amount of memory allocated is the answer*257. This memory space is used to keep track of the location on the floppy disk where groups of a random file reside. Thus, the total memory required for each random file is 138+257=395 bytes. Example:

HOW MANY RANDOM FILES? 1

A typical dialog might appear as follows:

```
MEMORY SIZE? <carriage return>
HIGHEST DISK NUMBER? <carriage return>
HOW MANY FILES? 2 <carriage return>
HOW MANY RANDOM FILES? 1 <carriage return>

xxxxx BYTES FREE
Altair BASIC REV. 4.Ø
[DISK EXTENDED VERSION]
COPYRIGHT 1976 BY MITS INC.

OK
```

APPENDIX I

THE PIP UTILITY PROGRAM

A BASIC Utility program has been provided to perform such such common functions as printing directories, initializing disks, copying disks etc.

NOTE

Some of the PIP commands (LIS, DIR) require that one <file number> be configured during the Disk BASIC initialization dialog. This is done by answering the "HOW MANY FILES?" question with a value greater than zero. If an attempt is made to perfrom a LIS or DIR without following this procedure, a BAD FILE NUMBER error will occur.

Once the BASIC disk has been mounted, type the following command:

```
RUN "PIP"<carriage return>
(PIP will type)
*
```

PIP is now ready to accept commands. To exit PIP, type a carriage return to the prompt asterisk. To initialize the floppy disk in drive Ø, type:

```
*INIØ
```

PIP will type "DONE" when it is finished. Any disk number may be substituted for the Ø in the above command and PIP will format the disk in that drive. Any previous files on the disk initialized will be lost. If you wish to use blank disks with Disk BASIC, they must be initialized in this fashion before they can be MOUNTed.

NOTE

DO NOT INITIALIZE THE DISK WITH DISK EXTENDED BASIC ON IT. THIS WILL WIPE OUT ALL THE FILES PROVIDED ON THE DISK.

Printing a Directory

Giving PIP the command:

*DIR<disk number>

prints out a directory of the files on the specified disk. The name of each file is printed, along with the file's "mode" (S for sequential, R for random), and the starting track and sector number of the first block in the file.

SRT<disk number>

prints a sorted directory of the files on the specified disk.

LISting Sequential Files

The LIS command is used to list the contents of a sequential data file on the terminal:

Syntax:

LIS<disk number>,<file name>

Example:

```
*LIS0,PIPA      user types
7 CLEAR 1000    computer prints
      .
      .
      .

*
```

COPying Disks

The COP command is used to copy a disk placed in one drive to a disk on another drive. Neither disk need be MOUNTed for the COP command to work properly.

Syntax:

COP<old disk number>,<new disk number>

Before the copy is done, PIP verifies the actionn by printing the following massage:

FROM<disk number>TO<disk number>

Typing Y followed by a carriage return causes execution to proceed. Any other responce aborts the command. Example: *COP0,1 FROM 0 TO 1? YCARRIAGE return> DONE *

The DAT command

The DAT command is used to dump out a particular sector of the disk in octal.

Syntax:

DAT<disk number>

When the DAT command is issued, PIP asks for the numbers of the track and sector to be dumped. Example: *DAT0 (DAT is equivalent) TRACK? 0 SECTOR? 0 000 000 000 000 000 000 000 000 000 000 000 000 000 000 etc.

The CNV command

CNV converts disks written under Altair BASIC version 3.4 and 3.3 to a format useable by version 4.0. The format of the command is as follows:

CNV<disk number>

CNV makes sure that the next to last byte of each sector is 255.

Other Programs Provided on the System Disk

Program Name	Use
STARTREK	Plays game based on TV series.

APPENDIX J
BASIC TEXTS

Below are a few of the many texts that may be helpful in learning BASIC.

1) BASIC PROGRAMMING, John G. Kemeny, Thomas E. Kurtz, 1967, 145pp.
2) BASIC, Albrecht, Finkel and Brown, 1973
3) A GUIDED TOUR OF COMPUTER PROGRAMMING IN BASIC, Thomas A. Dwyer and Michael S. Kaufman; Boston: Houghton Mifflin Co., 1973

Books numbered 1 and 2 may be obtained from:

People's Computer Company
P.O. Box 310
Menlo Park, California 94025

They also have other books of interest, such as:

101 BASIC GAMES, David Ahl, Ed., 1974, 250pp.
WHAT TO DO AFTER YOU HIT RETURN or PCC's FIRST BOOK OF COMPUTER GAMES
COMPUTER LIB AND DREAM MACHINES, Theodore H. Nelson, 1974, 186pp.

APPENDIX K

USING Altair BASIC ON THE INTELLEC* 8/MOD 80 AND MDS SYSTEMS.

This appendix covers procedures for loading and operating Altair BASIC on Intellec and MDS development systems.

A. Loading BASIC. To load Altair BASIC, put the hex paper tape of BASIC in the system reader device. Now enter the System and assign the CONSOLE I/O device as desired (see Section 4.2.1 of the Intellec 8/Mod 80 Operator's Manual). Now read in BASIC with the following R command.

.R(Cr)

The BASIC tape will be loaded into memory and the system monitor will type a period on the CONSOLE device. If you are only using contiguous RAM memory below the system monitor (3800H) or are using BASIC on a MDS System, proceed to step 2. If you have RAM memory above the PROM Intellec monitor which you wish BASIC to use for program and variable storage, you must patch the two locations known as INTLOC to point to the bottom (lowest address) of memory. The is most easily accomplished by using the System Monitor S command. INTLOC is given below under "Memory Requirements."

.SXXXX 00 40 (Cr)

The above S command would make INTLOC point to RAM, starting at 16K.

NOTE

If you are using RAM above 16K for program and variable storage and have patched INTLOC, retain all the math functions at initialization time (see Appendix B). Essentially, this means that the WANT SIN-COS-TAN-ATN? questions asked by BASIC's initialization dialog should be answered by a Y(Cr). Also, you must answer the MEMORY SIZE? question with the highest decimal or RAM address in your system.

Start BASIC by giving the monitor GOTO command

.G0000<carriage return>

NOTE

Once BASIC has been started, it may always be restarted by depressing the RESET switch on the Intellec 8 console.

When BASIC types MEMORY SIZE?, Typing carriage return will cause BASIC to use all the RAM memory it can find above the end of BASIC. Otherwise, if you wish to specify an exact amount of memory, type the decimal address of the highest byte of memory in the computer and type carriage return.

B. BASIC I/O.

The system devices used for terminal I/O in BASIC are CI, CO and CSTS.

C. Saving and Loading Programs.

To save a program on paper tape, re-enter the PROM monitor and reassign the CO device to the paper tape punch or other output device. Then restart BASIC by using the G0000 command and type LIST(Cr). The characters of the LIST command will not be echoed, but the BASIC program currently saved in memory will be put on the output device.

To load a program enter the system monitor, re-assign CI to the input device where the program resides, and then start BASIC with a G0000. When the program has been completely read in, reassign CI to the user console. Then re-enter BASIC with a G0000, and start the I/O device. The program will be echoed on CO as it is read in.

D. Memory Requirements

BASIC uses locations 0000H-0003H and 0010H-approximately 19DFH in the 8K version, and 0010H-2F0EH in the Extended version. For Intellec 8K and MDS 8K BASICs, INTLOC is 6520 decimal. For MDS Extended, INTLOC is 14257 decimal.

E. Calling Assembly Language Routines

USRLOC for 8K BASIC is 0055H. ADR(DEINT) is stored in locations 0043H. ADR(GIVACF) is stored in location 0045H. In the Extended version these locations contain the addresses of FRCINT and MAKINT, respectively. Interrupt driven subroutines using RST 7 are not allowed in the Intellec/MDS version of Altair BASIC. See Appendix C. for further information on calling assembly language subroutines.

* Intellec is a registered trademark of the Intel Corporation.

APPENDIX L
PATCHING BASIC'S I/O ROUTINES

BASIC's I/O routines may be changed to accommodate non-standard terminal equipment. After BASIC is loaded and before it has been initialized, location 71 contains a pointer to a list of addresses. These addresses contain the I/O routines of BASIC:

```
        ORG     7Q1
        DW      IOLST           ;TWO  BYTE ADDRESS OF ADDRESS LIST
        .
        .
        .
IOLST:  DW      TRYOUT          ;ADDRESS OF OUTPUT ROUTINE
        DW      TRYIN           ;CHARACTER INPUT ROUTINE
        DW      ISCNTC          ;POLL FOR CONTROL/C CHECK
        DW      NEWSTT          ;FAST POLL FOR CONTROL/C CHECK
                                ;8K AND LARGER ONLY
        DW      IN2SIO          ;ADDRESS OF INITIALIZATION
                                ;ROUTINE FOR 2SIO BOARDS
        DW      IN4PIO          ;ADDRESS OF INITIALIZATION ROUTINE FOR
                                ;4PIO BOARDS
        DW      LPTCOD          ;ADDRESS OF LPT ROUTINE (IN EXTENDED
                                ;AND DISK ONLY.)
        DW      LPTCD2          ;2ND LPT ROUTINE
        DW      LPTCD3          ;3RD LPT ROUTINE
        DW      IOCHNL          ;ADDRESS OF I/O RESET LOCATION
                                ;(IN EXTENDED AND DISK ONLY)
        .
        .
        .
TRYOUT: IN      Ø               ;GET DEVICE STATUS
        ANI     2ØØ             ;AND OFF BIT 7
        JNZ     TRYOUT          ;WAIT UNTIL TERMINAL CAN OUTPUT
        POP     PSW             ;GET CHARACTER TO OUTPUT OFF STACK
        OUT     1               ;TRANSMIT IT
        PUSH    PSW             ;SAVE CHARACTER BACK ON STACK
        NOP                     ;CHANGED TO "IN 41" FOR 4PIO BOARDS
        NOP
        POP     PSW             ;GET CHARACTER BACK OFF STACK
        RET                     ;ALL DONE WITH CHARACTER OUTPUT ROUTINE
        .
        .
        .
TRYIN:  IN      Ø               ;GET TERMINAL STATUS
        ANI     1               ;CHARACTER READY?
        JNZ     TRYIN           ;NO, KEEP WAITING
```

```
        IN      1               ;READ IN THE CHARACTER
        ANI     127             ;GET RID OF PARITY BIT
        CPI     CONTO           ;CONTROL/O?
        RNZ                     ;RETURN IF NOT
        .
        .
        .
ISCNTC: IN      Ø                 ;READ TERMINAL STATUS
        ANI     11              ;HAS THE TERMINAL A CHARACTER
                                  ;TO SEND?
        RNZ                     ;NO, RETURN
        .
        .
        .
;FOLLOWING ROUTINE IS IN 8K AND LARGER VERSIONS ONLY
;AND IS EXECUTED FOR EACH STATEMENT
NEWSTT: IN      Ø                 ;READ TERMINAL STATUS
        ANI     1               ;TEST BIT Ø
        CZ      CNTCCN          ;YES, SEE IF CHARACTER CONTROL/C
        .
        .
        .
IN2SIO: CPI     2*4               ;IS IT 2SIO
        RNC                     ;NO, OTHER GO DIRECTLY TO SETIO
        ADI     21              ;GET PROPER INITIALIZATION BYTE
        PUSH    PSW             ;SAVE IT
        MVI     A,3             ;INITIALIZE THE 2SIO
        CALL    DOIO2Ø
        POP     PSW             ;GET BACK SECOND INITIALIZATION BYTE
        JMP     DOIO2Ø          ;PROGRAM TO DATA AND STOP BITS
        .
        .
        .
IN4PIO: MVI     A,54Q             ;RESET FOR DATA TRANSFER
        DCR     M               ;CHANNEL=22
        CALL    DOIO2Ø
        .
        .
        .
LPTCOD: LDA     PRTFLG            ;SEE IF WE WANT TO TALK TO LPT
        ORA     A               ;TEST BITS
        JZ      TTYCHR          ;IF ZERO THEN NOT
        POP     PSW             ;GET BACK CHAR
        PUSH    PSW
        CPI     9               ;TAB
        JNZ     NOTABL          ;NO
MORSPL: MVI     A,32              ;GET SPACE
        OUTCHR                  ;SEND IT
        LDA     LPTPOS          ;GET CURRENT PRINT POSIT
        ANI     7               ;AT TAB STOP?
```

```
        JNZ     MORSPL          ;GO BACK IF MORE TO PRINT
        POP     PSW             ;POP OFF CHAR
        RET                     ;RETURN
NOTABL:
          POP     PSW             ;GET CHARACTER WE WANT TO PRINT
        PUSH    PSW
        CPI     13              ;IS IT CARRIAGE RETURN?
        CZ      PRINTW          ;FORCE OUT A LINE
        CPI     13              ;GET CONDITION CODES BACK
        JC      PPSWRT          ;IF FUNNY CONTROL CHARACTER
                                  ;(LF), DO NOTHING
        LDA     LPTPOS          ;WHERE ARE WE?
        CPI     LPTLEN-1        ;ARE WE AT END OF LINE?
        JNZ     NOTELP          ;NO, JUST SEND CHAR
        MVI     A,1             ;SET LPTLST=1 AND LPTPOS=0
        CALL    FINLP2
        DCR     A               ;MAKE SURE LPTPOS ZERO.
NOTELP:         INR     A
        STA     LPTPOS
LPTWAT: IN      2
        ORI     245
        INR     A
        JNZ     LPTWAT
        POP     PSW
        OUT     3               ;SEND OUT CHAR
        RET                     ;RETURN
;THIS ROUTINE IS CALLED TO FORCE OUT A PARTIAL BUFFER
;FOR THE LINE PRINTER. IT ALSO RESETS PRTFLG SO ALL
;FURTHUR I/O GOES TO THE USER'S TERMINAL
FINLPT: XRA     A               ;RESET PRINT FLAG SO OUTPUT
        STA     PRTFLG          ;GOES TO THE TERMINAL
        LDA     LPTPOS          ;SEE IF ANY LEFTOVERS MUST BE
        ORA     A               ;FORCED OUT
        RZ                      ;BY LOOKING AT LPTPOS
;THE ROUTINE PRINTW IS CALLED TO FORCE OUT A LINE CURRENTLY
;IN THE LINE PRINTER BUFFER. THE CARRIAGE RETURN/LINE FEED
;OUTPUT SUBROUTINE CALLS PRINTW
PRINTW: IN      2               ;MAKE SURE LAST PRINT
        ORI     245
        INR     A
        JNZ     PRINTW          ;BIT
; SEE IF BUFFER MUST BE EMPTIED
        LDA     LPTPOS
        ORA     A               ;CHARACTERS IN THE BUFFER?
        JNZ     PRINTR          ;IF SO DON'T CLEAR THE BUFFER
        LDA     LPTLST          ;PRINT BLANK LINE.
                                  ;CHECK IF PRINT WAS LAST
        ORA     A               ;IF SO, DO SPECIAL DELAY BECAUSE
                                ;OF DESIGN
        JZ      NTEXDL          ;PROBLEM
        PUSH    H               ;SAVE [H,L]
        LXI     H,19000         ;DELAY COUNT
```

```
LPTDLY: DCX     H               ;COUNT DOWN
        MOV     A,H
        ORA     L               ;UNTIL ZERO
        JNZ     LPTDLY
        POP     H               ;RESTORE [H,L] REGS
        STA     LPTLST          ;RECORD LINE FEED LAST
NTEXDL: MVI     A,2             ;SEND A LINE FEED COMMAND
        OUT     2
        XRA     A               ;RETURN WITH Ø &CC'S=Ø
        RET
PRINTR: MVI     A,1             ;TELL LPT TO PRINT
        OUT     2               ;STATUS REG
FINLP2: STA     LPTLST
        DCR     A               ;[A]=Ø
        STA     LPTPOS          ;RESET LINE PRINTER POSITION
        RET
        .
        .
        .
LPTCD2: LDA     LPTPOS          ;GET CURRENT LPT PRINT  HEAD POSITION
        ADD     M
        CPI     LPTLEN          ;WILL THIS NUMBER OVERLAP?
        JMP     LINCHK
        .
        .
        .
LPTCD3: LDA     LPTPOS          ;GET LINE PRINTER POSITION
                                ;NOTE: COLUMN WIDTH (CLMWID)=
                                ;14 CHARACTERS
NLPPOS          EQU     (((LPTLEN/CLMWID)-1)*CLMWID);POSITION BEYOND
                                ;WHICH THERE ARE
                                ;NO MORE COMMA FIELDS, SO
        CPI     NLPPOS          ;COMMA JUST DOES A "CRDO"
        JMP     CHKCOM          ;USE TELETYPE CHECK
        .
        .
        .
IOCHNL: Ø                       ;DEPOSIT BOARD TYPE HERE
        Ø                       ;CHANNEL GETS DEPOSITED HERE.
IOREST: LXI     H,IOCHNL        ;GRAB POINTER TO IT
        CALL    HELPIO          ;SET UP THE NEW CONSOLE DEVICE
        CALL    STKINI          ;MAKE STACK OK
        JMP     READY           ;AND TYPE "OK" HOPEFULLY ON GOOD CONSOLE
```

