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PROGRAMS FOR THE TRANSONIC WIND TUNNEL DATA PROCESSING INSTALLA--ETC(U)
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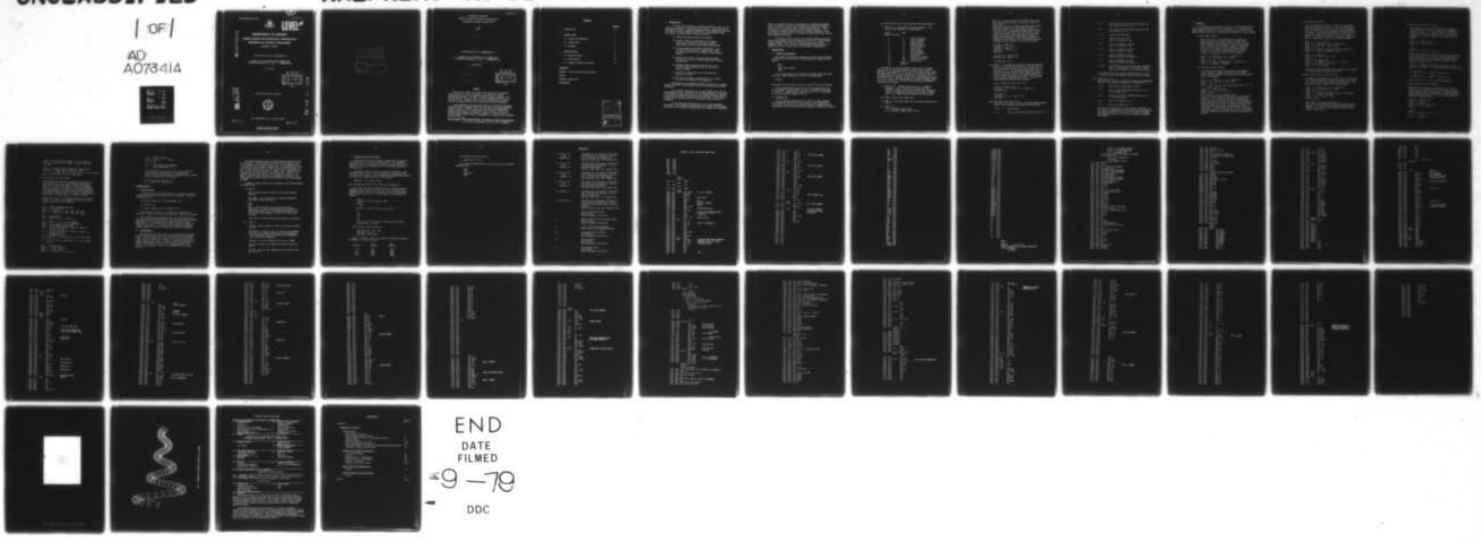

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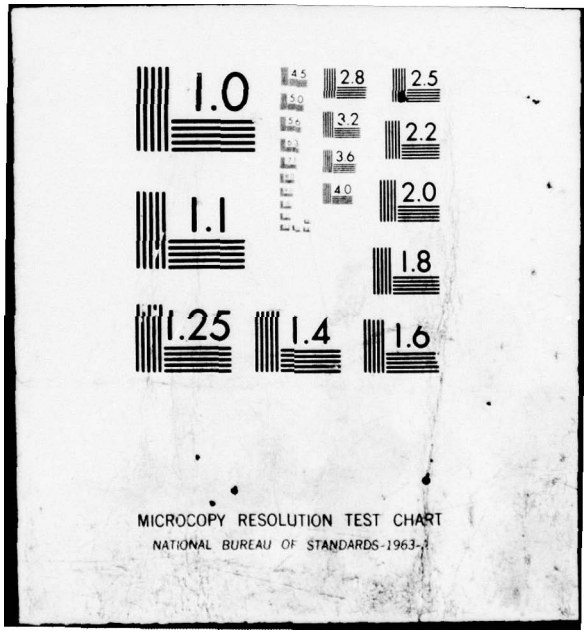
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AERONAUTICAL RESEARCH LABORATORIES

MELBOURNE, VICTORIA

Aerodynamics Technical Memorandum 314

PROGRAMS FOR THE TRANSONIC WIND TUNNEL DATA PROCESSING INSTALLATION - PART 7 - EXTENDED FOCAL

N. POLLOCK

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Aerodynamics Technical Memorandum 314

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PROGRAMS FOR THE TRANSONIC WIND TUNNEL DATA PROCESSING INSTALLATION, - PART 7, - EXTENDED FOCAL

(10) N. POLLOCK

(11) Mar 79

(12) 44 p.

SUMMARY

Since the transonic wind tunnel data processing installation, which is based on a PDP 8-I computer, was installed in 1968 a considerable library of standard programs have been produced. This program library covers all types of testing commonly carried out in the wind tunnel. However there remains the possibility of unusual tests being required which are not covered by existing programs.

This memorandum describes modifications to the Digital Equipment Corporation FOCAL language (FOCAL is a keyboard oriented interpretive language similar to BASIC) which permit the tunnel instrumentation, display and plotter to be operated by FOCAL programs. Using this extended FOCAL language it should be possible to rapidly write and de-bug programs to meet unusual requirements not covered by the standard program library.

POSTAL ADDRESS: Chief Superintendent, Aeronautical Research Laboratories, P.O. Box 4331, MELBOURNE, Victoria, 3001, AUSTRALIA

CONTENTS

1. INTRODUCTION

In 1968 a data processing installation based on a PDP 8-I computer was installed in the transonic wind tunnel. Since that time a considerable number of standard programs have been produced which cover all types of testing commonly carried out in the transonic tunnel. The current standard library includes programs to:

(a) compute and display tunnel Mach number[1],

(b) collect, reduce to coefficient form, display, plot, print and store on DEC tape, pressure measurements obtained from multiple Scanivalves[2],

(c) collect, reduce to body axes coefficients, shift to wind axes coefficients, display, plot, print and store on DEC tape, six component force measurements[3,4],

(d) perform curve fitting, axes shifting and matrix inversion to assist with strain gauge force balance calibration[5],

(e) translate tunnel force and pressure data into a DEC tape format compatible with the site PDP 10 computer system[6],

(f) cross plot a wide range of force coefficients against one another,

(g) edit data and produce formatted print out suitable for direct reproduction in publications.

The majority of the standard programs are written in assembly language (PAL-D)[11] to make maximum use of the available core storage (12K words).

It is probable that from time to time unusual tests will be required which are not covered by the standard programs. If the task is of sufficient magnitude, writing a new assembly language program or modifying an existing program would be justified. If the task is a minor one the program writing and de-bugging time would not be acceptable.

In this memorandum modifications to the Digital Equipment Corporation FOCAL language are described which permit FOCAL programs to operate all the tunnel instrumentation, the display and the plotter.

FOCAL is a keyboard oriented, conversational, interpretive language similar to BASIC with real time de-bugging so program development is rapid. Using the extended FOCAL language described here it should be possible to quickly develop new data handling programs. Due to the limited variable storage and the slow speed of execution, FOCAL data reduction programs are not suitable for major tasks which involve large quantities of data.

The extended FOCAL language and the FOCAL routines presented here were originally written in the period 1974-1976. When necessary program modifications were carried out to keep up with system hardware changes. The version of extended FOCAL presented here is compatible with the current (Feb. 1979) hardware configuration.

2. PROGRAM USAGE

2.1 Loading and Operating

The present extended FOCAL program is stored as three systems programs FC29, FCL9 and ST9K. The procedure for loading from the disk is:

. FC29
. FCL9
. CALL (USER PROGRAM)
. ST9K

If no user program is to be loaded the dummy program NUL9 must be called. When successfully loaded the program types:

```
? ØØ.ØØ
*
```

The program is then ready to accept a command[7,8] from the teletype.

Since extended FOCAL operates with the interrupt turned off the ↑C keyboard interrupt does not work. To persuade the program to listen to a command when it does not want to, it is necessary to stop and restart at Ø2ØØ in Field Ø.

2.2 Capabilities

All the standard capabilities[7,8] of FOCAL 8, 1969 including the extended functions are still available. The 8K overlay[7,8] is incorporated and there is storage available for 8ØØØ (decimal) characters of indirect program and 124 (decimal) identified variables.

The new functions that have been added are described below:

(i) FNEW (Ø, X). Read input from device number X. The current device numbers are listed below:

Device Number (decimal)	Input	
1	P	(Static Pressure)
2	H	(Total Pressure)
3	P_b	(Base Pressure)
4	Z	(Normal Force)
5	M	(Pitching Moment)
6	X	(Axial Force)
7	Y	(Side Force)
8	N	(Yawing Moment)
9	L	(Rolling Moment)
10	θ	(Incidence)
11	ϕ_b	(Balance Roll Angle)
12	ϕ_m	(Model Roll Angle)
13	T	(Temperature)
14	Ident No.	
15	Job No.	

