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USER'S GUIDE TO NOISE DATA ACQUISITION AND ANALYSIS PROGRAMS FOR HP9845 - NICOLET ANALYZERS

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SUMMARY

A complete software interface package has been written for use with the Hewlett Packard 9845B desktop computer and the Nicolet Scientific Corporation 444A and 446AR single channel Fast Fourier analyzers. This software features a portable measurement and analysis system with several options. Two types of interface hardware can alternately be used in conjunction with the software. Either an IEEE-488 Bus interface or a 16-bit parallel system may be used. Two types of storage medium, either tape cartridge or floppy disc can be used with the software. Five types of data may be stored, plotted, and/or printed. The data types include time histories, narrow band power spectra, and narrow band, one-third octave band, or octave band sound pressure level. The data acquisition programming includes a front panel remote control option for the FFT analyzers. Data analysis options include choice of line type and pen color for plotting.

INTRODUCTION

When gathering data for research purposes, the noise and vibration control engineer often uses special data acquisition and data analysis techniques. These techniques often require knowledge of the time history or frequency character of a time varying electrical signal that is proportional to sound pressure, vibration velocity, or some other physical parameter of interest. Recent advances in digital signal processing have resulted in widespread use of the digital Fast Fourier Transform (FFT) as one of the engineer's fundamental signal processing tools. On many occasions, the engineer finds that it is necessary or desirable to digitize, store, retrieve, and/or manipulate FFT data on site. This type of signal processing capability is not always available for many field experiments, where direct lines to large computer systems do not exist. Consequently, in the interest of expanding the

engineer's data analysis capabilities, and in the belief that the resarch engineer should have the FFT tool at his disposal for field experiments, the a general interface package for the portable Hewlett-Packard 9845B computer-calculator and the Nicolet Scientific Corporation 444A and 446AR Fast Fourier Analyzers has been written.

The user will find that the software is flexible enough to adapt to several modes of operation and intricate enough to include four types of data acquisition with five possible hardware setups. The user should also find, after some preliminary use, that the software is user oriented.

This paper has been written to serve as an introducto., guide to the operation of this software. Hopefully, after some practice, the user will find that he is so familiar with the various prompts in the programming that this document is no longer needed.

HARDWARE CONFIGURATIONS

The first step in using the HP 9845B software is deciding on which hardware configuration is best suited for a particular measurement. There are five distinct FFT-storage medium setups available to the user. Table I lists the programs for the various equipment combinations that are possible. Each combination has its advantages and disadvantages. For example, the simplest equipment setups of Table I uses the HP 9845B computer with the NSC 444A or the NSC 446AR analyzers with no extra peripheral equipment. The speediest equipment setup uses the HP 9895A disc drive along with the computer and the FFT analyzer. The most compact arrangement allows the user to measure and store data using the NSC 144A tape recorder with either FFT analyzer, and later use the NSC 446AR analyzer and HP 9845B to manipulate the data. The most optimum arrangement depends on the particular requirements for each individual experiment and on the user's personal preferences.

DATA ACQUISITION AND MEASUREMENT CAPABILITIES

A summary of the measurement capabilities of the interface programs is shown in Table II. All front panel settings on the NSC 444A and NSC 446A may be manually set or remotely controlled through the programming. If manual control is chosen, the volts per engineering unit and the initiation of the averaging process continue to be remotely controlled, while all other panel settings must be set manually. Once ensemble averaging has been initiated, the computer will automatically check for signal level voltage overloads. The computer will not accept the data if the A to D converter experiences an overload on the input signal. Once the FFT analyzer has finished the averaging process, the computer will automatically transfer the data from the analyzer to the internal memory of the computer. The data is transferred in a coded ASCIIhexadecimal format in a byte serial transmission mode. The user then has the option of storing the data on tape or disc, or he may elect to repeat the measurement. The data is stored on tape (or disc) in its coded ASCII hexadecimal format. Once the data is stored on tape (or disc), the user may continue with another measurement or he may terminate the program. If the user wishes to continue with further measurements, he has the option of leaving the FFT analyzer settings in their current configuration or he may alter any one or more of them either manually or by using the remote control option.

DATA REDUCTION

As explained earlier, the data brought over from the FFT analyzer and stored on tape (or disc) is in a coded ASCII hexadecimal format. The data is stored in this unreduced (coded) format in order to save time on the data acquisition process. This mode of operation allows the user to measure and store many independent spectra or time histories in a relatively short period of time. If the user should need to observe the data as he obtains it, the CRT on the FFT analyzer is available for monitoring purposes.

Once the data are obtained and stored on tape (or disc), it must be reduced (decoded) to its proper engineering units values. This step is accomplished using the program "REDUCE." This program reads the coded ASCII hexadecimal data off of tape (or disc), decodes and reduces the data to its proper engineering unit values, and stores the data on a second tape† (or disc). Once the data are in this reduced status, it is ready for plotting, printing, or manipulating (see the next section on Data Analysis). Program "REDUCE" performs its work in a file oriented mode of operation. "REDUCE" is capable of decoding anywhere from 1 to 400 data files of any or all of the four different types of data. Table III shows the names of the four types of unreduced data files (stored by the data acquisition programs NSC 444 and NSC 446) and the four types of reduced data files created by the program "REDUCE." The double asterisk (**) in Table III signifies a 1 or 2 digit number in the range of 0 to 99.

DATA ANALYSIS

The analysis (plotting or printing) of stored FFT data is performed through the use of one of three specialized computer programs. Table IV summarizes these analysis programs and their respective plotting and printing capabilities. All three of the analysis programs have provisions for printing the data in a frequency (or time) vs. engineering unit value format and for plotting engineering units values vs. frequency (or time). Two separate plotting routines allow the user to select 7 x 11.5 cm plots on the HP 9845B CRT (Cathode Ray Tube) or 12.5 x 16.5 cm plots on the HP 9872A digital bed

†With one very minor program change the user could alter program "REDUCE" so that it stores the reduced data on the same tape (or disc) as the unreduced data. For backup purposes (in case of tape or disc failure) the two tape-disc system should be preferred.

plotter. CRT plots may be optionally dumped to the thermal printer and the routine for the larger HP 9872A plots has provisions for choosing four possible pen colors and 10 possible line types for the data. The 12.5 x 16.5 cm size of the HP 9872A plots was chosen for optimal use with NASA Langley Form 92 (viewgraph size). Each program contains a printing routine which may be optionally used with the CRT or the thermal printer. Any of the two plotter options and two printer options may be operated independently or together with a singla program run. Additionally, any number of data files may be plotted or printed with a single program run. Provisions in the progrmas also exist so that the user may re-plot or re-print a data file any number of times without having to recall the data off of tape (or disc).

STEP-BY-STEP GUIDE TO THE DATA ACQUISITION PROGRAMS

Before using the data acquisition programs (NSC 444 or NSC 446), the user should make certain that the FFT analyzer, the HP 9845B calculator, and the HP 9895A disc drive are plugged in and turned on. Before powering up, the user must be sure to connect the FFT analyzer with the calculator using the appropriate interface cable. If program NSC 444 is to be used, the HP 98032A 16-Bit parallel interface must be in place. Alternatively, if program NSC 446 is to be used, the HP 98034A Bus interface must be installed.

The data acquisition programs are loaded using the "GET" command. Once the program is loaded, execution begins by depressing the RUN button. See the flow chart of figure 1 for a summary of the data acquisition programming.

Prompt #1

ENTER TODAY'S DATE

Response: Type in the current calendar date.

Example: July 18 1981

Prompt #2

ENTER A ONE-LINE EXPLANATION OF THE EXPERIMENT

Example: PROGRAM TEST

Prompt #3

ENTER THE TRANSDUCER NUMBER

Response: Enter some number corresponding to the transducer currently being used

Prompt #4

ENTER A STRING DESCRIBING THE UNITS OF THE TRANSDUCER

Response: Enter a word or string of words describing the units of the physical parameter being measured.

Examples: Pa; Volts; g; m/s^2; Newtons

Prompt #5

ENTER THE VOLTS/ENG. UNIT FOR THIS TRANSDUCER

Response: Type in a real, positive number corresponding to the volts per engineering unit gain factor. For example, if 124 dB on a microphone produces 500 mv at the analyzer the volts per engineering unit is given by

.5 volts/$[(2 \times 10^{-5})(10^{124/20})]$Pa or .0158 volts/Pascal

Prompt #6

DO YOU WANT REMOTE CONTROL OF THE FRONT PANEL? YES/NO

Response: If remote control of the front panel settings of the FFT analyzer is desired, then answer "YES." If manual control is desired, respond "NO."

Note: If the response to Prompt #6 is "YES," turn to the section entitled "Remote Control" and continue with Prompt #6A.

Prompt #7

DO YOU WISH TO BEGIN MEASURING? YES/NO

Response: If the user is ready to begin data acquisition, then reply "YES." If the user wishes to transfer existing data or make changes in the analyzer's front panel settings, he should reply "NO."

Note: If the response to Prompt #7 is "YES," then go to Prompt #9.

Prompt #8

DO YOU WISH TO TRANSFER EXISTING DATA? YES/NO

Response: If data already exists on the Nicolet 144A tape storage unit, the data should now be transferred to the NSC 446AR analyzer. Once the data are loaded into the analyzer, it may be transferred to the HP 9845B calculator simply by responding with a "YES" to this prompt.

