Directorate
INLAND WATERS ~~BRANCH~~
DEPARTMENT OF THE ENVIRONMENT

Computer Programs in Use in the Water Quality Division, Vol. 3

A. DEMAYO and P.D. GOULDEN

REPORT SERIES NO.16

CANADA

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DEPARTMENT OF THE ENVIRONMENT
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Preface

Volume 3 of "Computer Programs in Use in Water Quality Division" describes two programs used to process data from a "Data System for Technicon CSM-6 AutoAnalyzer". This data system was developed in the Water Quality Division of the Inland Waters Branch (Goulden, Demayo, 1971).

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Because of the memory size restrictions the complete program had to be divided into two parts. Two versions of the program are available depending on how the intermediate data are stored between the two parts.

In version I the intermediate data are stored on punched paper tape. Version II was written for PDP-8/L-8K computers equipped with Tennecomp magnetic tape cartridge system. In this version the intermediate data are stored on magnetic tape.

1. VERSION I - Program AD0015

1.1. PART 1

1.1.1. Input Data

The data are fed to the computer from the Teletype keyboard or via punched paper tape or any combination of the two.

The beginning of the data is marked by the word BEGIN. Any values entered before BEGIN are ignored by the program.

The word BEGIN is followed by:

a. Date: Day, Month, Year

b. Tray number

c. Number of operating channels (a maximum of six)

d. Channel number, test symbol (see Table 2), number of non-zero standards, concentration of non-zero standards.

Point d is repeated for each of the six channels.

If one of the channels is not operating then only the channel number and the symbol -N (see Table 2) are entered.

The concentration of non-zero standards must be entered in the same order they are in the tray. The standard corresponding to concentration zero (baseline reading) must be the first one in the tray.

e. Sample numbers entered in the same order they are in the tray. After all the sample numbers have been entered the word END is inputed.

f. Following the word END, the actual tape produced by the CSM-6 system is read-in via the paper tape reader.

An example of the input data is given in Figure 1. The input data is summarized in Table 1.

1.1.2. Output Data

The output from this program is done via Teletype ASR-33 and consists of a hard copy and a punched paper tape. The paper tape serves as input data for the Part 2 of program AD0015.

The format of the outputed punched paper tape is summarized in Table 3.

A hard copy output is reproduced in Figure 2.

1.1.3. Description of Program AD0015 - Part 1

This quite short program rearranges the input data in a format which has smaller computer memory requirements than the original format.

The rearrangement consists of:

(i) Matching the standard concentrations with the respective voltage outputs from the analytical instrument. In this process, any non-relevant data is dropped.

(ii) Matching the sample numbers with the respective voltage outputs from the analytical instrument.

A listing of the program is reproduced in Figure 3.

1.2. PART 2

1.2.1. Input Data

The input data for this second part of AD0015 is the output of Part 1 without any modification.

NOTE: In the case of the standards, the first standard which must be run is that of zero concentration (blank or baseline reading).

In the case of unknown samples every tenth sample must be a blank. The program uses this value to correct for the baseline drift. This is done by subtracting the output voltage for the blank sample from that of the unknown sample. The interval required for running a blank can be changed by changing the value of N1 in statement 01.60 (Figure 5). The water blanks are identified by their "sample number" which is always 9999.

1.2.2. Output Data

The output consists of:

(i) A series of identification data: date, tray no., no. of channels operating.

(ii) The results of calculations for the standard curve, separately for each channel: the coefficients of the standard curve and the experimental and calculated values at each standard point are typed out.

(iii) The results corresponding to the unknown samples.

A typical output is reproduced in Figure 4.

1.2.3. Description of the Program AD0015 - Part 2

For each operating channel, representing one particular analytical test, the standard points are fitted to an equation of the form:

$$Y = \sum_{i=0}^{L} B_i X^i \qquad (1)$$

$L = 2,3,4$ or 5

The fitting is done by the least squares method using program AD0001 (Demayo, 1970).

In the version reproduced in Figure 5 the fitting is done until the relative standard deviation calculated from relation 2 is equal to or smaller than 2%.

$$RSD = \left(\frac{\Sigma(Y_{obs} - Y_{calc})^2}{L1 - L}\right)^{\frac{1}{2}} \cdot \frac{L1}{\Sigma Y_{obs}} \cdot 100 \qquad (2)$$

where the sums are taken over the L1 standard points.

The 2% limit can be changed by modifying the value of L8 in statement 1.10.

Up to five adjustable coefficients can be used to fit the data. If the preset limit L8 has not been attained even with five coefficients then the computation is continued with this last set of five coefficients.

The next step in the program is to check if the calculated curve has maxima or minima within the range of standard points. This is done by calculating the first derivative Y' of the standard curve and then solving the equation:

$$Y' = 0 \qquad (3)$$

If any of the real roots has a value within the range of standard concentrations, then the calculated standard curve is rejected. A new standard curve with one less adjustable coefficient is calculated and the entire checking procedure repeated (calculate Y',...).

Every time a maximum (minimum) is found on the standard curve and a new curve must be calculated, appropriate messages are typed out to indicate the course the calculation takes.

Another control on the direction of the calculation is the following: if addition of new adjustable coefficients does not improve the fit, the set which gave the best fit (even if RSD is above the preset limit) is typed out and used for calculating the unknown samples.

After a standard curve has been calculated for each operating channel, the program starts calculating the unknown samples. This is done by solving the equation:

$$\sum_{i=0}^{L} B_i X^i - Y_{obs} = 0 \qquad (4)$$

Y_{obs} is the output voltage, corrected for baseline, for a particular analytical test, i.e., for a given channel. The smallest positive root is assumed to be the sought value. The results are typed out on a tabular form (see Figure 4).

If Y_{obs} is below the baseline, a B is typed. If Y_{obs} is exactly on the baseline a 0 (zero) is typed. If Y_{obs} is larger than the output voltage corresponding to the highest standard, then a G is typed out. If Y_{obs} exceeds the voltage of the highest standard by less than 10mv then Equation 4 is still solved, and the result with a G beside is typed out. These abbreviations are summarized in Table 4.

A listing of the program is reproduced in Figure 5. The program is written in FOCAL-69 and it requires 8K of memory. To obtain the output of Figure 4 the patches listed in Table 5 must be applied before starting the program.

On a PDP-8/L-8K equipped with an ASR-33 Teletype, typical running times are as follows:

(i) to calculate the standard curves on six channels (each curve has 12 points); approximately 15 minutes. The limiting factor here is the speed of the output device.

(ii) to calculate the results of ten samples, six chemical tests for each one: approximately 15 minutes.

TABLE 1

INPUT DATA FOR PROGRAM AD0015 - PART 1

NO.	DATA	SYMBOL USED IN THE PROGRAM	OBSERVATIONS
1	BEGIN	DU	The word BEGIN is entered as such
2	Day	TS(1)	
3	Month	TS(2)	
4	Year	TS(3)	
5	Tray No.	TS(4)	
6	No. of operating channels	TS(5)	
7	For each of the six channels:		
	7.1 Channel number	CN	
	7.2 Test	TS(CN)	
	7.3 Number of non-zero standards	NS(CN)	If channel is not operating items 7.3 and 7.4 are omitted
	7.4 Concentrations of non-zero standards	Z(I1)	
8	Sample numbers	N(J)	
9	END	N(J)	The word END is entered as such
Voltage corresponding to:			
10	Standard 1 on channel 1	ST(1)	
	Standard 1, Channel 2	ST(2)	
	.....		
	Standard 2, Channel 1	ST(7)	
	.....		
	Last Standard, Channel 1	ST(MX-1)*6+1	MX is the largest number of non-zero standards on a channel (largest NS(CN))
	.....		
	Last Standard, Channel 6	ST(MX-1)*6+6	
11	Sample 0, Channel 1	Z(1)	Samples 0, 10, 20,...are blanks (distilled water)
	Sample 0, Channel 2	Z(2)	
	.....		
	Sample 0, Channel 6		
12	Sample 1, Channel 1		
	.....		

* Denotes multiplication sign.

TABLE 2

PROGRAM AD0015. SYMBOLS USED FOR VARIOUS ANALYTICAL TESTS

NO.	TEST	SYMBOL
1	Phosphate	PO4
2	Nitrate	NO3
3	Iron	IR
4	Silica	SIO2
5	Chloride	CL
6	No test	-N or 0 (zero)

TABLE 3

PROGRAM AD0015 - PART 1. OUTPUT

NO.	DATA	SYMBOL	OBSERVATIONS
1	Date: Day	TS(1)	
2	Month	TS(2)	
3	Year	TS(3)	
4	Tray no.	TS(4)	
5	No. of operating channels	TS(5)	
	For each operating channel:		
6	Channel no.	I	
7	Test	TS(I)	This appears in the corresponding ASCII numerical code
8	No. of non-zero standards	NS(I)	
9	Output voltage corresponding to zero concentration	BL(I)	
10	Output voltage - Standard concentration	ST(J)-Z(I)	Item 10 is repeated NS(I) times for Channel I
	For each sample:		
11	Sample number	N(J)	
12	Output voltage for test	TS(I)	Item 11 is repeated TS(5) times for each sample, i.e. for each operating channel

TABLE 4

PROGRAM AD0015 - PART 2. MESSAGES ON TYPED OUTPUT OF UNKNOWN SAMPLES

NO.	MESSAGE	SIGNIFICANCE
1	B	Y_{obs} below the baseline
2	0 (zero)	Y_{obs} exactly on the baseline
3	G	Y_{obs} greater than the highest standards
4	xx.xxG	Y_{obs} exceeds the highest standard by not more than 10 mv.
5	I	All the roots of Equation 4 are negative or imaginary

TABLE 5

PATCHES TO FOCAL-69 COMPILER

NO.	SCOPE	LOCATION	OLD CONTENT (Octal Numbers)	NEW CONTENT
1	Suppress colon sign in input	1217	4551	7600
2	Suppress equal sign in output	6002	4551	7600
3	Suppress the typing of input data	2163	4551	7000
4	Read punched paper tapes (program, data) without creating an "input-buffer overflow"	0063	2676	1354
		0064	2666	2414
		2732	6001	5336
		2762	6046	7000

Reference: Digital Equipment Corporation, Digital Software News, May 1970.