The FNEW (Ø, X) Function returns to Focal with an integer value containing all the significant figures from the device selected i.e. a temperature of 16.2Ø will be read as 162Ø. Therefore when reading P, H, P_b, θ, ϕ_b, ϕ_m or T the value returned by the FNEW function must have a decimal point inserted at the appropriate point. Readings of the strain gauge equipment outputs Z, M, X, Y, N and L and the temperature T must be initiated from the record push button. Details of the necessary programming is contained in (vi) below:

(ii) FNEW (1, X). Display integer part of X (< 2ØØØ) on Machmeter. This function, and all the other new functions which do not return to FOCAL with a numerical result, is called by an instruction like SET Q = FNEW where Q is a dummy variable reserved for this purpose.

(iii) FNEW (2). Start data logger scan.

(iv) FNEW (3). Stop data logger scan and return Scanivalves to port Ø.

(v) FNEW (4, X).
X = Ø, Read data logger byte 1.
X = 1, Read data logger bytes 2 and 3.

Byte 1 is an integer where the hundreds digit is the Scanivalve number and the tens and units digits the port number.
Bytes 2 and 3 give an integer containing the sign and significant figures of the analogue to digital converter output. When using extended Focal, bytes 2 and 3 must be read immediately after byte 1 and if a number of readings are to be taken from the data logger they must be read consecutively without any intervening programming. The following program example will read and type out N data logger readings at logger stepping speeds of up to 10 per second.

```
1.Ø2 SET Q = FNEW (2)
1.Ø4 FOR A = 1, 1, N; DO 2
1.Ø6 SET Q = FNEW (3)
1.Ø8 FOR A = 1, 1, N; DO 3
1.1Ø QUIT

2.Ø1 SET X(A) = FNEW (4, Ø)
2.Ø2 SET Z(A) = FNEW (4, 1)

3.Ø1 TYPE X(A), Z(A), !
```

(vi) FNEW (5). This function checks the state of, and then clears, the record push button flag. If the flag is set, the function returns with the value 4Ø96, if not, with the value Ø. As noted previously readings of temperature and strain gauge gear output are initiated by the record push button. These readings must be taken as soon as the button is pushed. The following program example reads and types out T, Z, M, X, Y, N and L when the record button is pressed:

```
1.Ø2 IF (FNEW (5)) 1.Ø2, 1.Ø2, 2.Ø5

2.Ø5 S  T = FNEW (Ø, 13)
2.Ø7 FOR A = 4, 1, 9; SET X (A) = FNEW (Ø, A)
2.Ø8 GOTO 3.Ø3

3.Ø3 TYPE T, !
3.Ø5 FOR A = 4, 1, 9; TYPE X (A), !
3.Ø7 QUIT
```

(vii) FDIS (Ø, Z, XØ, YØ, X1, Y1)
This function is used to operate the VTØ1 storage display unit[10]. The operations available are listed below:

Z = Ø)	Erase screen
Z = 1	Draw a linear vector from XØ, YØ to X1, Y1

Z = 2 Draw an arc of 5.625° clockwise starting at XØ, YØ centred at X1, Y1.

Z = 3 Draw an arc of 90° clockwise starting at XØ, YØ centred at X1, Y1.

Z = 4) Display joystick cursor.

Z = 5 Plot a point at XØ, YØ. (Set X1 = XØ and Y1 = YØ).

Z = 6 Plot a (O) symbol at XØ, YØ. (Set X1 = XØ and Y1 = YØ).

Z = 7 Plot a (+) symbol at XØ, YØ. (Set X1 = XØ and Y1 = YØ).

Z = 8) Read X coordinate of cursor (Function returns with 1Ø24 + X)

Z = 9) Read Y coordinate of cursor (Function returns with 1Ø24 + Y)

Z = 1Ø) Check state of and then clear cursor interrupt flag. If flag is set, the function returns with the value 4Ø96, if not, with the value Ø.

The visible area of the screen is approximately X = ±256, Y = ±320, the total addressable area is ±511 units square.

(viii) FDIS (1, Z, X, Y).
This function is used to operate the calcomp 565 incremental plotter. The operations available are listed below:

Z = Ø) Reset plotter coordinates to Ø, Ø.

Z = 1 Pen up - move from current location to X, Y in a straight line.

Z = 2 Pen down - move from current location to X, Y in a straight line.

Z = 3 Plot a (+) symbol at X, Y.

Z = 4 Plot a (X) symbol at X, Y.

The value of Y used must be in the range Ø to 4Ø96 and, if the plotter coordinates are reset with the pen aligned with the right hand border, X may vary in the range Ø to 1ØØØ. The positive direction of X and Y pen travel is leftwards and upwards.

2.3 Examples

The following program segments for use with extended FOCAL cover some of the forseeable possible requirements. It is intended that these examples illustrate the type of problem that is suited to this approach rather than being a comprehensive compendium of user programs.

(a) Mach number display.

When the tunnel is being operated with a FOCAL data handling program the normal assembly language Mach number generation and display routine[1] cannot be used. Since a display of Mach number is usually required for tunnel speed setting, any FOCAL program for use with the tunnel will require its own Mach number display routine. The following program segment executed at convenient intervals will meet this requirement:

```
31.Ø1  S  P = FNEW (Ø, 1); S  H = FNEW (Ø, 2)
31.Ø2  I  (H - P) 31.Ø3, 31.Ø4, 31.Ø4
31.Ø3  S  H = P
31.Ø4  S  M = FSQT (5*(FEXP(Ø.2857*  FLOG(H/P))-1))
31.Ø5  S  D = FNEW (1, M* 1ØØØ)
```

(b) Indicated airspeed display.

On occasions when operating the tunnel at low speed it is more useful to display indicated airspeed (IAS) rather than Mach number. The following routine displays IAS on the Machmeter.

```
31.Ø1  S  P = FNEW (Ø, 1); S  H = FNEW (Ø, 2)
31.Ø2  I  (H - P) 31.Ø3, 31.Ø4, 31.Ø4
31.Ø3  S  H = P
31.Ø4  S  IA = 1479.1 * FSQT (FEXP(Ø.2857* FLOG ((H - P)/
       2992.1 + 1))-1)
31.Ø5  S  D = FNEW (1, IA*1Ø)
31.Ø6  F  D = 1, 1, 5Ø. S  E  = Ø
31.Ø7  G 31.Ø1
```

The display is in the form XXX.X knots.
(Note: the fixed hardware decimal point location must be ignored). If it is desired to display speeds above 199.9 knots the implicit decimal point location may be moved one place to the right by deleting the multiplying factor *1Ø from line 31.Ø5. To change the units of the displayed speed simply alter the multiplying factor in line 31.Ø5. Lines 31.Ø6 and 31.Ø7 cycle the routine at a convenient rate but if the routine is to be called from the main program when required, these two lines should be omitted.

(c) True airspeed display.

It may sometimes be required to display true airspeed (TAS) when operating the tunnel. This poses the problem that the temperature which is required for the computation of TAS can only be read when the record push button is pressed. The following program uses the waiting time between TAS computations looking at the record push button. Each time the button is pressed the temperature used by the program is updated to the current value.

```
3Ø.Ø1  F  E = 1, 1, 2Ø; D 31
3Ø.Ø2  S  P = FNEW (Ø, 1); S  H = FNEW (Ø, 2)
3Ø.Ø3  I (H - P) 3Ø.Ø4, 3Ø.Ø5, 3Ø.Ø5
3Ø.Ø4  S  H = P
3Ø.Ø5  S  M = FSQT (5* (FEXP (Ø.2857* FLOG (H/P))-1))
3Ø.Ø6  S  D = FNEW (1, M*A*1Ø); G 3Ø.Ø1

31.Ø1  S  D = FNEW (5)
31.Ø2  I  (D) 31.Ø3, 31.Ø3, 31.Ø4
31.Ø3  R
31.Ø4  S  TØ = FNEW (Ø,13)
31.Ø5  S  TT = (TØ/1Ø + 273.2)*1.8/(1 + Ø.2*M↑2)
31.Ø6  S  A = 29.Ø91 * FSQT (TT)
31.Ø7  S  E = 2Ø; G 3Ø.Ø6
```

The display units and decimal point location are identical to the IAS program described previously.

(d) Free stream kinetic pressure display.

To simplify the reduction of low speed data to coefficient form it may sometimes be convenient to operate the tunnel at a constant free stream kinetic pressure ($\frac{1}{2}\ell V^2$). The following routine displays $\frac{1}{2}\ell V^2$ on the Machmeter.

```
31.Ø1  S  P = FNEW (Ø, 1); S  H = FNEW (Ø, 2)
31.Ø2  I (H - P) 31.Ø3, 31.Ø4, 31.Ø4
31.Ø3  S  H = P
31.Ø4  K = (5 *(FEXP (Ø.2857*FLOG (H/P))-1))*P*Ø.Ø2371
31.Ø5  S  D = FNEW (1, K* 1ØØ)
31.Ø6  F  D = 1, 1, 5Ø; S  E = Ø
31.Ø7  G 31.Ø1
```

The display is in the form XX.XX kPa.
(Note: the fixed hardware decimal point location must be ignored). As before the units and the implicit display decimal point location may be changed by altering the factor in line 31.Ø5.

(e) Function plotting on the screen.

