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High-Speed Assembly Language (80386/80387) Programming for Laser Spectra Scan Control and Data Acquisition Providing Improved Resolution Water Vapor Spectroscopy

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

An assembly language program using the Intel 80386 CPU and 80387 math co-processor chips was written to increase the speed of data gathering and processing, and provide control of a scanning CW ring dye laser system. This laser system is used in high resolution (better than 0.001 cm-1) water vapor spectroscopy experiments. Laser beam power is sensed at the input and output of white cells and the output of a Fabry-Perot. The assembly language subroutine is called from Basic, acquires the data and performs various calculations at rates greater than 150 time faster than could be performed by the higher level language. The width of output control pulses generated in assembly language are 3 to 4 microseconds as compared to 2 to 3.7 milliseconds for those generated in Basic (about 500 to 1000 times faster).

Included are a block diagram and brief description of the spectroscopy experiment, a flow diagram of the basic and assembly language programs, listing of the programs, scope photographs of the computer generated 5-volt pulses used for control and timing analysis, and representative water spectrum curves obtained using these programs.

HIGH-SPEED ASSEMBLY LANGUAGE (80396/80387) PROGRAMMING FOR LASER SPECTRA SCAN CONTROL AND DATA ACQUISITION PROVIDING IMPROVED RESOLUTION WATER VAPOR SPECTROSCOPY

By

Robert J. Allen

INTRODUCTION

This report describes an Intel 80386 and 80387 assembly language program written to increase the speed of data gathering and processing, and provide control of a scanning CW ring dye laser system. This laser system is used in high resolution Water Vapor Spectroscopy Experiments. The 80386 is a 32-bit CPU chip operating at 16 MHz in a Compaq 386 computer, and the 80387 is a high speed math coprocessor. The assembly language subroutine is called from BASICA.

The program was originally written for the Compaq Portable 286 computer using the 80286 and 80287 chips. It was later updated for use with the faster Compaq 386.

WATER VAPOR SPECTROSCOPY EXPERIMENTS

A block diagram of the spectroscopy experiment is shown in Fig. 1.# An argon laser pumps a tunable CW ring dye laser. After receiving a Laser Scan Trigger, the Scanning Electronics will cause a very narrow line-width (0.0001 pm) laser beam to be outputted at wavelengths within pre-selected limits, for

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Figures 1 and 3 were provided by Dr. Benoist Grossmann, project scientists conducting the water vapor spectroscopy experiments.

example, 726.000 to 726.050 nm. This 50 pm scanning range can be selected anywhere between 725 nm (13,793.1 cm-1) to 730 nm (13,698 cm-1). A portion of the output beam is directed by beamsplitters to a Monochrometer for absolute wavelength calibration, a Fabry-Perot and photodiode P4 to provide the wavelength markers, and P3 as the Power Reference. The remaining beam is routed through White Cells #1 and #2 and sensed by photodiodes P1 and P2.

The outputs from the four photodiodes, P1-P4, are amplified and routed to four analog input channels multiplexed into a 10 KHz analog-to-digital converter with 12-bit resolution (A/D Board). The four multiplexed digital outputs are then processed as described later in this report. The A/D Board is part of an IBM Data Acquisition and Control Adapter card that fits inside the Compaq. This Adapter also contains two analog output channels; a 16-bit digital input port; a 16-bit digital output port; a 32-bit timer; and a 16-bit, externally-clocked, timer/counter. One bit of the digital output port is available for use as the Laser Scan Trigger.

CHOICE OF ASSEMBLY LANGUAGE PROGRAMMING

Since the four readings from photodiodes P1-P4 averaged N times are a single point on a rapidly changing plot of a single water vapor line, this data set should be obtained as rapidly as the hardware allows. More time, if needed, can be used to start the repeat (R) of subsequent data sets since this time is the separation between data points. Separation time, however,

should also be keep to a minimum since it is associated with the resolution of the curve.

As indicated in the general literature and by Rollins (1985), "assembly language is by far the fastest, most flexible, and most compact of all programming languages. It shows how and why higher-level languages operate. It gives access to features of a machine that are inaccessible with other languages." An assembly language matrix multiplication routine published by Startz (1985) is about 150 times faster than pre-8087 Basic.

Fortunately, assembly language routines are easily combined with either interpreted or compiled Basic, as well as with programs written in other high-level languages. The main program illustrated in this report was written in Basic (BASICA.COM) calling the assembly language routine for acquiring N sets of the four photodiode (P1-P4) readings and performing required calculations.

DESCRIPTION OF PROGRAMS

The basic program (Table II) and assembly language program (Table III) were prepared as part of this task and provided to the Project Scientists. He incorporated them into his Basic program which included plotting features for use in the high resolution spectroscopy experiments.

Figure 2 contains a flow diagram of both programs. Basic is used first (prior to scanning) to calculate and display the `mean' value of the background noise (W, X, Y & Z) from each of the four photodiodes (P1-P4). Scanning is initiated and the assemble language program called. The output from each of the

photodiodes are read and the corresponding background noise subtracted. The differences from P1, P2 and P4 are then normalized to the power reference difference P3. This process is repeated N times and the `mean' of each of the three ratios ((P1-X)/(P3-W), (P2-Y)/(P3-W), and (P4-Z)/(P3-W)) calculated. The process then returns to Basic where the `mean' of these three ratios are displayed. Each of the ratios constitute a single data point on each of three curves. The above process is then repeated R times obtaining new data points while the laser continues to scan. BASICA line numbers are then displayed for the background sample size (M), data sample size (N) and number of repeats during laser scanning (R). The results, when coupled with the plotting program, are the curves shown in Figures 3A and B.

Five-volt pulses, BO-0 and BO-1, are generated in Basic prior to scanning and can be used to trigger a scope and to initiate scanning. Binary output pulses, BO-2 and BO-3, are generated in Assembly Language and were used to measure the time for different processes during program development such as the: (1) greater-than 20 microsecond delay time required to allow transients to settle following each multiplexed operation, (2) total time used to read the four analog input from the photodiodes and subtract the backgrounds from each, and (3) time to calculate the mean of the ratios. Scope photographs of pulses BO-0 to BO-3, their pulse widths, and various times are shown in Figure 4 and Table I.

FORMULATING THE PROGRAMS

The assembly language program was written using WordStar, assembled using Microsoft Macro-Assembler version 4.00 (MASM ALLEN7R) and linked for high memory residence (LINK/H ALLEN7R). Debug was called (SYMDEB ALLEN7R.EXE) and Basic entered using N BASICA.COM. L and G. ALLENB7R.BAS was then loaded and a binary file created using DEF SEG = &H9FCA followed by BSAVE "ALLEN7R.BIN",0,&h178. Running ALLENB7.BAS produced the display shown in Table IIB.

ACKNOWLEDGMENT

Publications by Lafore (1984) and Startz (1985) provided excellent references supporting the assembly language portions of this task. The author wishes to thank Dr. Jerry Tucker of NASA Langley Research Center for his helpful suggestion in connection with the assembly language programming, Dr. Benoist Grossmann for providing the information concerning the experiments and review of this report, and Patrick Ponsardin for his review and comments concerning this report. Both Benoist and Patrick are affiliated with Old Dominion University Research Foundation (on leave from Electricite de France).

REFERENCES

Rollins, Dan (1985), "IBM-PC 8088 MACRO Assembler Programming", Macmillan Publishing Co.

Startz, Richard (1985), "8087 Applications and Programming for the IBM PC, XT, and AT", Brady Communications Co., Inc. NY, NY 10020.

Lafore, Robert (1984), "Assembly Language Primer for the IBM PC & XT", A Plume/Waite Book.

