

PDP-8

FLOATING-POINT SYSTEM

PROGRAMMING MANUAL

For additional copies specify Order No. DEC-08-YQYA-D to Program Library,
Digital Equipment Corporation, Maynard, Massachusetts. Price: \$2.00

1st Printing August 1965
2nd Printing January 1967
3rd Printing June 1967
4th Printing November 1967
5th Printing Revised February 1968
6th Printing Revised July 1968
7th Printing January 1969
8th Printing April 1969

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PREFACE

The PDP-8 comes to the user complete with an extensive selection of system programs and routines making the full data processing capability of the new computer immediately available to each user, eliminating many commonly experienced initial programming delays.

The programs described in these abstracts come from two sources, past programming effort on the PDP-5 computer, and present and continuing programming effort on the PDP-8. Thus the PDP-8 programming system takes advantage of the many man-years of program development and field testing by PDP-5 users.

Although in many cases PDP-8 programs originated as PDP-5 programs, all utility and functional program documentation is issued in a new, recursive format introduced with the PDP-8.

Programs written by users of either the PDP-5 or the PDP-8 and submitted to the users' library (DECUS - Digital Equipment Corporation Users' Society) are immediately available to PDP-8 users.

Consequently, users of either computer can take immediate advantage of the continuing program developments for the other.

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CHAPTER 1

INTRODUCTION

The PDP-8 Floating-Point System enables the programmer to concentrate on the logic of his computation rather than on decimal points. The system maintains a constant number of significant digits throughout the computation, thereby enhancing the accuracy of the result.

Floating-point notation is particularly useful for computations involving numerous multiplications and divisions where magnitudes are likely to vary widely and where only crude predictions can be made as to the amount of variation involved. The main advantage of the PDP-8 Floating-Point System is derived from the ability to store very large or very small numbers by storing only the significant digits together with the exponent for that number. In an integral or fractional fixed-point machine, the programmer must either include all of the 0's between the significant digits and the decimal point (and in so doing lose considerable accuracy), or account for the point in each step of his programming.

The PDP-8 Floating-Point System is constructed as a self-contained package which includes its own input, arithmetic, and output routines. It allows the programmer to use floating-point arithmetic without having to construct his own arithmetic subroutines. For example, the polynomial:

$$Y = AX^3 + BX^2 + CX + D$$

may be programmed as follows (the variables X and Y, and the parameters A, B, C, and D are stored in registers of the same name):

```
.....  
JMS   I 7      /ENTER FLOATING PACKAGE  
FGET  A        /LOAD PSEUDO AC  
FMPY  X        /MULTIPLY  
FADD  B        /ADD  
FMPY  X        /MULTIPLY  
FADD  C        /ADD  
FMPY  X        /MULTIPLY  
FADD  D        /ADD  
FPUT  Y        /STORE  
FEXT                      /EXIT FLOATING PACKAGE  
.....
```


CHAPTER 2

FLOATING-POINT REPRESENTATION

A floating-point number consists of a mantissa and an exponent. For example, the decimal number 12 may be represented as:

$1200.0 \cdot 10^{-2}$
 $120.00 \cdot 10^{-1}$
 $12.000 \cdot 10^0$
 $1.2000 \cdot 10^1$
 $.12000 \cdot 10^2$
....
etc.

where the exponents are the numbers -2 , -1 , 0 , etc.

Since the PDP-8 is a binary machine, floating-point numbers are stored as floating-point binary internally. For example, the binary number 110 (6 decimal) may be represented as:

....	
$11000.0 \cdot 2^{-2}$	$(24 \cdot 1/4 = 6)$
$1100.00 \cdot 2^{-1}$	$(12 \cdot 1/2 = 6)$
$110.000 \cdot 2^0$	$(6 \cdot 1 = 6)$
$11.0000 \cdot 2^1$	$(3 \cdot 2 = 6)$
$1.10000 \cdot 2^2$	$(3/2 \cdot 4 = 6)$
$.110000 \cdot 2^3$	$(3/4 \cdot 8 = 6)$
....	
etc.	

Notice that the binary exponent is always a signed integer. The PDP-8 Floating-Point System uses the convention:

$$1/2 \leq | \text{MANTISSA} | < 1.$$

When this is true, the word is said to be normalized.

The value of the number is then:

$$\text{MANTISSA} \cdot 2^{\text{EXPONENT}}$$

where the MANTISSA is a signed quantity. The result of this convention is that more significant bits are retained. For example, the number .10 (decimal) is equal to:

| 0.00 011 001 100 | 110 011 001 100 | 110 011 001 100 110

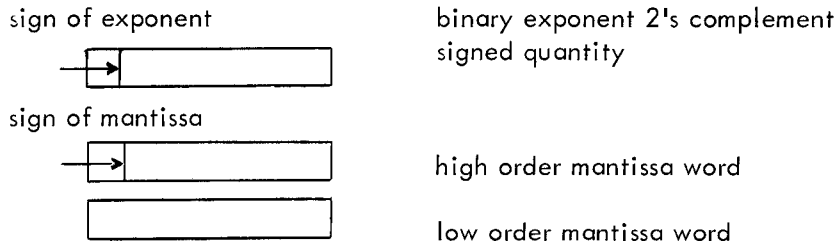
in binary.

When this word is stored in two 12-bit words (24 bits), the leading 0's are nonsignificant and only 20 bits of significance are maintained. If the number is rewritten as:

$2^{-3} \cdot | 0.11 001 100 110 | 011 001 100 110 | 011 001 100 110 \dots$

and the mantissa stored in two 12-bit words, 23 bits of significance are maintained.

The exponent is stored in a third word making a total of three words for storage.



The number .1 (decimal) would be stored as:

111 111 111 101 | 011001100110 | 011001100110

or written in octal:

7775 3146 3146

The address of this number would be considered 2146 if it were stored as follows:

2146/7775

2147/3146

2150/3146

The number -.1 (decimal) would be -.063146314 (octal) which is 0.000 110 011 001 100 110 011 011 100 (binary).

Normalized, this becomes: $(2^{-3})_8 \cdot (0.11 001 100 110 011 001 100 110)_2$

Complemented and incremented to become the negative 2's complement

this becomes: $(2^{-3})_8 \cdot (1.00 110 011 001 100 110 011 010)_2$

which is: $(2^{-3})_8 \cdot (4 \quad 6 \quad 3 \quad 1 \quad 4 \quad 6 \quad 3 \quad 2)_8$

This number would be stored (within octal) as:

7775	exponent of -3
4631	high order mantissa word
4632	low order mantiss word

Since the mantissa is greater (in magnitude) than $1/2$ and less than 1, its binary point is considered to be between bit 0 and bit 1 of the high order mantissa word.

Further examples:

12 (decimal)
 $1100. = (2^4) (0.110000000000000000000000)$

would be stored as (written in octal):

0004
 3000
 0000

<u>Octal</u>	<u>Decimal</u>	<u>Floating Binary</u>		
-1	-1	0001	6000	0000
-10	-8	0004	6000	0000
.4	.5	0000	2000	0000
3	3	0002	3000	0000
14	12	0004	3000	0000
.2	.25	7777	2000	0000
14.26074475	12.3456	0004	3054	1711
-14.26074475	12.3456	0004	4723	6067

Convert the decimal number 1.6 to PDP-8 floating-binary form for storage.

An easy method to convert a decimal fraction to an octal fraction is illustrated below:

$\begin{array}{r} .6 \\ \times 8 \\ 4 \overline{) .8} \end{array}$	$1.6_{10} = 1.46314631_8$
$\begin{array}{r} \times 8 \\ 6 \overline{) .4} \end{array}$	$= 1.10011001100110011001$
$\begin{array}{r} \times 8 \\ 3 \overline{) .2} \end{array}$	$= (2^1) (0.1100110011001100110)$
	$= 0001$

$$\begin{array}{r} \times 8 \\ 1 \overline{) .6} \end{array} \quad 3146$$

$$\begin{array}{r} 8 \\ 4 \overline{) .8} \end{array} \quad 3146$$

$$\begin{array}{r} 8 \\ 6 \overline{) .4} \end{array}$$

$$\begin{array}{r} 8 \\ 3 \overline{) .2} \end{array}$$

$$\begin{array}{r} 8 \\ 1 \overline{) .6} \end{array}$$

ARITHMETIC

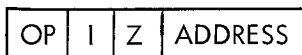
Since floating-point numbers are stored in a three-register format, the floating-point system uses a "pseudo" floating accumulator (FAC) which consists of three registers in the floating-point package: 44, 45, and 46. Register 44 contains the exponent; 45 and 46 contain the high and low order parts of the mantissa, respectively.

BASIC FLOATING-POINT COMMANDS

The basic floating-point commands include the following:

- load floating accumulator
- store floating accumulator
- add to floating accumulator
- subtract from floating accumulator
- multiply by floating accumulator
- divide into floating accumulator
- normalize floating accumulator

All arithmetic operations are called through an interpreter. The command codes have a format that is almost identical to the format of the PDP-8 memory reference instruction, namely:



where the op code is from 000 to 111 or $0_8 - 7_8$.

INTERPRETER

The interpreter contains, at all times, the address of the memory location containing the next pseudo instruction to be executed. This is initially stored when the program enters the interpreter using a JMS

instruction. When the interpreter encounters an instruction with an op code of 0 and with bits 8-11 of the pseudo instruction equal to 0, it exits to the next memory location.

FLOATING-POINT INSTRUCTIONS

The floating-point instructions are:

<u>Op Code</u>	<u>Mnemonic</u>	<u>Effect</u>
1	FADD	Floating Addition Add the contents of the effective address to the floating accumulator.
2	FSUB	Floating Subtract Subtract the contents of the effect address from the floating accumulator.
3	FMPY	Floating Multiply Multiply the floating accumulator by the contents of the effective address.
4	FDIV	Floating Divide Divide the floating accumulator by the contents of the effective address.
5	FGET	Floating Get Load the floating accumulator with the contents of the effective address.
6	FPUT	Floating Put Store the contents of the floating accumulator at the locations specified by the effective address. The contents of the floating accumulator are unchanged.
7	FNOR	Floating Normalize Normalize the contents of the floating accumulator.
0	is decoded as follows:	
Bits 8-11 = 0000		Floating Exit Return control to following instruction
= 0001		Floating Square Square the contents of the floating accumulator

= 0010

Floating Square Root
Take the root of the absolute value of the
floating accumulator

= 0011-1111

Expandable commands

This may be summarized:

FADD	Y; 1000;	$C(FAC) + C(Y) \rightarrow C(FAC)$	} Result is normalized	} C(Y) unchanged
FSUB	Y; 2000;	$C(FAC) - C(Y) \rightarrow C(FAC)$		
FMPY	Y; 3000;	$C(FAC) \times C(Y) \rightarrow C(FAC)$		
FDIV	Y; 4000;	$C(FAC) \div C(Y) \rightarrow C(FAC)$		
FGET	Y; 5000;	$C(Y) \rightarrow C(FAC)$		
FPUT	Y; 6000;	$C(FAC) \rightarrow C(Y)$		
FNOR	; 7000;	$C(FAC) \text{ normalized} \rightarrow C(FAC)$		
FEXT	; 0000;	exit from interpreter to instruction following this command		
SQUARE	; 0001;	$C(FAC)^2 \rightarrow C(FAC)$		
SQROOT	; 0002;	$C(FAC)^{1/2} \rightarrow C(FAC)$		

The assembler recognizes all of these mnemonics except for SQUARE and SQROOT which may be defined as:

SQUARE=0001

SQROOT=0002

The floating-point interpreter is entered with an effective JMS 5600.

For example:

SQROOT=0002

*7

5600

*200

	JMS I 7	200/	4407
	FGET A	201/	5206
	SQROOT	202/	0002
	FPUT I B	203/	6611
	FEXT	204/	0000
	HLT	205/	7402
A,	0003	206/	0003
	2000	207/	2000
	0000	210/	0000
B,	300	211/	0300
\$			

When this program is started at 0200, it will halt at location 205. The state of the machine will be:

44/	0002	
45/	2000	floating accumulator contains
46/	0000	2.0, i.e., $(4.0)^{1/2}$
206/	0003	
207/	2000	register A contains 4.0
210/	0000	
300/	0002	
301/	2000	answer stored here
302/	0000	

CHAPTER 3

FLOATING-POINT INPUT/OUTPUT

FLOATING-POINT INPUT

The basic floating-point package contains an input routine to read characters from the 33 ASR keyboard. Numbers are read in in decimal and converted to the internal floating-point binary format. Input format is floating decimal. The number 726.7 may be read in in any of the following forms:

726.7
.7267E3
.7267E+03
+7267E-1
etc.

Input is terminated when a character is typed that is not a part of this format. The conversion of "12.0." would be terminated on the second "." and the binary number:

000000000100	(octal 0004)
011000000000	(octal 3000)
000000000000	(octal 0000)

would be in the floating-point accumulator upon completion of the conversion.

Flags

There are several flags associated with the input routine that are useful to the programmer.

- | | |
|------|--|
| 0056 | This register is a switch that has the following meaning:

If C(56) = 0, do not type a line-feed after a carriage-return was read.
If C(56) = 7777, type a line-feed when a carriage-return is inputted.
This switch is initially set to 7777. |
| 0057 | This register contains the character that terminated the input conversion. |
| 0060 | This register contains 0000 if no input conversion was made; i.e., a space or other terminator was initially typed. |

The input routine is entered with an effective JMS 7400. It returns control to the instruction following the calling JMS upon receipt of a terminator. The floating accumulator contains the input number in normalized floating-binary. Register 0057 contains the terminating character in ASCII, and C(0060) indicates whether or not there was a valid input.