Figure 1. Programs AD0015 (Part 1) and AD0016 - Input

```
BEGIN
21 4 1971
134 6
1 PO4 11 .1 .2 .4 .6 .8 1 1.2 1.4 1.6 1.8 2
2 NO3 6 .1 .2 .4 .6 .8 1
3 IR 11.0 .05 .1 .2 .3 .4 .5 .6 .7 .8 .9 1
4 NO3 11 .1 .2 .4 .6 .8 1 6 2.2 8 4.2 10
5 SIO2 11 1.25 2.5 5 7.5 10 12.5 15 17.5 20 22.5 25
6 CL 11 10 20 40 60 80 100 120 140 160 180 200
99 4032 4033 4034 4035 4036 4065 4066 4067 4068 99 4278 4365
END
00118 000092 000114 000346 000081 000101
00358 000702 000518 000400 000364 000607
00612 001338 000923 000481 000650 001079
01156 002449 001664 000623 001221 001848
01673 003462 002283 000749 001806 002483
02204 004275 002839 000939 002386 002982
02710 004932 003351 001004 002965 003414
03219 007497 003791 003745 003559 003821
03704 007493 004132 001698 004139 004193
04186 007494 004413 004462 004715 004508
04626 007496 004702 002834 005203 004803
05021 007495 004953 005008 005612 005046
00118 000092 000114 000346 000081 000101
00358 000702 000518 000400 000364 000607
00612 001338 000923 000481 000650 001079
01156 002449 001664 000623 001221 001848
01673 003462 002283 000749 001806 002483
02204 004275 002839 000939 002386 002982
02710 004932 003351 001004 002965 003414
03219 007497 003791 003745 003559 003821
03704 007493 004132 001698 004139 004193
04186 007494 004413 004462 004715 004508
00118 000092 000114 000346 000081 000101
04626 007496 004702 002834 005203 004803
05021 007495 004953 005008 005612 005046
```

Figure 2. Program AD0015 (Part 1) - Output; also Program AD0015 (Part 2) - Input

```
  21     4 1971   134      6
   1    1754       11    118
 358     0.10     612     0.20    1156     0.40    1673     0.60
2204     0.80    2710     1.00    3219     1.20    3704     1.40
4186     1.60    4626     1.80    5021     2.00
   2    1553        6     92
 702     0.10    1338     0.20    2449     0.40    3462     0.60
4275     0.80    4932     1.00
   3     108       11    114
 518     0.05     923     0.10    1664     0.20    2283     0.30
2839     0.40    3351     0.50    3791     0.60    4132     0.70
4413     0.80    4702     0.90    4953     1.00
   4    1553       11    346
 400     0.10     481     0.20     623     0.40     749     0.60
 939     0.80    1004     1.00    3745     6.00    1698     2.20
4462     8.00    2834     4.20    5008    10.00
   5   20052       11     81
 364     1.25     650     2.50    1221     5.00    1806     7.50
2386    10.00    2965    12.50    3559    15.00    4139    17.50
4715    20.00    5203    22.50    5612    25.00
   6      42       11    101
 607    10.00    1079    20.00    1848    40.00    2483    60.00
2982    80.00    3414   100.00    3821   120.00    4193   140.00
4508   160.00    4803   180.00    5046   200.00
  99     118       92     114     346      81     101
4032     358      702     518     400     364     607
4033     612     1338     923     481     650    1079
4034    1156     2449    1664     623    1221    1848
4035    1673     3462    2283     749    1806    2483
4036    2204     4275    2839     939    2386    2982
4065    2710     4932    3351    1004    2965    3414
4066    3219     7497    3791    3745    3559    3821
4067    3704     7493    4132    1698    4139    4193
4068    4186     7494    4413    4462    4715    4508
  99     118       92     114     346      81     101
4278    4626     7496    4702    2834    5203    4803
4365    5021     7495    4953    5008    5612    5046*
```

Figure 3. Program AD0015 (Part 1) - Listing 0060_8 = 0656_8

```
*C-8K FOCAL @1969

01.05 E
01.10 A DU;I (DU-0BEGIN)1.12,1.15,1.12
01.12 G 1.10
01.15 S MX=0;F J=1,5;A TS(J);T %4,TS(J)
01.20 S I1=0;F J=1,6;A CN,TS(CN);D 4
01.26 S SA=0;F J=1,200;A N(J);D 2.30
01.28 F J=1,6;A BL(J)
01.30 F J=1,MX;F I=1,6;A ST((J-1)*6+I)
01.35 S I1=0;F I=1,6;D 4.30
01.40 F J=1,SA;T !,%6,N(J);F I=1,6;A Z(I);D 4.60
01.50 Q

02.10 T %6,ST((J-1)*6+I),%6.02,Z(I1);S MX=MX+1;I (3-MX)2.2;R
02.20 S MX=0;T !;R
02.30 I (N(J)-0END)2.4,2.5,2.4
02.40 S SA=SA+1;R
02.50 S J=202;R

04.05 I (-TS(CN))4.10;R
04.10 A NS(CN);I (NS(CN)-MX)4.15;S MX=NS(CN)
04.15 F I=1,NS(CN);S I1=I1+1;A Z(I1);R
04.30 I (-TS(I))4.4;R
04.40 T !,%6,I,TS(I),NS(I),BL(I),!;S MX=0;F J=1,NS(I);S I1=I1+1;D 2;R
04.60 I (-TS(I))4.7;R
04.70 T Z(I)
*
```

Figure 4. Program AD0015 (Part 2) - Output

CSM-6 ANALYTICAL RESULTS

DATE : 21. 4. 1971
TRAY NO. 134
NO. OF CHANNELS OPERATING = 6

CALCULATION OF THE STANDARD CURVE

CHANNEL NO. 1
TEST : PO4
NO. OF STANDARDS = 12

COEFFICIENTS:
B(1) =-0.363411E+02
B(2) = 0.277943E+04
B(3) =-0.145655E+03

NO.	CONCENTRATION STANDARDS	HEIGHT EXPERIMENTAL	HEIGHT CALCULATED	DIFFERENCE	%
1	0.00	0.0	- 36.3	36.3	0.3634E+08
2	0.10	240.0	240.2	- 0.2	- 0.1
3	0.20	494.0	513.7	- 19.7	- 4.0
4	0.40	1038.0	1052.1	- 14.1	- 1.4
5	0.60	1555.0	1578.9	- 23.9	- 1.5
6	0.80	2086.0	2094.0	- 8.0	- 0.4
7	1.00	2592.0	2597.4	- 5.4	- 0.2
8	1.20	3101.0	3089.2	11.8	0.4
9	1.40	3586.0	3569.4	16.6	0.5
10	1.60	4068.0	4037.9	30.1	0.8
11	1.80	4508.0	4494.7	13.3	0.3
12	2.00	4903.0	4939.9	- 36.9	- 0.8

MEAN (MEASURED) PEAK HEIGHT = 2347.6
STANDARD DEVIATION = 24.6
RELATIVE STANDARD DEVIATION (%)= 1.1

CALCULATION OF THE STANDARD CURVE

CHANNEL NO. 2
TEST : NO3
NO. OF STANDARDS = 7

COEFFICIENTS:
B(1) =-0.227495E+02
B(2) = 0.673627E+04
B(3) =-0.186299E+04

NO.	CONCENTRATION STANDARDS	HEIGHT EXPERIMENTAL	HEIGHT CALCULATED	DIFFERENCE	%
1	0.00	0.0	- 22.8	22.8	0.2274E+08
2	0.10	610.0	632.3	- 22.3	- 3.7
3	0.20	1246.0	1250.0	- 4.0	- 0.3
4	0.40	2357.0	2373.7	- 16.7	- 0.7
5	0.60	3370.0	3348.3	21.7	0.7
6	0.80	4183.0	4174.0	9.1	0.2
7	1.00	4840.0	4850.5	- 10.5	- 0.2

MEAN (MEASURED) PEAK HEIGHT = 2372.3
STANDARD DEVIATION = 22.3
RELATIVE STANDARD DEVIATION (%)= 1.0

CALCULATION OF THE STANDARD CURVE

CHANNEL NO. 3
TEST : FE
NO. OF STANDARDS = 12

COEFFICIENTS:
B(1) = 0.294492E+02
B(2) = 0.803932E+04
B(3) =-0.328529E+04

NO.	CONCENTRATION STANDARDS	HEIGHT EXPERIMENTAL	HEIGHT CALCULATED	DIFFERENCE	%
1	0.00	0.0	29.5	- 29.5	-0.2946E+08
2	0.05	404.0	423.2	- 19.2	- 4.8
3	0.10	809.0	800.5	8.5	1.1
4	0.20	1550.0	1505.9	44.1	2.9
5	0.30	2169.0	2145.6	23.4	1.1
6	0.40	2725.0	2719.5	5.5	0.2
7	0.50	3237.0	3227.8	9.2	0.3
8	0.60	3677.0	3670.3	6.7	0.2
9	0.70	4018.0	4047.2	- 29.2	- 0.7
10	0.80	4299.0	4358.3	- 59.3	- 1.4
11	0.90	4588.0	4603.8	- 15.8	- 0.4
12	1.00	4839.0	4783.5	55.5	1.2

MEAN (MEASURED) PEAK HEIGHT = 2692.9
STANDARD DEVIATION = 36.1
RELATIVE STANDARD DEVIATION (%)= 1.3

Figure 4. Program AD0015 (Part 2) - Output (Cont.)

