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FREQUENCY RESPONSE MEASUREMENTS FOR
CASSETTE TAPE PLAYERS

A. Lawrence Kolz, et al

Air Force Weapons Laboratory

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Automotive cassette tape players made by 21 companies were surveyed to determine a prototype unit that may be used as part of a mobile bird dispersal system to help reduce the USAF bird-strike hazard. Nine units were selected on the basis of the manufacturer's specifications and tested for frequency response. The three with the flattest measured response were then used to record audio sonagrams from taped recordings of four bird distress calls. These tests indicated that, of the nine players, the three exhibiting the flattest (over)		

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ABSTRACT (cont'd)

frequency response were the Hitachi Model CS-200, Pioneer Model KP-300, and Realistic catalog no. 12-1823.

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PREFACE

Original data for the frequency response curves and sonagrams are kept on file at the Air Force Weapons Laboratory in the Ecosystems Technology Section, Kirtland Air Force Base, New Mexico.

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SECTION I

INTRODUCTION

Dispersal of hazardous bird concentrations on airfields is an integral part in the reduction of bird-aircraft collisions. One dispersal technique that has been used with success on some bird species is biosonics. This technique utilizes pre-recorded alarm or distress calls of a problem species, broadcast through a sound system. When used properly, this technique can effectively reduce the number of birds on the airfield and consequently the bird strike hazard. To develop a prototype biosonics system for Air Force use, components need to be surveyed and examined to determine their potential application. Automatic 12-Vdc magnetic tape players are easy to use and are already adapted to mobile operation; however, little is known of the frequency response and reproductive qualities of these units for application in bird dispersal. To determine these qualities and their potential for possible field applications, frequency measurements were performed on selected commercially available magnetic tape playback units. These data are to aid in further testing and development of components for a prototype mobile bird dispersal system for Air Force research purposes. The playback units were primarily rated according to their capability to reproduce a flat frequency response. The three players with the flattest frequency response were also evaluated with tapes of actual bird distress calls using audio sonagrams.

SECTION II

MAGNETIC TAPE PLAYER SELECTION

The large number of automotive, 12-Vdc, magnetic tape players on the market precludes the possibility of testing every model. Ten players were selected for laboratory testing on the basis of a compilation of the manufacturer's published specifications. Appendix A tabulates these data for a total of 59 tape machines manufactured by 21 companies. Although players with both the cartridge and cassette tape formats are listed, only cassette models were selected for testing. This decision was reached because equipment distributors suggest that most future improvements will be with cassettes.

In tabulating the technical specifications for the playback units, it became apparent that much of the information is not available. Information obtained for the frequency response data was considered the best discriminating parameter for selecting the players for laboratory testing. Yet, even these data are nebulous and generally do not define a reference signal level to associate with the frequency response bandwidth. For example, to state an amplifier frequency response of 50 to 10,000 Hz is meaningless unless it is referenced to variations about some defined signal level at the output.

The 10 playback units selected from the tabulated data are listed below. When the Muntz, Model M-940, was received, it proved to be similar to the Lear Jet, Model A-52, simply with a different escutcheon. The Muntz unit was therefore returned, and the nine remaining units listed below in alphabetical order, were evaluated.

1. Craig - Model 3504
2. Hitachi - Model CS-200
3. Lear Jet - Model A-52
4. Muntz - Model M-940
5. Panasonic - Model RS-248
6. Pioneer - Model KP-300
7. Realistic - Catalog No. 12-1823
8. Sanyo - Model FT-453

9. Sony - Model TC-30
10. Teac - Model AC-9

After tests had been completed on all units, a second tape player of the model receiving the best evaluation was purchased and similarly tested. These data are supplied for two Model CS-200 Hitachi tape players, identified as No. 1 and No. 2.

SECTION III

MAGNETIC TAPE SELECTION

Significant differences in reproductive quality are known to exist in the magnetic tapes produced by various manufacturers. A detailed study would be required to evaluate these tapes, and we circumvented this problem by recording and playing back a 30- to 10,000-Hz signal using four brands of tapes. Appendix B contains the playback frequency response curves obtained with an identical recording technique using cassette tapes identified by the manufacturers as Maxell, Ultra Dynamic (UD); TDK Electronics Corp., Extra-Dynamic (ED); RCA, Red Seal Cobalt Energized; and 3-M Company, Scotch Cobalt Energized Oxide cassettes. The Maxell UD tape clearly presents the flattest frequency response to our recording techniques, and this brand of tape was used exclusively for the recording of our evaluation test tapes. For use in field applications, the reproductive quality of the tape must also be considered. The frequency response obtained from any biosonics system is necessarily limited by its poorest quality component, and it is a common error to overemphasize the frequency response of the amplification system and neglect the quality of the input magnetic tape.

SECTION IV

TEST TAPE PREPARATION AND INSTRUMENTATION TECHNIQUES

A test tape swept over a frequency of 30 to 15,000 Hz recorded with a Teac cassette deck (Model-450) was used as a reference standard for evaluating playback units. The Teac deck was the best cassette playback at our disposal, and we used it as a standard to reference all data recorded from other players. The standard deviation of the mean calculated for this Teac test tape was 0.45 dB within 500 to 12,000 Hz with the half-power bandwidth (-3 dB limits) being 50 to 12,600 Hz.

The test equipment used to measure frequency responses for the playback units is shown in Fig. 1. Each test unit was measured at the output of the power amplifiers, which were driven at about 0.1 watt into 8 ohms. The original plan to measure the response at the preamplifiers had to be modified because it was difficult to obtain circuit diagrams and some units have integrated circuits which cannot be modified. Using the power amplifier output is a practical alternative; no modifications are required, and the signal levels are more than adequate to drive the speaker amplifiers.

The frequency response recorded for each playback unit included in Appendix C is a linearly optimized response adjusted by means of the tape player's tone control. This tone control actually shapes the frequency response, and each machine had a different type of filter compensation and adjustment requirement. In actual practice, the optimal position of a tone control must be determined empirically by comparing the frequency response curves recorded at various dial settings. The dial position resulting in the flattest frequency response can then be noted and the control locked in position by a mechanical restraint. Even similar models of tape players were found to require different relative positioning of their tone controls for a linearly optimized response.

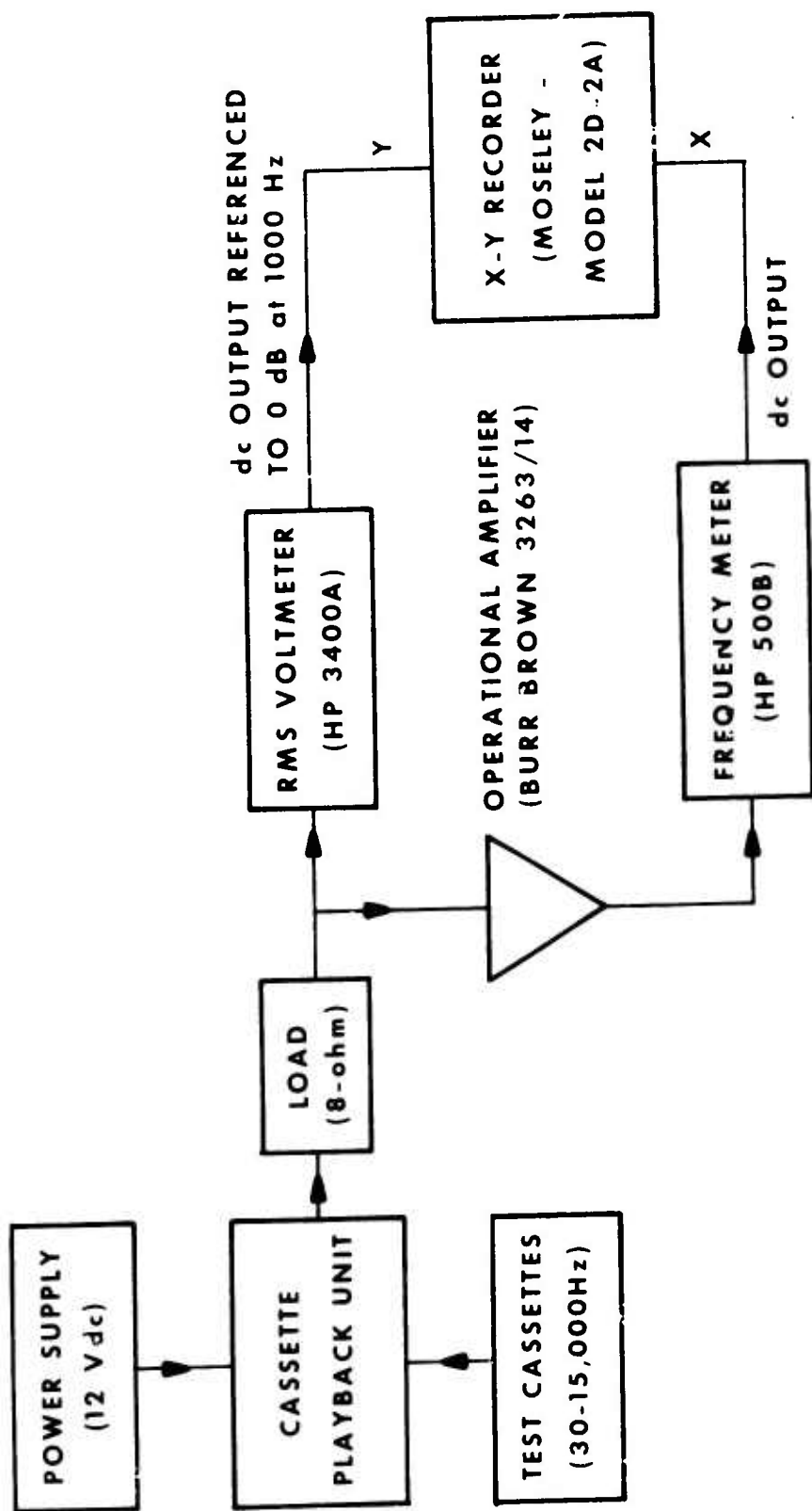


Figure 1. Test Equipment

SECTION V
ANALYSIS OF FREQUENCY RESPONSE DATA

Appendix C contains the frequency response data recorded for the different tape playback units. It was convenient, because of test equipment limitations, to record the frequency response of each tape player in two segments: 30 to 1,000 Hz and 500 to 14,000 Hz. Table 1 lists the respective half-power (-3 dB) bandwidths for each of the measured players. Comparison of these bandwidths against the response curves shows that players with comparable bandwidths exhibit significantly different bandpass excursions. Clearly, one needs a quantitative index which differentiates the relative bandpass flatness for the various players.

