PDP-8

FLOATING-POINT SYSTEM PROGRAMMING MANUAL

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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 loose 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 ....

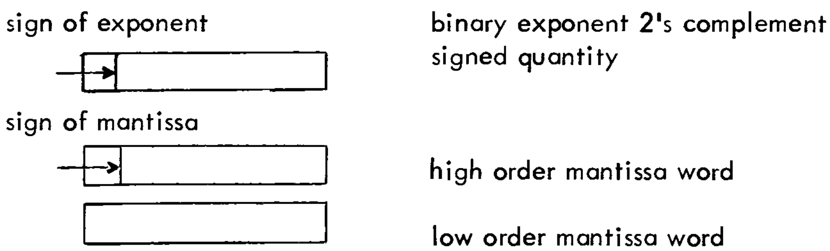
in binary. = 0.0631463146314...

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}. | 0.11 001 100 110 | 011 001 100 110 | 011 001 100 110 ....

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 0.000 110 011 001 100 110 011 001 100 (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: $(2^{-3})_8 \cdot (4\ \ 6\ \ 3\ \ 1\ \ 4\ \ 6\ \ 3\ \ 2\ )_8$

This number would be stored (within octal) as:

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

$1100. = (2^4)\ (0.11000000000000000000000)$

0004 3 0 0 0

would be stored as (written in octal):

0004

3000

0000

Octal	Decimal	Floating Binary		
-1	-1	0001 0000	6000 4000	0000 0000 ? No.
-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	1712
-14.26074475	12.3456	0004	4723	6066

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:

```
  .6
 x 8
4) .8
 x 8
6) .4
 x 8
3) .2
  8
1) .6
  8
4) .8
  .
```

$1.6_{10} = 1.46314631_8$

$= 1.100|110|011|001|100|110|011|001$

$= (2^1)\ (0.11|001|100|110|011|001|100|110)$

3 1 4 6 3 1 4 6

= 0001

```
   x 8
1)  .6          3146
     8
4)  .8          3146
     8
6)  .4
     8
3)  .2
     8
1)  .6
```

ARITHMETIC

Since floating-point numbers are stored in a three-register format, the floating-point system uses a "psuedo" 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:

OP	I	Z	ADDRESS

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:

Op Code	Mnemonic	Effect
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 effecitve 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) → C(FAC)	Result is normalized; C(Y) unchanged
FSUB	Y; 2000; C(FAC) - C(Y) → C(FAC)	Result is normalized; C(Y) unchanged
FMPY	Y; 3000; C(FAC) x C(Y) → C(FAC)	Result is normalized; C(Y) unchanged
FDIV	Y; 4000; C(FAC) ÷ C(Y) → C(FAC)	Result is normalized; C(Y) unchanged
FGET	Y; 5000; C(Y) → C(FAC)	C(Y) unchanged
FPUT	Y; 6000; C(FAC) → C(Y)	
FNOR	; 7000; C(FAC) normalized → C(FAC)	
FEXT	; 0000; exit from interpreter to instruction following this command	
SQUARE	; 0001; $C(FAC)^2$ → C(FAC)	
SQROOT	; 0002; $C(FAC)^{1/2}$ → 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          and C(57) = 0331, the second TERMINATOR
B,  0002
    2000
    0000
```

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 1T
```

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:

±0.XXXXXXXE±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:

Can operands be aligned?

Yes → Align Exponents, Add Mantissas, Normalize, Return to Interpreter

No → Put larger number in FAC → Return to Interpreter

Subtraction

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

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.

Is divisor = 0?

No → Subtract Exponents; Divide Mantissas; Normalize; Return to interpreter

Yes → +1 to error flag; Set result to highest possible → Return to 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 $\sqrt{N}$:

then:

$$X_i+1 = 1/2\,(X_i + \frac{N}{X_i})$$

is $|X_i - X_{i+1}| <$ least significant bit?

No → (return to "then:")

Yes → Return to interpreter

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	

Storage

The floating accumulator is in registers:

44 - Exponent

45 - High Order Mantissa

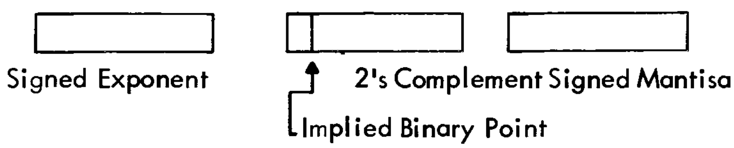
46 - Low Order Mantissa

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:

$$SIN(-X)=-SIN(X)$$

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

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

$$SIN(\pi-F)=-SIN(F)$$

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

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

$$SIN(X)=(C_1F+C_3F^3+C_5F^5+C_7F^7+C_9F^9)$$

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:

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

It then uses the SINE routine.