For example:

```

*5
7400
*7
5600
*200
JMS I 5      /INPUT ROUTINE
JMS I 7      /CALL FLOATING POINT
FPUT A
FEXT
JMS I 5
JMS I 7
FPUT B
FEXT
HLT
A, 0
   0
   0
B, 0
   0
   0
$

```

When this program is started at 0200 and the following is typed:

X2.0Y

The program will halt at location 0210, and A and B will contain

```

A, 0
   0
   0
B, 0002
   2000
   0000

```

and C(57) = 0331, the second TERMINATOR

The first input was considered a 0 because a terminator "X" was inputted.

This program could be written to ignore the non-numeric information as follows:

```

*5      7400
*7      5600
*200
      JMS I 5      /CALL INPUT ROUTINE
      TAD 60      /ANY VALID INPUT?
      SNA CLA
      JMP .-3      /NO - IGNORE
      JMS I 7      /YES
      FPUT A      /STORE IT
      FEXT
      JMS I 5      /GET NEXT
      TAD 60
      SNA CLA      /VALID?
      JMP .-3      /NO - IGNORE
      JMS I 7      /YES
      FPUT B      /STORE IT
      FEXT
      HLT      /HALT
A, 0
   0
   0
B, 0
   0
   0
$

```

Register 57 may be used for integrating control characters into the input.

Rubout

There is one special input character, the rubout. If it is struck before an input delimiter, the input routine is restarted and previous numbers deleted.

For example, assume the input routine has been entered.

```

      276 rubout
      RJT

```

The input routine would exit with 1 (decimal) in the floating accumulator or:

```

44/      0001
          2000
          0000

```

FLOATING-POINT OUTPUT

The basic floating-point package contains an output routine. Upon entry the contents of the floating accumulator are converted to floating-point decimal and typed out on the ASR 33 in the following format:

$\pm 0.XXXXXXXE\pm XX$

For example, if the floating accumulator contained:

44/ 0002
 2000
 0000

and the output routine were entered,

+0.2000000E+01

would be typed.

Entry

The output routine is entered by an effective JMS 7200. After outputting the contents of the floating accumulator, it returns control to the instruction following the calling JMS instruction. The contents of the floating accumulator are lost. The floating-output routine has a flag or program switch in location 0055 on page 0.

If C(0055) does not equal 0, type a carriage-return/line-feed following each output. This location initially contains 7777.

Program Example

```
/SOLVE THE QUADRATIC EQUATION
/AX2+BX+C=0 FOR VALUES
/OF A, B, C.        TYPE OUT ROOTS
SQROOT=0002
SQUARE=0001
*5     7400        /POINTER TO INPUT ROUTINE
      7200        /POINTER TO OUTPUT ROUTINE
      5600        /POINTER TO INTERPRETER
*200
         KCC
         TLS
BEGIN,   JMS I 5     /INPUT A
         JMS I 7     /ENTER INTERPRETER
```

	FMPY TWO	/2.0
	FPUT A	/STORE 2.0·A
	FEXT	
	JMS I 5	/INPUT B
	JMS I 7	/ENTER INTERPRETER
	FPUT B	/STORE B
	FEXT	
	JMS I 5	/INPUT C
	JMS I 7	/ENTER INTERPRETER
	FMPY TWO	/MULTIPLY BY 2.
	FMPY A	/MULTIPLY BY 2A
	FPUT TEMP	/4AC
	FGET B	
	SQUARE	/B SQUARED
	FSUB TEMP	/B SQUARED -4AC
	SQROOT	/TAKE SQUARE ROOT
	FPUT TEMP	/STORE IT
	FGET B	
	FMPY MIN1	/-1·B = - B
	FPUT B	/STORE
	FSUB TEMP	/-B-SQUARE ROOT
	FDIV A	
	FEXT	/ANSWER IN FAC
	JMS I 6	/OUTPUT IT
	JMS I 7	/ENTER INTERPRETER
	FGET B	/-B
	FADD TEMP	/-B + SQUARE ROOT
	FDIV A	
	FEXT	/ANSWER IN FAC
	JMS I 6	/OUTPUT IT
	JMP BEGIN	/CONTINUE
TWO,	0002	/CONSTANT 2.0
	2000	
	0000	
MIN1,	0001	/CONSTANT -1.0
	6000	
	0000	
TEMP,	0	
	0	
	0	
A,	0	
	0	
	0	
B,	0	
	0	
	0	
C,	0	
	0	
	0	
\$		

Both the input-conversion routine and the output-conversion routine use a typeout subroutine that contains the instructions:

```

...
TSF
JMP .-1
TLS
CLA
...

```

This means that the teleprinter flag must be set when these routines are entered or it must be in the process of typing. A TLS instruction can be put into the initialization section of a program.

THE BASIC PACKAGE

Subroutines

When the floating-point interpreter encounters a 0 op code, it further decodes bits 8-11. If these bits equal 0, the interpreter exits. If the bits are nonzero, they are used in a table look-up to specify the address of a subroutine. The called subroutine may use the floating-point interpreter, the input, or the output, but it may not use bits 8-11 to call another subroutine. The look-up table is on page 16 of the interpreter listing. For example, if the user wished to define a routine that negated the contents of the floating accumulator, the following steps would be taken:

On page 6 of the interpreter listing, there is a routine to negate the floating accumulator. It is a subroutine and has, as entry point, the address 6000. If the negate subroutine were to be called by 0010 in the interpreter mode, the word 6000 would be placed in address 6554 of the calling table. Input and output could be called in the interpreter mode if 7400 were placed in 6555 (0011) and 7200 were placed in 6556 (0012).

```

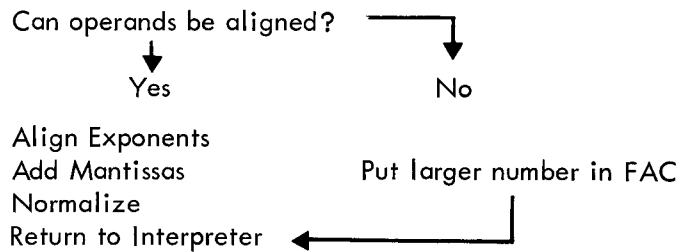
NEGATE = 0010
INPUT   = 0011
OUTPUT  = 0012
SQUARE  = 0001
*7
5600
*200
KCC
TLS
JMS I 7   /ENTER INTERPRETER
INPUT    /CALL INPUT ROUTINE
SQUARE   /SQUARE IT
NEGATE    /CALL OUTPUT ROUTINE
OUTPUT    /CALL OUTPUT ROUTINE
FEXT      /EXIT
HLT       /HALT
$

```

DESCRIPTION OF BASIC FUNCTION

Addition

Floating-point addition is carried out by first aligning the binary points of the two numbers. This is accomplished by scaling the smaller number to the right. Then the mantissas are both scaled right once so that overflow will not occur into the sign bit. A 2's complement addition of the mantissas is then made. The result is normalized and control returns to the interpreter. This may be represented as:



Subtraction

Floating-point subtraction is accomplished by negating the operand, and then calling the addition sub-program.

Negate Operand
Call Addition

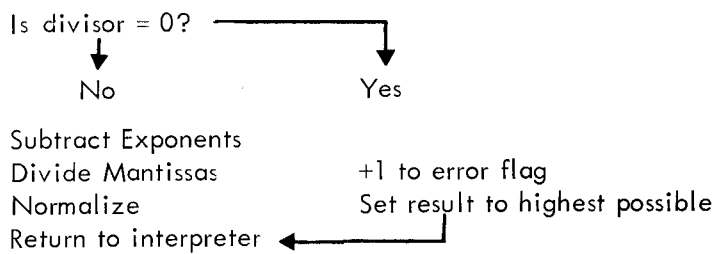
Multiplication

Floating-point multiplication is accomplished by adding the exponents together and then performing a double-precision multiplication. The result is normalized and control returns to the interpreter.

Add Exponents
Multiply Mantissas carrying result to 35 bits
Normalize
Return to Interpreter

Division

Floating-point division is accomplished by subtracting the exponent of the divisor from the exponent of the dividend. The mantissa is divided and the result is normalized. Control returns to the interpreter.



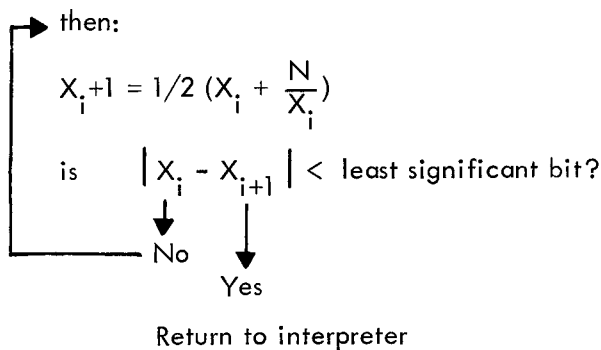
Square

The square routine calls the multiplication routine internally.

Square Root

The square root is calculated using Newton's method in which an initial approximation is made and then each succeeding approximation is calculated. The routine exits when two successive approximations are equal to within the least significant bit of the mantissas.

Form first approximation, X_1 , of $\sqrt{N}$:



Error Flag

Division by 0 causes C(61) to be incremented by 1. The quotient is set to the highest positive number.

Attempting to extract the square of a negative number causes C(61) to be incremented by 1. The root of the absolute value is taken.

The contents of 61 are set to 0 at the beginning of each divide and square root operation.

SUMMARY OF BASIC PACKAGE

Entry Points

5600	Arithmetic Interpreter
7400	Floating Input
7200	Floating Output

NOTE: Both the input and the output routines require that register 7 contains the interpreter entry point: 5600.

Flags

55	If $\neq 0$, type carriage-return/line-feed after output.
56	If $\neq 0$, follow each input carriage-return by a line-feed.
57	Contains the input terminating character.
60	Equals 0 if no valid input.
61	Is nonzero if (a) divide by 0 or (b) square root of a negative number.

Commands

FADD	1000	Floating Add
FSUB	2000	Floating Subtract
FMPY	3000	Floating Multiply
FDIV	4000	Floating Divide
FGET	5000	Floating Get
FPUT	6000	Floating Put
FNOR	7000	Floating Normalize
FEXT	0000	Floating Exit
SQUARE	0001	Square
SQROOT	0002	Square Root
	0003	
		Expandable
	0017	

The floating accumulator is in registers:

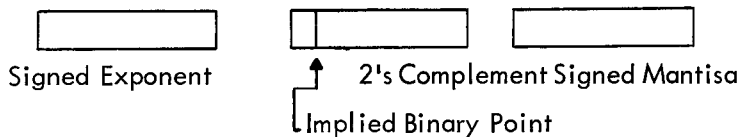
- 44 - Exponent
- 45 - High Order Mantissa
- 46 - Low Order Mantissa

The basic floating-point package (Digital 8-5A-S) uses memory locations:

7; 40-61; 5600-7577

FIXED TO FLOATING/FLOATING TO FIXED

Since the floating-point package stores numbers in the following format:



and since the exponent indicates where the real exponent is, this information may be used to either convert a floating-point number to fixed point or to convert a fixed-point number to floating point.

For example, assume that there is an integer in the accumulator that is less in magnitude than 2047. To float this number, the following sequence of steps may be employed:

	...	
	DCA 45	/PUT INTO HIGH-ORDER MANTISSA
	DCA 46	/PUT 0 INTO LOW-ORDER MANTISSA
	TAD C13	/11 (10) INTO
C,	DCA 44	/EXPONENT
	JMS I 7	/CALL INTERPRETER
	FNOR	/NORMALIZE
	FEXT	/LEAVE INTERPRETER
	...	
C13,	0013	/11 (DECIMAL)

At point C, we have set the binary point of the integer to the right end of the high order mantissa word, or eleven (decimal) locations to the right of the implicit binary point.

To float this number, the floating accumulator is scaled right until the exponent contains the location of the desired binary point. To fix the floating accumulator as an 11-bit signed integer, the following sequence of coding may be employed:

```

....
CLA
TAD 44      /FETCH EXPONENT
SZA SMA     /IS THE NUMBER <1?
JMP .+3     /NO:
CLA         /YES: FIX IT TO 0
JMP DONE+1
TAD M13     /NO: SET BINARY POINT AT
SNA         /11 (10) PLACES TO RIGHT OF CURRENT POINT
JMP DONE    /IT IS ALREADY THERE: ALL DONE
SMA         /TEST TO SEE IF IT IS TOO LARGE
JMP ERROR   /YES: NUMBER >2**11
DCA 44      /NO: SET SCALE COUNT
GO,  CLL    /0 TO C(L)
TAD 45      /FETCH MANTISSA
SPA         /IS IT <0?
CML         /YES: PUT A 1 IN LEFT BIT
RAR         /SCALE RIGHT
DCA 45      /RESTORE IT
ISZ 44      /TEST IF SHIFTED ENOUGH
JMP 00      /NO: CONTINUE
DONE, TAD 45 /ANSWER IN C(AC)
....
....
M13,  -13   /-11 (DECIMAL)

```

This may be coded as a subroutine.

EXTENDED FLOATING-POINT PACKAGE

The extended floating-point package contains the following additional commands:

- 0003 Floating Sine
Take the sine of the angle in the floating accumulator (considered to be in radians) and leave the result in the floating accumulator.

- 0004 Floating Cosine
Take the cosine of the angle in the floating accumulator (considered to be in radians) and leave the result in the floating accumulator.