Table 1
HALF-POWER BANDWIDTHS OF CASSETTE TAPE PLAYERS*

Player	Bandwidth (Hz)
1. Hitachi CS-200, No. 2	85 - 12,900
2. Hitachi CS-200, No. 1	90 - 12,700
3. Realistic 12-1823	55 - 11,200
4. Pioneer KP-300	50 - 12,300
5. Sony TC-30	50 - 11,300
6. Craig 3504	45 - 11,400
7. Teac AC-9	100 - 11,300
8. Lear Jet A-52	55 - 11,500
9. Panasonic RS-248	110 - 10,600
10. Sanyo FT-453	50 - 12,000
11. Teac Deck (Model 450)	50 - 12,600

* 0 dB referenced to the response at 1,000 Hz.

In order to develop a rating index indicative of the linearity of a given bandpass, the response curves were statistically analyzed by two techniques. The first analysis assumes that the recorded test tape response is absolutely reproduced by the Teac Model-450 tape deck. Test players are

therefore evaluated by calculating the standard deviation for data representing the difference between their frequency response and that recorded by the Teac deck. Table 2 rates the players according to the results of this procedure using data recorded for two bandwidths.

Table 2
CASSETTE TAPE PLAYER RATINGS REFERENCED TO A TEAC MODEL 450

Player	Standard Deviation (dB)
<u>Bandwidth - 500 to 10,000 Hz</u>	
1. Hitachi CS-200, No. 2	0.13
2. Hitachi CS-200, No. 1	.26
3. Realistic 12-1823	.32
4. Pioneer KP-300	.44
5. Sony TC-30	.58
6. Craig 3504	.61
7. Teac AC-9	.62
8. Lear Jet A-52	.74
9. Panasonic RS-248	.84
10. Sanyo FT-453	.85
<u>Bandwidth - 500 to 12,000 Hz</u>	
1. Hitachi CS-200, No. 2	.25
2. Hitachi CS-200, No. 1	.39
3. Pioneer KP-300	.45
4. Sony TC-30	.71
5. Craig 3504	.75
6. Sanyo FT-453	.80
7. Lear Jet A-52	.88
8. Teac AC-9	.99
9. Realistic 12-1823	1.05
10. Panasonic RS-248	1.16

The second analysis assumes that the test tape recording is absolutely linear and that all deviations are due to playback equipment limitations. Therefore, the standard deviation is calculated for each machine with reference to a flat response. The results of this procedure are listed in Table 3 for two bandwidths.

Table 3
CASSETTE TAPE PLAYER RATINGS REFERENCED TO A LINEAR RESPONSE

Player	Standard Deviation (dB)
<u>Bandwidth - 500 to 10,000 Hz*</u>	
1. Hitachi CS-200, No. 2	0.17
2. Hitachi CS-200, No. 1	.18
3. Pioneer KP-300	.36
4. Realistic 12-1823	.37
5. Sony TC-30	.63
6. Craig 3504	.68
7. Teac AC-9	.71
8. Lear Jet A-52	.82
9. Sanyo FT-453	.91
10. Panasonic RS-248	.92
<u>Bandwidth - 500 to 12,000 Hz**</u>	
1. Hitachi CS-200, No. 1	.26
2. Hitachi CS-200, No. 2	.27
3. Pioneer KP-300	.49
4. Sanyo FT-453	.94
5. Sony TC-30	1.06
6. Craig 3504	1.11
7. Lear Jet A-52	1.20
8. Teac AC-9	1.39
9. Realistic 12-1823	1.47
10. Panasonic RS-248	1.54

* Teac Model-450 cassette deck, standard deviation 0.09 dB.

** Teac Model-450 cassette deck, standard deviation 0.45 dB.

A study of these statistical tabulations indicates that the Hitachi, Realistic, and Pioneer players exhibit the most linear response up to 10,000 Hz. For applications requiring a 12,000-Hz response, the Hitachi and Pioneer players exhibited the most linear response and show significantly smaller standard deviations than the other players tested using either analysis technique.

SECTION VI

FREQUENCY RESPONSE EVALUATION BY AUDIO SONAGRAMS

Audio sonagrams were recorded on a Kay Missilyzer (Model-675) by monitoring the output signals of the Teac (Model-450), Hitachi (Model CS-200), Pioneer (Model KP-300), and Realistic (catalog no. 12-1823) tape players. Sonagrams are visual displays showing the relative amplitudes of frequencies present in a complex audio signal as a function of time. In this study, the signal sources were recorded segments (0.8 second in duration) of distress calls for Starlings, Red-winged Blackbirds, Ring-billed Gulls, and Herring Gulls. In addition, composite amplitude response curves were recorded showing the relative sound envelopes as reproduced by each tape player.

The sonagrams show subtle differences between tape machines in reproducing a complex sound but do not provide any quantitative measures. Evaluation of the sonagrams ensured that the three tape players determined to have the flattest frequency response did not have any serious intermodulation distortion. Nothing observed in analyzing these sonagrams would indicate a major distortion problem. However, the Pioneer tape player generated sonagrams with more pattern distinctions from the Teac standard than did the other two machines.

Because of the difficulty in accurately reproducing sonagrams for a report (i.e., shades of gray are not easily duplicated), these data are not included.

SECTION VII

CONCLUSIONS

Nine cassette tape players were selected from an equipment tabulation which included the products of 21 companies. These players were evaluated according to their ability to reproduce a flat frequency response. The Hitachi Model CS-200 and Pioneer Model KP-300 were rated as having the best reproductive fidelity characteristics within the bandwidths of 85 to 12,000 Hz and 50 to 12,000 Hz, respectively. A third tape player, Realistic catalog no. 12-1823, showed excellent linearity in a narrower bandpass, 55 to 10,000 Hz.

The Pioneer KP-300 and the Lear Jet A-52 did not have a fast rewind capability, which may be considered an annoyance factor for certain applications. The Craig 3504 did not eject the tape cassettes and they had to be pried out with a tool. The Teac AC-9 and Panasonic RS-248 were judged to have the best controls for manipulating the tape action (i.e., stopping, starting, fast forward and reverse), and prominent indicator lights. The Panasonic player was the only unit which allowed a view of the tape cassette for easier replay indexing.

These preliminary tests should not be considered conclusive or indicative of the final system that may evolve, but are intended only to provide some of the basic data necessary to assist in the development of a prototype field test system.

APPENDIX A

MANUFACTURER'S SPECIFICATIONS FOR CASSETTE AND CARTRIDGE MAGNETIC TAPE PLAYERS

Manufacturer	Model	Cassette	Cartridge	Frequency Response (hertz)	% Wow & Flutter	S/N (dB)	Separation (dB)	Cross-talk (dB)	Comments
1. Ampex	Micro 44	x		100-9,000 10dB	.5	35			Discontinued
2. Craig	3134		x	80-8,000	.3	40	30	40	\$ 47.95
3. Craig	3141		x						
4. Craig	3504	x		40-10,000	.3	>45	>25	40	Floor mount - auto reverse Dash mount Model 3505 \$164.95
5. Craig	3507	x		40-10,000	<.3	>45	>30	>40	Incorporates Dolby FM radio \$259.00
6. Craig	3508	x		50-7,500	.35	>40	>35	>40	\$109.95
7. Craig	3510	x							FM-AM radio included \$129.95
8. Hitachi	CS-200	x		50-10,000					Auto reverse Sold by Lafayette Radio \$159.00
9. Hitachi	CS-214	x		50-10,000	<.35	>40			Fast forward rewind \$ 89.95
10. Inland Dynamics, Inc. (IDI)	S-75		x	70-8,000	<.3	>40	>40		Cassettes not available according to Burstein-Applebee

Manufacturer	Model	Cassette	Cartridge	Frequency Response (hertz)	% Wow & Flutter	S/N (dB)	Separation (dB)	Crosstalk (dB)	Comments
11. IDI	S-88	x	x	100-8,000	<.3	>40			
12. IDI	S-705A	x	x	70-8,000					\$ 39.95
13. IDI	S-808	x	x	50-10,000	<.3	>40	40		
14. IDI	QK-48	x	x	45-8,000					\$29.95
15. Jet Sounds	500	x		33-12,000	.3				
16. Kraco	KIS-444	x	x	70-8,000	.3			>40	Sold by Sears and J. C. Penney Co.
17. Kraco	900	x		100-10,000	.3			>35	
18. Kraco	999	x	x	100-10,000	.3			>35	Playback and recorder Sears Model 5073
19. Lear Jet Stereo, Inc.	A-20	x	x		<3.0				
20. Lear Jet Stereo, Inc.	A-55	x	x						
21. Lear Jet Stereo, Inc.	A-52	x	x	50-10,000	<.35	>40	>30	>40	\$ 99.95
22. Montgomery Ward (CTI)	61B16798	x	x						\$ 79.95
23. Montgomery Ward	61B73004	x	x						\$ 49.95