When examining the results of mathematical analyses it is often helpful to plot the functional relationship between variables. For complex functions this can be a laborious procedure if done by hand. The following program can be used to quickly plot functions on the screen:

```
1.Ø1  S  Q = FDIS (Ø, Ø)
1.Ø2  F  X = 3ØØ, 1, 3ØØ; D 2
1.Ø3  Q

2.Ø1  D 3
2.Ø2  S  Q = FDIS (Ø, 5, X, Y, X, Y)
```

Group 3 lines define the function Y = F(X) scaled so that as X varies from -300 to +300, Y varies in the range ±380. Alternatively if X and Y are both functions of Z line 1.Ø2 can be used to increment Z and both X and Y defined in group 3 lines.

In Fig. 1 an example of the type of plot that can be produced is presented. The function plotted in this figure is:

$$X = 24Øe^{-Ø.1Z} \sin Z + 1ØØe^{-Ø.2Z} \sin 2ØZ \sin Z$$

$$Y = 24Øe^{-Ø.1Z} \cos Z + 1ØØe^{-Ø.2Z} \sin 2ØZ \cos Z$$

where Z varies from Ø to 28 in Ø.ØØ5 increments.

(f) Function plotting on the plotter.

Functions can be plotted on the plotter in a similar manner to that described above for the screen. On the plotter better results are obtained by drawing straight lines between adjacent computed (X, Y) points rather than simply plotting the points. A basic function plotting program is presented below:

```
1.1Ø  S  Q = FDIS (1, Ø)
1.2Ø  S  X = Ø; D 3
1.3Ø  S  Q = FDIS (1, 1, V, Y)
1.4Ø  F  X = Ø, 1, 1ØØØ; D 2
1.5Ø  Q

2.1Ø  D 3
2.2Ø  S  Q = FDIS (1, 2, V, Y)

3.Ø1  S  V = 1ØØØ - X
```

Group 3 lines define the function Y = F(X) scaled so that as X varies from Ø to 1ØØØ Y varies in the range Ø to 4Ø96.

In Fig. 2 a sample plot is reproduced. The function plotted is $X = 2ØØ + 1ØØ\ (Z + Ø.3 \cos 62.84Z)$

$Y = 5ØØ + 3ØØ\ (e^{-0.35Z} \sin 3.14Z + Ø.1 \sin 62.84Z)$

where Z varies from Ø to 1Ø in Ø.ØØ5 steps.

(g) Non standard real time display.

The standard force reduction program has facilities for the display of the six force and moment components as functions of either Mach number, sideslip or incidence angle. If a real time display of a cross plot between two force components, or some other non standard display, is required a FOCAL program can be written to produce it. The following example plots the transonic range parameter Mach number X Lift/Drag $(\frac{ML}{D})$ as a function of Mach number (M). Each time the record push button is pressed a point is plotted on the display and the values of M and $\frac{ML}{D}$ are printed on the teletype.

```
1.Ø1  C  ERASE SCREEN AND DRAW AXES
1.Ø2  S  Z = FDIS (Ø, Ø)
1.Ø4  S  Z = FDIS (Ø, 1, -25Ø, -31Ø, -25Ø, 31Ø)
1.Ø6  S  Z + FDIS (Ø, 1, -25Ø, -31Ø, 25Ø, -31Ø)

2.Ø1  C  PUSH BUTTON?
2.Ø3  I (FNEW (5)) 31.Ø1, 31.Ø1, 3.Ø2

3.Ø2  C  READ Z, M, X, Y, N, L AND THETA
3.Ø4  F  A = 4, 1, 1Ø; S  X(A) = FNEW (Ø, A)
3.Ø6  C  APPLY BALANCE INTERACTIONS
3.Ø8  S  Z = ZZ*X(4) + ZM*X(5) + ZX*X(6) + ZY*X(7) +
         ZN*X(8) + ZL*X(9)
3.09  S  X = XZ*X(4) + XM*X(5) + XX*X(6) + XY*X(7) +
         XN*X(8) + XL*X(9)
3.11  C  CALCULATE L AND D
3.13  S  L =-Z* F cos (X(1Ø)/5729.6) + X* F sin (X(1Ø)/
      5729.6 )
3.15  S  D = -X* F cos (X(1Ø)/5729.6 - Z* F sin (X(1Ø)/
      5729.6 )

4.Ø2  C  DISPLAY POINT
4.Ø4  S  Z = -31Ø + 25*M*L/D
4.Ø6  S  X = -25Ø + 5ØØ*M
4.Ø8  S  L = FDIS (Ø, 7, X, Z, X, Z)
```

```
5.1Ø  C  PRINT M AND ML/D
5.12  T  %6.Ø3, M, "   ", M*L/D, !
5.14  G 2.Ø3

31.Ø1  C MACH ROUTINE, SEE EXAMPLE A.
         LAST INSTRUCTION G 2.Ø3
```

The variables ZZ, ZM, ZX etc. used in lines 3.Ø8 and 3.Ø9 are equal to the product of the appropriate sensitivity and inverse balance calibration matrix element. Using the terminology of reference 4:

ZZ = SZ.k'ZZ, ZM = SM.k'ZM, etc.
XZ = SZ.k'XZ, XM = SM.k'XM, etc.

3. PROGRAM DETAILS

3.1 Present version

A complete listing and symbol table of the present version of the FOCAL modifications are presented in the appendix. The core locations used are:

(a) Field Ø, ØØ35, Ø377, 041Ø and 44ØØ to 4577

(b) Field 1, Nil

(c) Field 2, Ø2ØØ to 2177 and 62ØØ to 6777.

The remainder of Field 2 is available for additional new functions. Since the 8K overlay is used Field 1 must be left blank.

It was decided to exclude operation of the line printer and DEC tapes from the current version. This was done because a general operating routine for these devices would have been long and complicated. If a need arises for a FOCAL program to control the printer or DEC tapes it is suggested that a specific assembly language segment be written to cover the particular requirement.

3.2 Modifications

The following hints are aimed at assisting anyone who wishes to add further new functions to the current version of extended FOCAL. The best guide to new function writing is given in Ref. 9 a copy of which is held by the author. The various listings and symbols tables given in Refs. 7-9 do not agree with each other or with the FOCAL program which we have. When modifying FOCAL itself it is necessary to refer to a disassembly of the actual program.

The current program has two convenient entry points to further new functions. The FNEW function has been used for values of the first argument of the function from Ø to 5. If the FNEW function is used with a first argument greater than 5 the program will arrive at the error return at 4473 in field Ø with the first argument in TPS. To add the functions FNEW (6), FNEW (7) etc. simply put a JMP instruction at 4473 and look at the value of TPS. Similarly the function FDIS has been used for first arguments of Ø and 1. If FDIS is used with other arguments the program will arrive at the error return at 13ØØ in field 2 with the value of the first argument in INSEL.

A number of useful instructions available in the current program are listed below:

(i) Field Ø

4566 - Return control to FOCAL via the error recovery routine.

JMS I ØØ53 - Get integer part of floating accumulator and bring it into accumulator.

454Ø
ARG
4566 - This instruction string will get the next argument of the function into the floating accumulator and transfer control to the following instruction. If there are no more arguments it will do an error return to FOCAL.

JMP I Ø136 - Re-enter FOCAL after execution of function.

(ii) Field 2

JMP ERR - Return control to FOCAL via the error recovery routine.

JMP INSEL-12 - Returns control to FOCAL with the double precision binary number contained in the accumulator (high order word) and LOW (low order word) transferred into the floating accumulator.

JMS NEXT - Get next argument and store it in INSEL.

JMS IN2 - Get next two arguments and store them in XX and YY.

JMS IN4 - Get next four arguments and store them in XØ, YØ, X1 and Y1.

3.3 Assembly, Loading and Saving

Some difficulty was experienced in assembling, loading and saving the present version of extended FOCAL. The procedure described below, while somewhat involved, has been found to work and it is strongly recommended that it be followed for future modifications.

The program segment in Field 2 should be written in a self contained form so that it can be assembled[11] in isolation from the rest of the program. After assembly the program segment should be single pass loaded into Field 2 and saved by

SAVE FC29! core limits; 76ØØ.

For the required format of core limits see reference 12.

The modified program segment resident in Field Ø should be assembled into a binary file, MODS say. The two binary files comprising FOCAL, FOC1 and FOC2 along with the 8K overlay FC8K should also be on the disk. Fields Ø and 1 are then loaded as follows:

```
.   LOAD
*   IN-S:FOC1, S:FOC2, S:MODS, S:FC8K
*   OPT-2
*   ST-2ØØ
```

[Initial dialogue[7,8], answer questions]

```
*   L
    (A)
    (B)
    (C)
    (D)
```

A, B, C and D are four digit numbers typed by FOCAL following the L command.

Now save the program as follows:

```
.   SAVE ST9K! (D) - 7577; 2ØØ
.   SAVE FCL9! Ø - 3377;
.   SAVE NUL9: 1Ø1ØØ; 1Ø113
```

Now call FCL9 by .FCL9, stop computer and remove interrupts by toggling the following patch:

Location	Old Contents	New Contents
63	2676	1354
64	2666	2414
2732	6ØØ1	2Ø57
2762	6Ø46	7ØØØ

Then again save FCL9 as before:

```
. SAVE FCL9! Ø - 3377;
```

The complete modified FOCAL is then called by the following command string:

```
. FC29
. FCL9
. CALL NUL9
. ST9K
```

REFERENCES

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7. - FOCAL 8 Programming Manual. DEC-08-AJAD-D Digital Equipment Publication.