Note: If the user wishes to make front panel changes, he should respond with "NO." A "NO" reply will direct the user to Prompt #12. A "YES" reply will direct the user to Prompt #10.

Prompt #9

PRESS CONTINUE WHEN YOU ARE READY TO BEGIN AVERAGING

Response: Press the CONTINUE button to begin ensemble averaging.

Prompt #10

DO YOU WANT TO STORE THE DATA? STORE/STOP/RESTART

Response: "STORE" stores the data on tape or disc and directs the user to Prompt #11. "STOP" directs the user to Prompt #12. "RESTART" directs the user to Prompt #9.

Prompt #11

BEGIN STORAGE WITH (FILE TYPE) FILE NO?

Response: Enter a 1 or 2 digit number between 0 and 99. File storage will begin with this number and thereafter the files will be stored sequentially.

Note: This prompt only appears once for each type of data for a given program run.

Prompt #12

DO YOU WISH TO MEASURE AGAIN? YES/NO/CHANGES

Response: "YES" redirects the user to Prompt #7. "NO" terminates the program. "CHANGES" redirects the user to Prompt #6.

REMOTE CONTROL

Prompt #6A

DO YOU WISH TO REMOTELY SET ANY OF THESE SWITCHES? YES/NO

Response: Ten switches are listed on the CRT. If the user wishes to remotely set any of those switches, he must reply "YES." A "NO" response will return the user to Prompt #6A with a new listing of ten switches. Once all switches are remotely set to the user's specifications the program will direct the user to Prompt #6C. The "YES" reply directs the user to Prompt #6B.

Prompt #6B

WHICH SETTING DO YOU WISH TO CHANGE? Enter 1 through 10.

Response: Enter a number 1 through 10 corresponding to the number of the switch listed on the CRT that must be changed.

Note: Once the switch has been set to its desired position the program will return to Prompt #6A.

Prompt #6C

DO YOU WISH TO REMOTELY SET THE FRONT PANEL? YES/NO

Response: This is a fail-safe prompt. A "YES" reply will re-direct the user to Prompt #6A. A "NO" response directs the user to Prompt #6D.

Prompt #6D

DO YOU WANT MANUAL CONTROL? YES/NO

Response: A "YES" reply returns the user to the main program and directs him to Prompt #7. A "NO" response returns the user to the main program and directs him to Prompt #9.

STEP-BY-STEP GUIDE TO THE DATA REDUCTION PROGRAM

The data reduction program (REDUCE) should be loaded from tape or disc using the GET command. Once the program is loaded, the tape or disc containing the various programs should be removed. The tape (or disc) with the unreduced data should be placed in tape slot: T14 (disc slot: H8,0,0) and a blank tape (disc) that has already been initialized should be placed in tape slot: T15 (disc slot: H8,0,1). once these steps are taken, the user may begin execution by depressing the run button.

Prompt #1

DO YOU WANT TO DECODE ANY OF THE ABOVE FILES? YES/NO

Response: This prompt will appear for each of the four types of data files; TH$**, NB$**, TO$**, and OB$** respectively. If there are data files with time history information contained in them that must be reduced, the response to this prompt should be "YES." Similarly,

if there are unreduced files of one of the three types of spectral information, the response to the prompt should again be "YES."

Note: If the response to Prompt #1 is "YES," it will immediately be fo[illegible] by Prompts #2 and #3.

Prompt #2

ENTER THE LOWEST FILE NUMBER HERE

Response: The user should type in the lowest number (between 0 and 99) of the unreduced data files.

Prompt #3

ENTER THE HIGHEST FILE NUMBER HERE

Response: The user should type in the highest number (between 0 and 99) of the unreduced data files.

Prompt #4

PRESS CONTINUE WHEN YOU WANT TO COMMENCE THE DECODE SEQUENCE ....

Response: The user now may initiate the data reduction sequence by pressing the continue button. The program will begin with the lowest TH$** file number and reduce the files in sequence. The program will finish with the highest OB$** file number. During this data reduction process, the computer is on "automatic pilot" and need not be attended by the user. When the computer has completed its run it will leave a message on the CRT, informing the user that the data reduction task is complete.

STEP-BY-STEP GUIDE TO A DATA ANALYSIS PROGRAM

There are three distinct data analysis programs for the HP 9845B - Nicolet FFT analyzer interfae package (see Table IV). The data analysis programs for time history information, 400-line power spectrum information, and

for 400-line, third-octave, and octave sound pressure level information are named TSD444, PSD444, and SPL444 respectively. The programs may be loaded into the computer using the "GET" command. Each program requires that the data tape (disc) with the reduced data files (TMHS**, PRSD**, TOBD**, or OBSD**) be inserted into tape slot :T14 (disc slot :H8,0,1).

Operation and prompts of the three data analysis programs are very similar. Consequently, only the most complex program, SPL444, will be described in a step-by-step manner. See the flow chart of figure 2 for a summary of the data analysis programming.

THE MAIN PROGRAM

Prompt #1

ENTER THE 5 OR 6 LETTER NAME OF THE SPECTRAL DATA FILE

Response: The user should enter the name of the data file which he wishes to analyze. Any of the PRSD**, TOBD**, or OBSD** data files are acceptable choices.

Prompt #2

DO YOU WANT PLOTTED/PRINTED OUTPUT? PLOT/PRINT/BOTH

Response: If the user wishes to plot the data he should type "PLOT." If the user wishes to print the data he should type "PRINT." If the user wants both plotted and printed output he should type "BOTH."

NOTE: See the #3 series of prompts for plotting. See the #4 series of prompts for printing.

Prompt #5

PLOT/PRINT AGAIN USING THIS DATA FILE? YES/NO

Response: After the data has been plotted or printed or both, this prompt will appear. If the user wants another copy of the plotted or printed data or if the user is unsatisfied with the scaling on the first attempt at plotting, he may now reinitiate the analysis routines without re-reading the data off of tape or disc. A "YES" response re-directs the user to Prompt #2. A "NO" response directs the user to Prompt #6.

Prompt #6

PLOT ANOTHER FILE? YES/NO

Response: A "YES" response directs the user to Prompt #1. A "NO" response terminates the program.

PLOTTING

Prompt #3A

ENTER THE Y-AXIS UPPER PLOT LIMIT

Response: The maximum and minimum values of the data are printed on the CRT. The user should enter a number for the maximum value of the y-axis. Ordinarily, the maximum value of the y-axis should be some number greater than the maximum data value.

Prompt #3B

ENTER THE Y-AXIS LOWER PLOT LIMIT

Response: The maximum and minimum values of the data are printed on the CRT. The user should enter a number for the minimum value of the y-axis. Ordinarily, the minimum value of the y-axis is some number less than the minimum data value.

Prompt #3C

DO YOU WISH TO SEE THE PLOT ON THE CRT FIRST? YES/NO

Response: A "YES" response will create a plot on the CRT and moves on to Prompt #3D. A "NO" response directs the user to Prompt #3D.

Prompt #3D

DO YOU WANT A HARD COPY PLOT? YES/NO

Response: A "YES" response creates a plot on the HP 9872A digital bed plotter. Two additional prompts appear in the bed plotter routine which specify pen color and line type for the data. Once the bed plot is complete, the user is directed either to the printing routine or Prompt #5. A "NO" response directs the user either to the printing routine or Prompt #5.

PRINTING

Prompt #4

PRINT HARD COPY OR SOFT? HARD/SOFT

Response: If the user responds with "HARD" the computer will print the data on the thermal printer. If the user responds with "SOFT" the computer will list the data on the CRT.

This concludes the instructions for use of the HP 9845B-NSC 444A, NSC 446 AR software interface package.

DISCUSSION

Examples of the output produced by the data analysis programming is contained in Appendices A-C. Each appendix contains an example of the plots generated on the HP 9845B CRT, an example of the plots generated on the HP 9872A digital bed plotter, and an example of the printed output (listings) that can be obtained from the HP 9845B thermal printer. Appendix A contains example output of time histories, Appendix B contains example output of power spectrum data, and Appendix C contains example output for narrowband, 1/3 octave band, and octave band sound pressure level data.

Table I.- Data Acquisition Programs

(FOR VARIOUS HARDWARE CONFIGURATIONS)

*THE PROGRAM AUTOMATICALLY SPECIFIES THE INTERFACE		STORAGE MEDIUM			
		HP 9845B TAPE	HP 9895A DISC	Nicolet 144A TAPE	
FFT ANALYZER	Nicolet 444 A	NSC444	NSC444	X	PROGRAM NAMES
	Nicolet 446 AR	NSC444 or NSC446	NSC444 or NSC446	NSC446	

*PROGRAM NSC444 USES THE HP 98032A 16-BIT PARALLEL INTERFACE

*PROGRAM NSC446 USES THE HP 98034A BUS INTERFACE

Table II.- Data Acquisition Capabilities

(NSC444 & NSC446)

- OPTIONAL REMOTE CONTROL OF ANALYZER FRONT PANEL SETTINGS
- CALIBRATION IN ENGINEERING UNITS
- SIGNAL VOLTAGE OVERLOAD PROTECTION
- DATA STORAGE MEDIUM OVERFLOW PROTECTION
- TWO POSSIBLE STORAGE MEDIA (TAPE OR DISC)
- MULTIPLE MEASUREMENTS IN A SINGLE PROGRAM RUN
- OPTIONAL REPEAT OF A PARTICULAR MEASUREMENT
- MEASUREMENT AND STORAGE OF TIME HISTORIES
- MEASUREMENT AND STORAGE OF 400-LINE NARROW BAND SPECTRA, 1/3 OCTAVE BAND SPECTRA, AND OCTAVE BAND SPECTRA

Table III.- Data File Names

DATA TYPES	FILE NAMES	
	UNREDUCED DATA	REDUCED DATA
TIME HISTORIES	TH$**	TMHS**
400-LINE SPECTRA	NB$**	PRSD**
1/3 OCTAVE SPECTRA	TO$**	TOBD**
OCTAVE SPECTRA	OB$**	OBSD**

The double asterisk (**) signifies a 1 or 2 digit number in the range of 0 to 99.