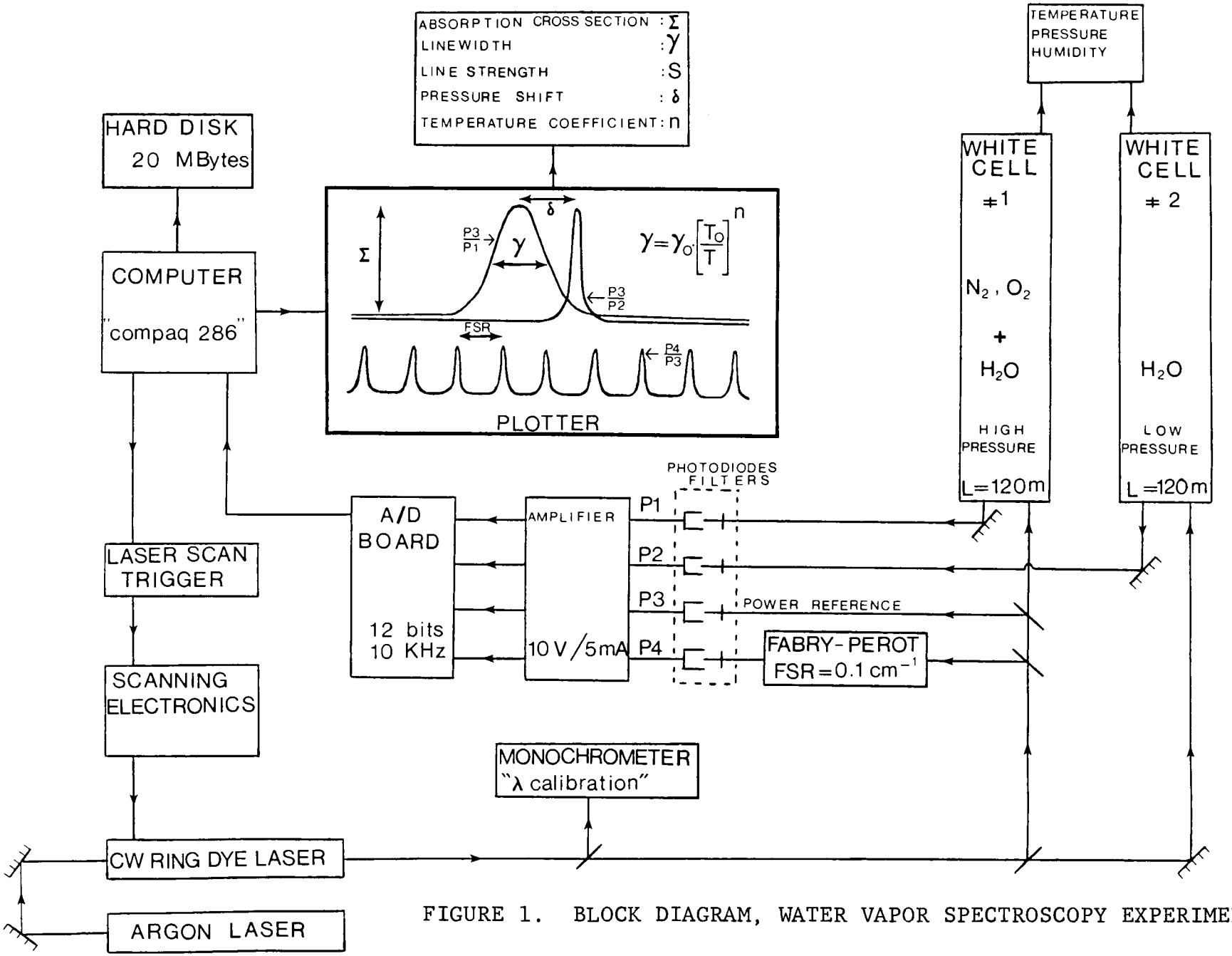


FIGURE 1. BLOCK DIAGRAM, WATER VAPOR SPECTROSCOPY EXPERIMENT.

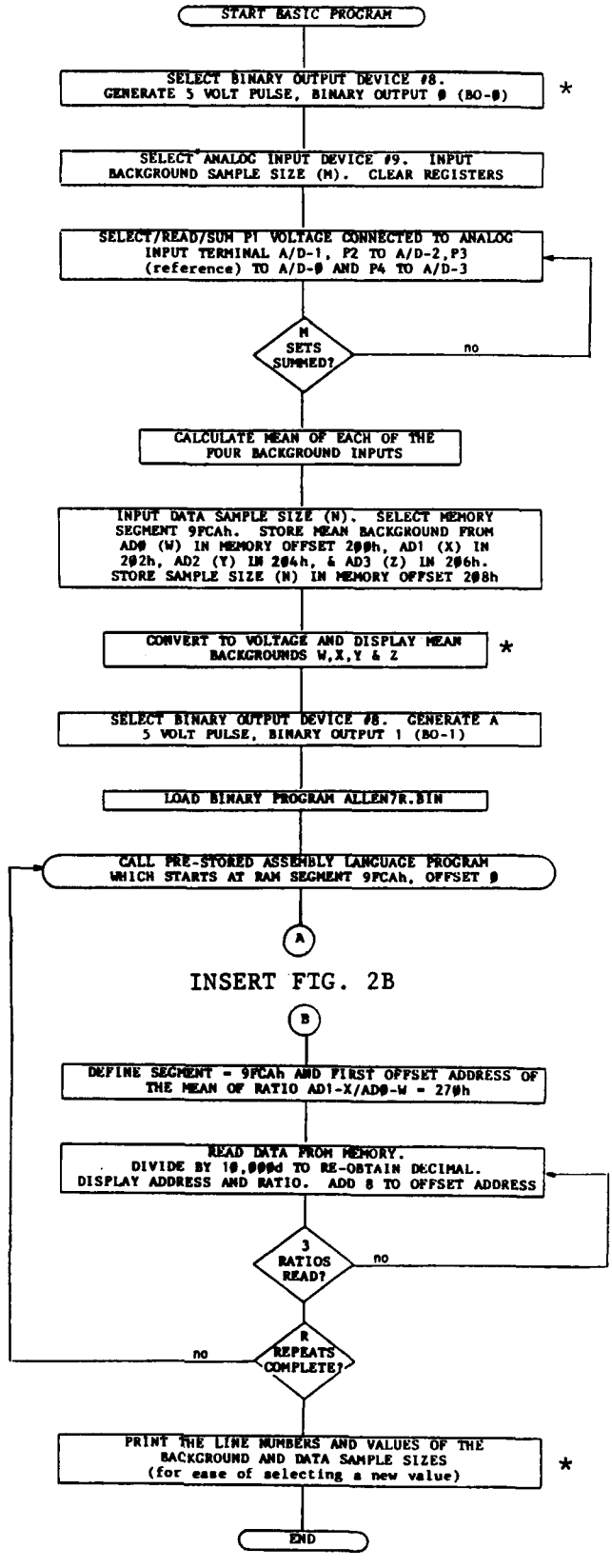
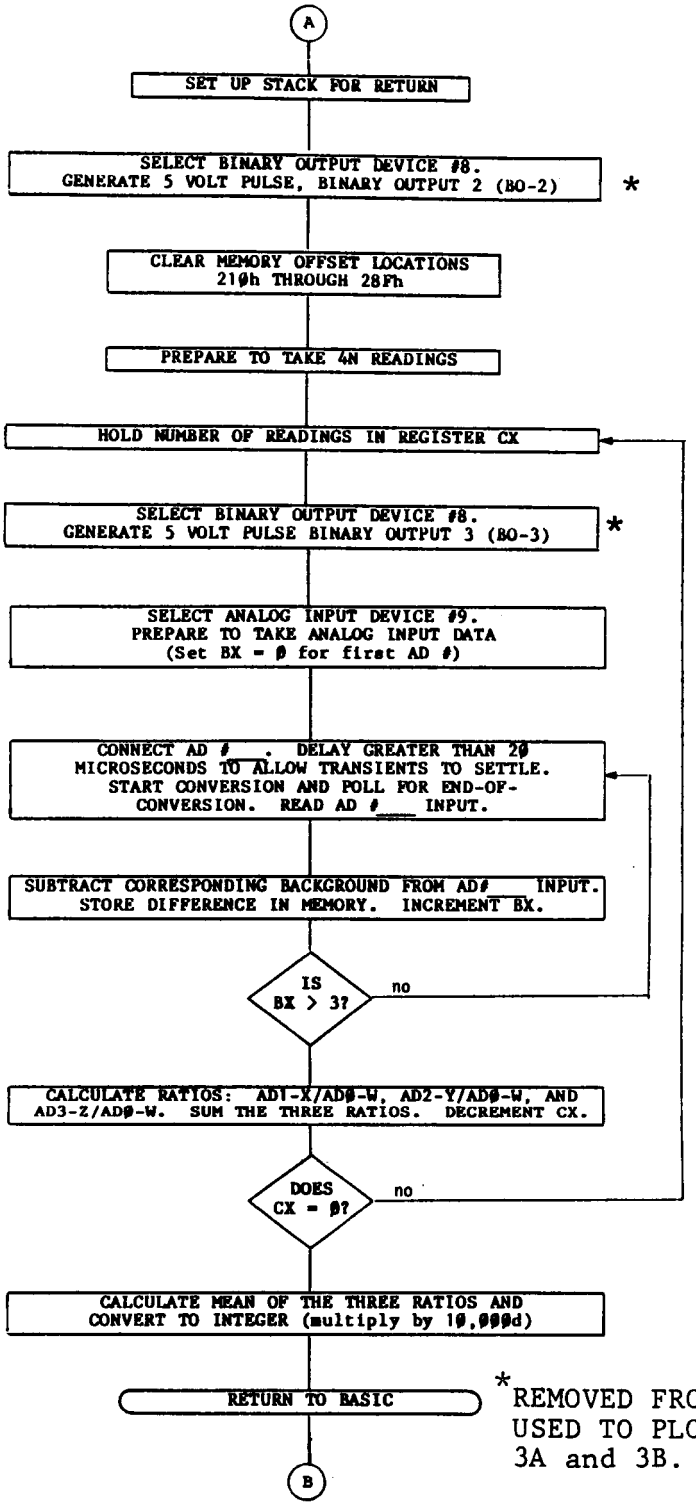


FIGURE 2A. FLOW DIAGRAM OF THE BASIC PROGRAM.

FROM FIG. 2A



*REMOVED FROM PROGRAM USED TO PLOT FIGURES 3A and 3B.

TO FIG. 2A

FIGURE 2B. FLOW DIAGRAM OF THE 80386/80387 ASSEMBLY LANGUAGE PROGRAM.