- 0005 Floating Arc Tangent
Take the arc tangent of the number in the floating accumulator and leave the result (in radians) in the floating accumulator.

- 0006 Floating Exponent
Raise e to the C(FAC) power. Leave the result in the floating accumulator.

- 0007 Floating Logarithm
Take the natural logarithm of the absolute value of the number in the floating accumulator.

Sine

The sine routine uses the following identities:

$$\text{SIN}(-X) = -\text{SIN}(X)$$

$$\text{SIN}(X) = \text{SIN}(2\pi N + F) = \text{SIN}(F)$$

where $0 < F < 2\pi$ and N is an integer:

$$\text{SIN}(\pi - F) = -\text{SIN}(F)$$

Using these identities, F is reduced to the range $-\pi/2 < F < \pi/2$.

If $Y = 2F/\pi$ so that $-1 < Y < 1$, then:

$$\text{SIN}(X) = (C_1 F + C_3 F^3 + C_5 F^5 + C_7 F^7 + C_9 F^9)$$

where:

$$C_1 = 1.57079631847$$

$$C_3 = -0.64596371106$$

$$C_5 = +0.07968967928$$

$$C_7 = -0.00467376557$$

$$C_9 = +0.00015148419$$

The sine subroutine is valid over the range:

$$-2\pi.2047 < X < 2\pi.2047$$

Cosine

The cosine routine uses the identity:

$$\text{COS}(X) = \text{SIN}(\pi/2 - X)$$

It then uses the SINE routine.

Arc Tangent

The arc tangent routine uses the following identities:

$$\text{ARCTAN}(-X) = -\text{ARCTAN}(X)$$

$$\text{IF } X > 1; \text{ then } \text{ARCTAN}(X) = \pi/2 - \text{ARCTAN}(1/X)$$

$$\text{FOR } 0 < X < 1,$$

$$\text{ARCTAN}(X) = \frac{X(A_0 + A_1 X^2 + A_2 X^4)}{B_0 + B_1 X^2 + B_2 X^4}$$

where:

$$A_0 = +0.6402481953$$

$$A_1 = +0.4229908144$$

$$A_2 = +0.0264694361$$

$$B_0 = +0.6402487022$$

$$B_1 = +0.6363779373$$

$$B_2 = +0.1108328778$$

The result is in the range:

$$-\pi/2 < \text{ARCTAN}(X) < \pi/2$$

$$-\infty < X < \infty$$

Logarithm

The logarithm routine uses the identities:

For $X < 1$;

$$\text{LOG}(X) = \text{LOG}(2^N \cdot F) \quad (1 < F < 2)$$

$$= N \text{LOG}(2) + \text{LOG}(F)$$

$$\text{LOG}(1+Y) = \sum_{i=1}^8 A_i Y^i$$

where:

$$A_1 = +0.9999964239$$

$$A_2 = -0.4998741238$$

$$A_3 = +0.3317990258$$

$$A_4 = +0.2407338084$$

$$A_5 = +0.1676540711$$

$$A_6 = -0.0953293897$$

$$A_7 = +0.0360884937$$

$$A_8 = -0.0064553442$$

for:

$0 < X < 1$, the identity:

$\text{LOG}(X) = -\text{LOG}(1/X)$ is used.

Floating Exponent

The exponent routine uses the identity for $X > 0$,

$$e^X = 2^{X \cdot \log_2 e} = 2^{N+F} = 2^N \cdot 2^F$$

where N is an integer and $0 < F < 1$

$$2^F = 1 + \frac{2F}{A - F + BF^2 - \frac{C}{D + F^2}}$$

where:

$$A = +9.95459578$$

$$B = +0.03465735903$$

$$C = +617.97226053$$

$$D = +87.417497202$$

$$\text{Log}_2 e = 1.4426950409$$

If $X < 0$

$$e^x = \frac{1}{e^{-x}}$$

Example, input A, B, and output:

$$Y = \text{LOG}(\text{COS}(A/B) + \sqrt{A \cdot B})$$

SQROOT=0002 /DEFINITIONS TO ASSEMBLER

COS=0004

LOG=0007

*5

7400

7200

5600

/USES EXTENDED INTERPRETER

```

*200
KCC
TLS
BEGIN,  JMS I 5      /INPUT A
        JMS I 7      /ENTER INTERPRETER
        FPUT A       /STORE A
        FEXT         /EXIT
        JMS I 5      /INPUT B
        JMS I 7      /ENTER INTERPRETER
        FPUT B       /STORE B
        FMPY A       /A·B
        SQROOT       /EXTRACT ROOT
        FPUT TEMP    /STORE IT
        FGET A       /LOAD FAC WITH A
        FDIV B       /DIVIDE BY B
        COS          /TAKE COSINE
        FADD TEMP    /ADD
        LOG          /TAKE LOG.
        FEXT
        JMS I 6      /OUTPUT ANSWER
        JMP BEGIN
A,      0
        0
        0
B,      0
        0
        0
TEMP,   0
        0
        0
$

```

Output Controller

There is an additional routine available that formats floating-point output. It is available with both the basic floating-point package and the extended package.

The controller routine requires two parameters for output formatting. It is called by an effective JMS 7200.

At this point:

C(62) = total number of digits to be outputted. If C(62)=0, output in E format.

C(AC) = number of digits to the right of the decimal point. If it equals 0, do not type a ".".

If the number in the floating accumulator is larger than the field width allows, "X's" will be typed. The sign is typed and leading 0's are suppressed.

Example: If the contents of the floating accumulator are 678.234 (decimal).

<u>C(62)</u>	<u>C(AC)</u>	<u>Output</u>
3	0	+ 678
4	0	+ 678
4	1	+ 678.2
5	2	+ 678.23
6	2	+ 678.23
3	2	+ 678.
2	0	+XX
0	1	+ 0.678234E+03

FLOATING POINT PACKAGE VERSIONS

Four versions of the floating-point package are available:

DEC-08-YQ1A-PB

This is the basic floating-point package. It consists of the input/output package and the basic arithmetic instructions. Its core limits are:

5-7; 40-61; 5600-7577

DEC-08-YQ2A-PB

This is the basic floating-point package with the output controller. Its limits are:

7; 40-62; 5400-7577

The output controller does not type a carriage-return/line-feed after output and, hence, the programmer must provide his own routine to do so. Because of the way in which the typeout routine in the floating-point packages are constructed, the user must construct similar typeout routines in order to avoid timing errors in the teleprinter. In other words, the floating-point package uses a routine similar to:

```
TSF
JMP .-1
TLS
```

to do its typing. The user must use a similar routine, i.e., one that waits for the teleprinter flag to be set before executing the TLS instruction.

DEC-08-YQ3A-PB

This is the basic floating-point package with the extended functions. In addition, two interpretive commands are provided for input and output. The additional interpretive commands are:

SINE	3
COSINE	4
ARCTANGENT	5
EXPONENTIAL	6
LOG	7
INPUT	13
OUTPUT	14

Its core limits are:

7; 40-61; 4757-7577

Using this package, the routine on page 3-14 and 3-15 for calculating:

$Y = \text{LOG}(\text{COS}(A/B) + \sqrt{A \cdot B})$ may be rewritten as:

```
SQROOT=2
COS=4
LOG=7
INPUT=13
OUTPUT=14
```

```
*7
```

```
5600
```

```
*200
```

```
KCC
```

```
TLS
```

```
BEGIN,  JMS I 7    /CALL INTERPRETER
        INPUT     /READ A
        FPUT A    /STORE IT
        INPUT     /READ B
        FPUT B
        FMPY A    /A·B
        SQROOT
        FPUT TEMP /(A·B)** .5
        FGET A
        FDIV B
        FCOS
        FADD TEMP
        FLOG
        OUTPUT
        FEXT
        JMP BEGIN
```

```
A,      0
```

```
0
```

```
0
```

```
B,      0
```

```
0
```

```
0
```

```
TEMP,   0
```

```
0
```

```
0
```

```
$
```

This is the basic package, the output controller, and the extended functions. This package does not have the interpretive I/O commands of input and output. Its core limits are:

7; 40-62; 4557-7577

CHAPTER 4

PROGRAM LISTINGS

/FLOATING POINT ARITHMETIC INTERPRETER

*40

0040	0000	EX1,	0	/OPERAND STORAGE
0041	0000	AC1H,	0	
0042	0000	AC1L,	0	
0043	0000	OVER1,	0	
0044	0000	EXP,	0	/F.A.
0045	0000	HORD,	0	
0046	0000	LORD,	0	
0047	0000	OVER2,	0	
0050	0000	EXP1,	0	
0051	0000	QUOL,	0	
0052	0000	FPAC1,	0	
0053	0000		0	
0054	0000		0	

*61

0061	0000	FLAG,	0	/ARITHMETIC ERROR FLAG
------	------	-------	---	------------------------

*5600

5600	0000	FPNT,	0	
5601	7300	CLA CLL		
5602	3043	DCA OVER1		
5603	3047	DCA OVER2		
5604	1600	TAD I FPNT		/GET NEXT INSTRUCTION
5605	3253	DCA JUMP		
5606	1253	TAD JUMP		
5607	0263	AND PAGENO		/GET PAGE BIT
5610	7650	SNA CLA		/PAGE ZERO?
5611	5214	JMP .+3		/YES
5612	1261	TAD MASK5		/NO
5613	0200	AND FPNT		/C(FPNT)0-4 CONTAINS PAGE BITS
5614	3256	DCA ADDR		
5615	1262	TAD MASK7		/GET 7 BIT ADDRESS
5616	0253	AND JUMP		
5617	1256	TAD ADDR		
5620	3256	DCA ADDR		
5621	1264	TAD INDRCT		/INDIRECT BIT=1?
5622	0253	AND JUMP		
5623	7650	SNA CLA		
5624	5227	JMP LOOP01		/NO-GO ON
5625	1656	TAD I ADDR		/YES DEFER
5626	3256	DCA ADDR		
5627	2200	LOOP01, ISZ FPNT		
5630	1656	TAD I ADDR		
5631	3040	DAC EX1		/EXPONENT
5632	1256	TAD ADDR		

5633	3257		DCA SAVE	
5634	2257		ISZ SAVE	
5635	1657		TAD I SAVE	
5636	3041		DCA AC1H	/HIGH ORDER MANTISSA
5637	2257		ISZ SAVE	
5640	1657		TAD I SAVE	
5641	3042		DAC AC1L	/LOW ORDER MANTISSA
5642	1253		TAD JUMP	
5643	7106		CLL RTL	
5644	7006		RTL	
5645	0260		AND MASK3	/GET BITS 0-2, IE OPCODE
5646	1265		TAD TABLE	/LOOKUP IN TABLE
5647	3254		DCA JUMP2	
5650	1654		TAD I JUMP2	
5651	3254		DCA JUMP2	
5652	5654		JMP I JUMP2	/GO THERE
5653	0000	JUMP,	0	
5654	0000	JUMP2,	0	
5655	0000	GO2,	0	
5656	0000	ADDR,	0	
5657	0000	SAVE,	0	
5660	0017	MASK3,	0017	
5661	7600	MASK5,	7600	
5662	0177	MASK7,	0177	
5663	0200	PAGENO,	0200	
5664	0400	INDRCT,	0400	
5665	5666	TABLE,	+.1	
5666	5742		EXIT	/TABLE USED IN INTERPRETING
5667	5716		FLAD	/BITS 0-2 OF PSEUDO
5670	5737		FLSU	/INSTRUCTION
5671	5761		FLMY	
5672	6305		FLDV	/IF OPCODE=0, GO TO EXIT
5673	5676		FLGT	/AND INTERPRET BITS 8-11
5674	5705		FLPT	
5675	5773		NORF	
5676	1040	FLGT,	TAD EX1	/FGET=5
5677	3044		DCA EXP	
5700	1041		TAD AC1H	
5701	3045		DCA HORD	
5702	1042		TAD AC1L	
5703	3046		DCA LORD	
5704	5201		JMP FPNT+1	
5705	1044	FLPT,	TAD EXP	/FPUT=6
5706	3656		DCA I ADDR	
5707	2256		ISZ ADDR	
5710	1045		TAD HORD	
5711	3656		DCA I ADDR	
5712	2256		ISZ ADDR	
5713	1046		TAD LORD	
5714	3656		DCA I ADDR	
5715	5201		JMP FPNT+1	
5716	4771	FLAD,	JMS I ALGN	/FLAD=1 - FIRST ALIGN EXPONENTS
5717	5201		JMP FPNT+1	/RETURN IF NO ALIGNMENT IS POSSIBLE
5720	4772		JMS I UNORM	/LARGER OF THE TWO IS IN F.A.