To patch the I/O routines, stop the machine after loading BASIC and insert the patches using the front panel switches or read in a tape containing the patches. Restart BASIC at location zero with all sense switches up. This will prevent BASIC from modifying the I/O routines. In general, these guidelines should be followed in writing I/O routines:

1. Insert a JMP at TRYOUT to the custom output routine. Be sure the PSW that is saved on the stack when the routine is entered is preserved. Make sure all registers are left unchanged when the routine is exited.

2. Insert a JMP at TRYIN to the custom input routine. Return the input character in the A register and do not change any of the other registers. The PSW may be changed.

3. To modify ISCNTC insert a CALL to the custom poll routine. This routine returns a non-zero condition code setting if no character is present, and zero if a character is present. The A register and the condition codes may be changed.

4. To change the initialization of the 2SIO board, change the "ADI 23Q" to "MVI A,XXX" where XXX is the new initialization byte.

5. To change the initialization of the 4PIO board, change the "MVI A,54Q" to a "MVI A,XXX" where XXX is the new initialization byte.

6. To patch in a new line printer driver change the code at LPTCOD. Note that PRINTW is also called by the routine which prints a carriage return line feed. The code at LPTCD2 and LPTCD3 must be changed if the line printer is not 80 characters wide.

7. To recover from an incorrect CONSOLE command, deposit the board type in IOCHNL, the board type in IOCHNL+1, and start the machine at IOCHNL+2.

Patching Disk BASIC - the PTD program. After Disk BASIC is loaded, deposit the desired patches in memory. Then examine and run PTD at location 54000 octal. After two or three seconds, the patched version of BASIC will be saved on disk. The save is complete when the Disk Enable light on disk drive zero goes out.

To save a patched version of BASIC on a disk which did not previously contain release 4.0 Altair BASIC, track 0 must be copied from a 4.0 disk.

PTD may also be used to save programs other than BASIC on tracks 0-4 of a diskette by loading the program after BASIC is loaded and running PTD. All memory locations between 0 and 46000 octal will be saved on tracks 0-4 on diskette zero.

APPENDIX M
USING ALTAIR DISK BASIC
An Example

The following is a discussion of how to program a typical application in BASIC. The example is the MITS in-house inventory system which is designed to run on the following hardware:

Altair 8800b computer with 32K memory, PROM memory board with the Disk PROM Bootstrap loader and a 2SIO serial I/O board
Two disk drives
24-line Lear-Sigler CRT terminal
Line printer

The most important part of the design for an application is setting up the files. Files that are correctly set up will be easy to use and maintain. Poorly set up files will be a perpetual headache, causing either an eventual rewrite or, more likely, abandonment of the system.

The first listing at the end of the appendix, INVEN, contains modules from the main program in the inventory system. INVEN shows how the central file (a random file) in the system is set up and how it is handled. The INVEN listing also shows the use of another random file and a sequential file. The CALC listing shows how to read programs as data files. CODE1 is a partial listing of a program that will be read as a data file.

The INVEN modules listed were included to show the following features:

1. program startup initialization and comments about the files used by the program (lines 1-35)

2. what the complete program does (lines 60-1000)

3. an example of how to modify records in a random file (lines 900-1040)

4. an example of how sequential files are used (lines 1800-1868 and 2700-2820)

5. one approach to the problem of handling a random file that spans more than one disk (lines 2000-2030)

6. three subroutines (lines 300-340, 9000-9020 and 9200-9220) that are called by the INVEN modules.

The function FNY (line 6) is used to round dollar amounts to thousandths of a cent. FNQ (line 7) is used to round quantities to thousandths and to convert single precision amounts to double precision.

INV3 is fielded once in the program initialization, but INV1 and INV2 are repeatedly fielded by calls to the subroutine at line 2000. The IF F>255 (line 60) avoids the possibility that the program can be stopped by an illegal function call at line 61.

PUT statements are the very last statements executed in the Remove from Inventory module, the Add to Inventory module, etc. This prevents updating one file but not the other. (This could happen if PUT Z, R1 was at line 1010.)

Line 2000 sets Z to 1 and R1 to N if the item wanted, N, is less than 2001. It sets Z to 2 and R1 to N-2000 if the item wanted is greater than 2000. Line 2020 then sets the pointers for the variables in the field statement to point into either the buffer for INV1 or the buffer for INV2, depending on whether the item wanted is less than 2001 or greater than 2000.

The CALC listing is a program which determines if there are enough parts in inventory to meet projected demands. Line 60 waits while the disk comes up to speed so the message "ENABLE DISK 1" will not be printed on the terminal. Lines 100-140 input up to fifty different product codes and the number of each product to be built. Line 170 opens a file for each product that contains the parts required for the product. Lines 220-250 build up a report heading extracting the product description contained in line 10 of each file.

Lines 120-150 accumulate the number of parts required for each product into the array Q. If more than 32767 of a part is required, a pointer is set in the array Q and the number of the part is accumuulated in the array Q!. This maneuvering is necessary since the system does not have enough memory to dimension Q as single precision instead of integer.

The parts lists for a product are programs saved with the A option. Since they are programs, their maintenance is very easy. For example, suppose that part 1071 in the 8800b is too marginal and that from now on part 1173 should be used instead. With the parts lists disk mounted on drive 0, the following sequence will update the 8800b file:

```
LOAD "CODE1"
160,1,1173
SAVE "CODE1",0,A
```

The programmer who is cramped for memory will find that programs can still be documented adequately if comments are set up as separate files. The memory used for variables when a program runs can be used for comments if the comments are merged in when the program is to be listed. Alternatively, the program could be listed in two or more parts. Additional memory can be obtained by bringing BASIC up without optional functions and with no files.

The main inventory program is set up so that a carriage return typed in responce to any prompt cause the program to dump the function descriptions on the CRT and to return to the FUNCTION NUMBER prompt. If the program were to be run on a printing terminal, instead of a 9600 baud CRT, it would not be set up to print the descriptions every time the operator wanted to get back to the FUNCTION NUMBER prompt. The list of function descriptions might be taped on the wall next to the terminal instead.

Listing of INVEN

```
1 DEFINT F-N
2 DEFINT R
3 DEFINT Z
5 DEFDBL P
6 DEF FNY#(Q8#)=INT(Q8#*A#+.5#)/A#
7 DEF FNQ#(Q9!)=INT(VAL(STR$(Q9!))*1000#+.5#)/1000#
8 A$=MKD$(0):B$=MKS$(0):A#=100000#
10 DIM Q$(2),P$(2)
11 '

INV1 ON DRIVE 0 HOLDS ITEMS 1-2000
INV2 ON DRIVE 1 HOLDS ITEMS 2001-4000
INV3 ON DRIVE 1 HOLDS SUMS LOGGED IN AND OUT BY DEPARTMENT
12 '
WEKLYRST AND MONTHRST ARE WRITTEN WHILE THE WEEKLY,
MONTHLY ACTIVE ITEMS LISTS ARE PRINTING;
CONTAIN THE ITEM #S THAT NEED TO BE RESET; AND ARE READ BY
THE WEEKLY,MONTHLY RESETS.
14 '
Q$() <=> THREE ON HAND QTY FOR: P$() <=> THREE PRICES
```

```
[P(0) OLDEST, P(1) NEXT OLDEST, Q(0)<>0 IF Q(1)<>0,
Q(1)<>0 IF Q(2)<>0]
D$ <=> DESCRIPTION   LEFT$(D$,3)="$$$" <=> INACTVE ITEM #
15 '
I1$ <=> WEEKLY QTY IN
I2$ <=> MONTHLY QTY IN
O1$ <=> WEEKLY QTY OUT
O2$ <=> MONTHLY QTY OUT
T$ <=> REORDER LEVEL
DI1$ <=> WEEKLY $ IN
ID2$ <=> MONTHLY $ IN
DO1$ <=> WEEKLY $ OUT
OD2$ <=> MONTHLY $ OUT
17 '
DT1$ <=> WEEKLY DEPT $ TAKEN
DX2$ <=> MONTHLY DEPT $ TAKEN
DG1$ <=> WEEKLY DEPT $ GIVEN
DY2$ <=> MONTHLY DEPT $ GIVEN

20 OPEN "R",#1,"INV1"
30 OPEN "R",#2,"INV2",1
32 OPEN "R",#3,"INV3",1
35 FIELD #3,8 AS DT1$,8 AS DX2$,8 AS DG1$,8 AS DY2$
60 PRINT:F=0:INPUT"FUNCTION NUMBER";F:IFF>255THEN63
61 ON F GOTO 210,350,350,1900,600,900,1700,
   2700,2500,2300,2400,1880,2900'
   2   3    4   5   6    7    8    9   10   11   12   13
   14   15   16
63 PRINT"1 - ENTER NEW ITEM"
64 PRINT"2 - LIST ITEM ON CRT (SHORT FORM)"
65 PRINT"3 - LIST ITEM ON CRT (LONG FORM)"
66 PRINT"4 - PRINT ITEMS ON LINE PRINTER
67 PRINT"5 - ADD TO INVENTORY"
68 PRINT"6 - REMOVE FROM INVENTORY"
69 PRINT"7 - PRINT WEEKLY DEPT DOLLAR RECORD ON LINE PRINTER
70 PRINT"8 - PRINT WEEKLY ACTIVE ITEMS LIST ON LINE PRINTER
71 PRINT"9 - WEEKLY RESET
72 PRINT"10- PRINT MONTHLY DEPT DOLLAR RECORD ON LINE PRINTER
73 PRINT"11- PRINT MONTHLY ACTIVE ITEMS LIST ON LINE PRINTER
74 PRINT"12- MONTHLY RESET
75 PRINT"13- RESET ORDER LEVELS
76 PRINT"14- PRINT LISTNG OF ITEMS NEEDING TO BE RE-ORDERED
77 PRINT"15- DELETE OLD ITEM
78 PRINT"16- ERRORS BACKOUT
100 GOTO60
298 '
*
SUB - INPUT PART # & GET RECORD
*
300 PRINT:PRINT:N=0:INPUT"PART NUMBER";N:IFN<1THENRETURN
310 IFN>4000THENPRINT:PRINT"''# TOO HIGH''":GOTO 300
320 GOSUB2000:GET#,R1
```

```
 330 IFLEFT$(D$,3)="$$$"THENPRINT:
    PRINT"''NO INFORMATION ON PART'";N:GOTO300
 340 RETURN
 890 '
 *
 F=6 - REMOVE FROM INVENTORY
 *
 900 GOSUB300:IFN=0GOTO63
 920 DN=-1:INPUT"NUMBER OF ITEMS REMOVED FROM INVENTORY";
    DN:IFDN=-1THEN63
 950 IFCVS(Q$(0))+CVS(Q$(1))+CVS(Q$(2))<DNTHENPRINT"
     ATTEMPT TO REMOVE MORE THAN ON HAND":PRINT:GOTO63
 960 D0=DN:P=0
 970 IFD0<CVS(Q$(0))THEN
     P=P+FNQ#(D0)*CVD(P$(0)):LSETQ$(0)=MKS$(CVS(Q$(0))-D0):
    GOTO1000
 980 P=P+FNQ#(CVS(Q$(0)))*CVD(P$(0)):D0=D0-CVS(Q$(0)):
     LSETQ$(0)=Q$(1):LSETQ$(1)=Q$(2):LSETQ$(2)=B$:
     LSETP$(0)=P$(1):LSETP$(1)=P$(2):LSETP$(2)=A$:IFD0THEN
    GOTO970
1000 LSETO1$=MKS$(CVS(O1$)+DN):LSETO2$=MKS$(CVS(O2$)+DN):
     LSETDO1$=MKD$(CVD(DO1$)+P):LSETOD2$=MKD$(CVD(OD2$)+P)
1020 GOSUB9200:IFC%=-1GOTO63
1030 LSETDT1$=MKD$(CVD(DT1$)+P):LSETDX2$=MKD$(CVD(DX2$)+P)
1040 PUT3,C%:PUTZ,R1:GOTO900
1790 '
*
F=9 - WEEKLY RESET
*
1800 PRINT"7 - WEEKLY DEPARTMENT RECORD
1802 PRINT"8 - WEEKLY ACTIVE ITEMS
1804 Z$="":INPUT"HAVE THE ABOVE BEEN LISTED FOR TODAY";Z$
1810 IFLEFT$(Z$,1)<>"Y"THENPRINT:PRINT
     "WEEKLY RESET NOT PERFORMED":GOTO63
1843 OPEN"I",4,"WEKLYRST"
1845 IFEOF(4)THENCLOSE4:KILL"WEKLYRST":GOTO1862
1850 INPUT#4,N:IF 1<=NANDN<=4000 THENGOSUB2000:GETZ,R1
     ELSEPRINTN;"OUT OF BOUNDS. RESET ABORTED.":END
1855 LSETI1$=B$:LSETO1$=B$:LSETDI1$=A$:LSETDO1$=A$:PUTZ,R1
1860 GOTO1845
1862 FORI=1TO20
1864 GET3,I:LSETDT1$=A$:LSETDG1$=A$:PUT3,I
1866 NEXT
1868 GOTO60
1999 '
*
SUB - GET Z,R1 FOR N AND FIELD TO INV1,2
*
2000 Z=1-(N>2000):R1=N+(Z=2)*2000
2020 FIELD Z,4 AS Q$(0),4 AS Q$(1),4 AS Q$(2), 8 AS P$(0),
    8 AS P$(1),8 AS P$(2),40 AS D$,4 AS I1$,4 AS I2$,
    4 AS O1$,4 AS O2$,8 AS DI1$,8 AS ID2$,8 AS DO1$,8 AS OD2$
```

```
2030 RETURN
2690 '
*
F=8,11 - WEEKLY,MONTHLY ACTIVE ITEMS LIST
*
2700 N=1:GOSUB2000:GOSUB2855
2703 IFF=8THENOPEN"O",4,"WEKLYRST"ELSEOPEN"O",4,"MONTHRST"
2705 IT#=0:OT#=0:TT#=0
2710 FORI=1TO2000
2720 GETZ,I:IFLEFT$(D$,3)="$$$"THEN2800
2723 Q0=CVS(Q$(0)):Q1=CVS(Q$(1)):Q2=CVS(Q$(2))
2725 IFF=8THENI!=CVS(I1$):O!=CVS(O1$):I#=CVD(DI1$):O#=CVD(DO1$)
     ELSEI!=CVS(I2$):O!=CVS(O2$):I#=CVD(ID2$):O#=CVD(OD2$)
2727 TT#=TT#+CVD(P$(0))*Q0+CVD(P$(1))*Q1+CVD(P$(2))*Q2
2730 IFI!+O!=0THEN2800
2733 PRINT#4,N+I-1
2735 IT#=IT#+I#:OT#=OT#+O#
2740 IFL9>59ANDKK=0THENGOSUB2850
2750 LPRINTUSING"######";99999!+N+I;
2770 LPRINTUSING"##,###,###";I!,O!,Q0+Q1+Q2,Q0+Q1+Q2+O!-I!;
2780 LPRINTUSING"$$,###,###.##";I#,O#
2790 L9=L9+1
2795 KK=KK+1:IFKK=5THENLPRINT:L9=L9+1:KK=0
2800 NEXT
2810 IFN=1THENN=2001:GOSUB2000:GOTO2710
2811 CLOSE4
2813 LPRINT:LPRINTUSING"TOTAL INVENTORY COST =$$##,###,###.##";TT#
2815 REM *GOTO2820 IN F=7,10
2820 LPRINT:LPRINTUSING"TOTAL IN = $$##,###,###.##";IT#
2830 LPRINTUSING"TOTAL OUT =$$##,###,###.##";OT#
2837 LPRINT:LPRINT
2840 GOTO50
2850 FORJ=L9TO66:LPRINT:NEXT
2855 IFF=8THENLPRINT"WEEKLY";:ELSELPRINT"MONTHLY";
2860 LPRINT" ACTIVE ITEMS LIST";:GOSUB9000
2865 LPRINTTAB(39);"STARTED"
2870 LPRINT"ITEM #    QTY-IN    QTY-OUT    ON-HAND    MO-WITH
      DOLLARS-IN    DOLLARS-OUT"
2880 LPRINT:KK=0:L9=6:RETURN
8990 '
*
SUB - PRINT TODAY'S DATE
*
9000 IFTD$=""THENLINEINPUT"TODAY'S DATE ?";TD$:IFTD$=""THEN63
9010 LPRINT" ";TD$
9015 LPRINT
9020 RETURN
9190 '
*
INPUT DEPARTMENT # AND GET TOTALS
*
9200 C%=-1:INPUT"ENTER DEPARTMENT CODE";C%:IFC%=-1THENRETURN
```

```
9210 IF1<=C%ANDC%<=20THENGET3,C%:RETURN
9220 PRINT"INVALID CODE":GOTO9200
```