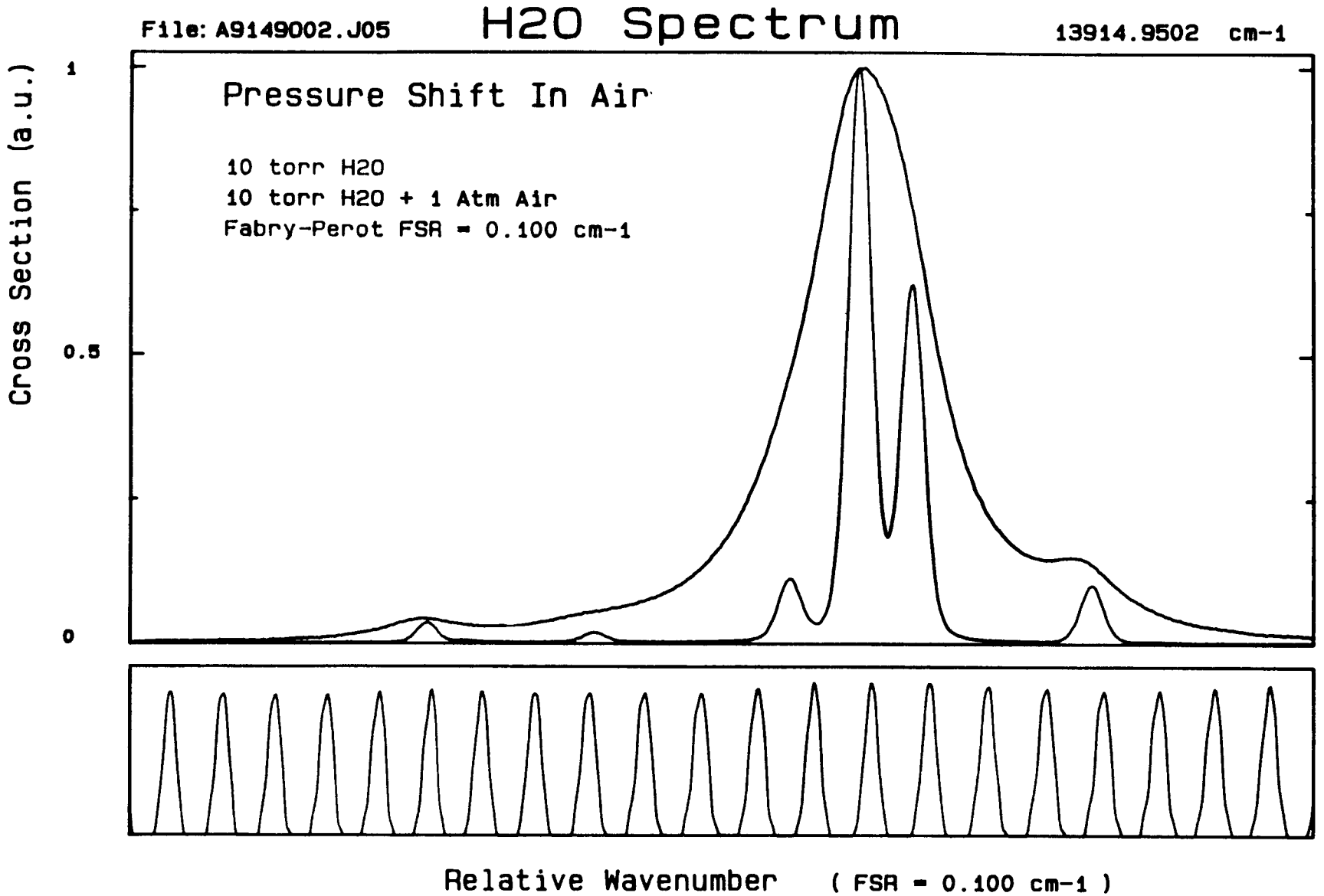


FIGURE 3A. CROSS SECTION VS. WAVENUMBER SHOWING PRESSURE SHIFT IN AIR FOR THE LINE CENTERED AT 13914.9502 cm-1.

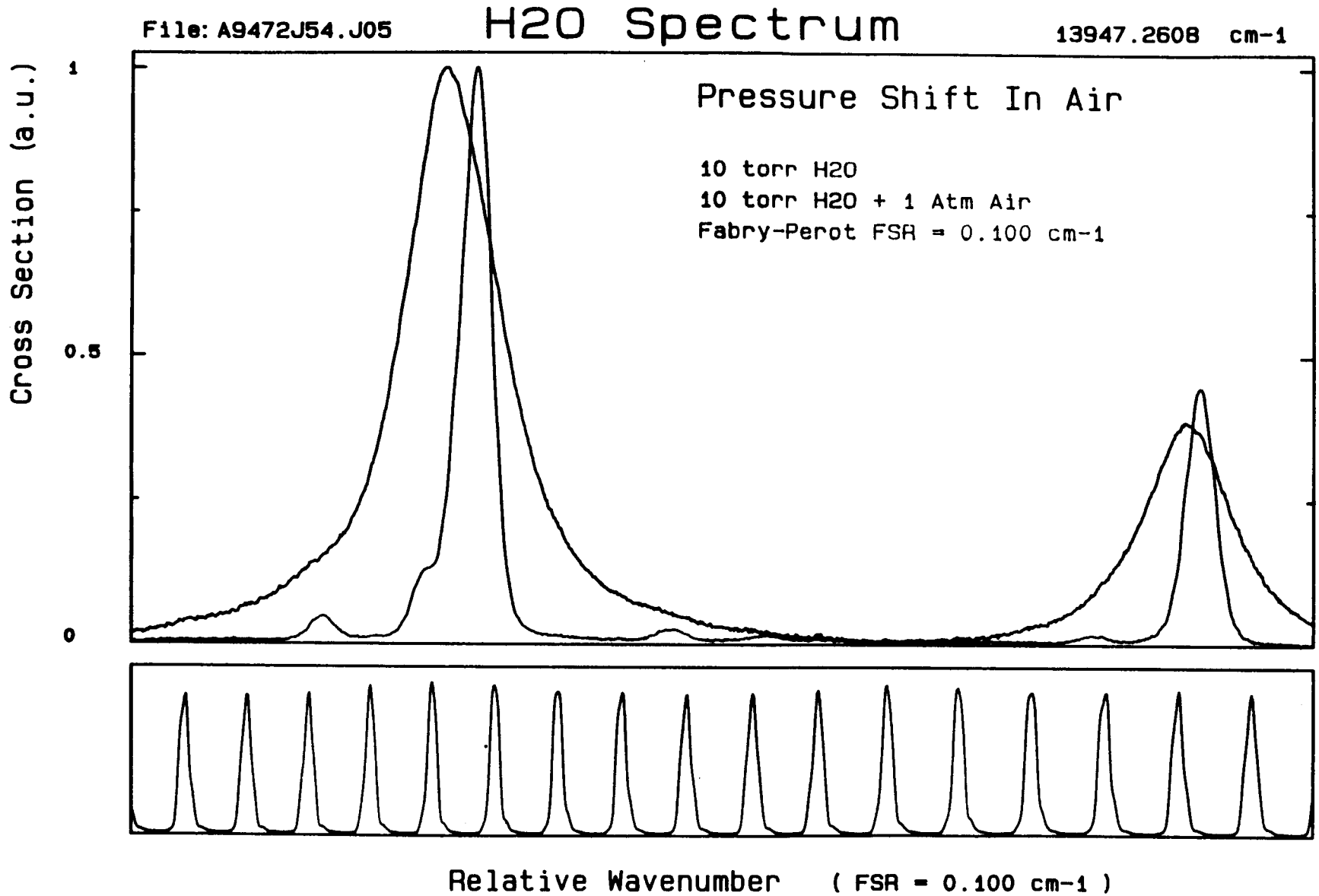
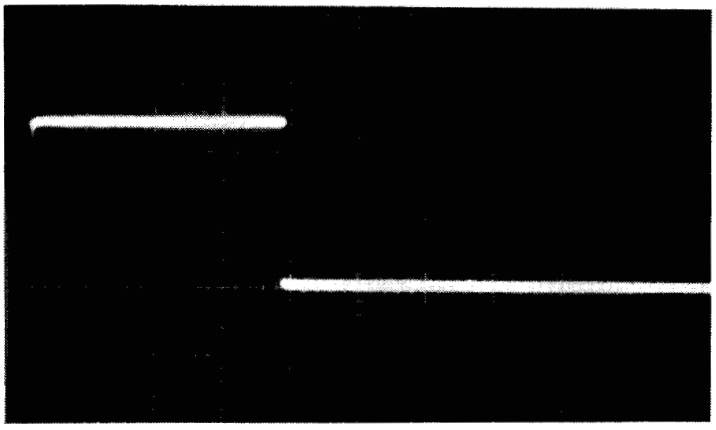


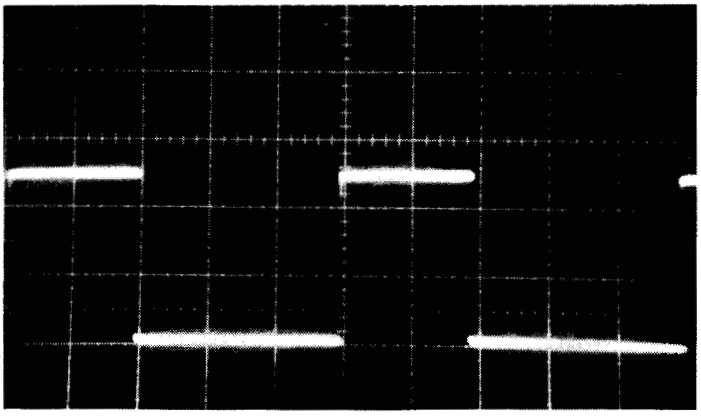
FIGURE 3B. CROSS SECTION VS. WAVENUMBER SHOWING PRESSURE SHIFT IN AIR FOR THE LINE CENTERED AT 13947.2608 cm-1.