8. - Advanced FOCAL Technical Specifications. DEC-08-AJBB-DL. Digital Equipment Publication.

9. - Writing FOCAL F NEW Functions. Notes from Digital Equipment Seminar.

10. - KV Graphics Display System. DEC-81-H6MA-D. Digital Equipment Publication.

11. - PAL-D Assembler. DEC-D8-ASAA-D Digital Equipment Publication.

12. - Disk Monitor System. DEC-D8-SDAB-D Digital Equipment Publication.

APPENDIX: PALD LISTING AND SYMBOL TABLE

```
ABC     4417
ARG     4432
BCD     4442
DEF     4450
EFG     4456
FGH     4470
TPS     4431
XDYS    4476
XFNEW   4400

            FIELD 0
            *0035
0035    4377        XFNEW-1
            *0377
0377    4476        XDYS
            *0410
0410    4400        XFNEW
            *4400
4400    4453  XFNEW, JMS I 0053     /GET FIRST ARGUMENT
4401    3231        DCA TPS
4402    1231        TAD TPS
4403    7440        SZA             /READ INPUT ?
4404    5217        JMP ABC
4405    4540        4540            /PUSHJ
4406    4432        ARG             /GET NEXT ARGUMENT
4407    4566        4566            /ERROR
4410    4453        JMS I 0053
4411    6222        6222            /INSTRUCTION FIELD 2
4412    5777        JMP 0200
4413    4407        4407            /RETURN WITH READING IN FLAC
4414    7000        7000            / NORMALISE
4415    0000        0000
4416    5536        JMP I 0136      /REENTER FOCAL
4417    7000  ABC,  NOP
4420    1376        TAD (-1
4421    7640        SZA CLA         /OUTPUT TO MACHMETER ?
4422    5242        JMP BCD
4423    4540        4540
4424    4432        ARG
4425    4566        4566
4426    4453        JMS I 0053
4427    6222        6222
4430    5775        JMP 0260
4431    0000  TPS,  0000
4432    1066  ARG,  TAD 0066        /EVALUATES ADDITIONAL ARGUMENTS
4433    1374        TAD (-254       /RETURN TO CALL+2 IF ,XXX -
4434    7640        SZA CLA         /OTHERWISE CALL+1
4435    5241        JMP .+4
4436    4540        4540
4437    1612        1612
4440    7001        IAC
4441    5541        5541            /POPJ
```

```
4442  1231  BCD,    TAD TPS
4443  1373          TAD (-2
4444  7640          SZA CLA          /START DATA LOGGER?
4445  5250          JMP DEF
4446  6324          6324
4447  5536          JMP I 0136
4450  1231  DEF,    TAD TPS
4451  1372          TAD (-3
4452  7640          SZA CLA          /STOP DATA LOGGER?
4453  5256          JMP EFG
4454  6364          6364
4455  5536          JMP I 0136
4456  1231  EFG,    TAD TPS
4457  1371          TAD (-4
4460  7640          SZA CLA          /READ DATA LOGGER?
4461  5270          JMP FGH
4462  4540          4540
4463  4432          ARG
4464  4566          4566
4465  4453          JMS I 0053
4466  6222          6222
4467  5770          JMP 0300
4470  1231  FGH,    TAD TPS
4471  1367          TAD (-5
4472  7640          SZA CLA          /CHECK RECORD FLAG
4473  4566          4566
4474  6222          6222
4475  5766          JMP 0342
              *4476
4476  4453  XDYS,   JMS I 0053       /GET FIRST ARGUMENT
4477  6222          6222
4500  5765          JMP 0400
              *4501                  /GET NEXT ARGUMENT -
4501  4540          4540             /AND RETURN TO 6604 -
4502  4432          ARG              /IN FIELD 2
4503  4566          4566
4504  4453          JMS I 0053
4505  6222          6222
4506  6221          6221
4507  5764          JMP 6604
4564  6604
4565  0400
4566  0342
4567  7773
4570  0300
4571  7774
4572  7775
4573  7776
4574  7524
4575  0260
4576  7777
4577  0200
```

