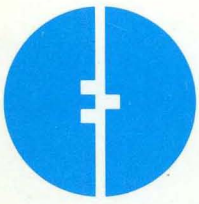
NEVADA FORTRAN™



ELLIS COMPUTING™

SOFTWARE TECHNOLOGY

NEVADA FORTRAN (TM)
Version 3.Ø

PROGRAMMER'S REFERENCE MANUAL

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PREFACE

This is an 8Ø8Ø/8Ø85/Z8Ø version of FORTRAN IV. It is a powerful subset implementation of this widely used language. The compiler works from disk (also using the assembler) to produce 8Ø8Ø/8Ø85/Z8Ø machine code that executes at maximum CPU speed.

A source program is entered as FORTRAN IV program statements. These statements must follow the conventions outlined in this document or errors may result. The compiler acts upon the source statements to produce assembly code. At this stage any mistakes are flagged with error messages. If an error should occur, the source may be corrected at this time and recompiled. After the program has been compiled without any errors, the final step (normally transparent to the user) is to assemble the intermediate code into 8Ø8Ø object code. The object module is then ready for execution under CP/M (or compatible operating system).

This manual is intended as a guide to using this version of FORTRAN and is not intended to be a complete instruction manual on the use of FORTRAN. This manual assumes that you already know how to program in FORTRAN and have read the CP/M operating system manuals. If you do not know FORTRAN there are many books that explain the syntax and semantics of the FORTRAN language. This manual explains the subset that is implemented in NEVADA FORTRAN.

This manual describes versions 3.Ø and later of the NEVADA FORTRAN compilier.

I would like to thank Colegate V. Spinks for his help and work in developing the initial release of the compiler, runtime and manual for this FORTRAN implementation.

1. GETTING STARTED

HARDWARE REQUIRED

1. 8Ø8Ø/8Ø85/Z8Ø processor
2. A minimum of 48K of RAM for the compiler
3. At least one disk drive

SOFTWARE REQUIRED

1. CP/M Operating System
2. Any text editor

FILES ON THE DISTRIBUTION DISK

FORT.COM	is the FORTRAN compiler
FRUN.COM	is the runtime execution package
CONFIG.COM	is a program to generate the error file and setup compiler and runtime defaults.
ERRORS	is the error text file used by CONFIG.
READ.ME	maybe on the disk and contains information and updates to this manual.

If room premits, there maybe some sample programs on the disk.

(Also see the NEVADA Assembler Manual for other files not listed here)

GETTING STARTED

If the master disk is not write protected, do it now!!

The very first thing that you should do is to make at least one backup copy of your NEVADA FORTRAN diskette. The original diskette should be kept in a safe place in case it is ever needed in the future.

1. NEVADA FORTRAN is distributed on a DATA DISK without the CP/M operating system. This disk will not "boot up".

2. On computer systems with the ability to read several disk formats, such as the KayPro computer, the master diskette must be in disk drive B.

3. Do not try to copy the master diskette with a COPY program! On most systems it won't work. You must use the CP/M PIP command to copy the files.

4. You must first, prepare a CP/M diskette for use as your NEVADA FORTRAN operations diskette. Usually you will use your system's FORMAT program (sometimes the COPY program will format the diskette) to prepare this diskette.

5. You should now use PIP to make copies of the original NEVADA FORTRAN diskette. To use PIP use the command:

```
PIP A:=B:*.*[V]
```

(this specifies that the NEVADA FORTRAN distribution disk is in drive B and the disk to copy onto is in drive A.)

On 5 1/4" diskettes you may have to remove (erase) other programs to make room for all the NEVADA FORTRAN programs, before the next step. Make sure the default drive has at least 8K of available space. If it does not, you will get a BDOS write error - CP/M's way of letting you know the

Disk is full!.

In some cases you will have to temporarily remove some of the FORTRAN example programs to make the space available.

NOTE: The NEVADA assembler, ASSM.COM, must be on the same disk which contains the FORTRAN compiler

1.1. Configuring the NEVADA FORTRAN system

1.1.1. Generating the error file FORT.ERR

The program CONFIG reads the text file ERRORS which contains the compiler error messages. These messages may be changed with the restriction that they can only be one line, the first 2 characters are the error number followed by a blank followed by the text of the error message. To generate the error file, just enter CONFIG at the CP/M prompt and reply Y to the question about generating the error file. You will then be asked to specify which drive contains the file ERRORS and which drive the file FORT.ERR is to be written to. Reply with a valid drive letter (A, B, ...) for your system. You must generate the error file as it is not supplied on the disk. This only needs to be done once or whenever any of the error text is changed.

1.1.2. Configuring the FORTRAN system

The CONFIG program also allows you to set certain default values in both the compiler and the runtime package. Just enter carriage return (or ENTER) to leave the default as it is, or enter the new default value. You will be asked to enter the drive that contains the compiler (FORT.COM). The default sizes of the parameters that can be changed with an OPTIONS statement can be modified along with the character used to delimit hexadecimal constants in strings. You will also be able to specify if your system console can handle lowercase letters. Enter Y if it can or N if it cannot.

Next, certain parameters in the runtime package can be set. You must first specify which drive contains the runtime package (FRUN.COM). The method that the runtime package performs CP/M console I/O can be specified as either CP/M function 1&2, CP/M function 6 (for CP/M rev 2.Ø only) or direct BIOS calls. Specifing CP/M functions 1&2 allows you to use control-P to send a copy of your FORTRAN output to the printer. You will also be able to specify if your system console can handle lowercase letters. Enter Y if it can or N if it cannot.

Since NEVADA FORTRAN supports the North Star floating point board, you must specify the address of the board if you have one and want FORTRAN to use it.

After creating FORT.ERR you can erase the files CONFIG.COM and ERRORS if you need the disk space.

2. COMPILING AND EXECUTING A PROGRAM

2.1. CREATING A PROGRAM

A program can be created with any of the numerous available text editors. The name of the FORTRAN source program should have the filename extension of .FOR, such as PROG.FOR. Refer to section 3.2 for a detailed description of the format of each source statement. Programs are created with a text editor and are later, in a separate step, compiled.

2.2. RUNNING THE COMPILIER

The general format of the command to compile a FORTRAN program is:

FORT U:PGM.LAO $OPTIONS

where:

FORT is FORT.COM, the FORTRAN compiler

PGM is the FORTRAN source program to compile and has the extension .FOR.

U: is the drive where PGM.FOR is located (if not present, the default drive is used).

L is the drive for the listing as follows:

A-P	uses that drive for the listing
X	listing to CP/M console
Y	listing to CP/M LST: device
Z	do not generate a listing

The listing will have the same filename as the source file but with the extension .LST.

A is the drive for the intermediate assembly file as follows:

A-P	uses that drive
Z	do not generate an assembly file.

The assembly file will have the same filename as the source file but with the extension .ASM. This file is normally deleted by the FORTRAN compiler.

O is the drive for the final object program as follows:

A-P	uses that drive
Z	don't generate an object file

The object program will have the same filename as the source file but with the extension .OBJ.

Notes:

If Z if specified in either the assembly or object drive position, no object program will be generated.

If the three drive specifiers are not specified, then the default drive will be used.

The files FORT.ERR and ASSM.COM must be present on the default drive when the compiler is run.

If the O is not specified as Z, then the assembly file will be automatically assembled and the intermediate .ASM file will be deleted. If Z is specified, then the file will not be assembled and the intermediate .ASM will remain on the disk.

2.3. COMPILE OPTIONS

Options that effect the compilation of the FORTRAN program can be specified on the command line by preceding the option string with dollar sign ($). For example:

```
FORT U:PGM.LAO $NP2
```

The following options can be specified:

N

No assembly file will be produced (and no object file also).

P

The listing file (if specified) will be paginated (66 lines to a page). Each new FORTRAN routine will start on a new page.

1

Source statements will be blank padded to 64 characters.

2

Source statements will be blank padded to 72 characters.

NOTE: Normally source statements are not blank padded. This may cause a problem where blanks are wanted inside a literal string and the string is started on one statement and continued over one or more continuation statements. Without the pad option, the trailing blanks may be lost (of course you could break the continued literal into several, making sure that there is a quote after any blanks at the end of a statement). For example:

```
     WRITE (1,1Ø)
1Ø   FORMAT ('THIS IS
    *A TEST')
```

Produces: THIS IS A TEST
without blank padding and

THIS IS A TEST
with blank padding.

If the last form is desired then this could be written as:

```
     WRITE (1,1Ø)
1Ø   FORMAT ('THIS IS
    *'A TEST')
```

to produce the same results as with the blank padding specified.

H

This option is used in conjunction with the P option to suppress the heading in the listing.

C=XXXX

This option specifies the maximum number of COMMON blocks that may be defined in the program to be compiled. The default is 15.

B=XXXX

This option specifies the size of the input statement buffer. The default is 53Ø characters and the buffer must be large enough to contain a complete statement (first record plus all continuations).

M=XXXX

This option specifies the memory address at which blank COMMON will end. In other words, blank COMMON will be allocated downward in memory from the specified address. The address specified must be in hexadecimal.

This option is useful in forcing blank COMMON to be allocated at the same address in memory for passing data between routines that CHAIN to each other.

Examples

```
FORT MYPROG $C=2Ø
```

Compiles MYPROG.FOR from the default drive, generating MYPROG.ASM, MYPROG.LST and MYPROG.OBJ on the default drive and allowing for the definition of up to 2Ø COMMON blocks.

```
FORT B:READ.XCD $P2
```

Compiles READ.FOR from drive B, generating READ.ASM on drive C and the listing to the console. The listing will be paginated and source statements will be padded to 72 characters.

```
FORT TEST.YZZ $P
```

Compiles TEST.FOR from the default drive, no .ASM or .OBJ file will be produced but a paginated listing will go to the CP/M list (LST:) device.

```
FORT UPDATE.XBZ $PH
```

Compiles UPDATE.FOR from the default drive, generating UPDATE.ASM on drive B, a paginated listing minus the heading line to the console and no .OBJ file.

2.4. EXECUTING A PROGRAM

Once the object file has been produced, the program can be executed by simply typing:

```
FRUN u:filename
```

Where **u:** is optional and if not present, the default drive is used. The FORTRAN runtime package, **FRUN** occupies memory from 1ØØH to 3FFFH. It will load the program to be executed starting at 4ØØØH. The program is then executed and continues until either it terminates normally or a runtime error occurs.

Example

To compile and run the program GRAPH (listing in the sample programs section) the commands would be:

```
FORT GRAPH  (listing, object to default disk)
FRUN GRAPH  (will execute the program)
```

2.5. CREATING A COM FILE

A CP/M .COM file can be created that contains a copy of the runtime package and the program to be executed. This has the advantage that just the filename need be entered to execute the program. Each program generated in this way will be at least 16K in length, that being the size of the FORTRAN runtime package. To create a COM file just add .C to the end of the FRUN command. The command to turn GRAPH.OBJ into GRAPH.COM would be:

```
FRUN GRAPH.C
```

Then to execute it, all that is needed is the command:

```
GRAPH
```

3. THE FORTRAN LANGUAGE

3.1. The FORTRAN Character Set

The FORTRAN character set is composed of the following characters:

The letters:

A,B,C,D,E,F,G,H,I,J,K,L,M,N,O,P,Q,R,S,T,U,V,W,X,Y,Z

The numbers:

Ø,1,2,3,4,5,6,7,8,9

The special characters:

	blank
=	equal sign (for replacement operations)
+	plus sign
-	minus sign
*	asterisk
/	slash
(	left parenthesis
)	right parenthesis
,	comma
.	decimal point
$	dollar sign
#	number sign
&	ampersand
\	backslash

NOTE: Lowercase letter will be converted to uppercase except when lowercase appears in string literals.

The following is a list of the meanings of the special characters used in this version of FORTRAN:

$ Preceding a constant with a dollar sign indicates that it is a hexadecimal constant.

Preceding a constant with a number sign indicates that it is a hexadecimal constant that is to be stored internally in binary format.

& The & has two functions:
1) if used in a FORMAT statement contains an ampersand, the character following the ampersand is interpreted as a control character (unless it is also an &).
2) used to indicate that a statement label is being passed to a SUBROUTINE for use in a multiple RETURN statement.

\ A constant enclosed in backslashes in a character string is assumed to be the hexadecimal code for an ASCII character.

3.2. FORTRAN Program Structure

A FORTRAN program is comprised of statements. Every statement must be of the following format.

1) The first 5 characters of the statement may contain a statement label if the statement is to be branched to.

2) The sixth character is used to indicate a continuation of the previous statement. Continuation is indicated by placing any character except a BLANK or ZERO in column 6 of the continuation statement.

3) Column 7 to the end of the line is used for the body of the statement. This is any one of the following statements which will be described later. All statements are terminated by a CR (Carriage Return) or semicolon (not enclosed in a character string) in the case of multiple statements per line. A statement may be of any length, but only the first 72 characters are retained during compilation. Statements will be processed until the carriage return is encountered. The character positions between the carriage return and character position 72 will NOT be padded with BLANKS as some FORTRAN systems will do, unless the 1 or 2 option is specified This means that if a character string is started on a line, and must be continued, the continuation logically starts immediately after the last character of the previous line.

4) Column 73 through 8Ø are used for identification purposes and are ignored.

5) A comment line is indicated by place a **C** in column 1. A comment line has no effect on the program and is ignored. It is only for documentation purposes.

Example

```
|-- Column 1
|
V

      WRITE (1,2)
    2 FORMAT ('THIS IS AN
     * EXAMPLE CHARACTER STRING')
```

will output: THIS IS AN EXAMPLE CHARACTER STRING

Uppercase and lowercase letters can be intermixed in a FORTRAN statement. Lowercase letters are retained ONLY when they appear between QUOTES or in the H FORMAT specification in a FORMAT statement. Otherwise they will be converted to uppercase internally. Thus the variables QUANTITY and quantity and QuAnTiTy represent the same variable.

There are four types of statements in FORTRAN:

1) Declaration
2) Assignment
3) Control
4) Input/Output.

These statement types are described in the following sections of this manual.

3.3. FORTRAN Statements

A statement may contain a statement label. A statement label is placed in columns 1 through 5 of the statement.

All labels on statements must be integers ranging between 1 and 99999. Leading zeros will be ignored.

Statement labels are not required to be in any sequence, and they will not be put in order.

In any program, a statement label can be used only once as a label.

A statement may contain no more than 53Ø characters excluding blanks (other than those between single quotes), unless the B= option is specified.

During compilation, blanks are ignored, except between single quotes and in H FORMAT specification.

Comments are indicated by placing a C in column 1; the remaining part of the statement may be in any format and is ignored by the compiler.

3.4. Multi-statements

Statements may be compacted more than one logical statement per line. Statements are separated from each other with a semicolon and a colon is used to separate the label, if any.

Example

```
    A=1
  3 CONTINUE
    A=A+1
    TYPE A
    GO TO 3
    END
```

could be written as:

```
    A=1;3:CONTINUE;A=A+1;TYPE A;GOTO 3;END
```

3.5. FORTRAN Program Preparation

A FORTRAN source program is prepared using one of the available CP/M text editors. The FORTRAN file must be in the following format:

```
Position 1...5....Ø....5....Ø....5....Ø....5....Ø....5
         OPTIONS
                :
                :
                :
           FORTRAN program
                :
                :
               END
         OPTIONS
               SUBROUTINE X
                :
            FORTRAN routine
                :
               END
```

All FORTRAN routines are required to be compiled at one time.

3.6. The COPY Statement

A FORTRAN program can contain COPY statements. The COPY statement contains the word COPY followed by at least one blank, followed by the FILENAME to be inserted at that point. COPY files may contain complete programs or just sections of programs. Copied files may not themselves contain COPY statements.

Example

```
DIMENSION A(1)
COPY ALLDEFS
READ (1,1Ø) I


A=1
T=5
CALL ADDIT
STOP
END
COPY B:ADDIT
```

3.7. The Options Statement

This is an optional statement of each program and/or subprogram which is to be compiled. If present, the OPTIONS statement must appear as the first statement in main program and prior to the SUBROUTINE or FUNCTION statement in each subprogram. The options statement allows the specification of various parameters to be used by the compiler during compilation of a particular routine. The options that are specified on an options statement are only in effect for that routine and revert back to the default unless an OPTIONS statement appears on subsequent routines. Options available are as follows:

S=n

n -> Is a decimal number indicating the number of allowable symbols. The default is 5Ø. Each entry requires 8 bytes. (n may be greater than 255). This default can be changed using the CONFIG program.

L=n

n -> Is a decimal number indicating the number of allowable labels. The default is 5Ø. Each entry requires 6 bytes. (n may be greater than 255). This default can be changed using the CONFIG program.

T=n

n -> Is a decimal number indicating the maximum number of temporary variables that are available during EXPRESSION evaluation. Default table size is 15; each variable requires 1 byte. This default can be changed using the CONFIG program.

D=n

n -> Is a decimal number which indicates the maximum allowable nesting of DO loops. Default is 5, each entry requires 4 bytes. This default can be changed using the CONFIG program.

A=n

n -> Is a decimal number which indicates the maximum number of arrays. Default is a maximum of 15; each entry requires 4 bytes. This default can be changed using the CONFIG program.

O=n

n -> Is a decimal number which indicates the maximum number of operators ever pushed on the internal stack while doing a prefix translation of input expression. Note functions and array subscripting require a double entry. Default is 4Ø; each entry is 2 bytes long. This default can be changed using the CONFIG program.

P=n

n -> Is a decimal number which indicates the maximum number of variables and/or constants ever pushed on the internal stack in evaluation. Default is 4Ø; each entry is 2 bytes long. This default can be changed using the CONFIG program.

I=n

n -> Is a decimal number specifying the depth that IF-THEN-ELSE's may be nested. The default nesting is 5. This default can be changed using the CONFIG program.

E

Instructs the compiler to list, as comments, a reference table equating user symbols, constants, and labels to internally generated ones.

G

Instructs the compiler to list all compile errors as error numbers, instead of explicit error statements. See Appendix 11.6.Ø for a list of error numbers and their meanings.

X

Instructs the compiler to generate code which will give explicit runtime errors. In this mode each statement has an extra 5 bytes of overhead to keep track of the statement number of the statement currently being executed.

N

Check for FORTRAN errors only. Do not output an assembly code file.

B

The FORTRAN source statement is included in the assembly file as a comment.

Q

This option must be used whenever the program expects to trap runtime errors. It causes code to be generated for handling user trapping of runtime errors.

n is less than or equal to 255 unless otherwise stated.

Example

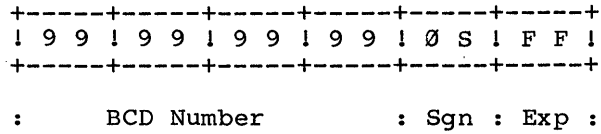
```
$OPTIONS X,G,S=2ØØ,L=1ØØ

      Options used will be:
          EXPLICIT runtime errors will be generated
          EXPLICIT compile errors are not generated
          the SYMBOL table has room for 2ØØ symbols, and
          the LABEL table has room for 1ØØ statement labels.
```

4. NUMBER SYSTEM

4.1. Internal Format of Numbers

Numbers are stored internally as a 6 byte BCD number containing 8 digits, a one byte exponent, and a sign byte. This allows for the number to range from .1ØØØØØØØE-127 to Ø.99999999E+127. The sign byte contains the sign of the number; Ø indicating a positive number and 1 indicating a negative number. The exponent is stored in excess 128. A one for the sign of the BCD number indicates a negative number. The number ZERO is stored as an exponent of zero; the rest of the number is ignored.

All numbers in FORTRAN are stored in the following format:



4.2. Number Ranges

Integer variables and constants can have any value from -99999999 to +99999999. Real variables and constants can take any value between -Ø.99999999E-127 and Ø.99999999E+126. Integer variables and constants are stored internally in the same format.

4.3. Constants

A constant is a quantity that has a fixed value. A numerical constant is an integer or real number; a string constant is a sequence of characters enclosed in single quotes. A logical constant has a value of .TRUE. or .FALSE.

4.3.1. Numerical Constants

Numerical constants can be either integer or real as follows:

Integer	1, 3Ø99, -7Ø
Real	1.34, -5.98, 1.4E1Ø

A hexadecimal constant can be specified by preceding the number with a dollar sign. A hexadecimal constant is converted internally into an integer and stored that way. The maximum value for a hexadecimal constant is $FFFF.

Example

```
$8Ø5Ø
I=$1ØØØ
z=-$CCØØ
```

Another way to specify a hexadecimal constant is to preceded the constant with a # sign. This way of representing a hexadecimal number differs in that the number is NOT converted to integer format and is stored in binary in the first two bytes of the constant. The number is stored high byte followed by low byte.

Example

```
#ØDØØ
i=#127F

$8Ø5F is stored internally as: 32 86 3Ø ØØ ØØ 85
#8Ø5F is stored internally as: 5F 8Ø ØØ ØØ ØØ ØØ
```

4.3.2. String Constants

A string constant is specified by enclosing a sequence of characters in single quotes. A single quote within a character string must be represented by TWO quotes in a row (with no space between these two quotes). By specifying a hexadecimal number within backslashes, any character (even unprintable ones) can be generated.

Example

```
'This is a string constant'
'This string constant''contains a single quote'
'Good\21\'  is equivalent to 'Good!'
'\7F\' is equivalent to a rubout
```

Warning: Never include \Ø\ as part of a string constant as that character is used internally to indicate the end of a string.

NOTE The character used to delimit a hexadecimal number (default is \) can be changed using the CONFIG program.

4.3.3. Logical constants

The two logical constants are .TRUE. and .FALSE.. Numerically, .FALSE. has the value Ø (zero) and .TRUE. has the value of 1 however any non-zero value will be considered as .TRUE. Logical operations always return a value of Ø or 1. These logical constants can be assigned to any variable, but is usually used as part of a logical expression.

Example

```
I=.TRUE.
I=(J .and. .TRUE)
```

4.4. Variable Names

A variable is a symbolic name given to a quantity which may change depending upon the operation of a program. A variable consists of from 1 to 6 alphanumeric characters, the first of which must be a letter.

An INTEGER variable is a variable that starts with I, J, K, L, M or N by default or explicitly typed INTEGER through the use of an INTEGER or IMPLICIT statement.

A REAL variable is a variable that starts with other than I, J, K, L, M or N by default or explicitly typed REAL through the use of a REAL or IMPLICIT statement.

A DOUBLE PRECISION variable must be explicitly typed DOUBLE PRECISION with a DOUBLE PRECISION or IMPLICIT statement.

A LOGICAL variable must be explicitly typed LOGICAL with a LOGICAL or IMPLICIT statement.

There are four types of variables supported: INTEGER, REAL, DOUBLE PRECISION and LOGICAL.

Example

```
I1Ø, ALPHA, BETA, I, MAXIM, MINII
IX=34
ALPHA=56.34
ZLOG=.TRUE.
```

4.5. Type Specification

There are three type specification statements that can be used to override the default types of variables. Remember that variables that begin with the letters I,J,K,L,M,N (unless changed by an IMPLICIT statement) will be of type INTEGER. All others will be of type REAL. The type specification statement overrides the default type of a variable.

Note an array can also be specified in a type statement.

Example

```
INTEGER A,ZOT,ZAP(1Ø)
REAL INT
LOGICAL LOG1,LOG2
```

4.5.1. INTEGER

The general format of the INTEGER statement is:

INTEGER v1,v2

The INTEGER statement is used to explicitly override the default type of the variable. Should a variable occur in the declaration string, the type is automatically set to integer. This works for both subscripted and nonsubscripted variables. A variable can appear only ONCE in a type specification statement.

Example

```
INTEGER MODE,K453,NUMBER(4Ø),MAXNUM
INTEGER ZAPIT
```

4.5.2. LOGICAL

The general format of the LOGICAL statement is:

```
LOGICAL v1,v2
```

The LOGICAL statement is used to override the default specification and type a variable as Logical. A logical variable's value is interpreted as:

.TRUE. if the variable has a non-zero value.
.FALSE. if the variable has a zero value.

Example

```
LOGICAL FTIME,LTIME
LOGICAL FLAG
```

4.5.3. REAL

The general format of the REAL statement is:

REAL v1,v2

The REAL statement is used to explicitly override the default type of the variable. Should a variable occur in the declaration string, the type is automatically set to real. This works for both subscripted and nonsubscripted variables. A variable can appear only ONCE in a type specification statement.

Example

```
REAL ALPHA,BETA(56),INIT,FIRST,ZAPIT,HI
```

4.5.4. DOUBLE PRECISION

The general format of the DOUBLE PRECISION statement is:

DOUBLE PRECISION v1,v2

The DOUBLE PRECISION statement is used to explicitly override the default type of the variable. Should a variable occur in the declaration string, the type is automatically set to real. This works for both subscripted and nonsubscripted variables. A variable can appear only ONCE in a type specification statement.

Example

```
DOUBLE PRECISION ALPHA,BETA(56),INIT,FIRST,ZAPIT,HI
DOUBLE PRECISION VALUE1,VALUE2
```

WARNING: Even though the DOUBLE PRECISION statement is supported, double precision arithmetic is NOT. All DOUBLE PRECISION variables will be treated as if they where REAL. A warning will be issued each time a DOUBLE PRECISION statement is encountered.

4.6. Data Statement

The DATA statement is used to initialize variables or arrays to a numeric value or character string. The general format is:

```
DATA list/n1,n2..../,list1/n1,n2/
```

where list is a list of variables (or array elements) to be initialized and n1, n2.. are numbers or strings (constants) that the corresponding item of list will be initialized to. An exception to this is the array name. If only the name of the array (no subscripts) appears in list, the whole array will be initialized. It is expected that enough constants will be listed to completely fill the array. If not enough constants are supplied to fill the entire array, then portions of the array will be undefined. Subprogram arguments may not appear in list. When a DATA statement is encountered during compilation, it is stored in memory and ALL DATA statements are processed when the END statement for the particular routine is encountered. If there are more DATA statements than can be stored in the available memory, a fatal compile error will result and compilation will terminate. Since DATA statements are processed when the END statement is encountered; errors in a DATA statement will be printed after the END statement. These errors will include the four digit FORTRAN assigned line number and the variable in the DATA statement being processed when the error occurred.

Example

```
DIMENSION B(3),C(3)
DATA A/1/,B/1,2,3/,C/3*Ø/
DATA LIST/'THIS IS A CHARACTER STRING'/
```

The above statement will assign the value 1 to A and the values 1 to B(1), 2 to B(2) and 3 to B(3). The asterisk is used to indicate a repeat count; thus the array C will be set to zeroes. An error will result if a variable in a DATA statement is not used elsewhere in a program.

NOTE: The other form of the DATA statement:

```
DATA A,B,C/1,2,3/
```

is not supported by NEVADA FORTRAN and must be rewritten as:

```
DATA A/1/,B/2/,C/3/
```

4.7. Common Blocks

The COMMON block declaration sets aside memory (variable space) to be shared between routines (SUBROUTINES, FUNCTIONS and the main program). Common blocks are associated with a name which is used by each declaring routine to point to a specific COMMON block.