5721	7100		CLL	
5722	1043		TAD OVER1	/TRIPLE PRECISION ADDITION
5723	1047		TAD OVER2	/SINCE BITS ARE SHIFTED
5724	3047		DCA OVER2	/RIGHT
5725	7004		RAL	
5726	1042		TAD AC1L	
5727	1046		TAD LORD	
5730	3046		DCA LORD	
5731	7004		RAL	
5732	1041		TAD AC1H	
5733	1045		TAD HORD	
5734	3045		DCA HORD	
5735	4770		JMS I NORM	/NORMALIZE THE RESULT
5736	5201		JMP FPNT+1	
5737	4741	FLSU,	JMS I OPMINS	/FSUB=2 - NEGATE THE OPERAND
5740	5316		JMP FLAD	/ADD
5741	6400	OPMINS,	MINUS2	
5742	1253	EXIT,	TAD JUMP	/OPCODE=0
5743	0260		AND MASK3	/ARE BITS 8-11=0?
5744	7450		SNA	
5745	5600		JMP I FPNT	/YES=FEXT
5746	1360		TAD ACON6	/LOOKUP ON TABLE
5747	3254		DCA JUMP2	
5750	1654		TAD I JUMP2	
5751	3254		DCA JUMP2	
5752	1200		TAD FPNT	
5753	3255		DCA GO2	
5754	4654		JMS I JUMP2	/CALL AS A SUBROUTINE
5755	1255		TAD GO2	/RESTORE F.P. POINTER
5756	3200		DCA FPNT	
5757	5201		JMP FPNT+1	/GET NEXT PSEUDO INSTRUCTION
5760	6544	ACON6,	TABLE6-1	/CALLING CAN BE TO A DEPTH ONE
5761	7201	FLMY,	CLA IAC	/FMPY=3
5762	1040		TAD EX1	
5763	1044		TAD EXP	/ADD EXPONENTS TOGETHER
5764	3044		DCA EXP	
5765	4767		JMS I MULT	/MULTIPLY
5766	5201		JMP FPNT+1	
5767	6221	MULT,	DMULT	
5770	6600	NORM,	DNORM	
5771	6020	ALGN,	ALIGN	
5772	6564	UNORM,	DUNORM	
5773	4770	NORF,	JMS I NORM	
5774	5201		JMP FPNT+1	
6000	0000	*6000		
6001	7300	ACMINS,	0	/ROUTINE TO PERFORM
6002	1047		CLL CLA	
6003	7041		TAD OVER2	/TRIPLE PRECISION NEGATION
6004	3047		CMA IAC	/OF FLOATING AC
6005	1046		DCA OVER2	
6006	7040		TAD LORD	
6007	7430		CMA	
			SZL	

6010	7101	CLL IAC	
6011	3046	DCA LORD	
6012	1045	TAD HORD	
6013	7040	CMA	
6014	7430	SZL	
6015	7101	CLL IAC	
6016	3045	DCA HORD	
6017	5600	JMP I ACMINS	
6020	0000	ALIGN, 0	/SUBROUTINE TO ALIGN
6021	1045	TAD HORD	/BINARY POINTS FOR
6022	7640	SZA CLA	/ADD-SUBTRACT
6023	5227	JMP .+4	
6024	1046	TAD LORD	/IS MANTISSA ZERO?
6025	7650	SNA CLA	
6026	5337	JMP NOHERE	/YES
6027	1041	TAD AC1H	/IS OPERAND ZERO?
6030	7640	SZA CLA	
6031	5235	JMP .+4	
6032	1042	TAD AC1L	
6033	7650	SNA CLA	
6034	5620	JMP I ALIGN	/BOTH ARE ZERO-EXIT
6035	1040	TAD EX1	
6036	7041	CMA IAC	
6037	1044	TAD EXP	
6040	7450	SNA	/ARE EXPONENTS EQUAL?
6041	5314	JMP DONE	/YES
6042	7500	SMA	
6043	7041	CMA IAC	
6044	3342	DCA AMOUNT	
6045	1342	TAD AMOUNT	
6046	1343	TAD TEST2	
6047	7700	SMA CLA	/CAN EXPONENTS BE ALIGNED?
6050	5256	JMP .+6	/YES
6051	4316	JMS OUTGO	/NO
6052	7430	SZL	
6053	1350	TAD TAG2	
6054	1347	TAD TAG1	
6055	5325	JMP NOGO	
6056	4316	JMS OUTGO	
6057	7420	SNL	/SET UP ADDRESSES
6060	1350	TAD TAG2	
6061	1347	TAD TAG1	
6062	3344	DCA TEST3	
6063	1342	TAD AMOUNT	
6064	7041	CMA IAC	
6065	1744	TAD I TEST3	
6066	3744	DCA I TEST3	
6067	2344	ISZ TEST3	
6070	1344	TAD TEST3	
6071	3345	DCA TEST4	
6072	2345	ISZ TEST4	
6073	1345	TAD TEST4	
6074	3346	DCA TEST5	
6075	2346	ISZ TEST5	

6076	7100	SHIFT,	CLL	/THIS ROUTINE DOES
6077	1744		TAD I TEST3	/THE ACUTAL SHIFTING
6100	7510		SPA	
6101	7020		CML	
6102	7010		RAR	
6103	3744		DCA I TEST3	
6104	1745		TAD I TEST4	
6105	7010		RAR	
6106	3745		DCA I TEST4	
6107	1746		TAD I TEST5	
6110	7010		RAR	
6111	3746		DCA I TEST5	
6112	2342		ISZ AMOUNT	
6113	5276		JMP SHIFT	
6114	2220	DONE,	ISZ ALIGN	
6115	5620		JMP I ALIGN	
6116	0000	OUTGO,	0	/DETERMINE WHICH TO SHIFT
6117	1040		TAD EX1	
6120	7041		CMA IAC	
6121	1044		TAD EXP	
6122	7004		RAL	
6123	7200		CLA	
6124	5716		JMP I OUTGO	
6125	3344	NOGO,	DCA TEST3	/CAN'T BE ALIGNED
6126	1744		TAD I TEST3	/LARGEST GOES INTO FAC
6127	3044		DCA EXP	
6130	2344		ISZ TEST3	
6131	1744		TAD I TEST3	
6132	3045		DCA HORD	
6133	2344		ISZ TEST3	
6134	1744		TAD I TEST3	
6135	3046		DCA LORD	
6136	5620		JMP I ALIGN	
6137	1040	NOHERE,	TAD EX1	/MANTISSA=0
6140	3044		DCA EXP	
6141	5314		JMP DONE	
6142	0000	AMOUNT,	0	
6143	0030	TEST2,	0030	
6144	0000	TEST3,	0	
6145	0000	TEST4,	0	
6146	0000	TEST5,	0	
6147	0044	TAG1,	EXP	
6150	7774	TAG2,	EX1-EXP	
6151	5601	RETN2,	FPNT+1	
6152	1362	ERROR1,	TAD GOOF	/DIVISION BY ZERO
6153	3044		DCA EXP	/SET TO LARGEST + VALUE
6154	1362		TAD GOOF	
6155	3045		DCA HORD	
6156	7040		CMA	
6157	3046		DCA LORD	
6160	2061		ISZ FLAG	/SET FLAG
6161	5751		JMP I RETN2	
6162	3777	GOOF,	3777	

6163	0000	SQUARE,	0	
6164	4407		JMS I 0007	
6165	6052		FPUT FPAC1	
6166	3052		FMPY FPAC1	
6167	0000		FEXT	
6170	5763		JMP I SQUARE	
6171	0000	EXIT6,	0	/DUMMY SUBROUTINE
6172	5771		JMP I EXIT6	
		*6200		
6200	0000	DIV1,	0	/SHIFT FAC RIGHT
6201	7300		CLA CLL	
6202	1045		TAD HORD	
6203	7510		SPA	
6204	7120		CLL CML	
6205	7010		RAR	
6206	3045		DCA HORD	
6207	1046		TAD LORD	
6210	7010		RAR	
6211	3046		DCA LORD	
6212	1047		TAD OVER2	
6213	7010		RAR	
6214	3047		DCA OVER2	
6215	7100		CLL	
6216	2044		ISZ EXP	
6217	7000		NOP	
6220	5600		JMP I DIV1	
6221	0000	DMULT,	0	/DOUBLE PRECISION MULTIPLY
6222	7300		CLA CLL	/SAVE PRODUCT TRIPLE PRECISION
6223	1363		TAD SMACLA	
6224	3347		DCA SNSWIT	/CALLS A SINGLE PRECISION
6225	4336		JMS SIGN	/MULTIPLY 3 TIMES
6226	1042		TAD AC1L	
6227	3756		DCA I MP2PT	
6230	1046		TAD LORD	
6231	4755		JMS I MP4PT	
6232	7200		CLA	
6233	1757		TAD I MP5PT	
6234	3047		DCA OVER2	
6235	1045		TAD HORD	
6236	3756		DCA I MP2PT	
6237	1042		TAD AC1L	
6240	4755		JMS I MP4PT	
6241	1047		TAD OVER2	
6242	3047		DCA OVER2	
6243	7004		RAL	
6244	1757		TAD I MP5PT	
6245	3367		DCA D	
6246	7004		RAL	
6247	3370		DCA KEEP	
6250	1041		TAD AC1H	
6251	3756		DCA I MP2PT	
6252	1046		TAD LORD	
6253	4755		JMS I MP4PT	

6254	1047		TAD OVER2	
6255	3047		DCA OVER2	
6256	7004		RAL	
6257	1757		TAD I MP5PT	
6260	1367		TAD D	
6261	3367		DCA D	
6262	7004		RAL	
6263	1370		TAD KEEP	
6264	3370		DCA KEEP	
6265	1045		TAD HORD	
6266	3756		DCA I MP2PT	
6267	1041		TAD AC1H	
6270	4755		JMS I MP4PT	
6271	1367		TAD D	
6272	3046		DCA LORD	
6273	7004		RAL	
6274	1757		TAD I MP5PT	
6275	1370		TAD KEEP	
6276	3045		DCA HORD	
6277	4760		JMS I NORMF	
6300	3047		DCA OVER2	
6301	2365		ISZ SGN	
6302	5621		JMP I DMULT	
6303	4773		JMS I MINS	
6304	5621		JMP I DMULT	
6305	1041	FLDV,	TAD AC1H	
6306	7640		SZA CLA	
6307	5313		JMP .+4	
6310	1042		TAD AC1L	
6311	7650		SNA CLA	
6312	5774		JMP I ERROR	/DIVISION BY ZERO
6313	1040		TAD EX1	
6314	7041		CMA IAC	
6315	1044		TAD EXP	
6316	7001		IAC	
6317	3044		DCA EXP	/SUBTRACT EXPONENTS
6320	1362		TAD SPACLA	
6321	3347		DCA SNSWIT	
6322	4336		JMS SIGN	/SET UP SIGNS
6323	4761		JMS I DIVIDE	/DIVIDE
6324	1757		TAD I MP5PT	
6325	1041		TAD AC1H	/ROUND OFF IN 23RD BIT
6326	7630		SZL CLA	
6327	7001		IAC	
6330	3042		DCA AC1L	
6331	3041		DCA AC1H	
6332	2365		ISZ SGN	/TEST SIGN
6333	4773		JMS I MINS	/NEGATE
6334	5735		JMP I .+1	/ADD ROUNDING
6335	5720		FLAD+2	
6336	0000	SIGN,	0	/TEST SIGN OF RESULT
6337	1366		TAD REST	/SET UP BY MULTIPLY AND
6340	3365		DCA SGN	/DIVIDE

6341	1045		TAD HORD	
6342	7700		SMA CLA	
6343	5346		JMP .+3	
6344	4773		JMS I MINS	
6345	2365		ISZ SGN	
6346	1041		TAD AC1H	
6347	7700	SNSWIT,	SMA CLA	/OR SPA CLA
6350	5736		JMP I SIGN	
6351	4771		JMS I MINS2	
6352	2365		ISZ SGN	
6353	7000		NOP	
6354	5736		JMP I SIGN	
6355	6437	MP4PT,	MP4	
6356	6471	MP2PT,	MP2	
6357	6465	MP5PT,	MP5	
6360	6600	NORMF,	DNORM	
6361	6472	DIVIDE,	DUBDIV	
6362	7710	SPACLA,	SPA CLA	
6363	7700	SMACLA,	SMA CLA	
6364	5601	RETURN,	FPNT+1	
6365	0000	SGN,	0	
6366	7776	REST,	7776	
6367	0000	D,	0	
6370	0000	KEEP,	0	
6371	6400	MINS2,	MINUS2	/-AC1H,AC1L
6372	6420	RAR2,	DIV2	/AC1H,AC1L/2
6373	6000	MINS,	ACMINS	
6374	6152	ERROR,	ERROR1	
		*6400		
6400	0000	MINUS2,	0	/NEGATE OPERAND
6401	7300		CLA CLL	/TRIPLE PRECISION
6402	1043		TAD OVER1	
6403	7041		CMA IAC	
6404	3043		DCA OVER1	
6405	1042		TAD AC1L	
6406	7040		CMA	
6407	7430		SZL	
6410	7101		CLL IAC	
6411	3042		DCA AC1L	
6412	1041		TAD AC1H	
6413	7040		CMA	
6414	7430		SZL	
6415	7101		CLL IAC	
6416	3041		DCA AC1H	
6417	5600		JMP I MINUS2	
6420	0000	DIV2,	0	/SHIFT OPERAND RIGHT
6421	7300		CLA CLL	/TRIPLE PRECISION
6422	1041		TAD AC1H	
6423	7510		SPA	
6424	7120		CLL CML	
6425	7010		RAR	
6426	3041		DCA AC1H	
6427	1042		TAD AC1L	