CALCULATION OF THE STANDARD CURVE

CHANNEL NO. 4
TEST : NO3
NO. OF STANDARDS = 12

COEFFICIENTS:
B(1) = 0.839375E+01
B(2) = 0.667607E+03
B(3) =-0.185584E+02
B(4) = 0.460246E+00
B(5) =-0.631860E-01

NO.	CONCENTRATION STANDARDS	HEIGHT EXPERIMENTAL	HEIGHT CALCULATED	DIFFERENCE	%
1	0.00	0.0	8.4	-8.4	-0.8394E+07
2	0.10	54.0	75.0	-21.0	-38.8
3	0.20	135.0	141.2	-6.2	-4.6
4	0.40	277.0	272.5	4.5	1.6
5	0.60	403.0	402.4	0.6	0.2
6	0.80	593.0	530.8	62.2	10.5
7	1.00	658.0	657.8	0.2	0.0
8	6.00	3399.0	3363.5	35.6	1.1
9	2.20	1352.0	1390.7	-38.7	-2.9
10	8.00	4116.0	4138.4	-22.4	-0.6
11	4.20	2488.0	2499.4	-11.4	-0.5
12	10.00	4662.0	4657.0	5.0	0.1

MEAN (MEASURED) PEAK HEIGHT = 1511.4
STANDARD DEVIATION = 33.6
RELATIVE STANDARD DEVIATION (%)= 2.2

CALCULATION OF THE STANDARD CURVE

CHANNEL NO. 5
TEST : SIO2
NO. OF STANDARDS = 12

COEFFICIENTS:
B(1) =-0.357824E+02
B(2) = 0.245066E+03
B(3) =-0.766036E+00

NO.	CONCENTRATION STANDARDS	HEIGHT EXPERIMENTAL	HEIGHT CALCULATED	DIFFERENCE	%
1	0.00	0.0	-35.8	35.8	0.3578E+08
2	1.25	283.0	269.4	13.7	4.8
3	2.50	569.0	572.1	-3.1	-0.6
4	5.00	1140.0	1170.4	-30.4	-2.7
5	7.50	1725.0	1759.1	-34.1	-2.0
6	10.00	2305.0	2338.3	-33.3	-1.5
7	12.50	2884.0	2907.9	-23.9	-0.8
8	15.00	3478.0	3467.9	10.2	0.3
9	17.50	4058.0	4018.3	39.7	1.0
10	20.00	4634.0	4559.1	74.9	1.6
11	22.50	5122.0	5090.4	31.6	0.6
12	25.00	5531.0	5612.1	-81.1	-1.5

MEAN (MEASURED) PEAK HEIGHT = 2644.1
STANDARD DEVIATION = 47.3
RELATIVE STANDARD DEVIATION (%)= 1.8

CALCULATION OF THE STANDARD CURVE

CHANNEL NO. 6
TEST : CL
NO. OF STANDARDS = 12

COEFFICIENTS:
B(1) = 0.302608E+02
B(2) = 0.497744E+02
B(3) =-0.204990E+00
B(4) = 0.398713E-03

NO.	CONCENTRATION STANDARDS	HEIGHT EXPERIMENTAL	HEIGHT CALCULATED	DIFFERENCE	%
1	0.00	0.0	30.3	-30.3	-0.3026E+08
2	10.00	506.0	507.9	-1.9	-0.4
3	20.00	978.0	947.0	31.1	3.2
4	40.00	1747.0	1718.8	28.2	1.6
5	60.00	2382.0	2364.9	17.1	0.7
6	80.00	2881.0	2904.4	-23.4	-0.8
7	100.00	3313.0	3356.5	-43.5	-1.3
8	120.00	3720.0	3740.3	-20.3	-0.6
9	140.00	4092.0	4075.0	17.1	0.4
10	160.00	4407.0	4379.6	27.5	0.6
11	180.00	4702.0	4673.3	28.7	0.6
12	200.00	4945.0	4975.3	-30.3	-0.6

MEAN (MEASURED) PEAK HEIGHT = 2806.1
STANDARD DEVIATION = 32.9
RELATIVE STANDARD DEVIATION (%)= 1.2

SAMPLE CALCULATION

NO.	SAMP.NO.	CH. 1 PO4	CH. 2 NO3	CH. 3 FE	CH. 4 NO3	CH. 5 SIO2	CH. 6 CL
0	99			BASELINE READING			
1	4032	0.10	0.10	0.05	0.07	1.31	9.96
2	4033	0.19	0.20	0.10	0.19	2.49	20.74
3	4034	0.40	0.40	0.21	0.41	4.87	40.80
4	4035	0.59	0.61	0.30	0.60	7.36	60.58
5	4036	0.80	0.80	0.40	0.90	9.86	79.05
6	4065	1.00	1.00	0.50	1.00	12.40	97.92
7	4066	1.21	G	0.60	6.08	15.05	118.9
8	4067	1.41	G	0.69	2.14	17.68	141.1
9	4068	1.61	G	0.78	7.93	20.35	161.9
10	99			BASELINE READING			
11	4278	1.81	G	0.89	4.18	22.65	182.0
12	4365	1.98	G	1.04G	10.03G	24.61	198.1

Figure 5. Program AD0015 (Part 2) - Listing 0060_8 *= 5672*

```
*C-8K FOCAL @1969

Ø1.Ø5 E
Ø1.1Ø S L8=2;F S=1,5;A TS(S)
Ø1.13 T !!!!!"CSM-6  ANALYTICAL RESULTS"!!"DATE :"
Ø1.14 T %2,TS(1),".",TS(2),".",%4,TS(3),!"TRAY NO.",TS(4),!
Ø1.15 T "NO. OF CHANNELS OPERATING =",TS(5);S L3=Ø
Ø1.2Ø S X(1)=1E-6;F S=1,TS(5);D 3;D 4
Ø1.3Ø T !!!!"SAMPLE CALCULATION"
Ø1.35 T !!" NØ.   SAMP.NO.    ";F S=1,TS(5);T "CH.",%1,CH(S),"     "
Ø1.4Ø T !"                    ";F S=1,TS(5);D 23;T "      "
Ø1.5Ø S L4(Ø)=Ø;S N=-1;S N1=-1
Ø1.55 S N1=N1+1;S N=N+1;A TS(1);T !,%3,N,%9,TS(1);F S=1,TS(5);D 5
Ø1.6Ø I (N1)1.55;S N1=-1Ø;F J1=1,15;T " "
Ø1.61 T "BASELINE READING"!;G 1.55

Ø2.17 S N2=2*L-1
Ø2.2Ø F J1=1,N2;S SX(J1)=Ø
Ø2.22 F J1=1,L;S YX(J1)=Ø
Ø2.25 F J2=1,N2;F J1=1,L1;S SX(J2)=SX(J2)+X(J1)↑(J2-1)
Ø2.27 F J2=1,L;F J1=1,L1;S YX(J2)=YX(J2)+Y(J1)*(X(J1)↑(J2-1))
Ø2.3Ø S SY=YX(1);F J2=1,L;F J1=1,L;S A(J2+J1*L)=SX(J1+(J2-1))
Ø2.35 D 15.Ø;S SD=Ø;F J1=1,L1;S YY=B(1);D 8
Ø2.4Ø S SD=FSQT(SD/(L1-L));I (2-L)2.5;G 2.86
Ø2.5Ø I (SD-TS(4))2.86;S TS(3)=TS(3)+1;I (TS(3)-2)2.52,2.55,2.99
Ø2.52 S TS(2)=TS(4);G 2.86
Ø2.55 I (SD-TS(2))2.56;S L=L-2;S TS(3)=3;D 24;G 2.17
Ø2.56 S TS(3)=Ø
Ø2.86 S TS(4)=SD;I (SD-SY*L8/L1*1ØØ)2.99,2.99;S L=L+1
Ø2.87 I (L-5)2.17,2.17;S L=L-1
Ø2.99 R

Ø3.Ø5 A CH(S),TE(S),L7(S);S L1=L7(S)+1;S TS(3)=Ø
Ø3.Ø7 T !!!"CALCULATION OF THE STANDARD CURVE"!!"CHANNEL NO.",%3,CH(S)
Ø3.Ø8 T !"TEST  :     ";D 23
Ø3.Ø9 T !"NO. OF STANDARDS =",L1;S W(S)=X(1);S V(S)=Ø
Ø3.11 A Y(1);F J1=2,L1;A Y(J1),X(J1);S Y(J1)=Y(J1)-Y(1);D 17;D 18
Ø3.12 S Y(1)=1E-4;S L=2;D 2
Ø3.14 I (L-3)3.18;D 2Ø;I (TS(3)-3)3.18;D 2
Ø3.15 S TS(3)=Ø;G 3.14
Ø3.18 S LT=Ø;T !!"COEFFICIENTS:";F K=1,L;T !"B(",%2,K,") =",%,B(K)
Ø3.22 T !!"NO.    CONCENTRATION       HEIGHT        HEIGHT         DIFFERENCE"
Ø3.23 T !"            STANDARDS     EXPERIMENTAL CALCULATED                %"
Ø3.24 F J1=1,L1;S YY=B(1);D 8;T !,%2,J1,%9.Ø2,X(J1);D 16
Ø3.25 S SD=FSQT(SD/(L1-L))
Ø3.26 T !"MEAN (MEASURED) PEAK HEIGHT     =",%5.Ø1,SY/L1
Ø3.27 T !"STANDARD DEVIATION              =",SD
Ø3.28 T !"RELATIVE STANDARD DEVIATION (%)=",SD*L1*1ØØ/SY
Ø3.4Ø R

Ø4.1Ø F S1=1,L;S B1(L3+S1)=B(S1)
Ø4.2Ø S L3=L3+L;S L4(S)=L3

Ø5.Ø5 I (N1)5.2Ø;A Y(S);R
Ø5.2Ø A TS(2);I (TS(2)-Y(S))5.7,5.75;I (TS(2)-Y(S)-V(S)-1Ø)5.21;G 5.77
Ø5.21 S L5=L4(S-1)+1;S L6=L4(S);S L2=L6-L5
Ø5.25 F S1=Ø,L2-1;S N2=L6-S1;S C(S1+1)=B1(N2)
Ø5.26 S C(L2+1)=B1(L5)-TS(2)+Y(S)
Ø5.3Ø D 11;S IJ=Ø;S MI=1E1ØØ;F J2=1,L2;D 1Ø
Ø5.4Ø I (IJ-L2)5.5,5.8,5.8
Ø5.5Ø T "  ",%4.Ø2,MI;I (MI-W(S))5.9,5.9,5.55
Ø5.55 T "G";R
Ø5.7Ø I (Y(S)/(1+L8/1ØØ)-TS(2))5.75,5.75;T "         B ";R
Ø5.75 T "         Ø ";R
Ø5.77 T "         G ";R
Ø5.8Ø T "         I"
Ø5.9Ø T " ";R

Ø7.Ø5 I (FABS(RI(J2))-1E-6)7.Ø7,7.Ø7;R
Ø7.Ø7 I (FABS(RR(J2))-1E-6)11.8Ø,11.8Ø;R

Ø8.1Ø F J2=2,L;S YY=YY+B(J2)*(X(J1)↑(J2-1))
Ø8.15 S D=Y(J1)-YY;S SD=SD+D*D;R

1Ø.1Ø I (RI(J2))1Ø.8,1Ø.2,1Ø.8
1Ø.2Ø I (RR(J2))1Ø.8;I (MI-RR(J2))1Ø.9;S MI=RR(J2);R
1Ø.8Ø S IJ=IJ+1
1Ø.9Ø R
```