Listing of CODE1

```
5  CODE1
10 PARTS LIST FOR: 8800B
20 OCT 30,1976
90 REM THIS IS THE START OF DATA
100 ,11,1042
110 ,3,1134
120 ,4,1040
130 ,1,1020
140 ,1,1021
150 ,1,1024
160 ,1,1071
170 ,1,1074
180 ,1,2105
190 ,24,348
200 ,2,326
```

Listing of CALC

```
10 CLEAR600
20 DEFINT A-Z
30 DIM CN(49),NU(49),Q(4000),Q!(200)
40 CLOSE:UNLOAD1
50 INPUT"PLACE DISK WITH PARTS LISTS IN DRIVE 1. HIT RETURN";G$
60 FORK!=1TO5000:NEXT:MOUNT1
90 LINEINPUT"TODAY'S MO/DA/YR ";DT$:H$(0)=DT$+" PARTS AVAILABLE FOR:"
95 '
INPUT QUANTITY OF EACH PRODUCT REQUIRED
*****
100 INPUT"CODE NUMBER(0 WHEN FINISHED)";CN(I)
110 IF CN(I)=0 THEN 150
120 IF CN(I)<1 OR 50<CN(I) THEN PRINT"INVALID CODE NUMBER":
    GOTO 100
130 INPUT"NUMBER OF UNITS TO BE MADE";NU(I)
140 I=I+1:IF I<50 THEN 100
145 '
ACCUMULATE QUANTITY OF EACH PART REQUIRED
*****
150 FOR K=0 TO I-1
160 ONERRORGOTO610
170 OPEN"I",#1,"CODE"+MID$(STR$(CN(K)),2),1
180 ONERRORGOTO0
190 LINEINPUT#1,A$:IFA$=""THEN190
200 IFLEFT$(A$,3)="90 "THEN260
210 IFLEFT$(A$,3)<>"10 "THEN190
220 IFKTHENH$(HK)=H$(HK)+","
```

```
 230 HH$=STR$(NU(K))+STR$(CN(K))+"=("+MID$(A$,20)+")"
 240 IFLEN(HH$)+LEN(H$(HK))>72THENHK=HK+1
 250 H$(HK)=H$(HK)+HH$:GOTO190
 260 ONERRORGOTO630
 270 IFEOF(1)THEN310
 280 INPUT #1,A,QN,PN
 290 IFQ(PN)<0THENQ!(-Q(PN))=Q!(-Q(PN))+NU(K)*QN
     ELSEQ(PN)=Q(PN)+NU(K)*QN
 300 GOTO270
 310 ONERRORGOTO0:CLOSE 1:NEXT K
 315 '
 GET SECOND HALF OF INVENTORY BACK ON LINE
 *****
 320 CLOSE:UNLOAD1
 330 INPUT"
 PLACE INVENTORY DISK #1 IN DRIVE 1. HIT RETURN TO START REPORT";G$
 340 FORI!=1TO5000:NEXT:MOUNT1
 360 OPEN"R",#2,"INV1"
 370 FIELD #2,4 AS Q1$,4 AS Q2$,4 AS Q3$,24 AS G$,40 AS D$
 375 '
 PRINT REPORT
 *****
 380 GOSUB570
 390 FOR I=1 TO 4000
 400 IF Q(I)=0 THEN 530
 410 QQ!=Q(I):IFQ(I)<0THENQQ!=Q!(-Q(I))
 420 IFL9>59ANDKK=0THENGOSUB560
 430 L9=L9+1
 440 RN=I
 450 IFI<2000THEN460ELSERN=RN-2000:IFFLAG=0THEN
     CLOSE2:OPEN"R",#2,"INV2",1:FLAG=1:
     FIELD#2,4 AS Q1$,4 AS Q2$,4 AS Q3$,24 AS G$,40 AS D$
 460 GET #2,RN
 470 IFLEFT$(D$,3)="$$$"THENLPRINTI+100000!;
     "********* NO INFORMATION ON PART ********";:
     LPRINTUSING"##,######";QQ!:GOTO520
 480 QH!=CVS(Q1$)+CVS(Q2$)+CVS(Q3$):QD!=QH!-QQ!
 500 LPRINTI+100000!;D$;" ";
 510 LPRINT USING "##,######";QQ!;QH!;QD!
 520 KK=KK+1:IFKK=5THENKK=0:LPRINT:L9=L9+1
 530 NEXTI:CLOSE:END
 560 FORK=L9TO66:LPRINT:NEXT
 565 '
 PRINT PAGE HEADING
 *****
 570 FORK=0TOHK:LPRINTH$(K):NEXT
 580 LPRINT:LPRINTTAB(52);"NEEDED  ON HAND   EXCESS":LPRINT
 590 KK=0:L9=5+HK:RETURN
 605 '
 TRAP ROUTINE: BAD CODE NUMBER
 *****
 610 IFERR=53THENPRINT:PRINT"NO CODE";MID$(STR$(CN(K)),2);" FILE"
```

```
620 ONERRORGOTO0
625 '
TRAP ROUTINE: ACCUMULATE INTO Q OVERFLOWED
*****
630 IFERR<>6ORERL<>290THENONERRORGOTO0
640 NQ=NQ+1:Q!(NQ)=Q(PN)+NU(K)*QN:Q(PN)=-NQ
670 RESUME270
```

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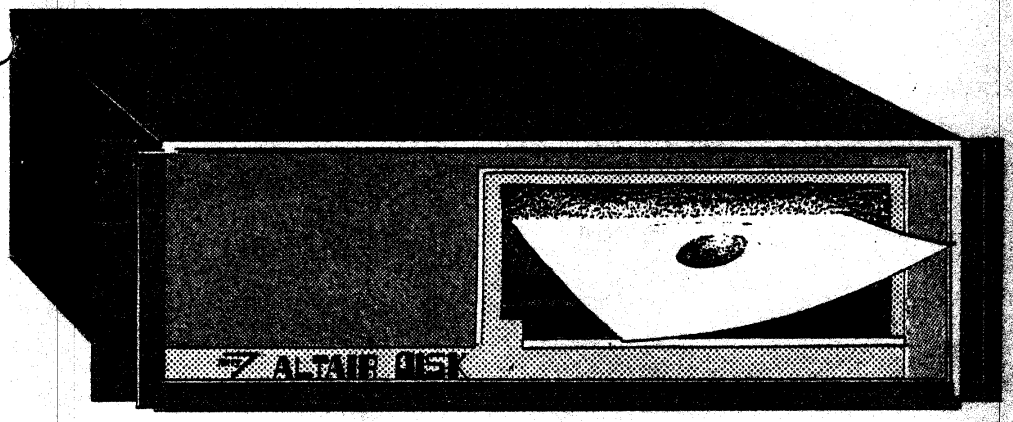
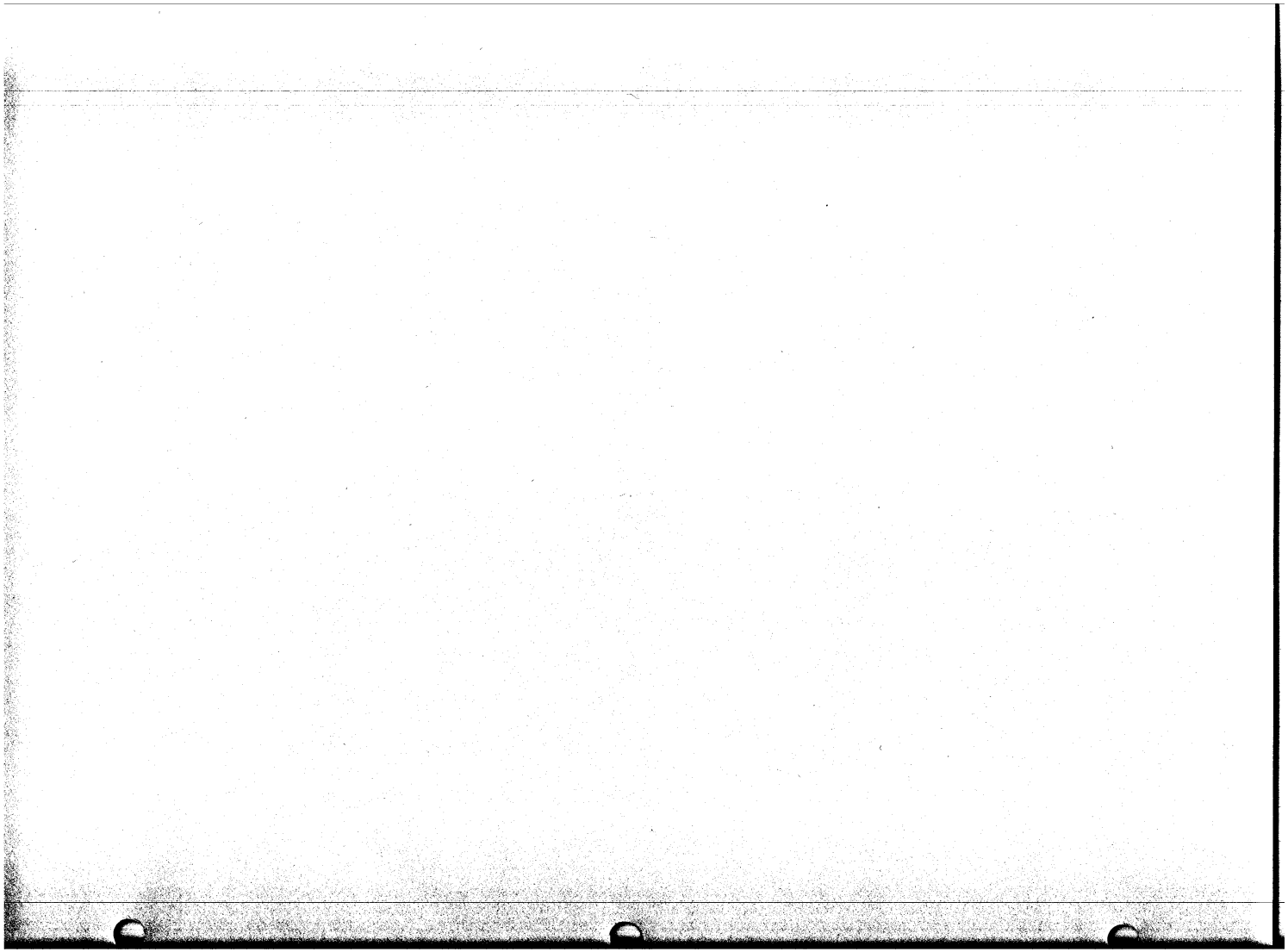
disk extended basic



mits



ALTAIR™ DISK EXTENDED BASIC

Table of Contents

This manual was prepared by Paul G. Allen

Introduction

ALTAIR DISK EXTENDED BASIC is an enhanced version of ALTAIR EXTENDED BASIC with added capabilities for saving and loading programs from the floppy disk and for manipulating data files on the disk.

