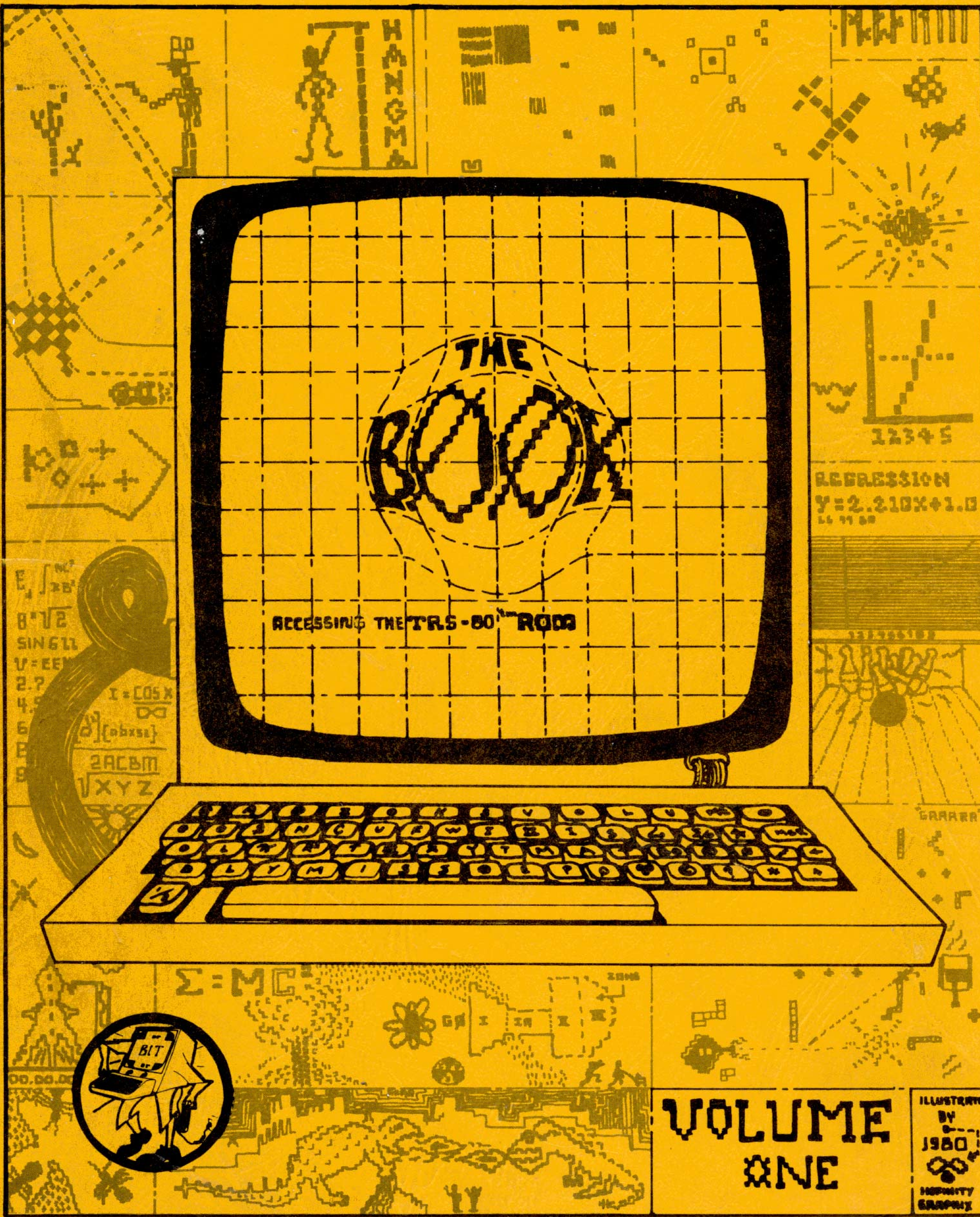
THE
BOOK
ACCESSING THE TRS-80 ROM
VOLUME
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INFINITY GRAPHIX
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THE BØØK

ACCESSING THE TRS-80 ROM

VOLUME I: MATH

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ILLUSTRATIONS BY
INFINITY GRAPHIX

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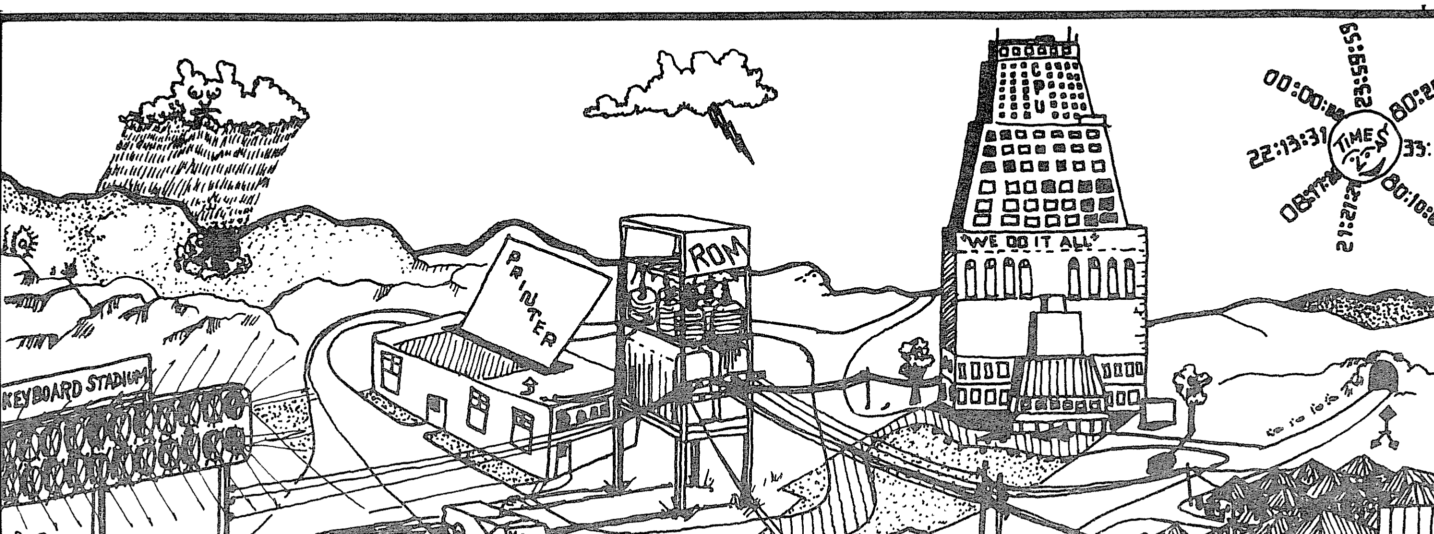
KEYBOARD STADIUM
PRINTER
ROM
CPU
"WE DO IT ALL"
TIMES
23:59:59
22:13:31
CASSETTE STATION
CLOAD
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PREFACE

This book has been written in a manner that resists non-sequential access methods. In other words, it is HIGHLY recommended that the reader start with the Introduction and continue on through the book. After the first reading, the Table of Contents can double as an Index, which was left out to discourage people from leaping into strange waters.

INTRODUCTION

Since you are reading this book, you are most likely the owner of a TRS-80 microcomputer. In spite of the disdain shown for your beast by those who don't know any better, you have probably found that it is generally adequate for most of your personal computing needs. Unfortunately, due to either disinterest or lack of knowledge, various organizations which should be making essential information available to you are failing to do so. This book is a response to the obvious desire of you--the owner, operator, and programmer of a TRS-80--to know as much about this machine as possible. It is our intention to make available to you information not readily obtainable from any other source.

This is the first of a three volume set that will detail the operation of the Level II ROM. Explicit descriptions will be given so that ROM routines, accessable from assembly language, may be used. The series will explore Level II BASIC at a depth that will be satisfactory for even the most skilled programmer and yet will still prove to be useful to the novice programmer with only minimal machine language experience.

This first volume describes in detail how numerical data is stored and manipulated in memory. In addition, it provides the complete assembly language interfacing procedures for all mathematical functions including addition, subtraction, multiplication, and division of integer, single precision, and double precision values. Also, the code necessary for accessing the logarithmic, trigonometric, and comparison routines is provided along with examples on how to manipulate data in memory. Although Input/Output will be covered in Volume II, complete instructions are provided for inputting and outputting numerical data. In Appendix A, the user will find a complete list of entry points and data areas used by Level II, including some areas used by DOS and Disk BASIC. This list provides a quick reference to all routines discussed in this volume and in the ones to follow.

The wealth of information that one will find in this book is substantial. Due to the amount of material available, you will find the next two volumes equally as informative. Topics will include data and tape formats, I/O routines, BASIC program storage, the editor, the parser, error-handler, and much, much more. Please refer to the coupon in the back of this book for a discount on the next volume in the series.

We welcome any comments or suggestions. Please feel free to write us.

Thank you and good luck,

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CHAPTER 1: FORMATS AND ACCUMULATORS

In order to fully understand the operation of the mathematics routines, one must have a basic understanding of the internal format of numerical data. The TRS-80 supports three types of numerical variables: integer, single precision (also known as "floating-point"), and double precision. In order to manipulate the different values, Level II utilizes various memory accumulators in low RAM memory. In the following sections, the format of these three types of values will be discussed along with the format of the memory accumulators.

Data in the form of integers, single precision, and double precision real numbers are stored in RAM memory. This data is typically stored in locations which are associated with variable names that are used in a BASIC program. Level II creates and maintains two tables of variable names and their associated values. The two tables of variables immediately follow the end of the BASIC program in memory. It is for this reason that whenever the program is modified (after a BREAK for example), all variable values are cleared and the pointers are reset.

The first variable area is for simple (i.e., non-array) variables. Variables for each of the four data types (strings included) can be stored in this region. The beginning of the simple variable storage area is indicated by a two-byte pointer, SCLERS, that is stored at locations 40F9H and 40FAH. Simple variables are placed in this region as they are encountered during program execution. Therefore, since the search through this table is done sequentially, all frequently used variables should be initialized at the beginning of the program before any program statements but following the CLEAR and DEF commands. This step is very important when one uses long programs with many variables. Early definition of variables used in FOR/NEXT loops first is very worthwhile.

The entry for each different type of variable follows a set format. The first byte of each entry is for the type of variable; two (2) for integer, three (3) for string, four (4) for single precision, and eight (8) for double precision. The next two bytes consist of the two significant characters in the variable name stored in reverse order. Thus, the variable name "AB" would be stored in the RAM variable table as "BA." However, in the case of single character variable names, the first byte will be zero (00) instead of being stored as a space. Numeric data folows the name, while string data is pointed to by an address following the name. The code representing the variable type also reflects the length of the following data. Accordingly, each integer will have two bytes, strings-three, single precision-four, and double precision will have eight.

The two bytes of the integer are stored, as is standard, least significant byte (LSB) first, followed by the most significant byte (MSB). Integers in the TRS-80 are signed, meaning that they are either positive or negative. The system used to represent integers is called "two's complement." In this representation, the most significant bit of the sixteen bits used for integer storage is the sign bit. The sign bit is set (1) for negative numbers and is zero (0) for positive values. Positive values are stored in the low order fifteen bits as a standard binary value. Therefore, a value of +3 would be represented as 00000000 00000101.

Negative numbers, on the other hand, are represented as if the corresponding positive value including the sign (zero for positive) had been complemented and then one was added to the result. Complementing is the process of changing each of the sixteen bits into its opposite; zero to one, one to zero. If the above process is performed twice on any sixteen bit value, the original number will always be returned. Any negative value number can be decoded by taking its two's complement and placing a minus sign (-) in front of it. Thus, the value 1234 in decimal will be represented as the sixteen bit value 00000100 11010010 (04D2H) and the value -1234 as 11111011 00101110 (FB2EH).

As stated previously, integer values are stored in memory in two contiguous bytes. The least significant byte (rightmost in the above examples) is stored in the lowest memory location and the most significant byte in the next higher memory location. Thus, the value for 1234 which in hex is 04D2H would be stored D2H 04H.

Using two's complement, the largest integer value that can be stored in memory is 32,767 (7FFFH) or, in binary, 01111111 11111111. The smallest negative value that can be represented using integers is -32,768 (8000H) or, in binary, 10000000 00000000. Values that do not fall within the -32,768 to +32,767 range must be represented as either single precision or double precision numbers.

Single precision numbers are handled in a totally different manner. Most readers should be familiar with scientific notation, a technique for representing a number as a real number between one and ten (called the mantissa) and an integer that represents the power of ten the real number must be multiplied by to produce the original value. As an example, the number 378.662 would be represented as 3.78662 x 10**2 (the two asterisks (**) meaning "raised to the power of"). In the TRS-80 and most computers, this value would be printed as 3.78662E+02, which will be the notation followed throughout the rest of this text.

A modification of this process requires that the mantissa always be less than one but greater than or equal to one-tenth (1 > X => .1). Using this procedure called normalization, the above example would be represented as .378662E+03.

Similarly, values can be represented with a binary mantissa and exponent (which now represents a power of two by which the binary mantissa must be multiplied in order to produce the original value). In this case, bits to the right of the binary point represent increasingly negative powers of two. Thus, 1/8 would be represented as .001 [1/(2**3)]. Examples are:

$$.5_{10} = .1_2 \quad (2^{-1})$$

$$.25_{10} = .01_2 \quad (2^{-2})$$

$$.125_{10} = .001_2 \quad (2^{-3})$$

$$.0625_{10} = .0001_2 \quad (2^{-4})$$

The representation of floating point numbers in the TRS-80 as well as other computers uses this concept.

In the TRS-80, four bytes are used to represent single precision (6 significant digits) and eight bytes for double precision (16 significant digits). In both cases, one byte is used to hold the exponent and the remaining three or seven (depending on the type of value) is used to hold the mantissa.

The exponent is stored in "excess 128" notation. This means that an exponent of zero (2**0 = 1) is represented by 128 (80H), positive exponents are denoted by values of greater than 128, and negative exponents by values of less than 128. Thus, by subtracting 128 from the value, the true exponent is obtained.

The mantissa of a floating-point number is always normalized, which when working in base 10 is within the range 10**0>X>=10**(-1). However, the TRS-80 stores the values in BINARY normalized form which means the values lie within the range [2**0>X>=2**-1]. A little simple arithmetic will show that this range, base 10, is [1>X>.5]. All this means is that there will always be a one (1) immediately to the right of the decimal point when the binary normalized mantissa is shown in its binary form.

As an example, the number 72.0 decimal when converted to hex (base 16) is 48H. This value in binary is 01001000. Now, let's normalize this binary number, how about 0.1001000? We have effectively moved the binary point seven places to the left, or divided it by 2**7. Therefore, to produce the original value from 0.1001000, we must multiply this value by 2**7. Hence, the representation for 72 decimal in binary normalized form would be:

$$0.1001000 \times 2^7$$

Now that we know what the external representation of this value is, we must now convert it to the TRS-80's internal representation.

The first point here is that, as stated before, the exponent is stored in "excess 128 (80H)" notation. Therefore, our positive exponent of seven would be converted to 87H by adding 80H (effectively setting the high order bit). Now that the exponent problem has been solved, we will move to the mantissa....

Here, one may get a bit confused. First of all, the mantissa will be stored as three bytes for single precision and seven bytes for double precision. Here is how our normalized mantissa would be represented using the full three bytes of a single precision value:

```
.10010000 00000000 00000000
    90H      00H      00H
```

That's fairly obvious; however, this does not provide for a sign bit, which of course is needed. The solution is a very good one. First of all, as you recall, the bit immediately to the right of the binary point is always one. Therefore, there is no need to maintain that bit in memory. The bit can then be used as a sign bit, indicating a negative value when set (1) and a positive value when reset (0). Using this procedure, we maintain our original 24 data bits, while also providing for the sign! Thus the MSB would be changed from 10010000 to 00010000 when then bit 7 is used as the sign bit.

One more detail and we will be able to correctly show the representation of the decimal number 72.0 as it is kept in the TRS-80. One must note that the four bytes of the single precision value are stored:

```
LSB  LSB  MSB  EXP
```

Thus, the three mantissa bytes must be placed in reverse order, from the least significant to the most significant.

```
   LSB      LSB      MSB
00000000 00000000 00010000  (note high order
   00H      00H      10H     bit of 3rd byte
                             is sign bit, de-
                             noting a positive
                             value)
```

Now we have all the information. Here is the number as it would appear in memory:

```
   LSB      LSB      MSB      EXP
00000000 00000000 00010000 10000111
   00H      00H      10H      87H
```

Before we continue, a few more examples might prove useful to firm up our understanding of the way in which the TRS-80 handles single and double precision values.

First, we shall examine the number 73.75. This value when converted to binary would be:

73.75 = 01001001.11000000

Then, normalize this value.

$.100100111000000 \times 2^7$

Convert this value to hex, making the high order bit into a sign bit:

MSB	LSB	LSB	EXP
00010011	10000000	00000000	10000111
13H	80H	00H	87H

The last thing we must do is reverse the order of the bytes of the mantissa and we are done:

LSB	LSB	MSB	EXP
00H	80H	13H	87H

One more value, this one negative, should be done. For ease of explanation, let's use -73.75. In binary, we have:

-73.75 = -01001001.11000000

Placing this value, normalized in the same manner as is +73.75, into four bytes with the high order bit as the sign bit, one gets:

MSB	LSB	LSB	EXP
10010011	10000000	00000000	10000111
93H	80H	00H	87H

Reversing the order, one gets:

LSB	LSB	MSB	EXP
00H	80H	93H	87H

This corresponds the the format of this value of -73.75 in the TRS-80 tables.

Now that single precision values have been discussed fully, it is almost trivial to explain double precision representation. In fact, the only difference is that double precision values use seven bytes of mantissa instead of three, thus utilizing 56 data bits instead of the 24 used in single precision representation. Hence, double precision values are stored:

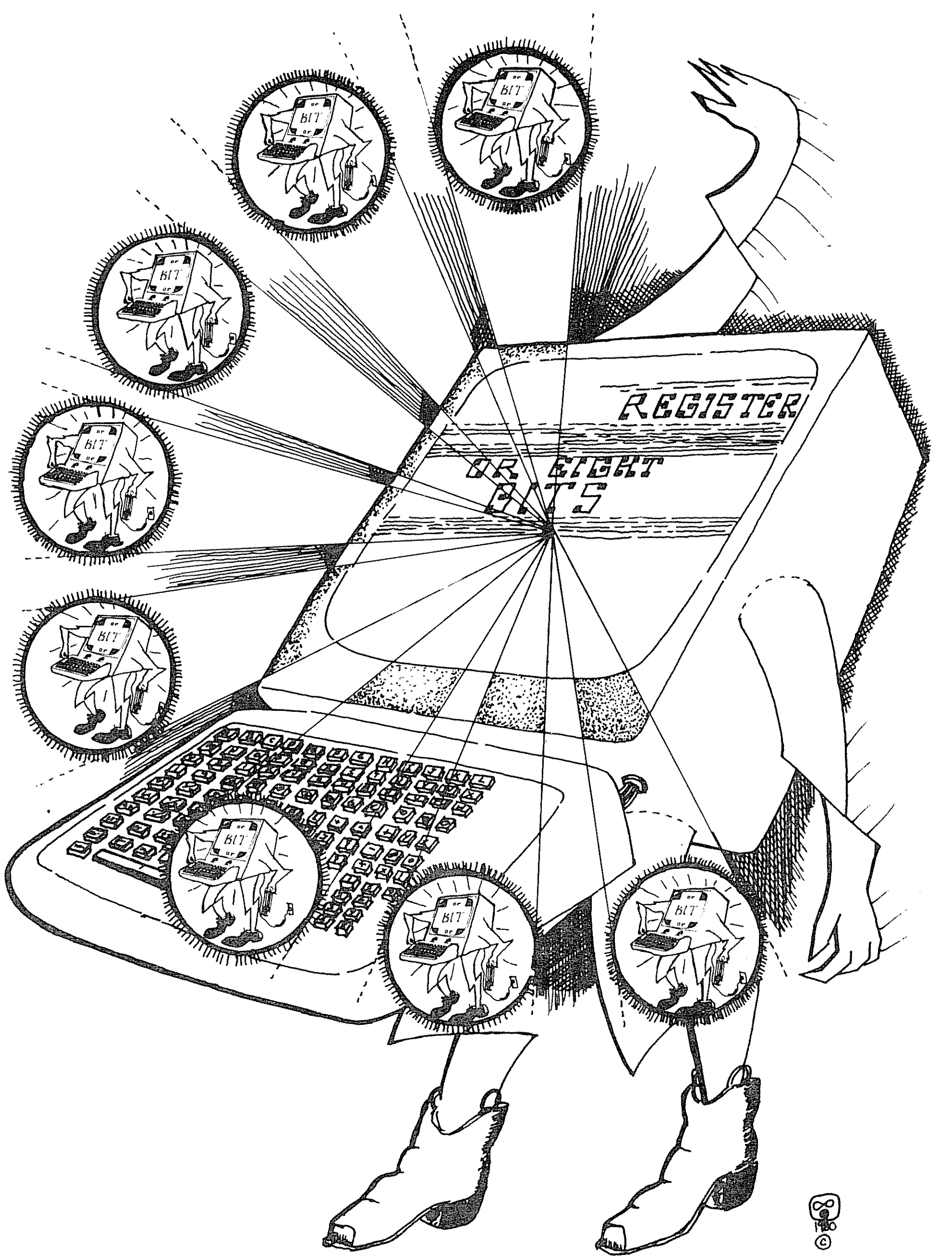
LSB LSB LSB LSB LSB LSB MSB EXP

As an example, we will use 73.75 again. Its double precision equivalent would be:

MSB	LSB	LSB	LSB	LSB	LSB	LSB	EXP
13H	80H	00H	00H	00H	00H	00H	87H

Stored in memory, it would be represented as:

LSB	LSB	LSB	LSB	LSB	LSB	MSB	EXP
00H	00H	00H	00H	00H	80H	13H	87H



MEMORY ACCUMULATORS

To manipulate the various types of data, TRS-80 BASIC utilizes several memory accumulators. In fact, almost all of the the mathematical functions utilize one or more of these areas. In the next sections of this volume, it is assumed that the terms that will be described in the next few pages will be fully understood by the user.

The accumulators that are used for mathematical manipulation are located in low RAM. The areas consist of eight bytes, although depending on the type of variable, not all of the eight bytes need to be utilized.

Each accumulator is organized in much the same format as an area used for the storage of a double precision variable. Let's take the most often utilized accumulator and use it as a model.

All of the memory accumulators are referred to as Floating Point Accumulators (FPA's), even though they are also used in conjunction with integer math. The first accumulator is named FPA1. It resides from 411DH to 4122H. Associated with this accumulator is a type flag (TYPFLG at 40AFH), which stores the type of variable currently present in the accumulator (remember, 8=double, 4=single, 2=integer). The format of this accumulator is as follows:

411DH	411EH	411FH	4120H	4121H	4122H	4123H	4124H
LSB	LSB	LSB	LSB	LSB	LSB	MSB	EXP
(DBL Only)	(DBL Only)	(DBL Only)	(DBL Only)	(SNG DBL)	(SNG DBL)	(SNG DBL)	

The above format holds true for single and double precision values. However, integers are in this format:

4121H	4122H
LSB	MSB

The next floating point accumulator is called FPA2. It is located at addresses 4127H - 412EH. Its type flag (TYPFL2) is stored at 40B0H. The manner in which the values are stored is as follows:

4127H	4128H	4129H	412AH	412BH	412CH	412DH	412EH
LSB	LSB	LSB	LSB	LSB	LSB	MSB	EXP
(DBL Only)	(DBL Only)	(DBL Only)	(DBL Only)	(SNG DBL)	(SNG DBL)	(SNG DBL)	

The last memory accumulator (FPA3) is located at addresses 414AH - 4151H. This accumulator is used by the single precision multiplication and double precision division routines. There is no need for direct user manipulation of this area, but the assembly language programmer should be aware of its use.

Remember that the majority of the math routines must be informed as to the type of data being manipulated. This can be accomplished by setting the type flags directly or through the use of the ROM calls that will be described in the next chapter. For further information on the type flag one can refer to:

<u>TRS-80 Level II User's Manual</u>, Ch. 8, pp. 8-9.

Another type of accumulator utilized by the Level II ROM is a Register Accumulator. Various routines, when dealing with single precision data values, use CPU registers B, C, D, and E to hold the 4-byte value and operate on it. The term "Register Floating Point Accumulator (RFPA)" will be used to refer to these registers collectively. They are utilized as follows:

Register E: Contains the Least Significant Byte of the mantissa of the Single Precision value.

Register D: Contains the next, more significant byte of the mantissa.

Register C: Contains the Most Significant Byte of the mantissa.

Register B: Contains the Exponent of the Single Precision Value to be manipulated.

Since the registers, when listed in the same order of significance as the value would be represented in memory, would be listed "EDCB," the RFPA may be referenced at times by this mnemonic.

As stated earlier, the majority of the math routines must be informed as to the type of data value being processed. Since the Floating Point Accumulators are used to hold integer, single precision, and double precision values, some method must be employed to specify the type currently contained in FPA1, the main accumulator. The codes for each type are as follows:

2 - Integer variable
3 - String variable
4 - Single Precision variable
8 - Double Precision variable

One of the above values must be stored in TYPFLG, the type flag for FPA1 located at 40AFH. The TYPFLG can be set to any non-string type through the use of one of the following calls:

```
SETINT   CALL   0A9DH      ;Set TYPFLG for Integer
SETSNG   CALL   0AEFH      ;Set TYPFLG for Single Prec.
SETDBL   CALL   0AECH      ;Set TYPFLG for Double Prec.
```

The type of the contents of FPA1 can easily be determined through the use of the routine at address 25D9H. The routine sets various flags (conditions the flag register, F) depending on the value of TYPFLG. This routine is the one that is ultimately executed through the use of the RST 32, which saves two bytes in a program. The following code sequence will determine the variable type and branch to the appropriate processing routine:

```
TSTTYP   RST    32          ;Test TYPFLG
         JP     Z,STRING    ;String Variable
         JP     M,INTGR     ;Integer Variable
         JP     PO,SNG      ;Single Precision Var.
         JP     NC,DBL      ;Double Precision Var.
```

(Note: to use RST 32, RAM addresses 4009H - 400BH must not have been changed from their original initilization. If there is a possibility that they will be, replace "RST 32" with "CALL 25D9H" in the above example.)

ERROR RECOVERY ROUTINE

One problem faced by those who have tried to interface with the ROM routines in the past is the fact that if an error occurs, any error, control is given to the BASIC interpreter, thousands of bytes away from the machine language program that was executing. For this reason, an error recovery routine had to be developed so that control would pass smoothly back to the calling routine for processing of the error.

Several conditions can cause an error in Level II when working with the math routines. One example is if the result of the addition, subtraction, multiplication, or division overflows the limits of the variable type. Errors can also occur when the RND function is called with a negative number as a parameter or with a number that exceeds the positive upper limit of an integer (32,767). Other problem areas include (but are by no means limited to): division by zero, undefined trigonometric call, type mis-matches, and other illegal function calls.

The following initialization routine should be placed at the beginning of the program, before any of the ROM routines are used:

```
TRAP    LD      HL,STACK      ;Point to program's STACK
        LD      (40E8H),HL    ;Replace Stack pointer in
                              ; error trap procedure.
        LD      HL,41A6H      ;Init trap vector
        LD      (HL),0C3H     ; to JP to Recovery rout.
        INC     HL
        LD      DE,RCVRY      ;Point to recovery rout.
        LD      (HL),E
        INC     HL
        LD      (HL),D
        LD      A,0C9H        ;Set-up RET in various
        LD      (41BEH),A     ; RAM vectors
        LD      (41C1H),A
        LD      (41D0H),A
        LD      (40F2H),A     ;This address <> zero!
        XOR     A             ;Clear A register
        LD      (409CH),A     ;This address = zero
```

The trap initialization routine is now complete. The following routine is executed when an error occurs in the ROM. It may be placed anywhere in the assembly language code.

```
RCVRY   LD      SP,STACK      ;Restore prog's stack
        LD      A,E           ;Pick-up Error number ptr
        SRA                   ;Divide error number by 2
        INC     A             ;Accumulator now contains
        .                     ; an error number which
        .                     ; matches on in Table B-1
        .                     ; of the Level II Manual
;Do error testing here...
```

DATA CONVERSION

In order to convert data values, it is necessary to initialize the addresses from 4080H - 408DH so that they contain the following values:

```
X'4080' = D6 00 6F 7C
X'4084' = DE 00 67 78
X'4088' = DE 00 47 3E
X'408C' = 00 C9
```

(This memory area is configured by the Level II initialization code and is used by the single precision division routine.)

The three-byte region at 4090H - 4092H must also be initialized if random number generation will be requested. The field contains the multiplicative mantissa constant used in the random number generator. The addresses are intialized as follows:

```
X'4090' = 40
X'4091' = E6
X'4092' = 4D
```

These intialization areas have been listed together since they can BOTH be set-up correctly through the execution of the following code:

```
INITRM   LD     DE,4080H      ;Point to RAM area
         LD     HL,18F7H      ;Point to data in ROM
         LD     BC,39         ;Bytes to move
         LDIR                 ;Initialize RAM
```

Data values in FPA1 can be converted from one TYPE to another, provided the resulting value does not overflow the requested type. The TYPFLG must have been previously set to the current type or the results will be unpredictable. This flag will be automatically revised upon completion of the conversion to the new type.

```
CINT     CALL   0A7FH         ;Convert FPA1 to Integer
CSNG     CALL   0AB1H         ;Convert FPA1 to Single
CDBL     CALL   0ADBH         ;Convert FPA1 to Double
```

These routines are general purpose, converting any type to the designated one. However, if the type is known, the routines below may be called to change the type. They provide slightly faster execution by skipping unneeded processing.

```
SNGINT   CALL   0ACCH         ;FPA1 from Integer to SNG
DBLSNG   CALL   0AB9H         ;FPA1 from DBL to SNG
SNGDBL   CALL   0AE3H         ;FPA1 from SNG to DBL
```

Also, if a value is stored at a different location in memory, it also can be converted by first setting TYPFLG and then calling the following routine:

```
         LD     HL,VALUE      ;Point HL to start of val.
HLSNG    CALL   0ACFH         ;Convert (HL) to SNG
```

** WARNING ** If the above routines are called with the type flag (TYPFLG) set for an string value (3), an error will result. If the error recovery routine has not been implemented, control will be given to the BASIC interpreter.

MOVING DATA

In order to effectively use the math routines, it will be necessary to shift data in and out of the accumulators, registers, and user buffer regions. The routines described in the following paragraphs should be used for this purpose.

The routine at 09A4H will move the single precision value from FPA1 to the stack. The routine pops the return address off the stack, pushes the value onto the stack, replaces the return address, then returns to the calling routine.

```
STKFP1   CALL   09A4H     ;Put SNG in FPA1 onto stack
```

The stacked value can be recovered into the RFPA through the following sequence:

```
POPRFP   POP    BC        ;Recover 4123H-4124H
         POP    DE        ;Recover 4121H-4122H
```

If the value in the RFPA is to be placed back into FPA1, call this routine:

```
SNGFPA   CALL   09B4H     ;RFPA into FPA1
```

The next routine copies four (4) bytes from the region pointed to by the register pair HL and moves it to FPA1. The first byte is placed at 4121H, the second at 4122H, the third at 4123H, and the fourth at 4124H (LSB, LSB, MSB, EXP).

```
HLFPA1   CALL   09B1H     ;(HL) placed into FPA1
```

To manipulate single precision values, the ROM at times will copy FPA1 into the RFPA. This routine performs this function:

```
LDFPA1   CALL   09BFH     ;Load RFPA from FPA1
```

To eliminate the need of first moving a value from a buffer to FPA1 and then loading it into the RFPA, a single routine may be called. The first byte is placed in E, the second in D, the third in C, and the fourth in B:

```
        LD      HL,BUFF     ;Load beginning of buffer
                            ; containing value.
LDFPHL  CALL    09C2H       ;(HL) to RFPA
```

Once a routine has been called, one may want to transfer the resulting value in FPA1 to a buffer so that another value can be manipulated. This is accomplished by this routine:

```
        LD      HL,BUFF     ;Load beginning of buffer
FPAMEM  CALL    09CBH       ;FPA1 moved to (HL)
```

The next two routines are used to transfer double and single precision values from one location to another. The number of bytes to be moved is based on the value of the TYPFLG (four or eight).