Manufacturer	Model	Cassette	Cartridge	Frequency Response (hertz)	% Wow & Flutter	S/N(db)	Separation (db)	Crosstalk (db)	Comments
24. Motorola	TM203S	x							No cassette available
25. Motorola	TM912S	x							
26. Muntz	M-880	x		50-10,000	<.3	>40		>30	
27. Muntz	M-940	x		50-10,000	<.44	>40		>30	Sold by Montgomery Ward
28. Panasonic	CX-325/326		x	70-10,000	.3	>40			\$ 49.99
29. Panasonic	CX-567		x	70-10,000	.3	>40			
30. Panasonic	CX-811		x	70-10,000	<.25	>40			
31. Panasonic	CX-880		x	50-10,000	.3	40			\$109.99
32. Panasonic	CX-131	x		50-10,000	.4	>40			\$ 99.99
33. Panasonic	CX-727	x		50-10,000	.4	>40			Discontinued
34. Panasonic	RS-248	x		40-10,000	.27	>50			Auto reverse Floor mount \$114.95
35. Pioneer	TP-222		x	50-10,000					
36. Pioneer	TP-777		x	40-10,000					
37. Pioneer	KP-300	x		40-10,000					Auto reverse FM stereo

	Manufacturer	Model	Cassette	Cartridge	Frequency Response (hertz)	% Wo 1 & Fluter	S/N(db)	Separation (db)	Crosstalk (db)	Comments
38.	Pioneer	KP-333	x		50-7,500					Auto reverse
39.	Ranger	RR-102C	x							\$ 79.95
40.	Realistic	12-1832		x	50-10,000					\$ 74.50
41.	Realistic	12-1823	x		50-10,000	.3	>45			\$ 87.50
42.	Realistic	12-1822	x							\$ 69.95
43.	RCA	12 R 200	x		50-10,000					Record feature \$109.95
44.	Sanyo	FT 818		x	50-10,000	.25	40			
45.	Sanyo	FT 842		x	50-12,000	.22	50			
46.	Sanyo	FT 883		x	50-10,000	.25	45			
47.	Sanyo	FT 453	x		50-12,000	.25	45			
48.	Sanyo	FT 1100	x	x	50-10,000	.22	45			
49.	Sears	28B5046		x						\$ 64.95
50.	Sony	TC-10	x		50-10,000	.25	45			
51.	Sony	TC-20	x		50-10,000	.28	45			
52.	Sony	TC-30	x		50-10,000	.25	50			Auto reverse \$159.00

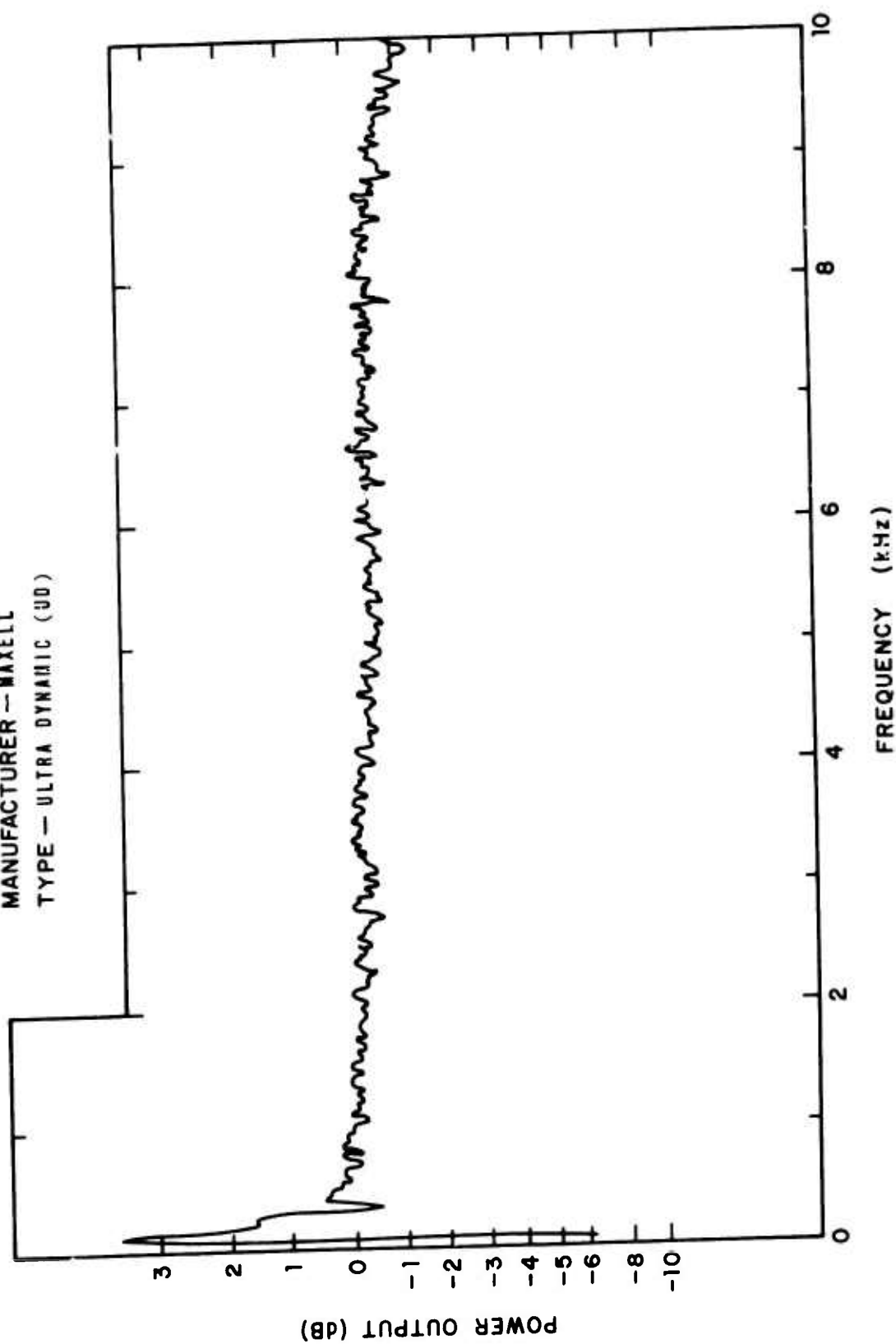
Manufacturer	Model	Cassette	Cartridge	Frequency Response (hertz)	% Wow & Flutter	S/N (dB)	Separation (dB)	Crosstalk (dB)	Comments
53. Teac	AC-5	x		40-10,000	.25				\$159.50
54. Teac	AC-9	x		40-10,000 -6dB @ 16,000	.25				Auto reverse Fast wind \$179.50
55. Toshiba	CT 8000		x	50-10,000	.3	>40			Speed deviation $\pm 3\%$
56. Xtal (Far Eastern Research Labs)	XA-80		x	100-8,000	.35	>35	>35	>40	No cassette available
57. Xtal	XA-82		x	50-10,000	.3	>40		>40	

APPENDIX B

MAGNETIC TAPE FREQUENCY RESPONSE CURVES

MAGNETIC TAPE
FREQUENCY RESPONSE

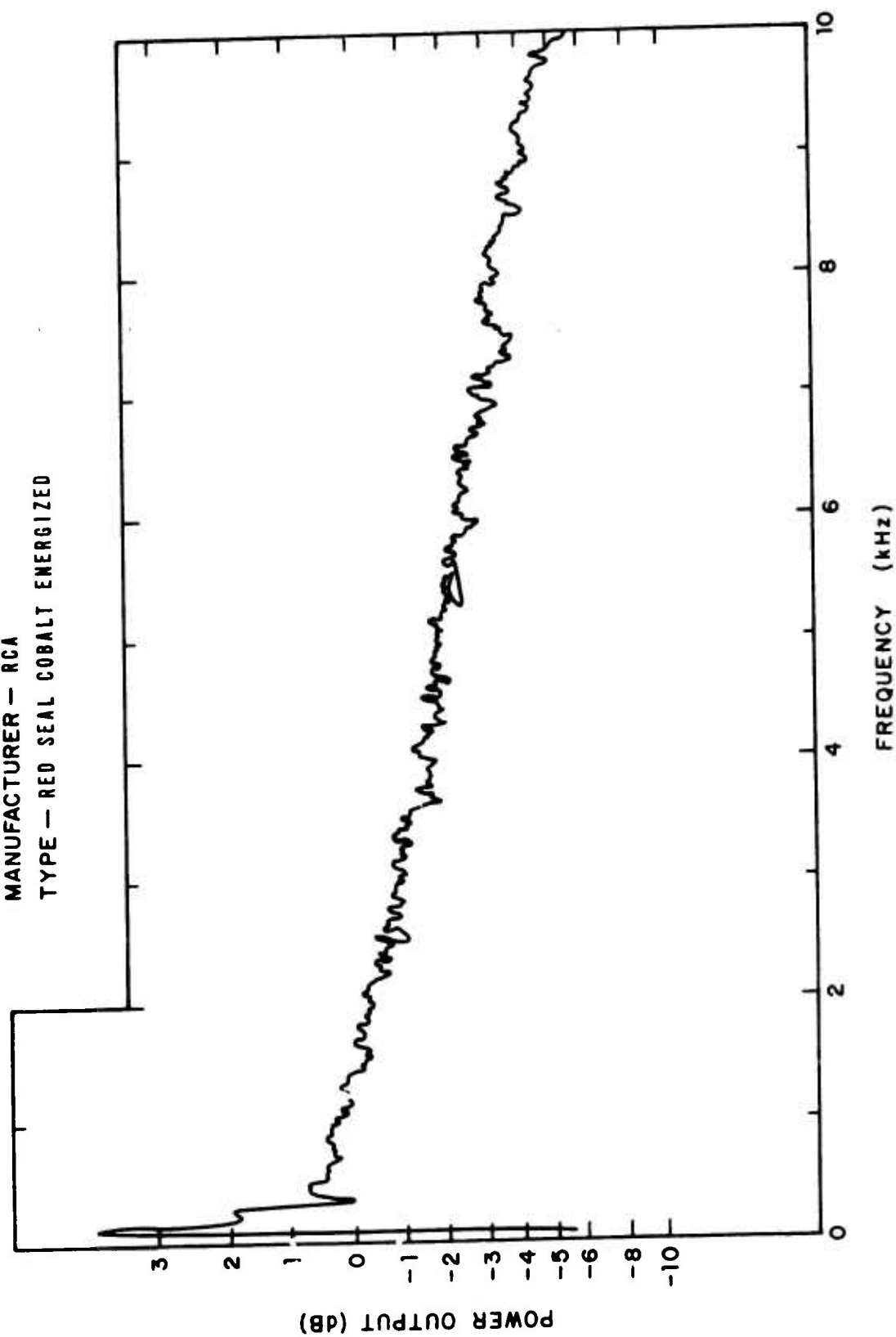
MANUFACTURER -- MAXELL
TYPE -- ULTRA DYNAMIC (UD)