The general form of a COMMON statement is:

COMMON /name1/ list1 /name2/ list2

where name1 and name2 are the COMMON block names associated with the corresponding list1 and list2.

Example

```
DIMENSION X(1ØØ)
COMMON /ZZZ/ FIRST,LAST,X
CALL ADDEM
    .
    .
END

SUBROUTINE ADDEM
REAL NUMBER
COMMON /ZZZ/ F,L,NUMBER(1ØØ)
    .
    .
END
```

An array declaration may be included in a COMMON statement as shown in the subroutine above. The use of common blocks allow data to be passed to and from a subprogram, but without passing it as arguments (in a heavily called routine, this method can save execution time). If an array is to be included in a common declaration, it must either be declared previously or declared in the COMMON statement.

If the name is omitted or the name is null (i.e. //) then it is called blank COMMON.

Example

```
COMMON A,B,C,D
COMMON // A,B,C,D   are equivalent statements
```

Blank COMMON differs from named COMMON in the following ways:

1) variables in blank common are allocated their actual memory addresses at runtime and therefore cannot be initialized with a DATA statement.

2) blank common is allocated at runtime directly below the BDOS (at the top of the TPA) in CP/M or at a user specified address. To override the default placing of the blank common block in memory, use the M= compiler option when the program is compilied. If the size of blank common blocks is the same, then blank common can be used to pass data between routines that CHAIN as the blank common variables will occupy the same place in memory.

NOTE: The name of a named COMMON block must not be the same as a SUBROUTINE or FUNCTION name.

4.8. Implicit Statement

The IMPLICIT statement is used to change the default INTEGER, REAL, DOUBLE PRECISION and LOGICAL typing.

The general format of the IMPLICIT statement is:

IMPLICIT type (range), type(range)

where:

Type is one of INTEGER, REAL, LOGICAL, DOUBLE PRECISION. Range is either a single letter or a range of letters in alphabetical order. A range is denoted by the first and last letter of the range separated by a hyphen or a sequence of single letters separated by commas.

Example

```
IMPLICIT INTEGER (Z),REAL (A,B,C,D,E,G),INTEGER (M-S)
IMPLICIT REAL (I,J)
IMPLICIT REAL (A-Z)
```

An IMPLICIT statement specifies the type of all variables, arrays and functions that begin with any letter that appears in the specification. Type specification by an IMPLICIT statement may be overridden for any particular variable, array or function name by the appearance of that name in a type statement.

The IMPLICIT statement must appear before all other statements in a particular routine: that is immediately after the SUBROUTINE or FUNCTION statement or before the first statement of the main program.

WARNING: Even though the DOUBLE PRECISION specification is supported, double precision arithmetic is NOT. All DOUBLE PRECISION variables will be treated as if they where REAL. A warning will be issued each time a DOUBLE PRECISION statement is encountered.

5. Expressions

An expression is a combination of variables, functions and constants, joined together with one or more operators.

Arithmetic Operators

** or ^	Exponentiation
*	Multiplication
/	Division
+	Addition
-	Subtraction

Comparison Operators

.EQ.	Equal to
.NE.	Not equal to
.GT.	Greater than
.LT.	Less than
.GE.	Greater than or equal
.LE.	Less than or equal to

Logical Operators

.NOT.	Logical Negation
.AND.	Logical and
.OR.	Logical or
.XOR.	Logical exclusive or

The .NOT. and unary minus (-) operators preceded an operand. All other operators appear between two operands.

5.1. Hierarchy of Operators

The following is the table of operator hierarchy and the correct FORTRAN symbolic representation to be used in coding:

Highest — System and User Functions

** OR ^ (up arrow)
* and /
+ and - (including unary -)
.LT., .LE., .NE., .EQ., .GE., .GT.
.NOT.
.AND.
.OR. and .XOR.
Replacement (=)

Lowest

5.2. Expression Evaluation

FORTRAN expressions are evaluated as follows:

1. Parenthesised expressions are always evaluated first, with the inner most set being evaluated first.

2. Within parentheses (or whenever there are none) the order of expression evaluation is:

   a. FUNCTION references
   b. Exponentiation
   c. Multiplication and division
   d. Addition and subtraction

3. Operators of the same precedence are evaluated from left to right during expression evaluation.

Example

A+1+Z*5 will be evaluated as:

((A+(1+(Z*5))

VAL*Z+(T+4)/6*X**Y will be evaluated as:

((VAL*Z)+(((T+4)/6)*(X**Y)))

NOTE: Operators of equal precedence are executed from left to right.

5.3. Integer Operations

A fundamental difference between INTEGER and REAL arithmetic operation, is the manner in which rounding occurs. If you were to divide 3.Ø by 2.Ø using floating point arithmetic, the answer would be 1.5. However, if the same operation were to be performed using integer arithmetic, 3/2 would equal 1.

Note in using integer arithmetic, the fractional part of the number is truncated. Another example is in the multiplication of two real numbers. 2.9 times 4.8 would equal 13.92. However in integer mode, the result is be 13. Also, no more than 8 digits of accuracy are maintained. Should more than 8 digits be generated by an integer operation, a runtime error of INT RANG will result.

Example

```
      6/3=2
but  7/3=2 (NOTE: no fraction is retained) and  7/9=Ø
      99999999+5=?  integer overflow
```

5.4. Real Operations

Unlike integers, Real operations and their results have a precision of eight significant digits plus an exponent (base 1Ø) between -127 and +127.

Example

```
12/6.Ø=2.Ø
15.Ø/2=7.5
 1./2.=Ø.5
```

5.5. Logical Operations

Logical operations are unlike INTEGER and REAL operations in that they always return a value of zero (Ø) or one (1). All the logical operations will return a one for a TRUE condition, however any NON-ZERO value will be interpreted as TRUE. If the logical operation is a logically true statement, the result is a one, if the statement is false, a zero is returned.

Example

```
A = 1 .GT. 2   (false)  A would evaluate to Ø
A = 1 .EQ. 1   (true)   A would evaluate to 1
A = 1 .LT. 2   (true)   A would evaluate to 1
```

The relational operator abbreviations in the previous table represent the following operations:

```
.LT.   Less Than
.LE.   Less Than or Equal
.NE.   Not Equal
.EQ.   Equal
.GE.   Greater Than or Equal
.GT.   Greater Than
```

```
.AND.  True only if both operands are true.
.OR.   True if either operand is true.
.XOR.  True if operands are different.
```

Example

```
IF (A .EQ. B) GO TO 5ØØ
IF (A .EQ. B.OR.K .EQ. D)STOP
```

Logical variables can also be used in assignment statements:

```
A=A .AND. B
I=(A .OR. B).XOR.((T .EQ. 35.4).OR.(T .EQ. 39))
```

The following logical operators are also available, as listed in the following truth charts.

.AND.

A	B	R
Ø	Ø	Ø
Ø	1	Ø
1	Ø	Ø
1	1	1

.OR.

A	B	R
Ø	Ø	Ø
Ø	1	1
1	Ø	1
1	1	1

.XOR.

A	B	R
Ø	Ø	Ø
Ø	1	1
1	Ø	1
1	1	Ø

.NOT.

A	R
Ø	1
1	Ø

5.6. Mixed Expressions

The standard FORTRAN rules for mixed mode expressions are:

integer <op> integer gives an integer result

real <op> integer gives a real result (with the integer being converted to real before the operation is performed).

real <op> real gives a real result

integer <op> real gives a real result, with the integer being converted to REAL before the operation is performed.

integer = real will cause truncation of any fractional part of real and an error if the truncated result is outside the range of integers.

real = integer will cause integer to be converted to real.

In general, in a mixed expression, integers are converted to real before the operation take place, giving a real result (unless both operands are integer).

<op> represents one of the operators: + - / *

6. Control Statements

There are several different statements that control the execution flow of a FORTRAN program:

These are:

1. GO TO statements
   a. Unconditional GO TO
   b. Computed GO TO
   c. Assigned GO TO

2. IF statements
   a. Arithmetic IF
   b. Logical IF
   c. IF-THEN-ELSE

3. DO

4. CONTINUE

5. PAUSE

6. STOP

7. CALL

8. RETURN
   a. explicit RETURN
   b. multiple RETURN

6.1. Unconditional GO TO Statement

The general format of the unconditional GO TO is:

GO TO n

where n is a label on an executable statement.

The unconditional GO TO Statement performs a transfer of control to the statement number specified as the object of the branch. If the statement number does not exist, an undefined label error will occur; this error is detected during compilation.

Note: Labels on FORMAT statements in most FORTRAN systems may not receive transfer of control. This is not true in this implementation of FORTRAN. FORMAT statements act the same as a CONTINUE statement which will be discussed later.

Example

```
      GO TO 1Ø
      GO TO 4ØØ

1Ø    CONTINUE
4ØØ   FORMAT (1X)
```

6.2. Computed GO TO Statement

The general format of the COMPUTED GO TO is:

GO TO (n1,n2,...nm),i

The computed GO TO statement works in a manner similar to the GO TO statement. However, one of the distinct advantages is that under program control, you may direct which statement is the next to be executed, based on the value of i. The computed GO TO works as follows:

Computed GO TO Statement	Present Value of Variable	Next Executed Statement
GO TO (1,5,98,167,4),K2	K2=5	4
GO TO (44,28),J	J=1	44
GO TO (51,6,7,1,46),M	M=4	1
GO TO (1,1,1,1,2,2),LOOT	LOOT=3	1

If the value of i exceeds the number of statement labels in the computed GOTO, a runtime error COM GOTO will be generated. If the value of i is less than 1, a runtime error will also be generated.

6.3. Assigned GO TO

The general format of the assigned GO TO is:

```
GO TO v,(n1,n2,...)
```

where v is the variable used in an ASSIGN statement and n1, n2 are statement labels.

Example

```
GO TO LABL,(1ØØ,4ØØ,5ØØ)
GO TO K,(1,2,3,4,5)
```

6.4. ASSIGN

The general format of the ASSIGN statement is:

ASSIGN n TO V

where n is the statement label to be ASSIGNed to v. The ASSIGN statement assigns a statement label to be used in conjunction with the ASSIGNED GO TO statement.

Example

```
ASSIGN 2Ø TO LABEL
.
.
IF (KNT .GT. 1Ø)ASSIGN 1Ø TO LABEL
.
.
GO TO LABEL,(1Ø,2Ø)
```

6.5. Arithmetic IF Statement

The Arithmetic IF allows the programmer to evaluate an expression which may be any combination of integer, real, or logical operators, and based upon its relationship to zero, transfers control to one of three specified statements.

The general form of the arithmetic IF is:

IF (e) n1,n2,n3

where e is an arithmetic expression which when evaluated is used to determine the next statement to be executed.

If e is:	next statement
<Ø	n1
=Ø	n2
>Ø	n3

Example

```
IF (A) 1,2,3
IF (BETA*SIN(BETA/DEGREE))1ØØ,15Ø,432
IF (A-1)1,1,99
IF (.NOT. FLAG)1,5,7
```

6.6. Logical IF Statement

The general format of the Logical IF is:

IF (e) s

The logical IF statement operates as follows:

1. The expression e is evaluated, and a logical result is derived, .TRUE. or .FALSE. (numerically 1 or Ø, respectively).

2. Depending on the value which is derived, one of the following two conditions occurs:

If e is evaluated as .TRUE. then the statement s is executed, and once the IF has completed, transfer is then passed to the next consecutive statement.

If e is evaluated as .FALSE. the statement s is NOT executed and control is then passed to the next sequential executable statement.

The statement s can be any statement other than an END, another Logical IF or a DO.

Example

```
IF (DEGREE .EQ. 1ØØ)WRITE (1,*) RADIAN
IF ((A .EQ. 12).OR.(LOOP .LE. 5ØØ))RETURN
IF (SIN(3Ø)/WHERE-.ØØØØ5 .LT. .ØØØØ4)STOP
IF (A .NE. B)GO TO 5ØØ
IF (A .EQ. 1)GO TO (1,2,3),J
IF (VALUE .EQ. 6)IF (J)99,33,67
IF (I .GE. 5ØØ)J=I+2Ø/8
IF (FLAG) A=2*A+5
```

6.7. IF-THEN-ELSE

The general format of the IF-THEN-ELSE statement is:

```
IF (e) THEN
        statement 1
        statement 2
        ...
        ELSE
        statement 3
        statement 4
        ...
   ENDIF
```

The IF-THEN-ELSE is an extension of the logical IF with two additions:

1) there can be more than 1 statement to execute if the IF is true

2) there is the provision of specifying one or more statements to be executed if the IF is false.

The ENDIF is required to indicate the end of the complete IF-THEN-ELSE statement.

To indicate an IF-THEN-ELSE the s part of the logical IF is replaced with the THEN statement. All statements between the THEN and the matching ELSE or ENDIF will be executed if the specified condition is true. All statements between the ELSE and ENDIF will be executed if the specified condition is false. The ELSE is optional and if the condition is false, all statements between the THEN and ENDIF will be skipped.

If no ELSE condition is to be specified, then the THEN can be terminated with an ENDIF. For example:

```
If (e) THEN
        statement 1
        statement 2
        ENDIF
```

The statements to be executed can be any statement including another IF-THEN-ELSE.

Note: THEN, ELSE and ENDIF are individual statements terminated by either a carriage return or semicolon.

Example

```
     IF (I .EQ. Ø) THEN
                    L=K+1
                    K=I
                    ELSE
                    K=Ø
                    ENDIF


     IF (J .LT. 7) THEN
                    LL=L+1
                    ELSE
                    IF (A .EQ. B)THEN
                         Q=Ø
                         D=N
                         ELSE
                         TYPE 'ERROR'
                         STOP
                         ENDIF
                    ENDIF
```

6.8. DO-LOOPS

The general format for a DO loop is:

DO n i=m1,m2,m3

The DO loop is the basic loop structure in FORTRAN. It works in a manner similar to the FOR-NEXT loop in BASIC. The DO Loop works as follows:

1) i is set to the value of m1.

2) After each pass through the loop (which ends with the statement labelled n), the step value, m3 is added to i. If the m3 term (step value), is omitted, then the step value is assumed to be one. Unlike other versions of FORTRAN the i and m terms do not have to be INTEGER values and the step may be negative. This allows fractional increments of the DO loop index, i. The ability of a negative increment, m3, allows loop to step in a downward direction. If the step value is positive, the loop continues until the value of i is greater than that of m2. If the step value is negative, the loop continues until the value of i is less than that of m1. n in the DO loop specifies the range of the DO loop. This is the statement number of the last statement of the DO loop.

Irrespective of the relation of the initial and ending values, the DO will always be executed once.

Note that 2 or more DO loops may end on the same statement.

DO loops may not terminate on GO TO, STOP, IF-THEN-ELSE, END or RETURN statements. A common way to terminate a DO is with a CONTINUE statement.

Example

```
      DO 8ØØ I=1,1ØØ
      DO 1 J=I,END,.ØØ5
      DO 99 A=START,END,AINCR


      DO 1Ø I=1,5
      DO 2Ø J=3,99
      .
      .
2Ø    CONTINUE
      .
      .
1Ø    CONTINUE
```

6.9. CONTINUE Statement

The format of the CONTINUE statement is:

```
CONTINUE
```

The CONTINUE statement is an executable FORTRAN statement. It generates no code and is generally used as the terminal statement of a DO loop.

Example

```
     DO 1ØØ I=1,5Ø
        .
        .
        .
 1ØØ CONTINUE
```

The CONTINUE statement simply serves to mark the range of the DO. It is also used for transfer of control i.e. you can GO TO it.

6.1Ø. ERROR TRAPPING

Normally when an error occurs during the execution of a FORTRAN program a runtime error message will be generated. However using the ERRSET and ERRCLR statements it is possible to control and trap runtime errors.

The general format of these statements is:

```
ERRSET n,v
ERRCLR
```

where n is the label of the statement to go to, if a runtime error occurs. And v is the variable to contain the error code of the runtime error that occurred.

The ERRSET statement causes control to be transferred to the statement labeled n when a runtime error occurs. No runtime error message will be printed if the error is trapped with an ERRSET statement. The ERRSET statement can only be used if the Q option was specified on the OPTIONS statement for the routine in which the error occurred. If an ERRSET or ERRCLR statement is encountered and the Q option was not specified, a compilation error will be generated.

The value placed in the variable v corresponds to the runtime error that occurred as follows:

1	Integer overflow
2	Convert error
3	Argument count error
4	Computed GOTO index out of range
5	Overflow
6	Division by zero
7	Square root of negative number
8	Log of negative number
9	Call stack push error
1Ø	Call stack pop error
11	CHAIN/LOAD error
12	Illegal FORTRAN logical unit number
13	Unit already open
14	Disk full
15	Unit not open
16	Binary I/O to system console
17	Line too long on READ or WRITE
18	FORMAT error
19	Input/Output error in READ or WRITE
2Ø	Invalid character on input
21	Invalid input/output list (impossible)
22	Assigned GOTO error
23	CONTROL/C abort
24	Illegal character in input

```
25        File operation error
26        Seek error
```

If more than one ERRSET statement is executed in a routine, then the last one executed is the one in effect. If a runtime error should be trapped with an ERRSET statement, the ERRSET statement is automatically cleared after control has transferred to the statement n.

The ERRCLR statement clears the effect of the ERRSET statement that was last executed in the routine in which the ERRCLR is executed.

Example

```
OPTIONS Q
     .
     ERRSET 1Ø,CODE
     .
     .
     ERRCLR
     .
     .
     STOP
  1Ø TYPE 'ERROR ,ERROR CODE = ',CODE
     .
     END
```

6.11. CONTROL/C CONTROL

At the beginning of each READ or WRITE statement the state of the CONTROL/C abort flag is tested. If the CONTROL/C abort flag is set, then the console is tested to see if CONTROl/C has been hit. If CONTROL/C has been hit, then one of two actions will occur:

1) if there is an ERRSET in effect, the error branch will be taken with a **CONTRL/C** error.

2) otherwise a runtime error of **CONTRL/C** will be generated.

The user has control of the CONTROL/C flag through the **CTRL ENABLE** and **CTRL DISABLE** statements. **CTRL ENABLE** sets the CONTROL/C flag and allows a CONTROL/C from the console to abort the program. **CTRL DISABLE** resets the flag and causes the CONTROL/C to be ignored.

Example

```
      DO 1 I=1,1ØØ
      IF (I .EQ. 51)CTRL DISABLE
    1 TYPE I
      END
```

The above program will only abort if CONTROL/C is entered while the first 5Ø numbers are being typed.

When program execution starts, the CONTROL/C flag will be set which allows CONTROL/C to abort the program.

Note: The CONTROL/C error, if enabled, can be trapped with an ERRSET statement. However, the CIN function will return a control-C to the caller, regardless of the setting of the CONTROL/C flag

6.12. TRACING

There are two statements that are used to trace a program:

```
TRACE ON
TRACE OFF
```

When program execution begins, tracing is initially off and must be explicitly turned on. Once tracing is on, it remains on until the program terminates or a TRACE OFF statement is executed. The effect of the both trace statements is global over the whole program and tracing does not have to be turned on in each subroutine. The trace function will output the line number of the FORTRAN statement before execution only if the X option was specified on the options statement for this routine. Otherwise the program will be traced only up to the entrance to the subroutine. It should be noted that the line number for any entrance to a subroutine (either SUBROUTINE or FUNCTION) will always be output as ???? regardless of the state of the X option.

Example

```
      IF (FLAG .EQ. Ø)TRACE ON
      TRACE OFF

      DO 1 I=1,1ØØ
      IF (I .EQ. 5Ø)TRACE ON
1     TYPE I
```

6.13. DUMP statement

The general format of the DUMP statement is:

DUMP /ident/ output list

where ident is up to a 1Ø character identifier for this DUMP statement and output list is a standard WRITE output list that may contain variables, constants, character strings, array elements, array names and implied DO loops.

The DUMP statement is used to display information when a runtime error occurs that is not trapped by an ERRSET statement.

More than one DUMP statement may be executed in a routine and the last one executed is the one that will be output on a runtime error. Each subprogram may contain its own DUMP statement, but only the last DUMP statement executed in a particular routine will be saved and output if a runtime error occurs.

Example

```
DUMP /AFTER-DIV/ 'Index after divide is ',K
.
.
.
.
A=K/I
.
.
END
```

will cause the dump statement to output if I is zero.

7. Program Termination Statements

7.1. PAUSE Statement

The general format of the PAUSE statement is:

PAUSE 'any char string'

This statement causes the program to wait for any input from the system console. To continue execution, press any key on the system keyboard. If the character string option is specified, the string will be displayed on the system console. The string is enclosed in single quotes ('). To output a quote, two quotes in a row must be entered; e.g. ('') outputs as (''). The quotes surrounding the text are not displayed.

Example

```
      PAUSE
      PAUSE 'DATA OUT OF SEQUENCE, IGNORED'
      PAUSE 'THIS IS A SINGLE QUOTE ('')    '

      ISUM=Ø
      DO 1Ø I=1,1Ø
      ISUM=ISUM+I
      IF (ISUM .EQ. 5) PAUSE 'SUM = 5'
1Ø    CONTINUE
      STOP
      END
```

7.2. STOP Statement

The general format of the STOP statement is:

```
STOP 'any char string'
STOP n
```

When a STOP statement is executed, termination of the executing program will occur. If the character string is specified it will be printed on the system console when the statement is executed. After the character string is output, the program terminates and returns to CP/M. The string is enclosed in single quotes. To output a quote, two quotes in a row must be entered. The quotes surrounding the text will not be output.

In the second form, **n** is a 1 to 5 digit integer number that will display. **n** is optional.

To terminate a program without the STOP being typed on the console, use the EXIT subroutine.

Example

```
STOP 'PROGRAM COMPLETE'
STOP 1267
STOP
STOP 'ERROR OCCURRED, CHECK OUTPUT'

IF (ERROR .NE. Ø)STOP 'ERROR'
IF (FLAG .AND. STOPIT)STOP 'ALL DONE'
```

7.3. END Statement

The format of the END statement is:

```
END
```

This is a required statement for every FORTRAN routine. It is used by the compiler to indicate the end of one logical routine. If an END statement is executed, then the message **STOP END IN - XXXXX** will be output to the system console, with XXXXX being replaced by the name of the FORTRAN routine in which the END statement was executed and the program will terminate.

8. Array Specification

An array is a collection of values that are referenced by the same name and the particular element is specified by a subscript. Subscripts can be real or integer expressions or constants and will be truncated to an integer value after the expression is evaluated.

Every array that is to be used must be dimensioned.

An array may have from one to seven dimensions.

Example

If GRADE has 3 elements then:

```
GRADE(1)   refers to the first element
GRADE(2)   refers to the second element
GRADE(3)   refers to the third element
```

NOTE: Subscripted variables cannot be used as subscripts, thus GRADE(A(I)) is invalid, where both GRADE and A are arrays.

8.1. Dimension Statement

The general format for a DIMENSION statement is:

DIMENSION v(n1,n2,..,nm),..

Where v us the array name and N1, N2,.. are the size of each of the dimensions of the array v.

The DIMENSION statement is used to define an array. The rules for using the DIMENSION statement are as follows:

1) Every subscripted variable must appear in a DIMENSION statement whether explicit (in a dimension statement) or implied (in a REAL, DOUBLE PRECISION, INTEGER, LOGICAL or COMMON statement) prior to the use of the first executable statement.

2) A DIMENSION specification must contain the maximum dimensions for the array being defined.

3) The dimensions specified in the statement must be numeric in the main routine. However, in subprograms the subscripts may be integer variables. Hence the following statement is valid only in a SUBROUTINE or FUNCTION:

DIMENSION A(I,J)

In the case where the dimensions of an array are specified as variables, the value of the variable at runtime will be used in computing the position within the array to be accessed.

4) All arrays passed to subprograms must be DIMENSIONED in the subprogram as well as in the main program. If the arguments in the subprogram differ from those in the main program, then only those sections of the array specified by the DIMENSION statement in the subprogram will be accessible in the subprogram.

5) The number of dimensions specified for a particular array cannot exceed 7.

6) No single array can exceed 32,767 bytes in size (5461 elements).

Note: The following is a method that can be used to get around the size limit of arrays. Allocate the large array in a named common block as 2 or more sequential arrays. Use just the first array and subscript out of it as neccessary. The way that common blocks are allocated will assure you that the arrays are allocated sequentially in memory. For example, if you want an array of 7ØØØ elements, it can be defined as:

```
COMMON /DUMMY/ TABLE(4ØØØ),TABLE1(3ØØØ)
```

Then you would just use the array TABLE. To access the 4945th element, just use TABLE(4945) (which is actually the 945th element of TABLE1).

Example

```
DIMENSION GUN(S,E)     (this statement is valid only
                        in a subprogram as it uses
                        variable dimensions).
DIMENSION A(2,2),B(1Ø)
DIMENSION ZIT(1Ø)
REAL APPLE(1Ø)
LOGICAL FUNCT(1ØØ)
DOUBLE PRECISION ARR(1Ø),B(8),A(SIZE)


DIMENSION A(3,2,3),C(1Ø),ZOT(1Ø,1Ø)
INTEGER SWITCH(15)

     "A" would require 3*2*3*(6) = 1Ø8 bytes
     "C" would require 1Ø*(6) = 6Ø bytes
     "ZOT" would require 1Ø*1Ø*(6) = 6ØØ bytes
     "SWITCH" would require 15*(6) = 9Ø bytes
```

In calculating the memory used by an array, multiply each of the dimensions times each other, then times 6. The result will be the number of bytes used by the array for storage.

WARNING: No subscript range checking is performed at runtime.

8.2. Subscripts

Subscripts are used to specify an entry into an array (i.e. the value specified in the subscript is the element of the array referenced). Subscripts may be integers, real (fractions are truncated), logical expressions or any other valid expression. Expressions are evaluated as explained in the EXPRESSION section (5.2.Ø).

Example

```
ZIT(8)
A(1+2)
ORANGES(I+5-(K*1Ø)/2)
APPLE(5)
```

9. Subprograms

Subprograms provide a means to define often needed sections of code that can be considered as a unit. FORTRAN provides the means to execute these subprograms whenever they are referenced.

There are 3 types of subprograms supported in this version of FORTRAN:

1) SUBROUTINE subprograms

2) FUNCTION subprograms

3) Built in library functions

The major differences between FUNCTIONS and SUBROUTINES are listed below.

1) FUNCTIONS are used in expressions, while SUBROUTINES must be CALLed.

2) FUNCTIONS require at least one parameter; SUBROUTINES do not require any.

3) The name on the FUNCTION statement must be the object of a replacement statement somewhere in the FUNCTION; this is not the case for a SUBROUTINE.

WARNING: If a constant is passed as an argument in either a CALL or FUNCTION reference, and the corresponding parameter in the SUBROUTINE or FUNCTION is modified, then the value of the constant that was passed will be changed, and remain that of the new value.

NOTE: All SUBROUTINES and FUNCTIONS must be compiled at the same time.