This routine transfers bytes from the buffer pointed to by HL to the one pointed to by DE.

```
MOVTDE  CALL    09D2H       ;Move (HL) to (DE)
```

The perform the exact opposite of the above call, access the routine to move from buffer DE to buffer HL.

```
MOVTHL  CALL    09D3H       ;Move (DE) to (HL)
```

The last routine transfers either four or eight bytes from FPA1 to FPA2. However, the bytes transfered will begin at address 4127H which will not place them in the correct position for single precision values, but the transfer is correct for double precision values. Again, the number of bytes to be transfered is based on TYPFLG.

```
FP1FP2  CALL    09FCH       ;Move (FPA1) to (FPA2)
```

NUMERIC I/O IN ASCII

Before discussing the interfaces to the actual math routines in the next chapter, the methods for inputting and outputting numerical data in ASCII must be listed.

ASCII TO BINARY

The first task one must face is converting an ASCII buffer to its binary representation. The ROM provides a single routine to handle all of the I/O of this type. Fortunately, it is a very flexible routine, allowing the conversion of a wide variety of strings. This routine should be used to read in ASCII numbers and convert them to their binary equivalent for processing by the various math routines. To access this routine, perform the following:

```
          LD      HL,BUFFER ;I/O Buffer
ASCBIN    CALL    0E65H     ;Convert ASCII to binary
                            ; Default type = DBL
```

The buffer should begin with the first character to be converted. All numeric specifications legal in BASIC are recognized here. Therefore, the buffer can begin with a plus (+) or minus (-) sign. The numeric part of the number can be integer or real (contain a decimal point). It can also have scientific notation. The value can be followed by a TYPE specification (% = integer, ! = single precision, # = double precision) which will force the converted value to take on the specified type.

The numeric value can also be followed by "E" for single precision scientific notation or "D" for double precision scientific notation, but DO NOT mix explicit type and exponent type.

If the data value overflows the type specified, it will automatically be converted up to the minimum type necessary to contain the data value. If no type is specified, it will default to double precision.

The last character in the buffer MUST be either a colon (:) or a hex zero (00) for proper conversion.

The binary result produced is placed in the floating point accumulator (FPA1) as follows:

a. Integer result stored in addresses 4121H (LSB) and 4122H (MSB). The TYPFLG at 40AFH will be set to X'02' denoting an integer.

b. Single precision result is stored in addresses 4121H containing the least significant byte through 4124H containing the exponent. TYPFLG will be set to X'04' denoting a single precision value.

c. Double precision result is placed in FPA1 in addresses 411DH containing the LSB through 4124H containing the exponent. TYPFLG will be set to X'08' denoting a double precision value.

Another manner to access the same conversion routine is provided which defaults to a integer value unless an overflow occurs.

```
        LD      HL,BUFFER ;Point to I/O buffer
                          ; value to convert
ASCINT  CALL    0E6CH     ;Convert, Default type=INT
```

BINARY TO ASCII

Outputting of binary data can take on two forms, formatted and unformatted. There exists three calling routines, one for each type of variable.

For each of the following routines, the data is placed unformatted in an I/O buffer beginning at 4130H. The last character in the buffer is followed by a hex zero (00) to mark the end.

For integers, use this code:

```
        LD      HL,VALUE  ;VALUE = Value to convert
SAVINT  CALL    0A9AH     ;Save integer to FPA1
BINASC  CALL    0FBDH     ;Convert to ASCII
```

For single precision, the following code is used:

```
        LD      HL,VPTR     ;Load address where value is
                            ;  stored.
SETSNG  CALL    0AEFH       ;Set TYPFLG to SNG
HLFPAE  CALL    09F7H       ;Value to FPA1
BINASC  CALL    0FBDH       ;Convert to ASCII
```

Double precision values are converted using this routine:

```
        LD      HL,VPTR     ;Load address of value
SETDBL  CALL    0AECH       ;Set TYPFLG to DBL
HLFPAE  CALL    09F7H       ;Value to FPA1
BINASC  CALL    0FBDH       ;Convert to ASCII
```

For formatted output, one can use the same code as above, but replace "CALL 0FBDH" in each one with the following:

```
FORMAT  LD      A,N         ;Load control codes
ASCUSG  CALL    0FBEH       ;Convert to formatted ASCII
                            ;  in 4030H buffer.
```

The value of "N" depends on the format desired:

a. Set bit 3 (X'08') to place a plus (+) sign as the first character in the buffer if a positive value.

b. Set bit 4 (X'10') to place a dollar sign ($) as the first character in the buffer.

c. Set bit 5 (X'20') to place an asterisk (*) as the first character in the buffer.

d. Set bit 6 (X'40') to place commas (,) at every third place of any assumed or explicit decimal point.

Any combination of the above is acceptable.

CHAPTER 3: ASSEMBLY INTERFACING

REGISTER UTILIZATION

Although some exceptions do exist, one should assume that ALL non-index registers will be used by the math routine calls. This includes registers AF, BC, DE, and HL. However, due to the fact that the BASIC part of the ROM was originally written in 8080 assembly language, the alternate registers are not used. Index register IX is only used by the I/O routines. Index register IY is not used at ANY time during execution of ROM code.

INTEGER MATH ROUTINES

As noted in the chapter on data formats, integers are represented in the TRS-80 as signed, sixteen bit values. These values are passed to the integer math routines in register pairs HL and DE. After performing the requested operation, the result is placed in the Floating Point Accumulator (FPA1) at addresses 4121H and 4122H (LSB/MSB). In addition, certain routines will place the result also in one of the register pairs. If this is the case, it will be specifically noted.

Addition of two signed integers is performed by loading one value into HL and the second into DE. The call is made to 0BD2H. The result is placed in FPA1, and if an overflow does not occur, it will also be placed in HL. After the return from the addition, the TYPFLG should be checked to determine whether an overflow has occured. The ADDINT routine updates the TYPFLG to two (2) if the result is an integer and four (4) if the result overflowed and had to be expressed as a single precision value.

```
        LD      HL,VAL1     ;First value to HL
        LD      DE,VAL2     ;Second Value to DE
ADDINT  CALL    0BD2H       ;(DE + HL) to FPA1
        RST     32          ;Check type
        JP      PO,OVRFL    ;If single prec., overflow
```

Subtraction of integers is performed in a similar manner. The values are placed in DE and HL, the call is made (this time to 0BC7H), the result of DE minus HL is returned in FPA1 and HL if no overflow, and the TYPFLG is adjusted automatically depending on the result.

```
        LD      HL,VAL1     ;First Value to HL
        LD      DE,VAL2     ;Second Value to DE
SUBINT  CALL    0BC7H       ;(DE - HL) to FPA1
        RST     32          ;Test overflow
        JP      PO,OVRFL    ;Jump if overflow
```

Multiplication is performed in the above manner also.

```
        LD      HL,VAL1     ;First Val. to Reg. HL
        LD      DE,VAL2     ;Second Val. to Reg. DE
MULINT  CALL    0BF2H       ;(DE * HL) to FPA1
        RST     32          ;Overflow?
        JP      PO,OVRFL    ;If SNG, overflow
```

Division of two integers is handled in a totally different fashion. Both values are first converted to single precision prior to performing the division. The result is always a single precision value in FPA1 with the TYPFLG set to four (4). If modular division is desired (true integer division), perform a call to the INT function following the call to 2490H.

```
        LD      HL,VAL1     ;Divisor to HL
        LD      DE,VAL2     ;Dividend to DE
DIVINT  CALL    2490H       ;(DE / HL) to FPA1
INT     CALL    0B37H       ;Take integer of (DE / HL)
                            ;  (Optional)
```

The last routine for integers is the comparison routine. Registers DE and HL are set-up in the same way. The call is then made to 0A39H. This routine returns a value in register A or -1, 0, or +1 depending on whether the contents of HL are less than, equal to, or greater than the contents of DE.

```
         LD      HL,VAL1    ;1st Value to Reg. HL
         LD      DE,VAL2    ;2nd Value to Reg. DE
CPRINT   CALL    0A39H      ;CP HL to DE
         JP      M,LESS     ;HL < DE
         JP      Z,EQUAL    ;HL = DE
         JP      P,PLUS     ;HL > DE
```

SINGLE PRECISION MATH ROUTINES

Single precision numbers require four bytes for storage as noted earlier in the Data Formats chapter. These values are passed to the single precision routines in the RFPA (registers BCDE) and FPA1. Several methods can be used to move the data to the RFPA and FPA1, many of which were presented in the chapter on data manipulation. In the following examples, only a few will be noted.

The result of the addition of two single precision values is placed in FPA1.

```
SETSNG   CALL    0AEFH      ;Set TYPFLG to SNG (4)
         LD      HL,BUF1    ;Point to 1st value
HLFPA1   CALL    09B1H      ;Move buffer to FPA1
         LD      HL,BUF2    ;Point to 2nd value
LDDPHL   CALL    09C2H      ;Load RFPA from buffer
ADDSNG   CALL    0716H      ;(RFPA + FPA1) to FPA1
```

The ROM has two dedicated routines for addition of single precision values. The first adds 0.5 to the contents of the FPA1. The other adds the four-byte value in the buffer pointed to by HL to the value in FPA1.

```
ADHALF   CALL    0708H      ;0.5 + FPA1 to FPA1

         LD      HL,BUFF1   ;Point to value
ADDHL    CALL    070BH      ;(HL) + FPA1 to FPA1
```

Subtraction of single precision values is handled by two routines. The first, like addition, utilizes the RFPA and FPA1. This call subtracts FPA1 from RFPA, placing the result in FPA1.

```
SETSNG   CALL   0AEFH      ;Set TYPFLG to SNG (4)
         LD     HL,BUF1    ;Point to 1st value
HLFPA1   CALL   09B1H      ;Move buffer to FPA1
         LD     HL,BUF2    ;Point to 2nd value
LDDPHL   CALL   09C2H      ;Load RFPA from buffer
SUBSNG   CALL   0713H      ;(RFPA - FPA1) to FPA1
```

An alternate method is to subtract the value pointed to by HL from FPA1. Linkage as follows:

```
         LD     HL,BUF1    ;Point to SNG Val. w/ HL
SUBHL    CALL   0710H      ;(HL) - FPA1 to FPA1
```

Single precision multiplication is performed using the same registers and accumulator as addition. A call is then made to 0847H.

```
SETSNG   CALL   0AEFH      ;Set TYPFLG to SNG (4)
         LD     HL,BUF1    ;Point to 1st value
HLFPA1   CALL   09B1H      ;Move buffer to FPA1
         LD     HL,BUF2    ;Point to 2nd value
LDDPHL   CALL   09C2H      ;Load RFPA from buffer
MULSNG   CALL   0847H      ;(RFPA * FPA1) to FPA1
```

Another routine multiplies the single precision value in FPA1 by ten (10), placing the result in FPA1.

```
MUL10    CALL   093EH      ;10.0 * FPA1 to FPA1
```

Single precision division divides the value in RFPA by the value in FPA1. Remember that the RAM area (4080H - 408DH) described in Chapter 2 MUST BE INITIALIZED BEFORE THE DIVISION ROUTINES ARE USED!

```
SETSNG   CALL   0AEFH      ;Set TYPFLG to SNG (4)
         LD     HL,BUF1    ;Point to 1st value
HLFPA1   CALL   09B1H      ;Move buffer to FPA1
CKRZMP   CALL   0955H      ;Check FPA1 for M,Z,P
         JP     Z,DIVZER   ;Divide by zero error
         LD     HL,BUF2    ;Point to 2nd value
```

```
LDDPHL   CALL   09C2H      ;Load RFPA from buffer
DIVSNG   CALL   08A2H      ;(RFPA / FPA1) to FPA1
```

The above routine tests the divisor for zero. If the test is not made, the divisor IS zero (remember Murphy's Law?!?), and the error trap has not been implemented, ...

```
?/0 ERROR
READY
>
```

An alternate linkage, assuming that the dividend is in FPA1, would be as follows:

```
SETSNG   CALL   0AEFH      ;Set TYPFLG to SNG (4)
STKFP1   CALL   09A4H      ;FPA1 (Dividend) to Stack
         LD     HL,BUF1    ;Point to 1st value
HLFPA1   CALL   09B1H      ;Move buffer to FPA1
CKRMZP   CALL   0955H      ;Check for -, 0, +
         JP     Z,DIVERR   ;Divide by zero error
POPFPA   CALL   08A0H      ;(STACK / FPA1) to FPA1
```

A divide by ten can be performed by loading FPA1 with the dividend and then issuing the following call:

```
DIV10    CALL   0897H      ;FPA1 / 10.0 to FPA1
```

To compare two single precision values, one in RFPA and the other in FPA1, use the following code:

```
SETSNG   CALL   0AEFH      ;Set TYPFLG to SNG (4)
         LD     HL,BUF1    ;Point to 1st value
HLFPA1   CALL   09B1H      ;Move buffer to FPA1
         LD     HL,BUF2    ;Point to 2nd value
LDDPHL   CALL   09C2H      ;Load RFPA from buffer
CPRSNG   CALL   0A0CH      ;CP FPA1 to RFPA
         JP     M,LESS     ;FPA1 < RFPA
         JP     Z,EQUAL    ;FPA1 = RFPA
         JP     P,MORE     ;FPA1 > RFPA
```

Also note that register A will contain -1, 0, or +1 depending on the outcome of the compare.

DOUBLE PRECISION MATH ROUTINES

The five operations--addition, subtraction, multiplication, division, and comparison--are performed using FPA1 (411DH - 4124H) and FPA2 (4127H - 412EH). If the operation requested results in a value that overflows the upper limit of a double precision variable (+1.701411834544556D+38), an overflow error will result. The calling program can recover by using the error recovery procedure outlined in chapter 2.

To add two double precision values, use:

```
SETDBL  CALL  0AECH     ;Set TYPFLG for DBL (8)
        LD    HL,BUF1   ;Point to first value
HLFPAE  CALL  09F7H     ;Move to FPA1
        LD    HL,BUF2   ;Point to 2nd value
        LD    DE,4127H  ;Point to FPA2
MOVTDE  CALL  09D2H     ;Move to FPA2
ADDDBL  CALL  0C77H     ;(FPA1 + FPA2) to FPA1
```

To subtract two double precision numbers, use:

```
SETDBL  CALL  0AECH     ;Set TYPFLG for DBL (8)
        LD    HL,BUF1   ;Point to first value
HLFPAE  CALL  09F7H     ;Move to FPA1
        LD    HL,BUF2   ;Point to 2nd value
        LD    DE,4127H  ;Point to FPA2
MOVTDE  CALL  09D2H     ;Move to FPA2
SUBDBL  CALL  0C70H     ;(FPA1 - FPA2) to FPA1
```

Multiplication of double precision numbers can be performed using:

```
SETDBL  CALL  0AECH     ;Set TYPFLG for DBL (8)
        LD    HL,BUF1   ;Point to first value
HLFPAE  CALL  09F7H     ;Move to FPA1
        LD    HL,BUF2   ;Point to 2nd value
        LD    DE,4127H  ;Point to FPA2
MOVTDE  CALL  09D2H     ;Move to FPA2
MULDBL  CALL  0DA1H     ;(FPA1 * FPA2) to FPA1
```

To divide FPA1 by FPA2, this linkage is employed (which includes error checking for a divisor of zero):

```
SETDBL   CALL   0AECH       ;Set TYPFLG for DBL (8)
         LD     HL,BUF1     ;Point to first value
HLFPAE   CALL   09F7H       ;Move to FPA1
         LD     HL,BUF2     ;Point to 2nd value
         LD     DE,4127H    ;Point to FPA2
MOVTDE   CALL   09D2H       ;Move to FPA2
         LD     A,(412EH)   ;Check FPA2 for zero
         OR     A           ;Set Z flag on zero
         JP     Z,DIVZER    ;Divide by zero error
DIVDBL   CALL   0DE5H       ;(FPA1 / FPA2) to FPA1
```

The comparison of two double precision values is performed as follows:

```
SETDBL   CALL   0AECH       ;Set TYPFLG for DBL (8)
         LD     HL,BUF1     ;Point to first value
HLFPAE   CALL   09F7H       ;Move to FPA1
         LD     HL,BUF2     ;Point to 2nd value
         LD     DE,4127H    ;Point to FPA2
MOVTDE   CALL   09D2H       ;Move to FPA2
CPRDBL   CALL   0A78H       ;Compare FPA1 to FPA2
         JP     M,LESS      ;FPA1 < FPA2
         JP     Z,EQUAL     ;FPA1 = FPA2
         JP     P,MORE      ;FPA1 > FPA2
```

INTERFACING TO FUNCTIONS

This section will discuss the methods of interfacing to the math functions (ABS, ATN, COS, EXP, FIX, INT, LOG, POWER, RND, SGN, SIN, SQR, TAN). It is important to note tht all of these functions, except ABS, FIX, INT, and RND, operate exclusively on single precision data. Therefore, in most cases, the floating point accumulator (FPA1) will be used to provide the argument to the function and will be the destination of the result. The POWER function is also an exception since it requires two arguments and also uses the RFPA as well as FPA1.

ABS(X) - Absolute Value Function

The ABS(X) function will return the absolute value of an integer, single precision, or double precision argument loaded into FPA1. The following linkages are used for ABS:

```
ABSINT   LD     HL,VALUE   ;Put integer value into HL
SAVINT   CALL   0A9AH      ;Place into FPA1
ABS      CALL   0977H      ;Take Absolute value.

ABSSNG   LD     HL,VALUE   ;Point to SNG value
HLFPA1   CALL   09B1H      ;Value to FPA1
SETSNG   CALL   0AEFH      ;TYPFLG set for SNG (4)
ABS      CALL   0977H      ;Take Absolute Value

ABSDBL   CALL   0AECH      ;Set TYPFLG for DBL (8)
         LD     HL,VALUE   ;Point to DBL Value
HLFPAE   CALL   09F7H      ;Value to FPA1
ABS      CALL   0977H      ;Take absolute Value
```

ATN(X) - Arctangent Function

Arctangent is a trigonometric function which requires a single precision argument loaded into FPA1. This argument is a number which represents the value of the TAN function at the specified angle, the exact value of which will be returned by the ATN function. (i.e., TAN(X)=Y, ATN(Y)=X).

```
         LD     HL,BUF1    ;Point to data value
HLFPA1   CALL   09B1H      ;Move to FPA1
SETSNG   CALL   0AEFH      ;TYPFLG to SNG (4)
ATN      CALL   15BDH      ;ATN(X) returned in FPA1
```

COS(X) - Cosine Function

COS is another trigonometric function that requires the argument to be a single precision number loaded into FPA1. The result is returned in FPA1. The cosine is computed by using the trig identity COS(X) = SIN(X+PI/2). The value "X+PI/2" is first computed, then its SIN is taken. The constant PI/2 is evaluated as 1.5708. Linkage to this function is as follows:

```
              LD      HL,BUF1     ;Point to data value
    HLFPA1    CALL    09B1H       ;Move to FPA1
    SETSNG    CALL    0AEFH       ;TYPFLG to SNG (4)
    COS       CALL    1541H       ;COS(X) returned in FPA1
```

EXP(X) - Exponential Function

The exponential function raises the value of "e" to the power, X. The argument, X, is a single precision value placed into FPA1. It is important to note that an overflow error can occur if the value of X is too large. Any value exceeding 87.3363 (126 divided by 1.4427 which is the Log base 2 of e) is too large and will result in overflow. Any value less than -88.7225 (-128 divided by 1.4427) will return a result of zero.

```
              LD      HL,BUF1     ;Point to data value
    HLFPA1    CALL    09B1H       ;Move to FPA1
    SETSNG    CALL    0AEFH       ;TYPFLG to SNG (4)
    EXP       CALL    1439H       ;EXP(X) returned in FPA1
```

FIX(X) - Truncation Function

The FIX function will truncate a data value (i.e., if Y=FIX(+2.76), Y=+2; if Y=FIX(-2.76), Y=-2). This function accepts arguments that are integer, single precision, or double precision; the TYPFLG indicates the type of argument. However, FIXing an integer performs no useful function.

```
    FIXINT    LD      HL,VALUE    ;Put integer value into HL
    SAVINT    CALL    0A9AH       ;Place into FPA1
    FIX       CALL    0B26H       ;FIX value.

    FIXSNG    LD      HL,VALUE    ;Point to SNG value
    HLFPA1    CALL    09B1H       ;Value to FPA1
    SETSNG    CALL    0AEFH       ;TYPFLG set for SNG (4)
    FIX       CALL    0B26H       ;FIX Value

    FIXDBL    CALL    0AECH       ;Set TYPFLG for DBL (8)
              LD      HL,VALUE    ;Point to DBL Value
    HLFPAE    CALL    09F7H       ;Value to FPA1
    FIX       CALL    0B26H       ;FIX Value
```

INT(X) - Greatest Integer Function

The INT function finds the greatest integer not exceeding the argument (i.e., if Y=INT(+2.76), Y=+2; if Y=INT(-2.76), Y=-3). All types of numeric types are accepted; TYPFLG should be set to the type to be INTed.

```
INTINT   LD     HL,VALUE   ;Put integer value into HL
SAVINT   CALL   0A9AH      ;Place into FPA1
INT      CALL   0B37H      ;INT value.

INTSNG   LD     HL,VALUE   ;Point to SNG value
HLFPA1   CALL   09B1H      ;Value to FPA1
SETSNG   CALL   0AEFH      ;TYPFLG set for SNG (4)
INT      CALL   0B37H      ;INT Value

INTDBL   CALL   0AECH      ;Set TYPFLG for DBL (8)
         LD     HL,VALUE   ;Point to DBL Value
HLFPAE   CALL   09F7H      ;Value to FPA1
INT      CALL   0B37H      ;INT Value
```

LOG(X) - Natural Logarithm Function

The LOG function returns the Log base e of the argument passed in FPA1. LOG cannot be used on negative values. The following interface, with error-checking, performs the LOG function:

```
         LD     HL,VAL1    ;Point to data value
HLFPA1   CALL   09B1H      ;Move value to FPA1
SETSNG   CALL   0AEFH      ;Set TYPFLG for SNG (4)
CKRMZP   CALL   0955H      ;Check for -, 0, +
         CALL   M,ERROR    ;Branch if Negative
LOG      CALL   0809H      ;Take LOG
         .
         .
         .
ERROR    CALL   0977H      ;Take ABS(FPA1)
         LD     HL,ERRMSG  ;Point to error msg
MSGOUT   CALL   2B75H      ;Output error msg to CRT
         RET               ;Return to take LOG(ABS(X))
ERRMSG   DEFM   'LOG Error - Negative Argument'
         NOP               ;End of Msg delimeter
```

The algorithm used to calculate the LOG is as follows:

```
LET      M = Mantissa(X)
         C = SQRT(2)/2
         R = Exponent(X)
        C1 =  .598979
        C2 =  .961471
        C3 = 2.88539
        C4 =  .693147

         M = (M-C)/(M+C)
         K = M * M
    LOG(X) = (((C1*K+C2)*K+C3)*M+R-0.5)*C4
```

POWER - Raise X to the power of Y

This routine is accessed from BASIC using the up-arrow key. The value of X must be a single precision value loaded onto the STACK. The value of Y can be of type single, double, or integer and is placed in FPA1. The TYPFLG is set according to the value of Y. Linkage reflecting a single precision Y is as follows:

```
         LD      HL,RETADR ;Set return address
         PUSH    HL        ;Ret addr. to top of stack
         LD      HL,BUFX   ;Point to X
HLFPA1   CALL    09B1H     ;Move to FPA1
STKFP1   CALL    09A4H     ;Place on Stack
SETSNG   CALL    0AEFH     ;Set TYPFLG to SNG (4)
         LD      HL,BUFX   ;Point to X
TOFPA1   CALL    09B1H     ;Move to FPA1
         JP      13F2H     ;Take X power Y
```

As can be noted from the above linkage, entry is made to the POWER routine via a JUMP instruction with a return address pushed onto the stack as the first operation. This must occur in this fashion since the data value X must be at the top of the stack upon entry to the POWER routine.

X POWER Y is computed by setting EXP(Z) = X POWER Y then solving for Z from Z = Y * LOG(X). The EXP function then uses Z as its argument to calculate EXP(Z), the answer.

RND(X) - Random Number Generation Function

The RND function provides for the generation of a random number as its result. Depending on the value of X, it will return either a single precision value in the range zero through one (0.0 to 1.0 when X=0), or an integer value between one (1) and the value of X (which must be between one and 32,767 or an error will result).

The RND routine uses RAM memory at addresses 4090H to 4092H which must be initialized to X'40 E6 4D', which can be accomplished by using the initialization routine described in Chapter 2. Addresses 40AAH to 40ACH are used as part of the "seed" value. After initialization, do not disturb these areas!

The random number generated can be "randomized" through a call to the RANDOM command:

```
RANDOM    CALL    01D3H       ;Randomize seed
```

The RANDOM routine sets a single byte in the "seed" field from the Z80 refresh register (LD A,R). This call only modifies the contents of reg. A.

The following code will return, in FPA1, a single precision random number between zero and one:

```
SETSNG    CALL    0AEFH       ;Set TYPFLG to SNG (4)
ZERFPA    CALL    0778H       ;Zero FPA1
RND       CALL    14C9H       ;Generate random number
```

This linkage will return an integer random number between one and the integer value passed to the RND routine in FPA1:

```
          LD      HL,MAXVAL ;Generate number between one
                            ;  and MAXVAL
SAVINT    CALL    0A9AH     ;Save in FPA1. TYPFLG=INT
RND       CALL    14C9H     ;Generate random number
CINT      CALL    0A7FH     ;Convert to integer
```

SGN(X) - Determine Sign of Argument

The SGN function determines the algebraic sign of integer, single or double precision arguments. The argument is loaded into FPA1. Depending on whether the argument is negative, zero or positive, the result is a value of -1, 0, or +1 expressed as an integer value in FPA1 (4121H - 4122H). The TYPFLG is automatically set to 2 to indicate an integer value. Be aware that the value one loads into FPA1 will be overwritten by the result. Linkage to the SGN routine for each argument type is as follows:

```
SGNINT    LD      HL,VALUE  ;Put integer value into HL
SAVINT    CALL    0A9AH     ;Place into FPA1
SGN       CALL    098AH     ;Return Sign of Value

SGNSNG    LD      HL,VALUE  ;Point to SNG value
HLFPA1    CALL    09B1H     ;Value to FPA1
SETSNG    CALL    0AEFH     ;TYPFLG set for SNG (4)
SGN       CALL    098AH     ;Return Sign of Value

SGNDBL    CALL    0AECH     ;Set TYPFLG for DBL (8)
          LD      HL,VALUE  ;Point to DBL Value
HLFPAE    CALL    09F7H     ;Value to FPA1
SGN       CALL    098AH     ;Return Sign of Value
```

SIN(X) - Sine Function

SIN is a trigonometric function which requires a single precision argument placed in FPA1. The resultant sine is returned in FPA1.

```
         LD     HL,BUF1    ;Point to data value
HLFPA1   CALL   09B1H      ;Move to FPA1
SETSNG   CALL   0AEFH      ;TYPFLG to SNG (4)
SIN      CALL   1547H      ;SIN(X) returned in FPA1
```

SQR(X) - Square Root Function

The SQR function takes the square root of a positive single precision value located in FPA1. An error will occur if it is called with a negative value in the floating point accumulator. For this reason, the following linkage takes the absolute value of any negative numbers before making the call.

```
         LD     HL,BUF1    ;Point to data value
HLFPA1   CALL   09B1H      ;Move to FPA1
SETSNG   CALL   0AEFH      ;TYPFLG to SNG (4)
CKRMZP   CALL   0955H      ;Check FPA1 for -, 0, +
ABS      CALL   M,0977H    ;Take ABS(-X)
SQR      CALL   13E7H      ;SQR(X) returned in FPA1
```

TAN(X) - Tangent Function

The TAN function also requires a single precision value in FPA1 as its argument. The resultant is placed in FPA1. The tangent is computed using the trig identity "TAN(X) = SIN(X) / COS(X)." The linakge for TAN is as follows:

```
         LD     HL,BUF1    ;Point to data value
HLFPA1   CALL   09B1H      ;Move to FPA1
SETSNG   CALL   0AEFH      ;TYPFLG to SNG (4)
TAN      CALL   15ABH      ;TAN(X) returned in FPA1
```


SIN COS ATN
SIGN

CHAPTER 4: DISASSEMBLY OF ROM MATH ROUTINES

In this chapter, one will find a commented disassembly of the Level II BASIC ROM mathematics routines. However, a few important points must be made.

First of all, the ROM code is the property of Microsoft and is protected by their copyright. For this reason, it is impossible to provide a complete disassembly of their code without violating their rights. For this reason, the publisher decided to provide the hex address of the instruction, the operator, and the comments. The hex object code and the operands are omitted.

If the reader is an owner of a TRS-80, he is then able to procure the full disassembly by using a machine language disassembler or the BASIC language disassembler provided in Appendix C. Space has been provided so that the operands can be written in next to the operators to provide a commented listing that can be used for reference.