Figure 5. Program AD0015 (Part 2) - Listing 0060_8 = 5672 (Cont.)

```
11.07 S IS=0;S I=1;S P=1/C(1);F J2=1,L2;S C(J2)=P*C(J2+1)
11.11 S P=C(L2-1)+1E-6;S Q=C(L2);I (I-L2+1)11.16,11.54,11.13
11.13 S RR(I)=-Q;S RI(I)=0;R
11.16 S IC=1;S B1=C(L2-2);I (B1)11.19,11.90,11.19
11.19 S B1=1/B1;S P=P/B1;S Q=Q*B1
11.21 S B1=1;S B3=1;S B2=0;S B4=0;F J2=I,L2;D 12
11.26 S RI(L2-1)=RI(L2-1)-RR(L2-1);S B2=1;S B3=RI(L2-1)
11.28 S B4=RI(L2-2);I (I-L2+2)11.30,11.32,11.30
11.30 S B2=RI(L2-3)
11.32 S B1=B4*B4-B3*B2;S B1=1/B1;S B3=(RR(L2-1)*B3-RR(L2)*B4)*B1
11.35 S B2=(RR(L2-1)*B4-RR(L2)*B2)*B1
11.38 I (FABS(B2)/(FABS(P)+1)-5E-6)11.40,11.40,11.42
11.40 I (FABS(B3)/(FABS(Q)+1)-5E-6)11.84,11.84,11.42
11.42 S P=P+B2;S Q=Q-B3;S IC=IC+1;I (IC-50)11.21,11.21,11.44
11.44 I (IS)11.46;R
11.46 S IS=1;S IN=I-1;S J3=L2;S L2=L2+1;S C(L2)=0
11.48 S C(J3+1)=C(J3+1)+C(J3);S J3=J3-1
11.50 I (J3)11.52,11.52,11.48
11.52 S C(1)=C(1)+1;G 11.11
11.54 I (P)11.56,11.61,11.56
11.56 S B4=4*Q/(P*P);I (FABS(B4)-1E-6)11.59,11.59,11.61
11.59 S RR(I)=-P;S RR(I+1)=-Q/P;G 11.69
11.61 S RR(I)=-.5*P;S RR(I+1)=RR(I);S B1=P*P-4*Q
11.63 I (B1)11.65,11.69,11.67
11.65 S RI(I)=.5*FSQT(-B1);S RI(I+1)=-RI(I);G 11.70
11.67 S B1=.5*FSQT(B1);S RR(I)=RR(I)+B1;S RR(I+1)=RR(I+1)-B1
11.69 S RI(I)=0;S RI(I+1)=0
11.70 S I=I+2;I (I-L2)11.11,11.11,11.72
11.72 I (-IS)11.74;R
11.74 S K2=IN+1;F J2=K2,L2;D 7
11.76 R
11.80 F J2=J3,L2;S RR(J2)=RR(J2+1);S RI(J2)=RI(J2+1)
11.82 S IN=L2-1;R
11.84 F J2=I,L2;S C(J2)=RR(J2-2)
11.86 G 11.54
11.90 S P=Q;G 11.21

12.05 S RR(J2)=C(J2)-P*B1-Q*B2;I (J2-L2)12.10;R
12.10 S RI(J2)=RR(J2)-P*B3-Q*B4;S B2=B1;S B4=B3
12.15 S B1=RR(J2);S B3=RI(J2)

14.05 S N=K+1; S DD=A(N+II*L)/A(II+II*L)
14.10 F J=II,L; S A(N+J*L)=A(N+J*L)-A(II+J*L)*DD
14.15 S YX(N)=YX(N)-YX(II)*DD; R

15.10 S MM=L-1;F II=1,MM; F K=II,MM; D 14.0
15.15 S B(L)=YX(L)/A(L+L*L)
15.20 F M=2,L;S N=L+1-M;S KK=N+1;S B(N)=YX(N)/A(N+N*L);D 15.25;R
15.25 F K=KK,L; S B(N)=B(N)-A(N+K*L)*B(K)/A(N+N*L)

16.10 T "       ",%9.01,Y(J1),"    ",%7.01,YY
16.20 T "    ",%4.01,D,"    ",D*100/Y(J1)

17.10 I (W(S)-X(J1))17.2;R
17.20 S W(S)=X(J1);R

18.10 I (V(S)-Y(J1))18.2;R
18.20 S V(S)=Y(J1);R

20.10 F J2=1,L-1;S C(J2)=B(L-J2+1)*(L-J2)
20.15 S L2=L-2;D 11;S IL=0;S IM=0;F J2=1,L2;D 21
20.30 I (IM)20.90,20.90,20.40
20.40 T !!"WARNING: STD. CURVE WITH",%1,L," ADJ. COEF. SHOWS",IM
20.41 T " MAX.(MIN.)"!"IN THE RANGE OF CONC. OF STD. SOL'N.:"!
20.45 F J1=1,IM;S Y1(J1)=B(1);F J2=2,L;D 20.8
20.50 F J1=1,IM;T !,%3,J1,"   CONCENTRATION=";D 20.60
20.52 T !!"CALCULATION IS CONTINUED WITH",%1,L-1," ADJ. COEF."!
20.53 S L=L-1;S TS(3)=4;S TS(4)=0;R
20.60 T %7.02,R2(J1),"   HEIGHT CALCULATED=",Y1(J1)
20.80 S Y1(J1)=Y1(J1)+B(J2)*(R2(J1)↑(J2-1))
20.90 R

21.10 I (RI(J2))21.20,21.30,21.20
21.20 R
21.30 I (RR(J2))21.2;I (RR(J2)-X(L1))21.5;R
21.50 S IM=IM+1;S R2(IM)=RR(J2)

23.10 I (TE(S)-0CL)23.2,23.15,23.2
23.15 T "  CL";R
23.20 I (TE(S)-0IR)23.3,23.25,23.3
23.25 T "  FE";R
23.30 I (TE(S)-0SIO2)23.4,23.35,23.4
23.35 T "SIO2";R
23.40 I (TE(S)-0NO3)23.5,23.45,23.5
23.45 T " NO3";R
23.50 I (TE(S)-0PO4)23.6,23.55;R
23.55 T " PO4"
23.60 R

24.10 T !!"THE STAND. DEV. INCREASES WHEN ADDING NEW ADJ. COEF."
24.20 T !"THE BEST RESULTS ARE OBTAINED WITH THE FOLLOWING COEF.:"!!
*
```

2. VERSION II - Program AD0016

2.1. PART 1

2.1.1. Input Data

The input data consist of items 1-10 of Table 6:

a. BEGIN: any other data appearing before BEGIN on the tape are neglected.

b. Date: Day, Month, Year

c. Tray no.

d. No. of operating channels (a maximum of six)

e. Channel number, test symbol (see Table 2), the number of non-zero standards, and the concentration of non-zero standards.

Point e is repeated for every channel with the following exception: if a channel is not operating only the channel number followed by symbol -N must be entered.

It is essential that the concentrations of standards be entered in the same order as the standard samples are arranged in the sample tray.

f. Sample numbers. A message stating the maximum number of sample numbers which can be entered is typed out after the last value corresponding to point e has been entered.

If the available number of sample numbers is smaller than the maximum stated by the message then the word END must be entered after last sample number. If the available number of sample numbers is larger than the maximum then the extra sample numbers are entered in Part 2 of this program (see Section 2.2.1).

The data up to this point are entered manually or via a punched paper tape prepared manually, beforehand, on any Teletype on "OFF LINE" position.

g. The output voltage corresponding to the standard samples. These data are produced by the CSM-6 Data System.

When all the necessary data have been read from the punched paper tape from CSM-6 Data System, the computer proceeds with the calculations.

The input data are the same as for program AD0015 illustrated in Figure 1.

2.1.2. The Calculations

In this part of the program, the standard curve for each of the operating channels is calculated by the method described in Section 1.2.3.

2.1.3. The Output

There are two separate outputs from Part 1 of program AD0016.

The results of the calculation for the standard curve are typed out in a format identical to that of program AD0015 (see Figure 4).

The coefficients of the standard curves, sample numbers, date, tray no., number of channels operating, and the test on each channel, are stored on track 3 of the Tennecomp magnetic tape cartridge. The configuration of the tape is shown in Table 7.

A printout of the contents of the magnetic tape can be obtained by typing in the following statements immediately after the execution of Part 1:

```
F J=1,60;T !;F I=0,4;S A=FGET((J-1)*5+I);T %,A

G
```

2.2. PART 2

In this part of program AD0016, the results for the unknown samples are calculated.

2.2.1. Input Data

The input data for this part of program AD0016 consist of:

(i) Data written onto magnetic tape from Part 1 (see Section 2.1.3.).

(ii) Output voltages corresponding to the concentration of unknown samples. These data are recorded by the CSM-6 Data System on punched paper tape at the present time.

When all the samples whose sample numbers have been entered at the beginning of Part 1 have been calculated, the following message is typed out:

ALL THE SAMPLES WHOSE NUMBERS HAVE BEEN ENTERED HAVE BEEN CALCULATED.

ARE ANY MORE SAMPLES TO BE CALCULATED (ANSWER Y OR N)?

If there are more samples to be processed, then Y must be typed in, followed by a new series of sample numbers (maximum: 298) terminated by the END. If exactly 298 sample numbers are entered, the terminator END is not necessary.

Then the calculation continues as before by reading in output voltages corresponding to the unknown samples from the punched paper tape produced by the CSM-6 Data System (see Section 6 for the operating instructions).