9.1. SUBROUTINE Statement

The general format of the SUBROUTINE statement is:

SUBROUTINE name(list)

The SUBROUTINE statement is used to identify the beginning of a logical routine. This statement is required at the beginning of every SUBROUTINE. The list that is to receive the values being passed to the subroutine is optional if no parameters are to be passed.

Example

```
SUBROUTINE ADDIT (RESULT,X,Y)
RESULT=X+Y
RETURN
END
```

9.2. FUNCTION Statement

The general format of the FUNCTION statement is:

FUNCTION name(list)

A FUNCTION Statement is used to define a logical routine as a FUNCTION. The type of result of a FUNCTION can be specified by preceding the FUNCTION with REAL, DOUBLE PRECISION, INTEGER, or LOGICAL; or the name of the FUNCTION may appear in a type statement within the FUNCTION.

Example

```
FUNCTION SWAP(A)
SWAP=A
RETURN
END


INTEGER FUNCTION SWAP (A)
SWAP=IFIX(A)
RETURN
END


FUNCTION SWAP (A)
INTEGER SWAP
SWAP=A/2
RETURN
END


DOUBLE PRECISION VALUE(WHAT)
VALUE=WHAT/4*7+5
RETURN
END
```

9.3. CALL Statement

The general format of the CALL statement is:

CALL name(list)

The CALL statement is used to transfer control to a SUBROUTINE. List specifies the parameters to be passed to the SUBROUTINE and may be omitted if no parameters are to be passed.

The number of parameters in a CALL and SUBROUTINE statement referring to the same subprogram must be the same, otherwise a runtime error will result.

Example

```
CALL XSWAP (NUM1,NUM2,TOTAL)
CALL XSWAP
```

9.4. RETURN Statement

There are 2 types of RETURN statements:

1) normal RETURN

2) multiple RETURN

9.4.1 Normal return

RETURN

The RETURN Statement is used to terminate execution of a subprogram whether it is a FUNCTION or a SUBROUTINE. Return is transferred to the next statement following the CALL statement, or in the case of a FUNCTION, return is transferred back to the point where it was called with the value of the FUNCTION returned. A RETURN statement is not valid in the MAIN routine and will cause an error during compilation if encountered in the MAIN routine.

Example

```
SUBROUTINE ZERO(I,J)
I=Ø
J=Ø
RETURN
END

FUNCTION ZZ(VAL)
COMMON /A/ A,B,C
ZZ=A+B/C-VAL
RETURN
END
```

9.5. Multiple return

The general format of the multiple RETURN statement is:

```
RETURN I
```

This variation of the RETURN statement is used to transfer back from a SUBROUTINE to a point other than the statement that immediately follows the CALL. The I in the RETURN is the name of a variable in the argument list of the subroutine and must have been passed as a label in the CALL. The CALL statement that invokes a routine that contains a multiple return must pass the label as one of the parameters. The statement label is indicated in the argument list by preceding the label with an ampersand (&).

Example

```
        CALL X(&1,Y,2,&2)
        .
        .
        SUBROUTINE X(I,A,IC,J)
        .
C
C THE FOLLOWING RETURN WILL TRANSFER TO THE STATEMENT
C LABELLED '1' IN THE CALLING PROGRAM.
C
        RETURN I
        .
C
C THE FOLLOWING RETURN WILL TRANSFER TO THE STATEMENT
C LABELLED '2' IN THE CALLING PROGRAM.
C
        RETURN J
        END
```

NOTE: Multiple RETURNS are only valid for SUBROUTINES.

9.6. BLOCK DATA SUBPROGRAM

The BLOCK DATA subprogram is used to initialize variables in named COMMON. The BLOCK DATA subprogram must contain no executable statements. It may contain only declaration statements for specifing variable types, array dimensions, COMMON blocks and DATA statements.

Example

```
BLOCK DATA
INTEGER FIRST,LAST
COMMON /ONE/ NAMES(1ØØ) /TWO/ FIRST,LAST
DATA FIRST /1/, LAST/1Ø/
DATA NAMES /1,2.Ø,4,5,6,7,8,9,1Ø,9Ø*99999/
END
```

NOTE: The variable in named COMMON can be initialized in any routine. The BLOCK DATA subprogram appears only for compatibility with other FORTRAN systems.

1Ø. Input/Output

1Ø.1. Introduction to FORTRAN I/O

1Ø.1.1. General Information

Input and Output (I/O) under FORTRAN may take one of the following forms:

1) Standard Formatted I/O
2) Free Format I/O
3) Binary I/O

In formatted I/O, input and output is defined in terms of fields which are right justified on the decimal point, with zero suppression. In a FORMAT statement, no more than three levels of nested parentheses are allowed (outer set and two nested inner sets).

Free Format I/O is used as in BASIC. All the values are entered using commas (,) or carriage returns to delimit the numbers.

Binary I/O is a third option that allows passing of large files between FORTRAN programs, with the minimal amount of wasted disk space. Each variable written in binary format uses six bytes of disk space.

FORTRAN logical units Ø and 1 are dedicated to console input and output and cannot be either opened or closed. An attempt to open or close Ø or 1 will result in a runtime error. Logical unit Ø is used for console input and logical unit 1 is used for console output. Binary I/O cannot be specified for logical units Ø or 1 and doing so will result in a runtime error.

There are two special I/O statements:

TYPE
ACCEPT

Both of these are followed by a standard I/O list. TYPE is equivalent to WRITE (1,*) and ACCEPT to READ (Ø,*). This is just a convenient method of doing console I/O.

Example

```
TYPE I,J,(A(I),I=1,1Ø)
ACCEPT 'INPUT THE MAX COUNT',COUNT
```

A RUNTIME FORMAT can be specified for any formatted I/O statement by substituting an **ARRAY** name for the FORMAT number. At runtime, the array is assumed to contain a valid FORTRAN FORMAT (complete with its outer set of parentheses). This allows a FORMAT statement to be input at runtime and then to be used in either READ or WRITE statements within the program. Thus a particular FORMAT can be changed at runtime instead of having to recompile the program. The FORMAT should be input using an A6 format specification as imbedded blanks (added if using less than an A6) will cause a runtime error.

Example

```
      DIMENSION FORM(1Ø)
      READ (Ø,1Ø) 'ENTER DATA FORMAT ',FORM
   1Ø FORMAT (1ØA6)
      .
      .
      .
      READ (4,FORM) A,B,C
      .
      .
      .
      WRITE (5,FORM) R1,R2,R3
```

1Ø.1.2. I/O List Specification

The I/O List is used to specify which variables are to be READ or WRITTEN in a particular I/O statement. The list has the same form for both READ and WRITE statements. The list can be composed of one or more of the following:

1) simple (non-subscripted) variable
2) array element
3) array name
4) implied DO loop
5) literal
6) constant (WRITE only)

The above types are combined to form the I/O list specification. Items 1-4 are self explanatory, however item 4, the implied DO loop is explained further below:

The implied DO loop is used mainly to output sections of one or more arrays and functions in the same way as does a regular DO loop. An example of an implied DO loop is:

```
WRITE (1,*) (F(I),I=1,3,1)
```

It should be noted that the outer parentheses and the comma preceding the DO index are always necessary when using an implied DO loop. Nested loops can be used. Each loop must be enclosed in parentheses. An example follows:

```
WRITE (1,*) (J,(F(I,J),I=1,4),J=1,3Ø,2)
```

The inner DO (I) is performed for each iteration of the outer DO (J). Note that other than array elements can be included within the range of an implied DO. Implied DO's can be nested to any depth, each within its own set of parentheses.

LITERALS (character strings enclosed in quotes) can be used in any WRITE statement and in READ statements that reference the system console. The literals can be used as prompts for input or identification on output.

Example

```
WRITE (1,*) 'A= ',A
TYPE 'The answer is ',ANS
WRITE (5,3) 'X= ',X

READ (Ø,*) 'A= ',A,' B= ',B
ACCEPT 'Enter quantity ',QUANT
```

NOTE: An attempt to use a literal in a READ statement that doesn't reference the console will result in an INPUT ERR runtime error.

1Ø.2. READ Statement

READ(unit{,format}{,END=end}{,ERR=error}) I/O list

The READ statement is required in order for the user to do input through the FORTRAN system. If a unit number of Ø is used there is no need to open this file as it is assumed to be system console input. Note: do not use 1 as the logical unit as it is reserved for the system console output. Any other unit number must first have been opened by the user through the OPEN or LOPEN subroutine. The FORMAT entry may take one of the following forms:

1) The FORMAT number is the label on the FORMAT statement which is to be used.

2) An asterisk (*) in the FORMAT entry indicates that input is to be free format. The exact format of the output depends on the value of the number being output and is determined at runtime.

3) If the FORMAT entry is left blank (or not specified), binary input is assumed.

4) The name of an array that contains the FORMAT to be used.

END= is the label to which transfer of control is to be made should an end of file condition be encountered. ERR= is the label to which control will be transferred, should an error other than end of file occur during input, such as a bad sector. The ERR= does not handle input format errors (such as decimal point in a integer field). Use ERRSET to handle these input errors. I/O list is the string of variables which accept the data to be read.

Example

READ (Ø,2) A	read from the system console the variable 'A' under FORMAT number 2
READ (Ø,*) A	read from the system console the variable 'A' in free format.
READ (4) A	read from logical file 4, the variable A in binary.

```
READ (4,,END=1Ø) A
```
read from logical file 4, the variable A, in binary, and if end-of-file is encountered, go to statement label 1Ø

```
READ (4,*,END=1Ø,ERR=1ØØ) A
```
read from logical file 4, the variable A in free format, should end-of-file be encountered, go to statement label 1Ø. If an error occurs, go to statement label 1ØØ.

```
READ (4,,ERR=1ØØ) A
```
read from logical file 4, the variable A in binary format, and if an error occurs, go to statement label 1ØØ.

NOTE: The END= and ERR= parameters are optional and can appear in any order.

10.3. WRITE Statement

WRITE (unit{,format}{,END=end}{,ERR=error}) I/O list

The WRITE statement is used to output to either disk files or the console. It performs a function that is the opposite of the READ statement. The I/O list is specified exactly the same as for the READ statement with the exception that a string can always be used in the I/O list. However the END= serves no function and will never be used by the WRITE statement.

Example

```
WRITE (1,2) I,J,PAY,WITHOLD
WRITE (1) (I,I=1,10)
WRITE (10,*) THIS
WRITE (6,12,END=99,ERR=66) LOOP,COUNT
```

1Ø.4. MEMORY TO MEMORY I/O statements

The ENCODE and DECODE statements allow I/O to be performed to or from a specified memory location. This allows data in memory to be read (using DECODE) with perhaps a different format code depending on the data itself. The ENCODE statement is similar to a WRITE statement in that data is formatted according to the specified format type, but instead of being output to a file it will be placed in memory at the specified location for further processing.

1Ø.4.1. DECODE statement

The general form of the DECODE statement is:

DECODE (variable,length,format) I/O list

The DECODE statement is similar to a READ statement in that it causes data to be converted from external ASCII format to internal FORTRAN type. **Variable** is either an unsubscripted variable name or an array name. **Length** is the number of bytes to process for this READ starting at variable. If multiple records are required by the I/O list, successive records of length will be retrieved from memory. Input records will be blank padded on the right end as necessary as in a READ statement. **FORMAT** is either an asterisk for free formatting or the number of a FORMAT statement.

Example

```
      DIMENSION A(15)
      READ (1,1Ø) A
1Ø    FORMAT (15A6)
      DECODE (A,8Ø,11) KNT1,KNT2,CNT3
11    FORMAT (I1Ø,I3,F1Ø.5)
```

1Ø.4.2. ENCODE statement

The general form of the ENCODE statement is:

ENCODE (variable,length,format) I/O list

The ENCODE statement is similar to a WRITE statement in that it is used for a memory to memory formatted WRITE. Variable is either an unsubscripted variable name or an array name. **Length** is the number of bytes (or characters) that the output record is to contain. If the number of characters generated by the ENCODE statement is less than **length**, then the record will be blank padded to length. If the number of characters in the generated record is greater than **length**, then the record will be truncated after the **length** character. If multiple output records are generated, successive records of length character will be placed in memory starting at **variable**. **FORMAT** is either an asterisk for free formatting or the number of a FORMAT statement.

Example

```
DIMENSION A(15)
ENCODE (A,8Ø,*) (I,I=1,5)
```

1Ø.5. Format Statement and Format Specifications

The general form of the FORMAT statement is:

n FORMAT (s1,s2,...sn)

The FORMAT statement is used in FORTRAN to do formatted input and output. Through the use of this statement the programmer has the ability to select the fields in which to read, or specify the columns on which to write. It is the use of this statement which gives FORTRAN its I/O power. On FORMATTED input, blanks are treated as if they were zeros except when reading in A format. A constant enclosed in backslashes (eg \A\) can be used to enter a binary constant from a string within a FORMAT statement.

If a number cannot be written in the specified field width, then the entire field will be filled with asterisks (*) to indicate the error condition. Note: some FORTRANS will print a negative number, even when there is not room enough to place the negative sign in the field, by omitting the negative sign. In this case, NEVADA FORTRAN will fill the field with asterisks. Asterisk filling of a field that is not large enough to output a number applies on all output specifications.

A ZERO will always be printed as Ø.Ø under a F, E or D field specification. If a field is printed as Ø.ØØØ... this indicates that the digits have been truncated because the d portion of the field specification was not large enough.

All floating numbers output using the F, E or D (and G with a floating point number) specifications will be rounded to the appropriate number of digits specified by the d portion of the field specifier.

1Ø.5.1. X-Type (wX)

The X-Type specification is used to space over any number of columns with a maximum of 255 character positions. w may have any value from 1 to 255.

On output the columns spaced over will be set to blanks. On input w characters of the input record will be skipped.

Example

```
1Ø FORMAT (1ØX,I1Ø,3X,I5)
99 FORMAT (1X,'THIS IS A LITERAL',5X,'$$$$')
```

1Ø.5.2. I-Type (Iw)

The I-Type specification is used as a method of performing I/O with integer numbers. On input, the number must be right justified in the specified field with leading zeros or blanks. On output the leading zeros are replaced by blanks, and the number is right justified in the field.

Example

```
1Ø FORMAT (1ØI1Ø)
```

1Ø.5.3. A-Type (Aw)

The A-Type specification is used to perform the input of alphanumeric data in ASCII character form. Up to 6 ASCII characters may be stored per variable name. However, this is entirely under program control. For example the user may choose to store only one character per variable in a dimensioned array, in order to do character manipulation. Characters are stored in the variable left justified and zero filled. On output these padding zeros will be printed as blanks. It is not advisable to perform any arithmetic operations on a variable that contains character data as unpredicatable results may occur. A format code of A6 is the maximum field width for both input and output.

Example

```
1Ø FORMAT (A1Ø,I1Ø,A6)
```

1Ø.5.4. /-TYPE (/)

The /-Type specification is used to cause I/O to skip to the next record. During input this causes a new input record to be read, even though the previous one was not fully used. On output the slash will cause the current line to be written out to the associated file.

Example

```
     54 FORMAT (I1Ø/)

     WRITE (1,1ØØ) 1,2Ø,45
1ØØ  FORMAT (I3/2I3)
```

will generate

```
  1
 2Ø 45
```

1Ø.5.5. Z-Type

The Z-Type specification is used only for output, to indicate to the system that a carriage return/line feed is not to be written at the end of the record. The Z specification is ignored on input.

Example

```
     WRITE (1,1Ø)
1Ø   FORMAT ('INPUT X ',Z)
     READ (Ø,*) X
```

1Ø.5.6. L-Type (Lw)

The L-Type specification is used with LOGICAL variables, where w is the width of the field. On output, the letter T or F is printed (for .TRUE. or .FALSE. respectively). The T or F will be right justified in the field. On input, the field is scanned from left to right until a T or F is found. The T or F can be located anywhere in the field and all characters that follow the T or F in the remainder of the field are ignored. If the first character found is not a T or F an error will be generated. If the input field is completely blank, then a .FALSE. value will be used.

Example

```
      LOGICAL WHICH
      WRITE (1,11) WHICH
11    FORMAT (8L1Ø)
```

1Ø.5.7. T-Type (Tw)

The T-Type code can be used on both input and output. It is used to move to a explicit column within the input or output buffer. W specifies an absolute column number that the next character is to be read from (on input) or to be placed upon (on output). The first column number is 1. On input the T format code can be used to re-read a particular set of columns in different format codes in the same read statement. Tabbing beyond the end of the input record causes the input record to be blank padded. On output, the output cursor can be moved back (to the left) over text already inserted into the output buffer, thus causing text already there to be over written with new data. Tabbing beyond the maximum character inserted into the output buffer will cause blanks to be inserted into the output buffer to the indicated column. The maximum value of w is 255.

Example

```
      WRITE (1,56) I,LOT
56    FORMAT (I1Ø,T5Ø,I4)

      J=1234
      WRITE (1,34) J
34    FORMAT ('$$$$$$$$$$',T5,I4)
```

will produce:

```
$$$$$1234$
```

1Ø.5.8. K-Type (Kw)

The K-Type format code is used to transmit data in hexadecimal format. Each byte of internal memory occupies 2 hexadecimal characters. If w is less than 12 characters (6 bytes/variable, 2 hex characters/byte), the hexadecimal characters will be either input or output starting from the low order memory address (beginning of the variable).

Example

```
     WRITE (1,99) 1
99   FORMAT (K12)
```

will output the line:

```
1ØØØØØØØØØØ81
```

1Ø.5.9. F-Type (Fw.d)

The F-Type specification is one of several specifications for performing I/O with floating point numbers. The digit portion of the decimal number works the same as in the I-Type format. The fractional part of the number is always printed, including trailing zeros. During input, the decimal point is assumed to be at the indicated position, unless explicitly overridden in the input field. The number ZERO will always print as Ø.Ø (with the decimal point aligned where specified) regardless of the field width or decimal digits specified. Remember to consider the decimal point and negative sign of the number when specifing the width of the output field.

Example

	Output
F4.1	32.2
F7.5	Ø.ØØØØ1
F3.Ø	7.
F7.2	bbb4.5Ø

	Input
F7.2	b4.5bbb
F2.1	7Ø
F7.5	bbbbØØ1
F4.1	32.2

NOTE: b is used to indicate a blank position.

During input the F field specifier reads w characters. If there is not a decimal point in the field read, a decimal is inserted d digits from the right. A decimal point in the input field overrides the field specification.

1Ø.5.1Ø. E-Type (Ew.d)

The E-Type specification is another method of performing I/O with floating point (real) numbers. It is through this specification that the programmer may perform I/O using an exponential format. That is a mantissa followed by an exponent of ten. Again as with the F type, the decimal point is assumed to be at the indicated position if not overridden in the input field. The exponent part of the input number can be omitted, in which case it is treated as if it were an F type specification. The number will be printed as d digits followed by the letter E, exponent sign, and a three digits exponent. The d part cannot be zero for output.

Example

	Output
E9.2	Ø.ØØE+ØØØ
E9.2	Ø.12E+ØØ4
E1Ø.Ø	invalid

	Input
E1Ø.Ø	1ØØØ.
E9.2	1.23E+ØØ4
E9.2	Ø.

NOTE: Data can be read in the F format using the E or D format specification without causing an error.

When the E format is used for input, the data must be right justified in the field. If it is not, then the blanks appearing in the exponent field will be interpreted as zeros.

1Ø.5.11. D-Type (Dw.d)

The D-Type format is treated exactly the same way as the E format code, except on output a D is inserted into the number instead of an E. On input they are treated exactly the same.

1Ø.5.12. G-Type (Gw.d)

The G-Type can be used on either input or output and for both integer and real values where w and d have the same meaning as in the E, D and F type formats. The G format is treated as follows:

Output

If the output element is of type integer, then the format code used will be Iw.

If the output element is of type real, the actual format code used depends on the value of the number being output:

Ew.d will be used if the number is outside the range of Ø.1<= number < 1Ø**d, or

```
F(w-5).d,5X        if      .1 <= number <1
F(w-5).(d-1),5X    if       1 <= number <1Ø
                   .
                   .
                   .
F(w-5).1,5X        if       1Ø**(d-2)<= number< 1Ø**(d-1)
F(w-5).Ø,5X        if       1Ø**(d-1)<= number< 1Ø**d
```

In general in this range:

F(w-5).(d-(exponent of number)),5X

Input

If the input element is of type integer: Iw

If the input element is of type real: Ew.d

Example

```
      A=5.67
      WRITE (1,34) A
34    FORMAT (G1Ø.5)

      READ (Ø,9) A
9     FORMAT (G9.3)
```

1Ø.5.13. Repeating field specifications

A field specification can be repeated in a FORMAT statement by preceding it with the number of times that it should be repeated. Thus 4I1Ø is the same as I1Ø,I1Ø,I1Ø,I1Ø. The following FORMATS are equivalent:

```
1Ø    FORMAT (3I4,2F1Ø.4)
1Ø    FORMAT (I4,I4,I4,F1Ø.4,F1Ø.4)
```

A single field specification or a group of field specifications can be enclosed in parentheses and preceded by a group count. In this case, the entire group is repeated the specified number of times. The following FORMATS are equivalent:

```
19    FORMAT (I4,2(I3,F4.1))
19    FORMAT (I4,I3,F4.1,I3,F4.1)
```

The FORMATS:

```
1Ø    FORMAT (I5,2(I3,F5.1))
1Ø    FORMAT (I5,I3,F5.1,I3,F5.1)
```

execute exactly the same for output, but differ for input. In a FORMAT without group counts, control goes to the beginning of the FORMAT statement for reading or writing of additional values. In a FORMAT with group counts, additional values are read according to the last complete group.

Example

```
      READ (2,1Ø) KNT,(Z(I),I=1,KNT)
1Ø    FORMAT (I5/(F1Ø.5))
```

The I5 specification will be used once and the array values will be read using the F1Ø.5 specification.

Group counts can be nested to a maximum depth of two. Thus:

```
1Ø    FORMAT (2(I5,3(I1Ø))          is ok, while
1Ø    FORMAT (2(I5,3(I1Ø,2(I1)))    is not legal.
```

1Ø.5.14. String Output

Character strings are written using a FORMATTED write. The string to be written is enclosed in SINGLE QUOTES (') and may not contain a backslash (\). To output a single quote within the string, two single quotes in a row must be entered. The string format type is only valid on output and if used with a READ will result in a runtime error being produced.

A character string can also be specified using the H (or Hollerith) field specification. This is an awkward method of specifing a character string as the number of characters in the string must be specified in front of the H. The H type should be avoided as it can lead to problems.

The hexadecimal code for any character (except Ø) can be inserted in a string by enclosing it in backslashes (\). The backslash character can be changed using the CONFIG program.

Placing an ampersand (&) in front of a character in a string causes the character to be treated as a control character. To output an ampersand, two ampersands in a row must be used.

Example

```
      WRITE (1,46)
46    FORMAT ('THIS IS A TEXT STRING')
65    FORMAT (21HTHIS IS A TEXT STRING)
48    FORMAT ('This is an exclamation point\21\')

           generates:     This is an exclamation point!

99    FORMAT ('This is a control L: &L')

           generates:     This is a control L: (followed by a
                          control/L

11    FORMAT ('This is an ampersand: &&')

           generates:     This is an ampersand: &
```

1Ø.6. Free Format I/O

1Ø.6.1. INPUT

FREE format input is similar to BASIC. Blanks in this mode of input are ignored completely. Numbers are entered in any format (F, D, I or E) and can be intermixed as desired. Numbers must be separated from each other by a comma or a carriage return. A comma may appear after the last number on an input line and is ignored if present. If the I/O list specifies more variables than there are in an input record, succeeding records will be read until the list is satisfied. Blank input records and blanks imbedded in numbers are ignored in this mode. The last number in any input record does not have to be followed by a comma.

1Ø.6.2. OUTPUT

With FREE format output the exact output format used depends on the type of the variable or constant being output. An integer will result in an I type format being used, and a real will use a G-type. (The actual format used in this case depends on the value being output).

Example

```
ACCEPT I
ACCEPT 'PLEASE ENTER ID NUMBER',ID,'HOW MUCH',AMOUNT
READ (Ø,*) A,B,C

TYPE 'THE RESULTING VALUE IS ',VALUE
WRITE (Ø,*) 'THE RESULTING VALUE IS',VALUE
TYPE '1+1=',2
```

Free format I/O can also be used to any file, not just the console. The file must first be opened using either the OPEN or LOPEN routine. Then specifing an asterisk as the FORMAT number will perform free format I/O to the specified file.

Example

```
CALL OPEN (2,'INFILE')
CALL OPEN (4,'B:FILE')
CALL OPEN (3,'LST:')
READ (2,*) (A(I),I=1,1Ø)
WRITE (3,*) (A(I),I=1Ø,1,-1)
```

1Ø.7. BINARY I/O

BINARY I/O provides a quick and efficient means of transferring information to and from a file. The variables are READ or WRITTEN in BINARY format. That is, six bytes for each item in the I/O list. WRITE causes the item in the I/O list to be written exactly as it is stored in memory without any additional conversion. READ does the opposite, reading six bytes directly into the I/O list item. No conversion or check is made on the data being read.

Example

```
WRITE (1) (I,I=1,1ØØ)
WRITE (1,,ERR=66) ARRAY

READ (1,,END=99) VALUE
READ (1) THIS,IS,IT
```

NOTE: the binary READ and WRITE transfers 6 bytes from the file specified directly to the variable in the I/O list. No check on the validity of the data is performed and the user should be sure that the variable contains valid numerical data before any arithmetic operations are done on the variable. An end-of-file is indicated by either the physical end of the file or a six byte field of all FF (hex). This is the value that ENDFILE will place at the end of a file that has had binary writes performed on it.

1Ø.8. REWIND Statement

The general format of the REWIND statement is:

REWIND unit

The REWIND Statement is used to position the file pointer associated with unit to the beginning of the file. Essentially this statement closes and then re-opens the file at the beginning.

Example

```
REWIND 3
REWIND INFILE
REWIND OUTF
```

1Ø.9. BACKSPACE Statement

The general format of the BACKSPACE statement is:

BACKSPACE unit{,error}

The BACKSPACE statement is currently not implemented and will produce a message to that effect if encountered at runtime.

1Ø.1Ø. ENDFILE Statement

The general format of the ENDFILE statement is:

```
ENDFILE unit
```

The ENDFILE statement is used to force an end-of-file on unit. Any data that existed beyond the point in the file where the ENDFILE was executed will be lost.

Note: The ENDFILE file statement will also CLOSE the specified file. Essentially the ENDFILE is equivalent to just closing the file; both do the same thing.

Example

```
ENDFILE 4
ENDFILE FILE
```

1Ø.11. GENERAL COMMENTS ON FORTRAN I/O UNDER CP/M

The OPEN or LOPEN subroutine is used to associate a file with a FORTRAN logical unit. Eight files are available, numbered Ø through 7 with Ø being permanently open and associated with input from the CP/M console, logical file 1 also is permanently open and is associated with output to the CP/M console. Logical files Ø and 1 cannot be opened or closed. Additionally any logical unit associated with the CP/M console (through the use of the filename CON:) cannot have binary I/O done to it, cannot be rewound (using REWIND), endfiled (using ENDFILE) or seeked (using the SEEK routine).