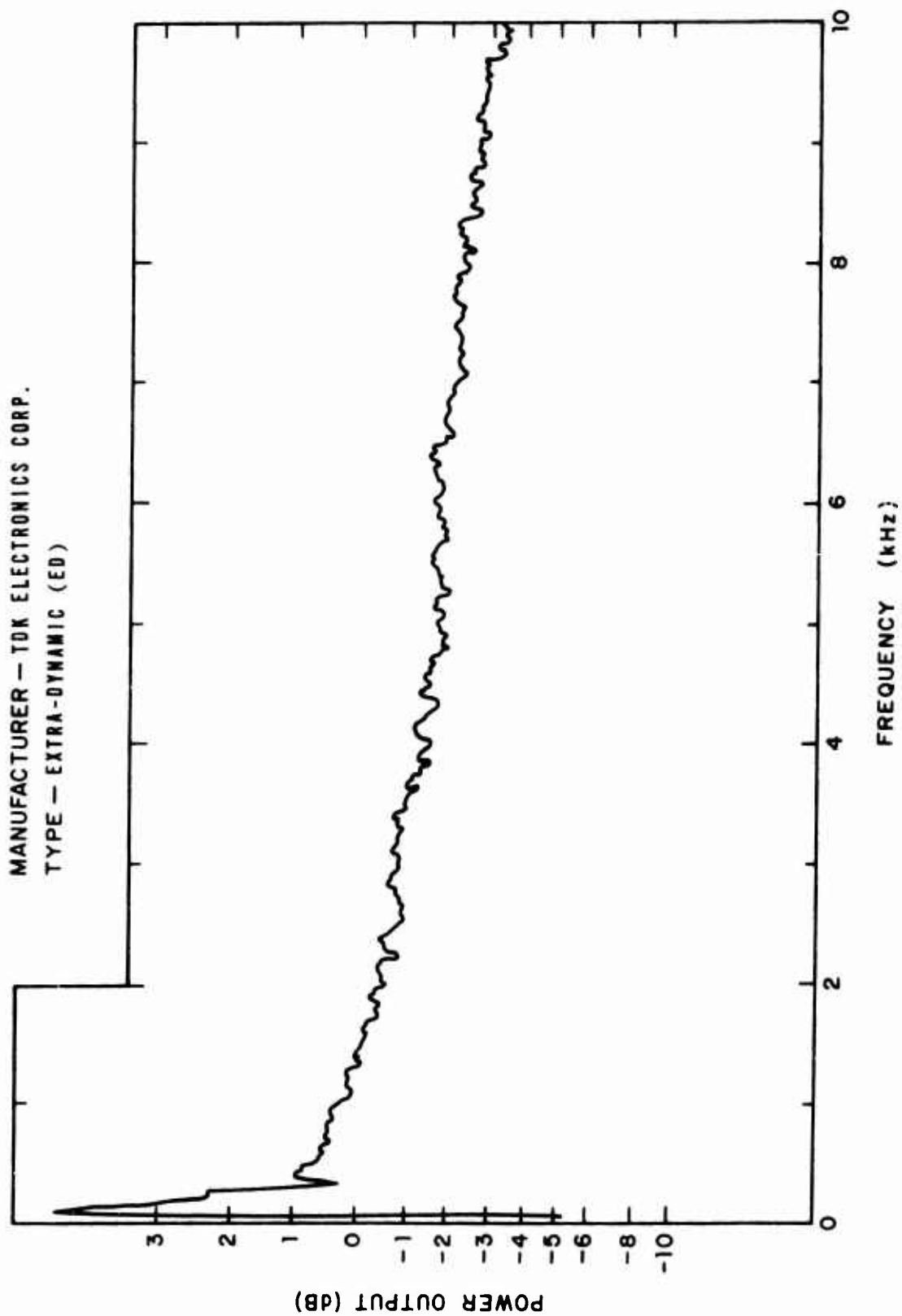
MAGNETIC TAPE
FREQUENCY RESPONSE

MANUFACTURER - RCA

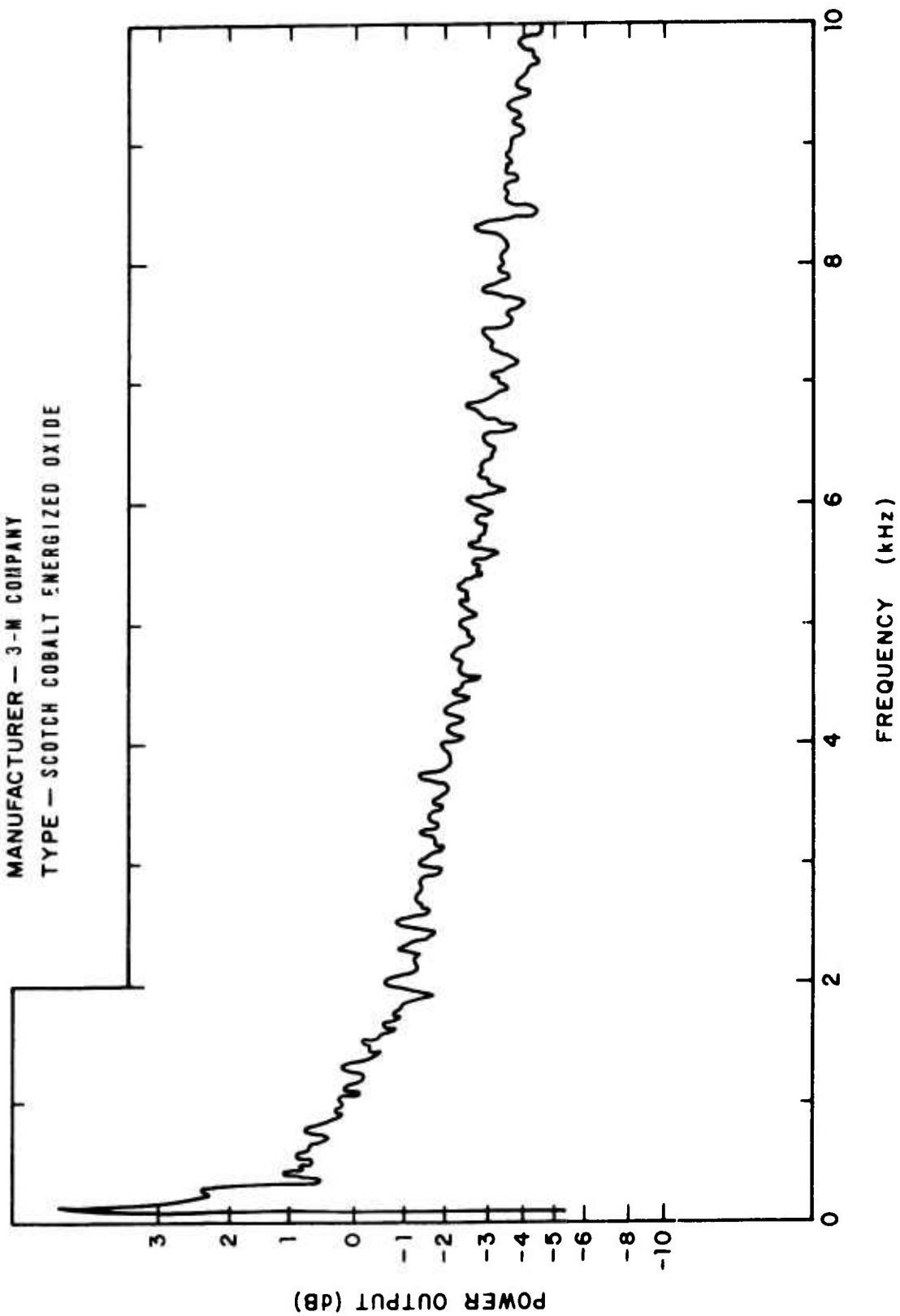
TYPE - RED SEAL COBALT ENERGIZED



MAGNETIC TAPE
FREQUENCY RESPONSE
MANUFACTURER — TDK ELECTRONICS CORP.
TYPE — EXTRA-DYNAMIC (ED)