A	0242
AC	1266
ADC	1217
ADL	1235
ARC	0500
B	0243
BCDBIN	6275
BCDM	6400
C	0244
CNT	0670
CT	6464
CT3	6465
DEL	0245
DELCO	0253
DEP	0240
DIAG	1651
DOUBLE	6200
DOUM	2000
DPY	6611
DSPLY	6625
ERR	6606
EXIT	1264
FLAG	1201
FORM	6613
FORMAT	6655
HIGH	6274
HIGH1	6272
INSEL	0237
IN2	1321
IN4	0424
K10	1272
K177	6327
K7	6324
K7400	6330
K7600	6325
K7760	6323
K7770	6326
LOT	1331
LOW	6273
LOW1	6271
LO2	1642
MACH	0260
MB	1267
MIN	2034
MO3	1270
NEG	6617
NEXT	6600
NP	0446
NUT	1650
ONEM	0272
PER	1274
PLO	1335
PLOTA	1420
PLOTDB	1531

```
PLOTDX 1564
PLOTDY 1565
PLOTMV 1567
PLOTNA 1566
PLOTNX 1562
PLOTNY 1563
PLOTPN 1561
PLOTT1 1542
PLOTT2 1545
PLOTT3 1550
PLOTWT 1570
PLOTX  1400
PLOT1  1427
PLOT2  1475
PLOT3  1516
PLOT4  1540
QRS    0467
THI    2033
TIM    1271
TSTOR  2032
TWO    0325
TWOM   0273
UBADDR 6463
UBARND 6416
UBBOX  6473
UBCNT  6466
UBCON1 6477
UBDO   6424
UBGET  6475
UBHIGH 6467
UBHSUB 6471
UBLOOP 6462
UBLOW  6470
UBLSUB 6472
UBOUT  6442
UBPTR  6476
UBTEML 6474
VAL    1273
XX     1332
XXX    6614
XX1    1644
X0     0474
X1     0476
YY     1333
YYY    6615
YY1    1645
Y0     0475
Y1     0477
ZXY    1336

        FIELD 2
        *6200
        /DIGITAL        8-11-U-SYM
        /DOUBLE PRECISION BCD TO BINARY CONVERSION
        /CALLING SEQUENCE:
        /       JMS DOUBLE
```

```
                /       ADDRESS OF HIGH ORDER ARGUMENT
                /       RETURN: C(AC)=HIGH ORDER PART
                /       C(LOW) = LOW ORDER PART
               /ALSO CONTAINS SINGLE PRECISION BCD TO BINARY
               /CALLING SEQUENCE:
                /       C(AC) = 3 BCD CHARACTERS
                /       JMS BCDBIN
                /       RETURN: ANSWER IN C(AC)
5200  0000  DOUBLE,0
5201  7300  CLA CLL
5202  1600  TAD I DOUBLE/FETCH ADDRESS
5203  3271  DCA LOW1/STORE
5204  2200  ISZ DOUBLE/INCREMENT RETURN
5205  1671  TAD I LOW1/FETCH HIGH ORDER
5206  4275  JMS BCDBIN/CONVERT IT
5207  3272  DCA HIGH1/STORE
5210  2271  ISZ LOW1/INCREMENT POINTER
5211  1671  TAD I LOW1/FETCH LOW ORDER
5212  4275  JMS BCDBIN/CONVERT IT
5213  3271  DCA LOW1/STORE IT
5214  1272  TAD HIGH1
5215  7112  CLL RTR
5216  7012  RTR
5217  7010  RAR/MULTIPLY HIGH ORDER
5220  3275  DCA BCDBIN/PART BY 128
5221  1275  TAD BCDBIN
5222  0327  AND K177
5223  3274  DCA HIGH
5224  1275  TAD BCDBIN
5225  7010  RAR
5226  0325  AND K7600
5227  3273  DCA LOW
5230  1272  TAD HIGH1/MULTIPLY HIGH ORDER
5231  7104  CLL RAL/BY THREE
5232  1272  TAD HIGH1/FORM 128*HIGH-3*HIGH
5233  7141  CIA CLL
5234  1273  TAD LOW
5235  3273  DCA LOW
5236  7420  SNL
5237  7040  CMA
5240  1274  TAD HIGH
5241  3274  DCA HIGH/125*HIGH
5242  1274  TAD HIGH/NOW MULTIPLY BY 8
5243  7106  CLL RTL
5244  7004  RAL
5245  0326  AND K7770/MASK 9 BITS
5246  3274  DCA HIGH
5247  1273  TAD LOW
5250  7106  CLL RTL
5251  7004  RAL
5252  3273  DCA LOW
5253  1273  TAD LOW
5254  7004  RAL
5255  0324  AND K7/3 BITS
5256  1274  TAD HIGH
5257  3274  DCA HIGH
```

```
6260  1273  TAD LOW
6261  0326  AND K7770/9 BITS
6262  7100  CLL
6263  1271  TAD LOW1/ADD LOW ORDER PART
6264  3273  DCA LOW/STORE LOW ORDER PART
6265  1274  TAD HIGH
6266  7430  SZL
6267  7001  IAC/CARRY
6270  5600  JMP I DOUBLE
6271  0000  LOW1,0
6272  0000  HIGH1,0
6273  0000  LOW,0
6274  0000  HIGH,0
            /SINGLE PRECISION CONVERSION
6275  0000  BCDBIN,0
6276  3274  DCA HIGH
6277  1274  TAD HIGH
6300  0330  AND K7400/LEFT DIGIT
6301  7112  CLL RTR
6302  3273  DCA LOW
6303  1273  TAD LOW
6304  7010  RAR
6305  1273  TAD LOW
6306  7041  CIA
6307  1274  TAD HIGH
6310  3274  DCA HIGH
6311  1274  TAD HIGH
6312  0323  AND K7760
6313  7112  CLL RTR
6314  3273  DCA LOW
6315  1273  TAD LOW
6316  7010  RAR
6317  1273  TAD LOW
6320  7041  CIA
6321  1274  TAD HIGH
6322  5675  JMP I BCDBIN
6323  7760  K7760,7760
6324  0007  K7,7
6325  7600  K7600,7600
6326  7770  K7770,7770
6327  0177  K177,177
6330  7400  K7400,7400
            FIELD 2
            *6400
6400  0000  BCDM,    0
6401  3270          DCA UBLOW
6402  1600          TAD I BCDM
6403  3267          DCA UDHIGH
6404  1262          TAD UDLOOP
6405  3266          DCA UDCNT
6406  1263          TAD UDADDR
6407  3276          DCA UDPTR
6410  2200          ISZ BCDM
6411  1377          TAD (-2
6412  3264          DCA CT
6413  1376          TAD (-3
```

```
6414  3265          DCA CT3
6415  3273          DCA UDBOX
6416  1676  UDARND, TAD I UDPTR
6417  2276          ISZ UDPTR
6420  3271          DCA UDHSUB
6421  1676          TAD I UDPTR
6422  2276          ISZ UDPTR
6423  3272          DCA UDLSUB
6424  7100  UDDO,   CLL
6425  1272          TAD UDLSUB
6426  1270          TAD UDLOW
6427  3274          DCA UDTEML
6430  7004          RAL
6431  1271          TAD UDHSUB
6432  1267          TAD UDHIGH
6433  7420          SNL
6434  5242          JMP UDOUT
6435  2273          ISZ UDBOX
6436  3267          DCA UDHIGH
6437  1274          TAD UDTEML
6440  3270          DCA UDLOW
6441  5224          JMP UDDO
6442  7200  UDOUT,   CLA
6443  1273          TAD UDBOX
6444  2265          ISZ CT3
6445  7410          SKP
6446  5254          JMP .+6
6447  7106          CLL RTL
6450  7106          CLL RTL
6451  3273          DCA UDBOX
6452  2266          ISZ UDCNT
6453  5216          JMP UDARND
6454  2264          ISZ CT
6455  3775          DCA ONEM
6456  3774          DCA TWOM
6457  2266          ISZ UDCNT
6460  5213          JMP UDARND-3
6461  5600          JMP I BCDM
6462  7772  UDLOOP, -6
6463  6477  UDADDR, UDCON1
6464  0000  CT,     0
6465  0000  CT3,    0
6466  0000  UDCNT,  0
6467  0000  UDHIGH, 0
6470  0000  UDLOW,  0
6471  0000  UDHSUB, 0
6472  0000  UDLSUB, 0
6473  0000  UDBOX,  0
6474  0000  UDTEML, 0
6475  0000  UDGET,  0
6476  0000  UDPTR,  0
6477  7747  UDCON1, 7747
6500  4540          4540
6501  7775          7775    /-10,
6502  4360          4360
6503  7777          7777
```

```
6504  6030          6030
6505  7777          7777
6506  7634          7634
6507  7777          7777
6510  7766          7766
6511  7777          7777
6512  7777          7777
                              /END TAPE 4
      PAUSEFIELD 2
6574  0273
6575  0272
6576  7775
6577  7776
      *0200                   /FNEW(0)
0200  6221          6221      /DATA FIELD 2
0201  3237          DCA INSEL /DEVICE NUMBER
0202  6334          6334      /LOAD INPUT SELECTOR
0203  6331          6331      /CLEAR RECORD FLAG
0204  1237          TAD INSEL
0205  6334          6334      /LOAD INPUT SELECTOR
0206  7300          CLA CLL
0207  4245          JMS DEL
0210  7300          CLA CLL
0211  6332          6332      /READ BYTE 2
0212  3240          DCA DEP
0213  1237          TAD INSEL
0214  6334          6334
0215  7300          CLA CLL
0216  4245          JMS DEL
0217  7300          CLA CLL
0220  6322          6322      /READ BYTE 1
0221  3241          DCA DEP+1
0222  6334          6334      /0 IN INPUT SELECTOR
0223  4777          JMS DOUM  /CONVERT TO BINARY
0224  7000          NOP
0225  6201          6201
0226  3642          DCA I A
0227  6221          6221
0230  1776          TAD LOW
0231  6201          6201
0232  3643          DCA I B
0233  1375          TAD (27
0234  3644          DCA I C
0235  6202          6202
0236  5774          JMP 4413
0237  0000  INSEL,  0000
0240  0000  DEP,    0000
0241  0000          0000
0242  0045  A,      0045
0243  0046  B,      0046
0244  0044  C,      0044
0245  0000  DEL,    0000
0246  1373          TAD (7470
0247  3253          DCA DELCO
0250  2253          ISZ DELCO
0251  5250          JMP .-1
```

```
0252  5645          JMP I DEL
0253  0000  DELCO,  0000
            *260
0260  6221  MACH,   6221              /FNEW(1)
0261  4772          JMS BCDM
0262  0000          0
0263  1273          TAD TWOM
0264  6304          6304
0265  7300          CLA CLL
0266  1272          TAD ONEM
0267  6316          6316
0270  7300          CLA CLL
0271  5225          JMP INSEL-12
0272  0000  ONEM,   0000
0273  0000  TWOM,   0000
            *300
0300  6221          6221              /FNEW(4)
0301  7000          NOP
0302  3237          DCA INSEL
0303  1237          TAD INSEL
0304  7440          SZA               /SKIP FOR FIRST BYTE
0305  5325          JMP TWO
0306  6351          6351              /CLEAR DATA LOGGER FLAG
0307  6341          6341              /SKIP ON DATA LOGGER FLAG
0310  5307          JMP .-1
0311  7300          CLA CLL
0312  6344          6344              /READ BYTE 1
0313  6351          6351              /CLEAR FLAG
0314  4771          JMS BCDBIN
0315  6201          6201
0316  3643          DCA I B
0317  3642          DCA I A
0320  1375          TAD (27
0321  3644          DCA I C
0322  7000          NOP
0323  6202          6202
0324  5774          JMP 4413
0325  7300  TWO,    CLA CLL
0326  6341          6341              /SKIP ON FLAG
0327  5331          JMP .+2
0330  7402          HLT               /TIMING FOUL UP
0331  7300          CLA CLL
0332  6352          6352              /READ BYTE 2
0333  3240          DCA DEP
0334  6354          6354              /READ BYTE 3
0335  3241          DCA DEP+1
0336  7000          NOP
0337  5223          JMP INSEL-14      /RETURN WITH DATA
            *342                      /FNEW(5)
0342  6221          6221
0343  6311          6311
0344  5351          JMP .+5
0345  6331          6331
0346  7200          CLA
0347  7001          IAC
0350  5225          JMP INSEL-12
```

```
0351  7200          CLA
0352  3776          DCA LOW
0353  5225          JMP INSEL-12
0371  6275
0372  6400
0373  7470
0374  4413
0375  0027
0376  6273