Arc Tangent

The arc tangent routine uses the following identities:

$$ARCTAN(-X)=-ARCTAN(X)$$

IF $X\geq 1$; then $ARCTAN(X)=\pi/2-ARCTAN(1/X)$

FOR $0<X<1$,

$$ARCTAN(X) = \frac{X(A_0+A_1X^2+A_2X^4)}{B_0+B_1,X^2+B_2X^4}$$

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:

$-\pi/2<ARCTAN(X)<\pi/2$

$-\infty<X<\infty$

Logarithm

The logarithm routine uses the identities:

For X<1;

$LOG(X)=LOG(2^N \cdot F)$ (1<F<2)

$=NLOG(2)+LOG(F)$

$$LOG(1+Y)= \sum_{C=1}^{8} A_iY^i$$

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:

LOG(X)=-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 <F<1

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

where:

A = +9.95459578

B = +0.03465735903

C = +617.97226053

D = +87.417497202

$\log_2 e = 1.4426950409$

If X<0

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

Example, input A, B, and output:

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

```
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).

C(62)	C(AC)	Output
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 (LN)	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:

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

DEC-08-YQ4A-PB

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
6000  0000  ACMINS,     0                /ROUTINE TO PERFORM
6001  7300              CLL CLA
6002  1047              TAD OVER2        /TRIPLE PRECISION NEGATION
6003  7041              CMA IAC          /OF FLOATING AC
6004  3047              DCA OVER2
6005  1046              TAD LORD
6006  7040              CMA
6007  7430              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 0007
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
ACON6	5760
AC1H	0041
AC1L	0042
ADDR	5656
ALGN	5771
ALIGN	6020
AMOUNT	6142
AMT1	6655
CLCU	6710
D	6367
DIVIDE	6361
DIV1	6200
DIV2	6420
DMULT	6221
DNORM	6600
DONE	6114
DUBDIV	6472
DUNORM	6564
DVX	6506
DV2	6522
DV3	6500
ERROR	6374
ERROR1	6152
EXIT	5742
EXIT1	6641
EXIT2	6651
EXIT6	6171
EXP	0044
EXP1	0050
EX1	0040
FLAD	5716
FLAG	0061
FLAG1	6762
FLDV	6305
FLGT	5676
FLMY	5761
FLPT	5705
FLSU	5737
FPAC1	0052
FPNT	5600
GOOF	6162
GO2	5655
GO6	6617
HORD	0045
INDRCT	5664
ITER1	6756
JUMP	5653
JUMP2	5654
KEEP	6370
LOOP01	5627
LOP	6622
LORD	0046
MASK3	5660
MASK5	5661
MASK7	5662
MIF	6544
MINS	6373
MINS2	6371
MINUS2	6400
MP1	6466
MP2	6471
MP2PT	6356
MP3	6467
MP4	6437
MP4PT	6355
MP5	6465
MP5PT	6357
MULT	5767
NEG	6653
NOGO	6125
NOHERE	6137
NORF	5773
NORM	5770
NORMF	6360
OPMINS	5741
OUTGO	6116
OVER1	0043
OVER2	0047
PAGENO	5663
QUOL	0051
RAR1	6572
RAR2	6372
REST	6366
RETN2	6151
RETURN	6364
ROOTGO	6745
SAVE	5657
SGN	6365
SHIFT	6076
SIGN	6336
SIGN1	6654
SMACLA	6363
SNSWIT	6347
SPACLA	6362
SQCON1	6761
SQEND	6754
SQEND1	6751
SQROOT	6656
SQUARE	6163
TABLE	5665
TABLE6	6545
TAG1	6147
TAG2	6150
TEST2	6143
TEST3	6144
TEST4	6145
TEST5	6146
THIR	6470
UNORM	5772

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

                *7
0007    5600    FPNT,       5600

                *44
0044    0000    EXPONT,     0 )
0045    0000    HORDER,     0 } Floating Point Accumulator
0046    0000    LORDER,     0 )

                *52
0052    0000    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
6767    0000    PRCHAR,     0
6770    1056                TAD SWIT2
6771    7650                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
```