Secondly, since a full interfacing guide is provided in the first three chapters, it is unnecessary to refer to this listing in order to interface with the routines. Nevertheless, this chapter has been provided for those that may be curious as to the manner in which the ROM operates.

```
        ;*****
        ;SINGLE PRECISION ADDITION & SUBTRACTION
        ;       0708 -> 0.5  + FPA1 -> FPA1
        ;       070B -> (HL) + FPA1 -> FPA1
        ;       0710 -> (HL) - FPA1 -> FPA1
        ;       0713 -> RFPA - FPA1 -> FPA1
        ;       0716 -> RFPA + FPA1 -> FPA1
        ;*****
0708    LDHALF  LD              ;LOAD RFPA WITH 0.5
070B    Z070B   CALL            ;LOAD REAL VALUE AT (HL) INTO FPA1
070E            JR
0710    Z0710   CALL            ;LOAD RFPA WITH (HL)
0713    SUBSNG  CALL            ;MAKE FPA1 NEGATIVE
0716    ADDSNG  LD              ;TEST RFPA FOR ZERO (VAR2)
0717            OR              ;& RETURN IF SO
0718            RET
0719            LD              ;IF FPA1 (VAR1) IS ZERO,
071C            OR              ;PUT VAR2 -> FPA1 & EXIT
071D            JP
0720            SUB
0721            JR              ;JUMP IF VAR1 > VAR2
0723            CPL             ;CVRT EXP DIFF TO +
0724            INC
        ;*****
        ;EXCHANGE VAR1 IN FPA1 WITH VAR2 IN RFPA
        ;*****
0725            EX              ;PLACE VAR1 ON STACK
0726            CALL            ;PUT REAL ONTO STACK
0729            EX
072A            CALL            ;RFPA (VAR2) -> FPA1
072D            POP             ;RECOVER VAR1 IN RFPA
072E            POP
        ;*****
        ;IF DIFF IN EXP > 10**7, DON'T BOTHER TO ADD
        ;*****
072F    Z072F   CP              ;2**25 APPX 10**7
0731            RET             ;RET WITH FPA1 = LARGER VAL
0732            PUSH
0733            CALL            ;TURN ON SIGN BITS
0736            LD
0737            POP
0738            CALL            ;DIVIDE VAR1 MANTISSA BY THE
                                ;DIFFERENCE IN EXPONENTS
073B            OR              ;TEST RESULT OF SIGNS
073C            LD
073F            JP              ;JUMP IF SIGN BITS WERE .NE.
0742            CALL            ;ADD MANTISSA (HL) TO EDC
0745            JP              ;INC EXPON IF ADD OVERFLOWED
0748            INC             ;PT TO EXPONENT & ADD 1 DUE
0749            INC             ;TO CARRY ON MANTISSA ADD
```

```
074A         JP           ;OVERFLOW ERROR
074D         LD           ;INIT ROTATE LOOP TO 1 TO
074F         CALL         ;DIV MANTISSA BY 2 FOR
0752         JR           ;EXPONENT INCREASE
     ;*****
     ; SUBTRACT ONE NBR FROM ANOTHER WHEN 'SIGNS' WERE DIFFERENT
     ;*****
0754  Z0754  XOR          ;COMPLEMENT EXPON IN RFPA
0755         SUB          ;AND SET THE CARRY FLAG
0756         LD
     ;*****
     ;SUBTRACT MANTISSA IN RFPA FROM MANTISSA IN FPA1
     ;*****
0757         LD           ;SUB LOW BYTE
0758         SBC
0759         LD
075A         INC          ;PT TO 4122
075B         LD           ;SUB MID BYTE
075C         SBC
075D         LD
075E         INC          ;PT TO 4123
075F         LD           ;SUB HIGH BYTE
0760         SBC
0761         LD
0762  Z0762  CALL         ;TWOS COMPLEMENT THE RFPA
     ;*****
     ;       SNGL PREC NORMALIZATION ROUTINE
     ;*****
0765  NRMLZS LD           ;XFER EXPON & LOW BYTE SINCE
0766         LD           ;NEED THE REGS B & E
0767         XOR          ;SET SHIFT COUNTER TO ZERO
0768  SSHFT8 LD           ;SET SHIFT COUNTER FROM ACCUMULATOR
0769         LD           ;IF HIGH BYTE IS 0
076A         OR           ;SHIFT LEFT 8 BITS
076B         JR
076D         LD           ;LEFT SHIFT THE MANTISSA 8 BITS
076E         LD           ;BY JUGGLING THE REGISTERS
076F         LD
0770         LD
0771         LD           ;P/U THE COUNTER & COUNT DOWN 8
0772         SUB
0774         CP           ;IF MANTISSA WAS NOT SHIFTED
0776         JR           ;OUT OF RFPA, THEN CYCLE
     ;*****
     ; MANTISSA WAS ALL ZEROES, ZERO THE RESULT
     ;*****
0778  ZERFPA XOR          ;ZERO FPA1
0779  Z0779  LD
077C         RET
     ;*****
```

```
       ; CONTINUE TO NORMALIZE WITH SINGLE BIT SHIFTS
       ;*****
077D   SSHFT1  DEC            ;REDUCE THE SHIFT COUNTER
077E           ADD            ;MUL 'E' & 'B' BY 2 (HL SAVED B&E)
077F           LD             ;SHIFT MID BYTE (MUL BY 2)
0780           RLA
0781           LD
0782           LD             ;SHIFT HIGH BYTE (MUL BY 2)
0783           ADC
0784           LD
0785   SCHKP   JP             ;HAS 1 SHIFTED INTO SIGN?
       ;*****
       ; A 1 HAS SHIFTED INTO THE SIGN POSITION, CLEANUP THE NUM
       ;*****
0788           LD             ;P/U THE SHIFT COUNTER
0789           LD             ;SET THE LOW BYTE
078A           LD             ;P/U THE EXPON MODIFIED
078B   Z078B   OR             ;SEE IF ANY SHIFTING HAD OCCURRED
078C           JR             ;I.E. WAS IT ALREADY NORMALIZED?
       ;*****
       ; NUMBER HAD TO BE SHIFTED TO BE NORMALIZED. CORRECT THE EXPON
       ;*****
078E           LD             ;ADD THE SHIFT COUNTER (WHICH
0791           ADD            ;IS A NEGATIVE VALUE) TO
0792           LD             ;FPA1'S EXPONENT
0793           JR             ;ZERO FPA1 IF SHIFT < EXPON
0795           RET            ;RET WITH ZERO IF SHIFT = EXPON
       ;*****
       ; SHIFT WAS GREATER THAN EXPONENT, CONTINUE
       ;*****
0796   Z0796   LD             ;P/U THE RESULT EXPONENT
0797   Z0797   LD
079A           OR             ;IS BIT 7 SET?
079B           CALL           ;INC RFPA BY 1 IF IT IS!
079E           LD             ;P/U  THE FPA1 EXPON -> B
079F           INC            ;THEN PT TO 4125 FOR 'SIGN'
07A0           LD             ;P/U THE PROCESSED SIGN BITS
07A1           AND            ;& STRIP OFF ALL BUT THE SIGN BIT
       ;*****
       ; REPLACE THE SIGN POSITION IN RFPA (WHICH IS ALWAYS A 1
       ;AFTER NORMALIZATION) WITH THE CORRECT SIGN
       ;*****
07A3           XOR            ;PUTCORRECT SIGN INTO RFPA
07A4           LD
07A5           JP             ;REPLFPA1 WITH ADD/SUB RESULT
       ;*****
       ; INCREASE THE RFPA BY 1
       ;*****
07A8   Z07A8   INC            ;INC LOW BYTE
07A9           RET
```

```
07AA          INC          ;INC MID BYTE IF 'CARRY'
07AB          RET
07AC          INC          ;INC HIGH BYTE IF 'CARRY'
07AD          RET
07AE          LD           ;PUT THE 1 BACK INTO THE 'SIGN' BIT
07B0          INC          ;& INC THE EXPONENT
07B1          RET
07B2   OVERR  LD           ;OVERFLOW ERROR
07B4          JP
       ;*****
       ; ADD MANTISSA POINTED TO BY HL TO MANTISSA IN REGS EDC
       ;*****
07B7   Z07B7  LD           ;ADD LOW BYTE
07B8          ADD
07B9          LD
07BA          INC          ;PT TO MID BYTE AND ADD
07BB          LD
07BC          ADC
07BD          LD
07BE          INC          ;PT TO HIGH BYTE AND ADD
07BF          LD
07C0          ADC
07C1          LD
07C2          RET
       ;*****
       ; TWO'S COMPLEMENT OF RFPA
       ;*****
07C3   S2SCMP LD           ;INVERT THE 'SIGN' BIT RESULT
07C6          LD
07C7          CPL
07C8          LD
07C9          XOR          ;SET L TO ZERO
07CA          LD
07CB          SUB          ;COMP 'B' & SET C-FLAG
07CC          LD
07CD          LD           ;ZERO ACCUM
07CE          SBC          ;COMP LOW BYTE
07CF          LD
07D0          LD           ;ZERO ACCUM
07D1          SBC          ;COMP MID BYTE
07D2          LD
07D3          LD           ;ZERO ACCUM
07D4          SBC          ;COMP HIGH BYTE
07D5          LD
07D6          RET
       ;*****
       ; PERFORM A RIGHT CIRCULAR SHIFT OF A MANTISSA
       ; BASED ON THE VALUE IN REG A
       ;*****
07D7   SSHTR  LD           ;INIT B TO ZERO
```

```
07D9  SSHTR8  SUB               ;TEST FOR 8 OR MORE BITS
07DB          JR                ;JUMP IF SHIFT < 8
07DD          LD                ;JUGGLE THE REGS
07DE          LD
07DF          LD
07E0          LD
07E2          JR
07E4  Z07E4   ADD               ;ADD BACK THE 8 + 1 MORE
07E6          LD                ;INIT THE SHIFT COUNTER
07E7  SSHTR1  XOR               ;ZERO A & REDUCE COUNTER
07E8          DEC
07E9          RET               ;FINISHED WHEN CTR RUNS OUT
07EA          LD                ;SHIFT HIGH BYTE
07EB  Z07EB   RRA
07EC          LD
07ED          LD                ;SHIFT MID BYTE
07EE          RRA
07EF          LD
07F0          LD                ;SHIFT LOW BYTE
07F1          RRA
07F2          LD
07F3          LD                ;SHIFT EXPONENT
07F4          RRA
07F5          LD
07F6          JR
      ;*****
      ;LOG ROUTINE DATA VALUES
      ;*****
07F8  Z07F8   DEFW    0         ;REAL 1.0
07FA          DEFW    810
07FC  Z07FC   DEFB    3         ;3 LOG CONSTANTS FOLLOW
07FD          DEFW    56AAH     ;0.598979
07FF          DEFW    8019H
0801          DEFW    22F1H     ;0.961471
0803          DEFW    8076H
0805          DEFW    0AA56H    ;2.88539
0807          DEFW    8238H
      ;*****
      ;PROCESS LOG(X)
      ;       ALGORITHM AS FOLLOWS:
      ;LET M = MANTISSA(X) : C=SQRT(2)/2 : R = EXPONENT(X)
      ;    M = (M-C)/(M+C) : K = M * M
      ;    LOG(X) = (((C1*K+C2)*K+C3)*M+R-0.5)*C4
      ;    C1=.598979 C2=.961471 C3=2.88539 C4=.693147
      ;*****
0809  LOG     CALL              ;CHECK MINUS,ZERO,PLUS
080C          OR                ;ILLEGAL FUNCTION CALL
080D          JP                ;IF NEG ARGUMENT
0810          LD                ;PLACE FPA1 EXPONENT -> A
0813          LD
```

```
0814          LD        ;0.707107 (SQRT(2)/2)
0817          LD
081A          SUB       ;SUB OFF X'80' FROM EXP
081B          PUSH      ;& SAVE RESULT
081C          LD        ;PLACE X'80' AS NEW EXPONENT
081D          PUSH      ;SAVE SQRT(2)/2
081E          PUSH
081F          CALL      ;ADD SINGLE PRECISION
0822          POP       ;RECOVER SQRT(2)/2
0823          POP
0824          INC       ;& MULTIPLY BY 2
0825          CALL      ;RFPA/FPA1
0828          LD        ;SUBTRACT FPA1 FROM 1.0
082B          CALL
082E          LD        ;POINT TO TABLE VALUES
0831          CALL      ;& PROCESS THE SERIES
0834          LD        ;-0.5
0837          LD
083A          CALL      ;SUBTRACT 0.5
083D          POP       ;RECOVER EXPONENT EXCESS
083E          CALL
0841  Z0841   LD        ;0.693147 = LOG(2)
0844          LD
      ;*****
      ;MULTIPLICATION, SINGLE PRECISION
      ;*****
0847  MULSNG  CALL      ;IMMEDEDIATE RET IF VARIABLE = 0
084A          RET
084B          LD
084D          CALL      ;ADD BOTH EXPONENTS
0850          LD        ;STORE BYTE WITH THE SIGN BIT
0851          LD
0854          EX        ;SAVE TWO LOW ORDER BYTES
0855          LD        ;OF THE MANTISSA
0858          LD        ;ZERO RFPA
085B          LD
085C          LD
085D          LD        ;INIT RETURN TO NORMALIZE
0860          PUSH
0861          LD        ;INIT RET TWICE FOR
0864          PUSH      ;2ND & 3RD BYTES
0865          PUSH
0866          LD        ;PT TO LOW ORDER BYTE
0869  Z0869   LD        ;P/U BYTE FROM FPA1
086A          INC       ;& PT TO NEXT BYTE
086B          OR
086C          JR        ;JUMP IF BYTE IS ALL ZERO
086E          PUSH      ;SAVE PTR TO FPA1 BYTE
086F          LD        ;INIT FOR 8 BITS
0871  Z0871   RRA       ;PASS BIT TO CARRY FLAG
```

```
0872            LD              ;SAVE TEST BYTE
0873            LD              ;PUT HIGH ORDER BYTE -> A
0874            JR              ;BYPASS ADD IF TEST BYTE BIT=0
0876            PUSH            ;SAVE TEST BYTE
0877            LD              ;P/U 2 LOW ORDER BYTES
087A            ADD             ;ADD MANTISSA (RFPA)
087B            EX
087C            POP             ;RESTORE TEST BYTE
087D            LD              ;ADD IN THE HIGH ORDER BYTE
0880            ADC
0881    Z0881   RRA             ;ROTATE RFPA RIGHT BY 1 BIT
0882            LD
0883            LD
0884            RRA
0885            LD
0886            LD
0887            RRA
0888            LD
0889            LD
088A            RRA
088B            LD
088C            DEC             ;DECREMENT THE BIT COUNTER
088D            LD              ;XFR TEST BYTE
088E            JR              ;LOOP IF ANOTHER BIT TO DO
0890    Z0890   POP             ;RESTORE THE FPA1 BYTE PTR
0891            RET             ;RET TO ANOTHER BYTE OR
                                ;NORMALIZE RESULT
0892    Z0892   LD              ;SHUFFLE 8 BITS RIGHT
0893            LD
0894            LD
0895            LD
0896            RET
        ;*****
        ;DIVISION, SINGLE PRECISION
        ;       0897 -> FPA1 / 10.0         -> FPA1
        ;       08A0 -> STACK VALUE / FPA1  -> FPA1
        ;       08A2 -> RFPA / FPA1         -> FPA1
        ;*****
0897    Z0897   CALL            ;FPA1 TO STACK
089A            LD              ;10.0 TO FPA1
089D            CALL
08A0    Z08A0   POP             ;RECOVER ORIG FPA1 INTO RFPA
08A1            POP
08A2    DIVSNG  CALL            ;DIV BY ZER ERROR IF
08A5            JP              ;DIVISOR IS 0.0
08A8            LD              ;INIT TO SUB EXPONENTS
08AA            CALL            ;THEN DO IT
08AD            INC             ;BUILD VALUES INTO
08AE            INC             ;RAM ROUTINE 4080-408D
08AF            DEC             ;PT TO LOW ORDER DIVISOR
```

```
08B0          LD                   ;BYTE, PICK IT UP & STUFF
08B1          LD                   ;INTO RAM ROUTINE
08B4          DEC                  ;PT TO MIDDLE DIVISOR
08B5          LD                   ;BYTE, PICK IT UP & STUFF
08B6          LD                   ;INTO RAM ROUTINE
08B9          DEC                  ;PT TO HIGH ORDER DIVISOR
08BA          LD                   ;BYTE, PICK IT UP & STUFF
08BB          LD                   ;INTO RAM ROUTINE
08BE          LD                   ;PLACE DIVIDEND MANTISSA
08BF          EX                   ;INTO REGS B,H,& L
08C0          XOR                  ;CLEAR THE RFPA MANTISSA
08C1          LD
08C2          LD
08C3          LD
08C4          LD                   ;CLEAR "TEST" BYTE
08C7   Z08C7  PUSH                 ;SAVE DIVIDEND
08C8          PUSH
08C9          LD                   ;P/U DIVIDEND HIGH ORDER
08CA          CALL                 ;RAM ROUTINE BUILT ABOVE
       ;*****
       ;      RAM ROUTINE AS FOLLOWS
       ;      4080H   SUB     N        ;SUB HIGH ORDER DIVISOR
       ;              LD      L,A
       ;              LD      A,H      ;P/U DIVIDEND MID ORDER
       ;      4084H   SBC     A,N      ;SUB MID ORDER DIVISOR
       ;              LD      H,A
       ;              LD      A,B      ;P/U DIVIDEND LOW ORDER
       ;      4088H   SBC     A,N      ;SUB LOW ORDER DIVISOR
       ;              LD      B,A
       ;      408BH   LD      A,N      ;SET TO TEST OVERFLOW
       ;              RET
       ;*****
       ;      SUBTRACT 0 FROM TEST BYTE IF HIGH ORDER DID NOT CARRY
       ;               1 FROM TEST BYTE IF HIGH ORDER DID CARRY
       ;      THEN SWITCH CARRY FLAG FROM THIS SUBTRACT
       ;*****
08CD          SBC
08CF          CCF                  ;SWITCH RESULT OF CARRY
08D0          JR                   ;BYPASS IF ORIGINALLY CARRIED
08D2          LD                   ;RESET "TEST" VALUE
08D5          POP                  ;POP OFF DIVIDEND
08D6          POP                  ;AND IGNORE IT
08D7          SCF                  ;RESET THE CARRY FLAG
08D8          DEFB    0D2H         ;HIDE NEXT 2 INST WITH 'JP NC'
08D9   Z08D9  POP                  ;POP DIVIDEND INTO B, H, & L
08DA          POP
08DB          LD                   ;TEST FOR C HAVING BIT 7
08DC          INC                  ;SET (I.E. SHOWS UP AS A
08DD          DEC                  ;NEGATIVE VALUE)
08DE          RRA                  ;P/U CARRY FLAG INTO BIT 7
```

```
        ;*****
        ;        EXIT THIS PROCEDURE WHEN REG "C" OF RFPA
        ;        HAS HAD A ONE SHIFTED INTO ITS BIT 7
        ;*****
08DF             JP                  ;JUMP IF "C" HAD BIT 7 SET
08E2             RLA                 ;ELSE RESTORE STATE OF CARRY
08E3             LD                  ;NOW SHIFT THE REGISTER
08E4             RLA                 ;FLOATING POINT ACCUMULATOR
08E5             LD                  ;ONE BIT LEFT
08E6             LD                  ;IF CARRY WAS SET FROM
08E7             RLA                 ;08D7H, A BIT IS SHIFTED
08E8             LD                  ;INTO THE RFPA
08E9             LD
08EA             RLA
08EB             LD
08EC             ADD                 ;SHIFT DIVIDEND (B, H, L)
08ED             LD                  ;ONE BIT LEFT
08EE             RLA
08EF             LD
08F0             LD                  ;SHIFT "TEST" VALUE
08F3             RLA                 ;ONE BIT LEFT
08F4             LD
08F7             LD                  ;RECYCLE UNTIL RFPA IS
08F8             OR                  ;COMPLETELY VOIDED
08F9             OR
08FA             JR
08FC             PUSH
08FD             LD                  ;DEC RESULT EXPONENT SINCE
0900             DEC                 ;DIVISOR WAS > DIVIDEND
0901             POP
0902             JR                  ;RECYCLE IF NOT ZEROED
0904             JP                  ;ELSE OVERFLOW ERROR
        ;*****
        ;ROUTINE TO PERFORM EXPONENT ADDITION OR SUBTRACTION
        ;*****
0907    Z0907    LD                  ;INIT FOR SUBTRACTION
0909             DEFB     2EH        ;HIDE NEXT INST WITH 'LD L'
090A    Z090A    XOR                 ;INIT FOR ADDITION
090B             LD
090E             LD
090F             INC
0910             XOR
0911             LD
0912             LD
0914    Z0914    LD                  ;TEST EXPONENT FOR ZERO
0915             OR
0916             JR
0918             LD                  ;L HAS 'FF' FROM DIV; '00' FROM MUL
0919             LD
091C             XOR
```

```
091D          ADD
091E          LD
091F          RRA                 ;BRING CARRY INTO BIT 7
0920          XOR
0921          LD                  ;P/U THE NEW EXPONENT
0922          JP
0925          ADD
0927          LD
0928          JP                  ;-> POP HL, RET
092B          CALL                ;SWITCH SIGN BIT
092E          LD
092F  Z092F   DEC
0930          RET
0931  Z0931   CALL
0934          CPL
0935          POP
0936  Z0936   OR
0937  Z0937   POP
0938          JP                  ;ZERO FPA1
093B          JP
      ;*****
      ;MULTIPLY FPA1 BY 10.0
      ;*****
093E  Z093E   CALL                ;FPA1 -> RFPA
0941          LD                  ;RET IF VALUE = 0.0
0942          OR
0943          RET
0944          ADD                 ;MULT BY 4
0946          JP
0949          LD
094A          CALL                ;ADD ONCE TO MULT BY 5
094D          LD                  ;INC FPA1 EXPONENT
0950          INC                 ;MULT RESULT BY 2 = X 10
0951          RET                 ;RETURN IF IT DID NOT GO
0952          JP                  ;FROM FF TO 00, ELSE ERROR
      ;*****
      ;ROUTINE CHECKS FPA1 FOR MINUS, ZERO, PLUS
      ;       RETURNS -1, 0, +1
      ;*****
0955  CKRMZP  LD                  ;RETURN IF EXPONENT = 0
0958          OR
0959          RET
095A          LD                  ;GET SIGN BIT
095D          DEFB     0FEH       ;HIDE NEXT INST WITH 'CP'
095E  Z095E   CPL
095F  Z095F   RLA                 ;SIGN BIT -> CARRY FLAG
0960  Z0960   SBC                 ;CONVERT TO -1 OR +1
0961          RET
0962          INC
0963          RET
```

```
        ;*****
        ;INIT RFPA WITH 128.0
        ;*****
0964    Z0964   LD              ;INIT RFPA WITH 128.0
0966            LD
0969    Z0969   LD
096C            LD
096D            LD
096E            LD
0970            INC
0971            LD
0973            RLA
0974            JP
        ;*****
        ;INITIAL PROCESSING OF ABS(X)
        ;*****
0977    ABS     CALL            ;TEST FOR +, 0, -
097A            RET             ;RETURN IF + OR 0
097B    Z097B   RST             ;CHECK TYPE
097C            JP
097F            JP
0982    Z0982   LD              ;CPL SIGN BIT OF FPA1
0985            LD
0986            XOR
0988            LD
0989            RET
        ;*****
        ;INITIAL PROCESSING OF SGN(X)
        ;       RETURN VALUE (-1, 0, +1) IN INTEGER ACCUM
        ;*****
098A    SGN     CALL            ;TEST VALUE
098D    XPNDCF  LD              ;PLACE -1, 0, OR +1 -> L
098E            RLA             ;ZERO OUT IF ZERO OR +
098F            SBC             ;MAKE FF IF MINUS
0990            LD              ;THEN LOAD INTO H
0991            JP              ;CHANGE TYPE TO INT & HL -> ACCUM
        ;*****
        ;VALUE TESTING FOR ABS & SGN
        ;*****
0994    Z0994   RST
0995            JP
0998            JP              ;JUMP IF SGL OR DBL
099B            LD              ;GET INTEGER
099E            LD              ;RET IF ZERO
099F            OR
09A0            RET
09A1            LD              ;HIGH ORDER BYTE TO A
09A2            JR
        ;*****
        ;TRANSFER FPA1 TO STACK
```

```
       ;*****
09A4   STKFP1  EX
09A5           LD
09A8           EX
09A9           PUSH
09AA           LD
09AD           EX
09AE           PUSH
09AF           EX
09B0           RET
       ;*****
       ;TRANSFERS SNGL POINTED TO BY HL INTO FPA1
       ;*****
09B1   HLFPA1  CALL
09B4   SNGFPA  EX
09B5           LD
09B8           LD
09B9           LD
09BA           LD
09BD           EX
09BE           RET
       ;*****
       ;TRANSFER FPA1 (OR VALUE POINTED TO BY HL) INTO REGS RFPA
       ;*****
09BF   LDFPA1  LD              ;LD FPA1 -> EDCB REGS
09C2   LDFPHL  LD              ;LD (HL) -> EDCB REGS
09C3           INC
09C4           LD
09C5           INC
09C6           LD
09C7           INC
09C8           LD
09C9   Z09C9   INC
09CA           RET
       ;*****
       ;TRANSFER FPA1 TO MEMORY POINTED TO BY HL
       ;*****
09CB   FPAMEM  LD              ;TRANSFER FPA1 TO MEMORY
09CE           LD              ;POINTED TO BY HL
09D0           JR
       ;*****
       ;TRANSFERS DATA VALUE FROM (DE) TO (HL) DEPENDING ON TYPE
       ;OR FROM (HL) TO (DE) DEPENDING ON ENTRY POINT
       ;*****
09D2   Z09D2   EX              ;TRANSFER 'TYPE' BYTES
09D3   MOVDAT  LD              ;FROM (HL) -> (DE)
09D6           LD
09D7   Z09D7   LD
09D8           LD
09D9           INC
```

```
09DA          INC
09DB          DEC
09DC          JR
09DE          RET
      ;*****
      ;ALTER SIGN BIT OF FLOATING POINT VALUES
      ;RESULTANT SIGN BIT IN A IS 1 IF BOTH + OR BOTH -
      ;          SIGN BIT      IS 0 IF BOTH UNEQUAL SIGN
      ;*****
09DF  Z09DF   LD               ;PT TO MSB
09E2          LD               ;SET THE SIGN BIT
09E3          RLCA
09E4          SCF
09E5          RRA
09E6          LD               ;& REPL MSB
09E7          CCF
09E8          RRA
09E9          INC              ;PLACE ORIG MSB BUT WITH A
09EA          INC              ;COMPLEMENTED SIGN BIT
09EB          LD               ;INTO ADDR 4125H
09EC          LD               ;SET SIGN BIT OF VAR2
09ED          RLCA
09EE          SCF
09EF          RRA
09F0          LD               ;& REPL MSB
09F1          RRA
09F2          XOR
09F3          RET
      ;*****
      ;VARIOUS DATA TRANSFERS FROM VARIABLE TABLES TO ACCUMULATOR
      ;*****
09F4  Z09F4   LD
09F7  Z09F7   LD
09FA          JR
```

```
       ;*****
       ;SINGLE PRECISION COMPARISONS
       ;          -1 IF FPA1 < RFPA
       ;           0 IF FPA1 = RFPA
       ;          +1 IF FPA1 > RFPA
       ;*****
0A0C   CPRSNG   LD               ;IF RFPA IS ZERO, THEN RESULT
0A0D            OR               ;IS BASED ON FPA1'S SIGN
0A0E            JP
0A11            LD               ;ELSE STACK RET TO -1/+1 RTN
0A14            PUSH             ;WHICH WILL SET THE RESULT
0A15            CALL             ;TEST SIGN OF FPA1
0A18            LD               ;LOAD SIGN BYTE OF RFPA
0A19            RET              ;IF FPA1 IS ZERO, RESULT IS
0A1A            LD               ;BASED ON RFPA'S SIGN, ELSE
0A1D            XOR              ;TEST IF EXACTLY ONE VAR IS
0A1E            LD               ;NEGATIVE (VIA EXCL OR)
0A1F            RET              ;IF SO, THEN RESULT BASED ON RFPA
0A20            CALL             ;ELSE COMPARE EACH BYTE
0A23   Z0A23    RRA              ;WILL RET HERE IF UNEQUAL
0A24            XOR              ;XOR C-FLG OF RESULT WITH
0A25            RET              ;RFPA'S SIGN & EXIT
0A26   Z0A26    INC              ;COMPARE EACH BYTE OF FPA1
0A27            LD               ;WITH EACH BYTE OF RFPA
0A28            CP               ;CPR EXPONENTS
0A29            RET
0A2A            DEC
0A2B            LD               ;CPR HI ORDER MANTISSA
0A2C            CP
0A2D            RET
0A2E            DEC
0A2F            LD               ;CPR MID MANTISSA
0A30            CP
0A31            RET
0A32            DEC
0A33            LD               ;CPR LOW ORDER MANTISSA
0A34            SUB
0A35            RET
0A36            POP              ;IF NONE DIFFER, THEY ARE EQUAL!
0A37            POP              ;POP OFF THE RET CODES AS
0A38            RET              ;RESULT IS CORRECTLY ZERO
       ;*****
       ;INTEGER COMPARISONS
       ;*****
0A39   CPRINT   LD               ;TEST IF ONE VAR IS NEGATIVE
0A3A            XOR              ;BY EXCL OR THE SIGNS
0A3B            LD               ;INIT TO CPR ON HL ONLY
0A3C            JP               ;IF ONE NEG, THEN RESULT BASED
0A3F            CP               ;ON SIGN OF HL, ELSE CPR
```

```
0A40          JP            ;HI ORDER, THEN LO ORDER
0A43          LD            ;IF NECESSARY
0A44          SUB
0A45          JP
0A48          RET
      ;*****
      ;DOUBLE PRECISION COMPARISONS
      ;*****
0A49          LD
0A4C          CALL
0A4F  Z0A4F   LD            ;TEST FPA2 FOR ZERO
0A52          LD
0A53          OR            ;IF FPA2 = ZERO, THEN RESULT
0A54          JP            ;BASED ON SIGN OF FPA1
0A57          LD            ;STACK RET TO +1/-1 RTN
0A5A          PUSH
0A5B          CALL          ;TEST SIGN OF FPA1
0A5E          DEC           ;PT TO SIGN BYTE OF FPA2
0A5F          LD            ;& PUT IT INTO REG C
0A60          LD            ;IF FPA1 IS ZERO, THEN RESULT
0A61          RET           ;BASED ON FPA2'S SIGN
0A62          LD            ;ELSE EXCL OR THE SIGNS TO
0A65          XOR           ;SEE IF ONE VAR IS NEGATIVE
0A66          LD            ;IF EXACTLY ONE IS NEGATIVE
0A67          RET           ;RESULT BASED ON FPA2'S SIGN
0A68          INC           ;ELSE POINT DE & HL TO THE
0A69          INC           ;EXPONENT BYTE TO CPR 8 BYTES
0A6A          LD            ;INIT LOOP CTR FOR 8 BYTES
0A6C  Z0A6C   LD            ;COMPARE EACH BYTE IN TURN
0A6D          SUB
0A6E          JP            ;EXIT IF UNEQUAL
0A71          DEC           ;ELSE DEC PTRS
0A72          DEC
0A73          DEC           ;& DEC THE LOOP COUNTER
0A74          JR            ;CYCLE IF MORE
0A76          POP           ;ALL ARE SAME, REMOVE RET TO
0A77          RET           ;095EH & EXIT AS RESULT IS ZERO
0A78  CPRDBL  CALL          ;INIT CALL TO CPR. IF UNEQUAL,
0A7B          JP            ;CVRT RESULT TO -1 OR +1
0A7E          RET           ;ELSE RET WITH ZERO
      ;*****
      ;PROCESS CINT(X)
      ;*****
0A7F  CINT    RST           ;CK TYPE
0A80          LD
0A83          RET           ;RETURN IF INTEGER
0A84          JP
0A87          CALL          ;CVRT DBL TO SNGL
0A8A          LD            ;ESTABLISH RETURN IN CASE
0A8D          PUSH
```

```
0A8E  Z0A8E   LD
0A91          CP            ;CK IF > 32768
0A93          JR
0A95          CALL
0A98          EX
0A99  Z0A99   POP
0A9A  SAVINT  LD
0A9D          LD            ;CHG TYPE TO INTEGER
0A9F  SETINT  LD
0AA2          RET
0AA3  Z0AA3   LD            ;-32768
0AA6          LD
0AA9          CALL
0AAC          RET
0AAD          LD
0AAE          LD
0AAF          JR
      ;*****
      ;PROCESS CSNG(X)
      ;*****
0AB1  CSNG    RST
0AB2          RET           ;RETURN IF SNGL
0AB3          JP            ;JUMP IF INTEGER
0AB6          JP            ;ERR IF NOT DBL
0AB9  DBLSNG  CALL          ;CVRT DBL TO SNGL FIRST
0ABC          CALL
0ABF          LD            ;TEST FOR ZERO
0AC0          OR
0AC1          RET
0AC2          CALL
0AC5          LD
0AC8          LD
0AC9          JP
0ACC  Z0ACC   LD            ;CVRT INTEGER TO SNGL
0ACF  Z0ACF   CALL          ;CHG TYPE TO SNGL
0AD2          LD
0AD3          LD
0AD4          LD
0AD6          LD            ;32768
0AD8          JP
      ;*****
      ;PROCESS CDBL(X)
      ;*****
0ADB  CDBL    RST           ;RET IF DBL
0ADC          RET
0ADD          JP            ;IF STRING
0AE0          CALL          ;CALL IF INT
0AE3  Z0AE3   LD            ;ZERO THE EXTENDED PART OF FPA1
0AE6          LD
0AE9          LD
```

```
0AEC  SETDBL  LD             ;CHANGE TYPE TO DBL
0AEE          DEFB     1     ;HIDE NEXT INST WITH 'LD BC'
0AEF  SETSNG  LD             ;CHANGE TYPE TO SNGL
0AF1          JP
      ;*****
      ;CHECK TYPE OF CURRENT VARIABLE & PROVIDE TM ERROR IF STRING
      ;*****
0AF4  CHKSTR  RST            ;ROUTINE CHECKS CURRENT VARIABLE
0AF5          RET            ;FOR STRING, RET IF OK ELSE ERROR
0AF6  TMERR   LD             ;TYPE MISMATCH ERROR
0AF8          JP
      ;*****
      ;LD B,C,D,E WITH REG. A
      ;*****
0AFB  Z0AFB   LD
0AFC          LD
0AFD          LD
0AFE          LD
0AFF          OR
0B00          RET            ;RET IF ZERO RFPA
0B01          PUSH
0B02          CALL           ;FPA1 TO RFPA
0B05          CALL
0B08          XOR
0B09          LD
0B0A          CALL           ;REDUCE BCDE BY ONE
0B0D          LD
0B0F          SUB
0B10          CALL           ;SHIFT RIGHT "A" BITS
0B13          LD
0B14          RLA
0B15          CALL           ;IF H NEG, THEN ADD 1 TO RFPA
0B18          LD
0B1A          CALL           ;TWOS COMP THE RFPA
0B1D          POP
0B1E          RET
0B1F  Z0B1F   DEC            ;REDUCE "BCDE" BY 1
0B20          LD             ;TEST IF DE WENT FROM
0B21          AND            ;0000 TO FFFF
0B22          INC            ;IF SO, THIS IS 0
0B23          RET            ;RET IF NOT SO
0B24          DEC            ;ELSE DEC BC FOR CARRY
0B25          RET
      ;*****
      ;PROCESS FIX(X)
      ;*****
0B26  FIX     RST            ;RET IF INT
0B27          RET
0B28          CALL
0B2B          JP
```

```
0B2E            CALL            ;CHG SIGN BIT FM M TO P
0B31            CALL
0B34            JP              ;COMPLEMENT THE INTEGER
        ;*****
        ;PROCESS INT(X)
        ;*****
0B37    INT     RST
0B38            RET             ;RETURN IF INTEGER
0B39            JR              ;JUMP IF DOUBLE
0B3B            JR              ;IF STRING
        ;*****
        ;FIND INTEGER PART OF SINGLE PRECISION
        ;       ENTER AT 0B40H TO TAKE INT(FPA1)
        ;*****
0B3D            CALL            ;FIND CINT OF SNGL
0B40    Z0B40   LD
0B43            LD
0B44            CP
0B46            LD
0B49            RET
0B4A            LD              ;LD FPA1 EXP. INTO A
0B4B            CALL            ;PUT EXP. INTO B,C,D, & E
0B4E            LD
0B50            LD
0B51            PUSH
0B52            LD
0B53            RLA
0B54            CALL            ;TWO'S COMP RFPA THEN NORMALIZE
0B57            POP
0B58            RET
        ;*****
        ;FIND INTEGER PART OF DOUBLE PRECISION
        ;*****
0B59    INTDBL  LD              ;LD HL WITH ADDR OF FPA1 EXP
0B5C            LD              ;LD EXP TO ACCUM
0B5D            CP              ;VAL WITHIN RANGE OF INTEGER, CINT
0B5F            JP
0B62            JR
0B64            LD
0B65            DEC
0B66            LD              ;LD FIRST BYTE MANTISSA
0B67            XOR             ;FLIP SIGN BIT
0B69            LD              ;SET-UP FOR 6-BYTES OF MANTISSA
0B6B    Z0B6B   DEC
0B6C            OR
0B6D            DEC
0B6E            JR              ;LOOP UNTIL DONE
0B70            OR
0B71            LD
0B74            JP
```

```
0B77            LD
0B78  Z0B78     CP
0B7A            RET
0B7B  Z0B7B     PUSH
0B7C            CALL            ;FPA1 -> RFPA
0B7F            CALL
0B82            XOR
0B83            DEC
0B84            LD
0B86            PUSH
0B87            CALL
0B8A            LD
0B8D            LD
0B8F            SUB
0B90            CALL            ;SHIFT RIGHT "A" BITS
0B93            POP
0B94            CALL            ;INC DBL BY ONE
0B97            XOR
0B98            LD
0B9B            POP
0B9C            RET
0B9D            JP              ;TWO'S COMPLEMENT
0BA0  Z0BA0     LD
0BA3  Z0BA3     LD
0BA4            DEC
0BA5            OR
0BA6            INC
0BA7            JR
0BA9            RET
      ;*****
      ;CALCULATION OF NUMBER OF BYTES USED IN A DIMENSION
      ;MULTIPLIES DE (TYPE LENGTH) BY BC (DIM) RESULT IN DE
      ;*****
0BAA            PUSH
0BAB            LD
0BAE            LD
0BAF            OR
0BB0            JR              ;JUMP IF DIM IS ZERO
0BB2            LD              ;ESTAB LOOP LIMIT
0BB4  Z0BB4     ADD
0BB5            JP              ;OVERFLOW ERROR
0BB8            EX              ;ADD DE+DE -> DE
0BB9            ADD
0BBA            EX
0BBB            JR
0BBD            ADD
0BBE            JP              ;OVERFLOW ERROR
0BC1  Z0BC1     DEC
0BC2            JR
0BC4  Z0BC4     EX
```

```
0BC5          POP
0BC6          RET
       ;*****
       ;INTEGER SUBTRACTION
       ;*****
0BC7   SUBINT LD                 ;OBTAIN SIGN BIT &
0BC8          RLA                ;PLACE IN REG B
0BC9          SBC
0BCA          LD
0BCB          CALL               ;HL -> FPA1
0BCE          LD                 ;ZERO REG A
0BCF          SBC
0BD0          JR                 ;NOW ADD
       ;*****
       ;INTEGER ADDITION
       ;*****
0BD2   ADDINT LD                 ;OBTAIN SIGN BIT &
0BD3          RLA                ;PLACE IN REG B
0BD4          SBC
0BD5   Z0BD5  LD
0BD6          PUSH               ;SAVE VALUE
0BD7          LD                 ;SIGN BIT -> REG A
0BD8          RLA
0BD9          SBC
0BDA          ADD                ;ADD VAL2 TO VAL1
0BDB          ADC
0BDC          RRCA
0BDD          XOR
0BDE          JP                 ;RESULT TO FPA1, TYPFLG=2
       ;*****
       ;ADDITION OVERFLOWED INTEGER LIMITS, CONVERT TO SINGLE
       ;*****
0BE1          PUSH
0BE2          EX                 ;VAL2 -> HL
0BE3          CALL               ;CVRT VAL2 TO SNGL
0BE6          POP
0BE7          POP                ;RCVR VAL1
0BE8          CALL
0BEB          EX
0BEC          CALL
0BEF          JP                 ;STACK -> RFPA -> ADDSNG
       ;*****
       ;INTEGER MULTIPLICATION
       ;*****
0BF2   MULINT LD                 ;TEST FOR ZERO VALUE
0BF3          OR
0BF4          JP                 ;HL -> FPA1, TYPFLG -> 2
0BF7          PUSH               ;SAVE VAL1
0BF8          PUSH               ;SAVE VAL2
0BF9          CALL               ;MAKE SURE BOTH VALS ARE +
```

```
0BFC          PUSH            ;RESULT SIGN SAVED IN B
0BFD          LD              ;NOW MULTIPLY HL BY DE
0BFE          LD              ;  RESULT IN HL (BOTH VALS
0BFF          LD              ;ARE POSITIVE). INIT TO 0
0C02          LD              ;INIT FOR 16 BITS
0C04  Z0C04   ADD             ;SHIFT MULTIPLICAND
0C05          JR              ;TEST FOR OVERFLOW
0C07          EX              ;SHIFT MULTIPLIER 1 BIT LEFT
0C08          ADD             ;BY ADDING IT TO ITSELF.
0C09          EX              ;IF A 1-BIT IS NOT SHIFTED INTO
0C0A          JR              ;THE CARRY, RECYCLE, ELSE
0C0C          ADD             ;ADD IN AN 'HL' THEN
0C0D          JP              ;TEST FOR OVERFLOW
0C10  Z0C10   DEC             ;REDUCE BIT COUNTER
0C11          JR              ;LOOP IF MORE TO DO
0C13          POP             ;RESTORE REGS
0C14          POP
0C15          LD              ;TEST RESULT FOR OVERFLOW
0C16          OR              ;INTO NEGATIVE (BIT 7 SET)
0C17          JP              ;OVERFLOW IF BIT 7 SET
0C1A          POP             ;ELSE RESTORE REG
0C1B          LD              ;PUT SIGN BACK INTO REG A
0C1C          JP              ;& EXIT
0C1F  Z0C1F   XOR             ;TURN OFF SIGN BIT OF NEG RESULT
0C21          OR
0C22          JR
0C24          EX
0C25          DEFB     1      ;HIDE NEXT 2 INST WITH 'LD BC'
0C26  Z0C26   POP             ;MULTIPLICAND OVERFLOWED
0C27          POP
0C28          CALL            ;CVRT VAL TO SNGL
0C2B          POP
0C2C          CALL            ;& STACK IT AWAY
0C2F          CALL            ;CVRT OTHER VAL TO SNGL
0C32  Z0C32   POP             ;RESTORE STACKED VAL
0C33          POP
0C34          JP              ;NOW MULTIPLY SINGLE
0C37  Z0C37   LD
0C38          OR
0C39          POP
0C3A          JP              ;CHG TYPE TO INT & HL -> ACCUM
0C3D          PUSH
0C3E          CALL            ;CVRT VAL TO SNGL
0C41          POP
0C42          JP
0C45  Z0C45   LD              ;EXCL OR SIGN BITS
0C46          XOR             ;& SAVE IN REG B
0C47          LD
0C48          CALL            ;MAKE VAL IN HL POSITIVE IF NOT
0C4B          EX              ;MAKE VAL IN DE POSITIVE IF NOT
```

```
0C4C  Z0C4C   LD             ;IF THE VAL IS POSITIVE,
0C4D  Z0C4D   OR             ;SAVE IT IN FPA1
0C4E          JP             ;AS AN INTEGER RESULT
0C51  Z0C51   XOR            ;ELSE CVRT IT TO POSITIVE
0C52          LD             ;BY TAKING THE TWO'S
0C53          SUB            ;COMPLEMENT OF HL
0C54          LD
0C55          LD
0C56          SBC
0C57          LD
0C58          JP             ;THEN SAVING THE INTEGER RESULT
      ;*****
      ;PROCESS ABSOLUTE VALUE OF AN INTEGER
      ;*****
0C5B  ABSINT  LD             ;P/U INTEGER
0C5E          CALL           ;COMPLEMENT IT
0C61          LD
0C62          XOR
0C64          OR
0C65          RET
0C66          EX
0C67          CALL           ;CHG TYPE TO SNGL
0C6A          XOR
0C6B  Z0C6B   LD
0C6D          JP
      ;*****
      ;DOUBLE PRECISION SUBTRACTION
      ;*****
0C70  SUBDBL  LD             ;CHANGE SIGN OF FPA2
0C73          LD
0C74          XOR            ;CHANGE SIGN, THEN ADD
0C76          LD
      ;*****
      ; DOUBLE PRECISION ADDITION
      ;*****
0C77  ADDDBL  LD
0C7A          LD             ;RETURN IF FPA2 IS ZERO
0C7B          OR             ;AS FPA1 WOULD HAVE THE
0C7C          RET            ;ANSWER
0C7D          LD             ;SAVE THE EXPONENT IN B
0C7E          DEC
0C7F          LD             ;P/U HIGH BYTE (CONTAINS SIGN)
0C80          LD             ;IF FPA1 IS ZERO, THEN
0C83          LD             ;SWAP FPA2 WITH FPA1 AS
0C84          OR             ;FPA2 WOULD BE THE ANSWER
0C85          JP
0C88          SUB            ;GET DIFF IN EXPONENTS
0C89          JR             ;JUMP IF FPA2 < FPA1
0C8B          CPL            ;CVRT EXPON DIFF TO +
0C8C          INC
```

```
        ;*****
        ;EXCHANGE FPA1 & FPA2
        ;*****
0C8D            PUSH
0C8E            LD              ;SET LOOP FOR 8 BYTES
0C90            INC
0C91            PUSH
0C92    AD1     LD
0C93            LD
0C94            LD
0C95            LD
0C96            LD
0C97            DEC
0C98            DEC
0C99            DEC             ;DEC CTR & CYCLE IF MORE
0C9A            JR
0C9C            POP             ;RECOVER 412E
0C9D            LD              ;EXPON -> B
0C9E            DEC
0C9F            LD              ;SIGN BYTE -> C
0CA0            POP
        ;*****
        ;DON'T ADD IF THE DIFFERENCE BETWEEN VALUES > 10**17
        ;*****
0CA1    Z0CA1   CP              ;2**57 APPX 10**17
0CA3            RET
0CA4            PUSH
0CA5            CALL            ;TURN ON SIGN BITS
0CA8            INC             ;PT TO 4126H & ZERO IT
0CA9            LD
0CAB            LD
0CAC            POP
0CAD            LD
0CB0            CALL            ;DIV VAR1 MANTISSA BY THE
0CB3            LD              ;DIFF IN EXPONENTS
0CB6            LD
0CB9            LD              ;TEST RESULT OF SIGNS
0CBA            OR
0CBB            JP              ;JUMP IF SIGN BITS WERE <>
0CBE            CALL            ;ADD DBL (HL) TO (DE)
0CC1            JP              ;INC EXPON IF ADD OVERFLOWED
0CC4            EX              ;PT TO EXPON AND ADD 1 DUE
0CC5            INC             ;TO CARRY ON MANTISSA ADD
0CC6            JP              ;ERROR IF EXPON ADD -> 0
0CC9            CALL            ;DIVIDE MANTISSA BY 2 FOR
0CCC            JP              ;EXPONENT INCREASE
        ;*****
        ; SUBTRACT ONE NUMBER FROM ANOTHER WHEN 'SIGNS' ARE <>
        ;*****
0CCF    Z0CCF   CALL            ;SUB DBL (HL) FROM (DE)
```

```
0CD2            LD
0CD5            CALL            ;TWO'S COMP FPA1
0CD8  Z0CD8     XOR             ;SET SHIFT CTR TO ZERO
0CD9  DSHFT8    LD              ;SET SHIFT CTR FROM ACCUM
0CDA            LD              ;IF HIGH BYTE IS ZERO,
0CDD            OR              ;SHIFT LEFT 8 BITS
0CDE            JR              ;ELSE BYPASS 8-BIT SHIFTER
0CE0            LD              ;PT TO LOW-1
0CE3            LD              ;INIT BYTE COUNTER
0CE5  DLOOP8    LD              ;SHIFT FPA1 DBL LEFT 8 BITS
0CE6            LD
0CE7            LD
0CE8            INC
0CE9            DEC             ;DEC THE BYTE CTR
0CEA            JR
0CEC            LD              ;P/U THS SHIFT CTR
0CED            SUB             ;& COUNT IT DOWN BY 8
0CEF            CP              ;IF MANTISSA WAS NOT SHIFTED
0CF1            JR              ;OUT OF FPA1, THEN CYCLE
0CF3            JP              ;ELSE ZERO FPA1 & GO HOME
      ;*****
      ; DBL PREC SINGLE BIT SHIFTER (LEFT)
      ;*****
0CF6  DSHFT1    DEC
0CF7            LD              ;SHIFT 1 BIT LEFT UNTIL
0CFA            CALL            ;THE SIGN BIT GOES TO 1
0CFD            OR
0CFE  DCHKP     JP
      ;*****
      ; A 1 HAS SHIFTED INTO THE SIGN POSITION
      ;*****
0D01            LD              ;P/U THE SHIFT COUNTER
0D02            OR              ;SEE IF SHIFTING HAD OCCURED
0D03            JR
      ;*****
      ; THE NBR HAD TO BE SHIFTED TO BE NORMALIZED.
      ; CORRECT THE EXPONENT.
      ;*****
0D05            LD              ;ADD THE SHIFT COUNTER
0D08            ADD             ;WHICH IS NEGATIVE, TO
0D09            LD              ;FPA1'S EXPONENT
0D0A            JP              ;ZERO FPA1 IF SHIFT < EXPON
0D0D            RET             ;RET WITH FPA1=0 IF SHIFT=EXPON
      ;*****
      ; SHIFT WAS GREATER THAN EXPONENT
      ;*****
0D0E  Z0D0E     LD
0D11  Z0D11     OR              ;IS BIT 7 SET?
0D12            CALL            ;INC FPA1 BY 1 IF IT IS
0D15            LD
```

```
0D18          LD              ;P/U THE PROCESSED SIGN BITS
0D19          AND             ;& STRIP OFF ALL BUT THE SIGN
0D1B          DEC
0D1C          DEC             ;PT TO FPA1'S SIGN BYTE
0D1D          XOR             ;& INSERT IN THE CORRECT SIGN
0D1E          LD
0D1F          RET
     ;*****
     ; INCREMENT DBL PREC FPA1 BY 1
     ;*****
0D20 INCDBL   LD
0D23          LD              ;SET CTR FOR MANTISSA BYTES
0D25 DLOOP7   INC             ;INC THE BYTE
0D26          RET             ;RET IF NO 'CARRY'
0D27          INC             ;ELSE PT TO NEXT BYTE
0D28          DEC             ;DEC THE BYTE CTR & CYCLE IF MORE
0D29          JR
0D2B          INC             ;INC THE EXPONENT & ERROR
0D2C          JP              ;IF IT OVERFLOWED
0D2F          DEC             ;PUT THE 'SIGN' BIT 1 BACK
0D30          LD
0D32          RET
     ;*****
     ; ADD DBL PREC MANTISSA HL TO DE
     ;*****
0D33 DAF1F2   LD              ;ADD FPA2 TO FPA1
0D36 DAF1HL   LD              ;ADD (HL) TO FPA1
0D39 DADEHL   LD              ;ADD (HL) TO (DE)
0D3B          XOR
0D3C DA1      LD
0D3D          ADC
0D3E          LD
0D3F          INC
0D40          INC
0D41          DEC
0D42          JR
0D44          RET
     ;*****
     ; SUBTRACT DBL PREC MANTISSA HL FROM DE
     ;*****
0D45 DSF1F2   LD              ;SUB FPA2 FM FPA1
0D48 DSF1HL   LD              ;SUB (HL) FM FPA1
0D4B DSDEHL   LD              ;SUB (HL) FM (DE)
0D4D          XOR
0D4E DS1      LD
0D4F          SBC
0D50          LD
0D51          INC
0D52          INC
0D53          DEC
```

```
0D54            JR
0D56            RET
        ;*****
        ; TWO'S COMPLEMENT THE DBL PREC FPA1
        ;*****
0D57    D2SCMP  LD                  ;INVERT THE RESULT SIGN BIT
0D58            CPL
0D59            LD
0D5A            LD
0D5D            LD                  ;INIT BYTE COUNTER
0D5F            XOR
0D60    Z0D60   LD                  ;SET REG C
0D61    Z0D61   LD                  ;REFRESH ACCUM TO ZERO
0D62            SBC                 ;COMPLEMENT A BYTE
0D63            LD
0D64            INC                 ;PT TO NEXT BYTE
0D65            DEC                 ;DEC BYTE CTR & CYCLE IF MORE
0D66            JR
0D68            RET
        ;*****
        ; PERFORM A RIGHT CIRCULAR SHIFT OF A MANTISSA BASED ON REG-A
        ;*****
0D69    DSHTR   LD
0D6A            PUSH
0D6B    DSHTR8  SUB                 ;TEST FOR 8 OR MORE BITS
0D6D            JR                  ;TO SHIFT
0D6F            POP
0D70    Z0D70   PUSH
0D71            LD                  ;INIT D TO 8, E TO 0
0D74    Z0D74   LD
0D75            LD                  ;JUGGLE THE 8 BYTES
0D76            LD
0D77            DEC
0D78            DEC                 ;DEC BYTE CTR
0D79            JR                  ;CYCLE IF MORE BYTES
0D7B            JR
        ;*****
        ; DBL PREC SINGLE BIT RIGHT SHIFTER
        ;*****
0D7D    Z0D7D   ADD                 ;ADD BACK THE 8 + 1
0D7F            LD                  ;INIT THE SHIFT COUNTER
0D80    DSHTRS  XOR                 ;ZERO A & REDUCE CTR
0D81            POP
0D82            DEC
0D83            RET                 ;FINISHED WHEN CTR RUNS OUT
        ;*****
        ; DBL PREC SHIFT RIGHT 'D' BITS
        ;*****
0D84    DSHTRD  PUSH                ;SAVE THE POINTER
0D85            LD                  ;INIT FOR 8 BYTES
```

```
0D87  Z0D87   LD              ;SHIFT EACH BYTE ONE BIT
0D88          RRA
0D89          LD
0D8A          DEC             ;PT TO NEXT LOWER BYTE
0D8B          DEC             ;DEC THE COUNTER
0D8C          JR              ;UNTIL 8 BYTES DONE
0D8E          JR
      ;*****
      ; DBL PREC SINGLE BIT SHIFT RIGHT (8-BYTES)
      ;*****
0D90  DSHTR1  LD
0D93          LD              ;INIT FOR 1 BIT
0D95          JR
      ;*****
      ;DOUBLE PRECISION MULTIPLICATION
      ;*****
0DA1  MULDBL  CALL            ;CHECK -,0,+ AND RETURN IF ZERO
0DA4          RET
0DA5          CALL            ;ADD THE EXPONENTS

0DA8          CALL
0DAB          LD
0DAC          INC
0DAD          LD              ; INIT FOR 7 BYTE MANTISSA
0DAF  Z0DAF   LD              ; PICKUP TEST BYTE AND POINT TO NEXT
0DB0          INC
0DB1          OR
0DB2          PUSH
0DB3          JR              ; BYPASS BIT CHECK IF BYTE IS ZERO
0DB5          LD              ;SET FOR 8 TIMES
0DB7  Z0DB7   PUSH            ;SAVE COUNTER REGISTERS
0DB8          RRA
0DB9          LD              ;SAVE ACCUM
0DBA          CALL            ;ADD MANTISSA 2 TO MANTISSA 1
0DBD          CALL            ;DBL SINGLE BIT SHIFT RIGHT (8 BYTES)
0DC0          LD              ;RESTORE ACCUM
0DC1          POP             ;RESTORE LOOP REGISTERS
0DC2          DEC             ;DEC INNER LOOP REGISTER
0DC3          JR              ;LOOP IF NOT DONE
0DC5  Z0DC5   POP             ;RECOVER POINTER TO BYTE
0DC6          DEC             ;OUTER LOOP REGISTER
0DC7          JR              ;LOOP IF NOT DONE
0DC9          JP              ;NORMALIZE
0DCC  Z0DCC   LD              ;LD FPA1 MANTISSA
0DCF          CALL            ;RIGHT CIRCULAR BYTE SHIFT
0DD2          JR              ;CONTINUE LOOP
      ;*****
      ;FLOATING POINT DATA
      ;*****
```

```
0DD4            DEFW   0000    ;10.0 (DOUBLE PRECISION)
0DD6            DEFW   0000
0DD8            DEFW   0000    ;10.0 (SINGLE PRECISION)
0DDA            DEFW   8420H
        ;*****
        ;DOUBLE PRECISION DIVISION ROUTINE
        ;*****
0DDC    Z0DDC   LD             ;LD 10.0D
0DDF            LD             ;LD ADDRESS OF FPA1
0DE2            CALL           ;MOVE 10.0D TO FPA2
0DE5    DIVDBL  LD             ;LOAD FPA2 AND
0DE8            OR             ;TEST FOR ZERO
0DE9            JP             ;DIV BY ZERO ERR IF ZERO
0DEC            CALL           ;EXPONENT SUBTRACTION
0DEF            INC
0DF0            INC
0DF1            CALL           ;MOVE FPA2 TO DIVISION WORK AREA
0DF4            LD
0DF7            LD
0DF8            LD
0DF9    Z0DF9   LD
0DFC            LD
0DFF            CALL           ;SUBTRACT DBL MANTISSA (HL) FROM (DE)
0E02            LD
0E03            SBC
0E04            CCF
0E05            JR
0E07            LD
0E0A            LD
0E0D            CALL           ;ADD (HL) TO (DE)
0E10            XOR
0E11            DEFB    0DAH   ;HIDE NEXT TWO INSTRUCTIONS W/JP C,0412H
0E12    Z0E12   LD
0E13            INC
0E14            LD             ;LD ACCUM 1ST BYTE FPA1 MANTISSA
0E17            INC            ;TEST ACCUM
0E18            DEC
0E19            RRA
0E1A            JP             ;JP IF ACCUM NEGATIVE
0E1D            RLA
0E1E            LD
0E21            LD             ;SET UP FOR 7 LOOPS
0E23            CALL           ;DBL PREC. SINGLE BIT SHIFT LEFT (7 BYTES)
0E26            LD             ;POINT TO DIVISION WORK AREA
0E29            CALL           ;DBL PREC. SINGLE BIT SHIFT LEFT (8)
0E2C            LD
0E2D            OR
0E2E            JR
0E30            LD             ;PT TO FPA1 EXP.
0E33            DEC            ;DEC EXPONENT
```

```
0E34            JR
0E36            JP                 ;JP OVERFLOW ERROR
0E39   Z0E39    LD
0E3A            LD
0E3D            DEC
0E3E            LD
0E41            LD
0E44   Z0E44    LD                 ;MOVE FPA1 TO DIVISION WORK AREA
0E45            LD
0E46            LD
0E47            DEC
0E48            DEC
0E49            DEC
0E4A            JR
0E4C            RET
       ;*****
       ; MULTIPLY A DOUBLE PRECISION VALUE BY 10.0
       ;*****
0E4D   Z0E4D    CALL               ;TRANS. FPA1 TO FPA2
0E50            EX
0E51            DEC
0E52            LD                 ;PICK UP EXPONENT
0E53            OR
0E54            RET
0E55            ADD                ;MULTIPLY BY FOUR
0E57            JP                 ;IF C, OVER FLOW ERROR
0E5A            LD
0E5B            PUSH
0E5C            CALL               ;ADD DOUBLE PRECISION TO MULTIPLY BY 5
0E5F            POP
0E60            INC                ;MULTIPLY BY TWO TO MAKE MULTIPLY BY 10
0E61            RET
0E62            JP                 ;OVER FLOW ERROR
       ;*****
       ;ROUTINE ENTERED @ 0E6C FROM PARSER WHEN FINDS DIGIT
       ;*****
0E65   ASCBIN   CALL               ;ZERO FPA1 EXP.(ROUTINE ASCII TO BINARY)
0E68            CALL               ;CHG TYPFLG TO DOUBLE
0E6B            DEFB      0F6H     ;NEXT INSTRUCTION 'OR 0AFH'
0E6C            XOR       A
0E6D            EX
0E6E            LD
0E71            LD                 ;ZERO OUT HL
0E72            LD
0E73            CALL               ;CALL IF FROM PARSER
0E76            EX
0E77            LD                 ;GET TOKEN
0E78            CP                 ;IS "-" ?
0E7A            PUSH               ;SAVE TOKEN AND FLAG
0E7B            JP
```

```
0E7E          CP                   ;IS "+" ?
0E80          JR
0E82          DEC                  ;BACK-UP TOKEN PTR
0E83   Z0E83  RST                  ;RE-GET TOKEN
0E84          JP                   ;JP IF DIGIT
0E87          CP                   ;IS IT "." ?
0E89          JP
0E8C          CP                   ;IS IT "E" ?
0E8E          JR
0E90          CP                   ;IS IT "%" ? (INTEGER)
0E92          JP
0E95          CP                   ;IS IT "#" ? (DBL)
0E97          JP                   ;CONVERT TO DBL,INC HL,RET TO 0EC7H
0E9A          CP                   ;IS IT "!" ? (SNG)
0E9C          JP                   ;CONVERT TO SNG,INC HL,RET TO 0EC7H
0E9F          CP                   ;IS IT "D" ? (DOUBLE)
0EA1          JR
0EA3          OR
       ;*****
       ;NEXT CALL CONVERTS TO SINGLE IF ENTERED FROM "E".
       ;OR TO DBL IF ENTERED FROM "D".
       ;*****
0EA4   Z0EA4  CALL
0EA7          PUSH
0EA8          LD                   ;PUT 0EBDH ON STACK FOR RET
0EAB          EX
0EAC          RST                  ;GET NEXT TOKEN
0EAD          DEC
0EAE          CP                   ;"-" FUNCTION ?
0EB0          RET
0EB1          CP                   ;"-" SIGN ?
0EB3          RET
0EB4          INC
0EB5          CP                   ;"+" FUNCTION ?
0EB7          RET
0EB8          CP                   ;"+" SIGN ?
0EBA          RET
0EBB          DEC                  ;BACKUP TOKEN PTR
0EBC          POP
0EBD   Z0EBD  RST                  ;REGET TOKEN
0EBE          JP                   ;JP IF DIGIT
0EC1          INC
0EC2          JR
0EC4          XOR
0EC5          SUB
0EC6          LD
0EC7   Z0EC7  PUSH
0EC8          LD
0EC9          SUB
0ECA   Z0ECA  CALL                 ;IF POS., MULTIPLY BY 10
```

```
0ECD            CALL            ;IF NEG., DIVIDE BY 10
0ED0            JR
0ED2            POP
0ED3            POP
0ED4            PUSH
0ED5            CALL            ;FIND ABS
0ED8            POP
0ED9            RST             ;RETURN IF NOT INT.
0EDA            RET
0EDB            PUSH
0EDC            LD
0EDF            PUSH
0EE0            CALL
0EE3            RET
0EE4    Z0EE4   RST             ;DETERMINE TYPE
0EE5            INC
0EE6            JR
0EE8            CALL            ;CONVERT TO SNG
0EEB            JP
0EEE    Z0EEE   RST             ;CHECK TOKEN TYPE
0EEF            JP
0EF2    Z0EF2   INC
0EF3            JR
0EF5    Z0EF5   OR
0EF6    Z0EF6   CALL
0EF9            JR
        ;*****
        ;ROUTINE CONVERTS TO SINGLE (Z SET) OR DBL (NZ SET)
        ;*****
0EFB    Z0EFB   PUSH            ;ENTER FROM 0EA5H,0EE8H, OR 0EF6H
0EFC            PUSH            ;SAVE ALL REGISTERS
0EFD            PUSH
0EFE            PUSH            ;SAVE FLAG STATUS
0EFF            CALL            ;IF Z, CONVERT TO SNG
0F02            POP             ;RESTORE FLAG
0F03            CALL            ;IF NZ, CONVERT TO DBL
0F06            POP             ;RESTORE REGISTERS
0F07            POP
0F08            POP
0F09            RET
        ;*****
        ;MULTIPLY FPA1 BY 10
        ;EITHER SINGLE OR DOUBLE
        ;*****
0F0A    Z0F0A   RET             ;RET IF Z
0F0B            PUSH            ;SAVE FLAGS
0F0C            RST             ;TEST TYPE FLAG FOR SGL OR DBL
0F0D            PUSH
0F0E            CALL            ;CALL IF SNG TO MULTIPLY BY 10
0F11            POP
```

```
0F12           CALL        ;CALL IF DBL TO MULTIPLY BY 10
0F15           POP
0F16           DEC         ;ADJUST ACCUM
0F17           RET
       ;*****
       ;DIVIDE FPA1 BY 10 EITHER SNG OR DBL
       ;*****
0F18   DIVTEN  PUSH
0F19           PUSH
0F1A           PUSH
0F1B           RST         ;TEST TYPE
0F1C           PUSH
0F1D           CALL        ;CALL IF SNG
0F20           POP
0F21           CALL        ;CALL IF DBL
0F24           POP
0F25           POP
0F26           POP
0F27           INC         ;ADJUST ACCUM
0F28           RET
       ;*****
       ;ROUTINE TO CONSTRUCT NUMBER FROM DIGITS PASSED 0E84H
       ;*****
0F29   Z0F29   PUSH
0F2A           LD          ;MAKE B NON-ZERO IF PARSER FOUND MORE
0F2B           ADC         ;THAN ONE DECIMAL POINT
0F2C           LD
0F2D           PUSH
0F2E           PUSH
0F2F           LD          ;PICK UP THE DIGIT
0F30           SUB         ;CONVERT TO BINARY
0F32           PUSH        ;SAVE FOR 0F46H
0F33           RST         ;TEST TYPE FLAG
0F34           JP          ;JP IF NOT INT
0F37           LD          ;RECOVER INT FROM FPA1
0F3A           LD          ;INIT FOR MAX NUM. (/10)
0F3D           RST         ;CP INT 3277
0F3E           JR          ;JP IF GREATER
0F40           LD          ;***
0F41           LD          ;MULTIPLY
0F42           ADD         ;  VAL IN REG. HL BY 10
0F43           ADD         ;***
0F44           ADD
0F45           ADD
0F46           POP
0F47           LD          ;PUT NEW DIGIT INTO REG C
0F48           ADD         ;ADD THE VALUE
0F49           LD          ;TEST FOR OVERFLOW
0F4A           OR
0F4B           JP          ;CONVERT TO SNG IF INTEGER OVERFLOW
```

```
0F4E            LD              ;ELSE REPLACE INT IN FPA1
0F51   Z0F51    POP
0F52            POP
0F53            POP
0F54            JP              ;GO BACK TO RST 20H
       ;*****
       ;NUMBER OVERFLOWS INT. CONVERT TO SINGLE
       ;*****
0F57   Z0F57    LD              ;PLACE DIGIT IN ACCUM
0F58            PUSH            ;   AND SAVE IT
0F59   Z0F59    CALL            ;CVRT INT. IN FPA1 TO SNG
0F5C            SCF
0F5D   Z0F5D    JR              ;JP IF CAME FROM 0F34H (IF NOT INT)
0F5F            LD              ;MOVE 1E+6 TO RFPA
0F62            LD
0F65            CALL            ;CP SINGLE PREC.
0F68            JP              ;JP IF FPA1 > 1E+6
0F6B            CALL            ;MULT. FPA1 BY 10
0F6E            POP
0F6F            CALL            ;ADD DIGIT TO FPA1
0F72            JR
       ;*****
       ;NUMBER CONVERTS TO DOUBLE PRECISION IF > 1E+6
       ;*****
0F74   Z0F74    CALL            ;CLEAR EXTENDED FPA1 AND SET TYP TO 8
0F77   Z0F77    CALL            ;MULT DBL BY 10
0F7A            CALL            ;FPA1 -> FPA2
0F7D            POP
0F7E            CALL            ;CVRT DIGITS TO FLOATING PT IN FPA1
0F81            CALL            ;CLEAR EXTENDED FPA1
0F84            CALL            ;FPA2 + FPA1 -> FPA1
0F87            JR
       ;*****
       ;CONVERT DIGIT TO SINGLE AND ADD TO FPA1
       ;*****
0F89   Z0F89    CALL            ;STACK FPA1
0F8C            CALL            ;PUT DIGIT VAL AND CONVERT TO FLOATING PT
0F8F            POP             ;RECOVER STACKED VAL
0F90            POP
0F91            JP              ;FPA1 + RFPA -> FPA1
       ;*****
       ;ROUTINE TO CONVERT EXPONENT DIGITS TO A VALUE
       ;*****
0F94   Z0F94    LD              ;PICK UP CURRENT EXPONENT
0F95            CP
0F97            JR              ;OVERFLOW IF >= 10
0F99            RLCA            ;***
0F9A            RLCA            ;SINGLE BYTE MULTIPLY BY 10
0F9B            ADD             ;***
0F9C            RLCA
```

```
0F9D            ADD
0F9E            SUB
0FA0            LD
0FA1            DEFB    0FAH    ;HIDE NEXT INSTRUCTION WITH
                                ;A JP M,321EH
0FA2   Z0FA2    LD              ;FORCE OVERFLOW ERROR (EXP TOO LARGE)
0FA4            JP
       ;*****
       ;ROUTINE TO PRINT OUT LINE NUMBER FOR TRON
       ;*****
0FA7            PUSH
0FA8            LD              ;PT TO " IN "
0FAB            CALL            ;OUTPUT LINE
0FAE            POP
0FAF   WRLNO    CALL            ;REG HL -> FPA1
0FB2            XOR             ;ZERO PRINT USING FLAG
0FB3            CALL            ;    VIA THIS CALL
0FB6            OR
0FB7            CALL            ;CVRT FPA1 TO ASCII
0FBA            JP              ;AND PRINT OUT NUMBER
       ;*****
       ;PROCESSING OF DATA VALUES OUTPUT (FLTG PT, INT)
       ;INCLUDES FORMATTING
       ;ENTER AT 0FBDH FROM 111DH, 20C0H (PRINT), 2836H (STR$)
       ;ENTER AT 0FBEH FROM 2DCEH (USING)
       ;*****
0FBD   BINASC   XOR             ;INIT TO CLEAR USGFLG
0FBE   ASCUSG   CALL            ;INIT USGFLG WITH CONVENTS REG A
       ;*****
       ;TEXT FOR USING "+" SPECIFIER
       ;*****
0FC1            AND             ;"+" IS BIT 3 OF USGFLG
0FC3            JR              ;DON'T INIT '+' IF NOT SPECIFIED
0FC5            LD              ;INIT WITH '+'
0FC7   Z0FC7    EX              ;TEST IF POS OR NEG
0FC8            CALL            ;SIGN FLAG SET AS TO SIGN
0FCB            EX              ;DE NOW HAS THE FPA1 INTEGER
0FCC            JP              ;BYPASS IF POSITIVE INTEGER
0FCF            LD              ;ELSE INSERT '-'
0FD1            PUSH            ;TAKE ABS VALUE
0FD2            PUSH
0FD3            CALL
0FD6            POP
0FD7            POP
0FD8            OR
0FD9   Z0FD9    INC             ;INSERT ASCII ZERO
0FDA            LD              ;AT NEXT BUFFER POS
0FDC            LD              ;P/U USING CONTROL BYTE
0FDF            LD
0FE0            RLA             ;SET CARRY IF BIT 7 ON
```

```
0FE1          LD
0FE4          JP             ;JUMP IF USGFLG HAS BIT 7 ON
0FE7          JP             ;JUMP IF USGFLG OFF (NOT USING)
0FEA          CP             ;JUMP IF DBL OR SNGL
0FEC          JP
0FEF          LD             ;NO COMMAS OR DEC PTS, NBR IS INTEGER
0FF2          CALL           ;CONVERT INT IN FPA1 TO ASCII AT ASCBUF
0FF5   Z0FF5  LD
0FF8          LD             ;P/U 1ST BUF CHAR (SPACE)
0FF9          LD             ;SPACE
0FFB          LD
0FFE          LD             ;TEST FOR '*' FUNCTION
0FFF          AND
1001          JR             ;BYPASS IF NOT "*" SPECIFIED
1003          LD             ;XFR BUF CHAR TO A
1004          CP             ;CPR WITH SPACE
1005          LD             ;'*'
1007          JR             ;JUMP IF BUF CHAR NOT SPACE
1009          LD             ;REPL B WITH "*"
100A   Z100A  LD             ;REPL BUF CHAR WITH "*"
100B          RST            ;P/U NEXT CHAR OR
100C          JR             ;JUMP IF AT END OF BUFFER
100E          CP             ;'E'?
1010          JR
1012          CP             ;'D'?
1014          JR
1016          CP             ;'0'?
1018          JR
101A          CP             ;','?
101C          JR
101E          CP             ;'.'?
1020          JR
1022   Z1022  DEC
1023          LD             ;INSERT ASCII ZERO
1025   Z1025  LD             ;CK USGFLG FOR BIT 4
1026          AND
1028          JR             ;JP IF NOT SPECIFIED
102A          DEC            ;INSERT FLOATING $
102B          LD
102D   Z102D  LD             ;CK USGFLG FOR BIT 2
102E          AND
1030          RET            ;RETURN IF SPECIFIED
1031          DEC
1032          LD             ;INSERT '*'
1033          RET
       ;*****
       ;ROUTINE TO INIT USGFLG
       ;*****
1034   Z1034  LD             ;MOVE CONTENTS OF ACCUM TO USING FLAG
1037          LD
```

```
103A            LD
103C            RET
        ;*****
        ;ROUTINE TO CONVERT SNGL OR DBL TO ASCII
        ;*****
103D    Z103D   CP              ;SET C FLAG IF SNGL
103F            PUSH            ;SAVE BUFFER POINTER
1040            SBC             ;REDUCE TYPE LEN IF SNGL
1042            RLA             ;MUL TYPE BY 2
1043            LD              ;INC THE RESULT BY 1
1044            INC             ;RESULT IS SNGL=7, DBL=17
1045            CALL            ;CONVERT FPA1 TO PROPER RANGE
1048            LD              ;INIT B=3 FOR DEC PTS
104B            ADD             ;ADD FIELD WIDTH TO # OF PLACES SHIFTED
104C            JP              ;JUMP IF SHIFTED > FIELD WIDTH
104F            INC
1050            CP
1051            JR              ;JUMP IF NBR > FIELD
1053            INC
1054            LD  B           ;SET B TO POSITION DEC PT
1055            LD
1057    Z1057   SUB
1059            POP
105A            PUSH
105B            CALL            ;INSERT "," OR "." IF NEEDED
105E            LD              ;INSERT ASCII ZERO
1060            CALL            ;INC HL, RET
1063            CALL            ;CONVERT TO ASCII
1066    Z1066   DEC
1067            LD
1068            CP              ;'0'
106A            JR
106C            CP              ;'.'?
106E            CALL            ;INC HL, RET
1071            POP             ;TEST EXPONENT FOR OUTPUT
1072            JR              ;IF ZERO, DON'T: ELSE DO 'E' OR 'D'
1074    INSEXP  PUSH            ;SAVE EXPONENT VALUE
1075            RST             ;SET C-FLAG IF SNGL, RESET IF DBL
1076            LD              ;22H + 22H + 0 (DBL) = "D"
1078            ADC             ;22H + 20H + 1 (SNGL)= "E"
1079            LD              ;INSERT "D" OR "E" INTO BUFFER
107A            INC
107B            POP             ;NEXT 3 INST INSERT EXPONENT SIGN
107C            LD              ;INSERT '+'
107E            JP              ;BYPASS IF POS
1081            LD              ;ELSE INSERT '-'
1083            CPL
1084            INC             ;CONVERT HEX 00-63 TO DEC 00-99
1085    Z1085   LD
1087    Z1087   INC
```

```
1088            SUB
108A            JR
108C            ADD
108E            INC
108F            LD              ;INSERT 1ST EXP DIGIT
1090            INC
1091            LD              ;INSERT 2ND EXP DIGIT
1092   Z1092    INC
1093   Z1093    LD              ;INSERT END-OF-BUFFER MARK
1095            EX
1096            LD
1099            RET
       ;*****
       ;HERE FROM OFE4H IF USGFLG HAS BIT 7 ON
       ;*****
109A   Z109A    INC
109B            PUSH
129C            CP              ;CPR VARTYP TO 4
109E            LD               RECOVER USGFLG
109F            JP              ;JP IF FPA1 IS SNGL OR DBL
10A2            RRA             ;JP IF SCIENTIFIC NOTATION
10A3            JP              ;REQUESTED (USGFLG BIT 0 SET)
10A6            LD              ;INIT FOR INTEGER
10A9            CALL            ;TEST USGFLG BIT 6
10AC            POP             ;RCVR DEC PT CTR IN D
10AD            LD
10AE            SUB
10B0            CALL            ;INSERT "A" ZEROES
10B3            CALL            ;CONVERT FROM POWER-OF-TEN TABLE
10B6   Z10B6    LD              ;TEST COMMA COUNTER
10B7            OR
10B8            CALL            ;"DEC HL, RET"
10BB            DEC
10BC            CALL            ;INSERT "A" ZEROES
10BF   Z10BF    PUSH
10C0            CALL
10C3            POP
10C4            JR
10C6            LD
10C7            INC
10C8   Z10C8    LD
10CA            LD
10CD   Z10CD    INC
10CE   Z10CE    LD              ;P/U PTR TO DEC PT IN BUFFER
10D1            SUB
10D2            SUB
10D3            RET
10D4            LD
10D5            CP              ;SPACE?
10D7            JR
```

```
10D9            CP              ;'*'?
10DB            JR
10DD            DEC
10DE            PUSH
10DF    Z10DF   PUSH
10E0            LD
10E3            PUSH
10E4            RST
10E5            CP              ;'-'?
10E7            RET
10E8            CP              ;'+'?
10EA            RET
10EB            CP              ;'$'?
10ED            RET
10EE            POP
10EF            CP              ;'0'?
10F1            JR
10F3            INC
10F4            RST
10F5            JR
10F7            DEC
10F8            DEFB    1       ;HIDE NEXT 2 INST WITH 'LD BC'
10F9    Z10F9   DEC
10FA            LD
10FB            POP
10FC            JR
10FE            POP
10FF            JP
1102    Z1102   POP
1103            JR
1105            POP
1106            LD              ;INSERT '%' OVERFLOW IND
1108            RET
        ;*****
        ;HERE IF FPA1 IS SNGL OR DBL & NO SCIENTIFIC NOTATION
        ;*****
1109    Z1109   PUSH
110A            RRA             ;TEST USGFLG(0) FOR SCIENTIFIC
110B            JP              ;JUMP IF WANT IT
110E            JR              ;JUMP IF FPA1 WAS SNGL (TESTED @ 109C)
1110            LD              ;1D+16
1113            CALL            ;FPA2 VS 1D+16
1116            LD              ;INIT FOR 16 DIGIT FIELD
1118            JP              ;JP IF < 1D+16
111B    Z111B   POP             ;ELSE CONVERT & ADD OVRFLW
111C            POP             ;SINCE NBR EXCEEDS FIELD
111D            CALL            ;CONVERT NBR TO ASCII
1120            DEC
1121            LD              ;INSERT '%' OVRFLW IND
1123            RET
```

```
        ;*****
        ;HERE ON SNGL & NO SCIENTIFIC NOTATION
        ;*****
1124  Z1124   LD                ;1E+16 -> BCDE
1127          LD
112A          CALL              ;CPR FPA1 TO 1E+16
112D          JP                ;JP IF < 1E+16 FOR OVRFLW
1130          LD                ;INIT FOR 6 DIGIT FIELD
1132  Z1132   CALL              ;TEST SIGN OF FPA1
1135          CALL              ;PUT IN RANGE IF <> 0
1138          POP
1139          POP
113A          JP                ;JP IF SMALLER THAN RANGE
113D          PUSH
113E          LD
113F          LD
1140          SUB
1141          SUB
1142          CALL              ;"A" ZEROES INTO BUFFER
1145          CALL
1148          CALL              ;CONVERT TO ASCII
114B          OR
114C          CALL
114F          OR
1150          CALL              ;CK ON "," OR "." NEEDED
1153          POP
1154          JP
        ;*****
        ;HERE ON SNGL OR DBL, NO SCIENTIFIC, NBR < RANGE
        ;*****
1157  Z1157   LD
1158          LD
1159          OR
115A          CALL              ;DEC A, RET
115D          ADD
115E          JP
1161          XOR
1162  Z1162   PUSH
1163          PUSH
1164  Z1164   CALL              ;IF NEG., DIV. 10
1167          JP                ;IF STILL NEG., DIV 10
116A          POP
116B          LD
116C          SUB
116D          POP
116E          LD
116F          ADD
1170          LD
1171          JP
```

```
1174          SUB
1175          SUB
1176          CALL              ;"A" ZEROES -> BUFFER
1179          PUSH
117A          CALL
117D          JR
117F   Z117F  CALL              ;"A" ZEROES -> BUFFER
1182          LD
1183          CALL
1186          LD
1187          XOR
1188          SUB
1189          SUB
118A          CALL              ;"A" ZEROES -> BUFFER
118D          PUSH
118E          LD
118F          LD
1190   Z1190  CALL              ;CONVERT HEX TO ASCII
1193          POP
1194          OR
1195          JR
1197          LD                ;DEC PT PTR -> HL
119A   Z119A  ADD
119B          DEC
119C          CALL              ;"A" ZEROES -> BUFFER
119F          LD
11A0          JP
       ;*****
       ;HERE IF INTEGER & SCIENTIFIC NOTATION REQUESTED
       ;*****
11A3   Z11A3  PUSH
11A4          PUSH
11A5          CALL              ;CONVERT INTEGER TO SNGL
11A8          POP
11A9          XOR
       ;*****
       ;HERE IF SNGL OR DBL & SCIENTIFIC NOTATION REQUESTED
       ;*****
11AA   Z11AA  JP
11AD          LD                 INIT FOR 16 DIGIT FIELD
11AF          DEFB    1         ;HIDE NEXT INST WITH 'LD BC'
11B0   Z11B0  LD                ;INIT SNGL FOR 6-DIGIT FIELD
11B2          CALL
11B5          SCF
11B6          CALL              ;CONVERT FPA1 TO RANGE IF <> 0
11B9          POP
11BA          POP
11BB          PUSH
11BC          LD
11BD          OR
```

```
11BE           PUSH
11BF           CALL          ;DEC A, RET
11C2           ADD
11C3           LD
11C4           LD            ;SET D TO -1 IF USGFLG(2)
11C5           AND            IS SET OR SET D TO +1 IF
11C7           CP            ;USGFLG(2) RESET
11C9           SBC           ;BIT 2 USED FOR '-' AT END
11CA           LD            ;OF FIELD
11CB           ADD
11CC           LD
11CD           SUB
11CE           PUSH
11CF           PUSH
11D0   Z11D0   CALL
11D3           JP
11D6           POP
11D7           POP
11D8           PUSH
11D9           PUSH
11DA           JP
11DD           XOR
11DE   Z11DE   CPL
11DF           INC
11E0           ADD
11E1           INC
11E2           ADD
11E3           LD
11E4           LD
11E6           CALL          ;CONVERT HEX TO ASCII
11E9           POP
11EA           CALL
11ED           POP
11EE           POP
11EF           CALL          ;DEC HL, RET
11F2           POP
11F3           JR
11F5           ADD
11F6           SUB
11F7           SUB
11F8   Z11F8   PUSH
11F9           CALL          ;INSERT THE EXPONENT
11FC           EX
11FD           POP
11FE           JP
       ;*****
       ;ROUTINE TO PUT FPA1 IN THE RANGE 1E+5 TO 1E+6 IF SNGL
       ;       FPA1 IN THE RANGE 1D+15 TO 1D+16 IF DBL
       ;*****
1201   Z1201   PUSH
```

```
1202            XOR
1203            PUSH
1204            RST
1205            JP              ;JUMP IF SNGL
1208    Z1208   LD
120B            CP              ;65536
120D            JP              ;JP WHEN EXP EXCEEDS 2**16
1210            LD              ;1D+10
1213            LD              ;XFR 1D+10 TO FPA2
1216            CALL
1219            CALL            ;MULTIPLY FPA1 BY 1D+10
121C            POP
121D            SUB             ;ADJUST COUNTER
121F            PUSH
1220            JR
        ;*****
        ;"      THIS PUTS FPA1 ABOVE MIN VALUE (1E+5/1D+15)
        ;*****
1222    Z1222   CALL
1225    Z1225   RST
1226            JR              ;JUMP IF DBL
1228            LD              ;1E+5 -> BCDE
122B            LD
122E            CALL            ;CPR SNGL TO 1E+5
1231            JR
1233    Z1233   LD              ;1D+15
1236            CALL            ;CPR DBL TO 1D+15
1239    Z1239   JP              ;JP IF FPA1 > MIN VALUE
123C            POP             ;ELSE RCVR COUNTER
123D            CALL            ;AND RAISE BY POWER OF TEN
1240            PUSH            ;SAVE COUNTER
1241            JR
1243    Z1243   POP             ;FPA1 EXCEEDS MAX, RCVR
1244            CALL            ;THE COUNTER AND REDUCE BY
1247            PUSH            ;A POWER OF TEN
1248            CALL
124B    Z124B   POP             ;RCVR SHIFT COUNTER
124C            OR              ;AND TEST SIGN
124D            POP             ;RCVR BUFFER POINTER
124E            RET
        ;*****
        ;THIS PUTS FPA1 BELOW MAX VALUE (1E+6/1D+16)
        ;*****
124F    Z124F   RST
1250            JP              ;JUMP IF NOT SNGL
1253            LD              ;1E+6 -> BCDE
1256            LD
1259            CALL            ;CPR SNGL TO MAX VALUE
125C            JR
125E    Z125E   LD              ;1D+16
```

```
1261            CALL            ;CPR DBL TO MAX VALUE
1264   Z1264    POP             ;POP RETURN ADDRESS
1265            JP              ;JP IF FPA1 > MAX VALUE
1268            JP              ;ELSE RETURN
       ;*****
       ;LOAD ZEROES -> ASCBUF FOR AS MANY BYTES AS COUNT IN REG A
       ;*****
1269   Z1269    OR
126A   Z126A    RET
126B            DEC
126C            LD              ;INSERT ASCII ZERO
126E            INC
126F            JR
       ;*****
       ;LOADS ZEROES -> ASCBUF FOR COUNT OF REG A
       ;& INSERTS COMMAS AS NEEDED PLUS THE DECIMAL POINT
       ;*****
1271   Z1271    JR
1273   Z1273    RET
1274            CALL
1277   Z1277    LD
1279            INC
127A            DEC
127B            JR
       ;*****
       ;
       ;*****
127D   Z127D    LD
127E            ADD
107F            INC
1280            LD
1281            INC
1282   Z1282    SUB
1284            JR
1286            ADD
1288            LD
1289   Z1289    LD
128C            AND             ;TEST BIT 6 FOR COMMA
128E            RET
128F            LD
1290            RET
       ;*****
       ;ROUTINE TO INSERT "," OR "." AS NEEDED
       ;*****
1291   Z1291    DEC
1292            JP
```

```
      ;*****
      ;ROUTINES TO CONVERT HEX DATA TO ASCII CHARACTERS
      ;*****
12A4  Z12A4   PUSH
12A5          RST
12A6          JP              ;JUMP IF SNGL
12A9          PUSH
12AA          PUSH
12AB          CALL            ;XFR DATA FROM FPA1 TO FPA2
12AE          LD              ;0.5
12B1          CALL            ;XFR FM MEM TBL TO FPA1
12B4          CALL
12B7          XOR
12B8          CALL
12BB          POP
12BC          POP
12BD          LD              ;PT TO DBL CONV TBL
12C0          LD              ;LOOP 12DE-12C2 10 TIMES
12C2  Z12C2   CALL            ;"," OR "." NEEDED?
12C5          PUSH
12C6          PUSH
12C7          PUSH
12C8          PUSH
12C9          LD              ;INIT TO COUNT THE SUBTRACTS
12CB  Z12CB   INC
12CC          POP
12CD          PUSH
12CE          CALL            ;SUB MANT (HL) FM (411D)
12D1          JR
12D3          POP
12D4          CALL            ;ADD MANT (HL) TO (411D)
12D7          EX
12D8          POP
12D9          LD              ;COUNT INTO BUFFER
12DA          INC             ;PT TO NEXT ASCBUF POS
12DB          POP             ;RECOVER LOOP COUNT
12DC          POP
12DD          DEC             ;DEC LOOP COUNT
12DE          JR              ;END OF DO LOOP
12E0          PUSH
12E1          PUSH
12E2          LD
12E5          CALL            ;(HL) -> FPA1
12E8          JR
      ;*****
      ;HERE IF SINGLE PRECISION
      ;*****
12EA  Z12EA   PUSH
12EB          PUSH
```

```
12EC            CALL           ;0.5 + FPA1
12EF            INC
12F0            CALL
12F3            CALL           ;BCDE -> FPA1
12F6   Z12F6    POP
12F7            POP
12F8            XOR
12F9            LD             ;PT TO SNGL CONV VALUES
12FC   Z12FC    CCF   C-FLG (RESET 2ND TIME LOOP)
12FD            CALL           ;CK IF '.' OR ',' NEEDED
1300            PUSH
1301            PUSH
1302            PUSH           ;SAVE BUFFER POINTER
1303            PUSH
1304            CALL           ;FPA1 -> BCDE
1307            POP
1308            LD             ;INIT ACCUM
130A   Z130A    INC            ;ACCUMULATE INTO REG B
130B            LD             ;HOW MANY TIMES THE
130C            SUB            ;CONV VALUE CAN BE
130D            LD             ;SUBTRACTED FROM THE
130E            INC            ;MANTISSA (DECIMAL)
130F            LD
1310            SBC
1311            LD
1312            INC
1313            LD
1314            SBC
1315            LD
1316            DEC            ;PT TO 1ST TABLE BYTE AGAIN
1317            DEC
1318            JR
131A            CALL           ;ADD BACK 3 BYTES (HL) + EDC
131D            INC            ;PT TO NEXT TABLE VALUE
131E            CALL           ;BCDE -> FPA1
1321            EX             ;TABLE PTR -> DE
1322            POP
1323            LD             ;INSERT ASCII VALUE INTO
1324            INC            ;BUFFER & ADVANCE POINTER
1325            POP
1326            POP
1327            JR
1329            INC            ;PT TO INTEGER TABLE @ 1000
132A            INC
132B            LD             ;ONLY 4 VALUES LEFT
132D            JR
       ;*****
       ;        CONVERT INTEGER TO ASCII
       ;*****
132F   Z132F    PUSH
```

```
1330            LD                  ;POWER OF 10 TABLE
1333            LD                  ;HAS 5 VALUES
1335  Z1335     CALL                ;NEED '.' OR ','?
1338            PUSH
1339            PUSH
133A            PUSH
133B            EX                  ;TABLE PTR -> HL
133C            LD                  ;TABLE VALUE -> STACK
133D            INC
133E            LD
133F            PUSH
1340            INC
1341            EX                  ;PTR TO STACK & VALUE TO HL
1342            EX                  ;TABLE VALUE -> DE
1343            LD                  ;& INTEGER -> HL
1346            LD                  ;INIT DECIMAL COUNTER
1348  Z1348     INC                 ;ACCUM # OF TIMES WE CAN
1349  Z1349     LD                  ;SUBTRACT THE CURRENT
134A            SUB                 ;POWER OF TEN INTO REG B
134B            LD
134C            LD
134D            SBC
134E            LD
134F            JR
1351            ADD                 ;ADD BACK ONE TIME
1352            LD                  ;UPDATE INTEGER VALUE
1355            POP
1356            POP
1357            LD                  ;PLACE ASCII DIGIT INTO BUF
1358            INC                 ;& PT TO NEXT BUFFER POS
1359            POP                 ;RECOVER DIGIT PLACE COUNTER
135A            POP
135B            DEC                 ;POSITION COUNT DOWN
135C            JR                  ;GO BACK FOR NEXT POSITION
135E            CALL                ;SEE IF '.' OR ',' NEEDED
1361            LD                  ;INSERT HEX ZERO INTO BUFFER
1362            POP
1363            RET
      ;*****
      ;VARIOUS DATA VALUES & CONVERSION CONSTANTS
      ;*****
1364  Z1364     DEFW     0          ;1D+10
1366            DEFW     0
1368            DEFW     2F9H
136A            DEFW     0A215H
136C  Z136C     DEFW     0FFFDH     ;1D+15
136E            DEFW     319FH
1370            DEFW     5FA9H
1372            DEFW     0B263H
1374  Z1374     DEFW     0FFFEH     ;1D+16
```

```
1376            DEFW    0BF03H
1378            DEFW    1BC9H
137A            DEFW    0B60EH
137C   HALF     DEFW    0        ;0.5
137E            DEFW    0
1380   Z1380    DEFW    0
1382            DEFW    8000H
1384   Z1384    DEFW    0        ;1D+16
1386            DEFW    0BF04H
1388            DEFW    1BC9H
138A            DEFW    0B60EH
       ;*****
       ;TEN GROUPS OF 7 BYTES EACH FOR CONVERSIONS OF DBL PREC
       ;*****
138C   Z138C    DEFW    8000H    ;1D+16
138E            DEFW    0A4C6H
1390            DEFW    8D7EH
1392            DEFB    3
       ;*****
1393            DEFW    4000H    ;1D+15
1395            DEFW    107AH
1397            DEFW    5AF3H
1399            DEFB    0
       ;*****
139A            DEFW    0A000H   ;1D+14
139C            DEFW    4E72H
139E            DEFW    918H
13A0            DEFB    0
       ;*****
13A1            DEFW    1000H    ;1D+13
13A3            DEFW    0D4A5H
13A5            DEFW    0E8H
13A7            DEFB    0
       ;*****
13A8            DEFW    0E800H   ;1D+12
13AA            DEFW    4876H
13AC            DEFW    017H
13AE            DEFB    0
       ;*****
13AF            DEFW    0E400H   ;1D+11
13B1            DEFW    540BH
13B3            DEFW    2
13B5            DEFB    0
       ;*****
13B6            DEFW    0CA00H   ;1D+10
13B8            DEFW    3B9AH
13BA            DEFW    0
13BC            DEFB    0
       ;*****
13BD            DEFW    0E100H   ;1D+9
```

```
13BF            DEFW    5F5H
13C1            DEFW    0
13C3            DEFB    0
        ;*****
13C4            DEFW    9680H   ;1D+8
13C6            DEFW    98H
13C8            DEFW    0
13CA            DEFB    0
        ;*****
13CB            DEFW    4240H   ;1D+7
13CD            DEFW    0FH
13CF            DEFW    0
13D1            DEFB    0
        ;*****
        ;TWO CONSTANTS TO CONVERT REAL TO ASCII
        ;*****
13D2    Z13D2   DEFW    86A0H   ;1E+6
13D4            DEFB    1
        ;*****
13D5            DEFW    2710H   ;1E+5
13D7            DEFB    0
        ;*****
        ;POWER OF 10 TABLE FOR CONVERTING INTEGERS TO DECIMAL ASCII
        ;*****
13D8    Z13D8   DEFW    10000
13DA            DEFW    1000
13DC            DEFW    100
13DE            DEFW    10
13E0            DEFW    1
        ;*****
        ;ROUTINE STACKS A CALL TO CHANGE SIGN OF RESULT IN FPA1
        ;*****
13E2    Z13E2   LD
13E5            EX
13E6            JP
        ;*****
        ;PROCESS SQR(X) : USES POWER & EXP FUNCTIONS
        ;       ALGORITHM RAISES FPA1 TO 0.5 POWER
        ;*****
13E7    SQR     CALL            ;FPA1 -> STACK
13EA            LD              ;0.5 -> FPA1
13ED            CALL
13F0            JR
        ;*****
        ;PROCESS RAISING TO A POWER  :  X POWER Y
        ;     ALGORITHM FINDS Z SUCH THAT EXP(Z) = X POWER Y
        ;      I.E. Z = Y * LOG(X)
        ;     THEN USES EXP(X) FUNCTION TO TAKE EXP(Z)
        ;*****
13F2    POWER   CALL            ;Y -- ↑
```

```
13F5  Z13F5   POP
13F6          POP
13F7          CALL         ;POWER FOR M, Z, P
13FA          LD
13FB          JR           ;IF POWER = 0
13FD          JP
1400          OR           ;BASE FOR ZERO (POWER IS NEG)
1401  Z1401   JP           ;BY ZERO ERROR
1404  Z1404   OR
1405          JP           ;ZEROES EXPONENT & RETURNS
1408          PUSH         ;SAVE X
1409          PUSH
140A          LD
140B          OR           ;ONES TO ALL BUT SIGN BIT
140D          CALL         ;FPA1 -> BCDE
1410          JP           ;JUMP ON POS X
1413          PUSH         ;SAVE X AGAIN
1414          PUSH
1415          CALL         ;FIND INT(Y)
1418          POP          ;RECOVER X
1419          POP
141A          PUSH
141B          CALL
141E          POP
141F          LD
1420          RRA
1421  Z1421   POP          ;STACK -> FPA1
1422          LD
1425          POP
1426          LD
1429          CALL         ;INIT TO CHG SIGN OF RESULT
142C          CALL         ;CHG SIGN OF FPA1
142F          PUSH
1430          PUSH
1431          CALL         ;TAKE LOG(X)
1434          POP
1435          POP
1436          CALL         ;Y * LOG(X)
      ;*****
      ;PROCESS EXP(X) FUNCTION
      ;*****
1439  EXP     CALL         ;SAVE X ON STACK
143C          LD           ;1.4427 (BASE 2 LOG OF E)
143F          LD
1442          CALL         ;X * 1.4427 -> FPA1
1445          LD
1448          CP           ;128
144A          JP           ;OVRFLW IF >=127
144D          CALL         ;TAKE INT(FPA1)
1450          ADD
```

```
1452            ADD
1454            JP
1457            PUSH
1458            LD                  ;1.0
145B            CALL                ;1.0 + FPA1
145E            CALL                ;.693147 * ( 1.0 + FPA1 )
1461            POP
1462            POP                 ;RCVR X
1463            POP
1464            PUSH
1465            CALL                ;X - ABOVE RESULT
1468            CALL
146B            LD                  ;PT TO COMP TABLE
146E            CALL                ;PERFORM SERIES CALC
1471            LD                  ;RECOVER EXPONENT ONLY
1474            POP
1475            LD
1476            JP                  ;& MULTIPLY BY PREV RESULT
        ;*****
        ;DATA VALUES FOR COMPUTING EXP(X)
        ;*****
1479    EXPTBL  DEFB    8           ;8 CONSTANTS FOR EXP POWER SERIES
147A            DEFW    2E40H       ;-1.41316E-14
147C            DEFW    7494H
147E            DEFW    4F70H       ;1.32988E-3
1480            DEFW    772EH
1482            DEFW    26EH        ;-8.30136E-3
1484            DEFW    7A88H
1486            DEFW    0A0E6H      ;0.0416574
1488            DEFW    7C2AH
148A            DEFW    0AA50H      ;-0.166665
148C            DEFW    7FAAH
148E            DEFW    0FFFFH      ;0.5
1490            DEFW    7F7FH
1492            DEFW    0           ;-1.0
1494            DEFW    8180H
1496            DEFW    0           ;1.0
1498            DEFW    8100H
        ;*****
        ;ROUTINE TO PROCESS SERIES CALCULATIONS
        ;       ALGORITHM COMPUTES : SIGMA C(I) * X**2I
        ;       EX) C1 * X**6 + C2 * X**4 + C3 * X**2
        ;*****
149A    Z149A   CALL                ;FPA1 -> STACK
149D            LD                  ;ESTAB RET TO 'STACK * FPA1'
14A0            PUSH
14A1            PUSH                ;SAVE TABLE PTR
14A2            CALL                ;FPA1 -> BCDE
14A5            CALL
14A8            POP
```