2.2.2. The Calculations

The concentrations of unknown samples are calculated by the method described in Section 1.2.3.

2.2.3. The Output

The output is essentially the same as the corresponding output from program AD0015. An example is shown in Figure 6.

TABLE 6

INPUT DATA FOR PROGRAM AD0016

NO.	DATA	SYMBOL USED IN THE PROGRAM	OBSERVATIONS
Part 1			
1	BEGIN	DU	The word BEGIN is entered as such
2	Day	G	
3	Month	G	
4	Year	G	
5	Tray No.	G	
6	No. of operating channels	G	
7	For each of the six channels:		
	7.1 Channel number	CN	
	7.2 Test	T,TT(I2)	
	7.3 Number of non-zero standards	NS(I2)	If channel is not operating, items 7.3 and 7.4 are omitted.
	7.4 Concentrations of non-zero standards	G	
8	Sample numbers	G	
9	END	G	The word END is entered as such
Voltage corresponding to:			
10	Standard 1 on channel 1	G	
	Standard 1, Channel 2	G	
	.....		
	Standard 2, Channel 1	G	
	.....		
	Last Standard, Channel 1	G	
	.....		
	Last Standard, Channel 6	G	
Part 2			
Voltage corresponding to:			
11	Sample 0, Channel 1	Y(S)	
	Sample 0, Channel 2		Samples 0, 10, 20,... are blanks (distilled water).
	Sample 0, Channel 6		
12	Sample 1, Channel 1	T	
	.....		

TABLE 7

THE CONFIGURATION OF THE MAGNETIC TAPE AT THE END OF EXECUTION OF PROGRAM AD0016 - PART 1

LOCATION	DESCRIPTION OF CONTENT
0-2	Date: Day, Month, Year
3	Tray number
4	Number of operating channels (N_C)
5,10,...	The operating channels numbers: CH_1,CH_2,... (maximum of six operating channels)
6,11,...	Test on channel CH_1, on channel CH_2,...
7,12,...	The number of adjustable coefficients of the standard curve from channel CH_1, from channel CH_2,...
8,13,...	Maximum peak height (Y value) of the standard samples corresponding to the test run on channel CH_1, on channel CH_2,...
9,14,...	Maximum concentration (X value) of the standard samples corresponding to the test run on channel CH_1, on channel CH_2,...
$4+L_1$	The number (N_{SA}) of sample numbers entered in part 1 of program AD0016
$5+L_1$ to $5+L_1+N_{SA}$	The actual sample numbers entered in part 1 of program AD0016
$6+L_1+N_{SA}$,$12+L_1+N_{SA}$,...	Coefficients B_0,B_1,... of the standard curve from channel CH_1.
$7+L_1+N_{SA}$,$13+L_1+N_{SA}$,...	Coefficients B_0,B_1,... of the standard curve from channel CH_2.
297	The value $4+L_1$

Notes

1. $$L_1 = \sum_{L=1}^{N_C} [3+N_S(L)]$$

   where $N_S(1)$ is the number of non-zero standards run on channel CH_1,$N_S(2)$ the number of non-zero standards on channel CH_2 and so on.

2. The CSM-6 system has six operating channels numbered 1 to 6. The operating channels can be entered in any order, i.e., the order does not have to be sequential.

Figure 6. Program AD0016 (Part 2) - Output

*

SWITCH TO TRACK NO. 3 !

CSM-6 ANALYTICAL RESULTS

DATE : 21. 4. 1971
TRAY NO. 134
NO. OF CHANNELS OPERATING = 6

SAMPLE CALCULATION

NØ.	SAMP.NO.	CH. 1 PO4	CH. 2 NO3	CH. 3 FE	CH. 4 NO3	CH. 5 SIO2	CH. 6 CL
Ø	99			BASELINE READING			
1	4Ø32	Ø.1Ø	Ø.1Ø	Ø.Ø5	Ø.Ø7	1.31	9.96
2	4Ø33	Ø.19	Ø.2Ø	Ø.1Ø	Ø.19	2.49	2Ø.74
3	4Ø34	Ø.4Ø	Ø.4Ø	Ø.21	Ø.41	4.87	4Ø.8Ø
4	4Ø35	Ø.59	Ø.61	Ø.3Ø	Ø.6Ø	7.36	6Ø.58
5	4Ø36	Ø.8Ø	Ø.8Ø	Ø.4Ø	Ø.9Ø	9.86	79.Ø5
6	4Ø65	1.ØØ	1.ØØ	Ø.5Ø	1.ØØ	12.4Ø	97.92
7	4Ø66	1.21	G	Ø.6Ø	6.Ø8	15.Ø5	118.9
8	4Ø67	1.41	G	Ø.69	2.14	17.68	141.1
9	4Ø68	1.61	G	Ø.78	7.93	2Ø.35	161.9
1Ø	99			BASELINE READING			
11	4278	1.81	G	Ø.89	4.18	22.65	182.Ø
12	4365	1.98	G	1.Ø4G	1Ø.Ø3G	24.61	198.1

ALL THE SAMPLES WHOSE NUMBERS HAVE BEEN ENTERED HAVE BEEN CALCULATED.
ARE ANY MORE SAMPLES TO BE CALCULATED (ANSWER Y OR N) ?

CALCULATION IS TERMINATED.*

Figure 7. Program AD0016 (Part 1) - Listing $0060_8 = 5764_8$

```
*C-8K FOCAL @1969

01.03 E
01.07 A DU;I (DU-0BEGIN)1.08,1.1,1.08
01.08 G 1.07
01.10 S L8=2;T !!!!!"CSM-6  ANALYTICAL RESULTS"!!"DATE :"
01.15 S I9=-1;S MX=0;F J=1,5;A G;D 30.1
01.16 F K9=0,1;D 30.2;D 30.3
01.17 S DU=FGET(2);T %4,DU,!"TRAY NO. ";S DU=FGET(3);T DU,!
01.20 S I2=0;F J=1,6;A CN,T;D 26
01.23 S MA=290-I9-MX*6;T !"A MAXIMUM OF",%3,MA," SAMPLE NUMPERS CAN"
01.24 T " BE ENTERED NOW ."
01.26 S SA=0;S I9=I9+1;S I8=I9;S G=FPUT(297,I8);F J=1,MA;A G;D 25
01.30 F J=1,MX+1;F I=1,6;A G;D 30.1
01.40 S X(1)=1E-6;S I1=3;S I9=4;S I8=I8+SA;S DU=FGET(4)
01.45 T !!"NO. OF CHANNELS OPERATING =",DU;F SS=1,DU;D 3
01.79 T !!"SWITCH TO TRACK NO. 3";F J=1,1000;S G=0
01.80 L W;Q

02.17 S N2=2*L-1;F J1=1,N2;S SX(J1)=0
02.22 F J1=1,L;S YX(J1)=0
02.25 F J2=1,N2;F J1=1,L1;S SX(J2)=SX(J2)+X(J1)↑(J2-1)
02.27 F J2=1,L;F J1=1,L1;S YX(J2)=YX(J2)+Y(J1)*(X(J1)↑(J2-1))
02.30 S SY=YX(1);F J2=1,L;F J1=1,L;S A(J2+J1*L)=SX(J1+(J2-1))
02.35 D 15.0;S SD=0;F J1=1,L1;S YY=B(1);D 8
02.40 S SD=FSQT(SD/(L1-L));I (2-L)2.5;G 2.86
02.50 I (SD-TW)2.86;S TS=TS+1;I (TS-2)2.52,2.55,2.99
02.52 S TV=TW;G 2.86
02.55 I (SD-TV)2.56;S L=L-2;S TS=3;D 24;G 2.17
02.56 S TS=0
02.86 S TW=SD;I (SD-SY*L8/L1*100)2.99,2.99;S L=L+1
02.87 I (L-5)2.17,2.17;S L=L-1
02.99 R

03.05 S S=CH(SS);S L1=NS(S)+1;S TS=0;S I7=I8-6+SS
03.07 T !!!"CALCULATION OF THE STANDARD CURVE"!!"CHANNEL NO.",%3,S
03.08 T !"TEST  :     ";D 23
03.09 T !"NO. OF STANDARDS =",L1;S W=X(1);S V=0
03.11 S Y(1)=0;F J1=1,L1;S Y(J1)=FGET(I8+S-6+J1*6)-Y(1)
03.12 F J1=2,L1;S X(J1)=FGET(I1+J1);D 17;D 18
03.13 S I1=I1+NS(S);S Y(1)=1E-4;S L=2;D 2
03.14 I (L-3)3.18;D 20;I (TS-3)3.18;D 2
03.15 S TS=0;G 3.14
03.18 S LT=0;T !!"COEFFICIENTS:";F K=1,L;D 30.4
03.22 T !!"NO.    CONCENTRATION       HEIGHT       HEIGHT        DIFFERENCE"
03.23 T !"           STANDARDS      EXPERIMENTAL CALCULATED                %"
03.24 F J1=1,L1;S YY=B(1);D 8;T !,%2,J1,%9.02,X(J1);D 16
03.25 S SD=FSQT(SD/(L1-L))
03.26 T !"MEAN (MEASURED) PEAK HEIGHT      =",%5.01,SY/L1
03.27 T !"STANDARD DEVIATION               =",SD
03.28 T !"RELATIVE STANDARD DEVIATION (%)=",SD*L1*100/SY
03.32 S G=S;D 30.1;S G=TT(S);D 30.1;S G=L;D 30.1;S G=V;D 30.1
03.33 S G=W;D 30.1;R

07.05 I (FABS(RI(J2))-1E-6)7.07,7.07;R
07.07 I (FABS(RR(J2))-1E-6)11.80,11.80;R

08.10 F J2=2,L;S YY=YY+B(J2)*(X(J1)↑(J2-1))
08.15 S D=Y(J1)-YY;S SD=SD+D*D;R

11.07 S IS=0;S I=1;S P=1/C(1);F J2=1,L2;S C(J2)=P*C(J2+1)
11.11 S P=C(L2-1)+1E-6;S Q=C(L2);I (I-L2+1)11.16,11.54,11.13
11.13 S RR(I)=-Q;S RI(I)=0;R
11.16 S IC=1;S B1=C(L2-2);I (B1)11.19,11.9,11.19
11.19 S B1=1/B1;S P=P/B1;S Q=Q*B1
11.21 S B1=1;S B3=1;S B2=0;S B4=0;F J2=I,L2;D 12
11.26 S RI(L2-1)=RI(L2-1)-RR(L2-1);S B2=1;S B3=RI(L2-1)
11.28 S B4=RI(L2-2);I (I-L2+2)11.3,11.32,11.3
11.30 S B2=RI(L2-3)
11.32 S B1=B4*B4-B3*B2;S B1=1/B1;S B3=(RR(L2-1)*B3-RR(L2)*B4)*B1
11.35 S B2=(RR(L2-1)*B4-RR(L2)*B2)*B1
11.38 I (FABS(B2)/(FABS(P)+1)-5E-6)11.4,11.4,11.42
11.40 I (FABS(B3)/(FABS(Q)+1)-5E-6)11.84,11.84,11.42
11.42 S P=P+B2;S Q=Q-B3;S IC=IC+1;I (IC-50)11.21,11.21,11.44
11.44 I (IS)11.46;R
11.46 S IS=1;S IN=I-1;S J3=L2;S L2=L2+1;S C(L2)=0
11.48 S C(J3+1)=C(J3+1)+C(J3);S J3=J3-1
11.50 I (J3)11.52,11.52,11.48
11.52 S C(1)=C(1)+1;G 11.11
11.54 I (P)11.56,11.61,11.56
11.56 S B4=4*Q/(P*P);I (FABS(B4)-1E-6)11.59,11.59,11.61
11.59 S RR(I)=-P;S RR(I+1)=-Q/P;G 11.69
```