A file that is going to be written on should be deleted, using the DELETE subroutine, before the file is opened. The OPEN routine does not delete a file as it does not know what type of I/O will be performed on it.

The CLOSE routine will not place any end-of-file indicator in a file that was written to; the ENDFILE statement must be used to write an end-of-file indicator to a file. The ENDFILE statement will write the normal CP/M end-of-file indicator (control-Z) if the file specified in the ENDFILE has been written to and no binary I/O was done to the file. If binary I/O has been done to the file, then an end-of-file of 6 bytes of FF (hex) will be written instead. If a file is written and then read without being ENDFILEd, it is possible to encounter unwritten data of unknown characters that may cause an error during the READ (illegal character, end-of-file, etc). All files that are written to should be ENDFILEd.

When SEEKing within a file, remember that it is a BYTE position that is specified in the call to SEEK. Each record written to a file will contain a carriage return and line feed appended to the end of it. Remember that the carriage return and line feed MUST be included in the count of characters that make up a record. If SEEKing on a record, it is up the user to insure that each record written contains the same number of characters. If the records do not contain the same number, SEEKing can become a very complicated task.

10.12. SPECIAL CHARACTERS DURING CONSOLE I/O

Entering a control-X during input from the CP/M console will cancel the current line and echo an exclamation point (!) followed by a carriage return and line feed.

End-of-file from the CP/M console is indicated by a control-Z being entered as the first character of an input line during console I/O.

Entering a DELETE (7F hex) or control-H will erase the last character entered.

11. General Purpose SUBROUTINE/FUNCTION Library

The following list of subroutines are available for the user of FORTRAN.

SUBROUTINE Name

OPEN
LOPEN
CLOSE
DELETE
SEEK
RENAME
SETUNT
MOVE
CHAIN
LOAD
EXIT
DELAY
CIN
CTEST
OUT
SETIO
RESET
POKE
BIT
PUT

FUNCTION Name

CHAR
INP
CALL
CBTOF
PEEK
COMP

For details as to the parameters required, see the following descriptions of the individual routines.

If the error is present in the CALL statement and a CP/M error should occur, return will be to the statement following the call and error will contain the appropriate error code as listed below. If error is present and the routine completes successfully, then a zero will be returned for error. However if error is not specified and the routine encounters an error, the program will terminate with a runtime error.

The following is a list of possible errors that may returned through the optional error parameter.

Ø = OK
1 = specified file not found
2 = disk is full
3 = end of file encountered
4 = new filename for RENAME already exists
5 = seek error
6 = seek error (but file is closed)
7 = format error in CHAIN or LOAD file

11.1. OPEN

CALL OPEN(unit,'file'[,error])

The OPEN routine is used to open a CP/M file the user may wish to access. unit and file are required entries. If the CP/M file does not exist and error is not specified, then the file will be created. However, if error is specified and the file does not exist, the appropriate CP/M error code will be returned and the file will not be opened.

There are 2 special filenames that are recognized by the OPEN routine:

CON: used to specify either CP/M console input or output
LST: used to specify CP/M list device

Example

```
CALL OPEN (3,'CON:')
WRITE (3,*) 'A= ',A
```

will output the text to the system console. Files opened with the name CON: can also use a literal in an input statement such as:

```
CALL OPEN (4,'CON:')
READ (4,*) 'INPUT QUANTITY ',QUANT
```

Output can be directed to the CP/M LST device by opening the file LST: as in:

```
CALL OPEN (2,'LST:')
WRITE (2,*) (I,I=1,123)
```

To open a disk file, just the filename needs to be specified such as:

```
        CALL OPEN (4,'C:FILE.BAS')
        CALL OPEN (2,'DISKFILE')
        CALL OPEN (3,'B:INPUT')
        READ (3,*) VALUE
        WRITE (2,22) VALUE
22      FORMAT (F1Ø.4)
        WRITE (4,55)
55      FORMAT ('THIS LINE WILL BE WRITTEN TO THE FILE')
```

To open a file and check if the file exists, the optional error parameter must be specified such as:

```
        CALL OPEN (3,'INPUT',IERROR)
        IF (IERROR .NE.Ø)THEN
                        TYPE 'CANNOT OPEN INPUT FILE'
                        STOP 'RUN ABORTED'
                        ENDIF
```

NOTE: The filename (whether a character string or array name) is defined as terminating when:

1) 13 characters are encountered.

2) a NULL is encountered.

11.2. LOPEN

CALL LOPEN(unit,'file'{,error})

This subroutine is functionally the same as OPEN in that it associates a FORTRAN unit with a CP/M file except that the first character of all output records will be processed as the printer's carriage control. This is usually used for a listing device such as a printer. The first character of the record will not be output to the file but processed as follows:

first character	action
+	overprint the last record
blank (space)	single skip
Ø	double skip
-	triple skip
1	page eject

If none of the above characters is present, then single-line spacing will be assumed. Overprinting is implemented by only generating a carriage return at the end of the line (not followed by a line feed). A page eject generates a form feed character (ØCH).

The output device that finally prints the output from this file must respond in the following manner:

ØDH (carriage return) -- return to beginning of this line
ØAH (line feed) -- space 1 line, do not return to beginning of line

ØCH (form feed) -- space to the top of the next page

A carriage return must cause the line to be printed on a line oriented device.

Example

```
      CALL LOPEN (2,'LST:')
C
C PAGE EJECT TO TOP OF NEW PAGE
C
      WRITE (2,1)
1     FORMAT ('1THIS SHOULD BE ON THE TOP OF A NEW PAGE')
C
      WRITE (2,2)
2     FORMAT ('ØONE BLANK LINE ABOVE THIS ONE'/
     * '+','THIS LINE WILL OVERPRINT THE ONE ABOVE'/
     * '-',5X,'THIS LINE WILL HAVE 2 LINES ABOVE IT')
      STOP
      END
```

11.3. CLOSE

CALL CLOSE(unit)

The CLOSE routine is used as a method of closing FORTRAN files which were previously opened through the OPEN or LOPEN routine. Once the file has been closed, the file number is then available for reuse.

Example

```
CALL CLOSE(3)
CALL CLOSE (FILE)
```

11.4. DELETE

CALL DELETE ('file'{,error})

The DELETE routine is used by the FORTRAN user to remove a file from the CP/M system. Note that once a file is deleted it cannot be recovered. No error is generated if the file does not exist and the error is not present.

Example

```
CALL DELETE('OUTFILE')
CALL DELETE ('OUTFILE',ERROR)
CALL DELETE (FILE)
```

11.5. SEEK

CALL SEEK (unit,position{,error})

The SEEK routines allow random positioning within a file. The file associated with unit will be positioned to position which specifies a displacement in bytes from the beginning of the file. If error is specified, there are two possible values that may be returned on a seek error. A 5 indicates a seek to a part of the file that doesn't exist, and a 6 indicates a seek to an extent of the file that does not exist. The difference between the two is that if error code 6 is return, the file associated with unit is closed. The file will have to be re-opened before it can be used again.

Example

```
      CALL SEEK (FILE,IPOS*1Ø+4)
      CALL SEEK (3,1ØØ,ERROR)
```

11.6. RENAME

CALL RENAME('old file','new file',{error})

The RENAME routine will rename old file to new file. A runtime error occurs if old file does not exist and error is not specified or new file already exists.

Example

```
      CALL RENAME ('OLD','NEW')

      DIMENSION OFILE(2),NFILE(2)
      READ (Ø,1) OFILE,NFILE
1     FORMAT (2A6/2A6)
      CALL RENAME (OFILE,NFILE,ERROR)
```

11.7. CHAIN

CALL CHAIN('program name'{,error})

The CHAIN routine is used to load in another program overwriting the existing one in memory. This is NOT an overlay, the program that issues the CALL CHAIN will be overwritten by the new program. If program name specified does not exist; and error, was not specified, a CHAIN FL runtime error will be produced. If the format of the program name file is incorrect, program execution will be terminated. The new program to be loaded is assummed to have the .OBJ extension. The CHAIN routine will NOT close any files that may be open. Thus the new routine will be able to use the same files as the routine that issued the CHAIN without having to reopen them.

Example

```
CALL CHAIN ('GRAPH')
CALL CHAIN ('NXTPGM',ERROR)
CALL CHAIN (NEXT)
```

11.8. LOAD

CALL LOAD('file to load',load-type{,error})

The LOAD routine is used to load either a standard CP/M .HEX file or a NEVADA ASSEMBLER .OBJ file. If load-type is zero, then the type of the file to be loaded will be .HEX, if load-type is non-zero, then the type will be .OBJ. This routine can be used to load assembly language routines into memory that can then be accessed through the CALL function. No check is made during the loading process to see whether the object code being read into memory overlays the program or runtime package.

It is left up to the user to insure that it does not occur. Normally the runtime package occupies memory from 1ØØH to 4ØØØH. If file to load does not exist and error is not specified a CHAIN FL runtime error will be produced. If the format of the program name file is incorrect, program execution will be terminated.

Example

```
CALL LOAD ('ASMFILE',Ø)
CALL LOAD ('ASMOBJ',1,ERROR)
```

11.9. EXIT

CALL EXIT

The EXIT routine will terminate execution of the FORTRAN program in the same manner as the STOP statement, except that EXIT does not output STOP to the system console.

Example

```
CALL EXIT
```

11.1Ø. MOVE

CALL MOVE(count,from,displacement,to,displacement)

The MOVE routine allows direct access to memory for both reads and writes. The count specifies the number of bytes to be moved. The arguments from and to specify either a memory address to be used or a character string to be moved. Which interpretation of, from, and to is based on the respective displacement. If the displacement is negative, then the associated from or to specifies an address to be used in memory access. If the displacement is positive then the from or to that is associated with it is a string.

Example

```
CALL MOVE(2,A,-1,$CCØØ,-1)
    This MOVES 2 bytes from the address specified by
    A to address CCØØ (HEX).
```

CALL MOVE(6,'STRING',Ø,$CCØØ,-1)
This MOVES 6 bytes of the string 'STRING' to address CCØØ (HEX).

CALL MOVE(1Ø24,$CCØØ,-1,A,Ø)
This MOVES 1Ø24 bytes from address CCØØ (HEX) to the address of A.

NOTE: The DOLLAR ($) sign indicates a hexadecimal constant. This hexadecimal constant is converted to floating point notation internally.

11.11. DELAY

CALL DELAY(wait time)

The DELAY routine enables the user to implement a time DELAY of 1/1ØØ of a second to 655.36 seconds. Wait time must be in range of Ø to 65535 with Ø being the maximum delay time, 1 being the shortest and 65535 being 1/1ØØ less than Ø. This time is based on a 2 MHZ 8Ø8Ø processor.

Example

```
CALL DELAY(1Ø)
CALL DELAY (HOWMUCH)
CALL DELAY (WAIT)
```

11.12. CIN

CALL CIN(variable)

The CIN routine enables the user to obtain a single character from the system console. The character is returned as the left most byte of variable. The left most bit of value read will be zeroed. The other 5 bytes of variable remain unchanged.

Example

```
  C WAIT FOR A CARRIAGE RETURN (ODH) FROM THE CONSOLE
  C BEFORE CONTINUING.
    8Ø  CALL CIN(CHAR)
        IF (COMP(CHAR,#ØDØØ,1) .NE. Ø)GO TO 8Ø
```

In the above example, #DØØØ must be specified like this as the # operator stores the number as ØD ØØ ØØ ØØ ØØ ØØ in memory. This forces the hex value of a carriage return (ØD) to be placed in the left most byte for the COMP routine.

11.13. CTEST

CALL CTEST(status)

The CTEST routine is used to test the status of the system console. A zero is returned in status if there is no character ready to input on the system console. A one is returned if there is a character.

Example

```
C WAIT IN A LOOP UNTIL A CHARACTER IS HIT ON THE
C SYSTEM CONSOLE, THEN CHECK THE CHARACTER FOR A
C LINE FEED (ØAH) BEFORE CONTINUING.
      ARAND=.3478
   1Ø ARAND=RAND(ARAND)
      CALL CTEST(STATUS)
      IF (STATUS .EQ. Ø)GO TO 1Ø
C
C CHARACTER HIT, READ IT
C
      CALL CIN(CHAR)
      IF (COMP(CHAR,#ØAØØ,1) .NE. Ø)GO TO 1Ø
```

11.14. OUT

CALL OUT (port,value)

This routine allows access to the 8Ø8Ø/8Ø85/Z8Ø output ports. Value will be converted to an 8 bit number and output to port.

Example

```
CALL OUT(1Ø,1)
CALL OUT (PORT,1Ø)
CALL OUT (CONTROL,BITVL)
```

11.15. SETIO

CALL SETIO(new I/O)

This routine allows changing how the runtime package performs console I/O. The default method is setup using the CONFIG program, however it can be changed as follows:

```
new I/O =  Ø to use direct BIOS I/O
new I/O =  2 to use CP/M function 1&2
new I/O <> Ø or 2 to use CP/M function 6
              (should be used with CP/M 2.X only).
```

The use of CP/M functions 1&2 permits the use of the control-p ability of CP/M to echo all the console output to the LST device. Use of other options will bypass this ability.

Example

```
CALL SETIO (2)
CALL SETIO (IO)
```

11.16. RESET

CALL RESET

The RESET routine is used to inform CP/M that a diskette has been changed at runtime. This routine must be called if a diskette is changed and you wish to write on the new diskette. If the RESET routine is not called, then a BDOS: R/O will occur and the program will abort if a write is attempted on the changed diskette. This routine will prompt for a change in diskette and wait for the change to occur. Also, all open files on the diskette to be changed should be closed (using the CLOSE routine) before RESET is called. The programmer is responsible for closing the file They can be done as follows:

Example

```
       ..
       CALL CLOSE (4)
       CALL CLOSE (5)
C
C THE "RESET" ROUTINE WILL PROMPT FOR THE CHANGE
C
       CALL RESET
       ....
```

11.17. POKE

CALL POKE(memory location,value)

This routine allows changing of memory locations. Value will be converted to an 8 bit quantity and stored at the location specified by memory location.

Example

```
     CALL POKE (Ø,34)
     CALL POKE (1,PEEK(1)+1)
```

The last example will increment the contents of memory location ØØØ1.

11.18. BIT

```
CALL BIT(variable,bit displacement,'S'      )
                                   'R'
                                   'F'
                                   'T',value
```

The BIT subroutine allows the setting (S), resetting (R), flipping (F), or testing (T) of individual bits.

The bit at **bit displacement** from the start of **variable** will be set if **S** is specified, reset if **R** is specified, flipped (1 will become Ø and Ø will become 1) if **F** is specified; and, finally, the value of the selected bit will be returned in **value** if **T** is specified. **Value** must be present only for **T**. Displacement is specified starting with the leftmost bit.

Example

```
CALL BIT (ZAPIT,Ø,'S')
CALL BIT (ZAPIT,Ø,'T',VALUE)
```

11.19. PUT

```
CALL PUT(value)
```

The PUT routine is used to output a character to the console without the FORTRAN system interpreting it. Using this routine it is possible to do such things as control the position of the cursor. **Value** must be a number or varable and cannot be a string.

Example

```
CALL PUT(27)
CALL PUT(61)          will clear the screen on an ADM  3A

CALL PUT (CHAR('A',Ø))     will output an A
```

11.2Ø. CHAR

A=CHAR(variable,displacement)

The CHAR routine is used to return the numerical value of an ASCII character located at variable+displacement where displacement is a byte displacement from the beginning of variable. For example:

Example

```
A='ABCDEF'
B=CHAR(A,Ø)          returns 61
B=CHAR(A,1)          returns 62
B=CHAR(A,5)          returns 66
```

11.21. INP

A=INP(port)

This routine allows access to the 8Ø8Ø/8Ø85/Z8Ø input ports. This is a function whose value is the current setting of the input port specified by port. No wait is done using the INP routine, it will return the current value that the input port contains.

Example

```
     I=INP(1Ø)
1Ø   IF (INP(CONSOLE) .NE. Ø)GO TO 1Ø
     VALID=INP(CLOCK) .AND. 48
```

11.22. CALL

A=CALL(address,argument)

The CALL function causes execution of assembly language routines that have been loaded into memory (usually by the LOAD subroutine). Address is the memory location to be CALLed. Argument will be converted to a 16 bit binary number and then passed to the called routine in both the BC and DE register pairs. The assembly routine places the value to be returned in register pair HL. The return address is placed on the 8Ø8Ø stack and the call'ed routine can just issue a standard RET instruction to return to the

FORTRAN program.

Example

```
CALL LOAD ('ASMFILE',1)
A=CALL ($DEØØ,VALUE)
```

11.23. CBTOF

A=CBTOF(from,displacement{,8-bit})

The CBTOF function is used to convert either a 16 bit or 8 bit binary number to its equivalent floating point value. The number to be converted is located at from+displacement if displacement is positive. If displacement is negative, then from contains the address to be used. The number is assumed to be 16 bit value (store in standard 8Ø8Ø format) unless 8-bit is present, in which case it will be assumed to be an 8 bit value. The binary number is considered to be unsigned.

Example

```
BIOS=CBTOF($ØØØ6,1)-3
```

gets the base address of the CP/M bios jump table by reading the 16 bit address at location ØØØ1 and subtracting 3 from it.

11.24. PEEK

A=PEEK(memory location)

The PEEK routine is used to read an 8 bit value from a memory location. The byte at the address specified by memory location will be returned as the value of the function.

Example

```
BIOS=(PEEK(1)+PEEK(2)*256)-3
```

This is equivalent to the example of using CBTOF.

11.25. COMP

A=COMP(string1,string2,length)

The COMP routine is used to compare character strings in the following manner:

```
A=COMP('string1','string2',length).
```

The strings will be compared on a byte basis for a byte count of length. The routine returns the following:

```
-1 if string1 < string2
 Ø if string1 = string2
+1 if string1 > string2
```

A. Statement Summary

variable = expression
: Assigns the value of the expression to the variable.

ACCEPT input list
: Reads values from the system console and assigns them to the variables in the input list.

ASSIGN n TO V
: Assigns a statement label to a variable to be used in an assigned go to.

BACKSPACE unit
: Positions the specified unit to the beginning of the previous record.

BLOCK DATA
: Begin a BLOCK DATA subprogram for initializing variables in COMMON.

CALL name(argument list)
: Call the subroutine passing the argument list.

COMMON /label1/list1 /label2/list2
: Declares the variables and array that are to be placed in COMMON with the various routines.

CONTINUE
: Causes no action to take place, usually used as the object of a GOTO or DO loop.

COPY filename
: The specified filename is inserted into the source at the point of the COPY statement.

CTRL DISABLE
: Disables program termination by control/c from the console.

CTRL ENABLE
: Enables program termination by control/C from the console.Control C being enabled is the default.

DATA /var1/const1,const2/var2/c1,c2,.../
: Initializes the specified variable, array element or arrays to the specified constants.

DIMENSION v(n1,n2,..),v2(n1,n2,..)
: Sets aside space for arrays v and v2.

DO n i=n1,n2,n3
Executes statements from DO to statement n, using i as index, increasing or decreasing from n1 to n2 by steps of n3.

DOUBLE PRECISION v1,v2,..
Declares v1, v2, etc, to be double precision variables.

DUMP /id/ output list
When a runtime error occurs, displayed id and items in output list.

END
This statement must be the last statement of every routine.

ENDFILE unit
Write an end of file at the current position of unit.

ERRCLR
Clears the effect of the ERRSET statement.

ERRSET n,v
When a runtime error occurs, control goes to the statement labeled n with variable v containing the error code.

FORMAT (field specifications)
Used to specify input and output record formats.

FUNCTION name(argument list)
Begins the definition of a function subprogram.

GO TO n
Transfer control to the statement labelled n.

GO TO v,(n1,n2,...),v
The COMPUTED GOTO transfers control to n1 if v=1, n2 if v=2, etc.

GO TO v,(n1,n2,..)
The ASSIGNED GOTO transfers control to statement n1, n2,.. depending on the value of v. V must have appeared in an ASSIGN statement.

IF (e)n1,n2,n3
The arithmetic IF transfers control to n1 if e<Ø, n2 if e=Ø or n3 if e>Ø.

IF (e)statement
The logical IF executes statement if the value of expression e is true (non-zero).

IF (e) THEN statement1 ELSE statement2 ENDIF
The IF-THEN-ELSE executes blocks of statements-statement1 if e is true, or blocks of statements-statement2 if e is false.

IMPLICIT type(letter list)
Changes the default type of variables that start with the letters in the letter list.

INTEGER v1,v2,..
Declares v1, v2, etc, to be integer variables.

LOGICAL v1,v2,...
v1, v2, etc, to be logical variables.

PAUSE 'character string'
Suspends program execution until any key is hit, displaying PAUSE and character string.

READ (unit,format{,ERR=}{,END=}) input list
Reads values from unit according to format and assigns them to the variables in input list.

REAL v1,v2,..
Declares v1, v2, etc, to be real variables.

RETURN
Returns control from a subprogram to the statement following either the call or the function reference.

RETURN i
The multiple return statement returns control from a subprogram to statement i in the calling routine.

REWIND unit
The file associated with unit is closed, then reopened at the beginning of the same file.

STOP 'character string'
Terminates program execution and displays character string on the system console.

STOP n
Terminates program execution and displays n on the system console.

SUBROUTINE name(argument list)
Begins the definition of a subroutine subprogram.

TRACE OFF
Turns statement tracing off.

TRACE ON
Turns statement tracing on.

TYPE output list
Displays the value of the variables in output list on the system console.

WRITE (unit,format{,ERR=}) output list
Writes the values of the variable in output list to unit according to format.

B. Summary of System Function

Name	Function	Arg	result	argument
SIN	Sine(x)	1	real	real
COS	Cosine(x)	1	real	real
TAN	Tangent(x)	1	real	real
ATAN	Arctangent(x)	1	real	real
ATAN2	Arctangent(y/x)	2	real	real
ALOG	Log base e (x)	1	real	real
ALOG1Ø	Log base 1Ø (x)	1	real	real
MOD	Remainder (x/y)	2	integer	integer
AMOD	Remainder (x/y)	2	real	real
SQRT	Square Root (x)	1	real	real
FLOAT	Make real (x)	1	real	integer
IFIX	Truncate (x)	1	integer	real
ABS	Absolute (x)	1	real	real
IABS	Absolute (x)	1	integer	integer
RAND	Random Number (x)	1	real	real Ø.Ø<R<1.Ø
EXP	e**(x)	1	real	real
COMP	Compare strings	3	either	real
CALL	CALL assembly pgm	2	either	real
AMAXØ	Maximum	<255	either	either
AMAX1	Maximum	<255	either	either
MAXØ	Maximum	<255	either	either
MAX1	Maximum	<255	either	either
AMINØ	Minimum	<255	either	either
AMINØ	Minimum	<255	either	either
MINØ	Minimum	<255	either	either
MIN1	Minimum	<255	either	either
BIT	Bit handling	3/4	either	either
SIGN	Transfer of sign	2	real	real
ISIGN	Transfer of sign	2	integer	integer
DIM	Positive difference	2	real	real
IDIM	Positive difference	2	real	real
CHAR	character value	1	either	character
CALL	execute asm pgm	2	either	either
INP	input from a port	1	either	either
CBTOF	convert to real	2/3	real	both
COMP	compare strings	3	either	either
PEEK	examine mem loc.	1	either	either

Most of the above functions are ANSI standard except for RAND. This function behaves as if it were returning an entry from a table of random numbers. The argument of RAND determines which entry of this table will be returned:

Rand Arg.	Value returned for RAND
Ø	The next entry in the table
-1	The first entry in the table. Also the pointer for the next entry (arg=Ø) is reset to the second entry in the table.
n	Returns the table entry following n.

C. Summary of System Subroutines

CALL BIT (variable,disp,code)
Set, resets or flips bit Ø+disp of variable according the code.

CALL CBTOF(locl,displ,loc2{,flag})
Converts a binary number to its floating point equivalent.

CALL CHAIN('program name'{,error})
Loads another program and executes it.

CALL CIN(var)
Reads a single character from the system console.

CALL CLOSE(unit)
Close the file associated with unit.

CALL CTEST(status)
Determines if a character has been entered on the system console.

CALL DELAY(time)
Delays execution the specified time in one hundreds of a second.

CALL DELETE('filename'{,error})
Delete the specified filename from the disk.

CALL EXIT
Terminates program execution.

CALL MOVE(n,locl,displ,loc2,disp2)
Moves n bytes from locl to loc2.

CALL OPEN(unit,'filename'{,error})
Opens the specified filename and associates it with unit.

CALL LOAD('filename',load-type{,error})
This routine is used to load a file of type .HEX or .OBJ into memory depending on the value of load-type. It is usually used to load assembly language routines into memory. No check is made to see if the code that is loaded into memory would overwrite the program or CP/M.

CALL LOPEN(unit,'filename'{,error})
Opens the specified filename and associates it with unit. This file is also treated as a printer file with the first character of each output record controlling paper movement.

CALL POKE(LOCATION,VALUE)
The POKE routine is used to change a memory location. Value will be stored in memory at location.

CALL OUT(port,value)
value is converted to an 8 bit number and output to port port.

CALL PUT(CHARACTER)
The PUT routine is used to output a character to the system console directly. It is commonly used to do such things as clear the screen or position the cursor.

CALL RENAME('old name','new name'{,error})
Renames old name to be new name.

CALL RESET
The RESET routine allows for the changing of a diskette at runtime and then being able to write on the changed diskette. Without using this function, an attempt to write on a diskette that has been changed will result in a BDOS read only error.

CALL SEEK (unit,position)
Positions the file associated with unit to the byte position specified by position.

CALL SETIO (new I/O)
Allows changing the way that console I/O is performed during program execution.

D. RUNTIME ERRORS

During execution of a program, there are numerous conditions that can occur which cause program termination. When one of these conditions is encountered, a RUNTIME ERROR message will be generated to the system console file. The message has the format:

Runtime error: XXXXXXXX, called from loc. YYYYH

Pgm was executing line LLLL in routine NNNN

where: XXXXXXXX is the ERROR, YYYY is the memory location of the CALL to the runtime package in which the error occurred.

The second line of the error message will be generated as a traceback of CALL statements that have been executed. The LLLL is the FORTRAN generated line number (shown on the listing of the source from the compiler) of the statement which caused the error, and NNNN if the name of the routine in which that line number corresponds. The line number will be output as ???? if the X option was not specified on the $OPTIONS statement for a given routine. If multiple 'PGM WAS ...' lines are printed, the first one specifies the line in which the error actually occurred.

Runtime Errors

INT RANG

INTEGER OVERFLOW: a result greater than 8 digits has been generated in an expression.