6430	7010		RAR	
6431	3042		DCA AC1L	
6432	1043		TAD OVER1	
6433	7010		RAR	
6434	3043		DCA OVER1	
6435	7100		CLL	
6436	5620		JMP I DIV2	
6437	0000	MP4,	0	/SINGLE PRECISION MULTIPLY
6440	3266		DCA MP1	/12 BITS BY 12 BITS
6441	3265		DCA MP5	
6442	1270		TAD THIR	
6443	3267		DCA MP3	
6444	7100		CLL	
6445	1266		TAD MP1	
6446	7010		RAR	
6447	3266		DCA MP1	
6450	1265		TAD MP5	
6451	7420		SNL	
6452	5255		JMP .+3	
6453	7100		CLL	
6454	1271		TAD MP2	
6455	7010		RAR	
6456	3265		DCA MP5	
6457	2267		ISZ MP3	
6460	5245		JMP MP4+6	
6461	1266		TAD MP1	
6462	7010		RAR	
6463	7100		CLL	
6464	5637		JMP I MP4	
6465	0000	MP5,	0	
6466	0000	MP1,	0	
6467	0000	MP3,	0	
6470	7764	THIR,	7764	
6471	0000	MP2,	0	
6472	0000	DUBDIV,	0	/DOUBLE PRECISION DIVIDE
6473	7300		CLA CLL	
6474	3051		DCA QUOL	
6475	1344		TAD MIF	
6476	3267		DCA MP3	
6477	5306		JMP DVX	
6500	1046	DV3,	TAD LORD	
6501	7004		RAL	
6502	3046		DCA LORD	
6503	1045		TAD HORD	
6504	7004		RAL	
6505	3045		DCA HORD	
6506	1042	DVX,	TAD AC1L	
6507	1046		TAD LORD	
6510	3271		DCA MP2	
6511	7004		RAL	
6512	1045		TAD HORD	
6513	1041		TAD AC1H	
6514	7420		SNL	

6515	5321		JMP DV2-1	
6516	3045		DCA HORD	
6517	1271		TAD MP2	
6520	3046		DCA LORD	
6521	7200		CLA	
6522	1051	DV2,	TAD QUOL	
6523	7004		RAL	
6524	3051		DCA QUOL	
6525	1047		TAD OVER2	
6526	7004		RAL	
6527	3047		DCA OVER2	
6530	2267		ISZ MP3	
6531	5300		JMP DV3	
6532	1051		TAD QUOL	
6533	3046		DCA LORD	
6534	1045		TAD HORD	
6535	7106		CLL RTL	
6536	3265		DCA MP5	
6537	1047		TAD OVER2	
6540	3045		DCA HORD	
6541	3047		DCA OVER2	
6542	1265		TAD MP5	
6543	5672		JMP I DUBDIV	
6544	7751	MIF,	7751	
6545	6163	TABLE6,	SQUARE	/TABLE FOR INTERPRETATION
6546	6656		SQROOT	/OF BITS 8-11
6547	6171		EXIT6	/CONTAINS ABSOLUTE ADDRESSES
6550	6171		EXIT6	/OF PROGRAMS CALLED AS
6551	6171		EXIT6	/SUBROUTINES
6552	6171		EXIT6	/EXIT6=A DUMMY OR NOP
6553	6171		EXIT6	
6554	6171		EXIT6	
6555	6171		EXIT6	
6556	6171		EXIT6	
6557	6171		EXIT6	
6560	6171		EXIT6	
6561	6171		EXIT6	
6562	6171		EXIT6	
6563	6171		EXIT6	
6564	0000	DUNORM,	0	
6565	4220		JMS DIV2	/SHIFT OPERAND RIGHT
6566	4772		JMS I RAR1	
6567	2040		ISZ EX1	
6570	7000		NOP	
6571	5764		JMP I DUNORM	
6572	6200	RAR1,	DIV1	
		*6600		
6600	0000	DNORM,	0	/SUBROUTINE TO NORMALIZE
6601	7300		CLA CLL	/FLOATING ACCUMULATOR
6602	3255		DCA AMT1	
6603	3254		DCA SIGN1	
6604	1045		TAD HORD	
6605	7510		SPA	/IS MANTISSA NEGATIVE?

6606	2254		ISZ SIGN1	/YES
6607	7640		SZA CLA	/IS MANTISSA=0?
6610	5217		JMP GO6	/NO
6611	1046		TAD LORD	
6612	7640		SZA CLA	
6613	5217		JMP GO6	
6614	1047		TAD OVER2	
6615	7650		SNA CLA	
6616	5251		JMP EXIT2	/YES
6617	1254	GO6,	TAD SIGN1	/NO
6620	7640		SZA CLA	/NEGATIVE?
6621	4653		JMS I NEG	/YES
6622	1045	LOP,	TAD HORD	/WILL SHIFT BE TOO FAR?
6623	7104		RAL CLL	
6624	7710		SPA CLA	
6625	5241		JMP EXIT1	/YES
6626	1047		TAD OVER2	
6627	7104		CLL RAL	
6630	3047		DCA OVER2	
6631	1046		TAD LORD	/NO SHIFT MANTISSA LEFT
6632	7004		RAL	
6633	3046		DCA LORD	
6634	1045		TAD HORD	
6635	7004		RAL	
6636	3045		DCA HORD	
6637	2255		ISZ AMT1	/COUNT NO. OF TIMES SHIFTED
6640	5222		JMP LOP	
6641	1255	EXIT1,	TAD AMT1	/CORRECT EXPONENT
6642	7041		CMA IAC	
6643	1044		TAD EXP	
6644	3044		DCA EXP	
6645	1254		TAD SIGN1	/NEGATIVE?
6646	7640		SZA CLA	
6647	4653		JMS I NEG	/YES
6650	5600		JMP I DNORM	
6651	3044	EXIT2,	DCA EXP	/SET TO ZERO
6652	5600		JMP I DNORM	
6653	6000	NEG,	ACMINS	
6654	0000	SIGN1,	0	
6655	0000	AMT1,	0	
6656	0000	SQROOT,	0	/FLOATING SQUARE ROOT
6657	3362		DCA FLAG1	/TAKES ROOT OF ABSOLUTE
6660	4407		JMS I 007	
6661	6052		FPUT FPAC1	/VALUE
6662	0000		FEXT	/NEWTON'S METHOD IS USED
6663	1045		TAD HORD	
6664	7710		SPA CLA	
6665	5351		JMP SQEND1	/NUMBER IS NEGATIVE
6666	1044		TAD EXP	
6667	7100		CLL	
6670	7510		SPA	
6671	7020		CML	
6672	7010		RAR	
6673	3356		DCA ITER1	/MAKE FIRST APPROXIMATION

6674	7430		SZL	
6675	2356		ISZ ITER1	
6676	7000		NOP	
6677	1361		TAD SQCON1	
6700	3357		DCA ITER1+1	
6701	3360		DCA ITER1+2	
6702	1053		TAD FPAC1+1	
6703	7640		SZA CLA	
6704	5310		JMP CLCU	
6705	1054		TAD FPAC1+2	
6706	7650		SNA CLA	
6707	5354		JMP SQEND	/NUMBER=0
6710	4407	CLCU,	JMS I 0007	
6711	5052		FGET FPAC1	
6712	4356		FDIV ITER1	
6713	1356		FADD ITER1	
6714	0000		FEXT	
6715	7240		CLA CMA	
6716	1044		TAD EXP	
6717	3044		DCA EXP	
6720	1044		TAD EXP	
6721	7041		CMA IAC	
6722	1356		TAD ITER1	
6723	7640		SZA CLA	/ARE EXPONENTS EQUAL?
6724	5345		JMP ROOTGO	/NO
6725	1045		TAD HORD	/ARE HIGH-ORDER MANTISSAS EQUAL?
6726	7041		CMA IAC	
6727	1357		TAD ITER1+1	
6730	7640		SZA CLA	
6731	5345		JMP ROOTGO	/NO
6732	1046		TAD LORD	
6733	7041		CMA IAC	
6734	1360		TAD ITER1+2	/DO LOW-ORDER MANTISSAS AGREE?
6735	7500		SMA	
6736	7041		CMA IAC	/WITHIN ONE BIT?
6737	7001		IAC	
6740	7710		SPA CLA	
6741	5345		JMP ROOTGO	/NO
6742	1362		TAD FLAG1	
6743	3061		DCA FLAG	
6744	5656		JMP I SQROOT	
6745	4407	ROOTGO,	JMS I 0007	
6746	6356		FPUT ITER1	
6747	0000		FEXT	
6750	5310		JMP CLCU	
6751	4653	SQEND1,	JMS I NEG	/NEGATE FAC
6752	2362		ISZ FLAG1	
6753	5260		JMP SQROOT+2	
6754	3044	SQEND,	DCA EXP	
6755	5656		JMP I SQROOT	
6756	0000	ITER1,	0	
6757	0000		0	
6760	0000		0	
6761	3015	SQCON1,	3015	
6762	0000	FLAG1,	0	

ACMINS	6000	FLPT	5705	NORMF	6360
ACON6	5760	FLSU	5737	OPMINS	5741
ACTH	0041	FPAC1	0052	OUTGO	6116
AC1L	0042	FPNT	5600	OVER1	0043
ADDR	5656	GOOF	6162	OVER2	0047
ALGN	5771	GO2	5655	PAGENO	5663
ALIGN	6020	GO6	6617	QUOL	0051
AMOUNT	6142	HORD	0045	RAR1	6572
AMT1	6655	INDRCT	5664	RAR2	6372
CLCU	6710	ITER1	6756	REST	6366
D	6367	JUMP	5653	RETN2	6151
DIVIDE	6361	JUMP2	5654	RETURN	6364
DIV1	6200	KEEP	6370	ROOTGO	6745
DIV2	6420	LOOP01	5627	SAVE	5657
DMULT	6221	LOP	6622	SGN	6365
DNORM	6600	LORD	0046	SHIFT	6076
DONE	6114	MASK3	5660	SIGN	6336
DUBDIV	6472	MASK5	5661	SIGN1	6654
DUNORM	6564	MASK7	5662	SMACLA	6363
DVX	6506	MIF	6544	SNSWIT	6347
DV2	6522	MINS	6373	SPACLA	6362
DV3	6500	MINS2	6371	SQCON1	6761
ERROR	6374	MINUS2	6400	SQEND	6754
ERROR1	6152	MP1	6466	SQEND1	6751
EXIT	5742	MP2	6471	SQROOT	6656
EXIT1	6641	MP2PT	6356	SQUARE	6163
EXIT2	6651	MP3	6467	TABLE	5665
EXIT6	6171	MP4	6437	TABLE6	6545
EXP	0044	MP4PT	6355	TAG1	6147
EXP1	0050	MP5	6465	TAG2	6150
EX1	0040	MP5PT	6357	TEST2	6143
FLAD	5716	MULT	5767	TEST3	6144
FLAG	0061	NEG	6653	TEST4	6145
FLAG1	6762	NOGO	6125	TEST5	6146
FLDV	6305	NOHERE	6137	THIR	6470
FLGT	5676	NORF	5773	UNORM	5772
FLMY	5761	NORM	5770		

/FLOATING POINT I/O ROUTINES
 /REQUIRES FLOATING POINT INTERPRETER
 /ENTRY AT 0007

0007	5600	*7 FPNT,	5600	
0044	0000	*44 EXPONT,	0	
0045	0000	HORDER,	0	
0046	0000	LORDER,	0	
0052	0000	*52 FPAC1,	0	
0053	0000		0	
0054	0000		0	
0055	7777	SWIT1,	7777	/IF = 0, NO CR-LF AFTER OUTPUT
0056	7777	SWIT2,	7777	/IF = 0, NO LF AFTER CR IN INPUT
0057	0000	CHAR,	0	/CONTAINS LAST CHARACTER READ
0060	0000	DSWIT,	0	/= 0 IF NO CONVERSION TOOK PLACE
6767	0000	*6767 PRCHAR,	0	
6770	1056		TAD SWIT2	
6771	7550		SNA CLA	
6772	5767		JMP I PRCHAR	
6773	1377		TAD LFED	
6774	4776		JMS I OPUT	
6775	5767		JMP I PRCHAR	
6776	7344	OPUT,	OUT	
6777	0212	LFED,	0212	

/DOUBLE PRECISION DECIMAL-BINARY
/INPUT AND CONVERSION
*7000

7000	0000	DECONV,	0	
7001	7200		CLA	/INITIALIZE MANTISSA
7002	3045		DCA HORDER	
7003	3046		DCA LORDER	
7004	3265		DCA SIGN	
7005	3266		DCA DNUMBR	
7006	4342		JMS INPUT	
7007	1336		TAD PLUS	/TEST FOR SIGN
7010	7450		SNA	
7011	5217		JMP DECON	
7012	1335		TAD MINUS	
7013	7440		SZA	
7014	5220		JMP .+4	
7015	7240		CLA CMA	
7016	3265		DCA SIGN	/IF-, SET SWITCH
7017	4342	DECON,	JMS INPUT	
7020	7200		CLA	
7021	1057		TAD CHAR	/IS IT A DIGIT
7022	1337		TAD MIN9	
7023	7500		SMA	
7024	5600		JMP I DECONV	/NO
7025	1340		TAD PLUS12	
7026	7510		SPA	
7027	5600		JMP I DECONV	/NO
7030	3263		DCA DIGIT	/YES
7031	1045		TAD HORDER	
7032	0341		AND MASK	/OVERFLOW?
7033	7440		SZA	
7034	5217		JMP DECON	/YES-IGNORE
7035	2060		ISZ DSWIT	
7036	2266		ISZ DNUMBR	/INDEX NUMBER OF DIGITS
7037	4241		JMS MULT10	
7040	5217		JMP DECON	/CONTINUE
7041	0000	MULT10,	0	/ROUTINE TO MULTIPLY
7042	1046		TAD LORDER	/DOUBLE PRECISION WORD
7043	3261		DCA LTEMP	/BY TEN (DECIMAL)
7044	1045		TAD HORDER	/REMAIN=REMAINDER
7045	3262		DCA HTEMP	
7046	3264		DCA REMAIN	
7047	4267		JMS MULT2	/CALL SUBROUTINE TO
7050	4267		JMS MULT2	/MULTIPLY BY TWO
7051	4303		JMS DUBLAD	/CALL DOUBLE ADD
7052	4267		JMS MULT2	
7053	1263		TAD DIGIT	/ADD LAST DIGIT RECEIVED
7054	3261		DCA LTEMP	
7055	3262		DCA HTEMP	
7056	4303		JMS DUBLAD	
7057	1264		TAD REMAIN	/EXIT WITH REMAINDER
7060	5641		JMP I MULT10	/IN AC
7061	0000	LTEMP,	0	/DOUBLE PRECISION WORD
7062	0000	HTEMP,	0	
7063	0000	DIGIT,	0	/STORAGE FOR DIGIT
7064	0000	REMAIN,	0	
7065	0000	SIGN,	0	/=0 IF PLUS: =7777 IF MINUS
7066	0000	DNUMBR,	0	/=NUMBER OF DIGITS
7067	0000	MULT2,	0	/MULTIPLY LORDER, HORDER BY 2