0377  2000
                *400                        /FDIS
0400  6221          6221                    /FIRST ARGUMENT
0401  3777          DCA INSEL
0402  1777          TAD INSEL
0403  7440          SZA                     /SCREEN?
0404  5776          JMP PER                 /PLOTTER
0405  4775          JMS NEXT                /GET NEXT ARGUMENT
0406  7300          CLA CLL
0407  1777          TAD INSEL
0410  7440          SZA
0411  5216          JMP .+5
0412  1374          TAD (0004               /ERASE SCREEN
0413  3773          DCA FORM
0414  4772          JMS DPY
0415  5771          JMP INSEL-12
0416  1370          TAD (7777
0417  7640          SZA CLA                 /LINEAR VECTOR?
0420  5300          JMP ARC
0421  4224          JMS IN4
0422  4246          JMS NP
0423  5267          JMP QRS
0424  0000  IN4,     0                       /GETS X0,X1,Y0&Y1
0425  4775          JMS NEXT
0426  1777          TAD INSEL
0427  4767          JMS NEG
0430  3274          DCA X0
0431  4775          JMS NEXT
0432  1777          TAD INSEL
0433  4767          JMS NEG
0434  3275          DCA Y0
0435  4775          JMS NEXT
0436  1777          TAD INSEL
0437  4767          JMS NEG
0440  3276          DCA X1
0441  4775          JMS NEXT
0442  1777          TAD INSEL
0443  4767          JMS NEG
0444  3277          DCA Y1
0445  5624          JMP I IN4
0446  0000  NP,      0                       /INVISIBLE VECTOR TO X0,Y0
0447  1366          TAD (0002
0450  3773          DCA FORM                /RESET INTEGRATORS
0451  4772          JMS DPY
0452  1274          TAD X0
0453  3765          DCA XXX
0454  1275          TAD Y0
```

```
0455  3764          DCA YYY
0456  1363          TAD (0440       /INVISIBLE VECTOR
0457  3773          DCA FORM
0460  4772          JMS DPY
0461  7300          CLA CLL
0462  1276          TAD X1          /GET X1&Y1
0463  3765          DCA XXX
0464  1277          TAD Y1
0465  3764          DCA YYY
0466  5646          JMP I NP
0467  7300  QRS,     CLA CLL
0470  1362          TAD (0441       /VISIBLE VECTOR
0471  3773          DCA FORM
0472  4772          JMS DPY
0473  5771          JMP INSEL-12
0474  0000  X0,      0
0475  0000  Y0,      0
0476  0000  X1,      0
0477  0000  Y1,      0
0500  1777  ARC,    TAD INSEL
0501  1361          TAD (7776
0502  7640          SZA CLA         /SHORT ARC?
0503  5312          JMP .+7
0504  4224          JMS IN4
0505  4246          JMS NP
0506  1360          TAD (0211
0507  3773          DCA FORM
0510  4772          JMS DPY
0511  5771          JMP INSEL-12
0512  1777          TAD INSEL
0513  1357          TAD (7775
0514  7640          SZA CLA         /LONG ARC?
0515  5324          JMP .+7
0516  4224          JMS IN4
0517  4246          JMS NP
0520  1356          TAD (0051
0521  3773          DCA FORM
0522  4772          JMS DPY
0523  5771          JMP INSEL-12
0524  1777          TAD INSEL
0525  1355          TAD (7774
0526  7640          SZA CLA         /DISPLAY CURSOR?
0527  5335          JMP .+6
0530  7300          CLA CLL
0531  1354          TAD (1400
0532  3773          DCA FORM
0533  4772          JMS DPY
0534  5771          JMP INSEL-12
0535  1777          TAD INSEL
0536  1353          TAD (7773
0537  5752          JMP 600
0552  0600
0553  7773
0554  1400
0555  7774
0556  0051
```

```
0557  7775
0560  0211
0561  7776
0562  0441
0563  0440
0564  6615
0565  6614
0566  0002
0567  6617
0570  7777
0571  0225
0572  6611
0573  6613
0574  0004
0575  6600
0576  1274
0577  0237

                *600
0600  7640        SZA CLA          /POINT?
0601  5210        JMP .+7
0602  4777        JMS IN4
0603  4776        JMS NP
0604  1375        TAD (1001
0605  3774        DCA FORM
0606  4773        JMS DPY
0607  5772        JMP INSEL-12
0610  1771        TAD INSEL
0611  1370        TAD (7772
0612  7640        SZA CLA          /CIRCLE SYMBOL?
0613  5231        JMP .+16
0614  4777        JMS IN4
0615  1767        TAD X0
0616  1366        TAD (5
0617  3767        DCA X0
0620  4776        JMS NP
0621  1365        TAD (7774
0622  3270        DCA CNT
0623  1364        TAD (0051
0624  3774        DCA FORM
0625  4773        JMS DPY
0626  2270        ISZ CNT
0627  5225        JMP .-2
0630  5772        JMP INSEL-12
0631  1771        TAD INSEL
0632  1363        TAD (7771
0633  7640        SZA CLA          /CROSS SYMBOL?
0634  5762        JMP 800
0635  4777        JMS IN4
0636  1767        TAD X0
0637  1361        TAD (-5
0640  3767        DCA X0
0641  1760        TAD X1
0642  1366        TAD (5
0643  3760        DCA X1
0644  4776        JMS NP
0645  1357        TAD (0441
```

```
0646  3774          DCA FORM
0647  4773          JMS DPY
0650  1767          TAD X0
0651  1366          TAD (5
0652  3767          DCA X0
0653  1767          TAD X0
0654  3760          DCA X1
0655  1756          TAD Y0
0656  1361          TAD (-5
0657  3756          DCA Y0
0660  1755          TAD Y1
0661  1366          TAD (5
0662  3755          DCA Y1
0663  4776          JMS NP
0664  1357          TAD (0441
0665  3774          DCA FORM
0666  4773          JMS DPY
0667  5772          JMP INSEL-12
0670  0000  CNT,     0
0755  0477
0756  0475
0757  0441
0760  0476
0761  7773
0762  1000
0763  7771
0764  0051
0765  7774
0766  0005
0767  0474
0770  7772
0771  0237
0772  0225
0773  6611
0774  6613
0775  1001
0776  0446
0777  0424
                    *800
1000  1777          TAD INSEL
1001  1376          TAD (7770
1002  7640          SZA CLA           /READ X CURSOR?
1003  5212          JMP .+7
1004  1375          TAD (1400
1005  6062          6062
1006  4774          JMS ADC
1007  3773          DCA LOW
1010  4772          JMS MIN           /SORT OUT NEGATIVE SIGN
1011  5771          JMP INSEL-12
1012  1777          TAD INSEL
1013  1370          TAD (7767
1014  7640          SZA CLA           /READ Y CURSOR
1015  5767          JMP FLAG
1016  1366          TAD (1440
1017  6062          6062
1020  4774          JMS ADC
```

```
1021  3773          DCA LOW
1022  4772          JMS MIN
1023  5771          JMP INSEL-12
1166  1440
1167  1201
1170  7767
1171  0225
1172  2034
1173  6273
1174  1217
1175  1400
1176  7770
1177  0237
            *6600
6600  0000  NEXT,   0                 /GETS NEXT ARGUMENT
6601  6201          6201
6602  6202          6202
6603  5777          JMP 4501
6604  3776          DCA INSEL
6605  5600          JMP I NEXT
6606  6201  ERR,    6201              /ERROR RETURN
6607  6202          6202
6610  5775          JMP 4425
6611  0000  DPY,    0
6612  4225          JMS DSPLY
6613  0000  FORM,   0
6614  0000  XXX,    0
6615  0000  YYY,    0
6616  5611          JMP I DPY
6617  0000  NEG,    0                 /SORTS OUT NEGATIVE SIGN -
6620  7500          SMA               /OF CURSOR LOCATION
6621  5617          JMP I NEG
6622  0374          AND (0777
6623  1373          TAD (1000
6624  5617          JMP I NEG
6625  0000  DSPLY,  0                 /SUBROUTINE TO DRIVE DISPLAY
6626  7300          CLA CLL
6627  1625          TAD I DSPLY
6630  2225          ISZ DSPLY
6631  6063          6063
6632  3255          DCA FORMAT
6633  1625          TAD I DSPLY
6634  6064          6064
6635  7200          CLA
6636  2225          ISZ DSPLY
6637  6071          6071
6640  5237          JMP .-1
6641  1625          TAD I DSPLY
6642  6065          6065
6643  7200          CLA
6644  2225          ISZ DSPLY
6645  6071          6071
6646  5245          JMP .-1
6647  1255          TAD FORMAT
6650  6066          6066
6651  7200          CLA
```

```
6652  6071          6071
6653  5252          JMP .-1
6654  5625          JMP I DSPLY
6655  0000  FORMAT, 0
                    PAUSE
              /DIGITAL 8-12-U
              /PLOT SUBROUTINE
              /CALLING SEQUENCE
              /   C(AC)=-1;  INITIALIZE
              /   C(AC)= 0;  PLOT WITH PEN DOWN
              /   C(AC)= 1; PLOT WITH PEN UP
              /     JMS PLOTX
              /     X CO-ORDINATE (IN STEPS) (RETURN IF AC=-1)
              /     Y CO-ORDINATE (IN STEPS)
                    FIELD 2
6773  1000
6774  0777
6775  4425
6776  0237
6777  4501
                    *1400
1400  0000  PLOTX,  0
1401  7510          SPA               /MOVE THE PEN?
1402  5220          JMP PLOTA         /NO: CONTINUE
1403  1361          TAD PLOTPN        /ADD PEN STATUS
1404  7112          CLL RTR
1405  7710          SPA CLA                   /ANY CHANGE?
1406  5227          JMP PLOT1         /NO: CONTINUE
1407  7620          SNL CLA
1410  5214          JMP .+4                   /LOWER THE PEN
1411  3361          DCA PLOTPN        /RAISE THE PEN
1412  6504          6504
1413  5216          JMP .+3
1414  2361          ISZ PLOTPN        /LOWER THE PEN
1415  6524          6524
1416  4370          JMS PLOTWT        /WAIT FOR FLAG
1417  5227          JMP PLOT1         /CONTINUE
1420  7200  PLOTA,  CLA
1421  6504          6504
1422  3361          DCA PLOTPN
1423  3362          DCA PLOTNX        /0 TO X CO-ORDINATE
1424  3363          DCA PLOTNY        /0 TO Y CO-ORDINATE
1425  4370          JMS PLOTWT
1426  5600          JMP I PLOTX
              /DIGITAL 8-12-U
              /PAGE 2
              /PICK UP ARGUMENTS
1427  1362  PLOT1,TAD PLOTNX /FETCH PREVIOUS X CO-ORDINATE
1430  7141  CIA CLL
1431  1600  TAD I PLOTX /FORM NX-NPX
1432  7420  SNL /L=0: NX<NPX
1433  7041  CIA
1434  3364  DCA PLOTDX /ABSOLUTE VALUE OF DIFFERENCE
1435  7004  RAL
1436  3367  DCA PLOTMV /SAVE SIGN BIT
1437  1600  TAD I PLOTX /SET NEW
```

```
1440  3362  DCA PLOTNX /PREVIOUS X