ALTAIR DISK EXTENDED BASIC is similar to version 3.3 of ALTAIR BASIC . This means that many additional features are available which are not found in the 3.2 versions of BASIC.

DISK BASIC includes such features as the line-printer commands (LPRINT and LLIST) as well as the cassette commands (CSAVE and CLOAD) and CONSOLE command. These features as well as other improvements are described in Appendix C.

In previous material, facilities have been described for reading and writing information to the terminal (using INPUT and PRINT) and for embedding information in a program (with READ and DATA). These techniques are useful only when a small amount of information is required. When more data needs to be saved and retrieved, disk files are required.

Conventions for Syntax descriptions.

When the syntax of BASIC statements are described, the following conventions are used:

1) Items enclosed in angle brackets (<,>) must be supplied by the user as explained in the text. Items in capital letters (MOUNT, OPEN) must appear exactly as they are given.

2) Items enclosed in square brackets ([,]) are optional.

3) Items which are followed by dots (....) may appear zero or more times.

Up to sixteen floppy disks may be connected to a single ALTAIR disk controller.

These disks have been assigned the physical disk numbers zero through 15. Users with one drive should address the drive for zero, and users with two drives should address them for zero and one, etc.

> NOTE
>
> When <disk number> is given, it may be a numeric formula. (This could be a complicated expression like 16*I AND 5, a constant like 1, or just a variable like N).

<disk number> is a formula which gives an integer value specifying the disk on which the file resides. If the <disk number> is ommited from a statement the <disk number> is defaulted to disk 0.

To initialize disk(s) for reading and writing, the user must give a MOUNT command:

MOUNT [<disk number>[,<disk number>...]]

Example:

MOUNT 0

Mounts the disk on drive zero, and

MOUNT 0,1

Mounts the disks on drives zero and one. If there is already a disk MOUNTed on the specified drive(s) a DISK ALREADY MOUNTED message will be printed.

Before removing a disk which has been used for reading and writing by DISK BASIC, the user should give an UNLOAD command:

UNLOAD [<disk number>[,<disk number>...]]

UNLOAD 0

or

UNLOAD Ø,1

UNLOAD to an unMOUNTed disk does nothing. UNLOAD CLOSES all the files open on a disk, and marks the disk as unmounted. Before any further I/O is done on an UNLOADed disk, a MOUNT command must be given.

If a MOUNT command or UNLOAD command with no arguments is given, disks Ø thru the highest disk number specified in initialization (see Appendix E) will be affected.

> NOTE
>
> MOUNT and UNLOAD or any other disk command may be used as a program statement.

All data and program files on the disk have an associated file name. This name is the result of evaluating a string formula and must be one to eight characters in length. The first character of the file name cannot be a null (Ø) byte or a byte of 255 decimal or 377 octal. An attempt to use a null file name (zero characters in length) , a file name over 8 characters in length or containing a Ø or 377 in the first character position will cause a BAD FILE NAME error. Any other sequence of one to eight characters of 8-bit values is acceptable.

Examples of valid file names:

```
ABC
abc              (Not the same as above ABC)
filename
file.ext
12345678
INVNTORY
FILE##22
```

> NOTE
>
> Commands that require a file name will use <file name> in the appropriate position. Remember that a <file name> can be any string formula as long as the resulting string follows the rules given above.

The FILES Statement

The FILES statement is used to print out the names of the files residing on a particular disk. The format of the FILES statement is:

FILES <disk number>

Example:

```
FILES          (prints directory of files on disk Ø)

STRTRK
PIP
CURFIT
DISASM
```

> **NOTE**
>
> A more complete listing of the information stored on a particular file may be obtained by RUNning the PIP utility program (described in Appendix I).

SAVEing and LOADing programs

Once a program has been written, it is often desirable to save it on a disk for use at a later time. This is accomplished by giving a SAVE command:

SAVE <file name>[,<disk number>[,A]]

Example:

```
SAVE "TEST",Ø

or

SAVE "TEST"
```

Would save the program TEST on disk zero.

Whenever a program is SAVEd, any existing copy of the program previously SAVEd will be deleted, and the disk space used by the previous program of the same name will then be availible.

LOAD

The syntax of the LOAD statement is:

LOAD <file name>[,<disk number>[,R]]

Correspondingly,

LOAD "TEST",Ø or LOAD "TEST"

would load the program TEST from disk zero.

If the file does not exist, a FILE NOT FOUND error will occur.

LOAD "TEST",Ø,R

OK

LOADs the program TEST from disk zero and RUNs it. The LOAD command with the "R" option may be used to chain or segment programs into small pieces if the whole program is too large to fit in the ALTAIR's memory. All variables and program lines are deleted by LOAD, but all data files are kept OPEN(see below) if the "R" option is used so that information may be passed between programs through the use of disk data files.

If the "R" option is not used, all files are automatically CLOSEd (see below) by a LOAD.

Example:

```
NEW
10 PRINT "FOO1":LOAD "FOO2",Ø,R
SAVE "FOO1",Ø

OK
10 PRINT "FOO2":LOAD "FOO1",Ø,R
SAVE "FOO2",Ø

OK
RUN
FOO2
FOO1
FOO2
FOO1
```

```
.... etc.

(control-C may be used to stop execution at this point)
```

In this example, program FOO2 is RUN. FOO2 prints the message "FOO2" and then calls the program FOO1 on disk. FOO1 prints "FOO1" and calls the program FOO2 which prints "FOO2" and so on indefinitely.

If an attempt is made to LOAD a program which does not exist, the error message "FILE NOT FOUND will be printed.

SAVEing and LOADing Program Files in ASCII

Often it is desirable to save a program in a form that allows the program text to be read as data by another program, such as a text editor or resequencing program. Unless otherwise specified, BASIC saves its programs in a compressed binary format which takes a minimum of disk space and loads very quickly.

If you desire to save a program in ASCII format you must specify the "A" option on the SAVE command:

```
SAVE "TEST",0,A

OK

LOAD "TEST",0

OK
```

As you can see above, the LOAD command is able to determine which format to LOAD a program in from information in the file . The first character of an ASCII file is never 255, and a binary program file always starts with 255 (377 octal).

Remember, the LOAD of an ASCII file is much slower than the LOAD of a binary file.

The MERGE Command

Sometimes it is very useful to put parts of two programs together to form a new program combining elements of both programs. In order to provide this feature DISK BASIC has a MERGE command. MERGE is a command, so as soon as the MERGE has been executed, BASIC will type OK and stop.

Therefore it is unlikely that MERGE would be used in a program, and will more likely be used as a direct command. The format of the MERGE statement is:

MERGE <file name>[,<disk number>]

Example:

```
MERGE "PRINTSUB",1
OK
```

The <file name> specified is merged into the program already in memory. The <file name> must specify an ASCII format saved program or a BAD FILE MODE error will occur. If there are lines in the program on disk which have the same line numbers as lines in the program in memory, the lines from the file on disk will replace the corresponding program lines in memory. In other words, it is as if the program lines of the file on disk were typed in from the user terminal.

Deleting Disk files

To delete a disk file, the user should use a KILL statement:

```
KILL "TEST",0
```

The KILL statement deletes a file from the disk, and returns any disk space used by the file to free disk space. If the file does not exist, a FILE NOT FOUND error will occur.

If a KILL statement is given for a file that is currently OPEN (see below) a FILE ALREADY OPEN error occurs.

The format of a KILL statement is:

KILL <file name>[,<disk number>]

Renaming Files - the NAME Statement

The NAME statement is used to change the name of a file:

NAME <old file name> AS <new file name>[,<disk number>]

Example:

```
NAME "OLDFILE" AS "NEWFILE"
```

The <old file name> must exist or A FILE NOT FOUND error will occur. A file with the same name as <new file name> must not exist or a FILE ALREADY EXISTS error will occur. After the NAME statement has been executed the file will exist on the same disk in the same area of disk space. Only the name has been changed.

OPENing data files

When a program wishes to read and write data to a disk file, it must first OPEN the file on the appropriate disk in one of several modes. The general form of the OPEN statement is:

```
OPEN <mode>,[#]<file number>,<file name>[,<disk number>]
```

<mode> is a string formula whose first character is one of the following:

O	Specifies sequential output mode
I	Specifies sequential input mode
R	Specifies random Input/Output mode

Sequential means that the file is a stream of characters that will be read or written in order much like an INPUT statement reads from the terminal and PRINT writes to the terminal. Random files are divided into groups of 128 characters called records. The nth record of a file may be read or written at any time. Random files have other attributes that will be discussed in detail later.

<file number> is a formula that evaluates to an integer between zero and fifteen and is used to associate the file being OPENed with a number that will be used to refer to the file in later I/O operations.

Examples:

```
OPEN "O",1,"OUTPUT",0
OPEN "I",1,"INPUT"
```

The above two statements would open the files OUTPUT for sequential output and the file INPUT for

sequential input on disk zero.

```
OPEN M$,N,F$,D
```

The above statement would open the file whose name was in the string F$ in mode M$ as file number N on disk D.

Sequential ASCII file I/O

Sequential input and output files are the simplest form of disk input and output as they involve the use of the INPUT and PRINT statements with a file that has been previously OPENed.

To use an INPUT to read data from a file instead of the system console, use:

```
INPUT #<file number>,<variable list>
```

Where <file number> represents the number of the file that was OPENed for input , and <variable list> is a list of the variables to be read, as in a normal INPUT statement.

When data is read from a sequential input file using an INPUT statement, no question mark (?) is printed on the terminal. The format of data in the file should appear exactly the same way that it would be typed to a standard INPUT statement to the terminal.

When reading numeric values, leading spaces are ignored, as are carriage returns and line feeds in the file. When a non-space, non-carriage return, non-line-feed character is found, it is assumed to be part of a BASIC format number. The number terminates on a space, a carriage return , line-feed, or a comma.

When scanning for string items, leading blanks, carriage returns and line-feeds are also ignored. When a character which is not a leading blank, carriage return or line-feed is found, it is assumed to be the start of a string item.If this first character is a quote sign (") the item is taken as being a quoted string, and all characters between the first double quote (") and a matching double quote are returned as characters in the string value. This means that a quoted string in a file may contain any characters except double quote, e.g. carriage returns, line feeds and commas.

If the first character of a string item is not a double quote, then it is assumed to be an unquoted string literal. The string returned will terminate on a comma, carriage return or line feed.

In the case of either a quoted or unquoted string item if the length of the string exceeds 128 characters, the string is immediately terminated at 128 characters.

Also for both numeric and string items, if end of file (EOF) is reached when the item is being INPUT, the item will be terminated whether or not a closing quote was seen.

Example of sequential I/O (NUMERIC ITEMS):

```
500 OPEN "O",1,"FILE",0
510 PRINT #1,X,Y,Z
520 CLOSE #1
530 OPEN "I",1,"FILE",0
540 INPUT #1",X,Y,Z
```

Note that CLOSE is used so that a file which has just been written may be read. When FILE is re-OPENed, the data pointer for that file is set back to the beginning of the file so that the first INPUT on the file will read data from the start of the file.

PRINT #<file number>,<expression list>

or

PRINT #<file number>
USING <string expression>;<expression list>

are used to write data to a sequential output file. Example of sequential I/O (quoted string items):

```
500 OPEN "O",1,"FILE"
510 PRINT #1,CHR$(48);X$;CHR$(48);
515 PRINT #1,CHR$(48);Y$;CHR$(48);CHR$(48);Z$;CHR$(48)
520 CLOSE 1
530 OPEN "I",1,"FILE",0
540 INPUT #1,X$,Y$,Z$
```

In this example, the strings being output (X$, Y$, Z$) are surrounded with double quotes through the use of the CHR$ function to generate the ASCII value for a double quote. This technique must be used if a string which is

being output to a sequential data file contains commas, carriage returns, line-feeds, or leading blanks that are signifigant.

When leading blanks are not signifigent and no commas, carriage returns or line-feeds exist in the strings to be output, it is sufficient to insert commas between the strings being output, as in tne following example:

```
500 OPEN "O",1,"FILE"
510 PRINT #1,X$;",";Y$;",";Z$
520 CLOSE 1
530 OPEN "I",1,'FILE",0
540 INPUT #1,X$,Y$,Z$
```

CLOSE

The format of the CLOSE statement is as follows:

CLOSE [<file number>[,<file number>...]]

Close is used to finish I/O to a particular BASIC data file. After CLOSE has been executed for a file, the file may be reOPENed for input or output on the same or a different <file number>. a CLOSE to an unOPEN file has no effect. A CLOSE for a sequential output file writes the final buffer of output. A CLOSE to any OPEN file finishes tne connection between the <file number> and tne <file name> given in the OPEN for that file, and allows the <file number> to be used again in another OPEN.

A CLOSE with no argument CLOSEs all OPEN files.

> NOTE
>
> A FILE can be OPENed for sequential input or random access on more than one <file number> at a time, but may be OPEN for output on only one <file number> at a time.

END and NEW always CLOSE all disk files automatically, as do some disk errors (see Appendix E).

LINE INPUT

Often it is desirable to read a whole line of a file into a string without using quotes, commas or other characters as delimiters. This is especially true if certain fields of each line are being used to contain data items, or if a BASIC program saved in ASCII mode is being read as data by another program. The facility provided to perform this function is the LINE INPUT statement:

LINE INPUT #<file number>,<string variable>

or

LINE INPUT <string variable>

The latter form of LINE INPUT is used to perform the LINE INPUT function on the user's terminal. When a LINE INPUT without a <file number> is executed, a question mark will not be typed on the user terminal, and all input up to a carriage return will be returned in the <string variable>. The only way to escape a LINE INPUT from the user terminal is to type a control-G as the first character of input. This will cause BASIC to cease program execution and print OK. Execution at the LINE INPUT may be continued by typing CONT <carriage-return>.