7070	7300		CLA CLL	
7071	1046		TAD LORDER	
7072	7004		RAL	
7073	3046		DCA LORDER	
7074	1045		TAD HORDER	
7075	7004		RAL	
7076	3045		DCA HORDER	
7077	1264		TAD REMAIN	
7100	7004		RAL	
7101	3264		DCA REMAIN	
7102	5667		JMP I MULT2	
7103	0000	DUBLAD,	0	/DOUBLE PRECISION ADDITION
7104	7300		CLA CLL	
7105	1046		TAD LORDER	
7106	1261		TAD LTEMP	
7107	3046		DCA LORDER	
7110	7004		RAL	
7111	1045		TAD HORDER	
7112	1262		TAD HTEMP	
7113	3045		DCA HORDER	
7114	7004		RAL	
7115	1264		TAD REMAIN	
7116	3264		DCA REMAIN	
7117	5703		JMP I DUBLAD	
7120	0000	MSIGN,	0	/ROUTINE TO FORM
7121	7300		CLA CLL	/2'S COMPLEMENT IF
7122	2265		ISZ SIGN	/MINUS
7123	5720		JMP I MSIGN	/SIGN=0000: EXIT
7124	1046		TAD LORDER	
7125	7041		CMA IAC	
7126	3046		DCA LORDER	
7127	1045		TAD HORDER	
7130	7040		CMA	
7131	7430		SZL	
7132	7001		IAC	
7133	3045		DCA HORDER	
7134	5720		JMP I MSIGN	
7135	7776	MINUS,	253-255	/TEST FOR SIGN
7136	7525	PLUS,	-253	
7137	7506	MIN9,	-272	/TEST FOR DIGIT
7140	0012	PLUS12,	272-260	
7141	7600	MASK,	7600	/TEST FOR OVERFLOW
		/INPUT A CHARACTER, IF CR, TEST		
		/INPUT SWITCH TO SEE IF LF SHOULD		
		/BE TYPED. IF RUBOUT, RESTART INPUT		
7142	0000	INPUT,	0	/INPUT A CHARACTER
7143	7200		CLA	
7144	6031		KSF JMS I 2 BREAD	
7145	5344		JMP .-1 JMP I INPUT	
7146	6036		KRB	
7147	3057		DCA CHAR	
7150	1057		TAD CHAR	
7151	4766		JMS I OUTPUT	
7152	1057		TAD CHAR	
7153	7450		SNA	
7154	5343		JMP INPUT+1	/IGNORE BLANKS
7155	1370		TAD MRBOUT	
7156	7450		SNA	
7157	5767		JMP I RESTRT	/RUBOUT-RESTART INPUT
7160	1371		TAD MINCR	

7161	7650	SNA CLA	
7162	4765	JMS I PRINT	/CR - SEE IF TO BE FOLLOWED
7163	1057	TAD CHAR	/BY LF
7164	5742	JMP I INPUT	/EXIT ROUTINE
7165	6767	PRINT,	PRCHAR
7166	7344	OUTPUT,	OUT
7167	7401	RESTR,	FLINTP+1
7170	7401	MRBOUT,	-377
7171	0162	MINCR,	377-215
		/FLOATING OUTPUT "E" FORMAT	
		/USES: TSF	
		/ JMP .-1	
		/ TLS	
		*7200	
7200	0000	FLOUTP,	0
7201	4217	JMS FOUTCN	/CONVERT MANTISSA AND OUTPUT
7202	1324	TAD BEXP	
7203	3044	DCA EXPONT	
7204	1343	TAD CHE	
7205	4344	JMS OUT	
7206	4737	JMS I FEXPPT	/CONVERT EXPONENT AND OUTPUT
7207	1055	TAD SWITI	/PRINT CR-LF?
7210	7650	SNA CLA	
7211	5600	JMP I FLOUTP	/NO-EXIT
7212	1341	TAD CARRIN	/YES
7213	4344	JMS OUT	
7214	1342	TAD LNFEED	
7215	4344	JMS OUT	
7216	5600	JMP I FLOUTP	/EXIT
		/THIS WHOLE SUBROUTINE MAY BE ALTERED TO BUFFER	
		/THE OUTPUT DIGITS : CHANGE JMS OUTDG TO DCA I 10, ETC.	
7217	0000	FOUTCN,	0
7220	7300	CLA CLL	
7221	1045	TAD HORDER	/NUMBER>0??
7222	7710	SPA CLA	
7223	7220	CLA CML	/NO SET LINK
7224	1327	TAD SPLUS	/YES
7225	7430	SZL	
7226	1330	TAD SMINUS	/NO
7227	4344	JMS OUT	
7230	4352	JMS OUTDG	/OUTPUT "0"
7231	1331	TAD PERIOD	
7232	4344	JMS OUT	/OUTPUT "."
7233	7300	CLA CLL	
7234	1045	TAD HORDER	
7235	7700	SMA CLA	
7236	5242	JMP FGO1	
7237	7040	CMA	/NUMBER IS NEGATIVE
7240	3733	DCA I SNPT	/NEGATE
7241	4732	JMS I MSNPT	
7242	7240	FGO1,	CLA CMA
7243	1044	TAD EXPONT	/SUBTRACT 1 FROM BINARY EXPONENT
7244	3044	DCA EXPONT	/COMPENSATE AT FGO4
7245	3324	DCA BEXP	/INITIALIZE DECIMAL EXPONENT
7246	1044	FGO2,	TAD EXPONT
7247	7500	SMA	/IS -4<EXPONENT<-1
7250	5263	JMP FGO3	/TOO LARGE: MULTIPLY BY 1/10
7251	1326	TAD FOUR	

7252	7700		SMA CLA	
7253	5270		JMP FG04	
7254	4407		JMS I FPNT	/TOO SMALL-TIMES TEN
7255	3740		FMPY I TENPT	/TEN
7256	0000		FEXT	
7257	7240		CLA CMA	
7260	1324		TAD BEXP	
7261	3324		DCA BEXP	
7262	5246		JMP FG02	
7263	4407	FG03,	JMS I FPNT	
7264	3372		FMPY C.10	/ONE TENTH
7265	0000		FEXT	
7266	2324		ISZ BEXP	
7267	5246		JMP FG02	
7270	3734	FG04,	DCA I DPT	/MULTIPLY BY TWO
7271	4736		JMS I M2PT	/IE.SHIFT LEFT
7272	4735		JMS I M10PT	/MULTIPLY BY TEN
7273	7410		SKP	
7274	4357	FG05A,	JMS DIVTWO	/COMPENSATE FOR
7275	2044		ISZ EXPONT	/BINARY EXPONENT
7276	5274		JMP FG05A	
7277	7450		SNA	/IS FIRST DIGIT A ZERO
7300	5311		JMP FG07	/YES, IGNORE
7301	4352	FG06,	JMS OUTDG	/MULTIPLICATIONS YIELD
7302	1325		TAD MINUS7	/DECIMAL DIGITS AS HIGH
7303	3044		DCA EXPONT	/ORDER REMAINDERS
7304	4735	FG06A,	JMS I M10PT	/IE. .672X10=6+.72.. ETC
7305	4352		JMS OUTDG	
7306	2044		ISZ EXPONT	/7 DIGITS OUTPUT??
7307	5304		JMP FG06A	/NO: CONTINUE
7310	5617		JMP I FOUTCN	/YES:EXIT
7311	7240	FG07,	CLA CMA	/IGNORE FIRST DIGIT
7312	1324		TAD BEXP	/SUBTRACT 1 FROM
7313	3324		DCA BEXP	/DECIMAL EXPONENT
7314	1045		TAD HORDER	
7315	7640		SZA CLA	
7316	5322		JMP .+4	/IS MANTISSA ZERO?
7317	1046		TAD LORDER	
7320	7650		SNA CLA	
7321	3324		DCA BEXP	/YES:EXP=0
7322	7240		CLA CMA	
7323	5302		JMP FG06+1	
7324	0000	BEXP,	0	/CONTAINS DECIMAL EXPONENT
7325	7772	MINUS7,	7772	/NUMBER OF DIGTS OUTPUT
7326	0004	FOUR,	0004	
7327	0253	SPLUS,	253	240 PRINT SPACES
7330	0002	SMINUS,	255-253	INSTEAD OF PLUSSES
7331	0256	PERIOD,	256	
7332	7120	MSNPT,	MSIGN	
7333	7065	SNPT,	SIGN	/POINTERS
7334	7063	DPT,	DIGIT	
7335	7041	M10PT,	MULT10	
7336	7067	M2PT,	MULT2	
7337	7522	FEXPPT,	FEXC	
7340	7504	TENPT,	TEN	
7341	0215	CARRTN,	0215	
7342	0212	LNFEED,	0212	
7343	0305	CHE,	305	

7344	0000	OUT,	0	JMS I Z B R I T E	OUTPUT ONE ASCII CHARACTER
7345	6041		TSF		
7346	5345		JMP	.-1	JMP I OUT
7347	6046		TLS		
7350	7200		CLA		
7351	5744		JMP	I OUT	
7352	0000	OUTDG,	0		/OUTPUT ONE DIGIT
7353	1356		TAD	C260	
7354	4344		JMS	OUT	
7355	5752		JMP	I OUTDG	
7356	0260	C260,	0260		
7357	0000	DIVTWO,	0		/DIVIDE BY TWO IE.
7360	7110		CLL	RAR	/ROTATE RIGHT
7361	3344		DCA	OUT	/TEMPORARY STORAGE
7362	1045		TAD	HORDER	
7363	7010		RAR		
7364	3045		DCA	HORDER	
7365	1046		TAD	LORDER	
7366	7010		RAR		
7367	3046		DCA	LORDER	
7370	1344		TAD	OUT	
7371	5757		JMP	I DIVTWO	
7372	7775	C.10,	7775	7775	/CONSTANT .10 USED IN
7373	3146		3146	3146	/FLOATING OUTPUT-PROVIDES
7374	3147		3147	3147	
		/FLOATING	POINT INPUT		
		*7400			
7400	0000	FLINTP,	0		
7401	7240		CLA	CMA	/INITIALIZE "PERIOD SWITCH"
7402	3313		DCA	PRSW	
7403	3060		DCA	DSWIT	
7404	4716		JMS	I DPCVPT	/7777 = NO PERIOD
7405	7200		CLA		
7406	1057		TAD	CHAR	
7407	1312		TAD	PER	
7410	7640		SZA	CLA	
7411	5220		JMP	FIG01	
7412	1313		TAD	PRSW	/PERIOD FOUND
7413	7650		SNA	CLA	/SECOND PERIOD
7414	5222		JMP	FIG02	/YES,TERMINATE
7415	3721		DCA	I DPN	/NO - SET NUMBER OF DIGITS TO 0
7416	3313		DCA	PRSW	/SET PERIOD SWITCH TO 0
7417	5717		JMP	I DPCSPT	/CONVERT REST OF STRING
7420	1313	FIG01,	TAD	PRSW	/PERIOD READ IN PREVIOUSLY?
7421	7650		SNA	CLA	
7422	1721	FIG02,	TAD	I DPN	/YES:-NUMBER OF DIGITS IN SEXP
7423	7041		CMA	IAC	/NO
7424	3314		DCA	SEXP	
7425	4720		JMS	I MSGNPT	/TEST SIGN
7426	1311	FIG03,	TAD	C27	
7427	3044		DCA	EXPONT	
7430	4407		JMS	I FPNT	/NORMALIZE F.P. NUMBER
7431	7000		FNOR		
7432	6052		FPUT	FPAC1	/SAVE NUMBER
7433	0000		FEXT		
7434	1057		TAD	CHAR	
7435	1310		TAD	MINUSE	