CONVERT

16 BIT CONVERSION ERROR: in converting a number from integer to internal 16 bit binary, an overflow has occurred. This can occur on all statements associated with I/O (unit number), subscript evaluation and anywhere that a number has to be converted from floating to 16 BIT binary. Also subscripting outside of the DIMENSIONED space for an array can cause this error.

ARG CNT

ARGUMENT COUNT ERROR: a subprogram call had too many or too few arguments. In other words, the number of arguments in the CALL or function reference is not the same as the number of parameters specified for this SUBROUTINE or FUNCTION.

COM GOTO

COMPUTED GO TO INDEX OUT OF RANGE: the variable specified in a computed GOTO is either zero or greater than the number of statement labels that where specified.

OVERFLOW

FLOATING POINT OVERFLOW: the result of a floating point operation has resulted in a number whose value is too large to be stored.

DIV ZERO

DIVIDE BY ZERO: an attempt has been made to divide by zero.

SQRT NEG

SQRT OF NEGATIVE NUMBER: argument of the square root function is negative.

LOG NEG

LOG OF NEGATIVE NUMBER: argument of the log either (ALOG or ALOGlØ) function is negative.

CALL PSH

CALL STACK PUSH ERROR: this error is caused by a recursive subprogram CALLS of depth greater than 36. Only in very special cases should a subprogram CALL itself or one of those that has CALLED it.

CALL POP

CALL STACK POP ERROR: this error should never occur (This means that a RETURN has been executed that does not have a corresponding CALL or FUNCTION reference. Usually caused by user assembly language programs).

CHAIN FL

CHAIN FILE ERROR: the filename specified in a call to the CHAIN or LOAD routine was not found on the disk.

ILL UNIT

ILLEGAL UNIT NUMBER (<2 OR >7): the unit number in a READ, WRITE, OPEN, LOPEN, REWIND, CLOSE, SEEK is either < 2 or greater than 7.

UNIT OPN

UNIT ALREADY OPEN: this is generated by the OPEN or LOPEN routine when an attempt to open a file on an already open FORTRAN logical unit. This error will also occur is units Ø or 1 is specified in the OPEN or LOPEN call.

DSK FULL

DISK FULL: either the disk is full or the directory is full.

UNIT CLO

UNIT CLOSED: the unit number passed to the CLOSE routine specifies a unit number that has not been OPENed.

CON BIN

BINARY I/O TO CONSOLE: binary I/O is not supported to the system console.

LINE LEN

LINE LENGTH ERROR: an attempt has been made to READ or WRITE a record whose length exceeds 25Ø characters. This count also includes a carriage return at the end of the line.

FORMAT

FORMAT ERROR: an unrecognized or invalid FORMAT specification has been encountered in a FORMATTED READ or WRITE. The most likely error is an unrecognized format specification or blanks in a variable format.

I/O ERR

I/O ERROR: an error occurred during a READ or WRITE operation and the ERROR label was not specified in the statement. It will also be generated during a READ if END OF FILE is encountered and an EOF label was not specified.

ILL CHAR

ILLEGAL CHARACTER: an illegal character has been encountered during a READ.

I/O LIST

INVALID I/O LIST: this error indicates an error in the I/O list specification of a formatted WRITE or READ. This error will not normally occur.

ASN GOTO

ASSIGNED GO TO ERROR: the value of the variable specified in an ASSIGNED GO TO does not match that of one of the statement labels listed.

CONTRL/C

CONTROL/C error: CONTROL/C was hit and the CONTROL/C was not trapped.

INPT ERR

INPUT ERROR: during a READ an invalid character has been encountered for the number being processed. This will be generated for such things as: two decimal points in a number, an E in an F type field, decimal point in an I type field, etc.

FILE OPR

FILE OPERATION ERROR: an error has occurred while trying to do some file operation, such as renaming when the new file already exists.

SEEK ERR

SEEK ERROR: an error has occurred while positioning a file to the specified position and no error variable was specified in the CALL.

E. COMPILE TIME ERRORS

The following is a list of errors that may occur during the compilation of a FORTRAN program. If the G option is not selected a two digit error number will be printed instead. This number can be found at the beginning of each line.

ØØ *FATAL* compiler error
Ø1 Syntax error, 2 operators in a row
Ø2 unexpected continuation (column 6 not blank or Ø)
Ø3 input buffer overflow (increase B= compiler option)
Ø4 invalid character for FORTRAN statement
Ø5 unmatched parenthesis
Ø6 statement label > 99999
Ø7 invalid character encountered in statement label
Ø8 invalid HEX digit encountered in constant
Ø9 expected constant or variable not found
ØA 8 bit overflow in constant
ØB unidentifable statement
ØC statement not implemented
ØD quote missing
ØE SUBROUTINE/FUNCTION/BLOCK DATA not first statement in routine
ØF columns 1-5 of continuation statement are not blank
1Ø cannot initialize BLANK COMMON
11 RETURN is not valid in main program
12 syntax error on unit specification
13 missing comma after) in COMPUTED GO TO
14 missing variable in COMPUTED GO TO
15 invalid variable in ASSIGNED/COMPUTED GO TO
16 invalid LITERAL, no beginning quote
17 number of subscripts exceeds maximum of 7
18 invalid SUBROUTINE or FUNCTION name
19 subscript not POSITIVE INTEGER CONSTANT
1A FUNCTION requires at least one argument
1B syntax error
1C invalid argument in SUBROUTINE/FUNCTION call
1D first character of variable not alphabetic
1E ASSIGNED/COMPUTED GOTO variable not integer
1F label has already defined
2Ø specification of array must be integer
21 invalid variable name
22 invalid DIMENSION specification
23 dimension specification is invalid
24 variable has already appeared in type statement
25 invalid subroutine name in CALL
26 SUBPROGRAM argument cannot be initialized
27 improperly nested DO loops
28 unit not integer constant or variable
29 Array size exceeds 32K
2A invalid use of unary operator
2B variable DIMENSION not valid in MAIN program
2C variable dimensioned array must be argument
2D DO/END/LOGICAL IF cannot follow LOGICAL IF
2E undefined label

2F unreferenced label
3Ø FUNCTION or ARRAY missing left parenthesis
31 invalid argument of FUNCTION or ARRAY
32 DIMENSION specification must precede first executable statement
33 unexpected character in expression
34 unrecognized logical opcode
35 argument count for FUNCTION or ARRAY wrong
36 *COMPILER ERROR* poped off bottom of operand stack
37 expecting end of statement, not found
38 statement too complex; increase P and/or O table
39 invalid delimiter in ARITHMETIC IF
3A invalid statement number in IF
3B HEX constant > FFFF (HEX)
3C replacement not allowed within IF
3D multiple assignment statement not implemented
3E subscripted-subscripts not allowed
3F subscript stack overflow; increase P= or O=
4Ø missing left (in READ/WRITE
41 invalid unit specified
42 invalid FORMAT, END= or ERR= label
43 invalid element in I/O list
44 built-in function invalid in I/O list
45 cannot subscript a constant
46 variable not dimensioned
47 invalid subscript
48 missing comma
49 index in IMPLIED DO must be a variable
4A invalid starting value for IMPLIED DO
4B invalid ending value of IMPLIED DO
4C invalid increment of IMPLIED DO
4D illegal use of built-in function
4E variable cannot be dimensioned in this context
4F invalid or multiple END= or ERR=
5Ø invalid constant
51 exponent overflow in constant
52 invalid exponent
53 character after . invalid
54 integer overflow
55 integer underflow (too small)
56 missing = in DO
57 string constant not allowed
58 invalid variable in DATA list
59 DATA symbol not used in program, line
5A invalid constant in DATA list
5B error in DATA list specification
5C FUNCTION invalid in DATA list
5D no filename specified on COPY
5E runtime format not array name
5F DUMP label invalid or more than 1Ø characters
6Ø more than 1 IMPLICIT is not allowed
61 IMPLICIT not first statement in MAIN, 2nd statement in SUBPROGRAM
62 data type not REAL, INTEGER or LOGICAL
63 illegal IMPLICIT specification
64 improper character sequence in IMPLICIT

65 variable already DIMENSIONED
66 Q option must be specified for ERRSET/ERRCLR
67 Hex constant of zero (Ø) invalid in I/O stmnt
68 Argument cannot also be in COMMON
69 Illegal COMMON block name
6A Variable already in COMMON
6B Array specification must precede COMMON
6C Executable statement invalid in BLOCK DATA
6D Hex constant of 27H (') invalid in FORMAT
6E Invalid number following STOP or PAUSE
6F invalid TRACE statement (operand not ON/OFF)
7Ø invalid IOSTAT= variable
71 missing , in ENCODE/DECODE
72 invalid label in ASSIGNED GOTO
73 invalid variable in ASSIGNED GOTO
74 label not allowed on this statement
75 multiple RETURN not valid in FUNCTION
76 UNUSED
77 no matching IF-THEN for ELSE or ENDIF
78 invalid ELSE or ENDIF
79 missing ENDIF
7A initialization of non-COMMON variable
7B "DOUBLE PRECISION" not supportted, treated as "REAL"
7C UNUSED
7D UNUSED
7E UNUSED
7F UNUSED

```
8Ø *FATAL* no program to compile
81 *FATAL* missing $OPTIONS statement
82 *FATAL* missing = in $OPTIONS statement
83 *FATAL* invalid digit in number in $OPTIONS
84 *FATAL* value exceeds 255 in $OPTIONS
85 *FATAL* COMMON table overflow, increase C=
86 *FATAL* unknown option (letter before =)
87 *FATAL* missing END statement
88 *FATAL* LABEL TABLE overflow, increase L=
89 *FATAL* SYMBOL TABLE overflow, increase S=
8A *FATAL* ARRAY STACK overflow, increase A=
8B *FATAL* DO LOOP STACK overflow, increase D=
8C *FATAL* stack overflow (compiler error)
8D *FATAL* stack overflow (compiler error)
8E *FATAL* internal tables exceed user memory
8F *FATAL* MEMORY ERROR
9Ø *FATAL* OPEN error on COPY file
91 *FATAL* too many routines to compile (> 62)
92 *FATAL* no more room to store DATA statements
93 *FATAL* IF-THEN stack overflow, increase I=
94 *FATAL* Nested "COPY" statements not permitted
95 *FATAL* Disk write error (disk probably full)
96 *FATAL* Cannot close file (disk probably full)
97 *FATAL* Input file not found
98 *FATAL* Invalid drive specifier
99 *FATAL* No filename found on COPY statement
9A *FATAL* File specified on COPY not found
```

F. ASSEMBLY LANGUAGE INTERFACE

ASSEMBLY statements can be directly inserted into a FORTRAN program by preceding the statement with an ASTERISK (*). The line that contains that asterisk will be directly output to the assembly file without further processing (the asterisk is deleted first). Because of the nature of the FORTRAN compiler (it actually reads one statement ahead of where it is processing) it is ALWAYS a good idea to put a CONTINUE statement immediately preceding the first assembly statement in each separated group of assembly statements. The CONTINUE will cause the assembly statements to be inserted at the expected place. FORTRAN maintains nothing in the registers between statements, but does use the 8Ø8Ø stack for saving RETURN addresses for user called FUNCTIONS and SUBROUTINES.

Example

```
      CONTINUE
* MVI A,'A'
* STA STRING
```

G. GENERAL COMMENTS

1. In the description of the individual routines, anywhere that a character string is specified, a variable or array name can be used. The variable or array can be set to the desired character string.

2. A variable can be set to a character string using an assignment statement such as:

```
A='STRING'
```

No more than 6 characters will be retained for any variable and if less than 6 will be zero filled in the low order bytes of the variable.

3. If a variable or array name is used to reference a CP/M file (such as in the OPEN routine) the filename itself within the variable (or array) is terminated after:

1) the first 15 characters,

2) a NULL is encountered.

4. Hexadecimal constants can be used anywhere that a constant or variable is permitted. A hexadecimal constant is specified by preceding it by a dollar sign ($). Examples are:

```
A=$EØ6Ø
A=-$CCØØ
```

Hexadecimal constants are limited to a maximum value of FFFF. An error is generated if a hexidecimal constant exceeds this limit. Internally a hexadecimal constant is treated as any other INTEGER constant would be.

5. A hexadecimal constant that is preceded by a # instead of a $ will be stored internally in binary format in the first two bytes of the variable. Numbers of this form should not be used in any expression as they are not stored in the normal floating point format. The number is stored in standard 8Ø8Ø format (HIGH byte followed by LOW byte).

6. A backslash (\) can be used in a literal to specify an 8 bit binary constant to be inserted at that point. The constant is enclosed in backslashes and is assumed to be a hexidecimal constant. The backslash can be changed using the CONFIG program supplied.

Example

```
      A='THIS \32\ IS AN EXAMPLE'

      CALL OUTIT(3,1,'\7F\\FF\',2,32)

   1Ø FORMAT ('IT IS ALLOWED \1\ HERE \FF\ ALSO')
```

NOTE The backslash is the default character and can be changed using the CONFIG program.

7. 8 Fortran files may be open at any one time (file numbers Ø-7). Remember that files Ø and 1 are permanently open.

H. USE OF THE NORTH STAR FLOATING POINT BOARD

A feature of NEVADA FORTRAN is that it will directly use the North Star floating point board if one is installed in the computer upon which the program is executed. Use the CONFIG program to specify the 2 memory addresses that the floating point board uses. If you should specify that you have a floating point board, at runtime the runtime package checks to see if the floating point board is actually in the system and if not, then uses the software floating point routines instead of the hardware. One disadvantage of using the floating point board is that the range of real number decreases to 1Ø**-63 to 1Ø**+63. Any number generated outside this range will produce an overflow error message.

I. COMPARISON OF NEVADA FORTRAN AND ANSI FORTRAN

NEVADA FORTRAN includes the following extensions to version X3.9-1966 of ANSI Standard FORTRAN:

1. Free-format input and output.
2. IMPLICIT statement for setting default variable types
3. Options end-of-file and error branches in READ and WRITE statements.
4. COPY statement to insert source files into a FORTRAN program.
5. Direct inline assembly language.
6. Access to file system for such functions as creating, deleting and renaming files.
7. Random access on a byte level to files.
8. Access to absolute memory locations.
9. Program controlled time delay.
1Ø. A pseudo random number generator function.
11. Program control of runtime error trapping.
12. Ability to chain a series of programs.
13. Ability to load object code into memory.
14. CALL function to execute previously loaded code.
15. Program tracing.
16. IF-THEN-ELSE statement.
17. Enabling and disabling console abort of program.
18. ENCODE and DECODE memory to memory I/O.
19. Multiple returns from subroutines.
2Ø. K format specification.

NEVADA FORTRAN does not included the following features of ANSI standard FORTRAN:

1. Double precision, double precision functions. (Double precision is treated as single precision).
2. Complex numbers, complex statements and functions.
3. EQUIVALENCE statement.
4. Extended DATA statement of the form:

```
DATA A,B,C/1,2/3/
```

5. The P format specifications.
6. Statement functions.
7. The following are reserved names and cannot be used for functions, subroutines, or COMMON block names:

```
A, B, C, D, E, H, L, M, SP, PSW
```

8. EXTERNAL statement.
9. Subscripted subscripts.
1Ø. Certain of the numerical library functions such as the hyperbolic functions and others.

J. SAMPLE PROGRAMS

On the following pages you will find listings of the sample programs that may have been included on your diskette.

```
C
C "CHAIN.FOR"
C
C THIS ROUTINE DEMONSTRATED THE 'CHAIN' FUNCTION, ALL IT
C DOES IS REQUEST THE NAME OF THE PROGRAM TO CHAIN TO
C AND THEN CHAIN.
C
        DIMENSION IF(3)
        TYPE 'FILE?'
C
C GET THE FILENAME TO CHAIN TO
C
        READ (Ø,1) IF
1       FORMAT (3A6)
C
C CHAIN TO IT
C
        CALL CHAIN (IF,IER)
C
C ONLY GETS HERE IF AN ERROR HAPPENS
C
        TYPE 'ERROR FROM CHAIN = ',IER
        CALL EXIT
        END
```

```
OPTIONS X
C
C "DUMP.FOR"
C
C THIS PROGRAM DEMONSTRATED THE USE OF THE DUMP STATEMENT.
C
C CALL 'X' FOR TRACEBACK PRINTOUT (JUST FOR SHOW)
C
        CALL X
        END
OPTIONS X
        SUBROUTINE X
C
C DEFINE THE DUMP STATEMENT TO BE USED IN CASE OF AN
C ERROR, WITH DUMP ID OF 'ROUTINE-X'
C

        DUMP /ROUTINE-X/ I,J,K
        I=1
        J=2
        K=I+J
C
C CREATE AN ERROR TO CAUSE DUMP STATEMENT TO BE ACTIVE
C
        Z=1/Ø
        END
```

```
OPTIONS X
C
C "GRAPH.FOR"
C
C GRAPH SINE FUNCTION FROM -PI TO PI IN INCREMENT OF .12
C
        DIMENSION LINE(7Ø)
        INTEGER WHERE
C
C OPEN UNIT 6 TO WRITE TO CONSOLE
C
        CALL OPEN (6,'CON:')
C
C WRITE TITLE
C
        WRITE (6,2)
2       FORMAT (28X,'GRAPH OF SIN')
        TYPE
        TYPE
C
C SET PI AND -PI
C
        PI=3.1415926
        MPI=-PI
C
C MAIN LOOP
C
        DO 1ØØ ANGLE=MPI,PI,.12
C
C FIGURE OUT WHICH ELEMENT IN ARRAY SHOULD BE SET TO *,
C SIN RETURNS -1 TO 1 WHICH IS CONVERTED TO -35 TO 35
C AND THEN OFFSET SO FINAL RANGE IS 1 TO 7Ø
C
        WHERE=SIN(ANGLE)*35+35
C
C FIGURE OUT HOW MUCH TO BLANK IN THE OUTPUT ARRAY
C
        IBLANK=MAXØ(35,WHERE)
C
C AND BLANK IT
C
        DO 15 I=1,IBLANK
15      LINE(I)=' '
C
C HMM... WHICH SIDE OF ZERO ARE WE ON?
C
        IF (WHERE .GT. 35)  THEN
C
C RIGHT SIDE
C
                        DO 2Ø I=36,WHERE
2Ø                      LINE(I)='*'
                            ELSE
```

```
C
C LEFT SIDE
C
                        DO 30 I=WHERE,35
30                      LINE(I)='*'
                            ENDIF
C
C SET "ZERO"
C
        LINE(35)='+'
C
C AND THE SIN VALUE
C
        LINE(WHERE)='*'
C
C IF THIS VALUE IS < 35, SET SO WE OUTPUT TO ZERO LINE
C
        IF (WHERE .LE. 35)WHERE=35
C
C AND FINALLY OUTPUT THE LINE
C
        WRITE (6,21) (LINE(I),I=1,WHERE)
21      FORMAT (70A1)
100     CONTINUE
        CALL EXIT
        END
```

```
C
C "LOAD.FOR"
C
C THIS ROUTINE DEMONSTRATED THE USE OF THE 'LOAD' ROUTINE
C TO LOAD AN ASSEMBLY LANGUAGE FILE INTO MEMORY AND
C THEN CALL IT FORM FORTRAN
C
       INTEGER A
C
C FIND OUT WHICH ONE TO LOAD
C
       TYPE 'Enter Ø to "LOAD" LD.HEX'
       TYPE 'Enter 1 to "LOAD" LD.OBJ'
       ACCEPT 'Which one: ',LTYPE
C
       IF (LTYPE .EQ. Ø) THEN
                        TYPE '"LOAD"ing "LD.HEX"'
                         ELSE
                        TYPE '"LOAD"ing "LD.OBJ"'
                         ENDIF
C
C MUST LOAD "LD.HEX" OR "LD.OBJ" INTO MEMORY
C BEFORE WE CAN CALL IT
C
       CALL LOAD ('LD',LTYPE,IER)
C
       TYPE 'ERROR FOR LOAD=',IER
C
C CHECK THE RETURNED ERROR CODE FROM LOAD
C
       IF (IER .NE. Ø)STOP 'LOAD ERROR'
C
C "CALL" THE ROUTINE
C
       A=CALL ($8ØØØ,1)
C
C RESULT SHOULD BE 2
C
       TYPE 'THE RESULT OF THE ASSEMBLY ROUTINE IS: ',A
       CALL EXIT
       END
```

```
;
; "LD.ASM"
;
; THIS ROUTINE IS USED BY "LOAD.FOR", ALL IT DOES IS TO
; DOUBLE THE NUMBER SENT TO IT
; NUMBER IS PASSED IN DE FROM FORTRAN PROGRAM AND RESULT
; IS PASSED BACK IN HL TO FORTRAN PROGRAM
;
       ORG     8ØØØH
       PUSH    D       ;NUMBER FROM FORTRAN PROGRAM
       POP     H       ;GET IT TO HL
       DAD     H       ;HL*2
       RET             ;RETURN IT
```

```
OPTIONS X,Q
C
C "RAND.FOR"
C
C THIS PROGRAM GENERATES A SEQUENCE OF RANDOM NUMBERS,
C DIVIDES THEM INTO 1Ø INTERVALS AND COUNTS HOW MANY
C RANDOM NUMBER FALL INTO EACH INTERVAL.  FINALLY IT
C PRINTS OUT THE COUNTS OF EACH INTERVAL.
C
        DIMENSION NUM(1Ø)
        DATA NUM/1Ø*Ø/
        INTEGER T,A,D,FLAG,TIME(6),DATE(6),START,END
99      DO 5Ø I=1,1Ø
5Ø      NUM(I)=Ø
        ACCEPT 'How many? ',K
        DO 1 I=1,K
        L=RAND(Ø)*1Ø+1
1       NUM(L)=NUM(L)+1
        TYPE NUM
        GO TO 99
        END
```

```
OPTIONS X,Q
C
C "SEEK.FOR"
C
C THIS PROGRAM DEMONSTRATES RANDOM ACCESS I/O
C
C IT FIRST WRITES A FILE OF NUMBERS, THEN REQUESTS
C A RECORD, READ NUMBER THAT THE RECORD CONTAINS,
C ADDS 1 TO THE NUMBER READ AND WRITES IT BACK INTO
C THE SAME RECORD
C
        ERRSET 500,I
        CALL DELETE('TEST')
C
C OPEN THE TEST FILE
C
        CALL OPEN (2,'TEST')
C
C READ HOW MANY RECORDS TO CREATE
C
        ACCEPT 'HOW MANY RECORDS? ',K
C
C WRITE THE FILE
C
        DO 1 I=0,K
1       WRITE (2,2) I
2       FORMAT (I5)
        TYPE 'FILE WRITTEN'
        TYPE
        REWIND 2
        GO TO 10
        CALL OPEN(2,'TEST')
C
C REQUEST RECORD TO DISPLAY
C
10      ACCEPT 'WHICH RECORD? ',K
C
C POSITION THE FILE (EACH RECORD IS 7 CHARACTERS,
C 5 FOR NUMBER, 1 FOR CARRIAGE RETURN AND 1 FOR LINE FEED
C
        CALL SEEK (2,7*K,IER)
C
C CHECK THE ERROR CODE
C
        IF (IER .NE. 0) THEN
                        TYPE 'SEEK ERROR, CODE= ',IER
                        CALL CLOSE (2)
                        CALL DELETE ('TEST')
                        STOP
                        ENDIF
```

```
C
C READ THE CURRENT VALUE
C
        READ (2,2) I
        TYPE 'CURRENT VALUE OF RECORD ',K,' IS ',I
C
C POSITION BACK TO THE SAME RECORD
C
        CALL SEEK(2,7*K)
        I=I+1
C
C WRITE THE UPDATED VALUE
C
        WRITE (2,2) I
        GO TO 1Ø
C
C TRAP ERROR
C
5ØØ     TYPE '*** ERROR TRAPPED ***'
        TYPE 'ERROR CODE = ',I
        CALL CLOSE (2)
        CALL DELETE ('TEST')
        STOP 'ERROR EXIT'
        END
```

```
C
C "SORT.FOR"
C
C THIS ROUTINE IS A DEMONSTRATION OF A SHELL SORT
C
        INTEGER T,A,D,FLAG,TIME(6),DATE(6),START,END
        DIMENSION A(2ØØØ)
        TYPE 'Shell sort'
        TYPE
C
C GET HOW MANY NUMBERS TO SORT
C
88      ACCEPT 'How many numbers (2-2ØØØ) ',NN
        IF (NN .LT. 2.OR.NN .GT. 2ØØØ)STOP
C
C GENERATE ARRAY OF NUMBERS TO SORT
C
        DO 1Ø I=1,NN
1Ø      A(I)=(RAND(Ø)*NN)+1
        TYPE 'Starting sort'
        D=NN
        FLAG=Ø
C
1ØØ     D=IFIX((D+1)/2)
C
C TYPE OUT INTERMEDIATE STUFF
C
        TYPE 'D=',D
C
11Ø     ND=NN-D
        DO 15Ø N=1,ND
        IF (A(N) .LE. A(N+D))GO TO 15Ø
        NPD=N+D
        T=A(N)
        A(N)=A(NPD)
        A(NPD)=T
        FLAG=1
C
15Ø     CONTINUE
        IF (FLAG .EQ. 1)THEN
                        FLAG=Ø
                        GO TO 11Ø
                        ENDIF
        IF (D .GT. 1)GO TO 1ØØ
        TYPE 'All done'
        TYPE
C
C TYPE OUT SORTED ARRAY
C
        TYPE (A(I),I=1,NN)
        GO TO 88
        END
```

```
OPTIONS X,Q
C
C "TRACE.FOR"
C
C THIS ROUTINE DEMONSTRATES THE USE OF THE 'TRACE' AND
C 'ERROR' TRAPPING FUNCTIONS
C
        TYPE 'STARTING EXECUTION'
C
C SET ERROR TRAPPING: ON ERROR GO TO STATEMENT 5ØØ WITH
C ERROR CODE IN VARIABLE I
C
        ERRSET 5ØØ,I
1Ø      CONTINUE
C
C TURN TRACING OFF
C
        TRACE OFF
C
C GET AN INPUT # FROM THE USER
C
        ACCEPT '#: ',K
C
C IF <Ø, TERMINATE
C
        IF (K .LE. Ø)GO TO 99
C
C IF INPUT # > 1ØØ, THEN TURN TRACING ON
C
        IF (K .GT. 1ØØ)TRACE ON
C
C AND OUTPUT THE NUMBERS, TO SEE EFFECT OF THE
C ERROR TRAPPING, HIT CONTROL-C
C
        DO 2Ø I=1,K
2Ø      TYPE I
        GO TO 1Ø
C
99      TYPE 'DONE'
        STOP
C
C ERROR TRAPPING HAPPENS HERE
C
5ØØ     TYPE 'ERROR TRAPPED, IER= ',I
        END
```

```
C
C THIS SAMPLE PROGRAM SHOWS HOW TO HANDLE THE
C CURSOR AND CLEAR SCREEN FUNCTIONS OF A CRT
C
        PAUSE 'CLEAR SCREEN'
        CALL SCREEN (1,Ø,Ø)
C
C WRITE THE LINE NUMBERS OUT FROM THE BOTTOM
C LINE TO THE TOP
C
        DO 1Ø I=23,Ø,-1
        CALL SCREEN (2,Ø,I)
        WRITE (1,2) I
2       FORMAT ('LINE ',I2,Z)
1Ø      CONTINUE
C
C WAIT 5 SECONDS
C
        CALL DELAY (5ØØ)
C
C CLEAR THE SCREEN AGAIN
C
        CALL SCREEN(1,Ø,Ø)
        ACCEPT 'ENTER ANY NUMBER ',A
        I=AMOD(A,3ØØ)+1
        DO 99 J=1,I
99      Z=RAND(Ø)
C
C AGAIN CLEAR IT
C
        CALL SCREEN(1,Ø,Ø)
C
C NOW PUT RANDOM PLUS SIGNS ALL OVER THE SCREEN
C
        DO 4Ø I=1,4ØØ
C
C GET NEXT SCREEN POSITION AND GO THERE
C
        CALL SCREEN(2,IFIX(RAND(Ø)*8Ø),IFIX(RAND(Ø)*23))
C
C PUT THE + ON THE SCREEN
C
4Ø      CALL PUT (CHAR('+',Ø))
C
        CALL DELAY(5ØØ)
C
C OUTPUT A BELL
C
        CALL SCREEN(5,Ø,Ø)
C
C CLEAR IT NOW
C
        CALL SCREEN(1,Ø,Ø)
        CALL EXIT
        END
```

```
        SUBROUTINE SCREEN(FUNCT,X,Y)
C
C THIS IS A SAMPLE SCREEN DRIVER FOR AN ADM-3A TERMINAL
C
        INTEGER FUNCT,X,Y
        IF (FUNCT .LE. Ø.OR.FUNCT .GT. 5)RETURN
C
C FUNCTION:
C
C       1=CLEAR SCREEN
C       2=POSITION CURSOR
C       3=SET REVERSE VIDEO
C       4=SET NORMAL VIDEO
C       5=BELL
C
        GO TO (1ØØ,2ØØ,3ØØ,4ØØ,5ØØ),FUNCT
C
C CLEAR SCREEN
C
1ØØ     CALL PUT (12)
        RETURN
C
C SET CURSOR TO X,Y
C
2ØØ     CALL PUT(27)
        CALL PUT(1Ø2)
        CALL PUT(X+32)
        CALL PUT(Y+32)
        RETURN
C
C SET REVERSE VIDEO
C
3ØØ     RETURN
C
C SET NORMAL VIDEO
C
4ØØ     RETURN
C
C OUTPUT A BELL
C
5ØØ     CALL PUT(7)
        RETURN
        END
```

```
C
C THIS PROGRAM DEMOSTRATES THE USE OF THE SET FUNCTION OF
C THE "BIT" ROUTINE.  YOU ENTER THE BIT TO BE SET AND
C CAN SEE EXACTLY WHICH BIT IS CHANGED.
C
1       A=Ø
        ACCEPT 'BIT? ',B
        IF (B .GT. 47) THEN
                TYPE 'INVALID BIT NUMBER, ONLY Ø-47'
                GO TO 1
                ENDIF
        IF (B .LT. Ø)STOP
C
C SET THE BIT
C
        CALL BIT (A,B,'S')
C
C OUTPUT THE WORD IN HEX FORMAT
C
        WRITE (1,2) A
2       FORMAT (K12)
        GOTO 1
        END
```

K. SAMPLE PROGRAM COMPILATIONS AND EXECUTION

On the following pages you will find examples of the compilation and execution of several of the sample programs listed above. The following notes refer to the next few pages:

1) input is underlined.