Table IV.- Data Analysis Capabilities

PLOTTING & PRINTING ROUTINES

KEY: • = BASIC CAPABILITIES , ★ = CHOICE OF COLOR , † = CHOICE OF LINE TYPES

DATA TYPE	PROGRAM NAME / DATA FILE	CAPABILITIES			
		PLOTTING		PRINTING	
		CRT	HP 9872A	CRT	THERMAL PRINTER
TIME HISTORIES	TSD444 / TMHS**	•	• ★ †	•	•
POWER SPECTRA	PSD444 / PRSD**	•	• ★ †	•	•
400-LINE SPL	SPL444 / PRSD**	•	• ★ †	•	•
1/3 OCTAVE SPL	SPL444 / TOBD**	•	• ★ †	•	•
OCTAVE SPL	SPL444 / OBSD**	•	• ★ †	•	•

The double asterisk (**) signifies a 1 or 2 digit number in the range of 0 to 99.

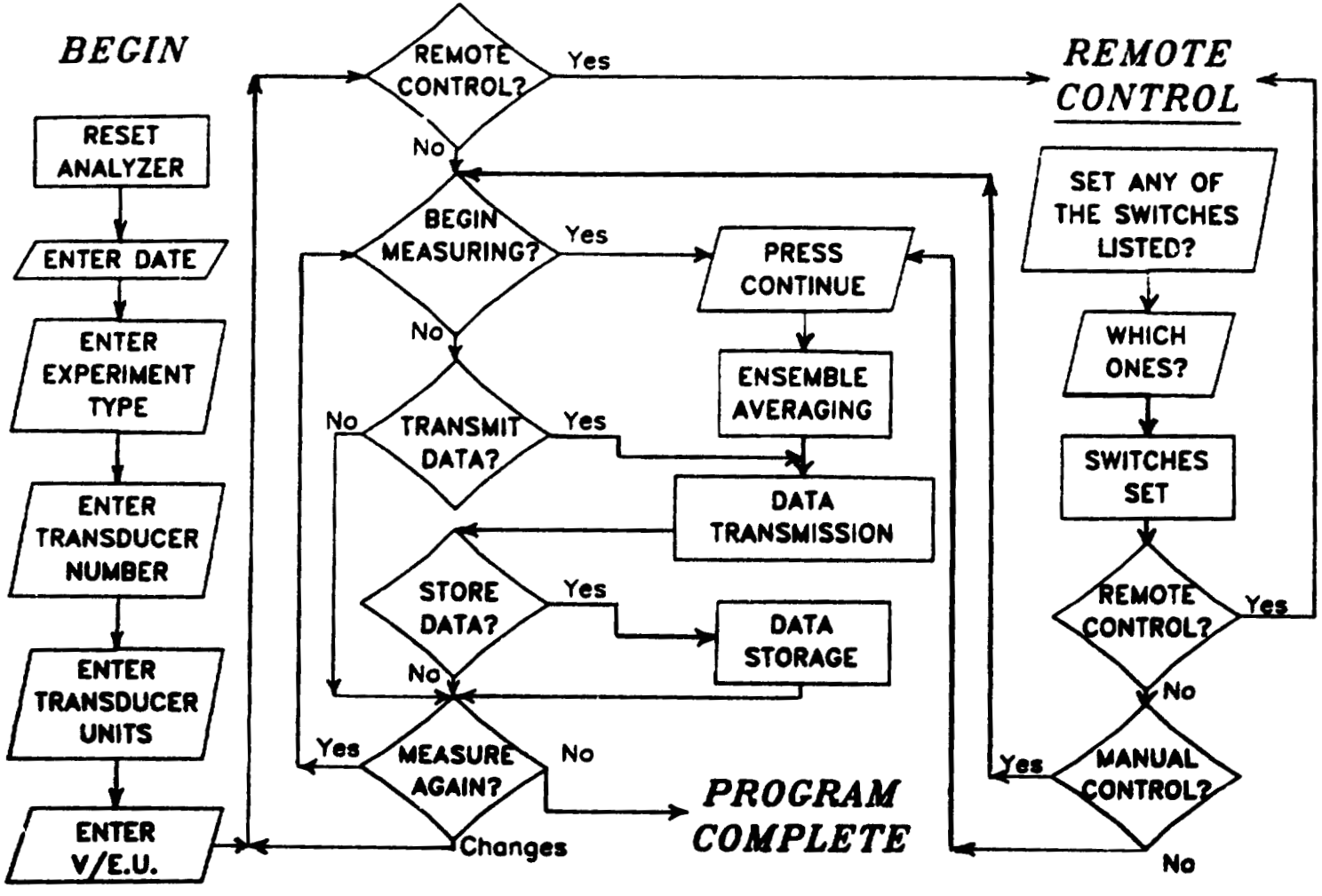

Figure 1.- Data acquisition flow chart.

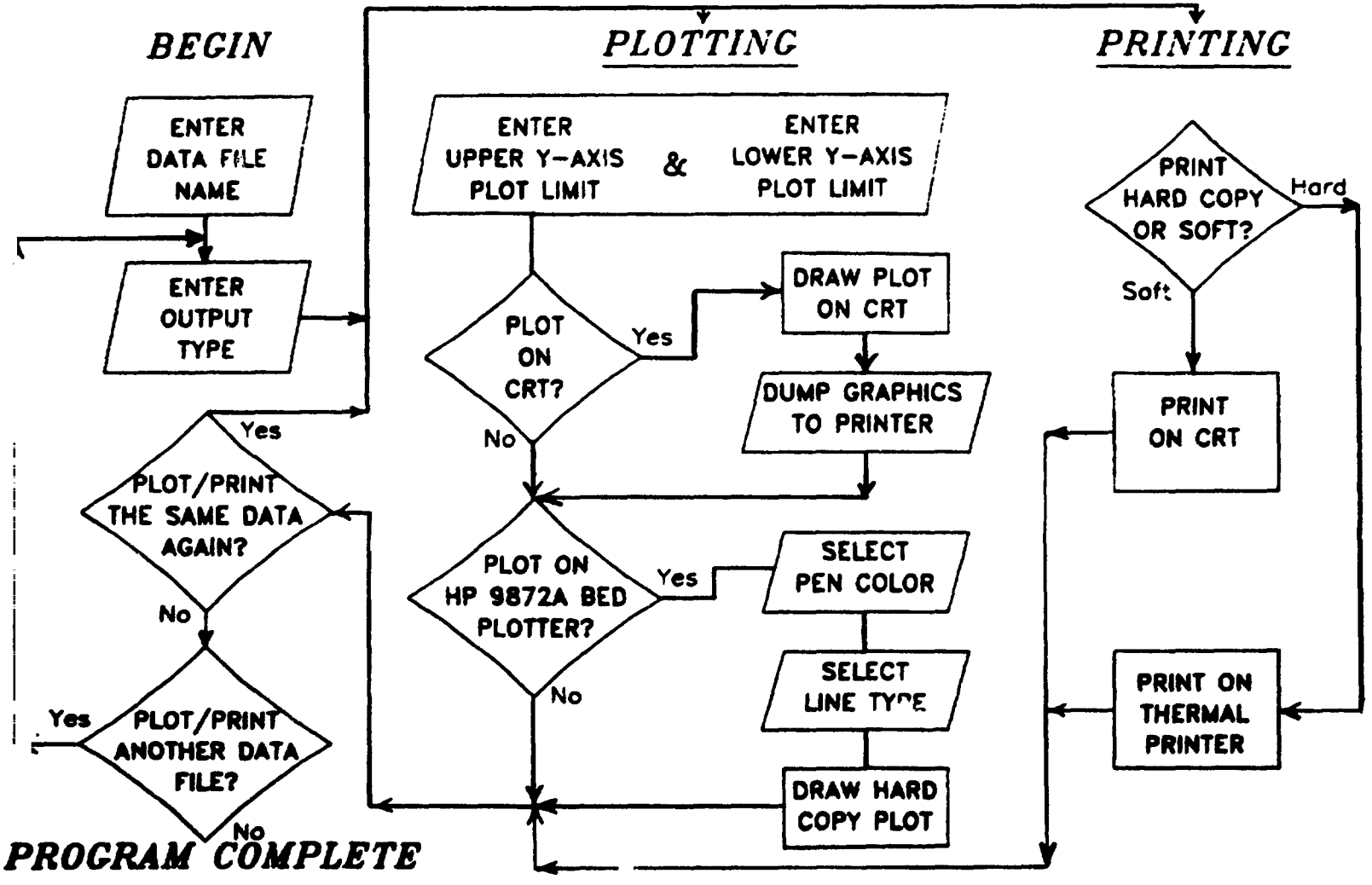

Figure 2.- Data analysis flow chart.