7436	7640		SZA CLA	/ "E" READ IN?
7437	5252		JMP ENDFI	/NO
7440	4716		JMS I DPCVPT	/YES - CONVERT DECIMAL EXPONENT
7441	4720		JMS I MSGNPT	/TEST SIGN
7442	1045		TAD HORDER	/EXPONENT TOO LARGE??
7443	7510		SPA	
7444	7001		IAC	
7445	7640		SZA CLA	
7446	5277		JMP EXCESS	/YES
7447	1046		TAD LORDER	/NO: DECIMAL POINT IS
7450	1314		TAD SEXP	/C(SEXP) PLACES TO RIGHT
7451	3314		DCA SEXP	/OF LAST DIGIT
/END OF FLOATING POINT INPUT				
/COMPENSATE FOR DECIMAL EXPONENTS				
7452	4407	ENDFI,	JMS I FPNT	/RESTORE MANTISSA
7453	5052		FGET FPAC1	
7454	0000		FEXT	
7455	1314		TAD SEXP	
7456	7450		SNA	
7457	5600		JMP I FLINTP	
7460	7700		SMA CLA	
7461	5270		JMP FIG04	
7462	4407		JMS I FPNT	/ . IS TO THE LEFT:
7463	3707		FMPY I PC.10	/TIMES .1000
7464	0000		FEXT	
7465	2314		ISZ SEXP	
7466	5255		JMP ENDFI+3	
7467	5600		JMP I FLINTP	
7470	4407	FIG04,	JMS I FPNT	/ . IS TO THE RIGHT:
7471	3304		FMPY TEN	/MULTIPLY BY 10
7472	0000		FEXT	
7473	7240		CLA CMA	
7474	1314		TAD SEXP	
7475	3314		DCA SEXP	
7476	5255		JMP ENDFI+3	
7477	1315	EXCESS,	TAD C3777	
7500	3044		DCA EXPONT	
7501	1315		TAD C3777	
7502	3045		DCA HORDER	
7503	5600		JMP I FLINTP	
7504	0004	TEN,	0004	0004
7505	2400		2400	2000
7506	0000		0000	0000
7507	7372	PC.10,	C.10	/ .10
7510	7473	MINUSE,	-305	
7511	0027	C27,	0027	
7512	7522	PER,	-256	
7513	0000	PRSW,	0	
7514	0000	SEXP,	0	/CONTAINS DECIMAL EXPONENT
7515	3777	C3777,	3777	
7516	7000	DPCVPT,	DECONV	
7517	7017	DPCSPT,	DECON	
7520	7120	MSGNPT,	MSIGN	
7521	7066	DPN,	DNUMBR	
/OUTPUT THE EXPONENT				
7522	0000	FEXC,	0	
7523	7300		CLA CLL	

7524	1044	TAD	EXPONT
7525	7510	SPA	
7526	7061	CMA	IAC CML
7527	3044	DCA	EXPONT
7530	1366	TAD	C253
7531	7430	SZL	
7532	1367	TAD	C255
7533	4774	JMS	I DGPT
7534	3045	DCA	HORDER
7535	1044	TAD	EXPONT
7536	2045	ISZ	HORDER
7537	1370	TAD	M144
7540	7500	SMA	
7541	5336	JMP	.-3
7542	1371	TAD	C144
7543	3044	DCA	EXPONT
7544	7040	CMA	
7545	1045	TAD	HORDER
7546	7440	SZA	
7547	4774	JMS	I DGPT
7550	3045	DCA	HORDER
7551	1044	TAD	EXPONT
7552	2045	ISZ	HORDER
7553	1372	TAD	M12
7554	7500	SMA	
7555	5352	JMP	.-3
7556	1373	TAD	C12
7557	3046	DCA	LORDER
7560	7240	CLA	CMA
7561	1045	TAD	HORDER
7562	4774	JMS	I DGPT
7563	1046	TAD	LORDER
7564	4774	JMS	I DGPT
7565	5722	JMP	I FEXC

7566	7773	C253,	0253-260
7567	0002	C255,	255-253
7570	7634	M144,	7634
7571	0144	C144,	0144
7572	7766	M12,	7766
7573	0012	C12,	0012
7574	7352	DGPT,	OUTDG

BEXP	7324
CARRTN	7341
CHAR	0057
CHE	7343
C.10	7372
C12	7573
C144	7571
C253	7566
C255	7567
C260	7356
C27	7511
C3777	7515
DECON	7017
DECONV	7000
DGPT	7574
DIGIT	7063
DIVTWO	7357
DNUMBR	7066
DPCSPT	7517
DPCVPT	7516
DPN	7521
DPT	7334
DSWIT	0060
DUBLAD	7103
ENDFI	7452
EXCESS	7477
EXPONT	0044
FEXC	7522
FEXPPT	7337
FG01	7242
FG02	7246
FG03	7263
FG04	7270
FG05A	7274
FG06	7301
FG06A	7304
FG07	7311
FIG01	7420
FIG02	7422
FIG03	7426
FIG04	7470
FLINTP	7400
FLOUTP	7200
FOUR	7326
FOUTCN	7217
FPAC1	0052
FPNT	0007

HORDER	0045
HTEMP	7062
INPUT	7142
LFED	6777
LNFEED	7342
LORDER	0046
LTEMP	7061
MASK	7141
MINCR	7171
MINUS	7135
MINUSE	7510
MINUS7	7325
MIN9	7137
MRBOUT	7170
MSGNPT	7520
MSIGN	7120
MSNPT	7332
MULT10	7041
MULT2	7067
M10PT	7335
M12	7572
M144	7570
M2PT	7336
OPUT	6776
OUT	7344
OUTDG	7352
OUTPUT	7166
PC.10	7507
PER	7512
PERIOD	7331
PLUS	7136
PLUS12	7140
PRCHAR	6767
PRINT	7165
PRSW	7513
REMAIN	7064
RESTR1	7167
SEXP	7514
SIGN	7065
SMINUS	7330
SNPT	7333
SPLUS	7327
SWIT1	0055
SWIT2	0056
TEN	7504
TENPT	7340

EXTENDED FUNCTIONS
/FLOATING POINT PACKAGE

GETSGN=TAD 45
CLFPNT=JMS I 7

/FLOATING POINT EXPONENTIAL

*5000

5000	0000	FEXP,	0	
5001	1045		GETSGN	
5002	7710		SPA CLA	
5003	4310		JMS FNEG	
5004	3304		DCA SIGN	/C(SIGN)=-1 IF X<0
5005	4407		CLFPNT	
5006	3273		FMPY LG2E	
5007	6315		FPUT X	
5010	0000		FEXT	
5011	4706		JMS I FIXIT	
5012	1045		GETSGN	
5013	3305		DCA FLAG2	
5014	4707		JMS I FLOAT	
5015	4407		CLFPNT	
5016	6320		FPUT XSQR	
5017	5315		FGET X	
5020	2320		FSUB XSQR	
5021	6315		FPUT X	
5022	3315		FMPY X	
5023	6320		FPUT XSQR	
5024	1270		FADD D	
5025	6323		FPUT TEMP	
5026	5265		FGET C	
5027	4323		FDIV TEMP	
5030	2315		FSUB X	
5031	1257		FADD A	
5032	6323		FPUT TEMP	
5033	5262		FGET B	
5034	3320		FMPY XSQR	
5035	1323		FADD TEMP	
5036	6323		FPUT TEMP	
5037	5315		FGET X	
5040	4323		FDIV TEMP	
5041	3301		FMPY TWO	
5042	1276		FADD ONE	
5043	0000		FEXT	
5044	1305		TAD FLAG2	
5045	1044		TAD 44	
5046	3044		DCA 44	
5047	2304		ISZ SIGN	
5050	5600		JMP I FEXP	
5051	4407		CLFPNT	
5052	6315		FPUT X	
5053	5276		FGET ONE	
5054	4315		FDIV X	
5055	0000		FEXT	
5056	5600		JMP I FEXP	

/CONSTANTS FOR FEXP

5057	0004	A,	0004
5060	2372		2372
5061	1402		1402

5062	7774	B,	7774	
5063	2157		2157	
5064	5157		5157	
5065	0012	C,	0012	
5066	5454		5454	
5067	0343		0343	
5070	0007	D,	0007	
5071	2566		2566	
5072	5341		5341	
5073	0001	LG2E,	0001	
5074	2705		2705	
5075	2435		2435	
5076	0001	ONE,	0001	
5077	2000		2000	
5100	0000		0000	
5101	0002	TWO,	0002	
5102	2000		2000	
5103	0000		0000	
5104	0000	SIGN,	0	
5105	0000	FLAG2,	0	
5106	4757	FIXIT,	FIX	
5107	5563	FLOAT,	FLOA	
		/NEGATION	SUBROUTINE	
5110	0000	FNEG,	0	
5111	4714		JMS I ACMINS	/CALL SUBROUTINE IN
5112	7240		CLA CMA	/INTERPRETER
5113	5710		JMP I FNEG	
5114	6000	ACMINS,	6000	/POINTER TO INTERPRETER
		/TEMPORARY STORAGE		
5115	0000	X,	0	
5116	0000		0	
5117	0000		0	
5120	0000	XSQR,	0	
5121	0000		0	
5122	0000		0	
5123	0000	TEMP,	0	
5124	0000		0	
5125	0000		0	
5126	0000	ZER,	0	
5127	0000		0	
5130	0000		0	
		/MAIN ALGORITHM FOR ARCTANGENT		
5131	4407	ARCALG,	CLFPNT	
5132	5315		FGET X	
5133	3315		FMPY X	
5134	6320		FPUT XSQR	
5135	3373		FMPY BET2	
5136	1370		FADD BET1	
5137	3320		FMPY XSQR	
5140	1365		FADD BETZ	
5141	6323		FPUT TEMP	
5142	5362		FGET ALF2	
5143	3320		FMPY XSQR	
5144	1357		FADD ALF1	
5145	3320		FMPY XSQR	
5146	1354		FADD ALFZ	
5147	3315		FMPY X	
5150	4323		FDIV TEMP	
5151	0000		FEXT	
5152	5753		JMP I .+1	
5153	5226		ARCRTN	

/CONSTANTS - FLOATING ARC TANGENT			
5154	0000	ALFZ,	0000
5155	2437		2437
5156	1643		1643
5157	7777	ALF1,	7777
5160	3304		3304
5161	4434		4434
5162	7773	ALF2,	7773
5163	3306		3306
5164	5454		5454
5165	0000	BETZ,	0000
5166	2437		2437
5167	1646		1646
5170	0000	BET1,	0000
5171	2427		2427
5172	2323		2323
5173	7775	BET2,	7775
5174	3427		3427
5175	7052		7052
/FLOATING POINT ARC TANGENT			
*5200			
5200	0000	ARTN,	0
5201	1045		GETSGN
5202	7710		SPA CLA
5203	4642		JMS I NEGIT
5204	3243		DCA FLAG1
5205	4407		CLFPNT
5206	6644		FPUT I X1
5207	5644		FGET I X1
5210	2645		FSUB I CON1
5211	0000		FEXT
5212	1045		GETSGN
5213	7710		SPA CLA
5214	5223		JMP GO
5215	4407		CLFPNT
5216	5645		FGET I CON1
5217	4644		FDIV I X1
5220	6644		FPUT I X1
5221	0000		FEXT
5222	7240		CLA CMA
5223	3251	GO,	DCA FLOG
5224	5625		JMP I .+1
5225	5131		ARCALG
5226	2251	ARCRTN,	ISZ FLOG
5227	5235		JMP EXIT
5230	4407		CLFPNT
5231	6644		FPUT I X1
5232	5246		FGET PIOT
5233	2644		FSUB I X1
5234	0000		FEXT
5235	2243	EXIT,	ISZ FLAG1
5236	5600		JMP I ARTN
5237	4642		JMS I NEGIT
5240	7200		CLA
5241	5600		JMP I ARTN
/CONSTANTS FOR ARCTANGENT			
5242	5110	NEGIT,	FNEG
5243	0000	FLAG1,	0
5244	5115	X1,	X
5245	5076	CON1,	ONE

/FLAG
/CALL ALGORITHM
/RETURN HERE

5246	0001	PIOT,	0001	
5247	3110		3110	
5250	3755		3755	
		/FLOATING	LOGARITHM	
5251	0000	FLOG,	0	
5252	1045		GETSGN	
5253	7440		SZA	
5254	5261		JMP OK	
5255	4407		CLFPNT	/INDICATE ERROR
5256	4775		FDIV I ZERO	/DIVIDE BY ZERO
5257	0000		FEXT	
5260	5651		JMP I FLOG	
5261	7710	OK,	SPA CLA	
5262	4642		JMS I NEGIT	
5263	4407		CLFPNT	
5264	6774		FPUT I TEM	
5265	2645		FSUB I CON1	
5266	0000		FEXT	
5267	1045		GETSGN	
5270	7450		SNA	
5271	5350		JMP ZERGO	
5272	7710		SPA CLA	
5273	5341		JMP INVERT	
5274	3243	START,	DCA FLAG1	
5275	7040		CMA	
5276	1774		TAD I TEM	
5277	3045		DCA 45	
5300	4777		JMS I FLOATP	
5301	4407		CLFPNT	
5302	3776		FMPY I LOG2	
5303	6644		FPUT I X1	
5304	0000		FEXT	
5305	7001		IAC	
5306	3774		DCA I TEM	
5307	4407		CLFPNT	
5310	5774		FGET I TEM	
5311	2645		FSUB I CON1	
5312	6774		FPUT I TEM	
5313	3773		FMPY I L8	
5314	1772		FADD I L7	
5315	3774		FMPY I TEM	
5316	1771		FADD I L6	
5317	3774		FMPY I TEM	
5320	1770		FADD I L5	
5321	3774		FMPY I TEM	
5322	1365		FADD L4	
5323	3774		FMPY I TEM	
5324	1362		FADD L3	
5325	3774		FMPY I TEM	
5326	1357		FADD L2	
5327	3774		FMPY I TEM	
5330	1354		FADD L1	
5331	3774		FMPY I TEM	
5332	1644		FADD I X1	
5333	0000		FEXT	
5334	2243		ISZ FLAG1	
5335	5651		JMP I FLOG	
5336	4642		JMS I NEGIT	
5337	7200		CLA	
5340	5651		JMP I FLOG	