Figure 7. Program AD0016 (Part 1) - Listing 0060_8 = 5764_8 (Cont.)

```
11.61 S RR(I)=-.5*P;S RR(I+1)=RR(I);S B1=P*P-4*Q
11.63 I (B1)11.65,11.69,11.67
11.65 S RI(I)=.5*FSQT(-B1);S RI(I+1)=-RI(I);G 11.70
11.67 S B1=.5*FSQT(B1);S RR(I)=RR(I)+B1;S RR(I+1)=RR(I+1)-B1
11.69 S RI(I)=0;S RI(I+1)=0
11.70 S I=I+2;I (I-L2)11.11,11.11,11.72
11.72 I (-IS)11.74;R
11.74 S K2=IN+1;F J2=K2,L2;D 7
11.76 R
11.80 F J2=J3,L2;S RR(J2)=RR(J2+1);S RI(J2)=RI(J2+1)
11.82 S IN=L2-1;R
11.84 F J2=1,L2;S C(J2)=RR(J2-2)
11.86 G 11.54
11.90 S P=Q;G 11.21

12.05 S RR(J2)=C(J2)-P*B1-Q*B2;I (J2-L2)12.1;R
12.10 S RI(J2)=RR(J2)-P*B3-Q*B4;S B2=B1;S B4=B3
12.15 S B1=RR(J2);S B3=RI(J2)

14.05 S N=K+1; S DD=A(N+II*L)/A(II+II*L)
14.10 F J=II,L; S A(N+J*L)=A(N+J*L)-A(II+J*L)*DD
14.15 S YX(N)=YX(N)-YX(II)*DD; R

15.10 S MM=L-1;F II=1,MM; F K=II,MM; D 14
15.15 S B(L)=YX(L)/A(L+L*L)
15.20 F M=2,L;S N=L+1-M;S KK=N+1;S B(N)=YX(N)/A(N+N*L);D 15.25;R
15.25 F K=KK,L; S B(N)=B(N)-A(N+K*L)*B(K)/A(N+N*L)

16.10 T "      ",%9.01,Y(J1),"    ",%7.01,YY
16.20 T "    ",%4.01,D,"    ",D*100/Y(J1)

17.10 I (W-X(J1))17.2;R
17.20 S W=X(J1);R

18.10 I (V-Y(J1))18.2;R
18.20 S V=Y(J1);R

20.10 F J2=1,L-1;S C(J2)=B(L-J2+1)*(L-J2)
20.15 S L2=L-2;D 11;S IL=0;S IM=0;F J2=1,L2;D 21
20.30 I (IM)20.9,20.9,20.4
20.40 T !!"WARNING: STD. CURVE WITH",%1,L," ADJ. COEF. SHOWS",IM
20.41 T " MAX.(MIN.)"!"IN THE RANGE OF CONC. OF STD. SOL'N.:"!
20.45 F J1=1,IM;S Y1(J1)=B(1);F J2=2,L;D 20.8
20.50 F J1=1,IM;T !,%3,J1,"    CONCENTRATION=";D 20.60
20.52 T !!"CALCULATION IS CONTINUED WITH",%1,L-1," ADJ. COEF."!
20.53 S L=L-1;S TS=4;S TW=0;R
20.60 T %7.02,R2(J1),"    HEIGHT CALCULATED=",Y1(J1)
20.80 S Y1(J1)=Y1(J1)+B(J2)*(R2(J1)^(J2-1))
20.90 R

21.10 I (RI(J2))21.20,21.30,21.20
21.20 R
21.30 I (RR(J2))21.2;I (RR(J2)-X(L1))21.5;R
21.50 S IM=IM+1;S R2(IM)=RR(J2)

23.10 I (TT(S)-0CL)23.2,23.15,23.2
23.15 T "  CL";R
23.20 I (TT(S)-0IR)23.3,23.25,23.3
23.25 T "  FE";R
23.30 I (TT(S)-0SIO2)23.4,23.35,23.4
23.35 T "SIO2";R
23.40 I (TT(S)-0NO3)23.5,23.45,23.5
23.45 T " NO3";R
23.50 I (TT(S)-0PO4)23.6,23.55;R
23.55 T " PO4"
23.60 R

24.10 T !!"THE STAND. DEV. INCREASES WHEN ADDING NEW ADJ. COEF."
24.20 T !"THE BEST RESULTS ARE OBTAINED WITH THE FOLLOWING COEF.:"!!

25.30 I (G-0END)25.4,25.5,25.4
25.40 S SA=SA+1;D 30.1;R
25.50 S J=MA+1;S DU=FPUT(I8,SA);R

26.05 I (-T)26.1;R
26.10 S I2=I2+1;S CH(I2)=CN;S TT(CN)=T;A NS(CN);I (NS(CN)-MX)26.15;C
26.11 S MX=NS(CN)
26.15 F I=1,NS(CN);A G;D 30.1;R

30.10 S I9=I9+1;S DU=FPUT(I9,G)
30.20 S DU=FGET(K9)
30.30 T %2,DU,"."
30.40 T !"B(",%2,K,") =",%,B(K);S G=B(K);S I7=I7+6;S DU=FPUT(I7,G)
*
```