Similarily, a LINE INPUT from a data file will return all characters up to a carriage return in <string variable>. LINE INPUT then skips over the following carriage return/line-feed sequence so that a subsequent LINE INPUT from the file will return the next line.

End of File (EOF) Detection

When reading a sequential data file with INPUT statements , it is usually desirable to detect when there is no more data in the disk file. The mechanism for detecting this condition is the EOF function:

X=EOF(<file number>)

EOF returns TRUE (-1) when there is no more data in the file and FALSE (0) if there is more. If an attempt is made to INPUT past the end of a data file, an INPUT PAST END error will occur.

Example:

```
100 OPEN "I",1,"DATA",0
110 I=0
120 IF EOF(1) THEN 160
```

```
130 INPUT #1,A(I)
140 I=I+1
150 GOTO 120
160 ......
```

In this example, numeric data from the sequential input file DATA is read into the matrix A. When end of file is detected, the IF statement at line 120 branches to line 160, and the variable I "points" one beyond the last element of A that was INPUT from the file.

Suppose one wishes to have a program that will calculate the number of lines in a BASIC program file that has been SAVEd in ASCII mode:

```
10 INPUT "WHAT IS THE NAME OF THE PROGRAM";P$
20 OPEN "I",1,P$,0
30 I=0
40 IF EOF(1) THEN 70
50 I=I+1:LINE INPUT #1,L$
60 GOTO 40
70 PRINT "PROGRAM ";P$;" IS ";I;" LINES LONG"
80 END
```

This example uses the LINE INPUT statement to read each line of the program into the "dummy" string L$, which is used essentially just to INPUT and ignore that part of the file.

Finding the Amount of Free Disk Space (DSKF)

It is sometimes necessary to determine the amount of free disk space remaining on a particular disk before allocating (writing) a file. The DSKF function provides the user with the number of free groups left on a given disk, after the disk has been MOUNTed. A group is the basic unit of file allocation, that is, files are always allocated in groups of eight sectors at a time. Each sector contains 128 characters (bytes). Therefore, the minimum size for a file is 1024 bytes.

Syntax for the DSKF function:

DSKF(<disk number>)

Example:

```
PRINT DSKF(0)
```

```
 200
```

The above example shows that there are 200*1024=204800 characters (bytes) that can still be stored on disk zero.

RANDOM FILE I/O

Previously, we have discussed how data may be PRINTed or INPUT from sequential data files.

However, it is often desirable to access data in a random fashion, for instance to retrieve information on a particular part number or customer from a large data base stored on a floppy disk. If sequential files were used, the whole file would have to be scanned from the start until the particular item was found. Random files remove this restriction and allow a program to access any record from tne first to the last in a speedy fashion.

Also, random files transfer data from variables to the disk ouput records and vice versa in a much faster, more efficient fashion than sequential files.

Random file I/O is more complex than sequential I/O, and it is recommended that beginners try sequential I/O first.

OPENing a FILE for Random I/O

Random I/O files are OPENed just like sequential data files, except tne <mode> is R:

```
OPEN "R",1,"RANDOM",Ø
```

When a file is OPENed for random I/O, it is always OPEN for both input and output simultaneously.

CLOSING Random Files

Random files must be closed when I/O operations are finished, just like sequential files. To CLOSE a random file, use the CLOSE operator as described previously.

```
CLOSE <file number>[,<file number>...]
```

Reading and writing data to a random file - GET and PUT

Each random file has associated with it a "random buffer" of 128 bytes. When a GET or PUT operation is performed, data is transferred directly from the buffer to the data file or from the data file to the buffer.

The syntax of GET and PUT is as follows:

PUT [#]<file number>[,<record number>]

GET [#]<file number>[,<record number>]

If <record number> is omitted from a GET or PUT statement, the record number that is one higher than the previous GET or PUT is read into the random buffer. Likewise, if <record number> is omitted. Initially a GET or PUT without a record number will read or write the first record. The largest possible record number is 2046. If an attempt is made to GET a record which has never been PUT, all zeroes are read into the record, and no error occurs.

LOC and LOF

LOC is used to determine what the current record number is for random files. In other words, it returns the record number that will be used if a GET or PUT is executed with the <record number> parameter omitted.

LOC(<file number>)

```
PRINT LOC(1)
 15
```

LOC is also valid for sequential files, and gives the number of sectors (128 byte blocks) read or written since the OPEN statement was executed.

LOF is used to determine the last record number written to a random file:

LOF(<file number>)

```
PRINT LOF(2)
 200
```

An attempt to use LOF on a sequential file will cause a BAD FILE MODE error.

The value returned by LOF is always 5 MOD 8. In other words, when the value LOF returns is divided by 8, the remainder is always 5. Therefore, the values returned by LOF are 5, 13, 21, 29 etc. This is due to the way random files are allocated.

> NOTE
>
> It is important to note that the value returned by LOF may be a record that has never been written in by a user program. This is because of the way random files are pre-extended.

Moving Data In and Out of the Random Buffer

So far we have described techniques for writing (PUT) and reading (GET) data from a file into its associated random buffer. Now we will describe how data from string variables is moved to and from the random buffer itself. This is accomplished through the use of the FIELD, LSET and RSET statements.

FIELD

The FIELD statement is used to associate some or all of a file's random buffer with a particular string variable. Then, when the file buffer is read with GET or written with PUT, string variables which have been FIELDed into the buffer will automatically have their contents read or written. The format of the FIELD statement is:

FIELD [#] <file number> [,<field size> AS <string variable>...]

<file number> is used to specify the file number of the file whose random buffer is being referenced. If the file is not a random file, a BAD FILE MODE error will occur.

<field size> is used to set the length of the string in the random buffer.

<string variable> is the string variable which is being associated with a certain number of characters (bytes) in the buffer.

Multiple fields may be associated with string variables in a given FIELD statement. Each successive string variable is assigned a successive field in the random buffer:

```
FIELD 10 AS A$, 20 AS B$, 30 AS C$
```

Thus, the above statement would assign the first 10 characters of the random buffer to the string variable A$, the next 20 characters to B$ and the next 30 characters to the variable C$.

It is important to note that the FIELD statement does not cause any data to be transferred to or from the random buffer. It only causes the string variables given as arguments to "point" into the random buffer.

Often, it is necessary to divide the random buffer into a number of sub-records to make more efficient use of disk space. For instance, it might be desirable to divide the 128 character record into two identical sub-records. To accomplish this, one need only place a "dummy" variable at the start of the FIELD statement to skip over the first sub-record in the record:

```
FIELD #1,64 AS D$, 20 AS NAME$,
        20 AS ADDRESS$, 26 AS OCCUPATION$
```

Then, the dummy variable D$ is used to skip over the first 64 characters in the record. Another way to do this would be to have a variable I that would select whether the first or second sub-record of a record was to be selected:

```
FIELD #1,64*(I-1) AS D$,
      20 AS NAME$, 20 AS ADDRESS$, 26 AS OCCUPATION$
```

Here, if the variable I is one, 1-1 *64 =0 characters will be skipped over, selecting the first sub-record. If I is two, 64 characters will be skipped over, selecting the second sub-record.

Another technique that is very useful is to use a FOR...NEXT loop and a matrix to set up sub-records in the random buffer:

```
1000 FOR I=1 TO 16
```

```
1010 FIELD #1, (I-1)*16 AS D$, 4 AS A$(I), 4 AS B$(I)
1020 NEXT I
```

In this example, we have divided the random buffer up into 16 sub-records, each composed of two fields , the first 4-character field in A$(X) and the second 4-character field in B$(X) where X is the sub-record number.

> **NOTE**
>
> The FIELD statement may be executed any number of times on a given file. It does not cause any allocation of string space, the only space allocation that occurs is for the string variables mentioned in the FIELD statement. These string variables have a one byte count and two byte pointer set up which points into the random buffer for the specified file.

Using Numeric Values in Random Files
MKI$, MKS$, MKD$ and CVI, CVS, CVD

As we have seen, data is always stored in the random buffer through the use of string variables. In order to convert between string and numbers and vice versa, a number of special functions have been provided.

To convert between numbers and strings:

MKI$(<integer value>)	Returns a two byte string (FC error if value is not >=-32768 and <=+32767. Fractional part lost)
MKS$(<single precision value>)	Returns a four byte string
MKD$(<double precision value>)	Returns an eight byte string

To convert between strings and numbers:

CVI(<two byte string>)	Returns an integer value
CVS(<four byte string>)	Returns a single precision value
CVD(<eight byte string>)	Returns a double precision value

CVI, CVS, and CVD all give an FC error if the string given as the argument is shorter than required. If the string argument is longer than necessary, the extra characters are ignored.

These functions are extremely fast, as they convert between BASIC's internal representation for integers, single and double precision values and strings. Conventional sequential I/O must perform time-consuming character scanning algorithms when converting between numbers and strings.

LSET and RSET

When a GET operation is performed, all string variables which have been FIELDed into the random buffer for that file automatically have values assigned to them. The CVI, CVS and CVD functions may be used to convert any numeric fields in the record to their numeric values.

When going the other way, i.e. inserting strings into the random buffer before performing a PUT statement, a problem arises. This is because of the way string assignments usually take place. For example:

```
LET A$=B$
```

When a LET statement is executed, the character string assigned to the left hand variable (A$) is created in string space. However, for assignments into the random we don't want this to happen. Instead, we want the string being assigned to stored where the string variable was FIELDed.

In order to do this, two special assignment statements have been provided, LSET and RSET:

```
LSET <string variable>=<string formula>

RSET <string variable>=<string formula>
```

```
LSET A$=MKS$(V)
RSET B$="TEST"
LSET C$(I)=MKD$(D#)
```

The difference between LSET and RSET concerns what happens if the string value being assigned is shorter than the length specified for the string variable in the FIELD statement. LSET left justifies the string, adding blanks to

pad out the right side of the string if it is too short. RSET right justifies the string, padding on the left. If the string value is too long, the extra characters at the end of the string are ignored.

> NOTE
>
> Do Not Use LSET or RSET on String variables which have not been mentioned in a FIELD statement, or a SET TO NON DISK STRING error will occur.

Appendix-A

DISK BASIC Error Messages

FIELD OVERFLOW

Attempt to allocate more than 128 characters worth of string variables in a single FIELD statement.

INTERNAL ERROR

Internal error in DISK BASIC. Report conditions under which error occurred to MITS software department, along with all relevant data. This error can also be caused by certain kinds of disk I/O errors.

BAD FILE NUMBER

An attempt was made to use a file number which specifies a file that is not OPEN, or that is greater than the largest file number allowed by the DISK BASIC initialization dialog.

FILE NOT FOUND

Reference was made in a LOAD, KILL OR OPEN statement to a file which did not exist on the disk specified.

BAD FILE MODE

Attempt to perform a PRINT to a random file, to OPEN a random file for sequential output, to perform a PUT or GET on a sequential file. An OPEN statement where the file mode is not I, O, or R.

FILE ALREADY OPEN

A sequential output mode OPEN for a file was issued for a file that was already OPEN and had never been CLOSEd or a KILL statement was given for an OPEN file.

DISK NOT MOUNTED

An I/O operation was issued for a file that was not MOUNTed.

DISK X I/O ERROR

An I/O error occured on disk X. A sector rea (checksum) error occurred five (5) consecutive times.

SET TO NON-DISK STRING

An LSET or RSET was given for a string variable whic nad not previously been mentioned in a FIELD statement.

DISK ALREADY MOUNTED

A MOUNT was issued for a DISK that was already MOUNTe but never UNLOADed.

DISK FULL

All disk storage is exhausted on the disk. Delete som old disk files and re-try.

INPUT PAST END

An INPUT statement was executed after all the data in a file had been INPUT. This will happen immediately if an INPUT is executed for a null (empty) file. Use of the EOF function to detect End Of File will avoid this error.

BAD RECORD NUMBER

PUT or GET statement, record number is eitner greater than allowable maximum (2046) or equal to zero.

BAD FILE NAME

A file name of 0 characters (null) or a file name whose first byte was 0 or 377 octal (255 decimal) or a file name with more than 8 characters was used as an argument to LOAD, SAVE, KILL or OPEN.

MODE-MISMATCH

Sequential OPEN (I or O) was executed for a file that already existed on the disk as a random (R) mode file, or vice versa.

DIRECT STATEMENT IN FILE

A direct statement was encountered during a LOAD of a program in ASCII format. The LOAD is terminated.

TOO MANY FILES

A SAVE or OPEN (O or R) was executed which would create a new file on the disk, but all 255 directory entries were already full.

Delete some files and try again.

OUT OF RANDOM BLOCKS

An attempt to have more random files OPEN at once than random blocks were allocated during initialization by the response to the "NUMBER OF RANDOM FILES?" question (see appendix E).

FILE ALREADY EXISTS

The new file name specified in a NAME statement had the same name as another file that already existed on the disk. Try a different new name.

Appendix-B

Format of Floppy Disk

Track Allocation:

Tracks	Use
0-5	Extended Disk BASIC memory image.
6-69	Space for either random or sequential files.
70	Directory track. See below.
71-76	space for sequential files only.

Format of DISK BASIC Memory Image (Tracks 0-5):

BASIC is loaded starting at track zero, sector zero then track 0 sector 1 through track 4, sector X. Each sector contains 128 bytes of BASIC. The first 128 bytes are loaded first, second 128 second, etc.

Sector format (Tracks 0-5):

Byte	Use
0	Track Number+128 decimal.
1-2	Sixteen bit address of first byte of memory that was not saved on disk.
3-130	128 bytes of BASIC.
131	255 decimal stop byte.
132	Checksum - sum of bytes 3-130 with no carry in 8 bits.

Even sectors 0, 2, . . ., 30 are recorded for the first 2048 memory bytes, and then the odd sectors 1, . . ., 31 for the next 2048 memory bytes.

Sector format (Tracks 6-76):

Byte	Use
0	MSB always on. Contains track number plus 200 octal.
1	Sector number * 17 mod 32.
2	File number in directory. Zero file number means that the sector is not part of any file. If the sector is the first file of a group of 8 sectors 0 means the whole group of 8 sectors is free.
3	Number of data bytes written (0 to 128) . Always 128 for random files. (Except for the random file index blocks in which case this byte indicates how many groups are allocated to the file.)
4	Checksum. The sum of all the data on the sector

except for the track number, the sector number and the terminating 255 byte.