APPENDIX A

EXAMPLES OF TIME SERIES OUTPUT

Table A1. Example time series output printed by program TSD444.

TIME (sec)	MAGNITUDE IN VOLTS TRANSDUCER NO. 1
.000008	1.121E+00
.000016	1.140E+00
.000023	1.165E+00
.000031	1.173E+00
.000039	1.204E+00
.000047	1.222E+00
.000055	1.244E+00
.000063	1.259E+00
.000070	1.282E+00
.000078	1.289E+00
.000086	1.308E+00
.000094	1.321E+00
.000102	1.351E+00
.000109	1.334E+00
.000117	1.364E+00
.000125	1.367E+00
.000133	1.377E+00
.000141	1.390E+00
.000148	1.388E+00
.000156	1.404E+00
.000164	1.414E+00
.000172	1.411E+00
.000180	1.440E+00
.000188	1.423E+00
.000195	1.437E+00
.000203	1.434E+00
.000211	1.442E+00
.000219	1.423E+00
.000227	1.440E+00
.000234	1.422E+00
.000242	1.419E+00
.000250	1.416E+00
.000258	1.408E+00
.000266	1.401E+00
.000273	1.395E+00
.000281	1.386E+00
.000289	1.366E+00
.000297	1.359E+00
.000305	1.360E+00
.000313	1.330E+00
.000320	1.337E+00
.000328	1.317E+00
.000336	1.296E+00
.000344	1.287E+00
.000352	1.263E+00
.000359	1.247E+00
.000367	1.228E+00
.000375	1.214E+00
.000383	1.199E+00
.000391	1.163E+00
.000398	1.155E+00
.000406	1.125E+00
.000414	1.114E+00
.000422	1.071E+00
.000430	1.068E+00
.000438	1.039E+00
.000445	1.006E+00
.000453	9.830E-01

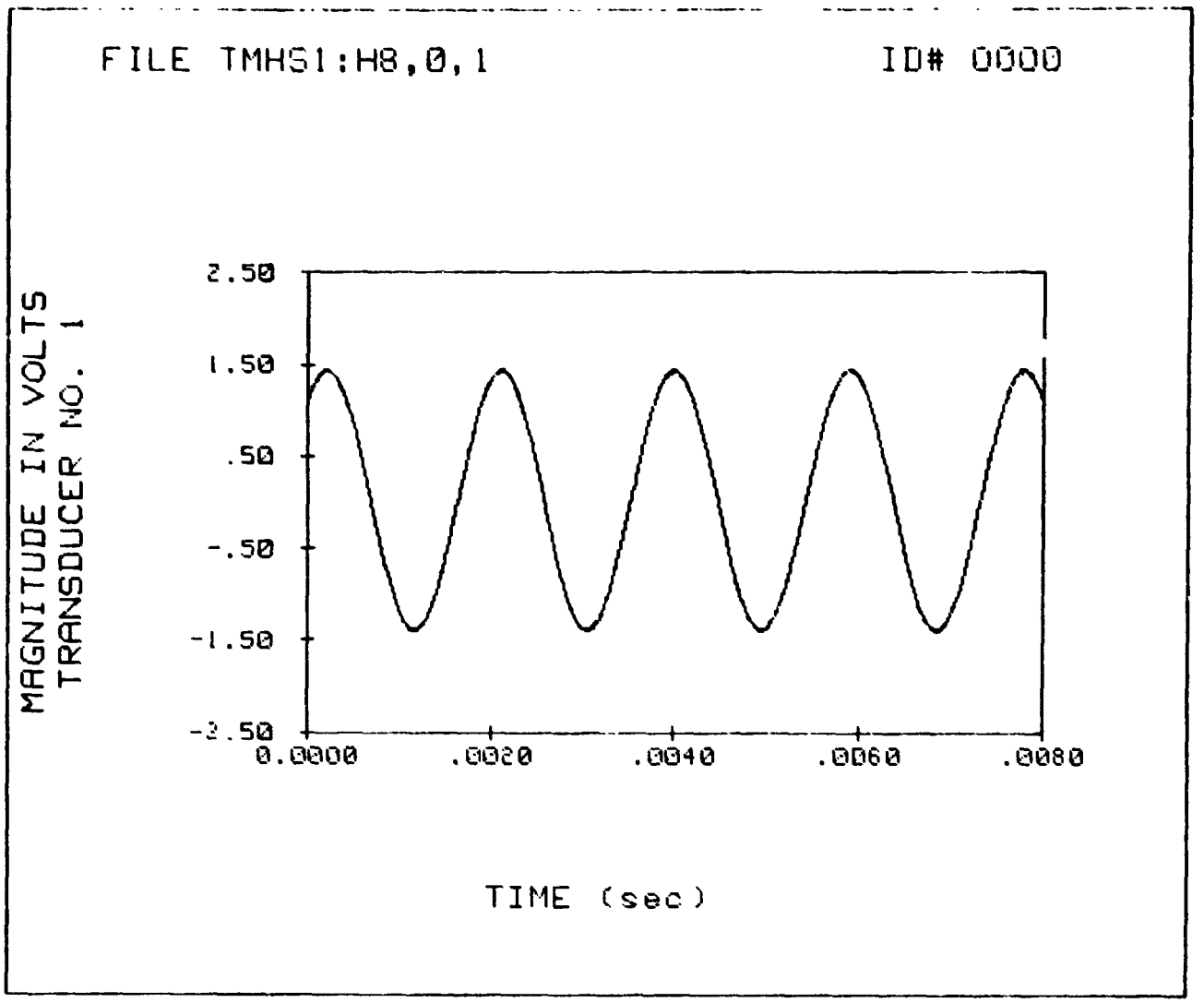

Figure A1. Example times series output on the HP 9845B CRT from program TSD444.

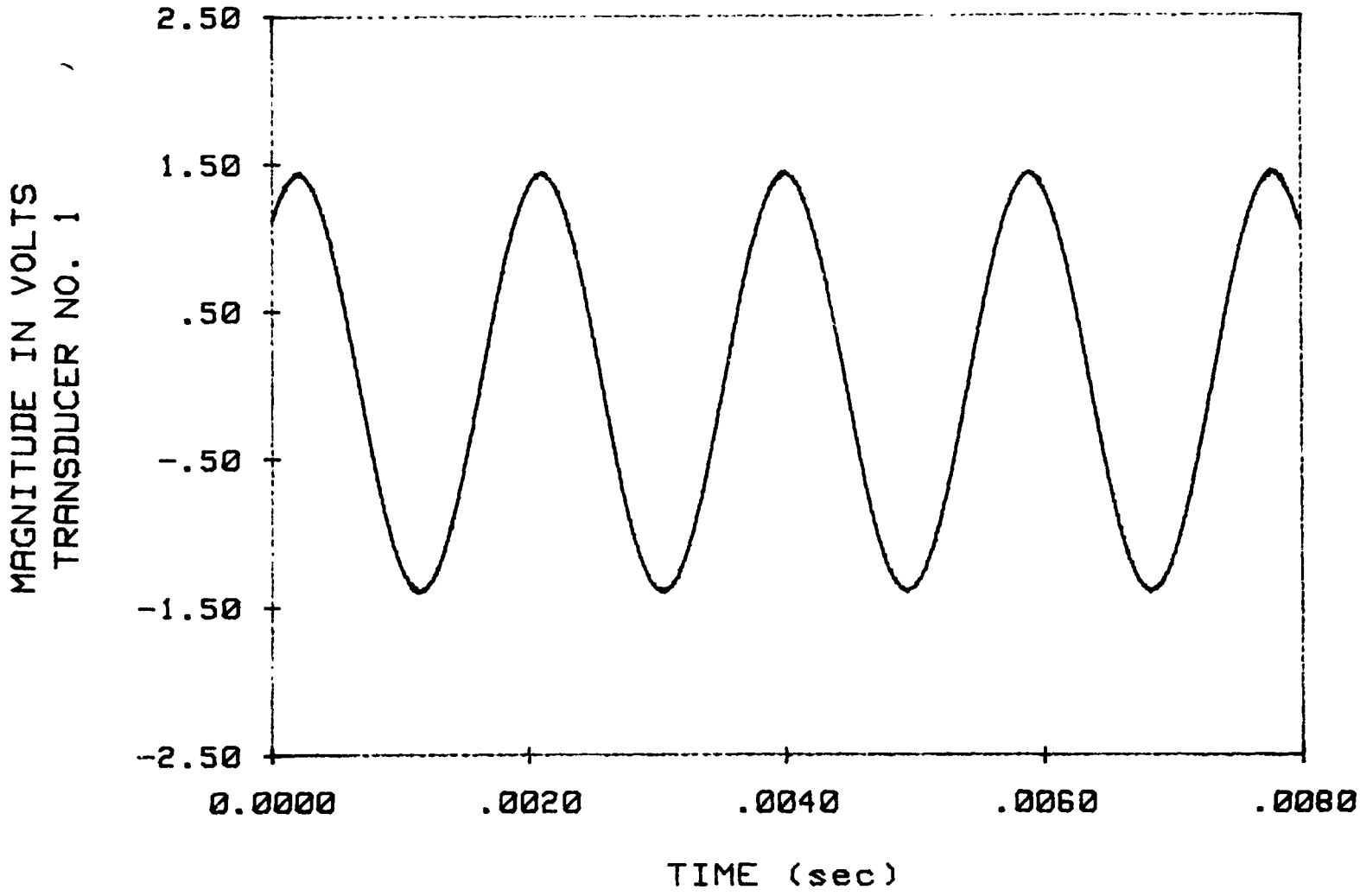

Figure A2. Example time series output on the HP 9872A from Program TSD444.