2) CP/M output is printed in bold.

3) FORTRAN output (either compiler or execution) is neither underlined or bold.

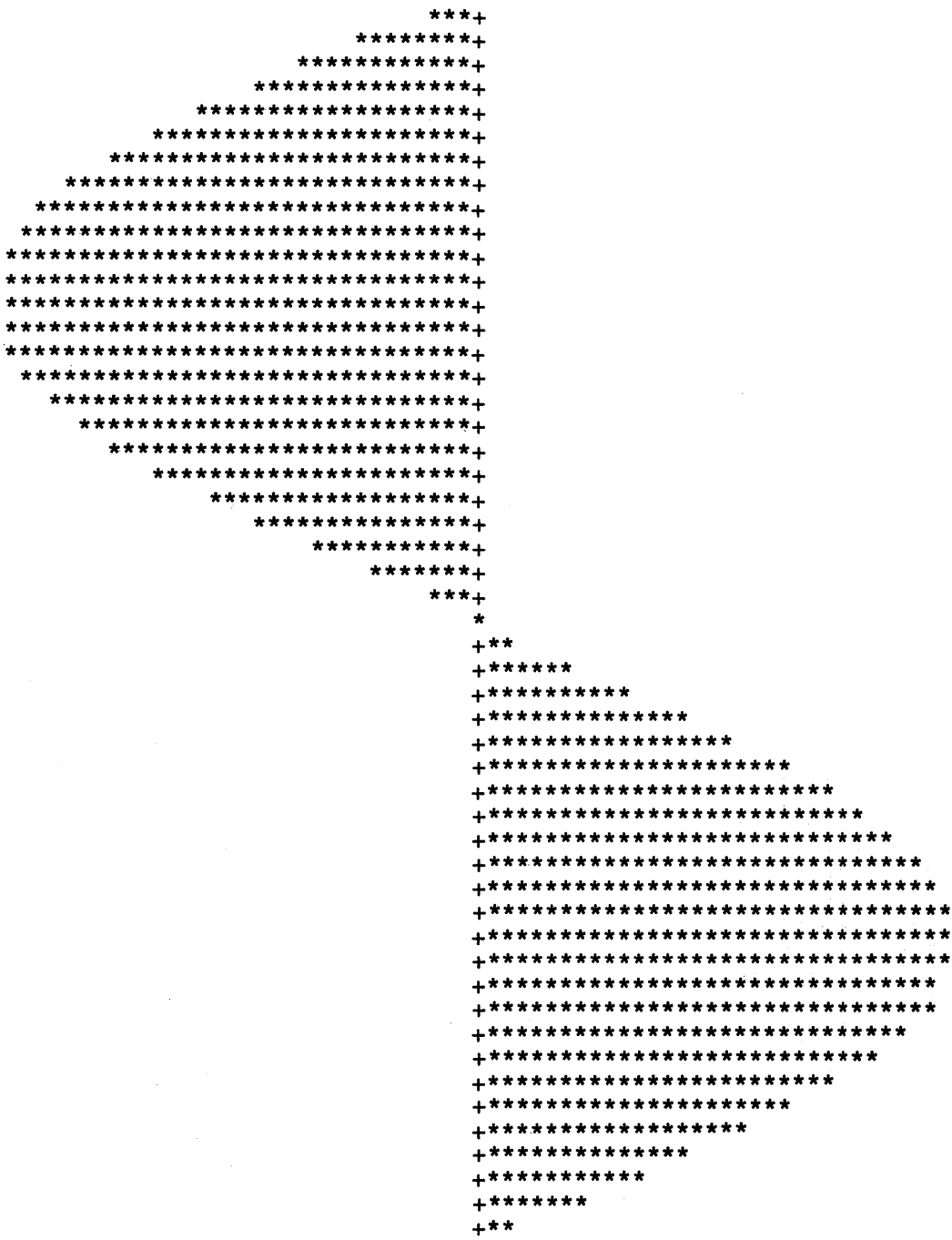
4) notes are in { }.

```
B>FORT GRAPH.XBB   {compile with listing to console,
                    .ASM and .OBJ to drive B}


NEVADA FORTRAN 3.Ø (MOD Ø)
Copyright (C) 1979, 198Ø, 1981, 1982, 1983 Ian Kettleborough

*****  NEVADA  Fortran  3.Ø  (Mod  Ø)  **  Compiling  File:
GRAPH.FOR *****

ØØØ1 OPTIONS X
     C
     C  GRAPH SINE FUNCTION FROM -PI TO PI IN
     C  INCREMENT OF .12
     C
ØØØ2          DIMENSION LINE(7Ø)
ØØØ3          INTEGER WHERE
     C
     C OPEN UNIT 6 TO WRITE TO CONSOLE
     C
ØØØ4          CALL OPEN (6,'CON:')
     C
     C WRITE TITLE
     C
ØØØ5          WRITE (6,2)
ØØØ6 2        FORMAT (28X,'GRAPH OF SIN')
ØØØ7          TYPE
ØØØ8          TYPE
     C
     C SET PI AND -PI
     C
ØØØ9          PI=3.1415926
ØØ1Ø          MPI=-PI
     C
     C MAIN LOOP
     C
ØØ11          DO 1ØØ ANGLE=MPI,PI,.12
     C
     C FIGURE OUT WHICH ELEMENT IN ARRAY SHOULD BE SET TO *,
     C SIN RETURNS -1 TO 1 WHICH IS CONVERTED TO -35 TO 35
     C AND THEN OFFSET SO FINAL RANGE IS 1 TO 7Ø
     C
ØØ12          WHERE=SIN(ANGLE)*35+35
     C
     C FIGURE OUT HOW MUCH TO BLANK IN THE OUTPUT ARRAY
     C
ØØ13          IBLANK=MAXØ(35,WHERE)
     C
     C AND BLANK IT
     C
ØØ14          DO 15 I=1,IBLANK
ØØ15 15       LINE(I)=' '
     C
     C HMM... WHICH SIDE OF ZERO ARE WE ON?
     C
```

```
0016          IF (WHERE .GT. 35)  THEN
      C
      C RIGHT SIDE
      C
0017                              DO 2Ø I=36,WHERE
0018 2Ø                           LINE(I)='*'
0019                                  ELSE
      C
      C LEFT SIDE
      C
0020                              DO 3Ø I=WHERE,35
0021 3Ø                           LINE(I)='*'
0022                                  ENDIF
      C
      C SET "ZERO"
      C
0023          LINE(35)='+'
      C
      C AND THE SIN VALUE
      C
0024          LINE(WHERE)='*'
      C
      C IF THIS VALUE IS < 35, SET SO WE OUTPUT TO ZERO LINE
      C
0025          IF (WHERE .LE. 35)WHERE=35
      C
      C AND FINALLY OUTPUT THE LINE
      C
0026          WRITE (6,21) (LINE(I),I=1,WHERE)
0027 21       FORMAT (70A1)
0028 1Ø0      CONTINUE
0029          CALL EXIT
0030          END
** Generated Code =    687 (Decimal), Ø2AF (Hex) Bytes
** Array Area      =    42Ø (Decimal), Ø1A4 (Hex) Bytes

  No Compile errors


 NO ASSEMBLY ERRORS.  175 LABELS WERE DEFINED.
```

B>FRUN GRAPH {execute the program}

GRAPH OF SIN



```
B>FORT LOAD.X       {compile, listing to console, .ASM
                     and .OBJ to default drive}

NEVADA FORTRAN 3.Ø (MOD Ø)
Copyright (C) 1979, 198Ø, 1981, 1982, 1983 Ian Kettleborough

***** NEVADA Fortran 3.Ø (Mod Ø) ** Compiling File: LOAD.FOR
*****

ØØØ1 C
     C "LOAD.FOR"
     C
     C THIS  ROUTINE  DEMONSTRATED THE USE
     C OF THE 'LOAD' ROUTINE
     C TO LOAD AN ASSEMBLY LANGUAGE FILE INTO MEMORY AND
     C THEN CALL IT FORM FORTRAN
     C
ØØØ2          INTEGER A
     C
     C FIND OUT WHICH ONE TO LOAD
     C
ØØØ3          TYPE 'Enter Ø to "LOAD" LD.HEX'
ØØØ4          TYPE 'Enter 1 to "LOAD" LD.OBJ'
ØØØ5          ACCEPT 'Which one: ',LTYPE
     C
ØØØ6          IF (LTYPE .EQ. Ø) THEN
ØØØ7                           TYPE '"LOAD"ing "LD.HEX"'
ØØØ8                            ELSE
ØØØ9                           TYPE '"LOAD"ing "LD.OBJ"'
ØØ1Ø                            ENDIF
     C
     C MUST LOAD "LD.HEX" OR "LD.OBJ" INTO MEMORY
     C BEFORE WE CAN CALL IT
     C
ØØ11          CALL LOAD ('LD',LTYPE,IER)
     C
ØØ12          TYPE 'ERROR FOR LOAD=',IER
     C
     C CHECK THE RETURNED ERROR CODE FROM LOAD
     C
ØØ13          IF (IER .NE. Ø)STOP 'LOAD ERROR'
     C
     C "CALL" THE ROUTINE
     C
ØØ14          A=CALL ($8ØØØ,1)
     C
     C RESULT SHOULD BE 2
     C
ØØ15          TYPE 'THE RESULT OF THE ASSEMBLY ROUTINE ',A
ØØ16          CALL EXIT
ØØ17          END
** Generated Code =   4Ø5 (Decimal), Ø195 (Hex) Bytes


 NO ASSEMBLY ERRORS.  135 LABELS WERE DEFINED.
```

```
B>FRUN LOAD          {execute the program}

Enter Ø to "LOAD" LD.HEX
Enter 1 to "LOAD" LD.OBJ
Which one: Ø
"LOAD"ing "LD.HEX"
ERROR FOR LOAD=          Ø
THE RESULT OF THE ASSEMBLY ROUTINE IS:          2
```

```
B>FORT TRACE.ZCC    {compile with no listing, .ASM and
                     .OBJ to drive C}


B>FRUN TRACE        {execute the program}
STARTING EXECUTION
#: 4
          1
          2
          3
          4
#: 14Ø
Pgm  is executing line ØØØ9 in routine MAIN
Pgm  is executing line ØØ1Ø in routine MAIN
          1
Pgm  is executing line ØØ1Ø in routine MAIN
Pgm  is executing line ØØ14 in routine MAIN
ERROR TRAPPED, IER=          23
STOP  END IN - MAIN
```

```
B>FORT SORT.BBB     {compile with listing, .ASM and
                     .OBJ files to drive B}

B>FRUN SORT         {execute the program}
Shell sort

How many numbers (2-2ØØØ) 1ØØ
Starting sort
D=        5Ø
D=        25
D=        13
D=         7
D=         4
D=         2
D=         1
All done

         2         6         6         6         7         8
         8         9         9        12        12        14
        14        18        19        21        21        21
        21        22        25        27        28        28
        29        29        3Ø        32        33        33
        34        34        37        38        39        4Ø
        4Ø        41        46        46        48        48
        48        49        5Ø        51        52        54
        58        58        59        6Ø        6Ø        61
        62        62        64        64        65        65
        66        67        68        7Ø        7Ø        71
        73        74        75        76        76        77
        8Ø        8Ø        82        82        83        84
        85        86        88        89        89        91
        91        91        93        93        93        93
        94        96        96        96        97        98
        99        99       1ØØ       1ØØ
How many numbers (2-2ØØØ) Ø
STOP
B>
```

L. SUGGESTED FURTHER READING

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NEVADA ASSEMBLER(tm)

Users' Reference Manual

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NEVADA ASSEMBLER

AN ASSEMBLER FOR CP/M

TABLE OF CONTENTS

SECTION 1

INTRODUCTION

The assembler translates a symbolic 8080 assembly language program "source code" into the binary instructions "object code" required by the computer to execute the program.

The assembler operates on standard CP/M text files. Each line of a normal text file consists of the characters of that line followed by a carriage return (0DH) and a line feed (0AH).

When the assembler is invoked, it is loaded into memory starting at location 100H. It processes the source code file in two passes. On the first pass, it builds a symbol table containing all of the labels defined in the source program. The symbol table begins at the memory location immediately following the assembler; each entry in the table is 7 bytes long. Certain errors may be detected during the first pass, causing error messages to be output to an error file (usually the console). On the second pass, the object code is generated and usually output to an object code file. In addition, a formatted listing of both source and object code may be output to a listing file, and the symbol table may be output to a file. Any errors detected during this pass cause messages to be output to the error file.

To abort the assembly process at any time, press the Control and C keys.

After the assembly runs to completion and no errors are detected, the resulting object code file (type .OBJ) can be executed by typing RUNA and its name.

EXAMPLE:

```
RUNA PROG     loads and executes a file called PROG.
```

SECTION 2

OPERATING PROCEDURES

HARDWARE REQUIREMENTS

1. 8080/Z80/8085 microprocessor.
   Z80 is a trademark of Zilog.
2. A minimum of 32K RAM.
3. Any disk drive.
4. CRT or Video display and keyboard.

SOFTWARE REQUIREMENTS

Digital Research, Incs. CP/M(R) operating system Version 1.4 or 2.2.
CP/M is a registered trademark of Digital Research, Inc.

FILES ON THE DISTRIBUTION DISKETTE

ASSM.COM is the assembler program.
RUNA.COM is the runtime loader.
(note: These files are on the Nevada FORTRAN diskette.)

FILE TYPE CONVENTIONS

Assembly source code files	.ASM
COBOL source code files	.CBL
FORTRAN source code files	.FOR
Object code run time files	.OBJ
Printer listing files	.PRN
Symbol table listing files	.SYM
Error files	.ERR
Work files	.WRK

GETTING STARTED

If the master disk is not write protected, do it now!

1. NEVADA ASSEMBLER is distributed on a DATA DISK without the CP/M operating system. There is no information on the system tracks, so don't try to "boot it up", it won't work!

2. On computer systems with the ability to read several disk formats, such as the KayPro computer, the master diskette must be used in disk drive B.

3. Do not try to copy the master diskette with a COPY program! On most systems it won't work. You must use the CP/M PIP command to copy the files.

4. First, prepare a CP/M system's diskette for use as your NEVADA ASSEMBLER operations diskette. On 5 1/4 inch diskettes you may have to remove (use the CP/M ERA command) most of the files in order to make room for the ASSEMBLER files. None of the CP/M files are needed for NEVADA ASSEMBLER, but PIP.COM and STAT.COM are useful if you have the space. You may want to do a CP/M STAT command on the distribution disk so you will know how much space you need on your operational diskette. For more information read the CP/M manuals about the STAT command.

5. Then insert the newly created CP/M diskette in disk drive A, and insert the NEVADA ASSEMBLER diskette in drive B and type (ctl-c) to initialize CP/M. Now copy all the files from the ASSEMBLER diskette onto the CP/M diskette:

```
PIP A:=B:*.*[VO]
```

If you get a BDOS WRITE ERROR message from CP/M during the PIP operation it usually means the disk is full and you should erase more files from the operational diskette.

At this point, put the NEVADA ASSEMBLER diskette in a safe place. You will not need it unless something happens to your operations diskette. By the way, back up your operations diskette with a copy each week! If your system malfunctions you can then pat yourself on the back for having a safe back up copy of your work.

Now, boot up the newly created NEVADA ASSEMBLER operations diskette. Notice that CP/M displays the amount of memory for which this version of CP/M has been specialized. The amount of memory available determines the size of the programs that can be assembled. The more memory available the larger the program that can be assembled.

EXECUTING THE ASSEMBLER

The assembler is invoked by a CP/M command with the following formats.

FORMAT-1:

```
ASSM file<CR>
```

FORMAT-2:

```
ASSM file[.uuu u$#LP0]<CR>
```

DESCRIPTION:

where:

file = [unit:]source-file-name
The name of the source code input file. This parameter must be present; all others are optional.

[ ] = optional parameters

unit: = disk drive unit letter. If this parameter is not included, the default drive is used.

u = the disk drive unit letter or the letter "X" for output to the console, or the letter "Z" for no output.

u for position one.
This single character code, if present, represents the drive onto which the listing file is to be written. If this argument is absent then the listing will be written on the default drive. Also, if the character is an X the listing will be sent to the console. If the character is a Z then no listing is produced.

u for position two.
The second letter of the file type represents the drive for the object (.OBJ) file. If this argument is absent then the file will be written on the default drive. If this character is a Z then no object code file will be produced.

u for position three.
The third letter of the file type represents the drive for the error (.ERR) file. If this argument is absent the console will be used to display the errors. This argument must be followed by a space or carriage return.

u for position one of the second set.
The first letter of the second set of arguments represents the drive for the symbol (.SYM) file. If this argument is absent no symbol table file will be produced.

<$options> Various assembler options may be controlled by following the $ with one or more of the following option specifiers. The list of options is terminated by a carriage return. For those options that may be preceded by + or -, the + is optional and will be assumed if absent.

+L The source file has line numbers in column 1-4 of each line.

-L The source file has no line numbers.

If neither of these is specified, the assembler will examine the first line to determine if the file has line numbers.

Instructs the assembler to generate its own line numbers in the listing in place of those in the source file (if any).

P Instructs the assembler to paginate output to the listing file. The file name of the source code file will be printed on the top left-hand corner of each page. A page number will be printed on the top right-hand corner of each page. If a TITL pseudo-operation occurs in the source code, a one- ot two-line title will be centered at the top of each page.

0,1,2, or 3 Specifies the spacing on the listing:

0 = no additional spacing
1 = 72 column output
2 = 80 column output (default)
3 = 132 column output

S Specifies output symbol table in format for SID.

EXAMPLES:

```
ASSM TST
ASSM TST.AAX A$-L#P0
```

STARTUP

To assemble your program, type ASSM and the source file name. The first thing that happens is the copyright message is displayed on the screen and the disk drive(s) begin working. When the assembly process is complete, a message

will be displayed and machine control will return to the operating system.

```
A>ASSM source-file<CR>
NEVADA ASSEMBLER (C) COPYRIGHT 1982
ELLIS COMPUTING, INC.
REV 2.1 ASSEMBLING

NO ASSEMBLY ERRORS.              4 LABELS WERE DEFINED.
A>
```

EXECUTING THE .OBJ FILE

To execute the program, type RUNA and the file-name. The assembly process creates a file with the extension type of (.OBJ). This object program file will be loaded into memory and executed.

```
A>RUNA file-name
```

There are several options that also can be specified with the RUNA command.

```
RUNA file-name[.ZLC]
```

Z = zero memory before loading the .OBJ file.

L = load the program but don't execute it. Control returns to CP/M.

C = create a .COM file for later execution. Control returns to CP/M. Remember .COM files alway begin execution at location 100H.

Example:

```
A>RUNA PROG.ZC      this will zero memory and create a file
                    named PROG.COM.
A>RUNA PROG.L       this will load PROG but not execute it.
```

NOTE: These object code files (.OBJ), if properly orged, can also be loaded and executed by the NEVADA COBOL and NEVADA FORTRAN run time packages. However, Nevada COBOL and Nevada FORTRAN generated type (.OBJ) files cannot be converted to (.COM) files by RUNA because of runtime package requirements. Please see the Nevada FORTRAN manual for the procedure to generate a FORTRAN (.COM) file.

MEMORY USAGE

The ASSEMBLER program is read into memory starting at location 100H and uses all memory available up to the bottom of CP/M.

The runtime package RUNA loads into memory at location 100H and relocates itself to just below CP/M and then begins loading your program.

TERMINATION

The normal termination of the assembly is signaled by the display of the following messages and return to CP/M.

```
NO ASSEMBLY ERRORS.              4 LABELS WERE DEFINED.
A>
```

The assembly process can be interupted at any time by pressing the Control and C keys.

SECTION 3

STATEMENTS

INTRODUCTION

An assembly language program (source code) is a series of statements specifying the sequence of machine operations to be performed by the program.

Each statement resides on a single line and may contain up to four fields as well as an optional line number. These fields, label, operation, operand, and comment, are scanned from left to right by the assembler, and are separated by spaces. The assembler can handle lines up to 80 characters in length.

LINE NUMBERS

Line numbers in the range 0000-9999 may appear in columns 1-4. Line numbers need not be ordered and have no meaning to the assembler, except that they appear in listings. Line numbers may also make it easier to locate lines in the source code file when it is being edited. The disk and memory space required for normal text files will be increased by five bytes per line if line numbers are used; this may become significant for large files.

If line numbers are not used, the label field starts in column 1 and the operation field may not start before column 2. If line numbers are used, they must be followed by at least one space, so the label field starts in column 6 and the operand many not start before column 7.

Once the starting column for the label has been established, the same format must be followed throughout the file: either all of the lines or none of the lines can have line numbers. Any other file(s) assembled along with the main file (using COPY pseudo-operation) must conform to the format of the main file.

Example of source statements with line numbers:

```
Column
1234567
0001 LABEL ORA A    label field must start at column 6.
0002  JNZ NEXT      operation field starts at column 7
0003 ;              (minimum).
0004 LOOP MOV A,B   operation field starts one space after
0005 *              label.
```

Example of source statements without line numbers:

```
Column
1234567
LABEL ORA A    label field must start at column 1.
 JNZ NEXT      operation field starts at column 2 (minimum).
LOOP MOV A,B   operation field starts one space after label.
```

LABEL FIELD

The label field must start in column 1 of the line (column 6 if line numbers are used). A label gives the line a symbolic name that can be referenced by any statement in the program. Labels must start with an alphabetic character (A-Z,a-z), and may consist of any number of characters, though the assembler will ignore all characters beyond the sixth; e.g. the labels BRIDGE, BRIDGE2 and BRIDGET cannot be distinguished by the assembler. A duplicate label error will occur if any two labels in a program begin with the same six letters.

A label may be separated from the operations field by a colon (:) insteat of, or in addition to, a blank.

The labels A, B, C, D, E, H, L, M, PSW, and SP are pre-defined by the assembler to serve as symbolic names for the 8080 registers. They must not appear in the label field.

An asterisk (*) or semi-colon (;) in place of a label in column 1 (column 6 if line numbers are used) will designate the entire line as a comment line.

OPERATION FIELD

The operation field contains either 8080 instruction mnemonics or assembler pseudo-operation mnemonics. Appendix 1 summarizes the standard instruction mnemonics recognized by the assembler, and Appendix 4 lists several references to consult if more information on the 8080 machine instructions is needed. Assembler pseudo-operations are directives that control various aspects of the assembly process, such as storage allocation, conditional assembly, file inclusion, and listing control.

An operation mnemonic may not start before column 2 (column 7 if line numbers are used) and must be separated from a label by at least one space (or a colon).

OPERAND FIELD

Most machine instructions and pseudo-operations require one or two operands, either register names, labels, constants, or arithmetic expressions involving labels and constants.

The operands must be separated from the operator by at least one space. If two operands are required, they must be separated by a comma. No spaces may occur within the operand field, since the first space following the operands delimits the comments field.

Register Names

Many 8080 machine instructions require one or two registers or a register pair to be designated in the operand field. The symbolic names for the general-purpose registers are A, B, C, D, E, H and L. SP stands for the stack pointer, while M refers to the memory location whose address is in the HL register pair. The register pairs BC, DE, and HL are designated by the symbolic names B, D, and H, respectively. The A register and condition flags, when operated upon as a register pair, are given the symbolic name PSW.

The values assigned to be register names A, B, C, D, E, H, L, M, PSW and SP are 7, 0, 1, 2, 3, 4, 5, 6, 6, and 6, respectively. These constants, or any label or expression whose value lies in the range 0 to 7, may be used in place of the pre-defined symbolic register names where a register name is required; such a substitution of a value for the pre-defined register name is not recommended, however.