5,6 Pointer to the next group of data. This is set up for random files and sequential files, and is even valid in the middle of a group. If it is zero it means there is no more data in the file. The track is the first byte and the sector number is the second byte.

7-135 Data

136 A 255 (octal 377) to make sure the right number of data bytes were read.

Directory Track (70) Format:

Each sector of the directory (which is all of track 68) is composed of up to 8 file name slots, 16 bytes per slot. Each slot can contain a file name (8 bytes), a link to the start of file data (2 bytes), and a byte which specifies the mode of a file (Random=4, Sequential=2). The remaining 5 bytes are not currently used. Any slot which has the first filename byte equal to zero contains a file which has been deleted. If the first byte of a slot is a 255 this means that it is the last slot currently in use in the directory. Slots beyond the "stopper" are garbage. File numbers are calculated by taking the sector of the directory track the file is in, times 16, plus the position of the slot in the sector (0-8) plus 1.

NOTE

The ith logical sector on a track is actually mapped to the i*17 mod 32 physical sector to improve latency in BASIC I/O operations.

Format of Random Files

Each random file starts with two random index blocks. The "number of data bytes" field in the first block indicates how many groups are currently allocated to this random file. The next 256 bytes in the two random index blocks give the location of each group in the random file in the order they are in the file. The upper two bits give the group number , and the lower six bits give the track number - 6.

Appendix-C

ALTAIR BASIC Version 3.3

Altair BASIC version 3.3 provides features not found in previous versions of ALTAIR BASIC.

Long Program Lines

BASIC Ver 3.3 Allows program lines to be up to 255 characters in length. In order to overcome the limitations of terminal widtn, <line-feed> characters may be inserted in a line to break it down into several "logical" lines:

```
10 IF X<0 THEN PRINT "NEGATIVE"<line-feed>
   ELSE IF X=0 THEN PRINT "ZERO"<line feed>
   ELSE PRINT "POSITIVE"<carriage return>
```

In general, <line feeds> may be placed anywhere in a line. However, it is not recommended that <line-feeds> be placed inside quoted string literals such as "ALTAIR 8800" or they will have the <line-feeds> embedded in their values. <line-feeds> embedded inside reserved words will be lost and will not appear when a line is LISTed. Each line must still be terminated by a <carriage return>, as shown above. When rubbing out characters with the backarrow or underline character, <line-feed> counts as one character only.

When LISTing or EDITing a line, <line-feed> is always printed as <line-feed><carriage-return> even though it is only counted as one character.

<line-feeds> can be very useful for formatting nested IF...ELSE sequences as shown above.

Leading Spaces Preserved

BASIC now preserves all spaces between the line number and the first non-blank character in the line. This makes indenting of nested loops and simular constructs feasible.

Example:

```
10 FOR I=1 TO 10
20   FOR J=1 TO 10
```

```
30   A(I,J)=0
40   NEXT J
50 NEXT I
```

CSAVEing and CLOADing Matrices

There is now a facility for saving numeric matrices on cassette, using CSAVE and CLOAD. The format of the statements is:

CSAVE.<matrix name>

and

CLOAD.<matrix name>

The matrix is written out in binary with four octal 210 header bytes to indicate the start of data. These bytes are searched for when CLOADing the matrix. The number of bytes written is four plus:

8*<number of elements> for a double precision matrix
4*<number of elements> for a single precision matrix
2*<number of elements> for an integer matrix

When a matrix is written out or read in, the elements of the matrix are written out with the rightmost subscript varying most quickly, the next most rightmost second, etc:

```
DIM A(10)
CSAVE.A
```

writes out A(0),A(1),...A(10)

```
DIM A(10,10)
CSAVE.A
```

writes out A(0,0), A(0,1)..A(1,0),A(1,1)..A(10,10)

Using this fact, it is possible to write out a matrix as a two dimensional matrix and read it back in as a single dimensional matrix, etc.

NOTE

Writing out a double precision matrix and reading it back in as a single precision or integer matrix is not recommended, due to the strange values that will undoubtedly be returned.

Octal Constants

Octal constants may be specified by placing an "&" sign before the number. These constants may take any value between &0 and &177777. Larger values will cause an "OVERFLOW" error. No sign (+ or -) should appear after the "&". If you wish to negate the number, place the sign before the "&" (-&10=-8).

Examples:

```
PRINT &377
 255

MEMORY SIZE? &20000

(&20000=8K or 8096 decimal)

10 READ N:PRINT VAL("&":STR$(N)):GOTO 10
20 DATA 377,201,350,10,42
```

the above program will print out the decimal equivalents of the octal numbers 377, 201, 350, 10 and 42.

End of Line Remarks - Single Quote

A single quote sign (') is used to cause BASIC to ignore the rest of a line. In many cases this is more convenient than using the REMark statement:

```
10 SUM=0'INITIALIZE SUM
20 R=X/Y ' COMPUTE RATIO OF X:Y
```

New CONSOLE Feature

A new standard feature has been implemented which allows the terminal console to be switched from the one specified at initialization to a new one. The format of the statement is:

CONSOLE <I/O channel number>,<switch register setting>

The <I/O channel number> is the hardware channel number of the low order (status) channel of the new I/O board. This value must be a numeric formula between 0 and 255 inclusive. If it is not in this range, a FUNCTION CALL error will occur. The <switch register setting> is also a value between 0 and 255 inclusive which specifies the type of I/O port (SIO, PIO, 4PIO etc) being CONSOLEd to. The table below or Appendix B of the BASIC manual and the first part of the Extended BASIC material should be referred to in order to find the appropriate value for <switch register setting>. If the user CONSOLEs to an I/O channel which is incorrect or non-existant, he should deposit the channel number at the location typed out by initialization, and then start the computer at that address plus one after setting the sense switches for his terminal configuration.

Table of values for <switch register setting>:

I/O Board	Value (Decimal)
SIOA,B,C (not REV 0)	0
SIOA,B,C (Rev 0)	64
88-PIO	32
4PIO	16
2SIO	8 (two stop bits), 12 (one stop bit)

WIDTH Statement

It is often desirable to be able to set the terminal width without having to re-initialize BASIC. To provide this facility, a WIDTH statement has been provided. The format of the WIDTH statement is:

WIDTH <numeric formula>

Example:

```
WIDTH 80
WIDTH 32
```

The <numeric formula> must have a value between 15 and 255 inclusive, or a FUNCTION CALL error will occur.

Expanded Assembly Language Features (DEFUSR)

Version 3.3 of BASIC now has the facility to call up to 10 different assembly language subroutines, numbered USR0-USR9. (USR is equivalent to USR0).

Also, a new statement has been provided to allow the user to specify the starting address in memory of any assembly language routines without having to remember what USRLOC is. This is done with the DEFUSR statement:

DEFUSR[<digit 0 through 9>]=<numeric formula>

Example:

```
DEFUSR1=&100000
DEFUSR2=31096
DEFUSR9=ADR
```

The <numeric formula> specifies the starting address of the USR routine specified.

Another important feature is the facility to pass string arguments, integer arguments and single precision arguments to a USR routine. When the USR subroutine is entered, the [H,L] register pair contains a pointer to the floating point accumulator (FAC) where all arguments are stored. The [H,L] registers point at the address FAC-3, which is the low order byte of the mantissa of a single precision floating point number or low byte of an integer quantity. Later documentation will explain how to force conversion of the FAC to different value types.

When the USR subroutine is entered, the A register contains the type of the argument which was given to the USR function. This is also the length of the descriptor for that argument type:

Value in A	Meaning
2	Two byte signed two's complement integer.
3	String.
4	Single precision four byte floating point number.
8	Double precision floating point number.

If the value in the FAC is a single precision floating point number, it is stored as follows:

FAC-3: Lowest 8 bits of mantissa.
FAC-2: Middle 8 bits of mantissa.
FAC-1: Highest 7 bits of mantissa with hidden (implied) leading one. Bit 7 is the sign of the number (0 positive,

1 negative).
FAC: Exponent excess 200 octal. An exponent of 200 is 2 to the zero power.

If the argument is double precision floating point, the FAC-7 to FAC-4 contain four more bytes of mantissa, low order byte in FAC-7, etc.

If the argument is an integer, FAC-3 contains the low order byte and FAC-2 contains the high order byte of the signed two's complement value.

If the argument was a string, [D,E] points to a string descriptor of the argument, whose form is:

Byte	Use
0	Length of string 0-255 decimal.
1-2	Sixteen bit address pointer to first byte of strings text in memory (Caution - may point into program text if argument is a string literal).

Normally, the value returned by a USR function will be the same type (integer, string, single or double precision floating point) as the argument which was passed to it.

However, calling the MAKINT routine whose address is stored in location 6 will return the integer in [H,L] as the value of the function, forcing the value returned by the function to be integer. Execute the following sequence to return from the function:

```
        PUSH    H               ;SAVE VALUE TO BE RETURNED
        LHLD    6               ;GET ADDRESS OF MAKINT ROUTINE
        XTHL                    ;SAVE RETURN ON STACK & GET BACK [H,L]
        RET                     ;RETURN
```

If the argument of the function could be integer, single or double precision, and you wish to force it to an integer, call the FRCINT routine whose address is located in location 4 to get the integer value of the argument in [H,L]:

```
SUBR:   LXI     H,SUB1          ;GET ADDRESS OF SUBROUTINE CONTINUATION
        PUSH    H               ;PLACE ON STACK
        LHLD    4               ;GET ADDRESS OF FRCINT
        PCHL                    ;CALL FRCINT

SUB1:   .....
```

INSTR Function

The INSTR function is used to find the position of the first occurrence of a string within another string:

X=INSTR(<string formula of string being searched>,<search string>)

or

X=INSTR(<numeric offset>,<string being searched>,<search string>)

Examples:

```
PRINT INSTR("MITS ALTAIR 8800","8800")
13

OK
PRINT INSTR(7,"MITS ALTAIR 8800","A")
9

OK
```

The first position of the string is always one. If the <numeric offset> is greater than the length of the string being searched or if the <string being searched> is null, INSTR returns zero. If the second string argument is the null (length zero) string, INSTR will return <numeric offset> (the default is one if <numeric offset> is omitted. If the <search string> cannot be found in the <string being searched>, INSTR returns zero.

Otherwise INSTR returns the character position of the first occurance of <search string> in the <string being searched>.

An FUNCTION CALL error will occur if the <numeric formula> is less than or equal to zero or greater than 255 decimal.

Improved RND function

The random number generator (RND(X)) has been much improved for BASIC version 3.3. It does not repeat after 30,000 calls.

The DSKI$ and DSKO$ Primitives

Often it is necessary for the user to perform disk I/O operations directly without using any of the normal file structure features of BASIC. To allow this, two special functions have been provided. These are the DSKI$ function and the DSKO$ statement.

First we will give examples of how to perform simple disk I/O commands using BASIC statements,

To Enable disk Ø:

```
OUT 8,Ø
```

To Enable disk N:

```
OUT 8,N
```

TO step the disk head out one track:

```
WAIT 8,2,2:OUT 9,1
```

To step the disk head in one track:

```
WAIT 8,2,2:OUT 9,2
```

To test for track Ø:

```
IF (INP(Ø) AND 64)=Ø THEN <statement or line number>
```

The above will execute the statements after the THEN if the head is positioned at track Ø.

This is the outermost track on the floppy.

To read sector Y (Y may be any expression, minimum sector =Ø, maximum = 31.)

```
A$=DSKI$(Y)
```

The statement

```
DSKO$ <string formula>,<sector formula>
```

writes the string formula on the sector specified. The high order bit (most signifigant) of the first character output will always be set to one when the string is written on the sector, and thus will always be one when the sector is read back in using DSKI$. A maximum of 137 characters are written. Giving a string whose length exceeds 137 characters will cause a "FUNCTION CALL" error. If the string argument is less than 137 characters in length, the end of the string will be padded with zeros to make a string

of length 137.

Example (variable Y contains the sector number):

```
DSKO$ A$,Y
```

Appendix-D

Line Printer features

A number of features are provided to make the line printer easy to use.

LLIST

LLIST allows the user to LIST his programs on the line printer. The syntax of LLIST is:

LLIST <line-range>

Examples:

LLIST

LLIST 10-500

LPRINT and LPRINT USING

LPRINT may be substituted for PRINT and LPRINT USING for PRINT USING in order to direct output to the line printer. The syntax is:

LPRINT <print list as in PRINT>

and

LPRINT USING <string formula>;<formula>[,<formula>....]

Examples:

```
LPRINT TAB(X*Y);"*";V

LPRINT X,Y,Z
LPRINT "ANSWER IS=";ANS
LPRINT USING "####.## GROSS INCOME ####.## NET INCOME";G,N
```

The LPOS Function

The LPOS function is used to determine the current position of the line printer print head within the line printer output buffer. It does not give the actual position of the line-printer's physical print head. The argument to LPOS must be a <numeric formula> but its value is ignored.

```
LPRINT TAB(10);LPOS(0)
```

would print 10 starting at column 11 on the line-printer.

Appendix-E

Disk Initialization Dialog

The initialization dialog has been expanded to allow the user to select the proper amount of memory he needs for using the disk(s) on his system. After the user has answered the MEMORY SIZE question, BASIC will ask:

HIGHEST DISK NUMBER?

The user should answer with the highest physical disk address in his system, or carriage return to default to 0. Each additional disk adds 40 bytes of memory.

Example:

HIGHEST DISK NUMBER? 1

BASIC next asks how many files the user wants to have OPEN in his program simultaneously. This number includes both random and sequential files. The default if the user types carriage return is zero: Each file allocated requires 138 bytes for buffer space.

HOW MANY FILES? 2

Finally, BASIC asks how many random files the user wants to have OPEN at one time. The amount of memory allocated is the answer*257. This memory space is used to keep track of the location on the floppy disk where groups of a random file reside.

HOW MANY RANDOM FILES? 1

A typical dialog might appear as follows:

```
MEMORY SIZE? <carriage return>
HIGHEST DISK NUMBER? <carriage return>
HOW MANY FILES? 2 <carriage return>
HOW MANY RANDOM FILES? 1 <carriage return>

xxxxx BYTES FREE
ALTAIR BASIC REV. 3.3
[DISK EXTENDED VERSION]
COPYRIGHT 1976 BY MITS INC.
CONSOLE RESTART LOCATION IS DECIMAL yyyyy
```

```
OK
```

Appendix-F

Assembly Code to Read and Write a Sector

The following code has been provided to help users write their own assembly language subroutines to read and write data on the floppy disk. It is assumed that the disk being used has already been enabled and positioned to the correct track.