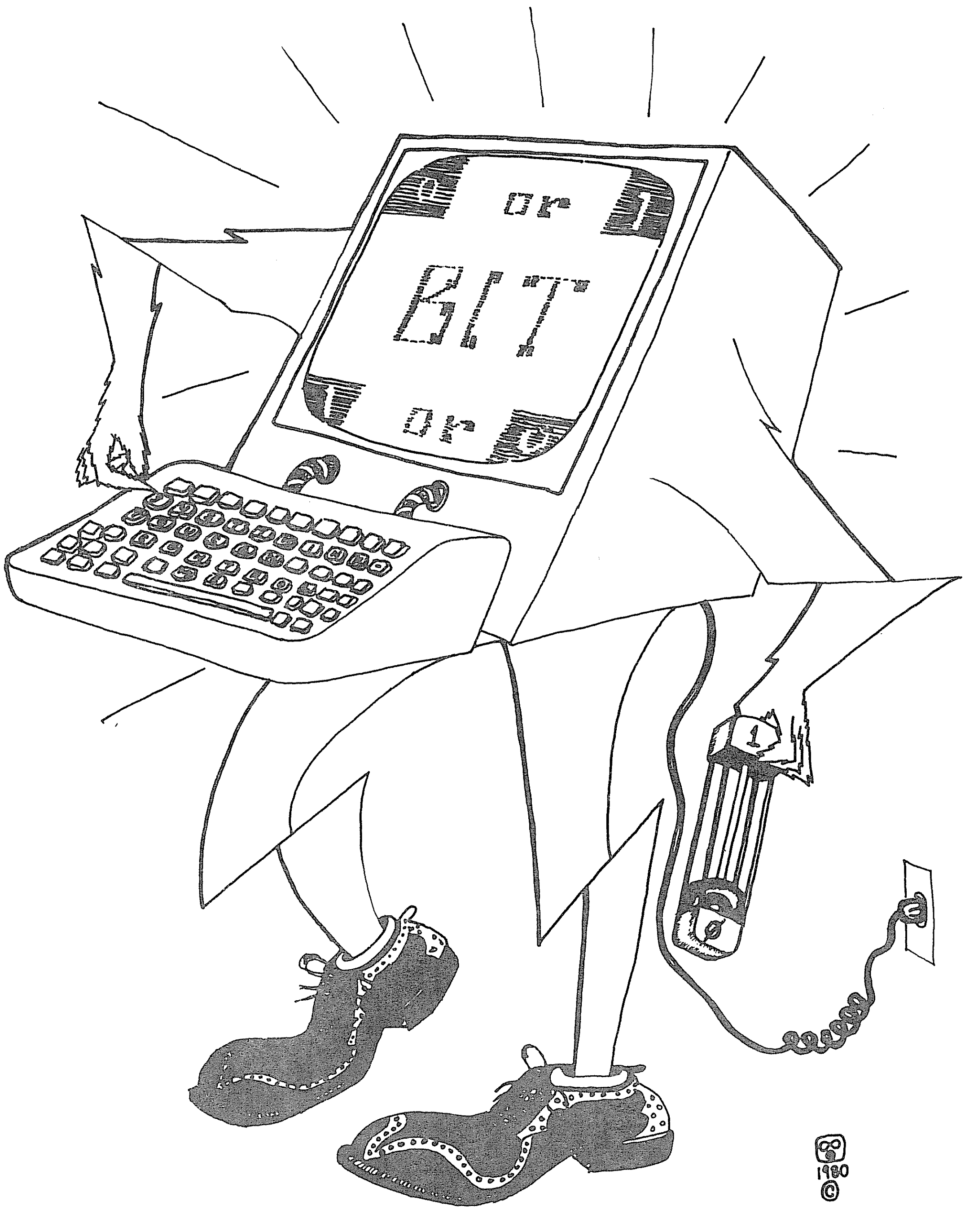
```
14A9  Z14A9   CALL             ;FPA1 -> STACK
14AC          LD               ;P/U CTR TO TABLE ENTRIES
14AD          INC              ;PT TO NEXT TABLE VALUE
14AE          CALL             ;VALUE TO FPA1
14B1          DEFB     6       ;HIDE NEXT INST WITH 'LD B'
14B2  Z14B2   POP              ;RECOVER TABLE COUNTER
14B3          POP              ;STACK TO BCDE
14B4          POP
14B5          DEC              ;DEC CTR & RET IF LAST VALUE
14B6          RET
14B7          PUSH             ;BCDE -> STACK
14B8          PUSH
14B9          PUSH             ;SAVE TABLE COUNTER
14BA          PUSH             ;SAVE PTR TO NEXT VALUE
14BB          CALL             ;BCDE * FPA1 -> FPA1
14BE          POP              ;NEXT TABLE VALUE -> BCDE
14BF          CALL
14C2          PUSH             ;& SAVE PTR TO NEXT VALUE
14C3          CALL
14C6          POP              ;RESTORE TABLE PTR & LOOP
14C7          JR
      ;*****
      ;       PROCESS RND(X) FUNCTION
      ;*****
14C9  RND     CALL             ;CVRT ARG TO INTEGER
14CC          LD               ;PROVIDE ERROR IF PARM
14CD          OR               ;EXCEEDS INTEGER BOUNDS
14CE          JP               ;OR IS NEG (FC ERROR)
14D1          OR               ;IF PARM IS ZERO, BYPASS NEXT
14D2          JP               ;PIECE TO RETURN (0-1)
      ;*****
      ;PARM IS > 1; RETURN RND NBR (1-PARM)
      ;*****
14D5          PUSH
14D6          CALL             ;GEN RND NBR (0-1)
14D9          CALL             ;FPA1 -> RFPA
14DC          EX               ;PUT THE RNDNBR (0-1) ONTO
14DD          EX               ;THE STACK & RECOVER THE
14DE          PUSH             ;INTEGER IN REG HL
14DF          CALL             ;CVRT HL TO SNGL IN FPA1
14E2          POP              ;RCVR (0-1) -> RFPA
14E3          POP
14E4          CALL             ;MULT (0-1) BY PARM
14E7          LD
14EA          CALL             ;ADD ONE TO ABOVE RESULT -> FPA1
14ED          JP               ;FIND INTEGER PART OF FPA1
                               ;& CVRT TO SINGLE PREC
      ;*****
      ;       GENERATE A RANDOM NUMBER BETWEEN 0 AND 1
      ;*****
```

```
14F0  RNDO    LD        ;PT TO MULTIPLIER CONSTANT
14F3          PUSH      ;AND SAVE PTR FOR NOW
14F4          LD        ;ZERO OUT MANTISSA RFPA
14F7          LD
14F8          LD        ;INIT TO MULT 3 BYTES
14FA  Z14FA   LD        ;INIT FOR 8 BITS PER BYTE
14FC  Z14FC   EX        ;*****
14FD          ADD       ;MULT VALUE IN DE BY 2
14FE          EX        ;*****
14FF          LD        ;*****
1500          RLA       ;MULT VALUE IN REG C BY 2
1501          LD        ;*****
1502          EX        ;EXCHANGE "SEED"
1503          LD        ;MULTIPLYING BY CONTENTS OF
1504          RLCA      ;4090, OR 4091, OR 4092
1505          LD        ;BY 2
1506          EX        ;EXCH BACK TO P/U COUNTER
1507          JP        ;JUMP IF END OF THIS ITERATION
150A          PUSH      ;SAVE LOOP COUNTER
150B          LD        ;*****
150E          ADD       ;ADD THE 3-BYTE SEED AT
150F          EX        ;40AAH - 40ACH TO THE
1510          LD        ;RFPA MANTISSA
1513          ADC
1514          LD        ;*****
1515          POP       ;POP LOOP COUNTER
1516  Z1516   DEC       ;DECREMENT BIT LOOP
1517          JP        ;GO BACK IF < 8
151A          EX        ;*****
151B          INC       ;ADVANCE 4090 -> 4091 -> 4092
151C          EX        ;*****
151D          DEC       ;DECREMENT BYTE COUNTER
151E          JP        ;GO BACK IF < 3
1521          POP       ;POP TO MAINTAIN STACK INTEGRITY
1522          LD        ;*****
1525          ADD       ;ADD 372837 TO MANTISSA
1526          LD        ;IN 2 STEP OPERATION.
1529          CALL      ;CHG TYPFLG TO SNGL
152C          LD        ;REST OF 3 BYTE ADD
152E          ADC
152F          LD
1532          EX
1533          LD        ;1/2 -> EXPONENT
1535          LD
1538          LD
1539          DEC
153A          LD
153B          LD
153C          LD
153E          JP
```

```
      ;*****
      ;PROCESS COS(X) : USES SIN(X)
      ;*****
1541  COS     LD               ;1.5708 (PI/2)
1544          CALL             ;(PI/2) + FPA1 -> FPA1
      ;*****
      ;PROCESS SIN(X) FUNCTION
      ;*****
1547  SIN     CALL             ;FPA1 -> STACK
154A          LD               ;6.28319 (2 PI)
154D          LD
1550          CALL             ;BCDE -> FPA1
1553          POP
1554          POP              ;RECOVER X
1555          CALL             ;X / 2PI
1558          CALL             ;X / 2PI -> STACK
155B          CALL             ;TAKE INT(X/2PI)
155E          POP
155F          POP              ;RECOVER X/2PI
1560          CALL             ;(X/2PI)-INT(X/2PI) -> FPA1
1563          LD               ;0.25
1566          CALL             ;0.25 - ABOVE RESULT
1569          CALL             ;TEST FOR M, Z, P
156C          SCF
156D          JP               ;BYPASS IF POS
1570          CALL             ;ELSE 0.5 + RESULT
1573          CALL             ;TEST FOR M, Z, P
1576          OR
1577  Z1577   PUSH
1578          CALL             ;CHG SIGN OF FPA1
157B          LD               ;0.25
157E          CALL             ;0.5 + FPA1 -> FPA1
1581          POP
1582          CALL
1585          LD               ;PT TO SERIES TABLE
1588          JP               ;& CALC SERIES
      ;*****
      ;DATA VALUES TO COMPUTE SIN(X)
      ;*****
158B  HALFPI  DEFW    0FDBH   ;1.5708 (PI/2)
158D          DEFW    8149H
158F  QUARTR  DEFW    0       ;0.25
1591          DEFW    7F00H
1593  SINTBL  DEFB    5       ;5 CONSTANTS FOR SIN TABLE
1594          DEFW    0D7BAH  ;39.7107
1596          DEFW    861EH
1598          DEFW    2664H   ;-76.575
159A          DEFW    8799H
159C          DEFW    3458H   ;81.6022
159E          DEFW    8723H
```