Figure 8. Program AD0016 (Part 2) - Listing

```
*C-8K FOCAL @1969

Ø1.Ø5 E
Ø1.Ø6 T !!"SWITCH TO TRACK NO. 3 !";F J=1,1ØØØ;S G=Ø
Ø1.Ø7 L R
Ø1.Ø8 T !!!!!"CSM-6  ANALYTICAL RESULTS"!!"DATE :"
Ø1.1Ø F J=Ø,1;S DU=FGET(J);T %2,DU,"."
Ø1.11 S DU=FGET(2);T %4,DU,!"TRAY NO. ";S DU=FGET(3);T DU,!
Ø1.15 S DU=FGET(4);T "NO. OF CHANNELS OPERATING =",DU
Ø1.3Ø T !!!!"SAMPLE CALCULATION"
Ø1.35 T !!" NØ.   SAMP.NO.    ";F S=1,DU;S A=FGET(S*5);T "CH.",%1,A,"     "
Ø1.4Ø T !"                   ";F S=1,DU;D 23;T "      "
Ø1.43 F S=1,DU;S L3(S)=FGET(5*S+2);S V(S)=FGET(5*S+3);S W(S)=FGET(5*S+4)
Ø1.45 S I8=FGET(297);S SA=FGET(I8)
Ø1.46 S J=Ø;F S=1,DU;F SS=1,L3(S);S J=J+1;S B(J)=FGET(I8+SA+S+6*SS-6)
Ø1.5Ø S SB=Ø;S N=-1;S N1=-1
Ø1.55 S N1=N1+1;S N=N+1;I (N-SA-SB)1.57;S SB=SA;S I9=-1;D 2
Ø1.56 G 1.55
Ø1.57 S I8=I8+1;S A=FGET(I8);T !,%3,N,%9,A;S J=Ø;S JJ=Ø;F S=1,DU;D 5
Ø1.6Ø I (N1)1.55;S N1=-1Ø;F J1=1,15;T " "
Ø1.61 T "BASELINE READING"!;G 1.55

Ø2.1Ø T !!"ALL THE SAMPLES WHOSE NUMBERS HAVE BEEN ENTERED HAVE BEEN "
Ø2.11 T "CALCULATED."!"ARE ANY MORE SAMPLES TO BE CALCULATED "
Ø2.12 T "(ANSWER Y OR N) ? ";A A;I (A-ØY)2.9,2.2,2.9
Ø2.2Ø T !!"ENTER THE NUMBERS OF THE SAMPLES TO BE CALCULATED "
Ø2.21 T "(MAX. NO."!"OF SAMPLES = 298) "!
Ø2.25 S I8=-1;S N=N-1;S SA=Ø;F J=1,298;A A;D 2.95
Ø2.3Ø R
Ø2.9Ø T !!"CALCULATION IS TERMINATED.";Q
Ø2.95 I (A-ØEND)2.96,2.97,2.96
Ø2.96 S SA=SA+1;S I9=I9+1;S G=FPUT(I9,A)
Ø2.97 S J=299;R

Ø5.Ø1 I (DU-6)5.Ø3,5.Ø5;T !!"NØ. OF OPERATING CHANNELS GREATER THAN"
Ø5.Ø2 T " SIX.";G 2.9
Ø5.Ø3 S JJ=JJ+1;I (JJ-FGET(S*5))5.Ø4,5.Ø5,2.9
Ø5.Ø4 A A;G 5.Ø3
Ø5.Ø5 I (N1)5.2Ø;A Y(S);R
Ø5.2Ø A T;I (T-Y(S))5.7,5.75;I (T-Y(S)-V(S)-1Ø)5.21;G 5.77
Ø5.21 F J2=1,L3(S);S J=J+1;S C(L3(S)-J2+1)=B(J)
Ø5.22 S C(L3(S))=C(L3(S))+Y(S)-T;S L2=L3(S)-1
Ø5.3Ø D 11;S IJ=Ø;S MI=1E1ØØ;F J2=1,L2;D 1Ø
Ø5.4Ø I (IJ-L2)5.5,5.8,5.8
Ø5.5Ø T "  ",%4.Ø2,MI;I (MI-W(S))5.9,5.9,5.55
Ø5.55 T "G";R
Ø5.7Ø I (Y(S)/(1+L8/1ØØ)-T)5.75,5.75;T "       B ";D 5.95;R
Ø5.75 T "       Ø ";D 5.95;R
Ø5.77 T "       G ";D 5.95;R
Ø5.8Ø T "       I"
Ø5.9Ø T " ";R
Ø5.95 S J=J+L3(S)

Ø7.Ø5 I (FABS(RI(J2))-1E-6)7.Ø7,7.Ø7;R
Ø7.Ø7 I (FABS(RR(J2))-1E-6)11.8Ø,11.8Ø;R
```

```
10.10 I (RI(J2))10.8,10.2,10.8
10.20 I (RR(J2))10.8;I (MI-RR(J2))10.9;S MI=RR(J2);R
10.80 S IJ=IJ+1
10.90 R

11.07 S IS=0;S I=1;S P=1/C(1);F J2=1,L2;S C(J2)=P*C(J2+1)
11.11 S P=C(L2-1)+1E-6;S Q=C(L2);I (I-L2+1)11.16,11.54,11.13
11.13 S RR(I)=-Q;S RI(I)=0;R
11.16 S IC=1;S B1=C(L2-2);I (B1)11.19,11.90,11.19
11.19 S B1=1/B1;S P=P/B1;S Q=Q*B1
11.21 S B1=1;S B3=1;S B2=0;S B4=0;F J2=I,L2;D 12
11.26 S RI(L2-1)=RI(L2-1)-RR(L2-1);S B2=1;S B3=RI(L2-1)
11.28 S B4=RI(L2-2);I (I-L2+2)11.30,11.32,11.30
11.30 S B2=RI(L2-3)
11.32 S B1=B4*B4-B3*B2;S B1=1/B1;S B3=(RR(L2-1)*B3-RR(L2)*B4)*B1
11.35 S B2=(RR(L2-1)*B4-RR(L2)*B2)*B1
11.38 I (FABS(B2)/(FABS(P)+1)-5E-6)11.40,11.40,11.42
11.40 I (FABS(B3)/(FABS(Q)+1)-5E-6)11.84,11.84,11.42
11.42 S P=P+B2;S Q=Q-B3;S IC=IC+1;I (IC-50)11.21,11.21,11.44
11.44 I (IS)11.46;R
11.46 S IS=1;S IN=I-1;S J3=L2;S L2=L2+1;S C(L2)=0
11.48 S C(J3+1)=C(J3+1)+C(J3);S J3=J3-1
11.50 I (J3)11.52,11.52,11.48
11.52 S C(1)=C(1)+1;G 11.11
11.54 I (P)11.56,11.61,11.56
11.56 S B4=4*Q/(P*P);I (FABS(B4)-1E-6)11.59,11.59,11.61
11.59 S RR(I)=-P;S RR(I+1)=-Q/P;G 11.69
11.61 S RR(I)=-.5*P;S RR(I+1)=RR(I);S B1=P*P-4*Q
11.63 I (B1)11.65,11.69,11.67
11.65 S RI(I)=.5*FSQT(-B1);S RI(I+1)=-RI(I);G 11.70
11.67 S B1=.5*FSQT(B1);S RR(I)=RR(I)+B1;S RR(I+1)=RR(I+1)-B1
11.69 S RI(I)=0;S RI(I+1)=0
11.70 S I=I+2;I (I-L2)11.11,11.11,11.72
11.72 I (-IS)11.74;R
11.74 S K2=IN+1;F J2=K2,L2;D 7
11.76 R
11.80 F J2=J3,L2;S RR(J2)=RR(J2+1);S RI(J2)=RI(J2+1)
11.82 S IN=L2-1;R
11.84 F J2=I,L2;S C(J2)=RR(J2-2)
11.86 G 11.54
11.90 S P=Q;G 11.21

12.05 S RR(J2)=C(J2)-P*B1-Q*B2;I (J2-L2)12.10;R
12.10 S RI(J2)=RR(J2)-P*B3-Q*B4;S B2=B1;S B4=B3
12.15 S B1=RR(J2);S B3=RI(J2)

23.10 S A=FGET(S*5+1);I (A-0CL)23.2,23.15,23.2
23.15 T "  CL";R
23.20 I (A-0IR)23.3,23.25,23.3
23.25 T "  FE";R
23.30 I (A-0SIO2)23.4,23.35,23.4
23.35 T "SIO2";R
23.40 I (A-0NO3)23.5,23.45,23.5
23.45 T " NO3";R
23.50 I (A-0PO4)23.6,23.55;R
23.55 T " PO4"
23.60 R
*
```

3. HARDWARE-SOFTWARE REQUIREMENTS

The hardware required to run this program is a PDP-8L-8K computer equipped with an ASR-33 Teletype, and a Tennecomp Magnetic Tape Unit No. 1351.

The standard FOCAL-69,4K has been modified by applying the patches listed in Table 5.

Additional patches for use in conjunction with the Magnetic Tape Unit have been provided by Tennecomp Co.

These patches allow the user to split the upper 4K of the memory in two parts:

(i) Locations 10000_8-15777_8 for storing program text

(ii) Locations 16000_8-17577_8 for storing numbers

Through a series of library commands the content of these locations (16000_8-17577_8) can be transfered onto the magnetic tape and read back from it.

The two patches used for this are labelled:

TSI-1351-8/I-EVSA (External Variable Storage Overlay)

TSI-8000-8/I-EXTA (Extended Text Overlay)

The two parts of program AD0016 are shown in Figures 7 and 8.

4. RESULTS AND DISCUSSION

The system will successfully handle the results of water samples analyzed on the CSM 6. In Table 8 are shown the parameters measured together with typical results obtained when the standard solutions are treated as unknown samples. These results are not significantly different from the results obtained when the calibration curves are prepared and read manually. The voltages recorded on the tape agree with the pen displacement on the recorder as accurately as the chart can be read. There is no distortion of the calibration curves by using the data collection system; curves plotted from the voltage readings printed on the tape are identical with the curves plotted from the peak heights on the recorder chart. Any difference from the manually-calculated results is due to how well the calculated standard curve fits the "standards" peak heights. The degree of fit can be controlled at least partially by the pre-determination in the computer programme of the relative standard deviation at which it is desired to stop the fitting procedure. Currently this is set at 2% and almost all standard curves meet this limit. The other factor affecting curve fit is the form of expression used for the standard curve. The relationships that have been investigated are shown in Table 2.

It is found that relationship 1 (Table 9) gives a marginally better fit than relationship 2 with data from the CSM 6. This type of polynomial has been used by others to fit data from an atomic absorption spectrophotometer (Wendt 1968, Marshall 1969, Gabler, Brown and Haynes, 1970). It is interesting to note that data from a single channel "AutoAnalyzer" with a non-linearized recorder were better fitted by relationship 2 (Demayo 1971). Over the concentration ranges studies, there was never a linear relationship found between the concentration of the parameter and the chart reading.

In Figure 9 are shown the different shapes of calibration curve obtained with various parameters; these different shapes are successfully handled by the curve-fitting procedure to the 2% R.S.D. limit.

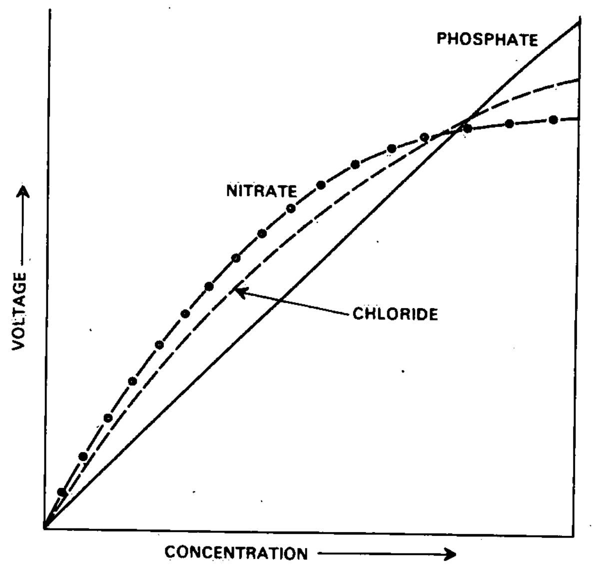

Figure 9. Standard curves produced by CSM-6 Technicon AutoAnalyzer interfaced to a CSM-6 Data System.

TABLE 8

PARAMETERS MEASURED, STANDARD CONCENTRATIONS AND RESULTS OF STANDARDS TREATED AS SAMPLES

CHANNEL	1	2	3	4	5	6
PARAMETERS	PO_4	NO_3	Fe	NO_3	SiO_2	Cl
RANGE	0-2 ppm	0-1 ppm	0-1 ppm	0-10 ppm	0-25 ppm	0-200 ppm
	0.1 (0.10)	0.1 (0.10)	0.05 (0.05)	0.1 (0.07)	1.25 (1.31)	10 (9.96)
	0.2 (0.19)	0.2 (0.19)	0.1 (0.10)	0.2 (0.14)	2.5 (2.49)	20 (20.74)
	0.4 (0.40)	0.4 (0.40)	0.2 (0.21)	0.4 (0.41)	5.0 (4.87)	40 (40.80)
	0.6 (0.59)	0.6 (0.59)	0.3 (0.30)	0.6 (0.60)	7.5 (7.36)	60 (60.58)
	0.8 (0.80)	0.8 (0.80)	0.4 (0.40)	0.8 (0.80)	10.0 (9.86)	80 (79.05)
	1.0 (1.00)	1.0 (1.00)	0.5 (0.50)	1.0 (1.00)	12.5 (12.40)	100 (97.92)
	1.2 (1.21)	6.0 (G)	0.6 (0.60)	6.0 (6.08)	15.0 (15.05)	120 (118.9)
	1.4 (1.41)	2.2 (G)	0.7 (0.69)	2.2 (2.14)	17.5 (17.68)	140 (141.1)
	1.6 (1.61)	8.0 (G)	0.8 (0.78)	8.0 (7.93)	20.0 (20.35)	160 (161.8)
	1.8 (1.81)	4.2 (G)	0.9 (0.89)	4.2 (4.18)	22.5 (22.65)	180 (182.0)
	2.0 (1.98)	10.0 (G)	1.0 (1.04)	10.0 (10.03)	25.0 (24.61)	200 (198.1)

Figures in parentheses are results of standards treated as samples.