Labels

Any label that is defined elsewhere in the program may be used as an operand. If a label is used where an 8-bit quantity is required (e.g., MVI C,LABEL), its value must lie in the range -256 to 255, or it will be flagged as a value error.

If a label is used as a register name, its value must lie in th range 0 to 7, or be 0, 2, 4, or 6 if it designates a register pair. Otherwise, it will be flagged as a register error.

During each pass, the assembler maintains an instruction location counter that keeps track of the next location at which an instruction may be stored; this is analogous to the program counter used by the processor during program execution to keep track of the location of the next instruction to be fetched.

The special label $ (dollar Sign) stands for the current

value of the assembler's instruction location counter. When $ appears within the operand field of a machine instruction, its value is the address of the first byte of the next instruction.

EXAMPLE:

```
FIRST EQU $       The label FIRST is set to the address
TABLE DB ENTRY    of the entry in a table and LAST
*                 points to the location immediately after
*                 the end of the table.  TABLN is then
*                 the length of the table and will remain
LAST EQU $        correct, even if later additions or
TABLN EQU LAST-FIRST  deletions are made in the table.
```

CONSTANTS

Decimal, hexadecimal, octal, binary and ASCII constants may be used as operands.

The base for numeric constants is indicated by a single letter immediately following the number, as follows:

D = decimal
H = hexadecimal
O = octal
Q = octal
B = binary

If the letter is omitted, the number is assumed to be decimal. Q is usually perferred for octal constants, since O is so easily confused with 0 (zero). Numeric constants must begin with a numeric character (0-9) so that they can be distinguished from labels; a hexadecimal constant beginning with A-F must be preceded by a zero.

ASCII constants are one or two characters surrounded by single quotes ('). A single quote within an ASCII constant is represented by two single quotes in a row with no intervening spaces. For example, the expression '''', where the two outer quote marks represent the string itself, i.e., the single quote character. A single character ASCII constant has the numerical value of the corresponding ASCII code. A double character ASCII constant has the 16-bit value whose high-order byte is the ASCII code of the first character and whose low-order byte is the ASCII code of the second character.

If a constant is used where an 8-bit quantity is required (e.g., MVI C,10H), its numeric value must lie in the range -256 to 255 or it will be flagged as a value error.

If a constant is used as a register name, its numeric value

must lie in the range 0 to 7, or be 0, 2, 4, or 6 if it designates a register pair. Otherwise it will be flagged as a register error.

Examples:

```
MVI A,128       Move 128 decimal to register A.
MVI C,10D       Move 10 decimal to register C.
LXI H,2FH       Move 2F hexadecimal to registers HL.
MVI B,303Q      Move 303 octal to register B.
MVI A,'Y'       Move the ASCII value for Y to reg A.
MVI A,101B      Move 101 binary to register A.
JMP 0FFH        Jump to address FF hexadecimal.
```

EXPRESSIONS

Operands may be arithmetic expressions constructed from labels, constants, and the following operators:

```
+       addition or unary plus
-       subtraction or unary minus
*       multiplication
/       division (remainder discarded)
```

Values are treated as 16-bit unsigned 2's complement numbers. Positive or negative overflow is allowed during expression evaluation, e.g., 32767+1=7FFFH+1=-32768 and -32768-1=7FFFH=32767. Expressions are evaluated from left to right; there is no operator precedence.

If an expression is used where an 8-bit quantity is required (e.g., MVI C,TEMP+10H), it must evaluate to a value in the range -256 to 255, or it will be flagged as a value error.

Examples:

```
MVI     A,255D/10H-5
LDA     POTTS/256*OFFSET
LXI     SP,30*2+STACK
```

High- and Low-order Byte Extraction

If an operand is preceded by the symbol <, the high-order byte of the evaluated expression will be used as the value of the operand. If an operand is preceded by the symbol >, the low-order byte will be used.

Note that the symbols < and > are not operators that may be applied to labels or constants within an expression. If more than one < or > appears within an expression, the rightmost will be used to determine whether to use the high-

or low-order byte of the evaluated expression as the value of the operand. That is, the rightmost < or > is treated as if it preceded the entire expression, and the others will be totally ignored.

Examples:

```
 MVI A,>TEST      Loads register A with the least
*                 significant 8 bits of the value of
*                 the label TEST.
 MVI B,<0CC00H    Loads register B with the most
*                 significant byte of the 16-bit value
*                 CC00H, i.e., CCH.
 MVI C,<1234H     Loads register C with the value 12H.
 MVI C,>1234H     Loads register C with the value 34H.
```

COMMENT FIELD

The comment field must be separated from the operand field (or operation field for instructions or pseudo-operations that require no operand) by at least one space. Comments are not processed by the assembler, but are solely for the benefit of the programmer. Good comments are essential if a program is to be understood very long after it is written or is to be maintained by someone other than its author.

An entire line will be treated as a comment if it starts with an asterisk (*) or semicolon (;) in column 1 (column 6 if line numbers are used).

Examples:

```
0001 ; is input ready?
0002 LOOP IN STAT input device status
0003      ANI 1   test status bit
0004      JZ LOOP wait for data
0005 *data is now available
```

If listing file formatting is specified in the ASM command ($=options contains 1, 2, or 3), the comment field must be preceded by at least two spaces to ensure proper output formatting. Futhermore, instructions and pseudo-operations requiring no operand must be followed by a dummy operand (a peRiod is recommended).

Examples:

```
MVI A,10  comments
RZ .  comments
```

SECTION 4

PSEUDO-OPERATIONS

Pseudo-operations appear in a source program as instructions to the assembler and do not always generate object code. This section describes the pseudo-operations recognized by the NEVADA assembler.

In the following pseudo-operation formats, <expression> stands for a constant, label, arithmetic expression constructed from constants and labels. Optional elements are enclosed in square brackets [].

Equate <label> EQU <expression>

This pseudo-operation sets a label name to the 16-bit value that is represented in the operand field. That value holds for the entire assembly and may not be changed by another EQU.

Any label that appears in the operand field of an EQU statement must be defined in a statement earlier in the program.

Examples:

```
BELL EQU 7       The value of the label BELL is set to 7.
BELL2 EQU BELL*2 The label BELL2 is ste to 7*2.
```

Set Origin [<label>] ORG <expression>

This pseudo-operation sets the assembler's instruction location counter to the 16-bit value specified in the operand field. In other words, the object code generated by the statements that follow must be loaded beginning at the specified address in order to execute properly. The label, if present, is given the specified 16-bit value.

Any label that appears in the operand field of an ORG statement must be defined in a statement earlier in the program.

If no origin is specified at the beginning of the source code, the assembler will set the origin to 100H. If no ORG pseudo-operation is used anywhere in the source program,

successive bytes of object code will be stored at successive memory locations.

Examples:

```
        ORG 4000H   Determines that the object code generated
*                   by subsequent statements must be loaded
*                   in locations beginning at 4000H.
START   ORG 100H    Determines that the object code generated
*                   by subsequent statements must be loaded
*                   in locations beginning at 100H.
```

Set Execution Address XEQ <expression>

This pseudo-operation specifies the entry point address for the program, i.e., the address at which it is to begin execution. If a program contains no XEQ pseudo-operation, the object code file will contain a starting address of 100H. If more than one XEQ appears in a program, the last will be used.

An example of the difference between ORG and XEQ is that a program whose first 100 bytes are occupied by data will have an ORG address 100 bytes lower in memory than its XEQ address.

Example:

```
        XEQ 100H    The entry point address for the assembled
*                   program is set to 100H.
```

Define Storage [<label>] DS <expression>
[<label>] RES <expression>

Either of these pseudo-operations reserves the specified number of successive memory locations starting at the current address within the program. The contents of these locations are not defined and are not initialized at load time.

Any label that appears in the operand field of a DS or RES statement must be defined in a statement earlier in the program.

Examples:

```
SPEED DS 1      Reserves one byte.
 DS 400         Reserves 400 bytes.
 RES 177Q       Reserves 177 (octal) bytes.
```

Define byte [<label>] DB <expression>[,<expression>,...]

This pseudo-operation sets a memory location to an 8-bit value. If the operand field contains multiple expressions separated by commas, the expressions will define successive bytes of memory beginning at the current address. Each expression must evaluate to a number that can be represented in 8 bits.

Examples:

```
 DB 1    one byte is defined.
 DB 0FFH,303Q,100D,11010011B,3*BELL,-10  multiple bytes.
TABLE DB 'A','B','C','D',0       multiple bytes are defined.
```

Define Word [<label>] DW <expression>

This pseudo-operation sets two memory locations to a 16-bit quantity. The least significant (low-order) byte of the value is stored at the current address and the most significant byte (high-order) is stored at the current address + 1.

Examples:

```
SAVE DW 1234H    1234H is stored in memory, 34H in the
*                low-order byte and 12H in the high-order
*                byte.
YES DW 'OK'      The ASCII value for the letters 'O' and 'K'
*                is stored with the 'K' at the lower memory
*                address.
```

Define Double Byte [<label>] DDB <expression>

This pseudo-operation is almost the same as DW, except that the two bytes are stored in the opposite order: high-order byte first, followed by the low-order byte.

Example:

```
FIRST DDB 1234H   1234H is stored in memory, 12H in the
;                 low-order byte and 34H in the high-order
;                 byte.
```

Define ASCII String **[<label>] ASC #<ASCII string>#**
[<label>] ASCZ #<ASCII string>#

The ASC pseudo-operation puts a string of characters into successive memory locations starting at the current location. The special symbols # in the format are "delimiters"; they define the beginning and end of the ASCII character string. The assembler uses the first non-blank character found as the delimiter. The string immediately follows this delimiter, and ends at the next occurence of the same delimiter, or at a carriage return.

The ASCZ pseudo-operation is the same except that it appends a NUL (00H) to the end of the stored string.

Examples:

```
WORDS ASC "THIS IS AN ASCII STRING"
      ASCZ "THIS IS ANOTHER STRING"
```

Set ASCII List Flag **ASCF 0**
ASCF 1

If the operand field contains a 0, the listing of the assembled bytes of an ASCII string will be suppressed after the first line (four bytes). Likewise, only the first four assembled bytes of a DB pseudo-operation with multiple arguments will be listed. If a program contains many long strings, its listing will be easier to read if the ASCF pseudo-operation is used.

If the operand field contains a 1, the assembled form of subsequent ASCII strings and DB pseudo-operations with multiple argumrnts will be listed in full. This is the default condition.
See Appendix 3 for an example of the listing format.

Conditional Assembly **IF <expression>**
.
source code
.
ENDF

The value of the expression in the operand field governs whether or not subsequent code up to the matching ENDF will be assembled. If the expression evaluates to a 0 (false), the code will not be assembled. If the expression evaluates to a non-zero value (true), the code will be assembled. Blocks of code delimited by IF and ENDF ("conditional code") may be nested within another block of conditional code.

Any label that appears in the operand field of an IF...ENDF pseudo-operation must be defined in a statement earlier in the program.

Example:

```
YES EQU 1       Sets the value of the label 'YES' to 1.
NO EQU 0        Sets the value of the label 'NO' to 0.
*
 IF YES         the expression here is true (1), so the
 MVI A,'Y'      code on this line will be assembled.
 IF NO          The expression here is false (0), so the
 MVI A,'N'      code on this line will not be assembled.
 ENDF           This terminates the NO conditional.
 ENDF           This terminates the YES conditional.
```

List Conditional code IFLS

This pseudo-operation enables listing of conditional source code even though no object code is being generated because of a false IF condition. The assembler will not list such conditional source code if this pseudo-operation is not used.

Copy file COPY [<unit:>]<file-name>

This pseudo-operation copies source code from a disk file into a program being assembled. The code from the copied file will be assembled starting at the current address. When the copied file is exhausted, the assembler will continue to assemble from the original file. The resulting object code will be exactly like what would be generated if the copied source code were part of the original file, but the COPY pseudo-operation does not actually alter any source file.

A copied file may not copy another file. And, all files that are accessed by the COPY pseudo-operation must be of the same format as the main source file, i.e., either having or not having line numbers. The files must be type (.ASM).

EXAMPLES:

```
 COPY FILE1
 COPY B:FILE2
```

Listing Control **NLST**
LST

The NLST pseudo-operation suppresses all output to the listing file. Object code will still be output to the object code file and the lines containing errors will still be output to the error file. The LST pseudo-operation re-enables output to the listing file.

Listing Title **TITL <first line>"<second line>**

If the P option is specified in the ASM command, the one- or two-line title specified by this pseudo-operation will be printed centered at the top of each page of the listing.

Page Eject **PAGE**

If the P option is specified in the ASM command, this pseudo-operation causes a skip to the top of the next page of the listing.

End of Source file **END**

This pseudo-operation terminates each pass of the assembly. Only one END statement should be in the file or files to be assembled, and it should be the last statement encountered by the assembler. Since an end-of-file on the sourec code input file will also terminate each pass, the END statement is unnecessary in most cases.

SECTION 5

ERROR CODES AND MESSAGES

ASSEMBLER COMMAND ERRORS

A number of console messages may be generated in response to errors in the ASM command. When an error of this sort occurs, the assembly is aborted and control returns to CP/M.

EXPECTED NAME The source code input file name is missing.

ILLEGAL OPTION An unrecognized option specifier follows $.

91 ERROR IN EXTENDING THE FILE
92 END OF DISK DATA - DISK IS FULL
93 FINE NOT OPEN
94 NO MORE DIRECTORY SPACE - DISK IS FULL
95 FILE CANNOT BE FOUND
96 FILE ALREADY OPEN
97 READING UNWRITTEN DATA

ASSEMBLY ERRORS

If a statement contains one of the following errors, there will be a single letter error code in column 19 of the line output to the listing and/or error files. An error detected during both the first and the second pass of the assembler will be flagged twice in the listing(s). If the error is not an opcode error, NULs will be output as the second and , if appropriate, third bytes of object code for that instruction. If the error is an opcode error, the instruction will be assumed to be a three-byte instruction, and three NULs will be written to the listing and/or error files. The error codes are:

A	ARGUMENT ERROR	An illegal label or constant appears in the operand field. This might be 1) a number with a letter in it, e.g., 2L, 2) a label that starts with a number, e.g., 3STOP, or 3) an improper representation of a string, e.g., '''A''' in the operand field of a statement containing the ASCII pseudo-operation.
D	DUPLICATE LABEL	The source code contains multiple labels whose first five characters are identical.
L	LABEL ERROR	The symbol in the label field contains illegal characters, e.g., it starts with a number.
M	MISSING LABEL	An EQU instruction does not have a symbol in the label field.
O	OPCODE ERROR	The symbol in the operation field is not a valid 8080 instruction mnemonic or an assembler pseudo-operation mnemonic.
R	REGISTER ERROR	An expression used as a register designator does not have a legal value.
S	SYNTAX ERROR	A statement is not in the format required by the assembler.
U	UNDEFINED SYMBOL	A label used in the operand field is not defined, i.e., does not appear in the label field anywhere in the program, or is not defined prior to its use as an operand in an EQU, ORG, DS, RES, or IF pseudo-operation.
V	VALUE ERROR	The value of the operand lies outside the allowed range.

C2	JNZ	Adr	C4	CNZ	Adr	C0	RNZ	CF	RST 1	0F	RRC	59	MOV E,C	81	ADD C	A9	XRA C
CA	JZ		CC	CZ		C8	RZ	D7	RST 2	17	RAL	5A	MOV E,D	82	ADD D	AA	XRA D
D2	JNC		D4	CNC		D0	RNC	DF	RST 3	1F	RAR	5B	MOV E,E	83	ADD E	AB	XRA E
DA	JC		DC	CC		D8	RC	E7	RST 4			5C	MOV E,H	84	ADD H	AC	XRA H
E2	JPO		E4	CPO		E0	RPO	EF	RST 5			5D	MOV E,L	85	ADD L	AD	XRA L
EA	JPE		EC	CPE		E8	RPE	F7	RST 6			5E	MOV E,M	86	ADD M	AE	XRA M
F2	JP		F4	CP		F0	RP	FF	RST 7			5F	MOV E,A	87	ADD A	AF	XRA A
FA	JM		FC	CM		F8	RM										
E9	PCHL																
												60	MOV H,B	88	ADC B	B0	ORA B
MOVE IMMEDIATE			**Acc IMMEDIATE***			**LOAD IMMEDIATE**		**STACK OPS**		**CONTROL**		61	MOV H,C	89	ADC C	B1	ORA C
												62	MOV H,D	8A	ADC D	B2	ORA D
06	MVI B,	D8	C6	ADI	D8	01	LXI B,	D16	C5	PUSH B	00	NOP	63	MOV H,E	8B	ADC E	B3	ORA E
0E	MVI C,		CE	ACI		11	LXI D,		D5	PUSH D	76	HLT	64	MOV H,H	8C	ADC H	B4	ORA H
16	MVI D,		D6	SUI		21	LXI H,		E5	PUSH H	F3	DI	65	MOV H,L	8D	ADC L	B5	ORA L
1E	MVI E,		DE	SBI		31	LXI SP,		F5	PUSH PSW	FB	EI	66	MOV H,M	8E	ADC M	B6	ORA M
26	MVI H,		E6	ANI									67	MOV H,A	8F	ADC A	B7	ORA A
2E	MVI L,		EE	XRI					C1	POP B	**MOVE**							
36	MVI M,		F6	ORI		**DOUBLE ADD†**			D1	POP D			40	MOV B,B	68	MOV L,B	90	SUB B	B8	CMP B
3E	MVI A,		FE	CPI					E1	POP H			41	MOV B,C	69	MOV L,C	91	SUB C	B9	CMP C
						09	DAD B		F1	POP PSW*			42	MOV B,D	6A	MOV L,D	92	SUB D	BA	CMP D
						19	DAD D						43	MOV B,E	6B	MOV L,E	93	SUB E	BB	CMP E
INCREMENT**			**DECREMENT****			29	DAD H		E3	XTHL			44	MOV B,H	6C	MOV L,H	94	SUB H	BC	CMP H
						39	DAD SP		F9	SPHL			45	MOV B,L	6D	MOV L,L	95	SUB L	BD	CMP L
04	INR B		05	DCR B									46	MOV B,M	6E	MOV L,M	96	SUB M	BE	CMP M
0C	INR C		0D	DCR C				**SPECIALS**					47	MOV B,A	6F	MOV L,A	97	SUB A	BF	CMP A
14	INR D		15	DCR D		**LOAD/STORE**														
1C	INR E		1D	DCR E					EB	XCHG			48	MOV C,B	70	MOV M,B	98	SBB B	**PSEUDO INSTRUCTION**	
24	INR H		25	DCR H		0A	LDAX B		27	DAA*			49	MOV C,C	71	MOV M,C	99	SBB C		
2C	INR L		2D	DCR L		1A	LDAX D		2F	CMA			4A	MOV C,D	72	MOV M,D	9A	SBB D	ORG Adr	
34	INR M		35	DCR M		2A	LHLD Adr		37	STC‡			4B	MOV C,E	73	MOV M,E	9B	SBB E	END	
3C	INR A		3D	DCR A		3A	LDA Adr		3F	CMC‡			4C	MOV C,H	74	MOV M,H	9C	SBB H	EQU D16	
													4D	MOV C,L	75	MOV M,L	9D	SBB L		
03	INX B		0B	DCX B		02	STAX B						4E	MOV C,M		----------	9E	SBB M	DS D16	
13	INX D		1B	DCX D		12	STAX D						4F	MOV C,A	77	MOV M,A	9F	SBB A	DB D8 [ ]	
23	INX H		2B	DCX H		22	SHLD Adr	**INPUT/OUTPUT**											DW D16 [ ]	
33	INX SP		3B	DCX SP		32	STA Adr		D3	OUT D8			50	MOV D,B	78	MOV A,B	A0	ANA B		
									DB	IN D8			51	MOV D,C	79	MOV A,C	A1	ANA C		
													52	MOV D,D	7A	MOV A,D	A2	ANA D		
													53	MOV D,E	7B	MOV A,E	A3	ANA E		
													54	MOV D,H	7C	MOV A,H	A4	ANA H		
													55	MOV D,L	7D	MOV A,L	A5	ANA L		
													56	MOV D,M	7E	MOV A,M	A6	ANA M		
													57	MOV D,A	7F	MOV A,A	A7	ANA A		

D8 constant, or logical/arithmetic expression that evaluates to an 8 bit data quantity.

all Flags (C,Z,S,P) affected

D16 = constant, or logical/arithmetic expression that evaluates to a 16 bit data quantity.

† = only CARRY affected

Adr = 16 bit address

** = all Flags except CARRY affected; (exception: INX & DCX affect no Flags)

APPENDIX I

00	NOP		28	---		50	MOV	D,B	78	MOV	A,B	A0	ANA	B	C8	RZ		F0	RP	
01	LXI	B,D16	29	DAD	H	51	MOV	D,C	79	MOV	A,C	A1	ANA	C	C9	RET		F1	POP	PSW
02	STAX	B	2A	LHLD	Adr	52	MOV	D,D	7A	MOV	A,D	A2	ANA	D	CA	JZ		F2	JP	Adr
03	INX	B	2B	DCX	H	53	MOV	D,E	7B	MOV	A,E	A3	ANA	E	CB	---		F3	DI	
04	INR	B	2C	INR	L	54	MOV	D,H	7C	MOV	A,H	A4	ANA	H	CC	CZ	Adr	F4	CP	Adr
05	DCR	B	2D	DCR	L	55	MOV	D,L	7D	MOV	A,L	A5	ANA	L	CD	CALL	Adr	F5	PUSH	PSW
06	MVI	B,D8	2E	MVI	L,D8	56	MOV	D,M	7E	MOV	A,M	A6	ANA	M	CE	ACI	D8	F6	ORI	D8
07	RLC		2F	CMA		57	MOV	D,A	7F	MOV	A,A	A7	ANA	A	CF	RST	1	F7	RST	6
08	---		30	---		58	MOV	E,B	80	ADD	B	A8	XRA	B	D0	RNC		F8	RM	
09	DAD	B	31	LXI	SP,D16	59	MOV	E,C	81	ADD	C	A9	XRA	C	D1	POP	D	F9	SPHL	
0A	LDAX	B	32	STA	Adr	5A	MOV	E,D	82	ADD	D	AA	XRA	D	D2	JNC	Adr	FA	JM	Adr
0B	DCX	B	33	INX	SP	5B	MOV	E,E	83	ADD	E	AB	XRA	E	D3	OUT	D8	FB	EI	
0C	INR	C	34	INR	M	5C	MOV	E,H	84	ADD	H	AC	XRA	H	D4	CNC	Adr	FC	CM	Adr
0D	DCR	C	35	DCR	M	5D	MOV	E,L	85	ADD	L	AD	XRA	L	D5	PUSH	D	FD	---	
0E	MVI	C,D8	36	MVI	M,D8	5E	MOV	E,M	86	ADD	M	AE	XRA	M	D6	SUI	D8	FE	CPI	D8
0F	RRC		37	STC		5F	MOV	E,A	87	ADD	A	AF	XRA	A	D7	RST	2	FF	RST	7
10	---		38	---		60	MOV	H,B	88	ADC	B	B0	ORA	B	D8	RC				
11	LXI	D,D16	39	DAD	SP	61	MOV	H,C	89	ADC	C	B1	ORA	C	D9	---				
12	STAX	D	3A	LDA	Adr	62	MOV	H,D	8A	ADC	D	B2	ORA	D	DA	JC	Adr			
13	INX	D	3B	DCX	SP	63	MOV	H,E	8B	ADC	E	B3	ORA	E	DB	IN	D8			
14	INR	D	3C	INR	A	64	MOV	H,H	8C	ADC	H	B4	ORA	H	DC	CC	Adr			
15	DCR	D	3D	DCR	A	65	MOV	H,L	8D	ADC	L	B5	ORA	L	DD	---				
16	MVI	D,D8	3E	MVI	A,D8	66	MOV	H,M	8E	ADC	M	B6	ORA	M	DE	SBI	D8	**HEX-ASCII TABLE**		
17	RAL		3F	CMC		67	MOV	H,A	8F	ADC	A	B7	ORA	A	DF	RST	3			
18	---		40	MOV	B,B	68	MOV	L,B	90	SUB	B	B8	CMP	B	E0	RPO		Non-Printing		
19	DAD	D	41	MOV	B,C	69	MOV	L,C	91	SUB	C	B9	CMP	C	E1	POP	H			
1A	LDAX	D	42	MOV	B,D	6A	MOV	L,D	92	SUB	D	BA	CMP	D	E2	JPO	Adr	00	NULL	
1B	DCX	D	43	MOV	B,E	6B	MOV	L,E	93	SUB	E	BB	CMP	E	E3	XTHL		07	BELL	
1C	INR	E	44	MOV	B,H	6C	MOV	L,H	94	SUB	H	BC	CMP	H	E4	CPO	Adr	09	TAB	
1D	DCR	E	45	MOV	B,L	6D	MOV	L,L	95	SUB	L	BD	CMP	L	E5	PUSH	H	0A	LF	
1E	MVI	E,D8	46	MOV	B,M	6E	MOV	L,M	96	SUB	M	BE	CMP	M	E6	ANI	D8	0B	VT	
1F	RAR		47	MOV	B,A	6F	MOV	L,A	97	SUB	A	BF	CMP	A	E7	RST	4	0C	FORM	
20	---		48	MOV	C,B	70	MOV	M,B	98	SBB	B	C0	RNZ		E8	RPE		0D	CR	
21	LXI	H,D16	49	MOV	C,C	71	MOV	M,C	99	SBB	C	C1	POP	B	E9	PCHL		11	X-ON	
22	SHLD	Adr	4A	MOV	C,D	72	MOV	M,D	9A	SBB	D	C2	JNZ	Adr	EA	JPE	Adr	12	TAPE	
23	INX	H	4B	MOV	C,E	73	MOV	M,E	9B	SBB	E	C3	JMP	Adr	EB	XCHG		13	X-OFF	
24	INR	H	4C	MOV	C,H	74	MOV	M,H	9C	SBB	H	C4	CNZ	Adr	EC	CPE	Adr	14		
25	DCR	H	4D	MOV	C,L	75	MOV	M,L	9D	SBB	L	C5	PUSH	B	ED	---		1B	ESC	
26	MVI	H,D8	4E	MOV	C,M	76	HLT		9E	SBB	M	C6	ADI	D8	EE	XRI	D8	7D	ALT MODE	
27	DAA		4F	MOV	C,A	77	MOV	M,A	9F	SBB	A	C7	RST	0	EF	RST	5	7F	RUB OUT	

D8 = constant, or logical/arithmetic expression that evaluates to an 8 bit data quantity

D16 = constant, or logical/arithmetic expression that evaluates to a 16 bit data quantity.