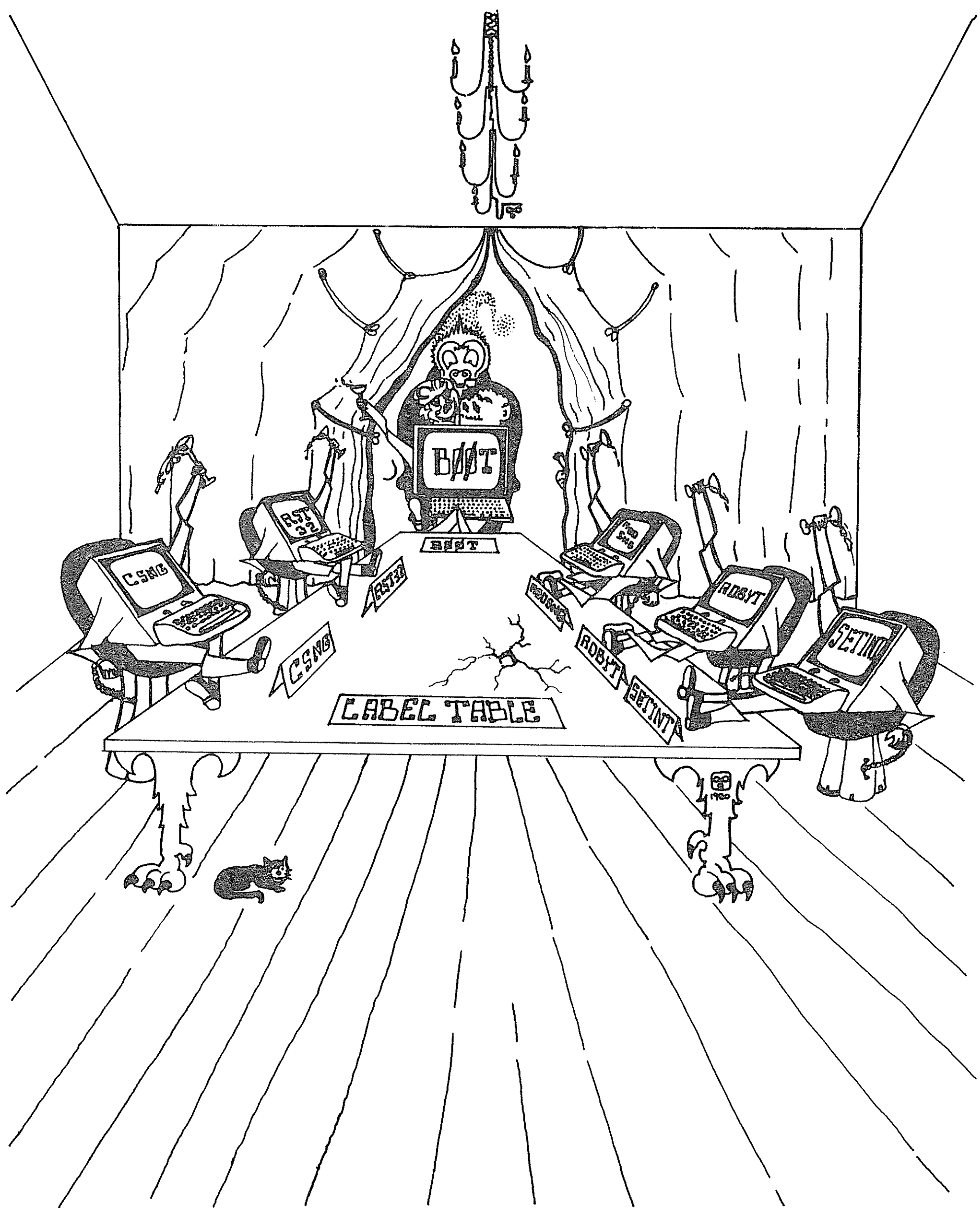
```
15A0            DEFW    5DE0H  ;-41.6022
15A2            DEFW    86A5H
15A4            DEFW    0FDAH  ;6.28319 (2 PI)
15A6            DEFW    8349H
        ;*****
        ;PROCESS TAN(X) : AS SIN(X)/COS(X)
        ;*****
15A8    TAN     CALL           ;FPA1 -> STACK
15AB            CALL           ;CALC SIN(X)
15AE            POP            ;RECOVER X
15AF            POP
15B0            CALL           ;SIN(X) -> STACK
15B3            EX
15B4            CALL           ;X -> FPA1
15B7            CALL           ;CALC COS(X)
15BA            JP             ;SIN(X)/COS(X)
        ;*****
        ;PROCESS ATN(X) FUNCTION
        ;*****
15BD    ATN     CALL           ;TEST X FOR M, Z, P
15C0            CALL           ;INIT TO CHG SIGN OF RESULT
15C3            CALL           ;X < 0, SO MAKE POS NOW
15C6            LD             ;GET EXPONENT
15C9            CP             ;1.0
15CB            JR             ;JUMP IF < ZERO
15CD            LD             ;1.0 -> BCDE
15D0            LD
15D1            LD
15D2            CALL           ;1.0 / X
15D5            LD             ;ESTAB RET ( PI/2 - FPA1 )
15D8            PUSH
15D9    Z15D9   LD             ;PT TO TABLE
15DC            CALL           ;CALC SERIES : C(I) + X**2I
15DF            LD
15E2            RET            ;TO 710H (PI/2 - FPA1)
        ;*****
        ;DATA VALUES TO COMPUTE ATN(X)
        ;*****
15E3    ATNTBL  DEFB    9      ;9 CONSTANTS FOR ATN POWER SERIES
15E4            DEFW    0D74AH ;2.86623E-3
15E6            DEFW    783BH
15E8            DEFW    6E02H  ;-0.0161657
15EA            DEFW    7B84H
15EC            DEFW    0C1FEH ;0.0429096
15EE            DEFW    7C2FH
15F0            DEFW    3174H  ;-0.0752896
15F2            DEFW    7D9AH
15F4            DEFW    3D84H  ;0.106563
15F6            DEFW    7D5AH
15F8            DEFW    7FC8H  ;-0.142089
```

```
15FA            DEFW    7E91H
15FC            DEFW    0BBE4H ;0.199936
15FE            DEFW    7E4CH
1600            DEFW    0AA6CH ;:0.333331
1602            DEFW    7FAAH
1604            DEFW    0      ;1.0
1606            DEFW    81H
```