(A) 5V 3.7 ms wide
Binary Output
pulse BO-0

2V/div 0.5 ms/div

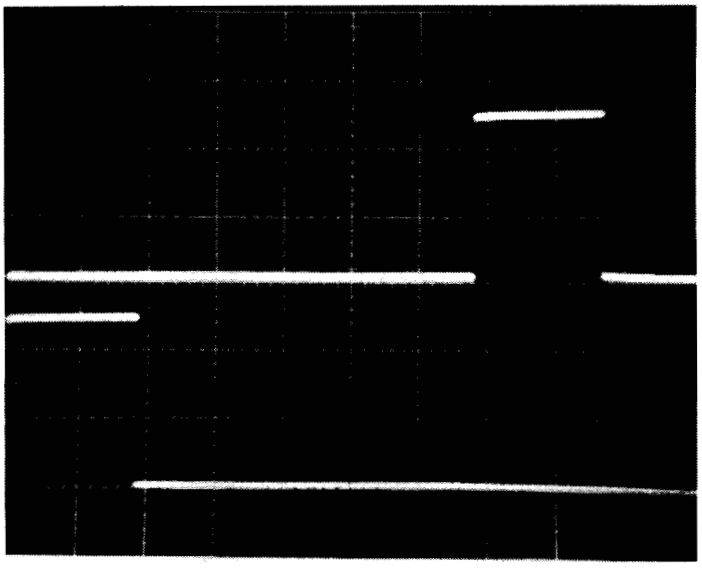
(added program:
1035 GOTO 80)



(B) 5V 2 ms wide
Binary Output
pulse BO-1

2V/div 1 ms/div

(added program:
1105 GOTO 1060



(C) BO-0

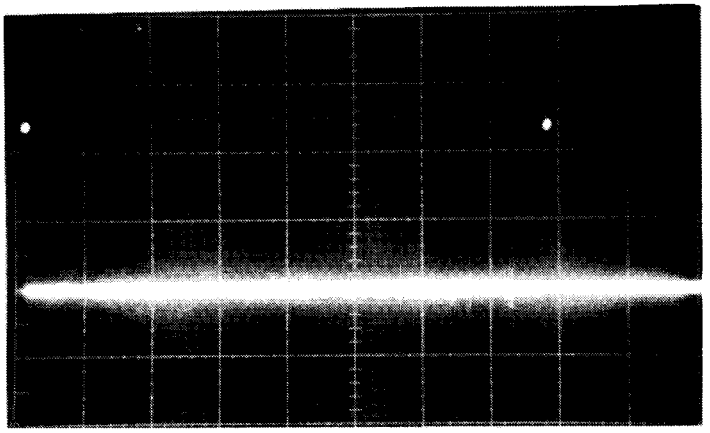
2V/div 1 ms/div

(D) BO-1 (scope trig)

2V/div 1 ms/div

(added program:
1105 GOTO 80)

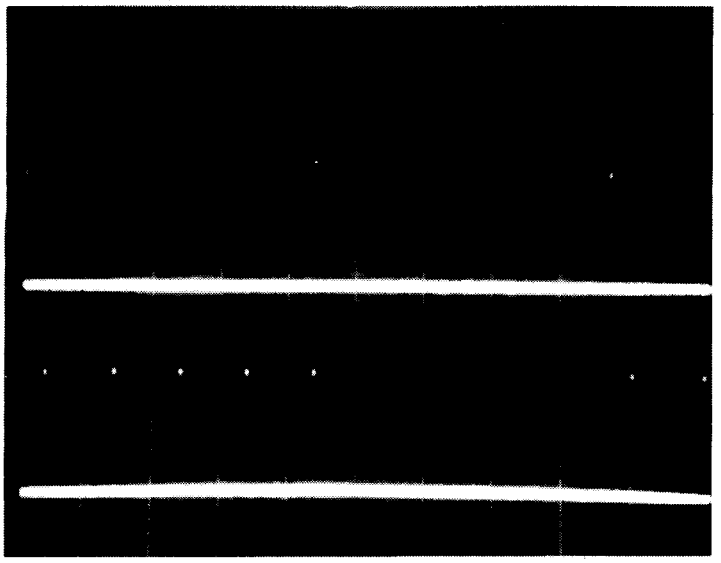
FIGURE 4. SCOPE PHOTOGRAPHS OF 5-VOLT PULSES GENERATED FROM BINARY OUTPUTS BO-0 TO BO-3. PULSE WIDTHS AND VARIOUS PROGRAM TIMES ARE LISTED IN TABLE I.



(E) BO-1

2V/div 100 ms/div

(added program:
1395 GOTO 1060)



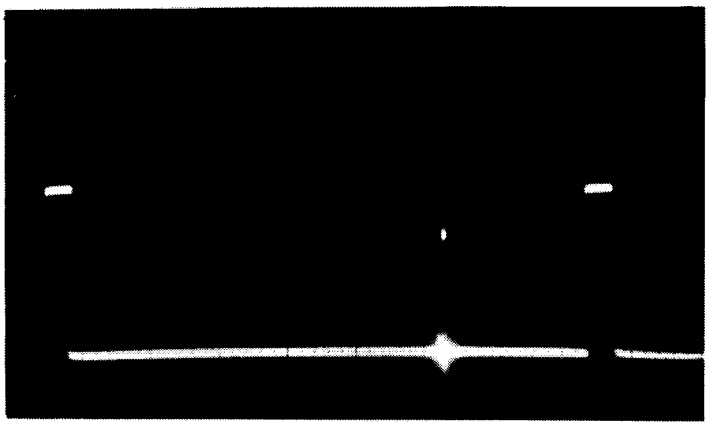
(F) BO-2

2V/div 1 ms/div

(G) BO-3

2V/div 1 ms/div

(added program:
1185 GOTO 1160)



(H) BO-1 ADDED TO
INTENSIFIED BO-2

(added program:
1185 GOTO 1060)

TABLE I. PROGRAM TIMES DETERMINED USING BINARY OUTPUT PULSES SHOWN IN FIGURE 4

BASICA LINE NUMBERS	ADDED PROGRAM STEP *	GENERATED BINARY OUTPUT PULSE	TIME FROM START OF BO-i TO START OF BO-j
80-140	1035 GOTO 80	BO-0, 5V 3.7 ms wide (FIG. 4A)	BO-0 to BO-0: 200 ms (M=1) 412 ms (M=10) 875 ms (M=30) 2500 ms (M=100)
1060-1100	1105 GOTO 1060	BO-1, 5V 2 ms wide (FIG. 4B)	BO-1 to BO-1: 3 ms
80-1100	DELETE 1040 1105 GOTO 80	BO-0 and BO-1 (FIG. 4C&D)	BO-0 to BO-1: 200 ms (M=1) BO-1 to BO-0: 6.8 ms
1060-1390	1395 GOTO 1060	BO-1 (FIG. 4E)	BO-1 to BO-1: 770 ms
1160-1185 includes total assembly language subroutine	1185 GOTO 1160	BO-2 & BO-3 3.5V into 10K WIDTHS: 3 us (BO-2) 4 us (BO-3) (FIG. 4F&G)	BO-2 to BO-2: 4.5 ms (N=1) 6.5 ms (N=3) 8.5 ms (N=5) 43.2 ms (N=40) FOR N=5: BO-2 to BO-3 -- 0.31 ms BO-31 to BO-32 -- 1.0 ms BO-35 to BO-2 -- 4.2 ms
1060-1185 includes total assembly language subroutine	1185 GOTO 1060	BO-1 ADDED TO INTENSIFIED BO-2. (BO-2 into 10K) (FIG. H)	BO-1 to BO-2: -- 29.6 ms BO-2 to BO-1: -- 10.4 ms BO-1 to BO-1: -- 40 ms

*Added program to produce a repetitive pulse for timing analyses and scope photographic purposes.