Two data bytes are always read or written at a time so that the CPU can keep up with the data rate (1 byte/32 microseconds) of the floppy disk. After two bytes are read or written, the CPU re-synchronizes with the next 'byte ready' status from the floppy disk controller.

```
; CALL WITH NUMBER OF DATA BYTES TO WRITE IN [A]
; AND POINTER TO DATA BUFFER IN [H,L]
; ALL REGS DESTROYED.

DSKO:   MOV     C,A             ;SAVE # OF BYTES IN C
        MVI     A,136           ;CALCULATE NUMBER OF ZEROS TO WRITE
        SUB     C               ;SUBTRACT THE NUMBER OF DATA BYTES
        MOV     B,A             ;NUMBER OF ZEROS+1
        CALL    SECGET          ;LATENCY
        MVI     A,128           ;ENABLE WRITE WITHOUT SPECIAL CURRENT
        OUT     9
;
; CALL WITH [B]=NUMBER OF ZEROS [C]=NUMBER OF DATA BYTES
; AND [H,L] POINTING AT OUTPUT DATA
;
OHLDSK: MVI     D,1             ;SETUP A MASK (READY TO WRITE)
        MVI     A,128           ;HIGH BIT (D7) ALWAYS ON IN FIRST BYTE
        ORA     M               ;OR ON DATA BYTE
        MOV     E,A             ;SAVE FOR LATER
        INX     H               ;INCREMENT BUFFER POINTER
NOTYTD: IN      8               ;GET WRITE DATA READY STATUS
        ANA     D               ;TEST STATUS BIT
        JNZ     NOTYTD          ;NOT READY TO WRITE, WAIT
        ADD     E               ;ADD BYTE WE WANT TO SEND TO ZERO
        OUT     10              ;SEND THE BYTE
        MOV     A,M             ;GET NEXT BYTE TO SEND
        INX     H               ;MOVE BUFFER POINTER AHEAD
        MOV     E,M             ;GET NEXT DATA BYTE
        INX     H               ;MOVE BUFFER POINTER AHEAD AGAIN
        DCR     C               ;DECREMENT COUNT OF CHARS TO SEND
        JZ      ZRLOP           ;IF DONE, QUIT & GO TO ZRLOP
        DCR     C               ;DECREMENT COUNT OF CHARS AGAIN
        OUT     10              ;SEND THIS BYTE
        JNZ     NOTYTD          ;STILL MORE CHARS, DO THEM.
ZRLOP:  IN      8               ;GET READY TO WRITE
        ANA     D               ;IS IT READY
```

```
        JNZ     ZRLOP           ;IF NOT, LOOP
        OUT     10              ;KEEP SENDING FINAL BYTE
        DCR     B               ;DECREMENT COUNT OF BYTES TO SEND
        JNZ     ZRLOP           ;KEEP WAITING
        EI                      ;RE-ENABLE INTERRUPTS
        MVI     A,8             ;UNLOAD HEAD
        OUT     9               ;SEND COMMAND
        RET                     ;DONE

; DISK INPUT ROUTINE. ENTER WITH POINTER
; OF 137 BYTE BUFFER IN [H,L]. ALL REGS DESTROYED.
DSKI:   CALL    SECGET          ;POINT TO RIGHT SECTOR
        MVI     C,137           ;GET # OF CHARS TO READ
READOK: IN      8               ;GET DISK STATUS
        ORA     A               ;READY TO READ BYTE
        JM      READOK
        IN      10              ;READ THE STUFF
        MOV     M,A             ;SAVE IN BUFFER
        INX     H               ;BUMP DESTINATION POINTER
        DCR     C               ;LESS CHARS
        JZ      RETDO           ;IF OUT OF CHARS, RETURN
        DCR     C               ;DECREMENT COUNT OF CHARS
        NOP                     ;DELAY INTO NEXT BYTE
        IN      10              ;GET NEXT BYTE
        MOV     M,A             ;SAVE BYTE IN BUFFER
        INX     H               ;MOVE BUFFER POINTER
        JNZ     READOK          ;IF CHARS STILL LEFT, LOOP BACK
RETDO:  EI                      ;RE-ENABLE INTERRUPTS
        MVI     A,8             ;UNLOAD HEAD
        OUT     9               ;SEND COMMAND
        RET

SECGET: MVI     A,4             ;LOAD THE HEAD
        OUT     9
        DI                      ;DISABLE INTERRUPTS
SECLP2: IN      9               ;GET SECTOR INFO
        RAR                     ;FIX UP SECTOR #
        JC      SECLP2          ;IF NOT, KEEP WAITING
        ANI     31              ;GET SECTOR #
        CMP     E               ;IS IT THE ONE WE WANTED
        JNZ     SECLP2          ;TRY TO FIND IT
        RET
```

Appendix-G

The Disk PROM Bootstrap Loader

To use the Disk PROM bootstrap loader, you must have the PROM in the PROM board and the PROM board must be strapped at the proper address. First, insert the PROM in the highest PROM position. This is the PROM IC socket on the opposite side of the board from the black finned heat sink. The black dot or '1' on the PROM should be in the upper left corner.

Next, strap the address on the PROM board for all ones (all address jumpers in the '1' position).

To use the Disk bootstrap loader, power up the ALTAIR. Raise RESET and STOP simultaneously. Lower RESET and then STOP. EXAMINE location 177400 (address switches A15-A8 up, rest down) and then set the sense switches for your terminal I/O board as explained in the BASIC manual (Appendix B). Depress the RUN switch. BASIC should print (or display):

```
MEMORY SIZE?
```

For the rest of the initialization procedure, see Appendix E.

Appendix-H

Using the Cassette and Paper Tape Bootstraps

If you do not have the PROM Disk Bootstrap, you must load in a paper tape or cassette program which will then read in BASIC from the disk. To do this, follow the procedure below:

1.) Key in the paper tape or cassette bootstrap loader with location 1=256, location 2=116 octal. Set the sense switches for your terminal (see Appendix A of the BASIC manual and the first part of the Extended BASIC manual).

2.) Start the paper tape or cassette (labeled DISK LOADER) reading, and then start the ALTAIR as per the instructions for loading BA from paper tape from cassette as given in the BASIC manual Appendix A.

BASIC should respond:

MEMORY SIZE?

For the rest of the initialization procdure, see Appendix E.

Appendix-I

The PIP Utility Program

A Utility BASIC program has been provided to perform such such common functions as printing directories, initializing disks, copying disks etc.

> **NOTE**
>
> Some of the PIP commands (LIS, DIR) require that one <file number> was configured during the Disk BASIC initialization dialog. This is done by answering the "HOW MANY FILES?" question with a value greater than zero. If an attempt is made to perfrom a LIS or DIR without following this procedure, a BAD FILE NUMBER error will occur.

Once you have MOUNTed the EXTENDED BASIC DISK, type the following command:

```
LOAD "PIP",0,R
(PIP will type)
*
```

To initialize the floppy disk in drive 0, type:

```
*INI0
```

PIP will type "DONE" when it is finished. Any disk number may be substituted for the 0 in the above command and PIP will format the disk in that drive. Any previous files on the disk initialized will be lost. If you wish to use blank disks with DISK EXTENDED BASIC, they must be initialized in this fashion before they can be MOUNTed.

NOTE

DO NOT INITIALIZE THE DISK WITH DISK EXTENDED BASIC ON IT. IF YOU DO SO, YOU WILL WIPE OUT ALL THE FILES PROVIDED ON YOUR DISK AND YOU WILL HAVE TO ORDER ANOTHER COPY.

Printing a Directory

Giving PIP the command:

```
*DIRØ
```

will print out a directory of the files on disk zero . The name of each file is printed, along with the files "mode" (S for sequential, R for random), and the starting track and sector number of the first block in the file.

LISting Sequential Files

The LISt command is used to list the contents of a sequential data file on the terminal:

Syntax:

LIS<disk number>,<file name>

Example:

```
*LISØ,PIPA
7 CLEAR 1ØØØ
.etc

*
```

COPying Disks

The COPy command is used to copy a disk placed in one drive to a disk on another drive. Neither disk need be MOUNTed for the COPy command to work properly.

Syntax:

COP<old disk number>,<new disk number>

Example:

```
*COPØ,1
FROM Ø TO 1
DONE
*
```

The DATa command

The DATa command is used to dump out a particular sector of the disk in octal.

Syntax:

DAT<disk number>

Example:

```
*DATØ           (DAT is equivalent)
TRACK? Ø
SECTOR? Ø
ØØØ ØØØ ØØØ ØØØ ØØØ ØØØ ØØØ ØØØ
ØØØ ØØØ ØØØ ØØØ ØØØ etc.
```

Appendix-J

Other Programs Provided on the System Disk

Program Name	Use
STARTREK	Plays game based on TV series.

Appendix-K

Miscellaneous

1.) If you are using a non-standard terminal port number, deposit the port number in octal location 47777 before starting BASIC at location zero.

INDEX

BASIC Disk Version 3.4 Released
by Paul Allen

Version 3.4 will be released only in the disk version because version 4.0 will be released within a month for all four versions of BASIC. Version 4.0 will allow cassettes of programs to be interchangeable between the different versions of BASIC (8K, Extended, Disk), so it was decided to release 3.4 only in the disk version until 4.0 was ready. Users who have ordered 3.4 will receive 4.0 (except for those who have ordered Disk 3.4). 4.0 in the Extended and Disk versions will have constant compression and line pointers which should speed up program execution in these versions significantly.

3.4 and 4.0 will have all the features of 3.3 which was described in detail in the Disk documentation. This means that the Extended and Disk versions will have long lines (255 characters), the INSTR function, CONSOLE, the WIDTH command for setting terminal width, single quote (') remarks, and multiple assembly language subroutines (DEFUSR). The 8K version , Extended version, and Disk version all have octal constants and CLOADing and CSAVEing of matrices on cassette.

> **NOTE**
>
> The Extended version of 4.0 BASIC will require 16K bytes minimum for execution (Extended BASIC 4.0 itself requires 12K).

BASIC version 3.4 has a number of added features as well as a number of bug fixes.

The bug fixes are:

1.) BASIC (all versions) now works properly with the 4PIO board as described in previous Extended BASIC documentation. The correct status bits are now used, and BASIC does an IN from octal channel 23 to clear the output status bit after each character is output. This IN is done matter what I/O board is used, so it is not recommended

that a board other than a 4PIO be used at I/O port 23.

2.) (Extended, Disk versions) The FRE function now returns a positive number if the amount of free memory exceeds 32K bytes.

3.) (Disk version) When a random file is deleted, all the space used by the random file is freed up. Previously, if a random file was extended incrementally, only the first group (8 records) would be freed when the file was deleted.

4.) (Disk version) When simultaneously accessing two files OPENed on different disks, BASIC sometimes forgot which disk it was currently accessing. This has been fixed.

5.) (3.2 8K and larger versions) Typing in a line with a large number of ? marks could cause BASIC to be wiped out. Fixed.

6.) (Disk version) The INSTR function did not free up its string temporaries properly, causing spurious "STRING FORMULA TOO COMPLEX" error messages. Fixed.

7.) (Extended 3.2 only) When subtracting double precision numbers of the same exponent of opposite sign, the sign was incorrect, e.g. PRINT 2-3 gave 1 as an answer. Fixed.

8.) (Disk Version 3.3) Use of the line printer caused unpredictable problems. Fixed.

9.) (Disk version 3.3) Use of the RND function with a negative argument caused the random number generator to return the same value over and over again. Fixed.

10.) (Disk version 3.3) Input or Output to sequential data files caused the current terminal position (POS) to be set to zero. Fixed.

11.) (All versions prior to 3.4 not fixed in 4K 3.4) If a direct GOSUB was given to a subroutine which did INPUT from the terminal, the INPUT would wipe out the direct statement, causing unpredictable results when a later RETURN was executed. Under these circumstances, 3.4 will immediately print OK and return to system level if a RETURN is executed back to a direct statement which has been destroyed by an INPUT.

The features and changes listed below are in order of the version for which they are applicable, i.e. features for 4K version first, 8K next, etc.

Additions to 4K and larger versions

Changes for 8K and Larger Versions

Control-C Interrupts INPUT statements

Control-C is now the only way to interrupt an INPUT statement. If a carriage return is typed in response to an INPUT statement, execution of the program will continue at the next statement after the INPUT without changing the values of the variables specified in the INPUT statement.

Rubout and Control-U

The rubout (octal 177) can now be used instead of backarrow (_) or underline to delete characters on an input line. The difference is that rubout prints each character that is deleted and precedes the first character deleted with a backslash (\). If deletion was in progress using rubouts and a new character is typed, a backslash will be echoed and then the new character will be typed.

Example:

```
100 X=\=X\Y=10
```

(In this case two rubouts were typed after 'X='
had been typed.)

Control-U may now be used to delete a line in the same fashion as the at-sign (@). A carriage return is printed and the current line of input is deleted.

Spaces No Longer Allowed in Reserved Words

Spaces may no longer appear inside reserved words such as THEN or AND. The only exception is GOTO which may have embedded spaces. The reason for this is to avoid statements like:

```
100 R=F OR Q
```

Being LISTed as:

```
100 R=FOR Q
```

with the corresponding SYNTAX (SN) error when the line is executed.

Pause (Control-S) and Proceed (Control-Q)

When executing a program, Control-S may be used to cause program execution to pause so that output may be examined and then resumed with Control-Q. This is especially useful when using high speed CRT terminals. After executing a BASIC statement, Control-S will cause BASIC to pause until Control-Q or Control-C is typed. Control-C will cause a BREAK and return to command level. Control-S and Control-Q are not echoed and have no effect when a program is not being executed.

Hexadecimal Constants

Hexadecimal (base sixteen) constants are now available by preceding the number with &H. If the hexadecimal value contains a character which is not A-F or 0-9, a SYNTAX (SN) error will occur. If the hexadecimal value is greater than 16 bits of significance (more than four hex digits), an OVERFLOW (OV) error will occur.

Examples:

```
PRINT &HFF
 255

100 LADDR=ADDR AND &HFF 'mask off low byte
```

Octal constants may optionally be expressed either with a preceding & or with a preceding &O.

Features Available Only in Extended and Larger Versions

Control-C Interrupts LINE INPUT

Control-C is now the only way to interrupt a LINE INPUT and return to command level. In version 3.3, a BEL (Control-G) was used to perform this function.

Control-C and Control-O Printing Changed

Control-C and Control-O now print as ^C and ^O when they are typed. Control-U in the Extended version also prints as ^U.