APPENDIX A: LABEL TABLE

The following list was developed to supply the assembly language programmer with a quick reference to routine entry points, I/O areas, storage areas, and pointers. It was <u>not</u> designed as a complete interfacing guide. Labels listed for the various addresses provide a meaningful code-word giving some indication of the use(s) of the routines or areas. Address locations not described in this volume are either self-explanatory, may be found in Radio Shack reference manuals, or are discussed in other volumes.



Start	End	Label	Description
0000	2FFF	L2ROM	Radio Shack Level II BASIC ROM
0000		CBOOT	ROM Level II Bootstrap
0008		RST8	(Parser) CP (Syntax)/RST16 if =/Else SNERR
000B		WHERE	Resolve Relocation Address
000D		DBOOT	Vector to disk bootstrap
0010		RST16	INC HL. If (HL) is ASCII 0-9 SCF.
			If value is zero, set Z flag. Skips spaces.
0013		INBYT	Input a byte from a device
0018		RST24	CP HL,DE (A lost.)
001B		OUTBYT	Output a byte to a device
0020		RST32	P/U TYPFLG at 40AFH. If <8 SCF. RRT.
			Flags set as a result of type. M=Int.,Z=Str,PO=SNG,NC=DBL
0023		CTLBYT	Output a control byte to a device.
0028		RST40	JP DOS command processor
002B		KBSCAN	Keyboard scan return input in A. (DE lost.)
0030		RST48	Debug breakpoint
0033		CRTBYT	Display byte in 'A' at cursor (DE lost)
0038		RST56	Interrupt Mode 1
003B		LPTBYT	Send byte in 'A' to printer (DE lost)
0040		BUFFNV	Vector to buffer input routine (BUFFIN)
0046		DRIVRV	Vector to I/O driver routine @ 03C2H
0049	004F	GETCHR	Scan keyboard waiting for input. (DE lost)
0050	005F	KBTBL	Table of Special Characters for keyboard routine
0060	0065	DELAY	Delay routine (BC=Counter. 14.66 msec/loop)
0066	0074	NMI	Non-maskable interrupt
0075		CSTLII	Cold start for Level II BASIC
00C4	00D5	MEMSIZ	Determine memory size
0105	0110	DMEMSZ	Data "MEMORY SIZE"
0111	012B	DRSL2B	Data "RADIO SHACK LEVEL II BASIC<CR>"
012D		L3ERR	Level III error
0132	01C8	GRPHCS	Graphics Routines
0132		POINT	Point (Bcmd C6H)
0135		SET	Set (Bcmd 83H)
0138		RESET	Reset (Bcmd 82H)
019D		INKEY	Inkey$ (Bcmd C9H)
01C9		CLS	CLS (Bcmd 84H)
01D3		RANDOM	Random (Bcmd 86H)
01D9	01F7	CWBIT	Write bit to cassette
01F8		CTOFF	Cassette off
01FE		CTON	Cassette on
0212	021D	DEFDRV	Define cassette drive from 'A'
021E	022B	CLRCFF	Clear CFF
0221		STATFF	Change status of CFF from HL
022C	0234	CSTAR	Change star in corner for cassette operations
0235	0240	CRBYTE	Read byte from cassette
0241	0260	CRBIT	Read bit from cassette
0261	0283	CW2BYT	Write byte to cassette twice
0264		CWBYT	Write byte to cassette
0284	0292	CTONWL	Cassette on, write leader and sync. byte
0287		CWLDR	Write leader and sync. byte
0293	02A8	CTONRL	Cassette on, find sync., put stars in corner

Start	End	Label	Description
0296		CRLDR	Find sync., put stars in corner
029F		CSTARS	Put stars in corner
02A9		GSYSTR	Get transfer address for system
02B2		SYSTEM	System entry point
0314	031C	GETADR	Get a 2 byte address from tape (Ret in HL)
031D	0329	SYSGO	Jump to system start address
032A	0347	DSPCHR	Display byte on current device (Device flg @ 409CH)
033A		CRTOUT	Output 'A' to video (DE saved)
0348	0357	POSIND	Line position indicator
0358	0360	KBDSCN	Scan keyboard. (DE NOT LOST)
0361	0383	INCHRS	Input up to 240 chars. into 'HL' buffer. End of line has zero byte.
0384	038A	GTDCHR	Get one char. input from keyboard. (DE saved)
038B	039B	RSTDEV	Reset devices. Set output back to CRT
039C	03C1	LPDCHR	Output byte in 'A' to printer (DE saved)
03C2	03E2	DRIVER	I/O Driver
03E3	0457	KEYIN	Keyboard scan driver
0458	058C	VIDEO	Video display driver
058D	05D8	LPTDRV	Printer driver
05D1		PSTATU	Test printer status. Z Flag set if ready.
05D9	0673	BUFFIN	Buffer input routine
0674	06CF	COLDST	Cold Start
069F		DISKBT	Disk bootstrap
06CC		BASIC	Proper re-entry to Level II BASIC
06D2	06DD	RSTRTS	RST's loaded into RAM starting @ 4000H
0708		ADHALF	FPA1 + 0.5 -> FPA1
070B		ADDHL	(HL) + FPA1 -> FPA1
0710		SUBHL	(HL) - FPA1 -> FPA1
0713		SUBSNG	Subtract single precision
0716		ADDSNG	Add single precision
0778		FPA1EZ	Zero exponent of FPA1
07B2		OVERR	Overflow error
07F8	07FB	ONE1	SNG: 1.0
07FD	0800		SNG: .598979
0801	0804		SNG: .981471
0805	0808		SNG: 2.88539
0809		LOG	Log (Bcmd DFH)
0814	0819	SQR202	SNG: .707107 (SQR(2)/2) into BCDE
0834	0839		SNG: -.5 into BCDE
0841	0846		SNG: .693147 into BCDE
0847		MULSNG	Multiply single precision
0897		DIV10	FPA1 / 10 -> FPA1
08A0		POPFPA	Restores old BCDE from stack
08A2		DIVSNG	Divide single precision
0955	0963	CKRMZP	Tests values for Minus, Zero, or Plus
0977		ABS	ABS (Bcmd D9H)
0982		CHGSGN	Change sign routine
098A		SGN	SGN (Bcmd D7H)
098D		SGNAE	Alternate entry point to SGN
09A4	09B0	STKFP1	Puts a real value onto the stack
09B1		HLFPA1	(HL) --> FPA1

Start	End	Label	Description
09B4		SNGFPA	BCDE (Single precision val.) --> FPA1
09BF		LDFPA1	Load FPA1 into BCDE
09C2		LDFPHL	Load real value pointed to by HL
09CB		FPAMEM	Transfer FPA1 to (HL)
09D2		MOVTDE	Move data from (HL) --> (DE)
09D3		MOVTHL	Move data from (DE) --> (HL)
0A0C		CPRSNG	Compare single precision
0A39		CPRINT	Integer compare
0A78		CPRDBL	Double precision compare
0A7F		CINT	CINT (Bcmd EFH)
0A7F		USRINP	Put 'USR' function argument in HL
0A9A		SAVINT	Save integer in HL to FPA1. Vartyp -> Int (2)
0A9A		USROUT	Make HL output of 'USR' call
0A9D		SETINT	Change TYPFLG to INT
0AA3	0AA8	MINVAL	SNG: -32768 / BCDE
0AB1		CSNG	CSNG (Bcmd F0H)
0AB9		DBLSNG	Convert double to single
0ACC		SNGINT	Convert integer to single
0ACF		HLSNG	Convert HL to single
0ADB		CDBL	CDBL (Bcmd F1H)
0AEC		SETDBL	Change type flag to DBL
0AEF		SETSNG	Change type flag to single
0AF4		CHKSTR	Check type for string and TMERR if not
0AF6		TMERR	Type mismatch error
0B26		FIX	Fix (Bcmd F2H)
0B37		INT	Int (Bcmd D8H)
0B3D	0B58	INTSNG	Take integer of single
0B59	0B9D	INTDBL	Take integer of double
0BC7		SUBINT	Integer subtract
0BD2		ADDINT	Integer add
0BF2		MULINT	Integer multiply
0C5B	0C6F	ABSINT	Take absolute value of integer
0C70		SUBDBL	Subtract double
0C77		ADDDBL	Add double
0D33	0D44	DBLMA	Double precision mantissa addition
0D45	0D56	DBLMS	Double precision mantissa subtract
0DA1		MULDBL	Double precision multiply
0DD4	0DDB	TENDBL	DBL: 10.0
0DE5		DIVDBL	Double precision division
0E65		ASCBIN	Convert ASCII buffer to binary value
0E6C		ASCINT	Convert ASCII buffer to integer value
0F18		DIVTEN	Divide by ten (10)
0FAF		WRLNO	Write current line number to video
0FBD		BINASC	Convert binary value to ASCII
0FBE		ASCUSG	Convert ASCII from 'USING' routine
1364	136B		DBL: 1D+10
136C	1373		DBL: 1D+15
1374	137B		DBL: 1D+16
137C	1384	HLFDBL	DBL: .5
1384	138B		DBL: 1D+16
13D8	13E1	P10TAB	Power of ten table: 10000,1000,100,10,1
13E7		SQR	SQR (Bcmd DDH)

Start	End	Label	Description
13F2		POWER	Raise to a power (Ex: X raised to the N, X**N)
1439		EXP	Exp (Bcmd E0H)
143C	1441		SNG: 1.4427
1479	1499	EXPTBL	Exp data table
147A	147D		SNG: -1.41316E-4
147E	1481		SNG: 1.32988E-3
1482	1485		SNG: -8.30136E-3
1486	1489		SNG: .0416574
148A	148D		SNG: -0.166665
148E	1491	HALF	SNG: .5
1492	1495	NEGONE	SNG: -1.0
1496	1499	ONE2	SNG: 1.0
14C9		RND	Rnd (Bcmd DEH)
1541		COS	Cos (Bcmd E1H)
1547		SIN	Sin (Bcmd E2H)
154A	154F	TWOPI	SNG: 6.28319 (2 PI) / BCDE
158B	15A7	SCDTBL	Sin/Cos data table
158B	158E	HALFPI	SNG: 1.5708 (PI/2)
158F	1592	QUARTR	SNG: .25
1593	15A7	SINTBL	Sin data table
1594	1597		SNG: 39.7107
1598	159B		SNG: -76.575
159C	159F		SNG: 81.6022
15A0	15A3		SNG: -41.3417
15A4	15A7	TWOPI	SNG: 6.28319 (2 PI)
15A8		TAN	Tan (Bcmd E3H)
15BD		ATN	Atn (Bcmd E4H)
15E3	1607	ATNTBL	Arctan data table
15E4	15E7		SNG: 2.86623E-03
15E8	15EB		SNG: -0.0161657
15EC	15EF		SNG: 0.0429096
15F0	15F3		SNG: -0.0752896
15F4	15F7		SNG: 0.106563
15F8	15FB		SNG: -0.142089
15FC	15FF		SNG: 0.199936
1600	1603		SNG: -0.333331
1604	1607	ONE3	SNG: 1.0
1608		FUNTBL	Function Table
1650	1820	BCTBL	BASIC command table (b7 of 1st char. of reserved word high)
1822		CMDTBL	Entry points for command table (BCTBL)
189A		HRCHY	Algebraic heirarchy table
18C9	18F6	ERRTBL	Error abbreviation table
1928	192E	DREADY	Data "READY<CR>"
1930	1934	DBREAK	Data "Break"
1963		CHKMEM	Check if enough memory available
197A		OMERR	Out of memory error
198A		NRERR	No resume error
1997		SNERR	Syntax error
199A		DOERR	Division by zero error
199D		NFERR	Next without For error
19A0		RWERR	Resume without error