TABLE IIA BASIC PROGRAM ALLENB7R.BAS

```
10 CLS  '--- WATER VAPOR SPECTROSCOPY EXPERIMENT, CONTROL & DATA PROCESSING ---
20 '
30 'GENERATES BINARY OUTPUT PULSE BO 0, CALCULATES THE MEAN OF M SETS OF THE
BACKGROUND DATA FROM AD0-AD3, POKES THE FOUR BACKGROUND VALUES & THE DATA
SAMPLE SIZE N INTO MEMORY, CONVERTS THE FOUR INTO A VOLTAGE, AND DISPLAYS THEIR
VALUES.
40 '  CALLS THE ASSEMBLY LANGUAGE PROGRAM.  AFTER RETURNING TO BASIC, DIVIDES
THE THREE CALCULATED DATA RATIOs (corrected for background noise) BY 10,000,
AND DISPLAYS THESE RATIOs.
50 '  THE ASSEMBLY LANGUAGE PROGRAM IS AGAIN CALLED AND THE PROCESS REPEATED
R TIMES.   THE PROGRAM LISTING FOR THE BACKGROUND SAMPLE SIZE (M), DATA SAMPLE
SIZE (N) AND THE NUMBER OF REPEATS DURING LASER SCANNING (R) ARE DISPLAYED FOR
EASE OF CHANGE.
60 '
70 ' ********** GENERATE BINARY OUTPUT PULSE BO 0 ***************
80 OUT 49890!,8          'Selects Reg. 12, Device 8
90 OUT 8930,0            'Zero volts from BO 0 (low byte)
100 OUT 8931,0            'Zero volts from BO 0 (high byte)
110 OUT 8930,1            '5 volts from BO 0  (low byte)
120 OUT 8931,0            '   (high byte) SCOPE TRIG +
130 OUT 8930,0            'Zero volts from BO 0 (low byte)
140 OUT 8931,0            '   (high byte)  START MEASURING BACKGROUND
150 ' ********* TAKE THE MEAN OF BACKGROUND READIDNGS FROM AD0-AD3 ********
160 OUT 49890!,9   'BASIC ADDRESS OF DATA ACQ ADAPTER 0 = 2E2H (AD# INPUTS)
170 M = 30         'BACKGROUND SAMPLE SIZE, M
180 AL=0:AH=0:BL=0:BH=0:CL=0:CH=0:DL=0:DH=0
190 WL=0:WH=0:XL=0:XH=0:YL=0:YH=0:ZL=0:ZH=0
200 FOR J=1 TO M
210 OUT 738,0
220 OUT 738,0    'SELECT AD 0 (P1)
230 OUT 739,0
240 OUT 738,1
250 OUT 739,0
260 OUT 738,0
270 OUT 739,0
280 AL=INP (8930)        'READ AD 0
290 WL=WL+AL
300 AH=INP (8931)
310 WH=WH+AH             'SUM AD 0
320 OUT 738,0    'SELECT/READ/SUM AD 1 (P2)
330 OUT 739,1
340 OUT 738,1
350 OUT 739,1
360 OUT 738,0
370 OUT 739,1
380 BL=INP (8930)
390 XL=XL+BL
400 BH=INP (8931)
410 XH=XH+BH
420 OUT 738,0    'SELECT/READ/SUM AD 2 (P3)
430 OUT 739,2
440 OUT 738,1
450 OUT 739,2
460 OUT 738,0
470 OUT 739,2
480 CL=INP (8930)
490 YL=YL+CL
500 CH=INP (8931)
510 YH=YH+CH
```

```
520 OUT 738,0    'SELECT/READ/SUM AD 3 (P4)
530 OUT 739,3
540 OUT 738,1
550 OUT 739,3
560 OUT 738,0
570 OUT 739,3
580 DL=INP (8930)
590 ZL=ZL+DL
600 DH=INP (8931)
610 ZH=ZH+DH
620 NEXT J       'REPEAT SELECT/READ/SUM DATA SET AD 0 - AD 3
630 '
640 WL=WL/M      'MEAN OF BACKGROUND READINGS FROM AD 0
650 WH=WH/M
660 XL=XL/M      'MEAN OF BACKGROUND READINGS FROM AD 1
670 XH=XH/M
680 YL=YL/M      'MEAN OF BACKGROUND READINGS FROM AD 2
690 YH=YH/M
700 ZL=ZL/M      'MEAN OF BACKGROUND READINGS FROM AD 3
710 ZH=ZH/M
720 '
730 N = 5          'DATA SAMPLE SIZE, N
740 '
750 ' ********* STORE MEAN BACKGROUND READINGS AND N IN MEMORY ********
760 DEF SEG = &H9FCA    'SEGMENT ADDRESS (page 426)
770 ADDR = &H200
780 POKE ADDR,WL    'SAVE AD 0 BACKGROUND IN MEMORY 200H
790 ADDR=ADDR+1
800 POKE ADDR,WH
810 ADDR=ADDR+1
820 POKE ADDR,XL    'SAVE AD 1 BACKGROUND IN MEMORY 202H
830 ADDR=ADDR+1
840 POKE ADDR,XH
850 ADDR=ADDR+1
860 POKE ADDR,YL    'SAVE AD 2 BACKGROUND IN MEMORY 204H
870 ADDR=ADDR+1
880 POKE ADDR,YH
890 ADDR=ADDR+1
900 POKE ADDR,ZL    'SAVE AD 3 BACKGROUND IN MEMORY 206H
910 ADDR=ADDR+1
920 POKE ADDR,ZH
930 ADDR = &H208
940 POKE ADDR,N     'SAVE DATA SAMPLE SIZE, N, IN MEMORY 208H
950 '
960 ' ********* CONVERT TO VOLTAGE AND DISPLAY ***************
970 W=.00244*(256*WH+WL)
980 X=.00244*(256*XH+XL)
990 Y=.00244*(256*YH+YL)
1000 Z=.00244*(256*ZH+ZL)
1010 PRINT "BACKGROUND","W","X","Y","Z"
1020 PRINT ,W,X,Y,Z
1030 PRINT
1040 STOP
1050 '********** GENERATE BINARY OUTPUT PULSE BO1 *************
1060 OUT 49890!,8         'Selects Reg. 12, Device 8
1070 OUT 8930,2          '5 volts from BO 1 (low byte)
1080 OUT 8931,0           '   (high byte) 4-CHANNEL MARKER
1090 OUT 8930,0           'Zero volts from BO 1 (LOW BYTE)
1100 OUT 8931,0           'Zero volts from BO 1 (high byte)
```

```
1110 '######### PREPARE FOR ASSEMBLY LANGUAGE PROGRAM #########
1120 BLOAD "ALLEN7R.BIN",0      '(R. L. Lafore, page 428)
1130 R = 300          'NUMBER OF REPEATS DURING LASER SCANNING, R
1140 R = 3            'NUMBER OF REPEATS DURING LASER SCANNING, R
1150 FOR S=1 TO R
1160 CALL ALLEN7R
1170 ' ######## GO TO ASSEMBLY LANGUAGE PROGRAM ###############
1180 '--------- RETURN FROM ASSEMBLY LANGUAGE PROGRAM ------
1190 '******** DISPLAY DATA CALCULATED IN ASSEMBLY LANGUAGE ***********
1200 DEF SEG = &H9FCA
1210 ADDR = &H270
1220 PRINT "DATA OFFSET ADDRESS",,"RATIO"
1230 FOR K=1 TO 3
1240 EL = PEEK(ADDR)
1250 EH = PEEK(ADDR+1)
1260 E=(256*EH+EL)
1270 PRINT "             " HEX$(ADDR),
1280 PRINT USING " ##.# ";E
1290 F=E/10000
1300 PRINT ,,,F
1310 ADDR = ADDR+8
1320 NEXT K
1330 NEXT S
1340 PRINT
1350 ' ************ DISPLAY SAMPLE SIZE OF CALCULATED DATA *********
1360 PRINT "170 M ="M "         'BACKGROUND SAMPLE SIZE, M
1370 N = PEEK(&H208)
1380 PRINT "730' N ="N "         'DATA SAMPLE SIZE, N
1390 PRINT "1140 R ="R"          'NUMBER OF REPEATS DURING LASER SCANNING, R
1400 END
1410 'SAVE"ALLENB7R 11/3/87
Ok
```

TABLE IIB DISPLAY PRODUCED BY RUNNING ALLENB7R.BAS

```
Break in 1040

Ok
CONT
DATA OFFSET ADDRESS                          RATIO
            270              %21154.0
                                             2.1154
            278              %31532.0
                                             3.1532
            280              %42287.0
                                             4.2287
DATA OFFSET ADDRESS                          RATIO
            270              %21053.0
                                             2.1053
            278              %31361.0
                                             3.1361
            280              %42071.0
                                             4.2071
DATA OFFSET ADDRESS                          RATIO
            270              %21055.0
                                             2.1055
            278              %31418.0
                                             3.1418
            280              %42143.0
                                             4.2143

170 M = 30          'BACKGROUND SAMPLE SIZE, M
730' N = 5          'DATA SAMPLE SIZE, N
1140 R = 3           'NUMBER OF REPEATS DURING LASER SCANNING, R
Ok
```