MAGNETIC TAPE
FREQUENCY RESPONSE
MANUFACTURER — 3-M COMPANY
TYPE — SCOTCH COBALT ENERGIZED OXIDE



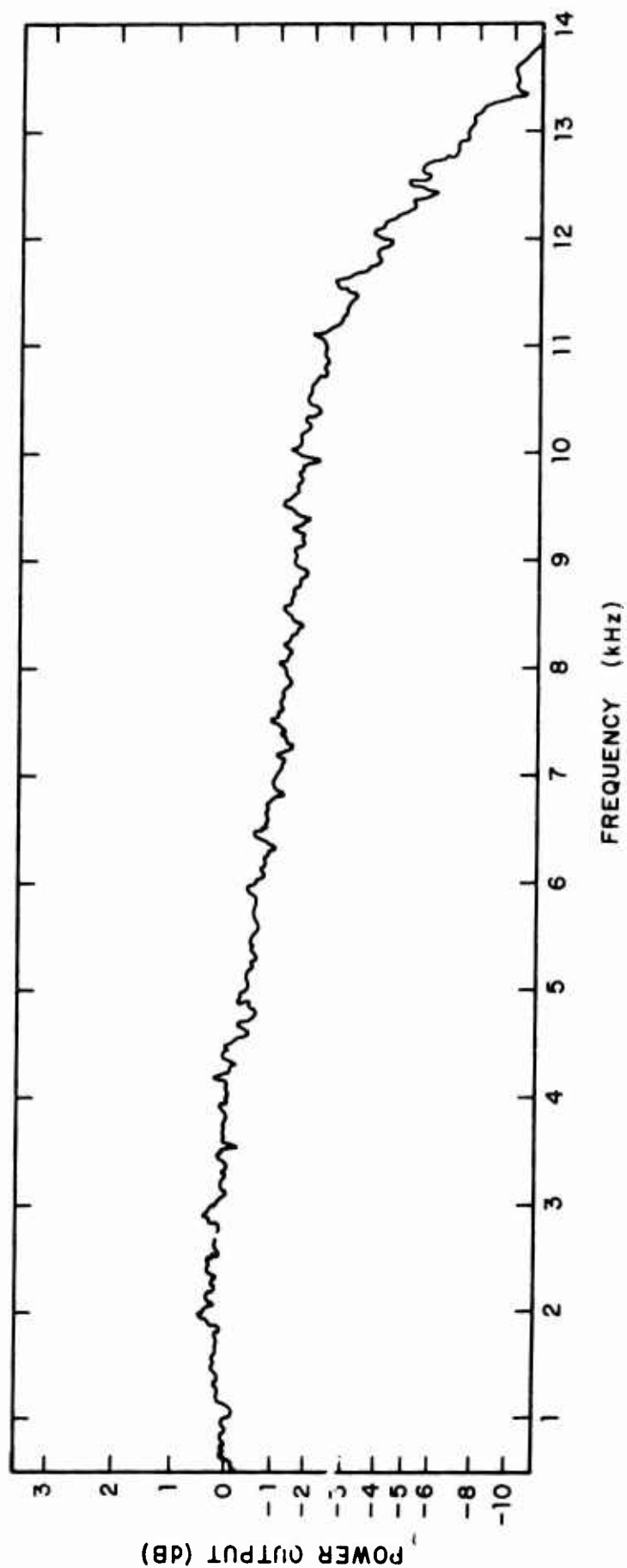
APPENDIX C

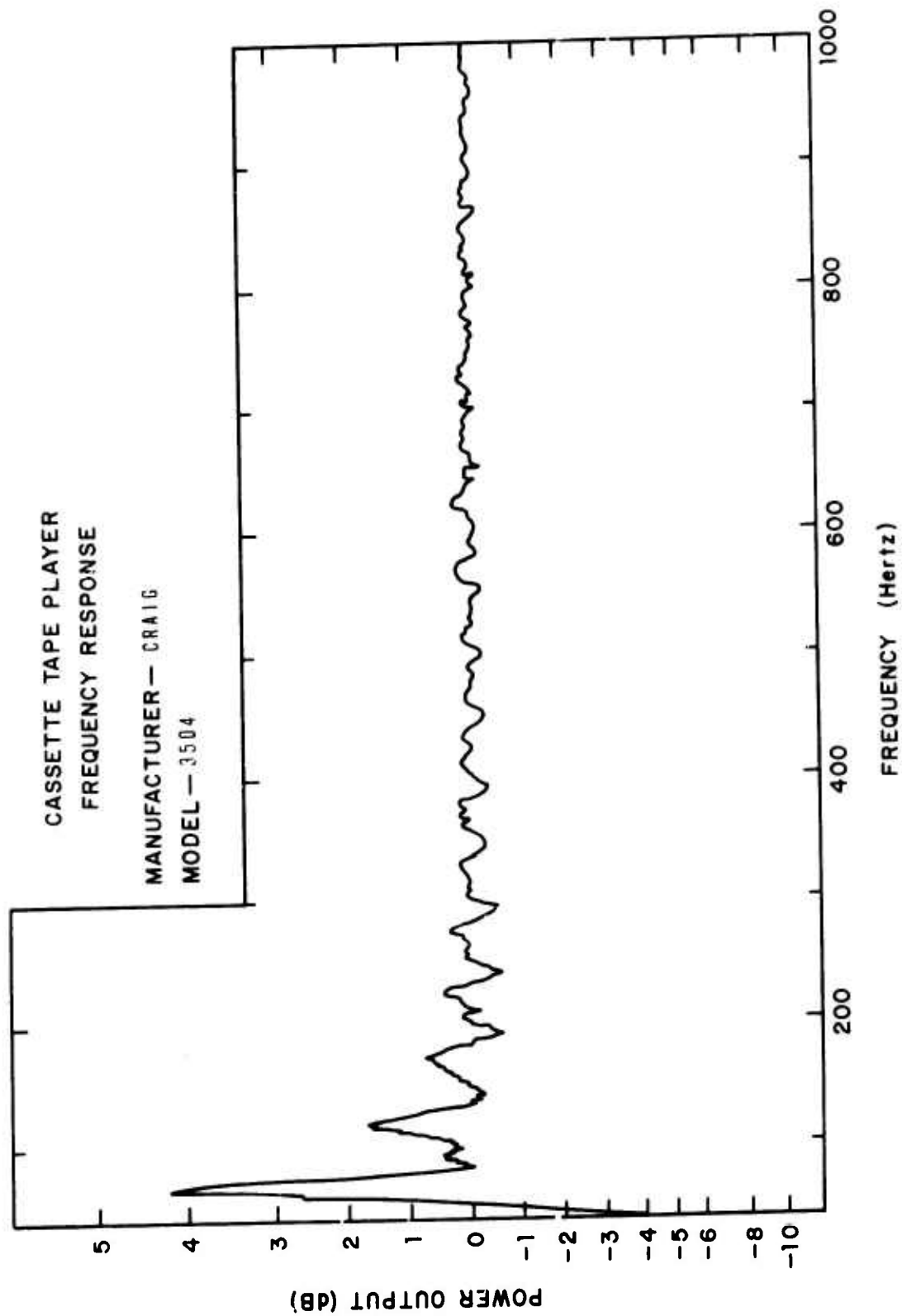
LINEARLY OPTIMIZED, FREQUENCY RESPONSE CURVES
FOR SELECTED CASSETTE TAPE PLAYERS