APPENDIX B

EXAMPLES OF POWER SPECTRUM OUTPUT

Table B1. Example of auto spectrum data printed by program PSD444.

FREQUENCY (Hz)	AUTO SPECTRUM [m/sec^2]^2 TRANSDUCER NO. 2
12.50	3.540E-02
25.00	4.834E-02
37.50	2.332E-02
50.00	1.697E-02
62.50	1.685E-02
75.00	1.300E-02
87.50	9.705E-03
100.00	9.583E-03
112.50	1.361E-02
125.00	1.184E-02
137.50	1.215E-02
150.00	8.545E-03
162.50	6.409E-03
175.00	3.189E-03
187.50	2.411E-03
200.00	5.005E-03
212.50	4.028E-03
225.00	2.991E-03
237.50	2.960E-03
250.00	3.891E-03
262.50	4.791E-03
275.00	6.714E-03
287.50	3.189E-03
300.00	1.045E-03
312.50	2.228E-03
325.00	3.235E-03
337.50	2.991E-03
350.00	3.769E-03
362.50	2.792E-03
375.00	3.357E-03
387.50	4.425E-03
400.00	4.791E-03
412.50	3.540E-03
425.00	2.991E-03
437.50	4.272E-03
450.00	2.182E-03
462.50	1.625E-03
475.00	1.457E-03
487.50	1.633E-03
500.00	2.304E-03
512.50	1.183E-03
525.00	1.137E-03
537.50	2.548E-03
550.00	2.396E-03
562.50	1.892E-03
575.00	1.087E-03
587.50	6.943E-04
600.00	1.305E-03
612.50	1.369E-03
625.00	1.678E-03
637.50	9.232E-04
650.00	1.228E-03
662.50	1.572E-03
675.00	1.297E-03
687.50	1.953E-03
700.00	1.129E-03
712.50	5.531E-04
725.00	1.312E-03
737.50	2.151E-03

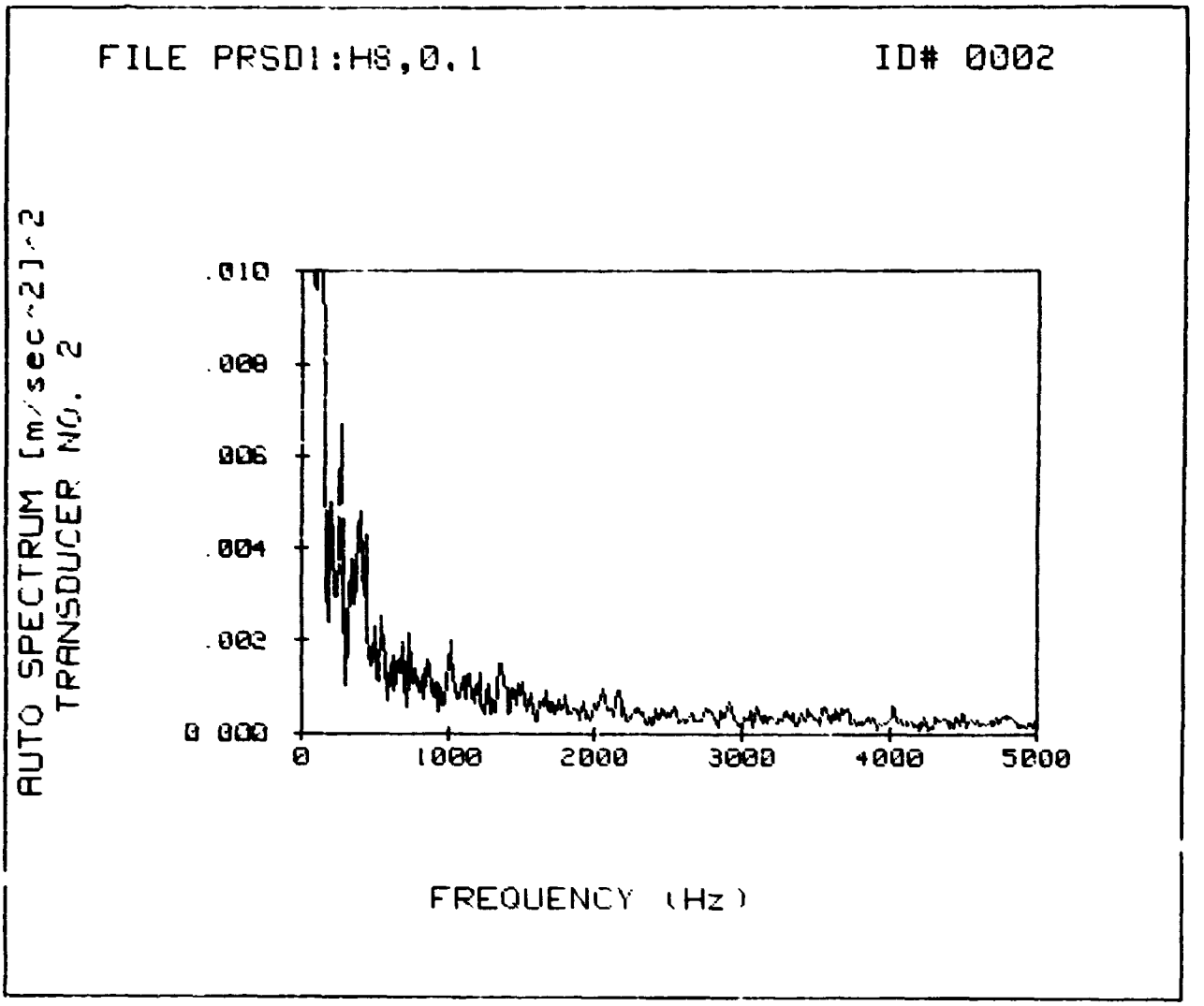

Figure B1. Example auto spectrum output on the HP 9845B CRT from program PSD444.

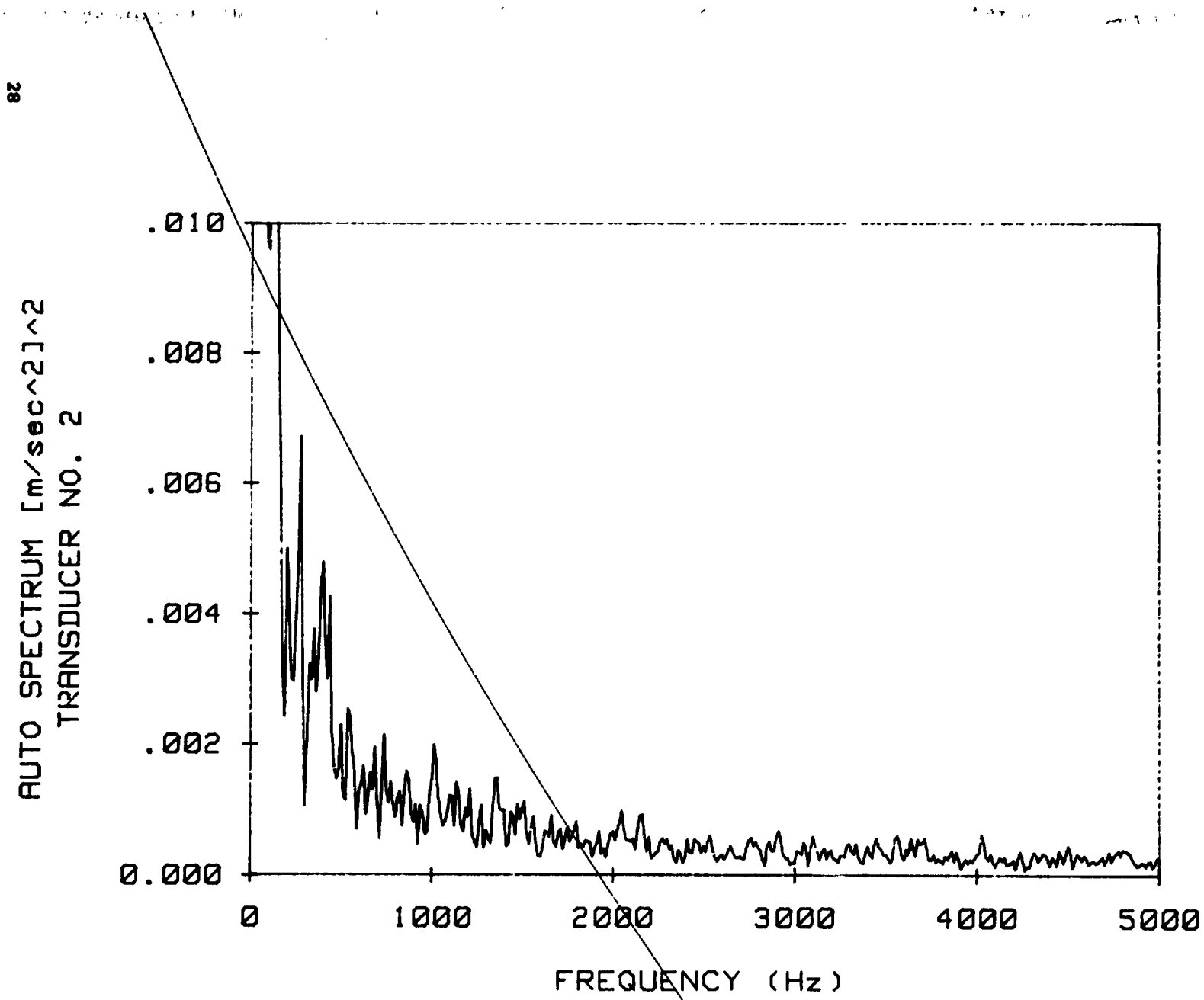

Figure B2. Example auto spectrum output on the HP 9872A from program PSD444.