TABLE IIIA ASSEMBLY LANGUAGE PROGRAM ALLEN7R.LST

```
Microsoft (R) Macro Assembler  Version 4.00                10/29/87 14:49:17
                                                           Page     1-1


                                ;ALLEN7R --.EXE file to be controlled by BASIC
                                ;
                                ;  Generates a BINARY OUTPUT PULSE (BO2) to
                                ;  indicate the START of taking data, follow-
                                ;  ed by a BO3 pulse to be used as a marker
                                ;  at the start of each set of ADC INPUTS.
                                ;  Reads data from AD0 and subtracts W (poked
                                ;  into RAM previously from BASICA) and holds
                                ;  the DIFFERENCE, then reads data from AD1
                                ;  and subtracts X and holds this DIFFERENCE,
                                ;  etc. for AD2-Y and AD3-Z.  This is repeat N
                                ;  time where  2>N>100 which was previously
                                ;  poked from BASICA.  A maximum of four
                                ;  memory locations (200H, 202H, 204H, & 206H)
                                ;  are required for the BACKGROUND data pre-
                                ;  viously averaged in BASIC; and four memory
                                ;  locations (210H, 218H, 220H, & 228H) for
                                ;  subtracted data, three memory locations
                                ;  (230H, 238H, & 240H) for the RATIO data,
                                ;  one (248H) for the value of N, three
                                ;  (250H, 258h, & 260H) for the summation of
                                ;  RATIOs, and the same three (250H, 258H,
                                ;  & 260H) for the MEAN of the RATIOs all
                                ;  obtained in this ASSMEBLY LANGUAGE program.
                                ;  The values are then multiplied by 10,000d
                                ;  to eliminate the decimal point.  The prog-
                                ;  ram then returns to basic.
                                ;             BASICA PROGRAM -- ALLENB7R.BAS
                                ;-----------------------------------------
                                .287

                                ;*********************************************

0000                            ST_SEG  SEGMENT STACK   ;DEFINE STACK SEGMENT
0000 0014[                              DB      20 DUP  ('STACK   ')
         53 54 41 43 4B
             20 20 20
                    ]


00A0                            ST_SEG  ENDS

                                ;*********************************************

0000                            PROGNAM SEGMENT         ;DEFINE CODE SEGMENT

                                ;-----------------------------------------
0000                            MAIN    PROC    FAR     ;MAIN PART OF PROGRAM

                                        ASSUME  CS:PROGNAM,DS:NOTHING

0000                            START:                  ;START EXECUTION ADDR
```

```
                                ;SET UP STACK FOR RETURN (p 439)
0000  55                                PUSH BP          ;SAVE BP
0001  1E                                PUSH DS          ;SAVE OLD DATA SEGMENT
0002  56                                PUSH SI          ;SAVE OLD SI
0003  8C C8                             MOV  AX,CS       ;DATA SEGMENT SAME AS
0005  8E D8                             MOV  DS,AX       ;  CODE SEGMENT
0007  2B C0                             SUB  AX,AX       ;ZERO AX
0009  50                                PUSH AX          ;SAVE IT ON STACK

                                ;SELECT/HOLD DATA ACQ/CTRL ADAPT--BINARY
000A  BA C2E2                           MOV  DX,0C2E2H   ;REG 12,ADPTR 0,LO B
000D  B8 0008                           MOV  AX,8        ;BINARY DEVICE 8
0010  EE                                OUT  DX,AL       ;  LOW BYTE OUTPUT
0011  BA C3E3                           MOV  DX,0C3E3H   ;REG 12,ADPTR 0,HI B
0014  B8 0000                           MOV  AX,0        ;BINARY DEVICE 8
0017  EE                                OUT  DX,AL       ;  HIGH BYTE OUTPUT

                                ;Select Binary Output (Write), register 2
                                ;  Set BO 2 TTL output low
0018  BA 22E2                           MOV  DX,22E2H    ;REG 2,BIN OUT,LO B
001B  B8 0000                           MOV  AX,0        ;BO 2 = 0 (LO & HI)
001E  EE                                OUT  DX,AL       ;OUTPUT LOW BYTE
001F  BA 22E3                           MOV  DX,22E3H    ;REG 2,BIN OUT,HI B
0022  EE                                OUT  DX,AL       ;OUTPUT HIGH BYTE

                                ;  Set BO 2 TTL output high
0023  BA 22E2                           MOV  DX,22E2H    ;REG 2,BIN OUT,LO B
0026  B0 04                             MOV  AL,4        ;BO 2 = 1, LO B
0028  EE                                OUT  DX,AL       ;OUTPUT LOW BYTE
0029  BA 22E3                           MOV  DX,22E3H    ;REG 2,BIN OUT,HI B
002C  B0 00                             MOV  AL,0        ;HIGH BYTE OF BO 2=0
002E  EE                                OUT  DX,AL       ;OUTPUT HIGH BYTE

                                ;  Set BO 2 TTL output low
002F  BA 22E2                           MOV  DX,22E2H    ;REG 2,BIN OUT,LO B
0032  B0 00                             MOV  AL,0        ;BO 2 = 0 (LO & HI)
0034  EE                                OUT  DX,AL       ;OUTPUT LOW BYTE
0035  BA 22E3                           MOV  DX,22E3H    ;REG 2,BIN OUT,HI B
0038  EE                                OUT  DX,AL       ;OUTPUT HIGH BYTE

                                ;Fill memory offset locations
0039  BB 0210                           MOV  BX,0210H    ;OFFSET FILL ADDR.
003C  8B FB                             MOV  DI,BX       ;  INTO REG. DI
003E  B9 0080                           MOV  CX,80H      ;# LOCATIONS TO FILL
0041  B8 0000                           MOV  AX,0000H    ;PUT # INTO AX
0044  89 05                     FILL:   MOV  [DI],AX     ;FILL MEMORY WITH #s
0046  47                                INC  DI          ;INCREASE ADDR. BY 1
0047  E2 FB                             LOOP FILL        ;REPEAT FILLING

                                ;Prepare to Take 4N readings
0049  BB 0208                           MOV  BX,0208H    ;N POKED FROM BASIC is
004C  8B 0F                             MOV  CX,[BX]     ;# OF READ. TO AVERAGE
004E  BB 0210                           MOV  BX,0210H    ;OFFSET DATA ADDR.
0051  8B FB                             MOV  DI,BX       ;  INTO REG. DI
```

```
0053  B0 04                        MOV  AL,4        ;# OF ADC CHANNELS
0055  51                    NEWSET: PUSH CX          ;HOLD # OF READING 4*N

                           ;SELECT/HOLD DATA ACQ/CTRL ADAPT--BINARY
0056  BA C2E2                      MOV  DX,0C2E2H   ;REG 12,ADPTR 0,LO B
0059  B8 0008                      MOV  AX,8        ;BINARY DEVICE 8
005C  EE                          OUT  DX,AL       ;  LOW BYTE OUTPUT
005D  BA C3E3                     MOV  DX,0C3E3H   ;REG 12,ADPTR 0,HI B
0060  B8 0000                     MOV  AX,0        ;BINARY DEVICE 8
0063  EE                          OUT  DX,AL       ;  HIGH BYTE OUTPUT

                           ;Select Binary Output (Write), register 2
                           ;  Set BO 3 TTL output high (WAS LOW)
0064  BA 22E2                     MOV  DX,22E2H    ;REG 2,BIN OUT,LO B
0067  B0 08                       MOV  AL,8        ;B0 3 = 1, LO B
0069  EE                          OUT  DX,AL       ;OUTPUT LOW BYTE
006A  BA 22E3                     MOV  DX,22E3H    ;REG 2,BIN OUT,HI B
006D  B0 00                       MOV  AL,0        ;HIGH BYTE OF BO 3=0
006F  EE                          OUT  DX,AL       ;OUTPUT HIGH BYTE

                           ;  Set BO 3 TTL output low
0070  BA 22E2                     MOV  DX,22E2H    ;REG 2,BIN OUT,LO B
0073  B0 00                       MOV  AL,0        ;B0 3 = 0 (LO & HI)
0075  EE                          OUT  DX,AL       ;OUTPUT LOW BYTE
0076  BA 22E3                     MOV  DX,22E3H    ;REG 2,BIN OUT,HI B
0079  EE                          OUT  DX,AL       ;OUTPUT HIGH BYTE

                           ;SELECT/HOLD DATA ACQ/CTRL ADAPT--ANALOG INPUT
007A  BA C2E2                     MOV  DX,0C2E2H   ;REG 12,ADPTR 0,LO B
007D  B0 09                       MOV  AL,9        ;DEVICE 9 LOW BYTE
007F  EE                          OUT  DX,AL       ;OUTPUT LOW BYTE
0080  BA C2E3                     MOV  DX,0C2E3H   ;REG 12,ADPTR 0,HI B
0083  B0 00                       MOV  AL,0        ;DEVICE 9 HIGH BYTE
0085  EE                          OUT  DX,AL       ;OUTPUT HIGH BYTE

                           ;PREPARE TO TAKE ANALOG INPUT DATA
0086  2B DB                      SUB  BX,BX       ;ZERO BL (AD# = AD0)

                           ;Select Analog Input Control Reg 0 (AD#)
                           ;  Connect AD#.  Hold conv (reset bit #0 to 0)
0088  BA 02E2             NEXTAD: MOV  DX,02E2H    ;REG 0,AD# INPUT,LO
008B  B0 00                       MOV  AL,0        ;HOLD CONVERT
008D  EE                          OUT  DX,AL       ;OUTPUT LOW BYTE
008E  BA 02E3                     MOV  DX,02E3H    ;REG 0, AD# INPUT, HI
0091  8A C3                       MOV  AL,BL       ;CODE FOR AD# 0 thru 3