Adr = 16 bit address

APPENDIX 2
TABLE OF ASCII CODES (Zero Parity)

Paper tape 123.4567P	Upper Octal	Octal	Decimal	Hex	Character		
.	0000	000	0	00	ctrl @	NUL	
•.	0004	001	1	01	ctrl A	SOH	Start of Heading
•.	0010	002	2	02	ctrl B	STX	Start of Text
••.	0014	003	3	03	ctrl C	ETX	End of Text
•.	0020	004	4	04	ctrl D	EOT	End of Xmit
•.•	0024	005	5	05	ctrl E	ENQ	Enquiry
••.	0030	006	6	06	ctrl F	ACK	Acknowledge
•••.	0034	007	7	07	ctrl G	BEL	Audible Signal
.•	0040	010	8	08	ctrl H	BS	Back Space
•.•	0044	011	9	09	ctrl I	HT	Horizontal Tab
•.•	0050	012	10	0A	ctrl J	LF	Line Feed
••.•	0054	013	11	0B	ctrl K	VT	Vertical Tab
•.•	0060	014	12	0C	ctrl L	FF	Form Feed
•.••	0064	015	13	0D	ctrl M	CR	Carriage Return
••.•	0070	016	14	0E	ctrl N	SO	Shift Out
•••.•	0074	017	15	0F	ctrl O	SI	Shift In
. •	0100	020	16	10	ctrl P	DLE	Data Line Escape
•. •	0104	021	17	11	ctrl Q	DC1	X On
•. •	0110	022	18	12	ctrl R	DC2	Aux On
••. •	0114	023	19	13	ctrl S	DC3	X Off
•. •	0120	024	20	14	ctrl T	DC4	Aux Off
•.•. •	0124	025	21	15	ctrl U	NAK	Negative Acknowledge
••. •	0130	026	22	16	ctrl V	SYN	Synchronous File
•••. •	0134	027	23	17	ctrl W	ETB	End of Xmit Block
.••	0140	030	24	18	ctrl X	CAN	Cancel
•. ••	0144	031	25	19	ctrl Y	EM	End of Medium
•. ••	0150	032	26	1A	ctrl Z	SUB	Substitute
••. ••	0154	033	27	1B	ctrl [	ESC	Escape
•. ••	0160	034	28	1C	ctrl \	FS	File Separator
•.•. ••	0164	035	29	1D	ctrl]	GS	Group Separator
••. ••	0170	036	30	1E	ctrl ^	RS	Record Separator
•••. ••	0174	037	31	1F	ctrl _	US	Unit Separator
•	0200	040	32	20	Space		
•. •	0204	041	33	21	!		
•. •	0210	042	34	22	"		
••. •	0214	043	35	23	#		
•. •	0220	044	36	24	$		
•.•. •	0224	045	37	25	%		
••. •	0230	046	38	26	&		
•••. •	0234	047	39	27	'		
.••	0240	050	40	28	(		
•. ••	0244	051	41	29	)		
•. ••	0250	052	42	2A	*		
••. ••	0254	053	43	2B	+		
•. ••	0260	054	44	2C	,		
•.•. ••	0264	055	45	2D	–		
••. ••	0270	056	46	2E	.		
•••. ••	0274	057	47	2F	/		
. •••	0300	060	48	30	0		
•. •••	0304	061	49	31	1		
•. •••	0310	062	50	32	2		
••. •••	0314	063	51	33	3		
•. •••	0320	064	52	34	4		
•.•. •••	0324	065	53	35	5		
••. •••	0330	066	54	36	6		
•••. •••	0334	067	55	37	7		
.••••	0340	070	56	38	8		
•. ••••	0344	071	57	39	9		
•. ••••	0350	072	58	3A	:		
••. ••••	0354	073	59	3B	;		
•. ••••	0360	074	60	3C	<		
•.•. ••••	0364	075	61	3D	=		
••. ••••	0370	076	62	3E	>		
•••. ••••	0374	077	63	3F	?		

APPENDIX 2
TABLE OF ASCII CODES *(Cont'd)* (Zero Parity)

Paper tape 123.4567P	Upper Octal	Octal	Decimal	Hex	Character	
. .	0400	100	64	40	@	
• . .	0404	101	65	41	A	
• . .	0410	102	66	42	B	
•• . .	0414	103	67	43	C	
. •. .	0420	104	68	44	D	
• •. .	0424	105	69	45	E	
•• . .	0430	106	70	46	F	
••• . .	0434	107	71	47	G	
. .• .	0440	110	72	48	H	
• . .• .	0444	111	73	49	I	
• . .• .	0450	112	74	4A	J	
•• . .• .	0454	113	75	4B	K	
. •. .• .	0460	114	76	4C	L	
• •. .• .	0464	115	77	4D	M	
•• . .• .	0470	116	78	4E	N	
••• . .• .	0474	117	79	4F	O	
. . • .	0500	120	80	50	P	
• . . • .	0504	121	81	51	Q	
• . . • .	0510	122	82	52	R	
•• . . • .	0514	123	83	53	S	
. •. . • .	0520	124	84	54	T	
• •. . • .	0524	125	85	55	U	
•• . . • .	0530	126	86	56	V	
••• . . • .	0534	127	87	57	W	
. .•• .	0540	130	88	58	X	
• . .•• .	0544	131	89	59	Y	
• . .•• .	0550	132	90	5A	Z	
•• . .•• .	0554	133	91	5B	[	
. •. .•• .	0560	134	92	5C	\	
• •. .•• .	0564	135	93	5D	]	
•• . .•• .	0570	136	94	5E	^	
••• . .•• .	0574	137	95	5F	_	
. . ••	0600	140	96	60	`	
• . . ••	0604	141	97	61	a	
• . . ••	0610	142	98	62	b	
•• . . ••	0614	143	99	63	c	
. •. . ••	0620	144	100	64	d	
• •. . ••	0624	145	101	65	e	
•• . . ••	0630	146	102	66	f	
••• . . ••	0634	147	103	67	g	
. .• ••	0640	150	104	68	h	
• . .• ••	0644	151	105	69	i	
• . .• ••	0650	152	106	6A	j	
•• . .• ••	0654	153	107	6B	k	
. •. .• ••	0660	154	108	6C	l	
• •. .• ••	0664	155	109	6D	m	
•• . .• ••	0670	156	110	6E	n	
••• . .• ••	0674	157	111	6F	o	
. . •••	0700	160	112	70	p	
• . . •••	0704	161	113	71	q	
• . . •••	0710	162	114	72	r	
•• . . •••	0714	163	115	73	s	
. •. . •••	0720	164	116	74	t	
• •. . •••	0724	165	117	75	u	
•• . . •••	0730	166	118	76	v	
••• . . •••	0734	167	119	77	w	
. .••••	0740	170	120	78	x	
• . .••••	0744	171	121	79	y	
• . .••••	0750	172	122	7A	z	
•• . .••••	0754	173	123	7B	{	
. •. .••••	0760	174	124	7C	|	
• •. .••••	0764	175	125	7D	}	
•• . .••••	0770	176	126	7E	~	Prefix
••• . .••••	0774	177	127	7F	DEL	Rubout

APPENDIX 3

ASSEMBLER LISTING

ADDRESS	ASSEMBLED CODE	ERROR FLAG	LINE NO.	LABEL	OPERATION	OPERAND	COMMENT
			0000	*			
			0001	*SEARCH TABLE FOR MATCH TO STRING			
			0002	*EACH TABLE ENTRY IS FOLLOWED BY A TWO-BYTE DISPATCH ADDRESS.			
			0003	*TABLE MUST HAVE AT LEAST ONE ENTRY AND IS TERMINATED BY A			
			0004	*ZERO BYTE.			
			0005	*ON ENTRY:	HL POINTS TO STRING		
			0006	*	DE POINTS TO TABLE		
			0007	*	C IS NUMBER OF CHARACTERS IN TABLE ENTRIES		
			0008	*ON RETURN:	ZERO FLAG SET IF NO MATCH, ELSE DE POINTS TO		
			0009	*	DISPATCH ADDRESS		
			0010	*			
0100	E5		0011	TSRCH	PUSH	H	SAVE STRING ADDRESS
0101	41		0012		MOV	B,C	INITIALIZE CHARACTER COUNT
0102	1A		0013	TS1	LDAX	D	COMPARE CHARACTERS
0103	BE		0014		CMP	M	
0104	C2 11 01		0015		JNZ	TS3	
0107	23		0016		INX	H	CHARACTERS MATCH, GO ON TO NEXT
0108	13		0017		INX	D	
0109	05		0018		DCR	B	
010A	C2 02 01		0019		JNZ	TS1	
010D	F6 01		0020		ORI	1	MATCHING ENTRY FOUND
010F	E1		0021	TS2	POP	H	
0110	C9		0022		RET		
0111	B7		0023	TS3	ORA	A	TEST FOR END OF TABLE
0112	CA 0F 01		0024		JZ	TS2	
0115	13		0025	TS4	INX	D	SKIP TO NEXT ENTRY
0116	05		0026		DCR	B	
0117	C2 15 01		0027		JNZ	TS4	
011A	13		0028		INX	D	
011B	13		0029		INX	D	
011C	E1		0030		POP	H	
011D	C3 00 01		0031		JMP	TSRCH	
			0032	*			
			0033	*EXAMPLE OF TSRCH USE:			
			0034	*			
			0035	*(ASSUME HL POINTS TO A FOUR-CHARACTER COMMAND STRING)			
0120	11 35 01		0036		LXI	D,CTABL	DE POINTS TO COMMAND TABLE
0123	0E 04		0037		MVI	C,4	TABLE ENTRIES ARE FOUR CHARACTERS LONG
0125	CD 00 01		0038		CALL	TSRCH	
0128	CA 00 00	U	0039		JZ	ERROR	COMMAND NOT IN TABLE
012B	EB		0040		XCHG	.	SET UP STACK FOR RETURN TO MAIN ROUTINE
012C	11 00 00	U	0041		LXI	D,COMMAND	
012F	D5		0042		PUSH	D	
0130	7E		0043		MOV	A,M	DISPATCH TO APPROPRIATE COMMAND ROUTINE
0131	23		0044		INX	H	
0132	66		0045		MOV	H,M	
0133	6F		0046		MOV	L,A	
0134	E9		0047		PCHL		
			0048	*			
			0049	*COMMAND TABLE			
			0050	*			
0135	43 4F 4D 31		0051	CTABL	ASC	'COM1'	FIRST ENTRY
0139	00 00	U	0052		DW	SUB1	ADDRESS OF SUB1
013B	43 4F 4D 32		0053		ASC	'COM2'	SECOND ENTRY
013F	00 00	U	0054		DW	SUB2	ADDRESS OF SUB2
0141	00		0055		DB	0	END OF TABLE MARK

SYMBOL TABLE LISTING

Label	Addr.	Label	Addr.	Label	Addr.	Label	Addr.
CTABL	0135	TS1	0102	TS2	010F	TS3	0111
TS4	0115	TSRCH	0100				

APPENDIX 4

This is a sample program. The loader source code.

```
0001 ************************************************
0002 *
0003 *                  RUNA file-name[.ZCL]
0004 *
0005 *     An .OBJ file consists of one or more segments that
0006 *     have the format:
0007 *        #BYTES           DESCRIPTION
0008 *          2           Number of code and data bytes in
0009 *                      segment
0010 *          2           Load address of code and data
0011 *                      belonging to the segment.
0012 *        Variable      Code and/or data.
0013 *
0014 *     The run time package will load each segment at the
0015 *     specified address until a starting address is
0016 *     encountered.  A starting address is represented as
0017 *     load address with a zero byte count.
0018 *
0019 * ************************************************
0020 *
0021 RELOC EQU 0     ;4200H FOR TRS-80 MOD 1
0022 BDOS EQU 5+RELOC  ;CP/M
0023 BLKSIZ EQU 128
0024 OFCB EQU 5CH+RELOC  ;IN CP/M
0025 OEX EQU OFCB+12
0026 OCR EQU OFCB+32
0027 OBUF EQU 80H+RELOC  ;IN CP/M
0028 *
0029 CSTART EQU $
0030  LXI SP,STK
0031  MVI C,0CH  ;RETURN VERSION #
0032  CALL BDOS
0033  MOV A,L
0034  ORA A
0035  JNZ VER2X
0036  LDA 4+RELOC  ;CPM 1.4 DEFAULT DRIVE
0037  CPI 5
0038  JC SETDF
0039  XRA A
0040 SETDF EQU $  ;11-30-81 FOR MP/M II
0041  STA ODRIVE  ;DEFAULT DRIVE
0042 *  GET OPTIONS FROM TYPE FIELD
0043  LXI H,5CH+8
0044  MVI C,4
0045 NEXT EQU $
0046  INX H
```

```
0047  DCR C
0048  JZ NOOPTIONS
0049  MOV A,M
0050  CPI ' '
0051  JZ NOOPTIONS
0052  CPI 'Z'
0053  JZ ZEROFIL
0054  CPI 'C'
0055  JZ COMFILE
0056  CPI 'L'
0057  JZ NOEXEC
0058 * ERROR ILLEGAL OPTION
0059  LXI H,MESGA
0060  CALL DISPLAY
0061  JMP 0+RELOC
0062 *  GET SIZE OF INSTRUCTION
0063 GETSZ LXI H,TBL-1
0064 AGAIN MOV A,C
0065  INX H
0066  MOV B,M
0067  ANA B
0068  JZ BYTE1
0069  INX H
0070  MOV B,M
0071  XRA B
0072  INX H
0073  JNZ AGAIN
0074  MOV A,M
0075  RET .  EXIT
0076 BYTE1 MVI A,1
0077  RET .  EXIT
0078 *
0079 REL EQU $  RELOCATION
0080  PUSH H
0081  PUSH D
0082  PUSH PSW
0083  INX H
0084  MOV E,M
0085  INX H
0086  MOV A,M
0087  ORA A  WE DON'T RELOCATE BELOW 100+RELOC
0088  JZ NOREL
0089  MOV D,A
0090  PUSH H
0091  LHLD BASE
0092  DAD D  ADDRESS IS NOW ADJUSTED
0093  XCHG
0094  POP H
0095  MOV M,D  PUT IT BACK
0096  DCX H
0097  MOV M,E
0098 NOREL EQU $
0099  POP PSW
0100  POP D
```

```
0101  POP H
0102  RET
0103 *
0104 VER2X EQU $
0105  MVI C,19H  ;GET CPM 2.X DEFAULT DRIVE
0106  CALL BDOS
0107  JMP SETDF
0108 *
0109 MESGA ASC 'ILLEGAL OPTION'
0110  DB 0DH,0AH
0111  ASC 'RUN D:FILE.ZCL<CR>'
0112  DB 0DH,0AH,0
0113 *
0114 TBL DB -1,11101001B,1
0115  DB -1,11001101B,3
0116  DB 11000111B,11000100B,3
0117  DB -1,11000011B,3
0118  DB 11000111B,11000010B,3
0119  DB 11000111B,11000111B,1
0120  DB -1,11001001B,1
0121  DB 11000111B,11000000B,1
0122  DB 11001111B,1,3
0123  DB 11100111B,00100010B,3
0124  DB 11110111B,11010011B,2
0125  DB 11000111B,6,2
0126  DB 11000111B,11000110B,2
0127  DB 0            END OF TABLE
0128 *
0129 BASE DW 0  BASE ADJ TO ADD TO ADDRESS TO BE RELOCATED
0130 START DW 0  STARTING ADDR OF RELOCATED CODE
0131 *
0132 ZEROFILL EQU $
0133  STA ZX
0134  JMP NEXT
0135 *
0136 COMFILE EQU $
0137  STA CX
0138  JMP NEXT
0139 *
0140 NOEXEC EQU $
0141  STA LX
0142  JMP NEXT
0143 *
0144 OSET EQU $
0145  LXI D,OBUF
0146  MVI C,26  ;SET DMA
0147  CALL BDOS
0148  LDA ODRIVE
0149  MVI D,0
0150  MOV E,A
0151  MVI C,14  ;SET DRIVE
0152  CALL BDOS
0153  LXI D,OFCB
0154  RET
```

```
0155 *
0156 NOOPTIONS EQU $
0157  LXI H,080H+3+RELOC
0158  MOV A,M
0159  CPI ':'  ;WAS DRIVE REQUESTED?
0160  JNZ DEFDRIVE  ;DEFAULT IS SET
0161  DCX H
0162  MOV A,M
0163  CPI 'A'
0164  JC DEFDRIVE
0165  SUI 'A'
0166  STA ODRIVE
0167 DEFDRIVE EQU $
0168  CALL SETFCB
0169  MVI M,'O'
0170  INX H
0171  MVI M,'B'
0172  INX H
0173  MVI M,'J'
0174  CALL OSET
0175  MVI C,15  ;OPEN
0176  CALL BDOS
0177  CPI -1
0178  JZ OERR  ;OPEN ERROR
0179  XRA A
0180  STA OCR
0181 *  RELOCATE CODE TO JUST BELOW CP/M
0182  LHLD 6+RELOC
0183  DCX H  HIGHEST ADDR
0184  LXI B,LAST-LOADFILE  SIZE OF CODE TO BE RELOCATED
0185  MOV A,L
0186  SUB C
0187  MOV L,A
0188  MOV A,H
0189  SBB B
0190  MOV H,A
0191 ; H&L= STARTING ADDRESS
0192  SHLD START
0193  PUSH H
0194  LXI D,LOADFILE
0195  MOV A,L
0196  SUB E
0197  MOV L,A
0198  MOV A,H
0199  SBB D
0200  MOV H,A
0201  SHLD BASE
0202  POP H
0203  LXI B,CONSTANTS-LOADFILE  SIZE OF INSTRUCTION MOVE
0204  XCHG
0205 NXTI EQU $
0206  PUSH H
0207  PUSH D
0208  PUSH B
```

```
0209  MOV C,M  GET OPCODE
0210  CALL GETSZ  GET SIZE OF INSTRUCTION
0211  POP B
0212  POP D
0213  POP H
0214  CPI 3
0215  JC SKPREL
0216  CALL REL  RELOCATE ADDR IN THIS 3 BYTE INST
0217 SKPREL EQU $
0218  PUSH B
0219  PUSH PSW
0220  MOV C,A  SIZE
0221 NXTM EQU $
0222  MOV A,M
0223  STAX D
0224  INX H
0225  INX D
0226  DCR C
0227  JNZ NXTM
0228  POP PSW
0229  POP B
0230 NXTD EQU $
0231  DCX B
0232  DCR A
0233  JNZ NXTD
0234  MOV A,C
0235  ORA B
0236  JNZ NXTI
0237 *  RELOCATE CONSTANTS
0238  LXI B,LAST-CONSTANTS  SIZE OF CONSTANTS
0239 NXTC EQU $
0240  MOV A,M
0241  STAX D
0242  INX H
0243  INX D
0244  DCX B
0245  MOV A,C
0246  ORA B
0247  JNZ NXTC
0248  LHLD START
0249  PCHL .  CODE HAS BEEN RELOCATED NOW GO TO IT
0250 *
0251 ****************************************************
0252 *  RUNA  A:FILE.OBJ<CR>
0253 *
0254 *  MOVE PARAMETERS AND CHECK
0255 ****************************************************
0256 *
0257 LOADFILE EQU $
0258  LXI SP,STK  SET STACK AFTER RELOCATION
0259  LDA ZX  ZERO FILL MEMORY?
0260  ORA A
0261  JZ SKPCLR
0262  LXI D,LOADFILE-1
```

```
0263  MVI H,1      STARTING ADDR  +RELOC
0264  MVI L,0
0265 CLEAR EQU $
0266  XRA A
0267  MOV M,A
0268  INX H
0269  MOV A,L
0270  SUB E
0271  MOV A,H
0272  SBB D
0273  JC CLEAR
0274 SKPCLR EQU $
0275  CALL ORD  ;GET 1ST RECORD OF .OBJ FILE
0276 OLOAD EQU $
0277  CALL GETOP
0278 MAO MOV A,M  ;MOVE 4 BYTES FROM BUF TO WORK
0279  STAX D
0280  INX H
0281  INX D
0282  DCR C
0283  CZ ORD
0284  DCR B
0285  JNZ MAO
0286 ; H&L = BUFFER  C=COUNT
0287  XCHG
0288  LHLD OWRK  ;SIZE OF NEXT READ
0289  MOV A,L
0290  ORA H
0291  JZ CLOSE
0292  SHLD OSIZE
0293  LHLD OWRK+2
0294  XCHG
0295 MAOA MOV A,M  ;MOVE FROM BUF TO OBJ ADDR
0296  STAX D
0297  INX H
0298  INX D
0299  DCR C
0300  CZ ORD
0301  PUSH H
0302  LHLD OSIZE
0303  DCX H
0304  SHLD OSIZE
0305  MOV A,L
0306  ORA H
0307  POP H
0308  JNZ MAOA
0309  CALL SAVOP
0310  JMP OLOAD
0311 *
0312 GETOP EQU $  ;GET O POINTERS
0313  LXI D,OWRK
0314  LHLD OCBA  ;BUF ADDR
0315  MVI B,4  ;LENGTH OF WRK
0316  LDA OCBC  ;BUF CNT
```

```
0317  MOV C,A
0318  RET
0319 *
0320 ORD EQU $
0321  PUSH B
0322  PUSH D  ;OPNT
0323  LXI D,OFCB
0324  MVI C,20  ;READ
0325  CALL BDOS
0326  POP D
0327  POP B
0328  ORA A
0329  JNZ RERR
0330  LXI H,OBUF
0331  MVI C,BLKSIZ
0332  RET
0333 *
0334 SAVOP EQU $
0335  SHLD OCBA  ;BUFF ADDR
0336  MOV A,C
0337  STA OCBC  ;BUF CNT
0338  LDA HIGH
0339  CMP D
0340  RNC
0341  MOV A,D
0342  STA HIGH
0343  RET
0344 *
0345 CLOSE EQU $
0346  LXI D,OFCB
0347  MVI C,16  ;CLOSE
0348  CALL BDOS
0349  LDA CX
0350  ORA A
0351  JNZ GENCOM
0352  LDA LX
0353  ORA A
0354  JNZ 0+RELOC  LOAD BUT DON'T EXECUTE
0355  LHLD OWRK+2  ;STARTING ADDRESS
0356  PCHL
0357 *
0358 SETFCB EQU $
0359  XRA A
0360  STA OFCB
0361  STA OCR
0362  LXI H,OEX
0363  MVI C,4
0364 EXLUP EQU $  ;10-2-81 ZERO CPM EXT AREA
0365  MOV M,A
0366  INX H
0367  DCR C
0368  JNZ EXLUP
0369  LXI H,OBUF
0370  SHLD OCBA
```

```
0371  MVI A,BLKSIZ
0372  STA OCBC
0373  LXI H,5CH+9+RELOC   ;CP/M FILE TYPE
0374  RET
0375 *
0376 CREATE EQU $
0377  LXI D,OFCB
0378  MVI C,22  CREATE
0379  CALL BDOS
0380  CPI -1
0381  RNZ
0382 OERR EQU $
0383  LXI H,MESGO  OPEN ERROR
0384  CALL DISPLAY
0385  JMP OXT1
0386 *
0387 GENCOM EQU $  GENERATE .COM FILE
0388  CALL SETFCB
0389  MVI M,'C'
0390  INX H
0391  MVI M,'O'
0392  INX H
0393  MVI M,'M'  .COM IN FCB
0394 *OPEN
0395  LXI D,OFCB
0396  MVI C,15  OPEN .COM FILE
0397  CALL BDOS
0398  CPI -1
0399  CZ CREATE
0400  XRA A
0401  STA OCR
0402 *WRITE
0403  LDA HIGH
0404  DCR A
0405  MOV H,A
0406  MVI L,0FFH
0407  SHLD SIZ  OF THIS WRITE
0408  MVI D,1  STARTING ADDRESS   +RELOC
0409  MVI E,0
0410  LXI H,OBUF  BUFFER ADDRESS
0411  MVI C,BLKSIZ  BUFFER SIZE
0412 NXTW EQU $
0413  LDAX D
0414  MOV M,A
0415  INX H
0416  INX D
0417  DCR C  BUFF COUNT
0418  CZ WRITE
0419  PUSH H
0420  LHLD SIZ
0421  DCX H
0422  SHLD SIZ
0423  MOV A,L
0424  ORA H
```

```
0425  POP H
0426  JNZ NXTW
0427  CALL WRITE  LAST BLOCK
0428 * CLOSE
0429  LXI D,OFCB
0430  MVI C,16  CLOSE
0431  CALL BDOS
0432  JMP 0+RELOC
0433 *
0434 WRITE EQU $
0435  PUSH D
0436  LXI D,OFCB
0437  MVI C,21  WRITE
0438  CALL BDOS
0439  POP D
0440  ORA A
0441  JNZ ERRW
0442  LXI H,OBUF
0443  MVI C,BLKSIZ
0444  RET
0445 *
0446 *++************************************************
0447 *$$  DISPLAY A MESSAGE TO THE CONSOLE
0448 *     ENTRY H&L CONTAIN STARTING ADDRESS OF THE MESSAGE
0449 *           THE MESSAGE TEXT IS TERMINATED BY 0 HEX
0450 *           CALL DISPLAY
0451 *--************************************************
0452 *
0453 DISPLAY EQU $
0454  MOV A,M
0455  ORA A
0456  RZ .  EXIT TO CALLING ROUTINE **
0457  MOV E,A
0458  MVI C,2
0459  PUSH H
0460  CALL BDOS  ;PUT THE CHAR TO THE CONSOLE
0461  POP H
0462  INX H
0463  JMP DISPLAY
0464 *
0465 ERRW EQU $
0466  LXI H,MESGW  WRITE ERROR
0467  CALL DISPLAY
0468  JMP OXT1
0469 *
0470 RERR EQU $
0471  LXI H,MESGR  READ ERROR
0472  CALL DISPLAY
0473 OXT1 EQU $
0474  LXI H,OFCB+1  ;FILE NAME
0475  CALL DISPLAY
0476  JMP 0+RELOC  RETURN TO CP/M
0477 ************************************************
0478 CONSTANTS EQU $
```

```
0479 HIGH DB 0  HIGHEST PAGE USED FOR .COM
0480 ZX DB 0  DEFAULT NO CLEAR ;Z=ZERO FILL BEFORE LOADING
0481 CX DB 0  DEFAULT NO .COM ;C=.COM FILE
0482 LX DB 0  DEFAULT EXECUTE ;L=LOAD BUT NO EXECUTION
0483 ODRIVE DB 0
0484 OWRK DB 0,0,0,0
0485 OCBA DW OBUF  ;CURRENT BUFFER ADDRESS
0486 OCBC DB BLKSIZ  ;CURRENT BUFFER COUNTER
0487 OSIZE DW 0  ;SIZE OF NEXT OBJ BLOCK
0488 SIZ DW 0  SIZE OF COM FILE CODE
0489 MESGO ASC 'OPEN ERROR '
0490  DB 0
0491 MESGR ASC 'READ ERROR '
0492  DB 0
0493 MESGW ASC 'WRITE ERROR '
0494  DB 0
0495  DS 30
0496 STK DB 'S'
0497 LAST DB 0
```

APPENDIX 5

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