APPENDIX C

EXAMPLES OF SOUND PRESSURE LEVEL OUTPUT

Table C1. Example narrow band sound pressure level output printed by program SPL444.

FREQUENCY (Hz)	SOUND PRESSURE LEVEL TRANSDUCER NO. 3
2.50	4.364E+01
5.00	4.297E+01
7.50	4.684E+01
10.00	5.207E+01
12.50	5.317E+01
15.00	5.229E+01
17.50	5.031E+01
20.00	5.498E+01
22.50	5.587E+01
25.00	5.633E+01
27.50	5.893E+01
30.00	6.205E+01
32.50	6.093E+01
35.00	5.984E+01
37.50	6.178E+01
40.00	6.367E+01
42.50	6.147E+01
45.00	6.283E+01
47.50	6.293E+01
50.00	6.335E+01
52.50	6.207E+01
55.00	6.417E+01
57.50	6.682E+01
60.00	6.635E+01
62.50	6.335E+01
65.00	6.436E+01
67.50	6.807E+01
70.00	6.570E+01
72.50	6.457E+01
75.00	6.202E+01
77.50	6.573E+01
80.00	6.912E+01
82.50	6.766E+01
85.00	6.631E+01
87.50	6.498E+01
90.00	6.743E+01
92.50	6.783E+01
95.00	6.839E+01
97.50	7.038E+01
100.00	6.965E+01
102.50	6.928E+01
105.00	6.817E+01
107.50	6.705E+01
110.00	6.822E+01
112.50	6.655E+01
115.00	6.856E+01
117.50	6.869E+01
120.00	6.695E+01
122.50	6.668E+01
125.00	6.889E+01
127.50	6.930E+01
130.00	6.829E+01
132.50	6.734E+01
135.00	6.889E+01
137.50	6.920E+01
140.00	6.939E+01
142.50	7.041E+01
145.00	7.081E+01
147.50	7.095E+01

Table C2. Example 1/3 octave band sound pressure level data printed by program SPL444.

1/3 OCTAVE BAND CENTER FREQUENCY

	SOUND PRESSURE LEVEL TRANSDUCER NO. 1 (dB)
1.25	2.037E+01
1.63	2.209E+01
2.00	2.365E+01
2.50	2.497E+01
3.15	2.683E+01
4.00	2.988E+01
5.00	3.200E+01
6.30	3.582E+01
8.00	3.845E+01
10.00	4.213E+01
12.50	4.454E+01
16.00	4.760E+01
20.00	5.040E+01
25.00	5.407E+01
31.50	5.651E+01
40.00	5.936E+01
50.00	6.175E+01
63.00	6.433E+01
80.00	6.734E+01
100.00	6.837E+01
125.00	7.013E+01
160.00	7.196E+01
200.00	7.229E+01
250.00	7.354E+01
315.00	7.368E+01
400.00	7.362E+01
500.00	7.273E+01
630.00	7.261E+01
800.00	7.203E+01
1000.00	7.022E+01

OVERALL SOUND PRESSURE LEVEL IS 82.9 (dB)

Table C3. Example octave band sound pressure level output printed by program SPL444.

OCTAVE BAND CENTER FREQUENCY

	SOUND PRESSURE LEVEL TRANSDUCER NO. 1 (dB)
1.63	2.644E+01
3.15	3.229E+01
6.30	4.123E+01
12.50	5.013E+01
25.00	5.934E+01
50.00	6.755E+01
100.00	7.291E+01
200.00	7.658E+01
400.00	7.807E+01
800.00	7.631E+01

OVERALL SOUND PRESSURE LEVEL IS 82.5 (dB)

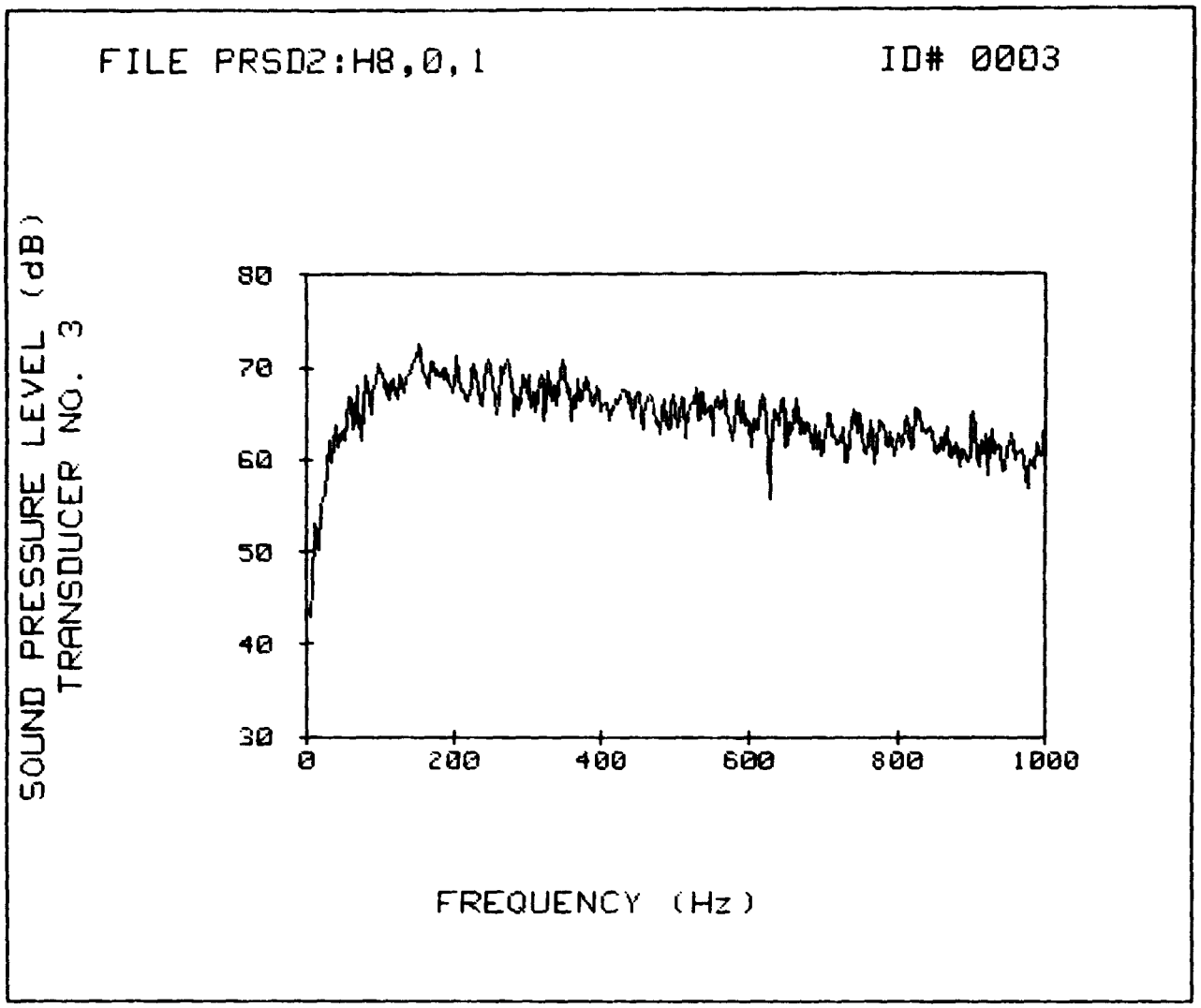

Figure C1. Example narrow band sound pressure level data output on the HP 9845B CRT from program SPL444.