CASSETTE TAPE PLAYER
FREQUENCY RESPONSE

MANUFACTURER — CRAIG

MODEL — 3504

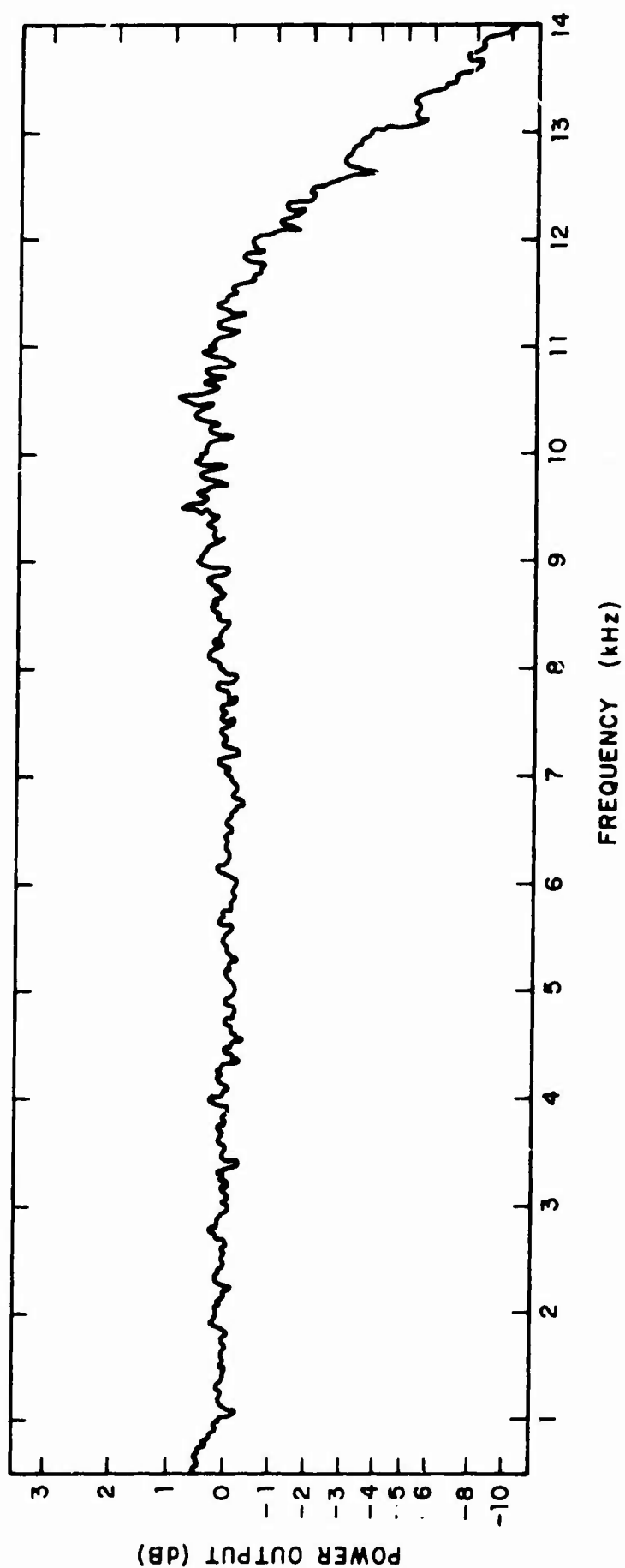


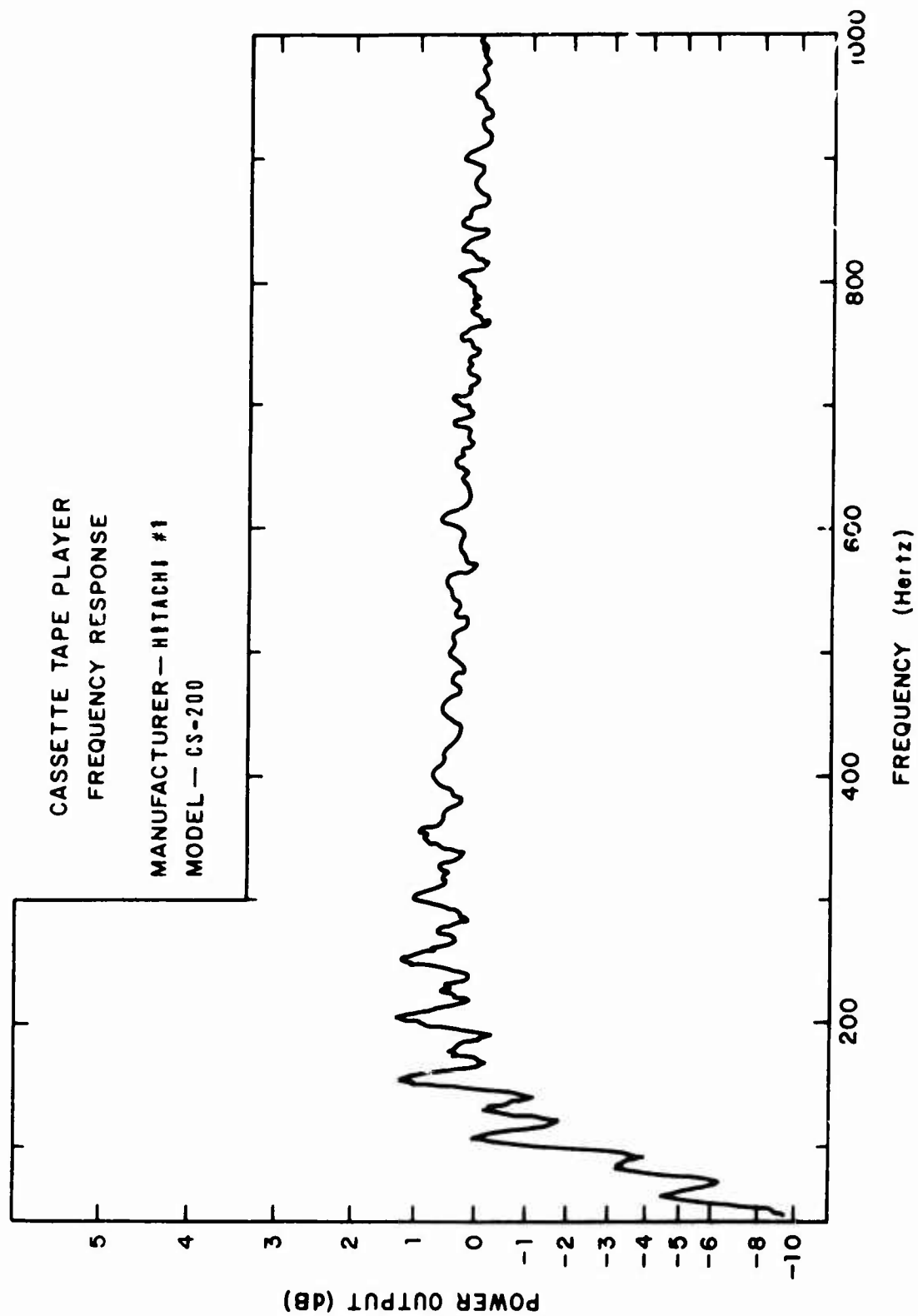


CASSETTE TAPE PLAYER
FREQUENCY RESPONSE

MANUFACTURER — HITACHI #1

MODEL — CS-200