The Tab (Control-I) Character

Tab (Control-I) is used on either input or output to move the terminal carriage or cursor to the next eight column field on the terminal. The tab stops are columns 1,9,17,25,33, etc.

This is especially useful for formatting lines continued with <line feed>:

```
100<Tab>        FOR I=1 TO 10:<line feed>
<tab><tab>      FOR J=1 TO 10:<line feed>
<tab><tab><tab>         A(I,J)=0:<line feed>
<tab>   NEXT J,I<carriage return>
```

LISTs as:

```
100     FOR I=1 TO 10:
                FOR J=1 TO 10:
                        A(I,J)=0:
        NEXT J,I
```

> **NOTE**
>
> <tab> characters always print as the appropriate number of spaces.

Lower Case Input

Lower case alphabetic characters are now accepted by BASIC. Lower case characters are always echoed as lower case, but when lower case is used as part of a direct command or program statement, translation of lower case to upper case is performed if the lower case character is not part of a quoted string literal, REMark statement, or single quote (') remark.

Thus, a line input as:

```
100 print a,b:rem print out the values of a and b
```

Will be LISTed as:

```
100 PRINT A,B:REM print out the values of a and b
```

or:

```
150 if a$="basic" then 200 'test for BASIC command
```

is LISTed as:

```
150 IF A$="basic" THEN 200 'test for BASIC command
```

Brackets Now Allowed as Matrix Subscript Delimiters

Brackets [,] are now interchangeable with parentheses as delimiters for matrix subscripts. Thus:

```
100 A[I]=0
```

is equivalent to:

```
100 A(I)=0
```

This has been done for compatibility with other BASICs, notably HP BASIC.

CONTinue Possible after Errors

It is now possible to CONTinue after an error in a direct statement. Also, errors no longer cause loss of the current FOR...NEXT context and subroutine (GOSUB...RETURN) context.

EDIT Command Types BEL on Errors

The EDIT command will now type a BEL character (control-G) if it receives a command which it does not recognize (e.g. Y).

Error Trapping

Often it is desirable to trap execution of errors within a BASIC program in order to take action to recover from the error, or to give a better explanation of why the error occurred than a simple error message.

This facility has been added to BASIC through the use of the ON ERROR GOTO, RESUME and ERROR statements, and with the ERR and ERL variables.

Enabling Error Trapping

The ON ERROR GOTO statement is used to specify which line of the BASIC program the error handling subroutine starts. The ON ERROR GOTO statement should be executed before the user expects any errors to occur. Once an ON ERROR GOTO statement has been executed, all errors detected during the execution of the BASIC program will cause BASIC to start execution of the specified error handling routine. If the<line number> specified in the ON ERROR GOTO statement does not exist, an UNDEFINED STATEMENT error will occur.

Syntax of the ON ERROR GOTO statement:

ON ERROR GOTO <line number>

Example:
1Ø ON ERROR GOTO 1ØØØ

Disabling the Error Routine

IF the user desires to disable the trapping of errors he should place an ON ERROR GOTO Ø statement in his program. This disables trapping of errors, and any error will cause BASIC to print an ERROR message and stop program execution.

If an ON ERROR GOTO Ø statement appears in an error trapping subroutine, it will cause BASIC to stop and print the error message which caused the trap. It is recommended that all error trapping subroutines execute an ON ERROR GOTO Ø if an error is encountered for which they have no recovery action.

> **NOTE**
>
> If an error occurs during the execution of an error trap routine, the error will immediately be "forced". An error message will be printed for the error detected inside the error trap routine.

The ERR and ERL Variables

When the error handling subroutine is entered, the variable ERR contains the error code for the error. The error codes and their meanings are listed below.

Code	Error
1	NEXT WITHOUT FOR
2	SYNTAX ERROR
3	RETURN WITHOUT GOSUB
4	OUT OF DATA
5	ILLEGAL FUNCTION CALL
6	OVERFLOW
7	OUT OF MEMORY
8	UNDEFINED STATEMENT
9	SUBSCRIPT OUT OF RANGE
1Ø	REDIMENSIONED ARRAY
11	DIVISION BY ZERO
12	ILLEGAL DIRECT
13	TYPE MISMATCH
14	OUT OF STRING SPACE
15	STRING TOO LONG
16	STRING FORMULA TOO COMPLEX
17	CAN'T CONTINUE
18	UNDEFINED USER FUNCTION
19	NO RESUME
Ø	RESUME WITHOUT ERROR

Disk Errors

50	FIELD OVERFLOW
51	INTERNAL ERROR
52	BAD FILE NUMBER
53	FILE NOT FOUND
54	BAD FILE MODE
55	FILE ALREADY OPEN
56	DISK NOT MOUNTED
57	DISK x I/O ERROR
58	FILE ALREADY EXISTS
59	SET TO NON-DISK STRING
60	DISK ALREADY MOUNTED
61	DISK FULL
62	INPUT PAST END
63	BAD RECORD NUMBER
64	BAD FILE NAME
65	MODE-MISMATCH
66	DIRECT STATEMENT IN FILE
67	TOO MANY FILES
68	OUT OF RANDOM BLOCKS

The ERL variable contains the line number of the line where the error was detected. For instance, if the error occurred on line 1000, ERL will be equal to 1000.

If the statement which caused the error was a direct (immediate mode) statement, the line number will be equal to 65535 decimal.

> NOTE
>
> Neither ERL nor ERR may appear to the left of the = sign in a LET or assignment statement.

The RESUME statement

The RESUME statement is used to continue execution of the BASIC program after the error recovery procedure has been performed. The user has three options. The user may RESUME execution at the statement that caused the error, at

the statement after the one that caused the error, or the user may RESUME execution on a different line than caused the error.

To RESUME execution at the statement which caused the error, the user should use:

```
RESUME
```

or

```
RESUME 0
```

To RESUME execution at the statement immediately after the one which caused the error, the user should use:

```
RESUME NEXT
```

To RESUME execution at a line different than the one where the error occurred, use:

```
RESUME <line number>
```

Where <line number> is not equal to zero.

Error Routine Example

The following example shows how a simple error trapping subroutine operates.

```
100 ON ERROR GOTO 500
200 INPUT "WHAT ARE THE NUMBERS TO DIVIDE";X,Y
210 Z=X/Y
220 PRINT "QUOTIENT IS";Z
230 GOTO 200
500 IF ERR=11 AND ERL=210 THEN 520
510 ON ERROR GOTO 0
520 PRINT "YOU CANT HAVE A DIVISOR OF ZERO!"
530 RESUME 200
```

In order to force an error to occur in a program, an ERROR statement has been provided. The primary use of the error statement is to allow the user to define his own error codes which can then conveniently be handled by a centralized error trap routine as described above. The format of the ERROR statement is:

ERROR <numeric formula>

Example:

```
ERROR 5
SYNTAX ERROR
```

When defining his own error codes, the user should pick values which are greater than the ones used by BASIC. Since further error messages may be added to BASIC in the future, it is recommended that error codes which are allocated from the last possible value (255) down to lower codes be used. If the <numeric formula> used in an ERROR statement is less than zero or greater than 255 decimal, a FUNCTION CALL error will occur.

If an attempt is made to print out an error message for an error which is greater than the highest defined system error, an FC error will be printed instead.

Of course, the ERROR statement may also be used to force SYNTAX or other standard BASIC errors.

Assigning String Substrings - The MID$ Statement

A new statement has been added that makes it much easier to change a single character or sequence of characters inside a string without altering the other characters in the string. As an added benefit, using such a statement does not incur the numerous string allocations if concatenation is used to perform this function.

The format of the MID$ statement is:

```
MID$(<string variable>,<numeric formula 1>
 [,<numeric formula 2>])=<string formula>
```

Examples:

```
100 MID$(A$,3,2)=" "
500 MID$(N$(I),2)="TEST"
```

<numeric formula 1> specifies the first character of the <string variable> that will be replaced by the <string formula> to the right of the '=' sign. If <numeric formula I> is greater than the length of the <string variable>, then a FUNCTION CALL error will occur.

The optional <numeric formula 2> specifies how many characters to copy into the <string variable> from the <string formula>.

Characters are copied from the <string formula> into the <string variable>, starting at the character position specified by <numeric formula 1>. They will be copied until either the end of the <string variable> is reached, the end of the <string formula> is reached, or <numeric formula 2> characters have been copied, whichever occurs first.

More Examples:

Suppose T$="TEST"
Then:
MID$(T$,2)="ORT"
T$ now equals "TORT"

or

MID$(T$,3,1)=" "
T$ now equals "TE T"

or

MID$(T$,3,2)="XTEND"
T$ now equals "TEXT"

Features Added to the DISK Version Only

Zero Bytes Allowed in Sequential Disk Files

Zero bytes are now allowed as valid data bytes in sequential data files on the disk. In version 3.3, zero bytes could not be written to sequential files.

The FILES command now prints the files on the floppy disk in columns across the page instead of down the page. This is much more convenient for CRT terminals.

PIP Lists Sorted Directory

The PIP Utility program now has an option which allows a file directory to be printed in sorted alphabetic order. Typing SRT<disk number> will print the directory.

Example:

```
LOAD "PIP",Ø,R
*SRTØ

DIRECTORY DISK Ø

APROG
MYFILE
STRTREK

*
```

FILES MUST BE CONVERTED

NOTE
ALL PROGRAM FILES MUST BE SAVED IN ASCII MODE AND THEN RELOADED TO WORK PROPERLY WITH 3.4 BECAUSE OF CHANGES IN THE RESERVED WORD BYTES.

Additional 3.4 BASIC Documentation

Patching Disk BASIC - the PTD program

Basic can now be patched simply and easily through the use of the PTD program. PTD resides in memory starting at octal location 45000 after BASIC is booted up from disk.

To patch BASIC, just boot it up from disk, deposit the patches in memory, and the examine and run PTD at 45000. After a two to three second delay the patched copy of BASIC will be saved on disk. Completion of the save is indicated when the disk enable light for disk zero goes out.

PTD may also be used to save programs other than BASIC on tracks 0-4 of a diskette. Simply load Disk BASIC, load the program you want to save, and then start PTD. All memory between address 0 and address 46000 octal will be saved on tracks 0-4 on diskette drive zero.

The FILE LINK ERROR

A new error message has been added to Disk BASIC. This is the FILE LINK ERROR. This error will occur during the reading of a file if a sector is read which does not belong to the file being read. This may occur when reading 3.3 sequential data files when the end of file is reached. If this is the case, the sequential file should be read and rewritten. The FILE LINK ERROR signaling end of file may be avoided by using an ON ERROR trapping routine to trap the LINK error. The error code for FILE LINK ERROR is decimal 69.

NO RESUME and RESUME WITHOUT ERROR Errors

Two new errors have been added to Extended and Disk BASIC for 3.4. These errors are associated with error trapping and the RESUME statement.

The NO RESUME error (decimal 19) occurs if an error trap routine is entered but the end of the program is encountered before a RESUME statement was executed.

RESUME WITHOUT ERROR (decimal 20) occurs if a RESUME statement is encountered but an error trap routine was not being executed.

Using BASIC with a 4PIO Board

BASIC can now be used successfully with a 4PIO board.

The initialization byte is an octal 44 for both the input (16) and output (18) sides of the board. This means that the handshake lines are levels and not pulses.

Disk Controller Fix

On the following pages a fix to the disk controller board number one is described. This fix applies to systems with more than one drive, but it is recommended that the fix be made to all controllers.

TERMINAL INTERFACING WITH THE 88-4PIO BOARD

(For Port Ø; 4PIO Address = 16 Sec)

INPUT

The program loops, testing Bit 7 of Input channel address 16 ('A' section control/status register). When device pulls CA1 low, CA2 goes high to the device indicating data has not been read. Also Bit y of channel 16 goes high indicating to the computer that valid data is available at channel 17. The computer reads channel 17, which clears Bit 7 of channel 16 and also resets CA2 back low to indicate to the device that new data may now be input.

OUTPUT

Bit 7 of Output channel address 18 ('B' section control/ status register) is tested for a device ready condition. When CB1 is forced low by the device, CB2 goes high to the device indicating data is <u>not</u> available. CB1 going low causes Bit 7 of channel 18 to go high indicating that the computer may output. When the computer outputs (writes) to the data channel, address 19, CB2 is cleared back low to indicate to the device that data is available. Note that this output does <u>not</u> clear Bit y of channel 18. To clear this Bit, the program must execute an Input from channel 19.

INITIALIZATION BYTE

A 44 octal must be used to initialize the status register of the PIAs. This byte should be output to the status channel (A & B control register). This causes the handshake signals to be levels, not pulses, and also selects the appropriate control lines (CA2 and CB1, CB2).

MITS SOFTWARE INITIALIZATION FOR 88-4PIO

	88-4PIO Signal Name	25 Pin Connector	Signal Description
Computer Input Channel	CA1	2	Active low input to computer indicating valid data from device.
	PAØ	4	Data bit Ø to Computer
	PA1	5	Data bit 1 to Computer
	PA2	14	Data bit 2 to Computer
	PA3	15	Data bit 3 to Computer
	PA4	16	Data bit 4 to Computer
	PA5	17	Data bit 5 to Computer
	PA6	18	Data bit 6 to Computer
	PA7	19	Data bit 7 to Computer
	CA2	3	Active high output from computer indicating data has not been received when low, computer is ready to receive new data
	CB1	12	Active low input to computer indicating that the device is ready to receive new data
omputer Output hannel	PBØ	20	Data bit Ø to Device
	PB1	21	Data bit 1 to Device
	PB2	22	Data bit 2 to Device
	PB3	23	Data bit 3 to Device
	PB4	24	Data bit 4 to Device
	PB5	25	Data bit 5 to Device
	PB6	10	Data bit 6 to Device
	PB7	11	Data bit 7 to Device
	CB2	13	Active low output from comput indicating that data is valid

DISK SECTORING PROBLEM

1. Problem caused by switching from one drive to another. If sector pulses from second drive occur too soon after last sector pulse from first drive, a false index pulse generated.

2. Problem occurs if first disk sector output is just detecting index and second disk sector output is just detecting sector Ø.

3. Solution: Prevent valid index detection for at least 10 ms after disk enabled.

4. Fix: On controller Board #1 connect head load status line to index detect circuit. This prevents valid index from being detected until 45 ms after head is loaded.

5. Correction: For units already assembled - Cut pin 7 of I.C. B3 and lift up from board. Connect jumper wire from pin 7 of I.C. B3 to pad labled "SSC" (pin 9 of I.C. B5). For units to be assembled bend pin 7 of I.C. B3 up before installing in board. Connect jumper wire as indicated before.

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