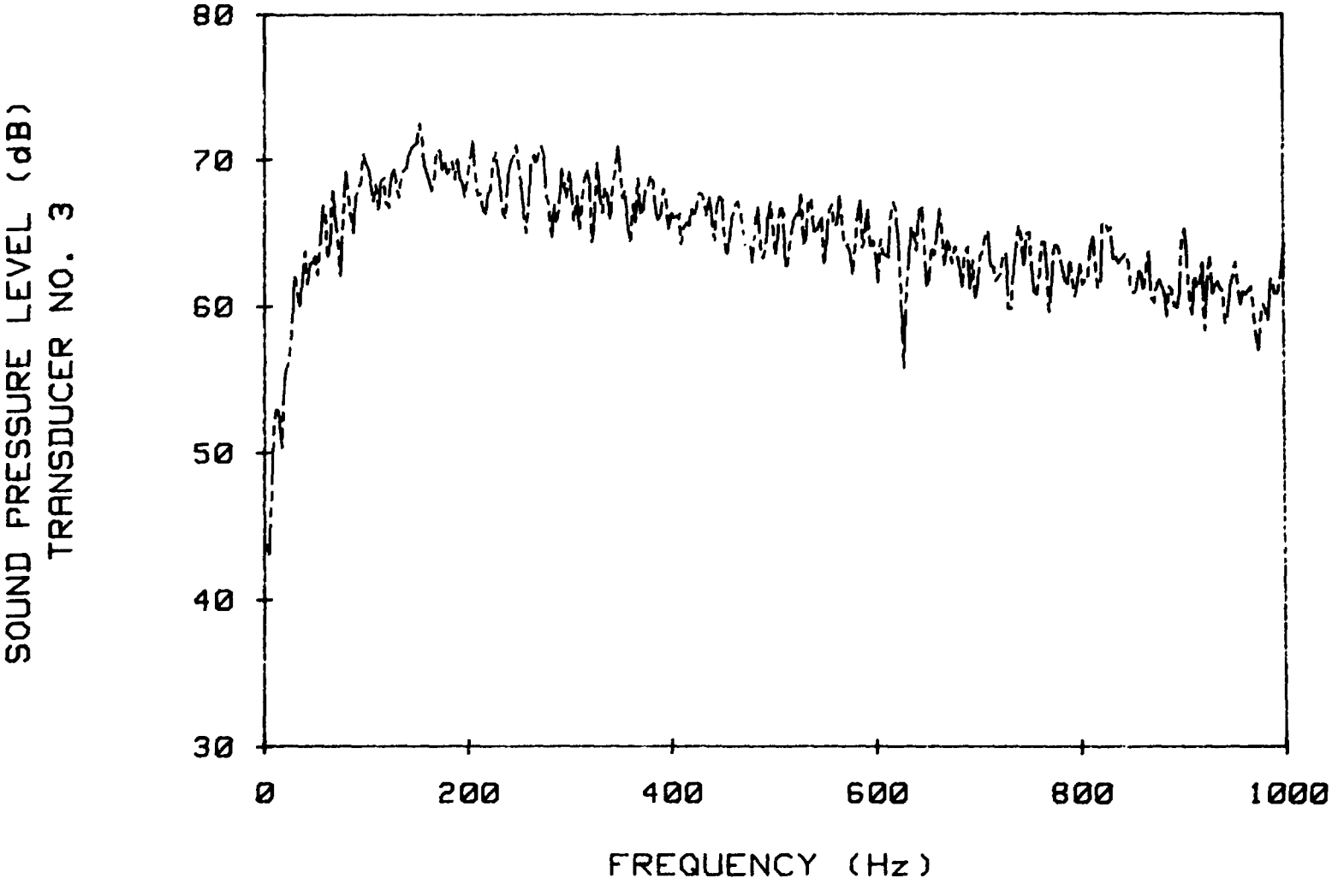

Figure C2. Example narrow band sound pressure level output on the HP 9872A from program SPL444.

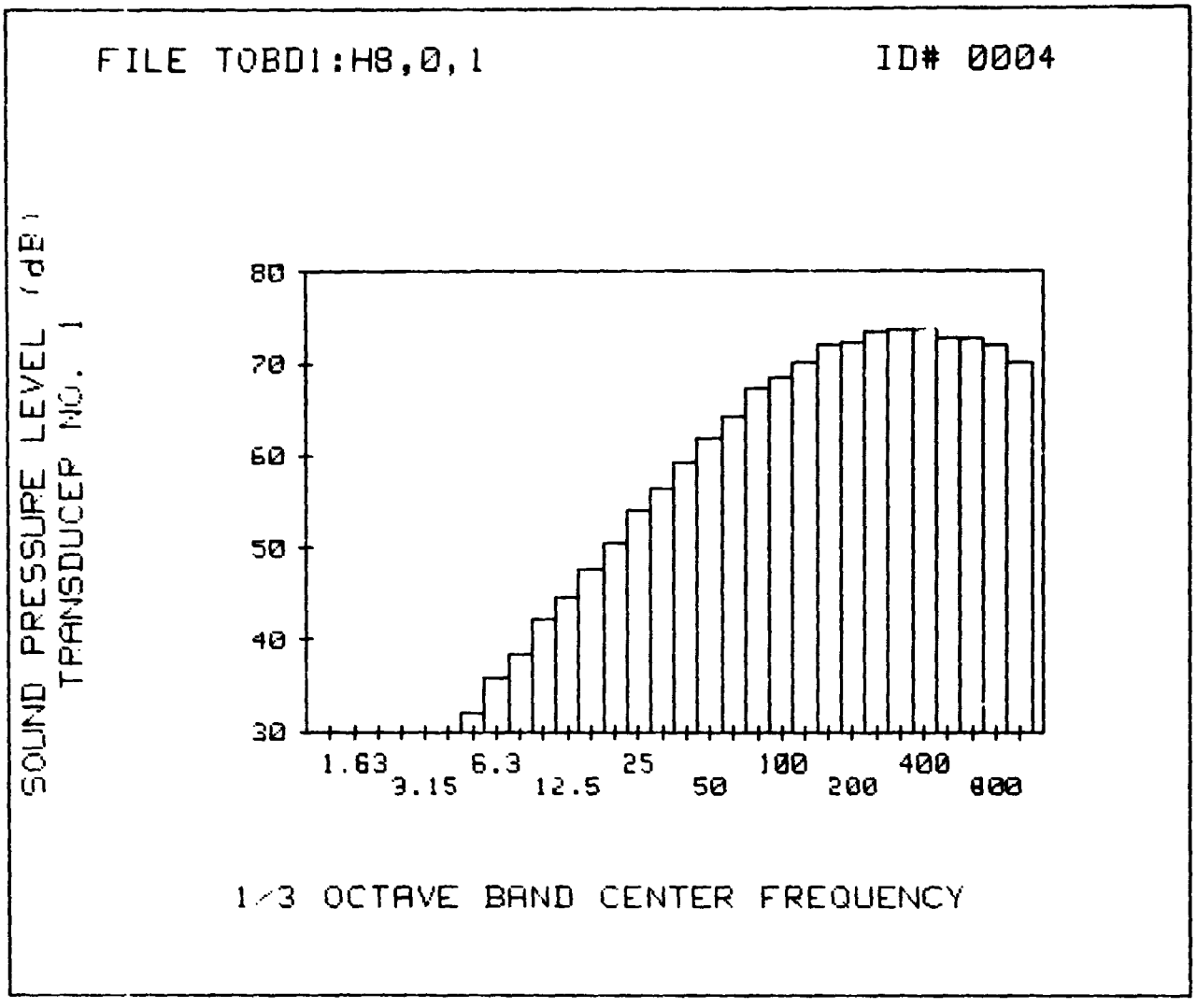

Figure C3. Example 1/3 octave band sound pressure level data output on the HP 9845B CRT from program SPL444.