1441  2200  ISZ PLOTX /INCREMENT POINTER
1442  1363  TAD PLOTNY /FETCH PREVIOUS Y CO-ORDINATE
1443  7141  CIA CLL
1444  1600  TAD I PLOTX /FORM NY-NPY
1445  7420  SNL /<=0: NPY<NY
1446  7041  CIA
1447  3365  DCA PLOTDY /ABSOLUTE VALUE OF DIFFERENCE
1450  1367  TAD PLOTMV /SAVE SIGN BIT
1451  7004  RAL /BIT 10(1)= DRUM-DOWN(POSITIVE)
1452  3367  DCA PLOTMV /BIT 11(1)=PEN-LEFT (POSITIVE)
1453  1600  TAD I PLOTX /SET NEW
1454  3363  DCA PLOTNY /PREVIOUS Y
1455  2200  ISZ PLOTX /INCREMENT POINTER
1456  1364  TAD PLOTDX
1457  7141  CIA CLL
1460  1365  TAD PLOTDY
1461  7620  SNL CLA /L=0: DELTA Y < DELTA X
1462  5275  JMP PLOT2
1463  1364  TAD PLOTDX /REVERSE NUMBERS
1464  3366  DCA PLOTNA
1465  1365  TAD PLOTDY
1466  3364  DCA PLOTDX
1467  1366  TAD PLOTNA
1470  3365  DCA PLOTDY
1471  7001  IAC /SET MAJOR MOTION
1472  0367  AND PLOTMV /INSTRUCTION
1473  1342  TAD PLOTT1
1474  5300  JMP .+4
            /DIGITAL 8-12-U
            /PAGE 3
1475  1367  PLOT2,TAD PLOTMV
1476  7110  CLL RAR
1477  1345  TAD PLOTT2
1500  3366  DCA PLOTNA
1501  1766  TAD I PLOTNA
1502  3340  DCA PLOT4
1503  1367  TAD PLOTMV /SET COMBINED MOTION
1504  1350  TAD PLOTT3
1505  3367  DCA PLOTMV
1506  1767  TAD I PLOTMV
1507  3331  DCA PLOTDB
1510  1364  TAD PLOTDX
1511  7110  CLL RAR
1512  3366  DCA PLOTNA
1513  1364  TAD PLOTDX
1514  7040  CMA
1515  3367  DCA PLOTMV
1516  2367  PLOT3,ISZ PLOTMV
1517  7410  SKP
1520  5600  JMP I PLOTX /ALL DONE
1521  1366  TAD PLOTNA
1522  1365  TAD PLOTDY
1523  3366  DCA PLOTNA
1524  1366  TAD PLOTNA
1525  7140  CMA CLL
```

```
1526  1364  TAD PLOTDX
1527  7630  SZL CLA
1530  5340  JMP PLOT4 /SINGLE MOTION
1531  0000  PLOTDB,0 /COMBINED MOTION
1532  1364  TAD PLOTDX
1533  7041  CIA
1534  1366  TAD PLOTNA
1535  3366  DCA PLOTNA
1536  4370  JMS PLOTWT
1537  5316  JMP PLOT3
1540  0000  PLOT4,0
1541  5336  JMP .-3
1542  1543  PLOTT1, .+1
1543  6511          6511
1544  6521          6521
1545  1546  PLOTT2, .+1
1546  6512          6512
1547  6514          6514
1550  1551  PLOTT3, .+1
1551  6513          6513
1552  6523          6523
1553  6515          6515
1554  4355  JMS .+1 /DOWN-LEFT
1555  0000  0
1556  6514          6514
1557  6521          6521
1560  5755  JMP I .-3
            /DIGITAL 8-12-U
            /PAGE 4
1561  0000  PLOTPN,0
1562  0000  PLOTNX,0
1563  0000  PLOTNY,0
1564  0000  PLOTDX,0
1565  0000  PLOTDY,0
1566  0000  PLOTNA,0
1567  0000  PLOTNV,0
1570  0000  PLOTWT,0
1571  6501          6501
1572  5371  JMP .-1 /NOT YET
1573  6502          6502
1574  5770  JMP I PLOTWT /EXIT
            PAUSE   FIELD 2
                    *1200
1200  7000          NOP
1201  1777  FLAG,   TAD INSEL        /GET STATE OF CURSOR FLAG
1202  1376          TAD (7766
1203  7640          SZA CLA
1204  5775          JMP ERR
1205  6051          6051
1206  5210          JMP .+2
1207  5214          JMP .+5
1210  6052          6052
1211  7200          CLA
1212  7001          IAC
1213  7510          SPA
1214  7200          CLA
```

```
1215  3774          DCA LOW
1216  5773          JMP INSEL-12
1217  0000  ADC,    0                    /SUBROUTINE TO READ -
1220  7200          CLA                  /CURSOR LOCATION
1221  6074          6074
1222  1270          TAD M03
1223  3271          DCA TIM
1224  2271          ISZ TIM
1225  5224          JMP .-1
1226  6073          6073
1227  7410          SKP
1230  1272          TAD K10
1231  3266          DCA AC
1232  1272          TAD K10
1233  3267          DCA MB
1234  1266          TAD AC
1235  3273  ADL,    DCA VAL
1236  1267          TAD MB
1237  7110          RAR CLL
1240  7430          SZL
1241  5264          JMP EXIT
1242  3267          DCA MB
1243  1267          TAD MB
1244  1266          TAD AC
1245  3266          DCA AC
1246  1266          TAD AC
1247  6074          6074
1250  7200          CLA
1251  1270          TAD M03
1252  3271          DCA TIM
1253  2271          ISZ TIM
1254  5253          JMP .-1
1255  6073          6073
1256  5262          JMP .+4
1257  1273          TAD VAL
1260  3266          DCA AC
1261  5236          JMP ADL+1
1262  1266          TAD AC
1263  5235          JMP ADL
1264  1273  EXIT,   TAD VAL
1265  5617          JMP I ADC
1266  0000  AC,     0
1267  0000  MB,     0
1270  7750  M03,    7750
1271  0000  TIM,    0
1272  1000  K10,    1000
1273  0000  VAL,    0
1274  7300  PER,    CLA CLL
1275  1777          TAD INSEL
1276  1372          TAD (7777
1277  7440          SZA
1300  5775          JMP ERR
1301  4771          JMS NEXT
1302  7300          CLA CLL
1303  1777          TAD INSEL
1304  7440          SZA
```

```
1305  5311          JMP .+4
1306  7240          CLA CMA
1307  4735          JMS I PLO
1310  5773          JMP INSEL-12
1311  7300          CLA CLL
1312  1777          TAD INSEL
1313  1372          TAD (7777
1314  7440          SZA                 /PLOT PEN UP?
1315  5336          JMP ZXY
1316  4321          JMS IN2
1317  7201          CLA IAC
1320  5331          JMP LOT
1321  0000  IN2,     0
1322  4771          JMS NEXT
1323  1777          TAD INSEL
1324  3333          DCA YY
1325  4771          JMS NEXT
1326  1777          TAD INSEL
1327  3332          DCA XX
1330  5721          JMP I IN2
1331  4735  LOT,     JMS I PLO
1332  0000  XX,      0
1333  0000  YY,      0
1334  5773          JMP INSEL-12
1335  1400  PLO,     PLOTX
1336  7300  ZXY,     CLA CLL
1337  1777          TAD INSEL
1340  1370          TAD (7776
1341  7440          SZA                 /PLOT PEN DOWN?
1342  5767          JMP 1600
1343  4321          JMS IN2
1344  7200          CLA
1345  5331          JMP LOT
1367  1600
1370  7776
1371  6600
1372  7777
1373  0225
1374  6273
1375  6606
1376  7766
1377  0237
                    *1600
1600  7300          CLA CLL
1601  1777          TAD INSEL
1602  1376          TAD (7775
1603  7440          SZA                 /PLOT + SYMBOL?
1604  5251          JMP DIA6
1605  4775          JMS IN2
1606  1774          TAD XX
1607  1373          TAD (-10
1610  3244          DCA XX1
1611  1772          TAD YY
1612  3245          DCA YY1
1613  7201          CLA IAC
1614  4242          JMS LO2
```

```
1615  1774          TAD XX
1616  1371          TAD (10
1617  3244          DCA XX1
1620  7200          CLA
1621  4242          JMS LO2
1622  1774          TAD XX
1623  3244          DCA XX1
1624  7200          CLA
1625  4242          JMS LO2
1626  1774          TAD XX
1627  3244          DCA XX1
1630  1772          TAD YY
1631  1371          TAD (10
1632  3245          DCA YY1
1633  7201          CLA IAC
1634  4242          JMS LO2
1635  1772          TAD YY
1636  1373          TAD (-10
1637  3772          DCA YY
1640  7200          CLA
1641  5770          JMP LOT
1642  0000  LO2,     0
1643  4650          JMS I NUT
1644  0000  XX1,     0
1645  0000  YY1,     0
1646  7300          CLA CLL
1647  5642          JMP I LO2
1650  1400  NUT,     PLOTX
1651  7300  DIAG,    CLA CLL          /PLOT X SYMBOL
1652  1777          TAD INSEL
1653  1367          TAD (7774
1654  7440          SZA
1655  5766          JMP ERR
1656  4775          JMS IN2
1657  1774          TAD XX
1660  1365          TAD (-5
1661  3244          DCA XX1
1662  1772          TAD YY
1663  1364          TAD (5
1664  3245          DCA YY1
1665  7201          CLA IAC
1666  4242          JMS LO2
1667  1774          TAD XX
1670  1364          TAD (5
1671  3244          DCA XX1
1672  1772          TAD YY
1673  1365          TAD (-5
1674  3245          DCA YY1
1675  7200          CLA
1676  4242          JMS LO2
1677  1774          TAD XX
1700  1365          TAD (-5
1701  3244          DCA XX1
1702  1772          TAD YY
1703  1365          TAD (-5
1704  3245          DCA YY1
```

```
1705  7201          CLA IAC
1706  4242          JMS LO2
1707  1774          TAD XX
1710  1364          TAD (5
1711  3774          DCA XX
1712  1772          TAD YY
1713  1364          TAD (5
1714  3772          DCA YY
1715  7200          CLA
1716  5770          JMP LOT
1764  0005
1765  7773
1766  6606
1767  7774
1770  1331
1771  0010
1772  1333
1773  7770
1774  1332
1775  1321
1776  7775
1777  0237

                    *2000
2000  0000  DOUM,    0               /SORTS OUT SIGN FOR -
2001  7300          CLL CLA         /DOUBLE PRECISION BCD -
2002  1777          TAD DEP         /TO BINARY CONVERSION
2003  0376          AND (0020
2004  3232          DCA TSTOR
2005  1777          TAD DEP
2006  0375          AND (0017
2007  3777          DCA DEP
2010  4774          JMS DOUBLE
2011  0240          DEP
2012  3233          DCA THI
2013  1232          TAD TSTOR
2014  7450          SNA
2015  5227          JMP .+12
2016  7300          CLA CLL
2017  1773          TAD LOW
2020  7041          CIA
2021  3773          DCA LOW
2022  1233          TAD THI
2023  7040          CMA
2024  7430          SZL
2025  7001          IAC
2026  3233          DCA THI
2027  1233          TAD THI
2030  7100          CLL
2031  5600          JMP I DOUM
2032  0000  TSTOR,   0
2033  0000  THI,     0
2034  0000  MIN,     0
2035  7300          CLL CLA
2036  1773          TAD LOW
2037  1177          TAD(-0454
2040  7710          SPA CLA
```

```
2041  5634        JMP I MIN
2042  7300        CLL CLA
2043  1773        TAD LOW
2044  1372        TAD (-2000
2045  7000        NOP
2046  3773        DCA LOW
2047  7300        CLL CLA
2050  7040        CMA
2051  7430        SZL
2052  7101        CLL IAC
2053  5634        JMP I MIN
2172  6000
2173  6273
2174  6200
2175  0017
2176  0020
2177  0240
0177  7324
```