Start	End	Label	Description
19A2		ERRPRT	Output an error msg
1A19		ENTLII	Entry point to Level II BASIC
1A25		READY	Load "READY" message
1A5A		ATOOFF	Turn AUTO off
1A60		AUTOON	INC to new AUTO line number
1A76		NOAUTO	Auto-off line input
1B49		NEW	New (Bcmd BBH)
1B4D		INIT	Initialize work area
1BB3		QINPUT	Print "? ". Input up to 240 characters
1BC0		SPACK	Source pack routine
1C90	1C95	RST24	CP HL,DE (A lost)
1C96	1CA0	RST8	(Parser) CP (Syntax). RST16 if equal. Else SNERR.
1CA1		FOR	For (Bcmd 81H)
1D78	1D90	RST16	Inc HL/ If (HL) is ASCII 0-9 SCF. If byte at HL=zero set Z flg. Routine skips spaces.
1D91		RESTOR	Restore (Bcmd 90H)
1DA9		STOP	Stop (Bcmd 94H)
1DAE		END	End (Bcmd 80H)
1DE4		CONT	Cont (Bcmd B3H)
1DE9		CNERR	Can't continue error
1DF7		TRON	Tron (Bcmd 96H)
1DF8		TROFF	Troff (Bcmd 97H)
1E00		DEFSTR	Defstr (Bcmd 98H)
1E03		DEFINT	Defint (Bcmd 99H)
1E06		DEFSNG	Defsng (Bcmd 9AH)
1E09		DEFDBL	Defdbl (Bcmd 9BH)
1E3D		CKA2Z	Check if a character A-Z
1E4A		FCERR	Illegal function call error
1E4F	1E79	GETLN	Scan line for line number
1E4F	1E79	GTLNUM	Get line number
1E5A		CONVRT	Convert bytes in buffer to two-byte DE value
1E7A		CLEAR	Clear (Bcmd B8H)
1EA3		RUN	Run (Bcmd 8EH)
1EB1		GOSUB	Gosub (Bcmd 91H)
1EC2		GOTO	Goto (Bcmd 8DH)
1ED9		ULERR	Undefined line error
1EDE		RETURN	Return (Bcmd 92H)
1EEA		RGERR	Return without Gosub error
1F05		DATA	Data (Bcmd 88H)
1F07		ELSE	Else (Bcmd 95H)
		REM	Rem (Bcmd 93H)
1F21		LET	Let (Bcmd 8CH)
1F6C		ON	On (Bcmd A1H)
1FAF		RESUME	Resume (Bcmd 9FH)
1FF4		ERROR	Error (Bcmd 9EH)
2003		UEERR	Unprintable error
2008		AUTO	Auto (Bcmd B7H)
2039		IF	If (Bcmd 8FH)
2067		LPRINT	Lprint (Bcmd AFH)
206F		PRINT	Print (Bcmd B2H)
20FE		OUTCR	Output a CR to current device

Start	End	Label	Description
2137		TAB	Tab((Bcmd BCH)
2169	2177	COFFIO	If cassette is on, turn off
2178	217D	DREDO	Data "?REDO"
218A		FDERR	Bad file data error
219A		INPUT	Input (Bcmd 89H)
21EF		READ	Read (Bcmd 8BH)
2212		ODERR	Out of data error
227C	2285	PEXTIG	Load "?Extra ignored"
2286	2294	DEXTIG	Data "?Extra ignored"
22A0		ODERR2	Out of data error (also @ 2212H)
22BC		NEXT	Next (Bcmd 87H)
2490		DIVINT	Integer divide
249F		ADD	+ (Bcmd CDH)
249F		FNSCAN	Scan for functions
24A0		MOERR	Missing operand error
24CF		ERR	Err (Bcmd C3H)
24DD		ERL	Erl (Bcmd C2H)
24ED		VARPTR	Varptr (Bcmd C0H)
2532		SUB	- (Bcmd CEH)
25D9		RST32	From RST 32: P/U flag @ 40AFH. If <8 SCF, RRT.
25F7		OR	Or (Bcmd D3H)
25FD		AND	And (Bcmd D2H)
2608		DIM	Dim (Bcmd 8AH)
2733		DDERR	Redimensioned array error
273D		BSERR	Subscript out of range error
27C9		MEM	Mem (Bcmd C8H)
27D4		FRE	Fre (Bcmd DAH)
27F5		POS	Pos (Bcmd DCH)
27FE		USR	Usr (Bcmd C1H)
2831		IDERR	Illegal direct error
2836		STR	Str$ (Bcmd F4H)
28A1		STERR	String formula too complex error
28A7		OUTLN	Output a line until zero (0)
28DB		OSERR	Out of string space error
298F		ADDSTR	Concatenate two strings
29A3		LSERR	String too long error
2A03		LEN	Len (Bcmd F3H)
2A0F		ASC	Asc (Bcmd F6H)
2A1F		CHR	Chr$ (Bcmd F7H)
2A2F		STRING	String$ (Bcmd C4H)
2A61		LEFT	Left$ (Bcmd F8H)
2A91		RIGHT	Right$ (Bcmd F9H)
2A9A		MID	Mid$ (Bcmd FAH)
2AC5		VAL	Val (Bcmd F5H)
2AEF		INP	Inp (Bcmd DBH)
2AFB		OUT	Out (Bcmd A0H)
2B01		STEP	Step (Bcmd CCH)
2B29		LLIST	LList (Bcmd B5H)
2B2E		LIST	List (Bcmd B4H)
2B75		MSGOUT	Output a msg until zero (0)
2B7E		STFUNP	Scan text until zero. Unpack into INBUFP buffer

Start	End	Label	Description
2BC6		DELETE	Delete (Bcmd B6H)
2BF5		CSAVE	CSave (Bcmd BAH)
2C1F		CLOAD	CLoad (Bcmd B9H)
2C8A	2C92	PBAD	Prints "BAD" on screen
2CA5	2CA8	DBAD	Data "BAD<CR>"
2CAA		PEEK	Peek (Bcmd E5H)
2CB1		POKE	Poke (Bcmd B1H)
2CBD		USING	Using (Bcmd BFH)
2E60		EDIT	Edit (Bcmd 9DH)
2FC4		NOT	Not (Bcmd CBH)
37DE		COMSTA	Communication Status Address
37DF		COMDAT	Communication Data Address
37E0		INTLAT	Interrupt Latch Address
37E1		DSELCT	Disk drive select latch address
37E4		CSELCT	Cassette select latch address
37E8		LPTADR	Line printer address
37EC		FDCADR	Floppy disk controller address
37ED		TRKREG	Floppy disk track register
37EE		SECREG	Floppy disk sector register
37EF		DATREG	Floppy disk data register
37F0	37FF		Same as 37E0-37EF
3800	3BFF	KEYMEM	Keyboard memory (1,2,4,8,10,20,40,80H)
3801		KB1	Location for: @ A B C D E F G
3802		KB2	Location for: H I J K L M N O
3804		KB3	Location for: P Q R S T U V W
3808		KB4	Location for: X Y Z
3810		KB5	Location for: 0 1 2 3 4 5 6 7
3820		KB6	Location for: 8 9 : ; , - . / (Also ()*+<=>?)
3840		KB7	Location for: Enter Clear Break Arrow D.Arrow L.Arrow R.Arrow Space
3880		SHIFT	Location for: Shift (Electric pencil control key @ 10H)
3C00	3FFF	CRTMEM	Video display memory
3C00	3C3F	CRTR1	Row 1 on CRT
3C40	3C7F	CRTR2	Row 2
3C80	3CBF	CRTR3	Row 3
3CC0	3CFF	CRTR4	Row 4
3D00	3D3F	CRTR5	Row 5
3D40	3D7F	CRTR6	Row 6
3D80	3DBF	CRTR7	Row 7
3DC0	3DFF	CRTR8	Row 8
3E00	3E3F	CRTR9	Row 9
3E40	3E7F	CRTR10	Row 10
3E80	3EBF	CRTR11	Row 11
3EC0	3EFF	CRTR12	Row 12
3F00	3F3F	CRTR13	Row 13
3F40	3F7F	CRTR14	Row 14
3F80	3FBF	CRTR15	Row 15
3FC0	3FFF	CRTR16	Row 16
4000	4014	L2VECS	Level II fixed RAM vectors
4000		RST8	RST8: 1C96; (Parser) CP (Syntax)/RST16 IF=/Else SNERR
4003		RST16	RST16: 1D78; INC HL/If ASCII 0-9 SCF/Set if Z/Skip Spa

Start	End	Label	Description
4006		RST24	RST24: 1C90; CP HL,DE (A lost.)
4009		RST32	RST32: 25D9; If TYPFLG<8, SCF/RRT/M=INT,Z=STR,PO=SNG,NC=DBL
400C		RST40	RST40: DOS Command Processor
400F		RST48	RST48: Debug breakpoint
4012		RST56	RST56: Interrupt mode 1
4015	401C	KEYDCB	Keyboard DCB
4015		KBTYP	DCB Type (01)
4016	4017	KBDADR	Driver address (03E3H)
4018	401C	KBCONS	Constant: 0 0 0 K I
401D	4024	CRTDCB	Video DCB
401D		CRTTYP	DCB Type (07)
401E	401F	CRTADR	Driver address (0458H)
4020	4021	CURPOS	Cursor position on screen (L,H)
4022		CURCHR	Cursor character
4023	4024	CRTCON	Constant: D O
4025	402C	LPTDCB	Lineprinter DCB
4025		LPTTYP	DCB Type (06)
4026	4027	LPTADR	Driver address (058DH)
4028		LPTLPP	Number of lines/page
4029		LPTLCT	Line counter
402A	402C	LPTCON	Constant: 0 P R
402D	402F	DOSVEC	DOS Transfer Vector
4030	4032	ABORT	ABORT under DOS (unused under LII)
4033	4035	IODERR	Called by driver after illogical driver call
4036	403C	KBIMAG	Keyboard image
4036		KBIM1	01H
4037		KBIM2	02H
4038		KBIM3	04H
4039		KBIM4	08H
403A		KBIM5	10H
403B		KBIM6	20H
403C		KBIM7	40H
403D		CSTATU	Cassette status byte
403E	403F		Unused under Level II
4040		RTSC	25 MSec Real-time scheduling counter
4041		SECS	Seconds
4042		MINS	Minutes
4043		HRS	Hours
4044		YR	Year
4045		DAY	Day
4046		MO	Month
4047	4048	LOW	Contains address of lowest byte of avail. mem under DOS
4049	404A	DOSMEM	DOS memory size determined at power-up
404B		INTMSK	Interrupt mask
404C	404F		Unused under Level II (interrupt processing under DOS)
404C		INTENB	Interrupts enabled (bit mask)
404D	405C	INTTBL	Interrupt jump address for interrupts 0-7
4052	4053	COMINT	Communications interrupt vector
405D		DEBUG1	Debug: A or H (ASCII or H) or LSB of first breakpoint
405E		DEBUG2	Debug: 0=Normal screen, <>0 = Full screen: or MSB of first BREAKPT

Start	End	Label	Description
405F		DEBUG3	Debug: Instruction byte at breakpoint
4060	4061	DEBUG4	Debug: Second breakpoint or single-step
4062		DEBUG5	Debug: Instruction byte at second breakpoint
4063	4064	DEBUG6	Debug: Address currently being displayed on screen
4065	407C	DEBUGS	DEBUG: Register save area (AF,BC,DE,HL,AF',BC',DE',HL',IX,IY,SP,PC)
407D	407E	DSKBSP	Disk boot stack pointer beginning location
407F			Unused under Level II
4080	408D	DIVRAM	RAM used with single precision divide
408E	408F	USRADR	USR function address
4090	4092	RNDMUL	Mantissa of multiplicative constant for RND
4093	4095	INPRAM	INP function (93 = "IN" instruction, 94 = port, 95 = Ret)
4096	4098	OUTRAM	OUT function (96=Out,97=port,98=Ret)
4099		KEYBUF	Inkey$ buffer or flag (last key hit on keyboard)
409A		ERRNBR	Level II Error
409B		LPTPOS	Line printer line position
409C		OUTBFL	Output bit flag: 0=Video, 1=Lp, 80=Cassette
409D		LINLEN	Maximum length of a line on the screen
409E		PRNTZN	Next print zone (reached after a comma as in ?A,B,C)
409F			Unused under Level II
40A0	40A1	STRNGS	Beginning of string area
40A2	40A3	CURLIN	Current line number
40A4	40A5	PGMBGN	Pointer to start of BASIC program
40A6		CRTPOS	Current line position on Video
40A7	40A8	INBUFP	Input buffer pointer
40A9		DATAFL	Data statement flag
40AA	40AC	RNSEED	RND function seed
40AD			Unused under Level II
40AE		DLFLG	Dimension/Let flag from parser
40AF		TYPFLG	Current variable type (8=DBL, 4=SGL, 3=STR, 2=INT)
40B0		TYPFL2	Variable type for FPA2
40B1	40B2	LSTBYT	Address of last usable byte in memory (BASIC)
40B3	40B4	STRPTR	String parameter pointer
40B5	40D2	STPRMS	String param. area. 3 byte sets. 1ST=Length, 2-3=Address
40D3		STRLEN	Length of current string
40D4	40D5	STRADR	Address of current string
40D6	40D7	STRFRE	Next free byte in string area
40D8	40D9	CURTKN	Stores pointer to current token
40D8		PUCBYT	Printusing control byte: Bit2=*,3=+,4=$,6=Comma
40DA	40DB	LSTDTL	Last data line number read
40DC		FORFLG	Set to 64 on FOR loop. Prevent subscripted variable.
40DE		RDINFL	Read/Input flag: Non-zero=read / Zero = input
40DF	40E0	TRAADR	Transfer address for system
40E1		AUTOFL	Auto flag (Non-zero=ON. Zero after BREAK)
40E2	40E3	AUTOLN	Auto line number
40E4	40E5	AUTINC	Auto increment
40E6	40E7	LLEND	Points to end of previous line or current line
40E8	40E9	SPSAV	Stack pointer save area
40EA	40EB	ERRLIN	Line containing error
40EC	40ED	CURNUM	Current line number
40EE	40EF	PLEND	Pointer to previous line end

Start	End	Label	Description
40F0	40F1	ERRPRC	Address of "ON ERROR"
40F2		ERRFLG	FFH after error. Zero if no error
40F7	40F8	NBIBP	Ptr to next byte to be used with "CONT"
40F9	40FA	SCLERS	Pointer to beginning of scalers
40FB	40FC	ARRAYS	Pointer to beginning of arrays
40FD	40FE	ENDVAR	End location of array variables
40FF	40A0	RESTLN	Used with RESTORE. Keeps current line number for "READ"
40FF	4100	DATPTR	Pointer to delimeter after last DATA Value read
4101	411A	TYPTBL	Variable types for each letter A-Z
411B		TRCFLG	TRON - AF, TROFF - 0
411D	4124	REAL8	Double precision variable
411D	4120	REAL8M	Extended mantissa : Double precision
4121	4124	FPA1	Floating Point Accumulator
4121	4123	FPA1M	Mantissa
4124		FPA1E	Characteristic (exponent)
4125		EXPWRK	Exponent work area
4127	412E	FPA2	Floating Point Accumulator #2
4130		ASCBUF	Numeric work area: converted binary to ASCII number
4152	41A5	DBJPVS	Disk BASIC jump vectors
4152		CVI	CVI: (DBcmd E6H)
4155		FN	FN: (DBcmd BEH)
4158		CVS	CVS: (DBcmd E7H)
415B		DEF	DEF: (DBcmd B0H)
415E		CVD	CVD: (DBcmd E8H)
4161		EOF	EOF: (DBcmd E9H)
4164		LOC	LOC: (DBcmd EAH)
4167		LOF	LOF: (DBcmd EBH)
416A		MKI	MKI$: (DBcmd ECH)
416D		MKS	MKS$: (DBcmd EDH)
4170		MKD	MKD$: (DBcmd EEH)
4173		CMD	CMD: (DBcmd 85H)
4176		TIME	TIME$: (DBcmd C7H)
4179		OPEN	OPEN: (DBcmd A2H)
417C		FIELD	FIELD: (DBcmd A3H)
417F		GET	GET: (DBcmd A4H)
4182		PUT	PUT: (DBcmd A5H)
4185		CLOSE	CLOSE: (DBcmd A6H)
4188		LOAD	LOAD: (DBcmd A7H)
418B		MERGE	MERGE: (DBcmd A8H)
418E		NAME	NAME: (DBcmd A9H)
4191		KILL	KILL: (DBcmd AAH)
4197		LSET	LSET: (DBcmd ABH)
419A		RSET	RSET: (DBcmd ACH)
419D		INSTR	INSTR: (DBcmd C5H)
41A0		SAVE	SAVE: (DBcmd ADH)
41A3		LINE	LINE: (DBcmd 9CH)
41A6		ERHOOK	Hook to Disk BASIC for long error msgs.
41E6	42E7	IOBUFF	I/O Buffer
4200	42FF	DOSIOB	DOS I/O buffer for sectors from disk
42E8		CONO	Constant: 0
42E9		WRKRAM	Begin BASIC program and work area

Start	End	Label	Description
4300	5FFF	TRSDOS	DOS routines
4300	4307	DIRTRK	Locations of the directory tracks of the different drives
4308		CURDRV	Current drive being used
4309		CDRVBT	Current drive being used with correct bit pattern already calcualted and stored at this address.
430A	430B	CURDCB	Address of currently active DCB
430C	430D	CURBUF	Currently active I/O buffer for file reads/writes.
430E		CUROVL	Current overlay in memory
430F		OVLDBG	Overlay/Debug flag
4315	4317	DEBUGV	Debug vector
4318	4347	DOSBUF	DOS Command buffer
4400		WMSTRT	Warmstart
4405		CMDINT	Command Interpreter entry point
4409		POSTER	Post error message entry point
440D		DEBUG	Enter the real-time debugging facility
4410		ACTINT	Activate an interrupt task
4413		TSKOFF	Turn off an interrupt task
4416		TSKCHG	Change state of an interrupt task
4419		DCTTSK	Deactivate an interrupt task
441C		GTSPEC	Get a file specification from buffer
4420		INIT	INIT (DOS file call. P#6-8)
4424		OPEN	OPEN (DOS file call. P#6-9)
4428		CLOSE	CLOSE (DOS file call. P#6-11)
442C		KILL	KILL (DOS file call. P#6-11)
4430		LOAD	Load a machine language format file
4433		RUN	Load and execute machine language file
4436		READ	READ (DOS file call. P#6-9)
4439		WRITE	WRITE a file by sector or Logical record
443C		VERIFY	Write and verify a file write
443F		REWIND	Rewind a file to the beginning
4442		POSN	POSN (DOS file call. P#6-9)
4445		BKSPA	Backspace a file
4448		POSEOF	Position a file to EOF
4467		OUTLIN	Output a line to the CRT
446A		OUTLP	Output a line to the printer
446D		TIME	Move current TIME to 8-byte HL buffer
4470		DATE	Returns DATE into 8-byte HL buffer
4473		DEFEXT	Add default file extension
4476		OPTION	Get optional command flags from buffer
4FFF		LAD4K	Last RAM address in a 4K TRS-80
51FF		ENDOVR	End of DOS overlay area
5200	6FFF	DSKUTL	Disk BASIC/DOS utilities/User memory
7FFF		LAD16K	Last RAM address in a 16K TRS-80
BFFF		LAD32K	Last RAM address in a 32K TRS-80
FFFF		LAD48K	Last RAM address in a 48K TRS-80

APPENDIX B: INTERFACING EXAMPLES

This appendix contains three programs which utilize the routines described in this book to perform their functions.

The first example is a program which inputs a double precision value from the keyboard and displays the number in hexadecimal form after the machine has converted it. The program includes the error recovery routines.

Beginning on page B-4, one will find a program that solves quadratic equations through the use of the math routines.

The final program which begins on page B-8 is a random number generator test which illustrates the use of the ASCII conversion and the random number generator routines.

These examples can be used by either entering and assembling the source statements provided or by entering the hex object code from the assembled output into memory using T-Bug or a similar utility.

```
                ;*****
                ;       DOUBLE PRECISION NUMBERS IN HEXADECIMAL
                ;       INCLUDES ERROR RECOVERY PRINCIPLES
                ;*****
7000                    ORG     7000H
7000 310070     BEGIN   LD      SP,$            ;SET STACK POINTER
7003 CDC901             CALL    01C9H           ;CLEAR SCREEN
                ;*****
                ;       RAM INITIALIZATION ROUTINE
                ;*****
7006 118040             LD      DE,4080H        ;RAM INITIALIZATION
7009 21F718             LD      HL,18F7H
700C 012700             LD      BC,27H
700F EDB0               LDIR
                ;*****
                ;       SETUP ERROR RECOVERY ROUTINE
                ;*****
7011 210070             LD      HL,BEGIN
7014 22E840             LD      (40E8H),HL
7017 21A641             LD      HL,41A6H
701A 36C3               LD      (HL),0C3H
701C 23                 INC     HL
701D 110070             LD      DE,BEGIN
7020 73                 LD      (HL),E
7021 23                 INC     HL
7022 72                 LD      (HL),D
7023 3EC9               LD      A,0C9H          ;SET UP A RETURN
7025 32BE41             LD      (41BEH),A
7028 32D041             LD      (41D0H),A
702B 32C141             LD      (41C1H),A
702E 32F240             LD      (40F2H),A       ;MUST BE <> 0
                ;*****
                ;       PROMPT USER INPUT OF NUMBER
                ;*****
7031 219C70     START   LD      HL,MSG
7034 CD6370             CALL    MSGOUT
                ;*****
                ;       READ INPUT RESPONSE
                ;*****
7037 213041             LD      HL,4130H        ;PT TO INPUT BUFFER
703A 0614               LD      B,20            ;SET BUF SIZE
703C CD4000             CALL    0040H           ;INPUT USER NUMBER
703F AF                 XOR     A
7040 B0                 OR      B               ;TEST FOR NO INPUT
7041 CA2D40             JP      Z,402DH         ;BACK TO DOS
                ;*****
                ;       BUFFER MUST END WITH HEX 00
                ;*****
7044 EB                 EX      DE,HL           ;INSERT ENDING ZERO
7045 68                 LD      L,B             ;BYTE COUNT TO BC
7046 2600               LD      H,0
7048 19                 ADD     HL,DE           ;PT TO <ENTER> BYTE
7049 3600               LD      (HL),0          ;PLACE A <0> INTO BUF
704B EB                 EX      DE,HL           ;RESTORE BUF PTR
                ;*****
                ;       CONVERT ASCII NUMBER IN BUFFER TO DOUBLE PRECISION
```

```
                00660 ;*****
704C CD650E     00670           CALL    0E65H           ;CVRT TO BINARY
704F 211D41     00680           LD      HL,411DH        ;POINT TO FPA1 EXTENDED
7052 11B070     00690           LD      DE,NUMBUF       ;POINT TO MY BUFFER
7055 CDD209     00700           CALL    9D2H            ;MOVE FPA1 EXTENDED TO BUF
7058 21B070     00710           LD      HL,NUMBUF       ;POINT TO MY BUFFER
705B CD7870     00720           CALL    HEXOUT          ;OUTPUT NUMBER IN HEX
705E CD6C70     00730           CALL    WRRET           ;WRITE AN <ENTER>
7061 18CE       00740           JR      START           ;RECYCLE
                00750 ;*****
                00760 ;         ;MESSAGE OUTPUT ROUTINE
                00770 ;*****
7063 7E         00780 MSGOUT    LD      A,(HL)          ;P/U CHARACTER
7064 B7         00790           OR      A               ;TEST FOR ZERO
7065 C8         00800           RET     Z               ;RET IF SO
7066 CD7270     00810           CALL    WRBYT           ;ELSE OUTPUT IT
7069 23         00820           INC     HL              ;BUMP POINTER
706A 18F7       00830           JR      MSGOUT          ;AND LOOP
                00840 ;*****
                00850 ;         MISCELLANEOUS OUTPUT ROUTINES
                00860 ;*****
706C 3E0D       00870 WRRET     LD      A,0DH           ;WRITE AN <ENTER>
706E 1802       00880           JR      WRBYT
7070 3E20       00890 WRSPA     LD      A,20H           ;WRITE A <SPACE>
7072 D5         00900 WRBYT     PUSH    DE              ;WRITE ANY CHARACTER
7073 CD3300     00910           CALL    33H
7076 D1         00920           POP     DE
7077 C9         00930           RET
7078 CD7B70     00940 HEXOUT    CALL    WRDBL           ;CVRT 4 BYTES
707B CD7E70     00950 WRDBL     CALL    WRHEX           ;CVRT 2 BYTES
707E CD7070     00960 WRHEX     CALL    WRSPA
7081 CD8470     00970           CALL    WR2             ;CVRT 1 BYTE
7084 7E         00980 WR2       LD      A,(HL)          ;P/U BYTE TO CONVERT
7085 CB3F       00990           SRL     A               ;SHIFT HIGH NYBBLE
7087 CB3F       01000           SRL     A               ;INTO LOW ORDER POSITION
7089 CB3F       01010           SRL     A
708B CB3F       01020           SRL     A
708D CD9470     01030           CALL    WRDIG           ;OUTPUT A HEX DIGIT
7090 7E         01040           LD      A,(HL)          ;P/U THE BYTE AGAIN
7091 E60F       01050           AND     0FH             ;STRIP HIGH NYBBLE
7093 23         01060           INC     HL              ;PT TO NEXT BUFFER BYTE
7094 C690       01070 WRDIG     ADD     A,90H           ;CVRT A LOW ORDER NYBBLE
7096 27         01080           DAA                     ;TO ASCII HEX
7097 CE40       01090           ADC     A,40H
7099 27         01100           DAA
709A 18D6       01110           JR      WRBYT           ;OUTPUT THE CHARACTER
                01120 ;*****
                01130 ;         DATA AREA
                01140 ;*****
709C 45         01150 MSG       DEFM    'ENTER YOUR NUMBER >'
     4E 54 45 52 20 59 4F 55
     52 20 4E 55 4D 42 45 52
     20 3E
70AF 00         01160           NOP
0008            01170 NUMBUF    DEFS    8
7000            01180           END     BEGIN
```

```
                ;*****
                ;        SOLUTION OF QUADRATIC EQUATION
                ;        VIA MACHINE LANGUAGE INTERFACE
                ;*****
7000                     ORG     07000H
7000 310070     BEGIN    LD      SP,$              ;SET STACK POINTER
7003 CDC901              CALL    01C9H             ;CLEAR SCREEN
                ;*****
                ;        RAM INITIALIZATION ROUTINE
                ;*****
7006 118040              LD      DE,4080H
7009 21F718              LD      HL,18F7H
700C 012700              LD      BC,27H
700F EDB0                LDIR
                ;*****
                ;        INIT ERROR RECOVERY
                ;*****
7011 210070              LD      HL,BEGIN
7014 22E840              LD      (40E8H),HL
7017 21A641              LD      HL,41A6H
701A 36C3                LD      (HL),0C3H
701C 23                  INC     HL
701D 110070              LD      DE,BEGIN
7020 73                  LD      (HL),E
7021 23                  INC     HL
7022 72                  LD      (HL),D
7023 3EC9                LD      A,0C9H            ;SET UP A RETURN
7025 32BE41              LD      (41BEH),A
7028 32D041              LD      (41D0H),A
702B 32C141              LD      (41C1H),A
702E 32F240              LD      (40F2H),A         ;MUST BE <> 0
                ;
7031 3E41       START    LD      A,'A'             ;INIT FOR 'A' COEFFICIENT
7033 CD1871              CALL    GETNUM
7036 217D71              LD      HL,VALA           ;XFR 'A' TO STORAGE
7039 CDCB09              CALL    09CBH
                ;
703C 3E42                LD      A,'B'             ;INIT FOR 'B' COEFFICIENT
703E CD1871              CALL    GETNUM
7041 218171              LD      HL,VALB           ;XFR 'B' TO STORAGE
7044 CDCB09              CALL    09CBH
                ;
7047 3E43                LD      A,'C'             ;INIT FOR 'C' COEFFICIENT
7049 CD1871              CALL    GETNUM
704C 218571              LD      HL,VALC           ;XFR 'C' TO STORAGE
704F CDCB09              CALL    09CBH
                ;*****
                ;        CALCULATE 'B*B'
                ;*****
7052 218171              LD      HL,VALB
7055 CDB109              CALL    09B1H             ;'B' TO FPA1
7058 CDBF09              CALL    09BFH             ;'B' TO RFPA FROM FPA1
705B CD4708              CALL    0847H             ;'B' * 'B'
705E CDA409              CALL    09A4H             ;STACK 'B*B'
                ;*****
                ;        CALCULATE '4AC'
```

```
                ;*****
7061 217D71             LD      HL,VALA
7064 CDB109             CALL    09B1H           ;'A' TO FPA1
7067 218571             LD      HL,VALC
706A CDC209             CALL    09C2H           ;'C' TO RFPA
706D CD4708             CALL    0847H           ;A * C
7070 217871             LD      HL,FOUR
7073 CDC209             CALL    09C2H           ;'4' TO RFPA
7076 CD4708             CALL    0847H           ;4 * A * C
                ;*****
                ;       CALCULATE B*B - 4AC
                ;*****
7079 C1                 POP     BC              ;RCVR 'B*B'
707A D1                 POP     DE
707B CD1307             CALL    0713H           ;B*B - 4AC
                ;*****
                ;       TEST DETERMINANT FOR < ZERO
                ;*****
707E 217271             LD      HL,ZERO
7081 CDC209             CALL    09C2H           ;'ZERO' TO RFPA
7084 CD0C0A             CALL    0A0CH           ;COMPARE SNGL
7087 2807               JR      Z,REAL          ;SOLUTION IS IMAGINARY IF
7089 F29070             JP      P,REAL          ;DETERMINANT IS NEGATIVE
708C CD8209             CALL    0982H           ;CHG SIGN OF FPA1
708F 3E                 DEFB    3EH             ;CONSTRUCT 'LD A,0AFH'
7090 AF         REAL    XOR     A               ;FLAG=0->REAL,FLAG<>0->IMAG
7091 327C71             LD      (FLAG),A        ;SET REAL/IMGNRY FLAG
7094 CDE713             CALL    13E7H           ;TAKE SQUARE ROOT
7097 CDA409             CALL    09A4H           ;STACK SQRT(B*B-4AC)
709A CDF970             CALL    TWOA            ;'2A' TO FPA1
709D C1                 POP     BC
709E D1                 POP     DE              ;RCVR NUMERATOR
709F CDA208             CALL    08A2H           ;SQRT(B*B-4AC)/2A
70A2 218971             LD      HL,TEMP
70A5 CDCB09             CALL    09CBH           ;& STORE IN TEMP
70A8 CDF970             CALL    TWOA            ;'2A' TO FPA1
70AB 218171             LD      HL,VALB
70AE CDC209             CALL    09C2H           ;'B' TO RFPA
70B1 CDA208             CALL    08A2H           ;B/2A
70B4 3A7C71             LD      A,(FLAG)        ;TEST REAL/IMGNRY FLAG
70B7 FE00               CP      0
70B9 201D               JR      NZ,IMGNRY
70BB CDA409             CALL    09A4H           ;& STACK IT
70BE 218971             LD      HL,TEMP         ;PT TO TEMP
70C1 CD0B07             CALL    070BH           ;& ADD TO B/2A
70C4 CD1271             CALL    ANSWER
70C7 218971             LD      HL,TEMP
70CA CDB109             CALL    09B1H           ;'TEMP' TO FPA1
70CD C1                 POP     BC
70CE D1                 POP     DE              ;RCVR B/2A
70CF CD1307             CALL    0713H           ;B/2A-SQRT(B*B-4AC)/2A
70D2 CD1271             CALL    ANSWER
70D5 C33170             JP      START           ;RECYCLE
                ;*****
                ;       ANSWER IS IMAGINARY - OUTPUT:
                ;       -B/2A +/- SQRT(ABS(B*B -4AC))I/2A
```

```
                ;*****
70D8 CD0971     IMGNRY  CALL    CVRT            ;OUTPUT B/2A
70DB 216771             LD      HL,PMMSG
70DE CD3C71             CALL    MSGOUT
70E1 218971             LD      HL,TEMP
70E4 CDB109             CALL    09B1H           ;'TEMP' TO FPA1
70E7 CD7709             CALL    0977H           ;TAKE ABS TO ENSURE POS
70EA CD0971             CALL    CVRT            ;OUTPUT SQRT(B*B-4AC)/2A
70ED 216E71             LD      HL,MSGI
70F0 CD3C71             CALL    MSGOUT
70F3 CD4571             CALL    WRRET
70F6 C33170             JP      START           ;RECYCLE
                ;*****
                ;       ROUTINE TO MULTIPLY 'A' BY 2.0
                ;*****
70F9 217D71     TWOA    LD      HL,VALA
70FC CDB109             CALL    09B1H           ;'A' TO FPA1
70FF 217471             LD      HL,TWO
7102 CDC209             CALL    09C2H           ;'2' TO RFPA
7105 CD4708             CALL    0847H           ;2 * A
7108 C9                 RET
                ;*****
                ;       CONVERT FPA1 TO ASCII AND OUTPUT TO SCREEN
                ;*****
7109 CDBD0F     CVRT    CALL    0FBDH           ;CVRT FPA1 TO ASCII
710C 213041             LD      HL,4130H        ;POINT TO ASCBUF
710F C33C71             JP      MSGOUT          ;OUTPUT & RETURN
7112 CD0971     ANSWER  CALL    CVRT
7115 C34571             JP      WRRET
                ;*****
                ;       ROUTINE TO INPUT COEFFICIENT
                ;*****
7118 326371     GETNUM  LD      (MSGVAR),A      ;LOAD COEFF CHAR INTO MSG
711B 215171             LD      HL,MSG1
711E CD3C71             CALL    MSGOUT          ;OUTPUT MSG
7121 213041             LD      HL,4130H        ;PT TO INPUT BUFFER
7124 0614               LD      B,20            ;SET BUF SIZE
7126 CD4000             CALL    0040H           ;INPUT USER NUMBER
7129 AF                 XOR     A
712A B0                 OR      B               ;TEST FOR NO INPUT
712B CA2D40             JP      Z,402DH         ;BACK TO DOS
                ;*****
                ;       ASCII BUFFER NEEDS ENDING ZERO BYTE
                ;*****
712E EB                 EX      DE,HL           ;INSERT ENDING ZERO
712F 68                 LD      L,B             ;BYTE COUNT TO BC
7130 2600               LD      H,0
7132 19                 ADD     HL,DE           ;PT TO <ENTER> BYTE
7133 3600               LD      (HL),0          ;PLACE A <0> INTO BUF
7135 EB                 EX      DE,HL           ;RESTORE BUF PTR
                ;*****
                ;       CONVERT ASCII INPUT TO BINARY SNGL PREC
                ;*****
7136 CD650E             CALL    0E65H           ;CVRT TO BINARY
7139 C3B10A             JP      0AB1H           ;ENSURE SNGL PREC & RETURN
                ;*****
```

```
                ;        MESSAGE OUTPUT ROUTINE
                ;*****
713C 7E         MSGOUT   LD      A,(HL)          ;P/U A CHARACTER
713D B7                  OR      A
713E C8                  RET     Z               ;RETURN IF CHAR IS ZERO
713F CD4B71              CALL    WRBYT           ;ELSE OUTPUT IT
7142 23                  INC     HL              ;BUMP POINTER
7143 18F7                JR      MSGOUT          ;AND LOOP
                ;*****
                ;        MISCELLANEOUS OUTPUT ROUTINES
                ;*****
7145 3E0D       WRRET    LD      A,0DH           ;WRITE AN <ENTER>
7147 1802                JR      WRBYT
7149 3E20       WRSPA    LD      A,20H           ;WRITE A <SPACE>
714B D5         WRBYT    PUSH    DE              ;WRITE ANY CHARACTER
714C CD3300              CALL    33H
714F D1                  POP     DE
7150 C9                  RET
                ;*****
                ;        BEGINNING OF DATA AREA
                ;*****
7151 45         MSG1     DEFM    'ENTER COEFFICIENT '
     4E 54 45 52 20 43 4F 45
     46 46 49 43 49 45 4E 54
     20
7163 58         MSGVAR   DEFM    'X >'
     20 3E
7166 00                  NOP
7167 20         PMMSG    DEFM    '  +/- '
     20 2B 2F 2D 20
716D 00                  NOP
716E 20         MSGI     DEFM    '  I'
     20 49
7171 00                  NOP
7172 0000       ZERO     DEFW    0               ;FLTG POINT ZERO
7174 0000       TWO      DEFW    0               ;FLTG POINT 2.0
7176 0082                DEFW    8200H
7178 0000       FOUR     DEFW    0               ;FLTG POINT 4.0
717A 0083                DEFW    8300H
0001            FLAG     DEFS    1               ;REAL/IMGNRY FLAG
0004            VALA     DEFS    4               ;SPACE FOR COEFFICIENTS
0004            VALB     DEFS    4
0004            VALC     DEFS    4
0004            TEMP     DEFS    4               ;TEMPY STORAGE
7000                     END     BEGIN
00000 TOTAL ERRORS
```

```
                   ;*****
                   ;        RANDOM NUMBER GENERATOR TEST
                   ;
                   ;        ILLUSTRATES USE OF ASCII CONVERSIONS
                   ;        AND RANDOM NUMBER INTERFACING
                   ;*****
7000                        ORG     7000H
7000 310070        BEGIN    LD      SP,$                ;SET STACK POINTER
7003 CDC901                 CALL    1C9H                ;CLEAR THE SCREEN
7006 CD5070                 CALL INIT                   ;SETUP DIVIDE PROG
                   ;*****
                   ;        PROMPT INPUT OF LIMIT
                   ;*****
7009 217170        START    LD      HL,MSG              ;POINT TO INPUT BUFFER
700C CD5C70                 CALL    MSGOUT              ;OUTPUT MESSAGE
700F 213041                 LD      HL,4130H            ;POINT TO INPUT BUFFER
7012 0614                   LD      B,20                ;SET BUFFER SIZE
7014 CD4000                 CALL    40H                 ;INPUT LIMIT
7017 AF                     XOR     A                   ;TEST FOR NO INPUT
7018 B0                     OR      B
7019 CA2D40                 JP      Z,402DH             ;EXIT (TO 6CCH FOR BASIC)
                   ;*****
                   ;        END OF INPUT MUST BE HEX 00
                   ;*****
701C EB                     EX      DE,HL               ;BUFFER ADDRESS TO DE
701D 68                     LD      L,B                 ;BYTE COUNT TO HL
701E 2600                   LD      H,0
7020 19                     ADD     HL,DE               ;PT TO <ENTER> BYTE
7021 3600                   LD      (HL),0              ;PLACE A ZERO INTO PLACE
7023 EB                     EX      DE,HL               ;REPOINT HL TO BUFFER
                   ;*****
                   ;        CONVERT ASCII NUMBER TO DOUBLE PRECISION
                   ;*****
7024 CD650E                 CALL    0E65H               ;CVRT TO BINARY
                   ;*****
                   ;        EXERCISE 'CSNG' FUNCTION
                   ;*****
7027 CDB10A                 CALL    0AB1H               ;CVRT TO SNGL
                   ;*****
                   ;        NOW GENERATE 256 RANDOM NUMBERS
                   ;*****
702A 0600                   LD      B,0                 ;INIT COUNTER
702C 218470                 LD      HL,NUM
702F CDCB09                 CALL    9CBH                ;SAVE FPA1 IN 'NUM'
7032 C5            LOOP     PUSH    BC                  ;SAVE COUNTER
7033 218470                 LD      HL,NUM              ;LOAD LIMIT
7036 CDB109                 CALL    9B1H                ;INTO FPA1 EACH ITERATION
7039 CDEF0A                 CALL    0AEFH               ;SET TYPFLG TO 4
                   ;*****
                   ;        GEN SNGL PREC RANDOM NUMBER IN FPA1
                   ;*****
703C CDC914                 CALL    14C9H               ;GEN RANDOM NUMBER
                   ;*****
                   ;        CONVERT FPA1 TO ASCII
                   ;*****
703F CDBD0F                 CALL    0FBDH               ;CVRT TO ASCII
```

```
                00660 ;*****
                00670 ;         OUTPUT TO CRT DEVICE
                00680 ;*****
7042 213041     00690           LD      HL,4130H        ;POINT TO BUFFER
7045 CD5C70     00700           CALL    MSGOUT          ;OUTPUT TO CRT
7048 CD6970     00710           CALL    WRSPA           ;& A <SPACE>
704B C1         00720           POP     BC              ;RECOVER COUNTER
704C 10E4       00730           DJNZ    LOOP            ;CYCLE IF MORE
                00740 ;*****
                00750 ;         CYCLE FOR ANOTHER NUMBER
                00760 ;*****
704E 18B9       00770           JR      START
                00780 ;*****
                00790 ;         RAM INITIALIZATION ROUTINE
                00800 ;*****
7050 118040     00810 INIT      LD      DE,4080H
7053 21F718     00820           LD      HL,18F7H
7056 012700     00830           LD      BC,27H
7059 EDB0       00840           LDIR
705B C9         00850           RET
                00860 ;*****
                00870 ;         ;MESSAGE OUTPUT ROUTINE
                00880 ;*****
705C 7E         00890 MSGOUT    LD      A,(HL)          ;P/U CHARACTER
705D B7         00900           OR      A               ;TEST FOR ZERO
705E C8         00910           RET     Z               ;RET IF SO
705F CD6B70     00920           CALL    WRBYT           ;ELSE OUTPUT IT
7062 23         00930           INC     HL              ;BUMP POINTER
7063 18F7       00940           JR      MSGOUT          ;AND LOOP
                00950 ;*****
                00960 ;         MISCELLANEOUS OUTPUT ROUTINES
                00970 ;*****
7065 3E0D       00980 WRRET     LD      A,0DH           ;WRITE AN <ENTER>
7067 1802       00990           JR      WRBYT
7069 3E20       01000 WRSPA     LD      A,20H           ;WRITE A <SPACE>
706B D5         01010 WRBYT     PUSH    DE              ;WRITE ANY CHARACTER
706C CD3300     01020           CALL    33H
706F D1         01030           POP     DE
7070 C9         01040           RET
                01050 ;*****
                01060 ;         DATA AREA
                01070 ;*****
7071 45         01080 MSG       DEFM    'ENTER UPPER LIMIT'
     4E 54 45 52 20 55 50 50
     45 52 20 4C 49 4D 49 54

7082 0D         01090           DEFB    0DH
7083 00         01100           NOP
0004            01110 NUM       DEFS    4
7000            01120           END     BEGIN
00000 TOTAL ERRORS
```