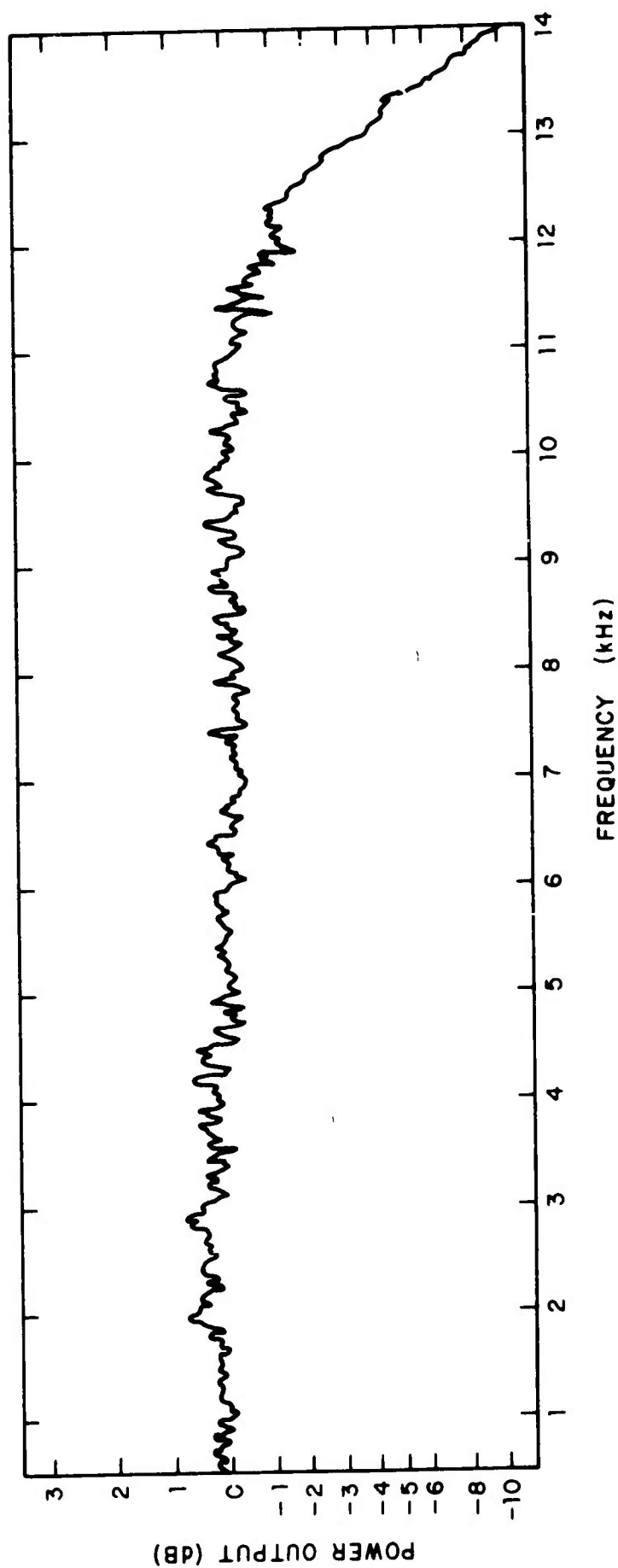


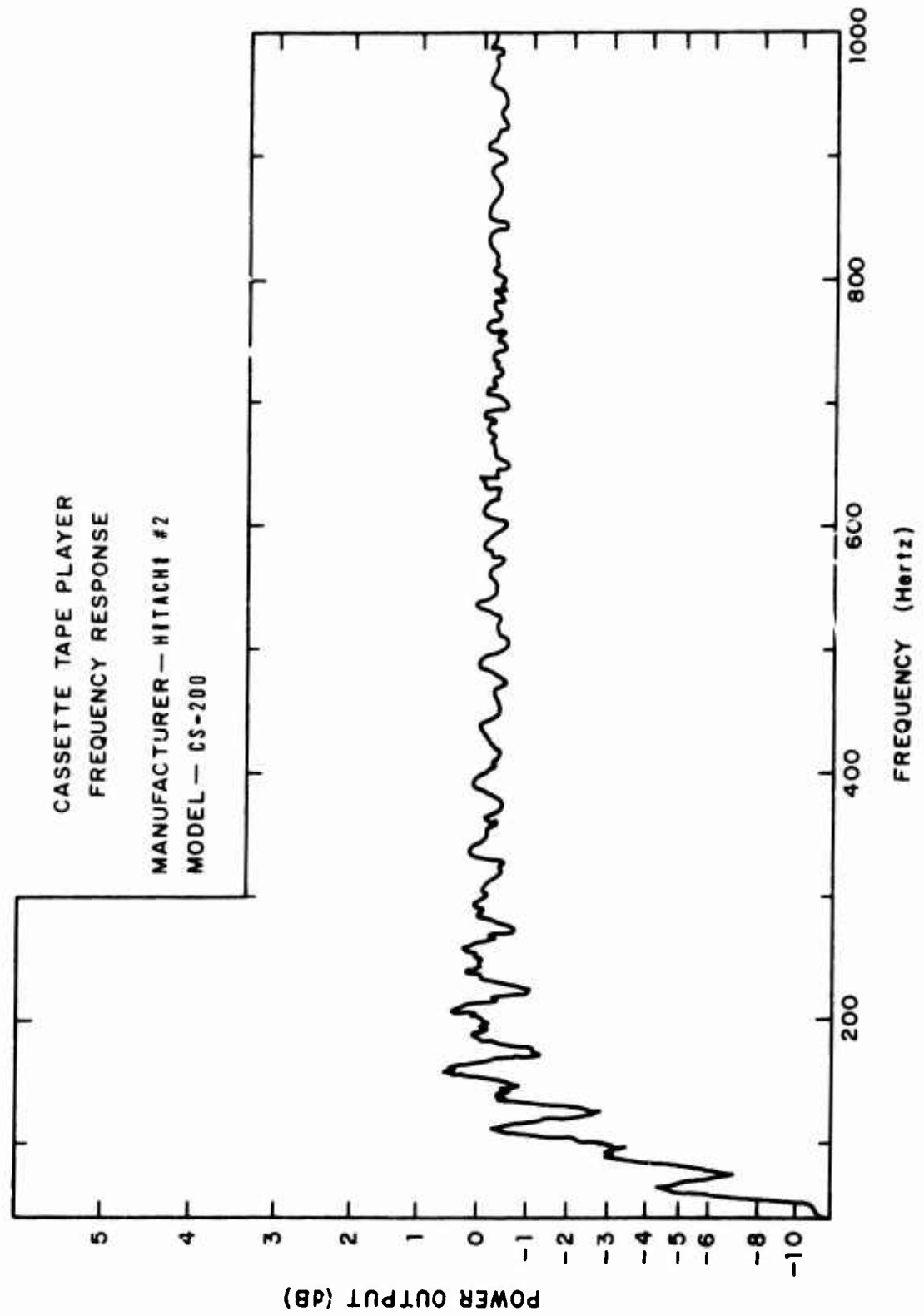


CASSETTE TAPE PLAYER
FREQUENCY RESPONSE

MANUFACTURER — HITACHI #2

MODEL — CS-200

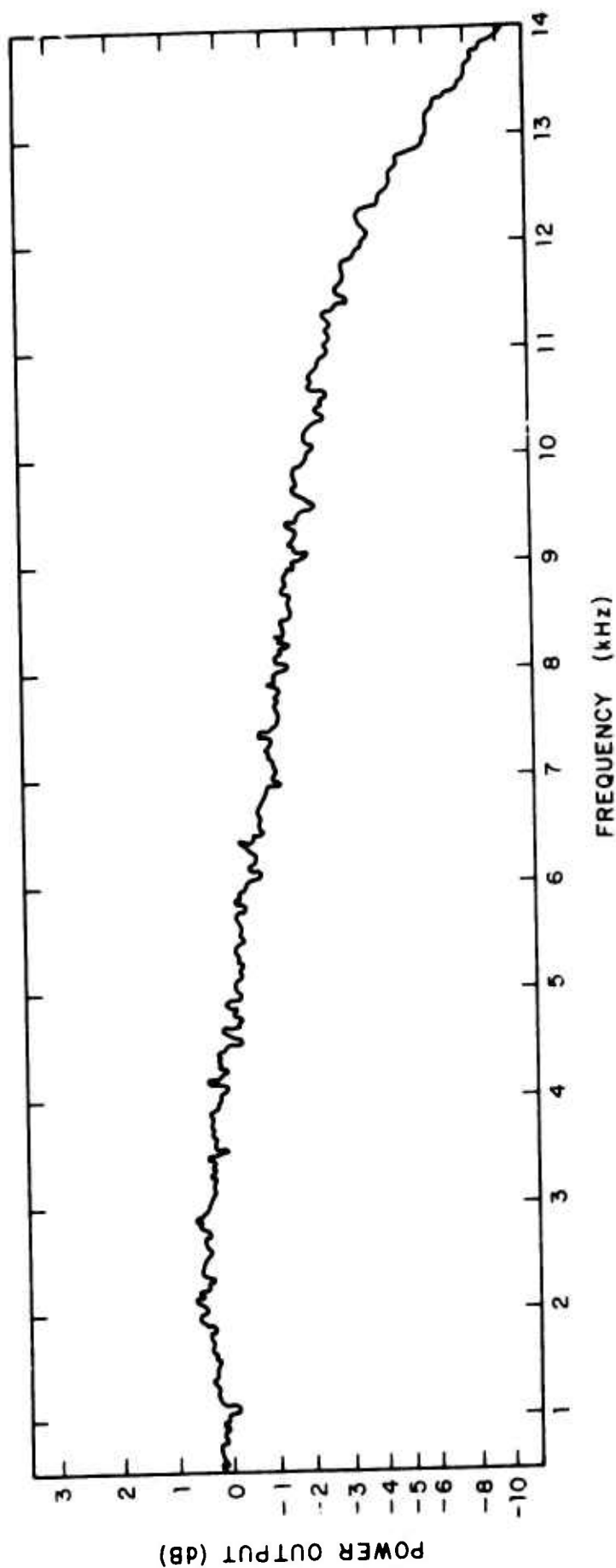


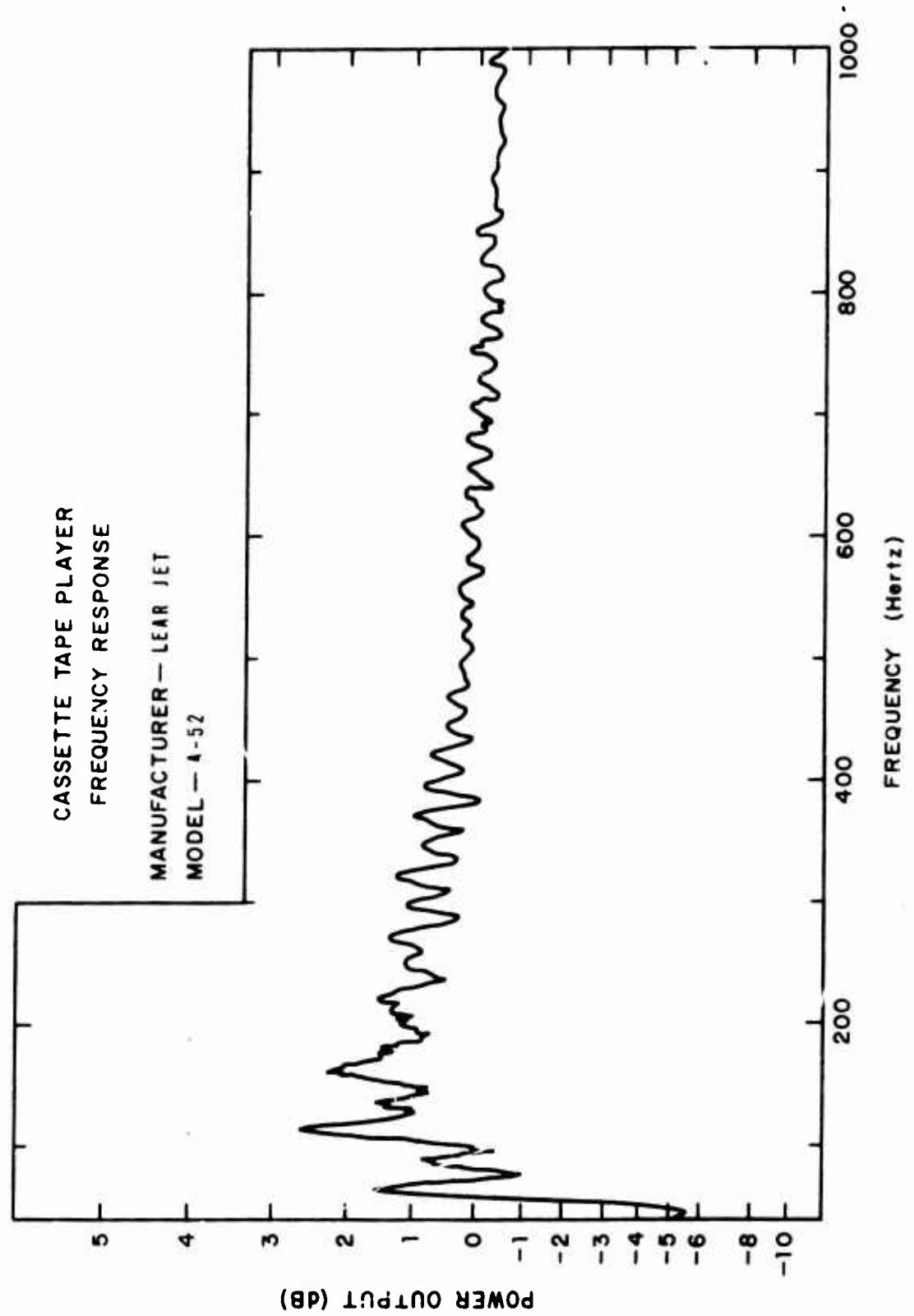


CASSETTE TAPE PLAYER