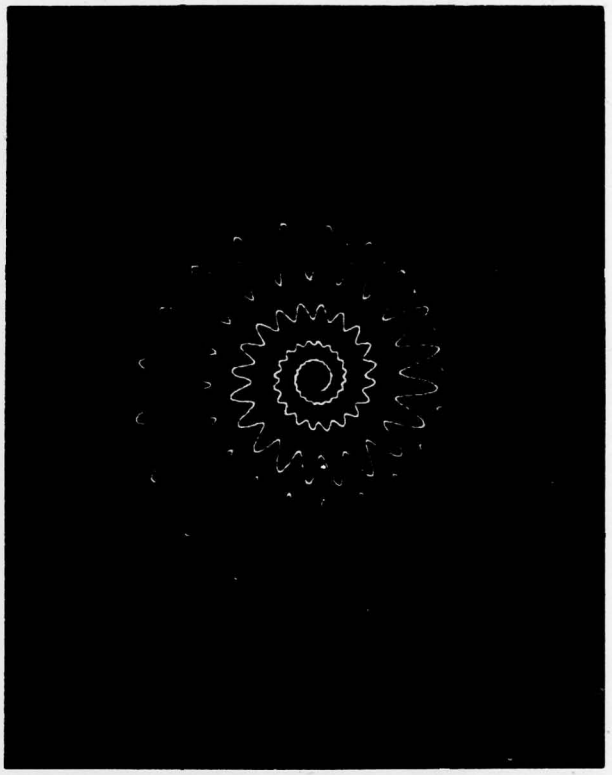

FIG. 1 EXAMPLE OF FUNCTION PLOTTING ON SCREEN

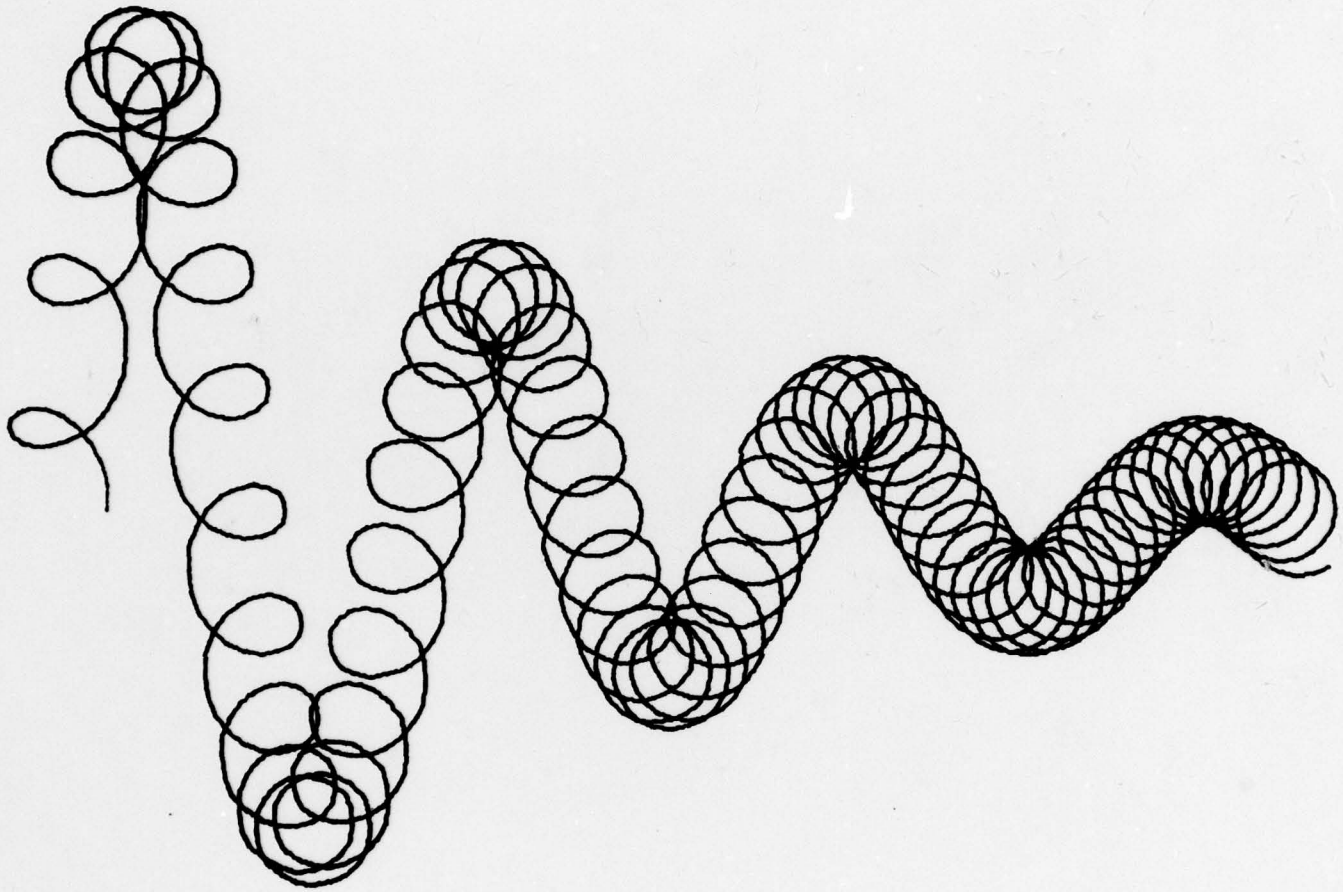

FIG. 2 EXAMPLE OF FUNCTION PLOTTING ON PLOTTER

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16. ABSTRACT:

Since the transonic wind tunnel data processing installation which is based on a PDP 8-I computer, was installed in 1968 a considerable library of standard programs have been produced. This program library covers all types of testing commonly carried out in the wind tunnel. However, there remains the possibility of unusual tests being required which are not covered by existing programs.

This memorandum describes modifications to the Digital Equipment Corporation FOCAL language (FOCAL is a keyboard oriented interpretive language similar to BASIC) which permit the tunnel instrumentation, display and plotter to be operated by FOCAL programs. Using this extended FOCAL language it should be possible to rapidly write and de-bug programs to meet unusual requirements not covered by the standard program library.

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