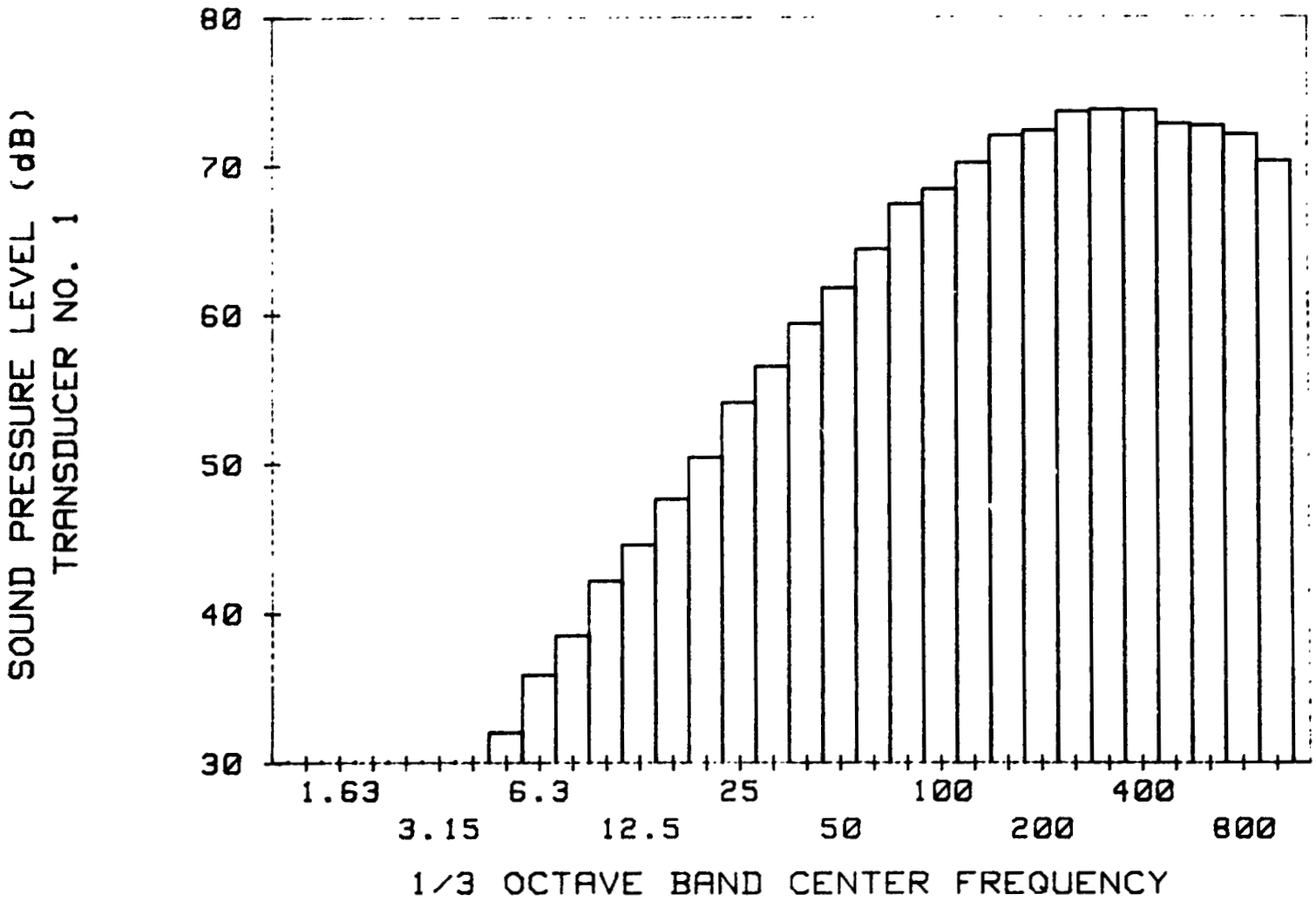

Figure C4. Example 1/3 octave band sound pressure level data output on the HP 9872A from program SPL444.

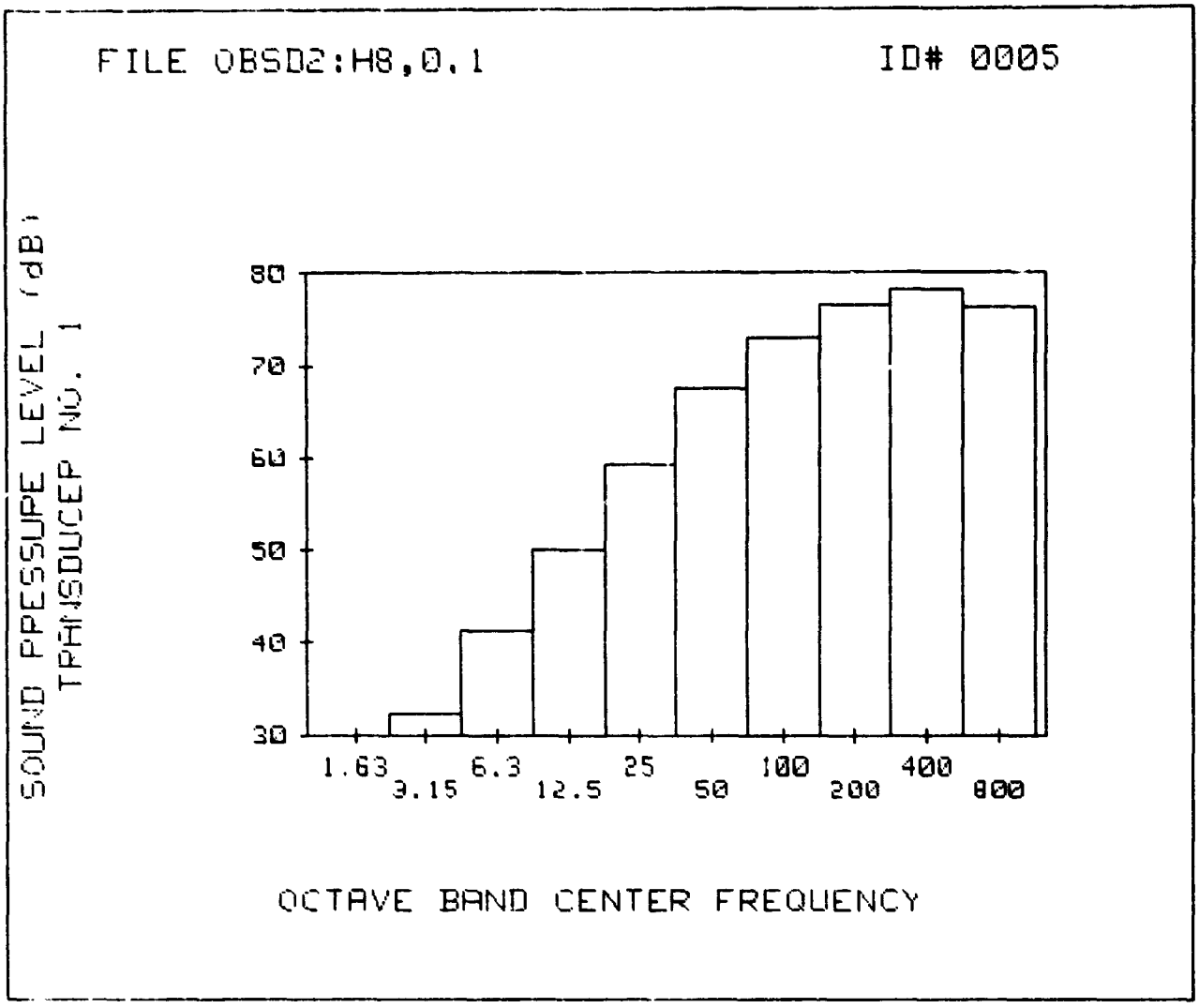

Figure C5. Example octave band sound pressure level data output on the HP 9845B CRT from program SPL444.

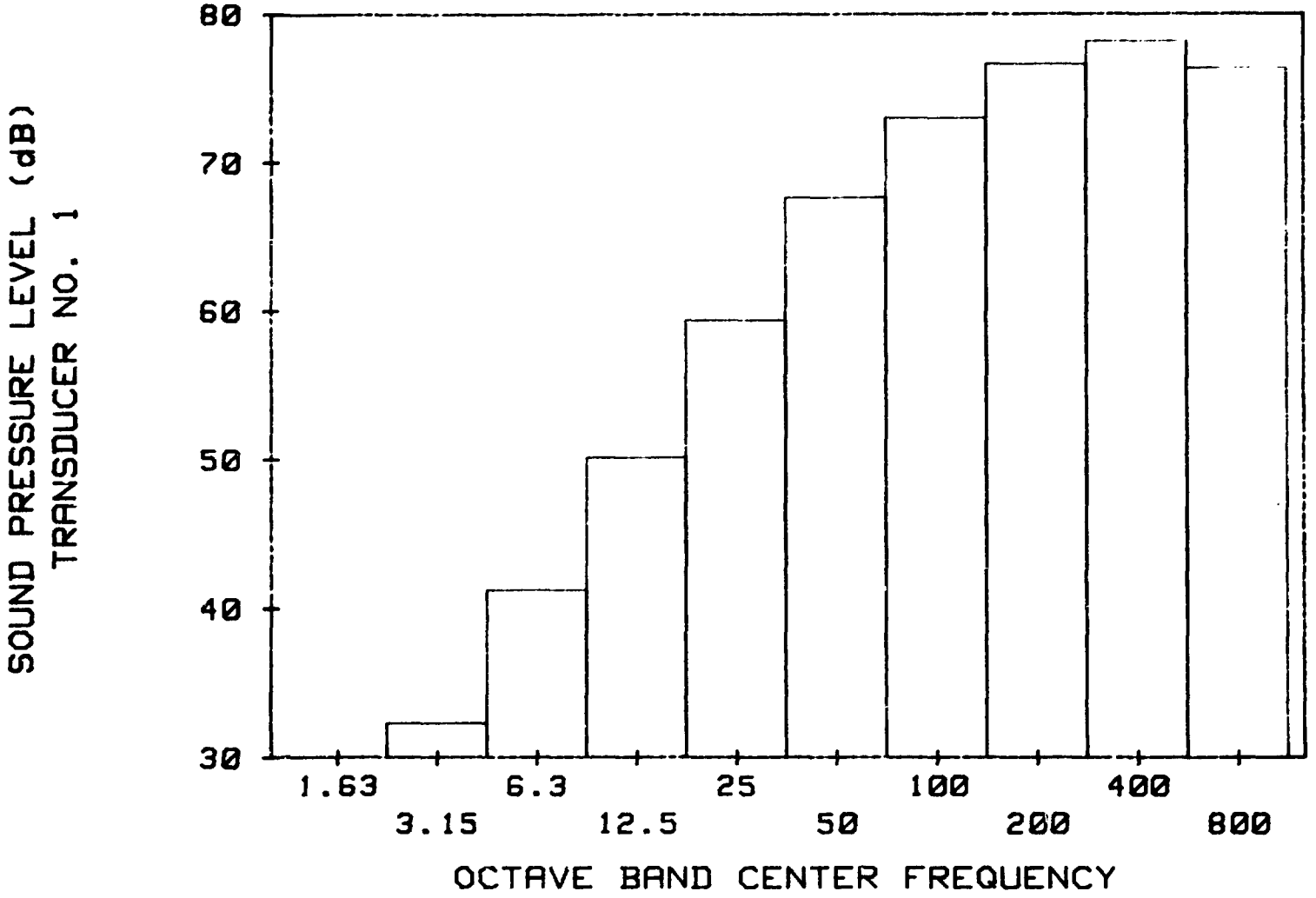

Figure C6. Example octave band sound pressure level data output on the HP 9872A from program SPL444.