5341	4407	INVERT,	CLFPNT	
5342	5645		FGET I CON1	
5343	4774		FDIV I TEM	
5344	6774		FPUT I TEM	
5345	0000		FEXT	
5346	7240		CLA CMA	
5347	5274		JMP START	
5350	4407	ZERGO,	CLFPNT	
5351	5775		FGET I ZERO	
5352	0000		FEXT	
5353	5651		JMP I FLOG	
5354	0000	L1,	0000	
5355	3777		3777	
5356	7742		7742	
5357	7777	L2,	7777	
5360	4000		4000	
5361	4100		4100	
5362	7777	L3,	7777	
5363	2517		2517	
5364	0307		0307	
5365	7776	L4,	7776	
5366	4113		4113	
5367	7211		7211	
5370	5547	L5,	LOG5	
5371	5552	L6,	LOG6	
5372	5555	L7,	LOG7	
5373	5560	L8,	LOG8	
5374	5123	TEM,	TEMP	
5375	5126	ZERO,	ZER	
5376	5544	LOG2,	LOGE2	
5377	5563	FLOATP,	FLOA	
		/FLOATING	POINT SINE	
		*5400		
5400	0000	FSIN,	0	
5401	1045		GETSGN	/X>0?
5402	7740		SMA SZA CLA	
5403	5210		JMP MOD	/YES
5404	1045		GETSGN	
5405	7700		SMA CLA	/NO X=0?
5406	5600		JMP I FSIN	/YES SIN(0)=0
5407	4741		JMS I NEG1	/NO: SIN(-X)=-SIN(X)
5410	3343	MOD,	DCA PNTR	/REDUCE X MODULO 2 PI
5411	4407		CLFPNT	
5412	4315		FDIV TWOPI	
5413	6724		FPUT I XSQ2	
5414	0000		FEXT	
5415	4742		JMS I FIXR	
5416	4363		JMS FLOA	
5417	4407		CLFPNT	
5420	6723		FPUT I X2	
5421	5724		FGET I XSQ2	
5422	2723		FSUB I X2	
5423	3315		FMPY TWOPI	
5424	6723		FPUT I X2	
5425	2320		FSUB PI	/X<PI?
5426	0000		FEXT	
5427	1045		GETSGN	
5430	7710		SPA CLA	
5431	5241		JMP PCHECK	/YES
5432	4407		CLFPNT	/NO SIN(X-PI)=-SIN(X)
5433	6723		FPUT I X2	
5434	0000		FEXT	

5435	1343		TAD PNTR	
5436	7650		SNA CLA	
5437	7040		CMA	
5440	3343		DCA PNTR	
5441	4407	PCHECK,	CLFPNT	/X<PI/2?
5442	5723		FGET I X2	
5443	2714		FSUB I PI2	
5444	0000		FEXT	
5445	1045		GETSGN	
5446	7710		SPA CLA	
5447	5255		JMP PALG	/YES
5450	4407		CLFPNT	/NO
5451	5320		FGET PI	/SIN(X)=SIN(PI-X)
5452	2723		FSUB I X2	
5453	6723		FPUT I X2	
5454	0000		FEXT	
5455	4407	PALG,	CLFPNT	
5456	5723		FGET I X2	
5457	4714		FDIV I PI2	
5460	6723		FPUT I X2	
5461	3723		FMPY I X2	
5462	6724		FPUT I XSQ2	
5463	5325		FGET C9	
5464	3724		FMPY I XSQ2	
5465	1330		FADD C7	
5466	3724		FMPY I XSQ2	
5467	1333		FADD C5	
5470	3724		FMPY I XSQ2	
5471	1336		FADD C3	
5472	3724		FMPY I XSQ2	
5473	1714		FADD I PI2	
5474	3723		FMPY I X2	
5475	0000		FEXT	
5476	2343		ISZ PNTR	
5477	5600		JMP I FSIN	
5500	4741		JMS I NEGT	
5501	7200		CLA	
5502	5600		JMP I FSIN	
		/FLOATING	POINT COSINE	
5503	0000	FCOS,	0	
5504	4407		CLFPNT	/COS(X)=SIN(PI/2-X)
5505	6723		FPUT I X2	
5506	5714		FGET I PI2	
5507	2723		FSUB I X2	
5510	0000		FEXT	
5511	1303		TAD FCOS	
5512	3200		DCA FSIN	
5513	5201		JMP FSIN+1	

/CONSTANTS AND POINTERS

5514	5246	PI2,	PIOT	/PI/2
5515	0003	TWOPI,	0003	
5516	3110		3110	
5517	3755		3755	
5520	0002	PI,	0002	
5521	3110		3110	
5522	3755		3755	
5523	5115	X2,	X	
5524	5120	XSQ2,	XSQR	

/SINE CONSTANTS			
5525	7764	C9,	7764
5526	2366		2366
5527	5735		5735
5530	7771	C7,	7771
5531	5466		5466
5532	6317		6317
5533	7775	C5,	7775
5534	2431		2431
5535	5053		5053
5536	0000	C3,	0000
5537	5325		5325
5540	0420		0420
5541	5110	NEGT,	FNEG
5542	4757	FIXR,	FIX
5543	0000	PNTR,	0

/LOGARITHM CONSTANTS

5544	0000	LOGE2,	0000
5545	2613		2613
5546	4414		4414
5547	7776	LOG5,	7776
5550	2535		2535
5551	3301		3301
5552	7775	LOG6,	7775
5553	4746		4746
5554	0771		0771
5555	7774	LOG7,	7774
5556	2236		2236
5557	4304		4304
5560	7771	LOG8,	7771
5561	4544		4544
5562	1735		1735

/FLOAT C(45)

5563	0000	FLOA,	0
5564	7300		CLA CLL
5565	3046		DCA 46
5566	1374		TAD C13
5567	3044		DCA 44
5570	4407		CLFPNT
5571	7000		FNOR
5572	0000		FEXT
5573	5763		JMP I FLOA
5574	0013	C13,	0013

*4757

/FIX C(FAC)

4757	0000	FIX,	0
4760	1044		TAD 44
4761	7540		SMA SZA
4762	5365		JMP .+3
4763	7200		CLA
4764	5375		JMP FIXEND
4765	1377		TAD M13
4766	3044		DCA 44
4767	1044	LOOP,	TAD 44
4770	7700		SMA CLA
4771	5757		JMP I FIX
4772	4774		JMS I .+2
4773	5367		JMP LOOP
4774	6200		6200

/DIVI IN INTERPRETER

4775	3045	FIXEND,	DCA 45
4776	5757		JMP I FIX
4777	7765	M13,	-13

A	5057
ACMINS	5114
ALFZ	5154
ALF1	5157
ALF2	5162
ARCALG	5131
ARCRTN	5226
ARTN	5200
B	5062
BETZ	5165
BET1	5170
BET2	5173
C	5065
CLFPNT	4407
CON1	5245
C13	5574
C3	5536
C5	5533
C7	5530
C9	5525
D	5070
EXIT	5235
FCOS	5503
FEXP	5000
FIX	4757
FIXEND	4775
FIXIT	5106
FIXR	5542
FLAG1	5243
FLAG2	5105
FLOA	5563
FLOAT	5107
FLOATP	5377
FLOG	5251
FNEG	5110
FSIN	5400
GETSGN	1045
GO	5223
INVERT	5341
LG2E	5073
LOGE2	5544

LOG2	5376
LOG5	5547
LOG6	5552
LOG7	5555
LOG8	5560
LOOP	4767
L1	5354
L2	5357
L3	5362
L4	5365
L5	5370
L6	5371
L7	5372
L8	5373
MOD	5410
M13	4777
NEG1T	5242
NEGT	5541
OK	5261
ONE	5076
PALG	5455
PCHECK	5441
PI	5520
PIOT	5246
PI2	5514
PNTR	5543
SIGN	5104
START	5274
TEM	5374
TEMP	5123
TWO	5101
TWOPI	5515
X	5115
XSQR	5120
XSQ2	5524
X1	5244
X2	5523
ZER	5126
ZERGO	5350
ZERO	5375

/FLOATING OUTPUT PROGRAM
 /IF(62)=0, THEN OUTPUT IN E FORMAT
 /ELSE, C(62)=NUMBER OF DIGITS
 /C(AC)=NUMBER OF PLACES TO RIGHT OF .
 /IF C(AC)=0, THEN DON'T OUTPUT POINT
 /SIGN AND . NOT COUNTED IN OUTPUT
 /CONTENTS OF 15 LOST DURING OPERATION

*7201

7201	4777	JMS I 7377 /ALTERATIONS FLQATING OUTPUT
7202	4217	JMS 7217
7203	1324	TAD 7324
7204	4776	JMS I 7376

*7207

7207	7200	CLA
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*7227

7227	3415	DCA I 15
7230	7000	NOP
7231	7000	NOP
7232	7000	NOP

*7301

7301	3415	DCA I 15
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*7305

7305	3415	DCA I 15
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*7376

7376	5412	TGO
7377	5400	EDIT
5400	0000	*5400 EDIT, 0
5401	3352	DCA SAC
5402	1062	TAD 62
5403	7041	CMA IAC
5404	3347	DCA COUNT1
5405	1357	TAD M8
5406	3350	DCA COUNT2
5407	1363	TAD SADI
5410	3015	DCA 15
5411	5600	JMP I EDIT
5412	0000	TGO, 0
5413	3044	DCA 44
5414	1363	TAD SADI
5415	3015	DCA 15
5416	1415	TAD I 15
5417	4761	JMS I OUT1
5420	1062	TAD 62
5421	7650	SNA CLA
5422	5327	JMP EFORM
5423	2212	ISZ TGO
5424	2212	ISZ TGO
5425	1044	TRYAGN, TAD 44
5426	7510	SPA
5427	5300	JMP MINS
5430	1352	TAD SAC
5431	7041	CMA IAC
5432	1062	TAD 62

*4600 DEC ERREN

5433	7510		SPA
5434	5266		JMP ERR
5435	7450		SNA
5436	5245		JMP G01
5437	7041		CMA IAC
5440	3351		DCA CNTR
5441	1353		TAD SPCE
5442	4321		JMS OUT
5443	2351		ISZ CNTR
5444	5241		JMP .-3
5445	1044	G01,	TAD 44
5446	7041		CMA IAC
5447	7450		SNA
5450	5256		JMP G02
5451	3351		DCA CNTR
5452	4337		JMS GET
5453	4321		JMS OUT
5454	2351		ISZ CNTR
5455	5252		JMP .-3
5456	1352	G02,	TAD SAC
5457	7650		SNA CLA
5460	5263		JMP .+3
5461	1354		TAD PERIOD
5462	4761		JMS I OUT1
5463	4337		JMS GET
5464	4321		JMS OUT
5465	5263		JMP .-2
5466	1352	ERR,	TAD SAC
5467	7700		SMA CLA
5470	5274		JMP ERGO
5471	1356		TAD CHX
5472	4321		JMS OUT
5473	5271		JMP .-2
5474	7240	ERGO,	CLA CMA
5475	1352		TAD SAC
5476	3352		DCA SAC
5477	5225		JMP TRYAGN
5500	7200	MINS,	CLA
5501	1062		TAD 62
5502	7041		CMA IAC
5503	1352		TAD SAC
5504	7450		SNA
5505	5313		JMP G03
5506	3351		DCA CNTR
5507	1353		TAD SPCE
5510	4321		JMS OUT
5511	2351		ISZ CNTR
5512	5307		JMP .-3
5513	1354	G03,	TAD PERIOD
5514	4761		JMS I OUT1
5515	4321		JMS OUT
5516	2044		ISZ 44
5517	5315		JMP .-2
5520	5263		JMP G02+5
5521	0000	OUT,	0
5522	4762		JMS I OUT2

5523	2347		ISZ COUNT1
5524	5721		JMP I OUT
5525	1355		TAD CHE
5526	5612		JMP I TGO
5527	4762	EFORM,	JMS I OUT2
5530	1354		TAD PERIOD
5531	4761		JMS I OUT1
5532	1360		TAD M7
5533	3347		DCA COUNT1
5534	4337		JMS GET
5535	4321		JMS OUT
5536	5334		JMP .-2

5537	0000	GET,	0
5540	2350		ISZ COUNT2
5541	5345		JMP .+4
5542	7240		CLA CMA
5543	3350		DCA COUNT2
5544	5737		JMP I GET
5545	1415		TAD I 15
5546	5737		JMP I GET
5547	0000	COUNT1,	0
5550	0000	COUNT2,	0
5551	0000	CNTR,	0
5552	0000	SAC,	0
5553	7760	SPCE,	240-260
5554	0256	PERIOD,	256
5555	0305	CHE,	305
5556	0050	CHX,	330-260
5557	7770	M8,	-10
5560	7771	M7,	-7
5561	7344	OUT1,	7344
5562	7352	OUT2,	7352
5563	5563	SAD1,	BUFFER-1
		BUFFER,	

260-260 260-260 PRINT ZEROES
INSTEAD OF
SPACES

BUFFER	5564
CHE	5555
CHX	5556
CNTR	5551
COUNT1	5547
COUNT2	5550
EDIT	5400
EFORM	5527
ERGO	5474
ERR	5466
GET	5537
GO1	5445
GO2	5456
GO3	5513
MIN5	5500
M7	5560
M8	5557
OUT	5521
OUT1	5561
OUT2	5562
PERIOD	5554
SAC	5552
SAD1	5563
SPCE	5553
TGO	5412
TRYAGN	5425