APPENDIX C: BASIC DISASSEMBLER

The listing which follows is a BASIC language, Z-80 disassembler. It can be used to complete the ROM listing provided in Chapter 4 by those readers who own a TRS-80 microcomputer but do not own a machine language disassembler. Entry of the starting and ending addresses is in decimal.

```
1       CLEAR 250
10      DEFINT A-Z
15      HEX$="0123456789ABCDEF"
20      CLS:
        PRINT CHR$(23):
        PRINT STRING$(27,"*")
21      PRINT " DISASSEMBLER BY MISOSYS *":
        PRINT STRING$(27,"*"):
        PRINT"READING DATABASE...."
50      DIM SIZE%(255),ED%(56),ED$(56),OPTBL$(255),
            CODE$(15),ARG$(7),CBTBL$(10),
            DDFD%(38),DDFD$(38),DF(38)
100     FOR I=0 TO 63:
          READ SIZE%(I):
        NEXTI:
        REM LENGTH TABLE
110     DATA 1,3,1,1,1,1,2,1,1,1,1,1,1,1,2,1:
        REM 00 - 0F
120     DATA 2,3,1,1,1,1,2,1,2,1,1,1,1,2,2,1:
        REM 10 - 1F
130     DATA 2,3,3,1,1,1,2,1,2,1,3,1,1,1,2,1:
        REM 20 - 2F
140     DATA 2,3,3,1,1,1,2,1,2,1,3,1,1,1,2,1:
        REM 30 - 3F
150     FOR I=64 TO 191:
          SIZE%(I)=1:
        NEXT:
        REM 40 - BF
160     FOR I=192 TO 255:
          READ SIZE%(I):
        NEXT:
        REM READ REMAINDER
170     DATA 1,1,3,3,3,1,2,1,1,1,3,4,3,3,2,1:
        REM C0 - CF
180     DATA 1,1,3,2,3,1,2,1,1,1,3,2,3,4,2,1:
        REM D0 - DF
190     DATA 1,1,3,1,3,1,2,1,1,1,3,1,3,4,,1:
        REM E0 - EF
```

```
200     DATA 1,1,3,1,3,1,2,1,1,1,3,1,3,4,2,1:
        REM F0 - FF
300     FOR I=1 TO 56:
          READ ED%(I),ED$(I):
        NEXT:
        REM READ ED TABLES
310     DATA 64,"IN B,(C)",65,"OUT (C),B",66,"SBC HL,BC"
320     DATA 67,BC,68,NEG,69,RETN,70,IM 0,71,
            "LD I,A",72,"IN C,(C)"
330     DATA 73,"OUT (C),C",74,"ADC HL,BC",75,
            BC,77,RETI,79,"LD R,A"
340     DATA 80,"IN D,(C)",81,"OUT (C),D",82,
            "SBC HL,DE",83,DE
350     DATA 86,IM 1,87,"LD A,I",88,"IN E,(C)",89,
            "OUT (C),E"
360     DATA 90,"ADC HL,DE",91,DE,94,IM 2,95,
            "LD A,R",96,"IN H,(C)"
370     DATA 97,"OUT (C),H",98,"SBC HL,HL",103,RRD,
            104,"IN L,(C)"
380     DATA 105,"OUT (C),L",106,"ADC HL,HL"
385     DATA 111,RLD,114,"SBC HL,SP"
390     DATA 115,SP,120,"IN A,(C)",121,"OUT (C),A",
            122,"ADC HL,SP"
400     DATA 123,SP,160,LDI,161,CPI,162,INI,163,
            OUTI,168,LDD
410     DATA 169,CPD,170,IND,171,OUTD,176,LDIR,
            177,CPIR,178,INIR
420     DATA 179,OTIR,184,LDDR,185,CPDR,186,INDR,187,OTDR
430     FOR I=0 TO 15:
          READ CODE$(I):
        NEXT
440     DATA "LD B,","LD C,","LD D,","LD E,"
450     DATA "LD H,","LD L,","LD (HL),","LD A,"
460     DATA "ADD A,","ADC A","SUB ","SBC A,"
470     DATA "AND ","XOR ","OR ","CP "
480     FOR I=0 TO 7:
          READ ARG$(I):
        NEXT
490     DATA B,C,D,E,H,L,(HL),A
500     FOR I=0 TO 127:
          READ OPTBL$(I):
        NEXT:
        REM READ PARTIAL OPS
510     DATA NOP,"LD BC,","LD (BC),A",INC BC
520     DATA INC B,DEC B,"LD B,",RLCA
530     DATA "EX AF,AF'","ADD HL,BC","LD A,(BC)",DEC BC
540     DATA INC C,DEC C,"LD C,",RRCA
550     DATA "DJNZ,","LD DE,","LD (DE),A",INC DE
560     DATA INC D,DEC D,"LD D,",RLA
570     DATA JR ,"ADD HL,DE","LD A,(DE)",DEC DE
580     DATA INC E,DEC E,"LD E,",RRA
```

```
590     DATA "JR NZ,","LD HL,","",INC HL
600     DATA INC H,DEC H,"LD H,",DAA
610     DATA "JR Z,","ADD HL,HL","LD HL,",DEC HL
620     DATA INC L,DEC L,"LD L,",CPL
630     DATA "JR NC,","LD SP,","",INC SP
640     DATA INC (HL),DEC (HL),"LD (HL),",SCF
650     DATA "JR C,","ADD HL,SP","LD A,",DEC SP
660     DATA INC A,DEC A,"LD A,",CCF
670     DATA RET NZ,POP BC,"JP NZ,","JP "
680     DATA "CALL NZ,",PUSH BC,"ADD A,",RST 00H
690     DATA RET Z,RET,"JP Z,",""
700     DATA "CALL Z,",CALL ,"ADC A,",RST 08H
710     DATA RET NC,POP DE,"JP NC,","OUT N,"
720     DATA "CALL NC,",PUSH DE,SUB ,RST 10H
730     DATA RET C,EXX,"JP C,","IN A,"
740     DATA "CALL C,","","SBC A,",RST 18H
750     DATA RET PO,POP HL,"JP PO,","EX (SP),HL"
760     DATA "CALL PO,",PUSH HL,AND ,RST 20H
770     DATA RET PE,JP (HL),"JP PE,","EX DE,HL"
780     DATA "CALL PE,","",XOR ,RST 28H
790     DATA RET P,POP AF,"JP P,",DI
800     DATA "CALL P,",PUSH AF,OR ,RST 30H
810     DATA RET M,"LD SP,HL","JP M,",EI
820     DATA "CALL M,","",CP ,RST 38H
830     FOR I=0 TO 10:
          READ CBTBL$(I):
        NEXT:
        REM READ CB OP TABLE
840     DATA RLC,RRC,RL,RR,SLA,SRA,XXX,SRL,BIT,"RES","SET"
850     FORI=0 TO 38:
          READ DDFD%(I),DDFD$(I):
        NEXT:
        REM READ DD & FD TABLES
860     DATA 9,"ADD X,BC",25,"ADD X,DE",33,"X"
870     DATA 34,X,35,"INC X",41,"ADD X,X",42,X
880     DATA 43,DEC X,52,INC (X+),53,DEC (X+),54,"LD (X+),"
890     DATA 57,"ADD X,SP",70,"LD B,(X+)",78,"LD C,(X+)
900     DATA 86,"LD D,(X+)",94,"LD E,(X+)",102,"LD H,(X+)"
910     DATA 110,"LD L,(X+)",112,"LD (X+),B",113,"LD (X+),C"
920     DATA 114,"LD (X+),D",115,"LD (X+),E",116,"LD (X+),H"
930     DATA 117,"LD (X+),L",119,"LD (X+),A",126,
            "LD A,(X+)",134,"ADD A,(X+)"
940     DATA 142,"ADC A,(X+)",150,"SUB (X+)",158,
            "SBC A,(X+)"
950     DATA 166,"AND (X+)",174,"XOR (X+)",182,"OR (X+)"
960     DATA 190,"CP (X+)",225,POP X,227,"EX (SP),X
970     DATA 229,PUSH X,233,JP (X),249,"LD SP,X"
980     FOR I=0 TO 38:
          READ DF(I):
        NEXT:
        REM READ ED/FD "LENGTH" TABLE
```

```
990     DATA 1,1,3,3,1,1,3,1,2,2,2,1,2,2,2,2,2,2,
             2,2,2,2,2,2,2,2,2,2,2,2,2,2,2,2,1,1,1,1,1
2000    INPUT "ENTER STARTING ADDRESS";LO
2001    INPUT "ENTER ENDING ADDRESS";HI
2005    PC=LO:
        CLS
2010    BYTE=PEEK(PC):
        GOSUB 12000:
        D=0:
        REM INITIALIZE DISPLACEMENT
2020    N=SIZE%(BYTE):
        ON N GOTO 2030,2040,2050,2060
2030    GOTO2100:
        REM BRANCH FOR STATEMENTS OF LENGTH 1
2040    GOTO2500:
        REM BRANCH FOR STATEMENTS OF LENGTH 2
2050    GOTO2600:
        REM BRANCH FOR STATEMENTS OF LENGTH 3
2060    GOTO2900:
        REM BRANCH FOR LENGTH CODE OF 4
2100    GOSUB 11000
2120    IF BYTE>63 AND BYTE<192 THEN 2200
2130    X=BYTE:
        IF X>191 THEN X=X-128
2140    PRINT TAB(16) OPTBL$(X);
2150    GOSUB 10000
2160    GOTO5000
2200    X=INT((BYTE-64)/8)
2210    IF BYTE <> 118 THEN 2230
2220    PRINT TAB(16) "HALT";:
        GOSUB10000:
        GOTO5000
2230    PRINT TAB(16) CODE$(X);
2240    R=BYTE AND 7
2250    PRINT ARG$(R);
2260    GOSUB 10000:
        GOTO5000
2500    IF BYTE=211 THEN 2560
2510    GOSUB 11000
2520    X=BYTE:
        IF X>191 X=X-128
2530    PRINT TAB(16) OPTBL$(X);
2540    N2=PEEK(PC+1):
        GOSUB12030:
        PRINT"H";
2545    N1=BYTE AND 199:
        IF N1=0 THEN D=N2
2550    GOSUB10000:
        GOTO5000
2560    GOSUB11000:
        PRINT TAB(16)"UT ";
```

```
2570   Y=PC:
       X=N:
       N=1:
       GOSUB11000:
       N=X:
       PC=Y:
       PRINT"H,A";
2580   GOSUB 10000:
       GOTO5000
2600   GOSUB 11000
2610   IF BYTE=34 THEN 2710
2620   IF BYTE=50 THEN 2810
2630   X=BYTE:
       IF X>191 X=X-128
2635   PRINT TAB(16) OPTBL$(X);:
       IFX=42 OR X=58 THEN PRINT"(";
2640   Z=N:
       Y=PC:
       N=2:
       PC=PC+1:
       GOSUB11090:
       N=Z:
       PC=Y:
       IF X=42 OR X=58 THEN PRINT "H)";
       ELSE PRINT"H";
2660   GOSUB10000:
       GOTO5000
2710   PRINT TAB(16)"LD (";
2720   X=N:
       Y=PC:
       N=2:
       PC=PC+1:
       GOSUB11090:
       PC=Y:N=X
2730   PRINT "H),HL";:
       GOSUB10000:
       GOTO5000
2810   PRINT TAB(16)"LD (";
2820   X=N:
       Y=PC:
       PC=PC+1:
       N=2:
       GOSUB11090:
       PC=Y:
       N=X
2830   PRINT "H),A";:
       GOSUB10000:
       GOTO5000
2890   GOSUB11000:
       GOSUB10000:
       GOTO5000
```

```
2900    IF BYTE<>203 THEN 3000
2910    NB=PEEK(PC+1):
        REM DISASSEMBLE 'CB' INSTRUCTIONS
2920    X=INT(NB/8):
        IF X>7 THEN X=INT(X/8)+7
2930    N=2:
        REM RESET LENGTH TO 2
2940    GOSUB11000:
        REM PRINT INSTRUCTION IN HEX
2950    PRINT TAB(16) CBTBL$(X);" ";:
        REM RECOVER OP
2970    IF X<8 THEN 2990
        ELSE X=INT((NB-64)/8)
2975    IF X<8 THEN 2980
2976    X=X-8:
        GOTO2975
2980    PRINTX;",";:
        REM PRINT THE BIT
2990    Y=NB AND 7:
        PRINT ARG$(Y);:
        GOSUB 10000:
        GOTO5000
3000    REM ***** THIS SECTION DECODES 'ED' INSTRUCTIONS
3010    IF BYTE<>237 THEN 3200:
        REM 237(10)=ED(16)
3020    NB=PEEK(PC+1):
        FOR I=1 TO 56:
          IF NB=ED%(I) THEN3040
        ELSE NEXT
3030    N=1:
        GOSUB11000:
        GOSUB 10000:
        GOTO5000:
        REM INVALID CODE, PRINT ASCII
3040    NX=I:
        IF NB=67 OR NB=83 OR NB=115 THEN 3070
3050    IF NB=75 OR NB=91 OR NB=123 THEN 3100
3060    N=2:
        GOSUB11000:
        PRINT TAB(16) ED$(NX);:
        GOSUB 10000:
        GOTO5000
3070    N=4:
        GOSUB11000:
        PRINT TAB(16)"LD (";
3080    Y=PC:
        PC=PC+2:
        N=2:
        GOSUB11000:
        N=4:
        PC=Y:
```

```
        PRINT"H),";ED$(NX);
3090    GOSUB10000:
        GOTO5000
3100    N=4:
        GOSUB11000:
        PRINT TAB(16)"LD ";ED$(NX);",(";
3110    Y=PC:
        PC=PC+2:
        N=2:
        GOSUB11000:
        N=4:
        PC=Y:
        PRINT"H)";
3120    GOSUB10000:
        GOTO5000
3200    REM ***** THIS SECTION DECODES 'Dd' & 'FD'
            INSTRUCTIONS *****
3210    NB=PEEK(PC+1):
        IF NB=203 THEN 3400:
        REM CHECK FOR BYTE 2=CB
3220    FOR X=0 TO 38:
          IF NB=DDFD%(X) THEN 3240
        ELSE NEXT
3230    N=1:
        GOSUB11000:
        GOSUB10000:
        GOTO5000:
        REM INVALID OP CODE
3240    P$=DDFD$(X):
        Q$="":
        FOR I=1 TO LEN(P$):
          IF MID$(P$,I,1)<>"X" OR NB=174 OR NB=227 THEN
             Q$=Q$+MID$(P$,I,1)
          ELSE IF BYTE=221 THEN Q$=Q$+"IX"
          ELSE Q$=Q$+"IY"
3250    NEXT:
        REM Q$ NOW CONTAINS PARTIAL INST FOR IX/IY
3260    ON DF(X) GOTO 3270,3280,3340
3270    N=2:
        GOSUB11000:
        PRINT TAB(16) Q$;:
        GOSUB10000:
        GOTO5000
3280    N=3:
        IF NB=54 THEN N=4
3290    GOSUB11000:
        P$=Q$:
        Q$="":
        FOR I=1TOLEN(P$):
          IF MID$(P$,I,1)<>"+"THEN Q$=Q$+MID$(P$,I,1)
          ELSE 3310
```

```
3300    NEXT:
        STOP
3310    PRINT TAB(16) Q$;"+";:
        N2=PEEK(PC+2):
        D=N2:
        GOSUB12030:
        PRINT "H";:
        PRINT RIGHT$(P$,LEN(P$)-I);:
        IF NB<>54 THEN 3330
3320    N2=PEEK(PC+3):
        GOSUB12030:
        PRINT"H";
3330    GOSUB10000:
        GOTO5000
3340    IF NB=33 THEN 3350
3342    IF NB=34 THEN 3360
3344    IF NB=42 THEN 3370
        ELSE 3030
3350    N=4:
        GOSUB11000:
        PRINT TAB(16)"LD ";Q$;
3355    PRINT ",";:
        Y=PC:
        N=2:
        PC=PC+2:
        GOSUB11000:
        PRINT"H";:
        PC=Y:
        N=4:
        GOSUB10000:
        GOTO5000
3360    N=4:
        GOSUB11000:
        PRINT TAB(16) "LD (";:
        Y=PC:
        PC=PC+2:
        N=2:
        GOSUB11000:
        PRINT"H),";Q$;
3365    PC=Y:
        N=4:
        GOSUB10000:
        GOTO5000
3370    N=4:
        GOSUB11000:
        PRINT TAB(16) "LD ";Q$;",(";:
        Y=PC:
        PC=PC+2:
        N=2:
        GOSUB11000:
        PRINT"H)";:
```

```
        N=4:
        PC=Y:
        GOSUB10000:
        GOTO5000
3400    N=4:
        NB=PEEK(PC+3):
        BIT=INT((NB AND 56)/8):
        X=INT((NB AND 192)/64):
        IF X=0 THEN X=BIT
        ELSE X=X+7:
        REM X NOW INDEXES CBTBL$
3410    GOSUB 11000:
        PRINT TAB(16) CBTBL$(X);" ";:
        IF X>7 PRINT BIT;",";
3420    IF BYTE = 221 PRINT "(IX+";
        ELSE PRINT"IY+";
3430    N2=PEEK(PC+2):
        D=N2:
        GOSUB12030:
        PRINT"H)";:
        GOSUB10000:
        GOTO5000
5000    IF D=0 THEN 5005
        ELSE GOSUB 13000
5005    L=L+1:
        IFL<16 THEN 5010
        ELSE INPUT" ...WAITING";Z$:
        CLS
5006    LO=LO+L:
        L=0
5010    PRINT" ":
        PC=PC+N:
        IF PC<HI+1 THEN 5020
        ELSE PRINT LO,"LINES OUTPUT":
        END
5020    IF BYTE<>207 THEN 2010
5030    BYTE=PEEK(PC):
        D=0:
        N=1:
        GOSUB12000:
        GOSUB11000:
        PRINT TAB(16)"DEFB ";
5040    IF BYTE<32 OR BYTE >127 THEN 5050
        ELSE PRINT "'";CHR$(BYTE);"'";:
        GOSUB10000:
        GOTO5005
5050    N2=BYTE:
        GOSUB 12030:
        PRINT"H";:
        GOSUB10000:
        GOTO5005
```

```
10000  FOR I=0 TO N-1
10020    IF Q>32 AND Q<128 THEN  PRINT TAB(32+I)CHR$(Q);
         ELSE PRINT TAB(32+I) ".";
10030  NEXT I
10040  RETURN
10090  Q=PEEK(PC+I)
11000  FOR I=0 TO N-1:
         GOSUB11010:
       NEXTI:
       RETURN
11010  Q=PEEK(PC+I)
11020  J=INT(Q/16)
11030  K=Q-J*16
11040  J$=MID$(HEX$,J+1,1)
11050  K$=MID$(HEX$,K+1,1)
11060  PRINT J$;K$;:
       RETURN
11090  FOR I=1 TO 2-N STEP -1:
         GOSUB 11010:
       NEXTI:
       RETURN
12000  N2=PC:
       K=VARPTR(N2):
       N1=PEEK(K+1):
       N2=N2 AND 255
12010  J=INT(N1/16):
       K=N1-J*16
12020  Q$=MID$(HEX$,J+1,1)+MID$(HEX$,K+1,1):
       PRINT Q$;
12030  J=INT(N2/16):
       K=N2-J*16
12040  Q$=MID$(HEX$,J+1,1)+MID$(HEX$,K+1,1):
       PRINT Q$;
12050  PRINT TAB(7):
       RETURN
13000  REM ***** ROUTINE TO COMPUTE RELATIVE DISPLACEMENTS
13010  D1=D AND 128:
       IF D1<>0 THEN POKE VARPTR(D)+1,255
13020  D=D+2
13030  Y=PC:
       PC=PC+D:
       PRINT TAB(40)"  ";:
       GOSUB 12000:
       PRINT "H";:
       PC=Y:
       RETURN
```

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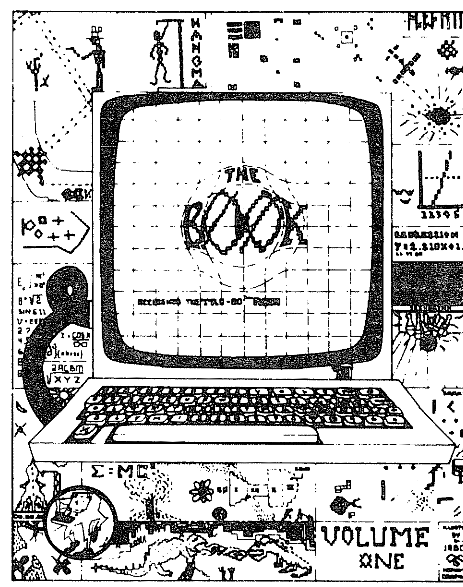

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