0093  EE                          OUT  DX,AL       ;OUTPUT HIGH BYTE

                           ;  Delay >20 us (allow transients to settle)
0094  B9 0022                     MOV  CX,0022H    ;MEASURED DELAY: 26us

0097  E2 FE                TRANS:  LOOP TRANS       ;EXECUTE DELAY #1

                           ;  Start Conversion (set bit #0 to 1)
0099  BA 02E2                     MOV  DX,02E2H    ;REG 0, AD# INPUT, LO
```

```
009C  B0 01                     MOV  AL,1        ;START CONVERT,LOW B
009E  EE                        OUT  DX,AL       ;OUTPUT LOW BYTE
009F  BA 02E3                   MOV  DX,02E3H    ;REG 0, AD# INPUT, HI
00A2  8A C3                     MOV  AL,BL       ;CODE FOR AD# 0 thru 3
00A4  EE                        OUT  DX,AL       ;OUTPUT HIGH BYTE

                        ;  Wait for BUSY STATE bit 0 = 0 (Polling)
00A5  BA 02E2                   MOV  DX,02E2H    ;REG 0, LOW BYTE
00A8  ED                CONV:   IN   AX,DX       ;IN FROM AI STATUS REG
00A9  25 0001                   AND  AX,0001H    ;MASK ALL BUT BIT 0
00AC  75 FA                     JNZ  CONV        ;REPEAT IF BIT 0 NOT 0

                        ;  Enable Reading of AD# Channel
00AE  BA 02E2                   MOV  DX,02E2H    ;REG 0, AD# INPUT, LO
00B1  B8 0000                   MOV  AX,0        ;ENABLE READING, LO B
                                                 ;ZERO AH FOR FUTURE IN
00B4  EE                        OUT  DX,AL       ;OUTPUT LOW BYTE
00B5  BA 02E3                   MOV  DX,02E3H    ;REG 0,A/D 0 INPUT,HI
00B8  8A C3                     MOV  AL,BL       ;CODE FOR AD# 0 thru 3
00BA  EE                        OUT  DX,AL       ;OUTPUT HIGH BYTE

                        ;  Read AD# Input (register 2--see p71)
00BB  BA 22E2                   MOV  DX,22E2H    ;REG 2, AD# INPUT, LO
00BE  ED                        IN   AX,DX       ;INPUT READING

                        ;Subtract background from A/D inputs
00BF  57                        PUSH DI          ;SAVE DATA ADDR.
00C0  BA 0200                   MOV  DX,0200H    ;BACKGROUND DATA
00C3  03 D3                     ADD  DX,BX       ;  ADDRESS
00C5  03 D3                     ADD  DX,BX       ;  + 2 TIMES
00C7  8B FA                     MOV  DI,DX       ;  BL (AD#)
00C9  8B 15                     MOV  DX,[DI]     ;GET BACKGROUND
00CB  2B C2                     SUB  AX,DX       ;DIFFERENCE IN AX

                        ;Store Difference in memory
                        ;  AD0-W, AD1-X, AD2-Y, & AD3-Z
00CD  5F                        POP  DI          ;DIFFERENCE ADDRESS
00CE  89 05                     MOV  [DI],AX     ;DIFFERENCE IN MEMORY
00D0  83 C7 08                  ADD  DI,8        ;INCREASE ADDR BY 8

                        ;Obtain another AD# (channel # 1, 2 or 3)
00D3  FE C3                     INC  BL          ;INCREASE AD# BY 1
00D5  80 FB 04                  CMP  BL,4        ;IS BL > 3 i.e. (= 4)
00D8  75 AE                     JNZ  NEXTAD      ;NO?  THEN REPEAT

                        ;Take three ratios:
                        ;   AD1-X/AD0-W, AD2-Y/AD0-W, AD3-Z/AD0-W
00DA  BB 0210                   MOV  BX,0210H    ;ADDR OF DIVISOR AD0-W
00DD  8B C3                     MOV  AX,BX       ;COPY INTO AX
00DF  05 0008                   ADD  AX,8        ;ADDRESS OF DIVIDEND
00E2  8B F8                     MOV  DI,AX       ;  AD1-X IN DI
00E4  8B CB                     MOV  CX,BX       ;ADDR OF AD1-X/AD0-W
00E6  83 C1 20                  ADD  CX,20H      ;  OFFSET FROM DIVISOR
```

```
00E9  8B F1                    MOV  SI,CX      ;  BY 20H (IN SI)
00EB  B9 0003                  MOV  CX,3       ;3 RATIOS
00EE  9B DB 05           NXRAT: FILD DWORD PTR [DI] ;LD DIVIDEND-80287
00F1  9B DA 37                  FIDIV DWORD PTR [BX];DIVIDE INTEGER
00F4  9B D9 1C                  FSTP DWORD PTR [SI] ;STORE REAL & POP
00F7  83 C7 08                  ADD  DI,8       ;NEXT AD# DIFFERENCE
00FA  83 C6 08                  ADD  SI,8       ;NEXT AD# RATIO ADDR
00FD  E2 EF                     LOOP NXRAT      ;CALCULATE NEXT RATIO

                         ;Sum the three ratios
00FF  83 C3 20                  ADD  BX,20H     ;ADDR OF AD1-X/AD0-W
0102  8B FB                     MOV  DI,BX      ;  IN DI
0104  8B C3                     MOV  AX,BX      ;ADDR SUM AD1-X/AD0-W
0106  05 0020                   ADD  AX,20H     ;  20H HIGHER ADDR
0109  8B F0                     MOV  SI,AX      ;  IN SI
010B  B9 0003                   MOV  CX,3       ;3 SUMS
010E  9B D9 04           NXSUM: FLD  DWORD PTR [SI] ;LD REAL SUM
0111  9B D8 05                  FADD DWORD PTR [DI] ;ADD REAL
0114  9B D9 1C                  FSTP DWORD PTR [SI] ;STORE REAL & POP
0117  83 C7 08                  ADD  DI,8       ;ADDR OF NEXT RATIO
011A  83 C6 08                  ADD  SI,8       ;ADDR OF NEXT SUM
011D  E2 EF                     LOOP NXSUM      ;CALCULATE NEXT SUM

                         ;Prepare to obtain another set of 4 AD# read.

011F  BB 0210                   MOV  BX,0210H   ;OFFSET DATA ADDR.
0122  8B FB                     MOV  DI,BX      ;  INTO PTR DI
0124  BB 0000                   MOV  BX,0000H   ;SELECT AD# = AD0
0127  59                        POP  CX         ;# READINGS REMAINING
0128  49                       DEC  CX         ;  DECREASE BY 1
0129  E3 03                    JCXZ MEAN       ;END IF CX = 0
012B  E9 0055 R                 JMP  NEWSET     ;OTHERWISE LOOP

                         ;Calculate mean (divide each sum by N)
012E  B9 0003            MEAN:  MOV  CX,3       ;3 GROUPS OF SUMS
0131  BB 0208                   MOV  BX,00208H  ;ADDRESS
0134  8B FB                     MOV  DI,BX      ;  PTR FOR N
0136  BB 0250                   MOV  BX,0250H   ;OFFSET SUM ADDR.
0139  8B F3                     MOV  SI,BX      ;  INTO PTR SI
013B  9B D9 04           NXMEAN: FLD DWORD PTR [SI]  ;LOAD INTO 80287
013E  9B DA 35                  FIDIV DWORD PTR [DI] ;DIVIDE BY N
0141  9B D9 1C                  FSTP DWORD PTR [SI] ;STORE & POP MEAN
0144  83 C6 08                  ADD  SI,8       ;NEXT OFFSET SUM ADDR
0147  E2 F2                     LOOP NXMEAN     ;REPEAT FOR NEXT MEAN

                         ;Multiply by 10000d and change to integer
0149  BB 0268                   MOV  BX,0268H   ;ADDRESS OF MULTIPLIER
014C  B8 2710                   MOV  AX,2710H   ;MOV+ 10000d MULTIPL.
014F  89 07                     MOV  [BX],AX    ;  INTO ADDR. 0268H
0151  BA 0250                   MOV  DX,0250H   ;OFFSET MEAN ADDR
0154  8B FA                     MOV  DI,DX      ;  POINTED TO BY DI
0156  BA 0270                   MOV  DX,0270H   ;ADDRESS OF ANSWER
0159  8B F2                     MOV  SI,DX      ;  POINTED BY SI
015B  B9 0003                   MOV  CX,3       ;REPEAT FOR 3 MEANS
```

```
015E  9B D9 05                CONINT: FLD DWORD PTR [DI] ;LOAD MEAN IN 80287
0161  9B DA 0F                        FIMUL DWORD PTR [BX];MULTIPLY X 10000D
0164  9B DB 1C                        FISTP DWORD PTR [SI]  ;STORE & POP ANS
0167  83 C7 08                        ADD  DI,8        ;POINT NEXT MEAN
016A  83 C6 08                        ADD  SI,8        ;POINT NEXT ANSWER
016D  E2 EF                           LOOP CONINT      ;NEXT CONVERT2INTEGER

                              ;Stop After 3 ANSWERS in memory--short integer
016F  58                              POP  AX
0170  5E                              POP  SI
0171  1F                              POP  DS
0172  5D                              POP  BP
0173  90                              NOP
0174  90                              NOP
0175  CB                              RET      ;RTN BASIC
0176  90                              NOP
0177  90                              NOP

                              MAIN    ENDP     ;END OF MAIN PART OF PROGRAM
0178  0190[                           DB 400D  DUP(?) ;RESERVE DATA AREA
        ??
                          ]

                              ;-----------------------------------------------
0308                          PROGNAM ENDS
                              ;***********************************************

                                      END      START   ;END ASSEMBLY
```

```
Microsoft (R) Macro Assembler  Version 4.00                10/29/87 14:49:17
                                                           Symbols-1


Segments and Groups:

                N a m e                 Size     Align   Combine Class

PROGNAM  . . . . . . . . . . . .        0308     PARA    NONE
ST_SEG . . . . . . . . . . . . .        00A0     PARA    STACK

Symbols:

                N a m e                 Type     Value   Attr

CONINT . . . . . . . . . . . . .        L NEAR   015E    PROGNAM
CONV . . . . . . . . . . . . . .        L NEAR   00A8    PROGNAM

FILL . . . . . . . . . . . . . .        L NEAR   0044    PROGNAM

MAIN . . . . . . . . . . . . . .        F PROC   0000    PROGNAM Length = 0178
MEAN . . . . . . . . . . . . . .        L NEAR   012E    PROGNAM

NEWSET . . . . . . . . . . . . .        L NEAR   0055    PROGNAM
NEXTAD . . . . . . . . . . . . .        L NEAR   0088    PROGNAM
NXMEAN . . . . . . . . . . . . .        L NEAR   013B    PROGNAM
NXRAT  . . . . . . . . . . . . .        L NEAR   00EE    PROGNAM
NXSUM  . . . . . . . . . . . . .        L NEAR   010E    PROGNAM

START  . . . . . . . . . . . . .        L NEAR   0000    PROGNAM

TRANS  . . . . . . . . . . . . .        L NEAR   0097    PROGNAM


    288 Source  Lines
    288 Total   Lines
     35 Symbols

  49350 Bytes symbol space free

      0 Warning Errors
      0 Severe  Errors

C:\BG>
```