in ASCII → Binary

```
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
7145  5344            JMP .-1
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  RESTRT,   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 SWIT1            /PRINT CR-LF?
7210  7650            SNA CLA
7211  5600            JMP I FLOUTP         /NO-EXIT
7212  1341            TAD CARRTN /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 FG01
7237  7040            CMA                  /NUMBER IS NEGATIVE
7240  3733            DCA I SNPT           /NEGATE
7241  4732            JMS I MSNPT
7242  7240  FG01,     CLA CMA              /SUBTRACT 1 FROM BINARY EXPONENT
7243  1044            TAD EXPONT           /COMPENSATE AT FG04
7244  3044            DCA EXPONT
7245  3324            DCA BEXP             /INITIALIZE DECIMAL EXPONENT
7246  1044  FG02,     TAD EXPONT           /IS -4<EXPONENT<-1
7247  7500            SMA
7250  5263            JMP FG03             /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
7330  0002  SMINUS,    255-253
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               /OUTPUT ONE ASCII CHARACTER
7345  6041            TSF
7346  5345            JMP .-1
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            /CONSTANT .10 USED IN
7373  3146            3146            /FLOATING OUTPUT-PROVIDES
7374  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 FIGO1
7412  1313            TAD PRSW        /PERIOD FOUND
7413  7650            SNA CLA         /SECOND PERIOD
7414  5222            JMP FIGO2       /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  FIGO1,    TAD PRSW        /PERIOD READ IN PREVIOUSLY?
7421  7650            SNA CLA
7422  1721  FIGO2,    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  FIGO3,    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 FIGO4
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  FIGO4,      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
7505  2400              2400
7506  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
FGO1	7242
FGO2	7246
FGO3	7263
FGO4	7270
FGO5A	7274
FGO6	7301
FGO6A	7304
FGO7	7311
FIGO1	7420
FIGO2	7422
FIGO3	7426
FIGO4	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
RESTRT	7167
SEXP	7514
SIGN	7065
SMINUS	7330
SNPT	7333
SPLUS	7327
SWIT1	0055
SWIT2	0056
TEN	7504
TENPT	7340

```
            /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                /FLAG
5224  5625            JMP I .+1               /CALL ALGORITHM
5225  5131            ARCALG
5226  2251  ARCRTN,   ISZ FLOG                /RETURN HERE
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
```

```
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 NEGT              /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                 /DIV1 IN INTERPRETER
```

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

A	5057	LOG2	5376
ACMINS	5114	LOG5	5547
ALFZ	5154	LOG6	5552
ALF1	5157	LOG7	5555
ALF2	5162	LOG8	5560
ARCALG	5131	LOOP	4767
ARCRTN	5226	L1	5354
ARTN	5200	L2	5357
B	5062	L3	5362
BETZ	5165	L4	5365
BET1	5170	L5	5370
BET2	5173	L6	5371
C	5065	L7	5372
CLFPNT	4407	L8	5373
CON1	5245	MOD	5410
C13	5574	M13	4777
C3	5536	NEGIT	5242
C5	5533	NEGT	5541
C7	5530	OK	5261
C9	5525	ONE	5076
D	5070	PALG	5455
EXIT	5235	PCHECK	5441
FCOS	5503	PI	5520
FEXP	5000	PIOT	5246
FIX	4757	PI2	5514
FIXEND	4775	PNTR	5543
FIXIT	5106	SIGN	5104
FIXR	5542	START	5274
FLAG1	5243	TEM	5374
FLAG2	5105	TEMP	5123
FLOA	5563	TWO	5101
FLOAT	5107	TWOPI	5515
FLOATP	5377	X	5115
FLOG	5251	XSQR	5120
FNEG	5110	XSQ2	5524
FSIN	5400	X1	5244
GETSGN	1045	X2	5523
GO	5223	ZER	5126
INVERT	5341	ZERGO	5350
LG2E	5073	ZERO	5375
LOGE2	5544		

```
                 /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 FLOATING OUTPUT
7202   4217                JMS 7217
7203   1324                TAD 7324
7204   4776                JMS I 7376

                 *7207
7207   7200                CLA


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

                 *7301
7301   3415                DCA I 15

                 *7305
7305   3415                DCA I 15

                 *7376
7376   5412                TGO
7377   5400                EDIT
                 *5400
5400   0000      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 SAD1
5410   3015                DCA 15
5411   5600                JMP I EDIT
5412   0000      TGO,      0
5413   3044                DCA 44
5414   1363                TAD SAD1
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
```

```
5433  7510          SPA
5434  5266          JMP ERR
5435  7450          SNA
5436  5245          JMP GO1
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  GO1,    TAD 44
5446  7041          CMA IAC
5447  7450          SNA
5450  5256          JMP GO2
5451  3351          DCA CNTR
5452  4337          JMS GET
5453  4321          JMS OUT
5454  2351          ISZ CNTR
5455  5252          JMP .-3

5456  1352  GO2,    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 GO3
5506  3351          DCA CNTR
5507  1353          TAD SPCE
5510  4321          JMS OUT
5511  2351          ISZ CNTR
5512  5307          JMP .-3

5513  1354  GO3,    TAD PERIOD
5514  4761          JMS I OUT1
5515  4321          JMS OUT
5516  2044          ISZ 44
5517  5315          JMP .-2
5520  5263          JMP GO2+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,
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
MINS     5500
M7       5560
M8       5557
OUT      5521
OUT1     5561
OUT2     5562
PERIOD   5554
SAC      5552
SAD1     5563
SPCE     5553
TGO      5412
TRYAGN   5425
```