TABLE 9

EXPRESSIONS INVESTIGATED FOR CURVE FIT

EXPRESSION NO.	RELATIONSHIP
1	$Y = \sum_{i=0}^{L} B_i X^i$
2	$Y = \sum_{i=0}^{L} B_i [\ln(x+1)]^i$
3	$Y = B_0 + B_1 \ln X$
4	$Y = B_0 + B_1 \ln X + B_2 X$
5	$Y = \exp \left(\sum_{i=0}^{L} B_i X^i \right)$

X = concentration

Y = peak height

L = 2,3,4 or 5 (No. of adjustable coefficients)

5. OPERATING INSTRUCTIONS FOR PROGRAM AD0015
(Paper Tape Version - Version 1)

(CSM-6 Data Acquisition System)

Follow these instructions very carefully, step by step.

Part 1

1. Turn the computer ON (if it is already ON, press STOP) and put the CSM-6-AD0015 tape cartridge into the Tennecomp unit.

2. Set track knob to 1.

3. Set:

   Data Field: 0
   Instruction Field: 0
   Switch Register: 7600_8

4. Press LOAD, START.

5. When the tape stops, check ACCUMULATOR: it must be zero (all lights out).

6. Set track knob to 2.

7. Set:

   Data Field: 1
   Instruction Field: 0
   Switch Register: 7600_8

8. Do steps 4 & 5.

9. Set:

   Data Field: 0
   Instruction Field: 0
   Switch Register: 0200_8

10. Do step 4.

11. Make sure the Teletype is "ON LINE" position.

12. Type: G

    Carriage Return

NOTE: When typing on the Teletype keyboard, the carriage will not move and nothing will appear on the paper (input echo suppressed), however, the data go into the computer.

Thus, because it is not possible to check the typing, the operator must exercise particular care and make sure the input is correct.

13. Switch Teletype to "OFF LINE" position.

14. Turn Paper Punch on.

15. Press "HERE IS" key twice. (This creates paper tape leader).

16. Turn Teletype to "ON LINE" position.

NOTE: At this point the data must be entered in the order indicated in Table 1. An example is shown in Figure 1. Items 10-12 are produced by the CSM-6 Data System.

Items 1-9 can be entered via Teletype keyboard from a list prepared beforehand. A better method is to prepare from this list a punched paper tape. This can be done in any Teletype in the "OFF LINE" position. Call this Tape 1.

Assuming that this Tape 1 has been prepared:

17. Make sure that the Tape Reader is in the FREE position.

18. Put Tape 1 (with the data corresponding to items 1-12, Table 1) in the Tape Reader.

19. Turn Tape Reader to START position.

20. When this punched paper tape has been read through, turn Tape Reader to FREE and remove the tape.

21 Put the punched paper tape produced by CSM-6 system in the Tape Reader (Call this Tape 2).

22. Turn Tape Reader to START position.

23. When Tape 2 has been read through, turn Tape Reader to FREE position and remove the tape.

24. Turn Teletype to "OFF LINE" position.

25. Press "HERE IS" key twice.

26. Turn Paper Tape punched to "OFF" position.

27. Tear-off the tape from the punch. Save it for the Part 2 of this program. Call this Tape 3.

28. Turn the Teletype to "ON LINE" position and make sure the Tape Reader is in FREE position.

At this point Part 1 of program AD0015 ends.

Part 2

Part 2 can be run immediately after or at a later time.

If it is run at a later time the procedure continues with item 29. If it is run immediately after Part 1, start the procedure at item 30.

29. Do steps 1 to 5.

30. Turn Track Selector on Tennecomp unit to position 3.

31. Set:

    Data Field: 1
    Instruction Field: 0
    Switch Register: 7600_8

32. Press: STOP, LOAD, START.

33. Do steps 5, 9, 4, 11, 12 in this order.

34. Put Tape 3 in the Tape Reader and turn Reader to START position. From this point on, the program will run by itself until the last data present on Tape 3 have been processed.

6. OPERATING INSTRUCTIONS FOR PROGRAM AD0016 (Magnetic Tape Version - Version II)

(CSM-6 Data Acquisition System)

Follow these instructions very carefully, step by step.

Part 1

1. Turn the computer ON (if it is already ON, press STOP) and put the CSM-6-AD0016 tape cartridge into the Tennecomp unit.

2. Set track knob to 1.

3. Set:

    Data Field: 0
    Instruction Field: 0
    Switch Register: 7600_8

4. Press LOAD, START.

5. When the tape stops, check ACCUMULATOR: it must be zero (all lights out).

6. Set track knob to 2.

7. Set:

   Data Field: 1
   Instruction Field: 0
   Switch Register: 7600_8

8. Do steps 4 & 5.

9. Set track knob to 3.

10. Set:

    Data Field: 0
    Instruction Field: 0
    Switch Register: 0200_8

11. Do step 4.

12. Make sure the Teletype is "ON LINE" position.

13. Type: G

    Carriage Return.

NOTE: When typing on the Teletype keyboard, the carriage will not move and nothing will appear on the paper (input echo suppressed); however, the data go into the computer.

Thus, because it is not possible to check the typing, the operator must exercise particular care and make sure the input is correct.

At this point the data must be entered in the order indicated in Table 6. An example is shown in Figure 1. Items 10-12 are produced by the CSM-6 Data System (the input data is exactly the same as for program AD0015).

Items 1-9 can be entered via Teletype keyboard from a list prepared beforehand. A better method is to prepare from this list a punched paper tape. This can be done in any Teletype in the "OFF LINE" position. Call this Tape 1.

Assuming that this Tape 1 has been prepared:

14. Make sure that the Tape Reader is in the FREE position.

15. Put Tape 1 (with the data corresponding to items 1-9, Table 1) in the Tape Reader.

16. Turn Tape Reader to START position.

17. When this punched paper tape has been read through, turn Tape Reader to FREE and remove the tape.

18. Put the punched paper tape produced by CSM-6 system in the Tape Reader (Call this Tape 2).

19. Turn Tape Reader to START position.

Part of this tape, the one containing item 10 of Table 1, is read through. The reading will stop by itself when all the appropriate data have been read in.

At this point, the computer starts calculating the standard curves on each operating channel. The results of these calculations are printed out as they are obtained.

20. At the end of this series of calculations the following message will be typed out:

    SWITCH TO TRACK NO. 3

A pause of approximately ten seconds will allow the operator to obey this instruction. NOTE: If all the instructions up to this point have been followed, the knob must be already on Track 3 (See Step 9). Because the proper setting of the "track knob" is essential, this extra check was introduced. Failure to set the knob on the proper track will result in erasing the program present on the track at which the knob is actually set.

At this point the execution of Part 1 of program AD0016 is finished.

21. Turn the paper tape reader to position FREE. If Part 2 is run immediately after, go to step 26.

22. Make a pencil sign at the exact point where the reading of the paper tape 2 has stopped. When starting Part 2, the paper tape must be restarted at exactly the same point.

23. Remove the paper tape from the reader.

<u>Part 2</u>

24. Make sure the tape reader is on FREE position. Put the paper tape 2 into the tape reader at the point where the pencil mark is present.

25. Do steps 1 to 5.

26. Set track knob to 4. Do steps 7, 4, 5 in this order.

27. Set track knob to 3.

28. Do steps 10, 4, 13 in this order.

29. Turn paper tape reader to ON position.

30. A message stating:

    SWITCH TO TRACK NO. 3

    will be typed out at the beginning of the execution of this part of program AD0016. During the ten seconds pause which follows the message, make sure that the track knob is indeed set at 3 (step 27). Failure to have this knob at the proper setting gives completely erroneous results.

31. When all the samples whose numbers have been entered via Tape 1 have been processed (see Notes), the following message is typed out:

> ALL THE SAMPLES WHOSE NUMBERS HAVE BEEN ENTERED HAVE BEEN CALCULATED
>
> ARE ANY MORE SAMPLES TO BE CALCULATED (ANSWER Y OR N)?

During the time this message is typed out, turn the paper tape reader to FREE position.

32. When the whole message has been typed, answer by pressing Y or N keys followed by a space (Y=Yes; N=No). If the answer was N the message:

> CALCULATION IS TERMINATED

is typed, and the calculation is terminated.

If the answer was Y, the message:

> ENTER THE NUMBERS OF THE SAMPLES TO BE CALCULATED (MAX. NO. OF SAMPLES = 298)

is typed.

33. As the message states, 298 new sample numbers can be entered. If less than 298 sample numbers are entered, the string of numbers must be terminated by the word END.

34. Turn the paper tape reader back to ON position. If the output of the CSM-6 Data System corresponding to this new series of samples is on another tape, put this tape in the tape reader and then turn it to the START position.

The calculation of samples continues from the point where it has left off at step 31.

NOTES:

1. Because of memory restrictions, only a limited number of samples can be entered at the beginning of Part 1.

$$N = 286\text{-}NS(1) - NS(2) - NS(3) - NS(4) - NS(5) - NS(6) - MX * 6$$

where N is the number of sample numbers (item 8, Table 1) which can be entered in the first part of program AD0016. NS(1) represents the number of non-zero standards on channel 1, NS(2) the same thing on channel 2, and so on. MX is the largest of NS(1)...NS(6).

Thus, when all six channels are operating and each channel has eleven, non-zero standards N has a value of 154.

2. The remaining sample numbers, if there are any, can be entered during Part 2 of this program (see step 31).

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* Denotes multiplication sign.

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