TABLE IIIB ASSEMBLY LANGUAGE PROGRAM ALLEN7R.EXE

```
SYMDEB ALLEN7R.EXE
Microsoft (R) Symbolic Debug Utility  Version 4.00
Copyright (C) Microsoft Corp 1984, 1985.  All rights reserved.

Processor is [80286]
-R
AX=0000  BX=0000  CX=03A8  DX=0000  SP=00A0  BP=0000  SI=0000  DI=0000
DS=2E17  ES=2E17  SS=9FC0  CS=9FCA  IP=0000   NV UP EI PL NZ NA PO NC
9FCA:0000 55              PUSH   BP
-U0,177
9FCA:0000 55              PUSH   BP
9FCA:0001 1E              PUSH   DS
9FCA:0002 56              PUSH   SI
9FCA:0003 8CC8            MOV    AX,CS
9FCA:0005 8ED8            MOV    DS,AX
9FCA:0007 2BC0            SUB    AX,AX
9FCA:0009 50              PUSH   AX
9FCA:000A BAE2C2          MOV    DX,C2E2
9FCA:000D B80800          MOV    AX,0008
9FCA:0010 EE              OUT    DX,AL
9FCA:0011 BAE3C3          MOV    DX,C3E3
9FCA:0014 B80000          MOV    AX,0000
9FCA:0017 EE              OUT    DX,AL
9FCA:0018 BAE222          MOV    DX,22E2
9FCA:001B B80000          MOV    AX,0000
9FCA:001E EE              OUT    DX,AL
9FCA:001F BAE322          MOV    DX,22E3
9FCA:0022 EE              OUT    DX,AL
9FCA:0023 BAE222          MOV    DX,22E2
9FCA:0026 B004            MOV    AL,04
9FCA:0028 EE              OUT    DX,AL
9FCA:0029 BAE322          MOV    DX,22E3
9FCA:002C B000            MOV    AL,00
9FCA:002E EE              OUT    DX,AL
9FCA:002F BAE222          MOV    DX,22E2
9FCA:0032 B000            MOV    AL,00
9FCA:0034 EE              OUT    DX,AL
9FCA:0035 BAE322          MOV    DX,22E3
9FCA:0038 EE              OUT    DX,AL
9FCA:0039 BB1002          MOV    BX,0210
9FCA:003C 8BFB            MOV    DI,BX
9FCA:003E B98000          MOV    CX,0080
9FCA:0041 B80000          MOV    AX,0000
9FCA:0044 8905            MOV    [DI],AX
9FCA:0046 47              INC    DI
9FCA:0047 E2FB            LOOP   0044
9FCA:0049 BB0802          MOV    BX,0208
9FCA:004C 8B0F            MOV    CX,[BX]
9FCA:004E BB1002          MOV    BX,0210
9FCA:0051 8BFB            MOV    DI,BX
9FCA:0053 B004            MOV    AL,04
9FCA:0055 51              PUSH   CX
9FCA:0056 BAE2C2          MOV    DX,C2E2
9FCA:0059 B80800          MOV    AX,0008
9FCA:005C EE              OUT    DX,AL
9FCA:005D BAE3C3          MOV    DX,C3E3
9FCA:0060 B80000          MOV    AX,0000
9FCA:0063 EE              OUT    DX,AL
```

```
9FCA:0064 BAE222        MOV     DX,22E2
9FCA:0067 B008          MOV     AL,08
9FCA:0069 EE            OUT     DX,AL
9FCA:006A BAE322        MOV     DX,22E3
9FCA:006D B000          MOV     AL,00
9FCA:006F EE            OUT     DX,AL
9FCA:0070 BAE222        MOV     DX,22E2
9FCA:0073 B000          MOV     AL,00
9FCA:0075 EE            OUT     DX,AL
9FCA:0076 BAE322        MOV     DX,22E3
9FCA:0079 EE            OUT     DX,AL
9FCA:007A BAE2C2        MOV     DX,C2E2
9FCA:007D B009          MOV     AL,09
9FCA:007F EE            OUT     DX,AL
9FCA:0080 BAE3C2        MOV     DX,C2E3
9FCA:0083 B000          MOV     AL,00
9FCA:0085 EE            OUT     DX,AL
9FCA:0086 2BDB          SUB     BX,BX
9FCA:0088 BAE202        MOV     DX,02E2
9FCA:008B B000          MOV     AL,00
9FCA:008D EE            OUT     DX,AL
9FCA:008E BAE302        MOV     DX,02E3
9FCA:0091 8AC3          MOV     AL,BL
9FCA:0093 EE            OUT     DX,AL
9FCA:0094 B92200        MOV     CX,0022
9FCA:0097 E2FE          LOOP    0097
9FCA:0099 BAE202        MOV     DX,02E2
9FCA:009C B001          MOV     AL,01
9FCA:009E EE            OUT     DX,AL
9FCA:009F BAE302        MOV     DX,02E3
9FCA:00A2 8AC3          MOV     AL,BL
9FCA:00A4 EE            OUT     DX,AL
9FCA:00A5 BAE202        MOV     DX,02E2
9FCA:00A8 ED            IN      AX,DX
9FCA:00A9 250100        AND     AX,0001
9FCA:00AC 75FA          JNZ     00A8
9FCA:00AE BAE202        MOV     DX,02E2
9FCA:00B1 B80000        MOV     AX,0000
9FCA:00B4 EE            OUT     DX,AL
9FCA:00B5 BAE302        MOV     DX,02E3
9FCA:00B8 8AC3          MOV     AL,BL
9FCA:00BA EE            OUT     DX,AL
9FCA:00BB BAE222        MOV     DX,22E2
9FCA:00BE ED            IN      AX,DX
9FCA:00BF 57            PUSH    DI
9FCA:00C0 BA0002        MOV     DX,0200
9FCA:00C3 03D3          ADD     DX,BX
9FCA:00C5 03D3          ADD     DX,BX
9FCA:00C7 8BFA          MOV     DI,DX
9FCA:00C9 8B15          MOV     DX,[DI]
9FCA:00CB 2BC2          SUB     AX,DX
9FCA:00CD 5F            POP     DI
9FCA:00CE 8905          MOV     [DI],AX
9FCA:00D0 83C708        ADD     DI,+08
9FCA:00D3 FEC3          INC     BL
9FCA:00D5 80FB04        CMP     BL,04
9FCA:00D8 75AE          JNZ     0088
```

```
9FCA:00DA BB1002          MOV     BX,0210
9FCA:00DD 8BC3            MOV     AX,BX
9FCA:00DF 050800          ADD     AX,0008
9FCA:00E2 8BF8            MOV     DI,AX
9FCA:00E4 8BCB            MOV     CX,BX
9FCA:00E6 83C120          ADD     CX,+20
9FCA:00E9 8BF1            MOV     SI,CX
9FCA:00EB B90300          MOV     CX,0003
9FCA:00EE 9B              WAIT
9FCA:00EF DB05            FILD    DWord Ptr [DI]
9FCA:00F1 9B              WAIT
9FCA:00F2 DA37            FIDIV   DWord Ptr [BX]
9FCA:00F4 9B              WAIT
9FCA:00F5 D91C            FSTP    DWord Ptr [SI]
9FCA:00F7 83C708          ADD     DI,+08
9FCA:00FA 83C608          ADD     SI,+08
9FCA:00FD E2EF            LOOP    00EE
9FCA:00FF 83C320          ADD     BX,+20
9FCA:0102 8BFB            MOV     DI,BX
9FCA:0104 8BC3            MOV     AX,BX
9FCA:0106 052000          ADD     AX,0020
9FCA:0109 8BF0            MOV     SI,AX
9FCA:010B B90300          MOV     CX,0003
9FCA:010E 9B              WAIT
9FCA:010F D904            FLD     DWord Ptr [SI]
9FCA:0111 9B              WAIT
9FCA:0112 D805            FADD    DWord Ptr [DI]
9FCA:0114 9B              WAIT
9FCA:0115 D91C            FSTP    DWord Ptr [SI]
9FCA:0117 83C708          ADD     DI,+08
9FCA:011A 83C608          ADD     SI,+08
9FCA:011D E2EF            LOOP    010E
9FCA:011F BB1002          MOV     BX,0210
9FCA:0122 8BFB            MOV     DI,BX
9FCA:0124 BB0000          MOV     BX,0000
9FCA:0127 59              POP     CX
9FCA:0128 49              DEC     CX
9FCA:0129 E303            JCXZ    012E
9FCA:012B E927FF          JMP     0055
9FCA:012E B90300          MOV     CX,0003
9FCA:0131 BB0802          MOV     BX,0208
9FCA:0134 8BFB            MOV     DI,BX
9FCA:0136 BB5002          MOV     BX,0250
9FCA:0139 8BF3            MOV     SI,BX
9FCA:013B 9B              WAIT
9FCA:013C D904            FLD     DWord Ptr [SI]
9FCA:013E 9B              WAIT
9FCA:013F DA35            FIDIV   DWord Ptr [DI]
9FCA:0141 9B              WAIT
9FCA:0142 D91C            FSTP    DWord Ptr [SI]
9FCA:0144 83C608          ADD     SI,+08
9FCA:0147 E2F2            LOOP    013B
9FCA:0149 BB6802          MOV     BX,0268
9FCA:014C B81027          MOV     AX,2710
9FCA:014F 8907            MOV     [BX],AX
```

```
9FCA:0151 BA5002          MOV     DX,0250
9FCA:0154 8BFA            MOV     DI,DX
9FCA:0156 BA7002          MOV     DX,0270
9FCA:0159 8BF2            MOV     SI,DX
9FCA:015B B90300          MOV     CX,0003
9FCA:015E 9B              WAIT
9FCA:015F D905            FLD     DWord Ptr [DI]
9FCA:0161 9B              WAIT
9FCA:0162 DA0F            FIMUL   DWord Ptr [BX]
9FCA:0164 9B              WAIT
9FCA:0165 DB1C            FISTP   DWord Ptr [SI]
9FCA:0167 83C708          ADD     DI,+08
9FCA:016A 83C608          ADD     SI,+08
9FCA:016D E2EF            LOOP    015E
9FCA:016F 58              POP     AX
9FCA:0170 5E              POP     SI
9FCA:0171 1F              POP     DS
9FCA:0172 5D              POP     BP
9FCA:0173 90              NOP
9FCA:0174 90              NOP
9FCA:0175 CB              RETF
9FCA:0176 90              NOP
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16. Abstract

An assembly language program using the Intel 80386 CPU and 80387 math co-processor chips was written to increase the speed of data gathering and processing, and provide control of a scanning CW ring dye laser system. This laser system is used in high resolution (better than 0.001 cm-1) water vapor spectroscopy experiments. Laser beam power is sensed at the input and output of white cells and the output of a Fabry-Perot. The assembly language subroutine is called from Basic, acquires the data and performs various calculations at rates greater than 150 faster than could be performed by the higher level language. The width of output control pulses generated in assembly language are 3 to 4 microseconds as compared to 2 to 3.7 milliseconds for those generated in Basic (about 500 to 1000 times faster).

Included are a block diagram and brief description of the spectroscopy experiment, a flow diagram of the basic and assembly language programs, listing of the programs, scope photographs of the computer generated 5-volt pulses used for control and timing analysis, and representative water spectrum curves obtained using these programs.

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