FREQUENCY RESPONSE

MANUFACTURER — LEAR 1ET

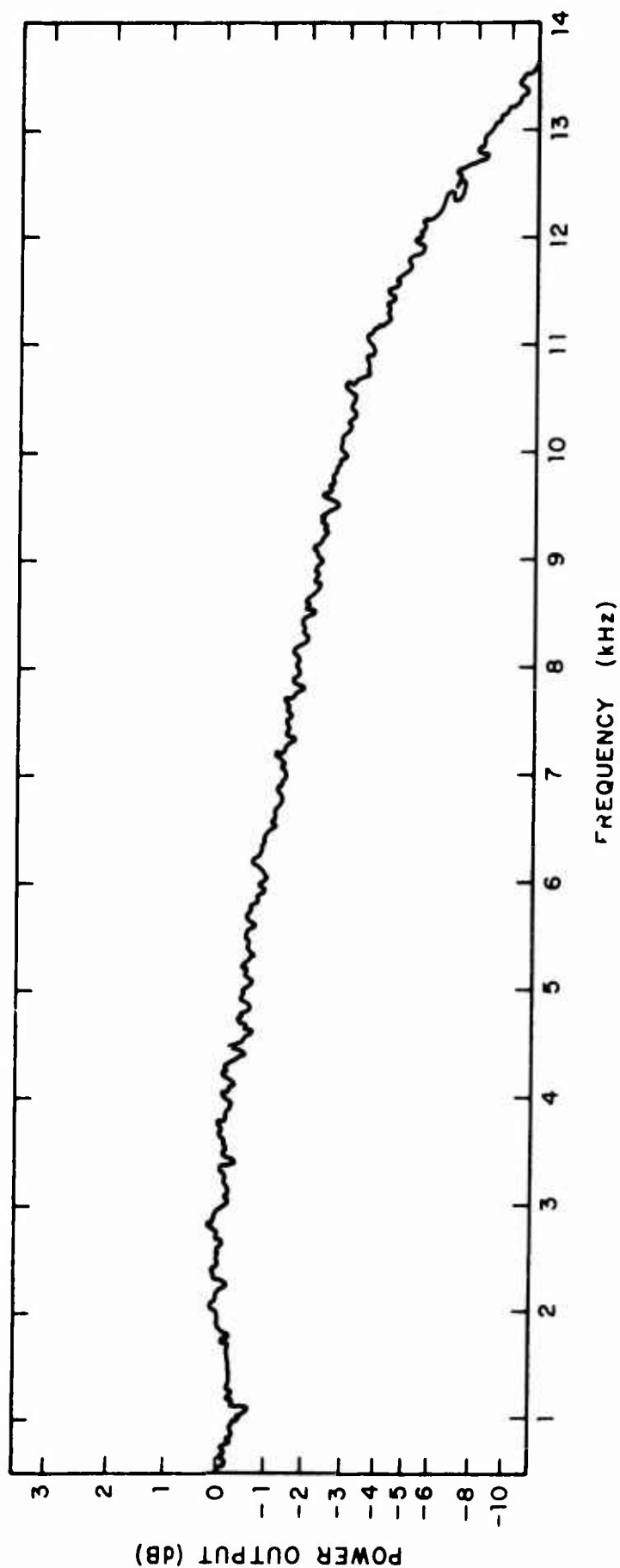
MODEL — A-52

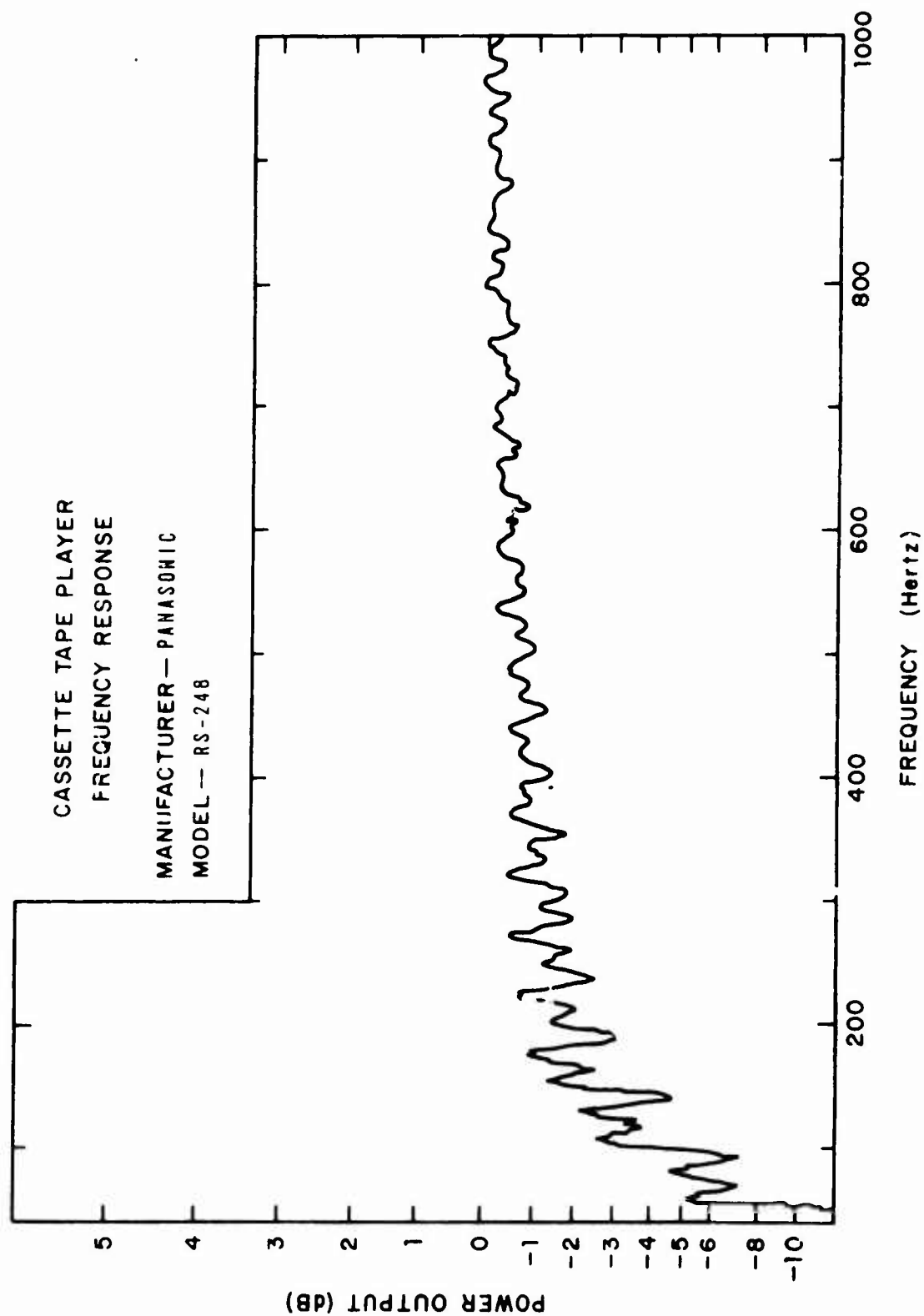




CASSETTE TAPE PLAYER
FREQUENCY RESPONSE

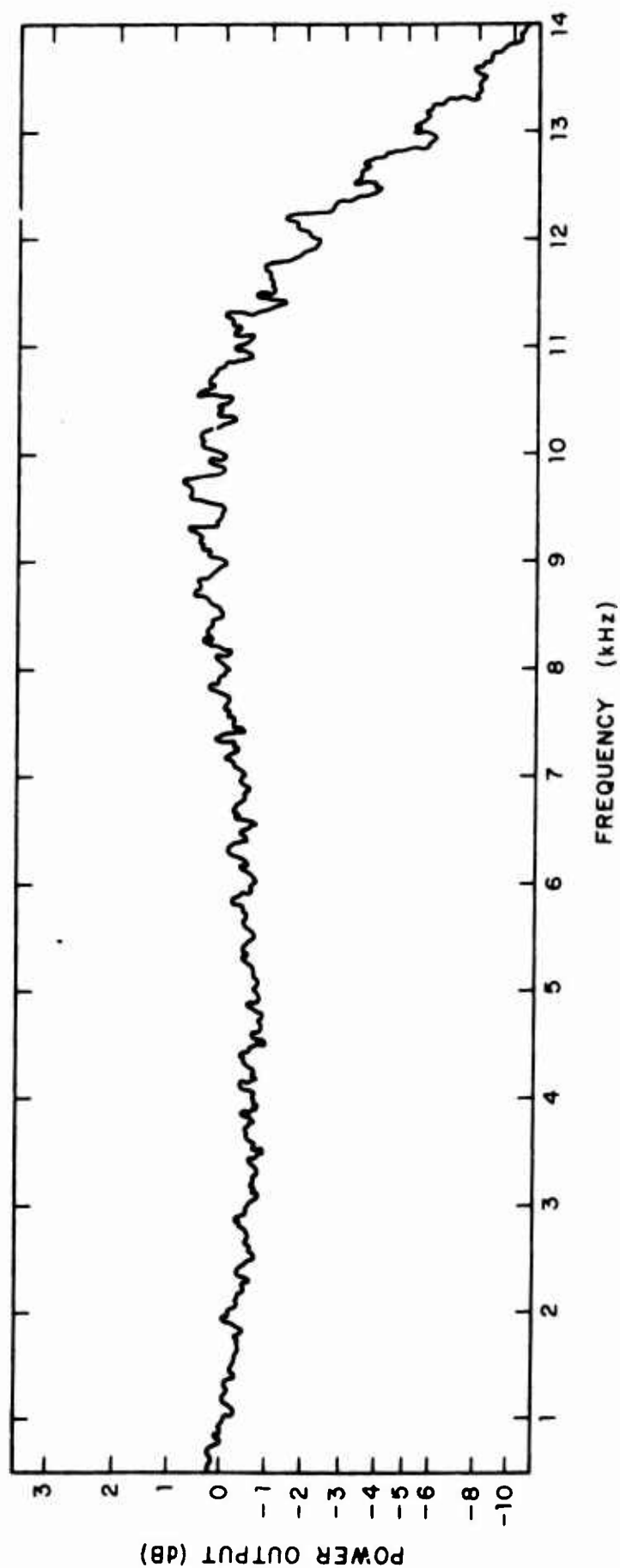
MANUFACTURER — PANASONIC
MODEL — RS-248

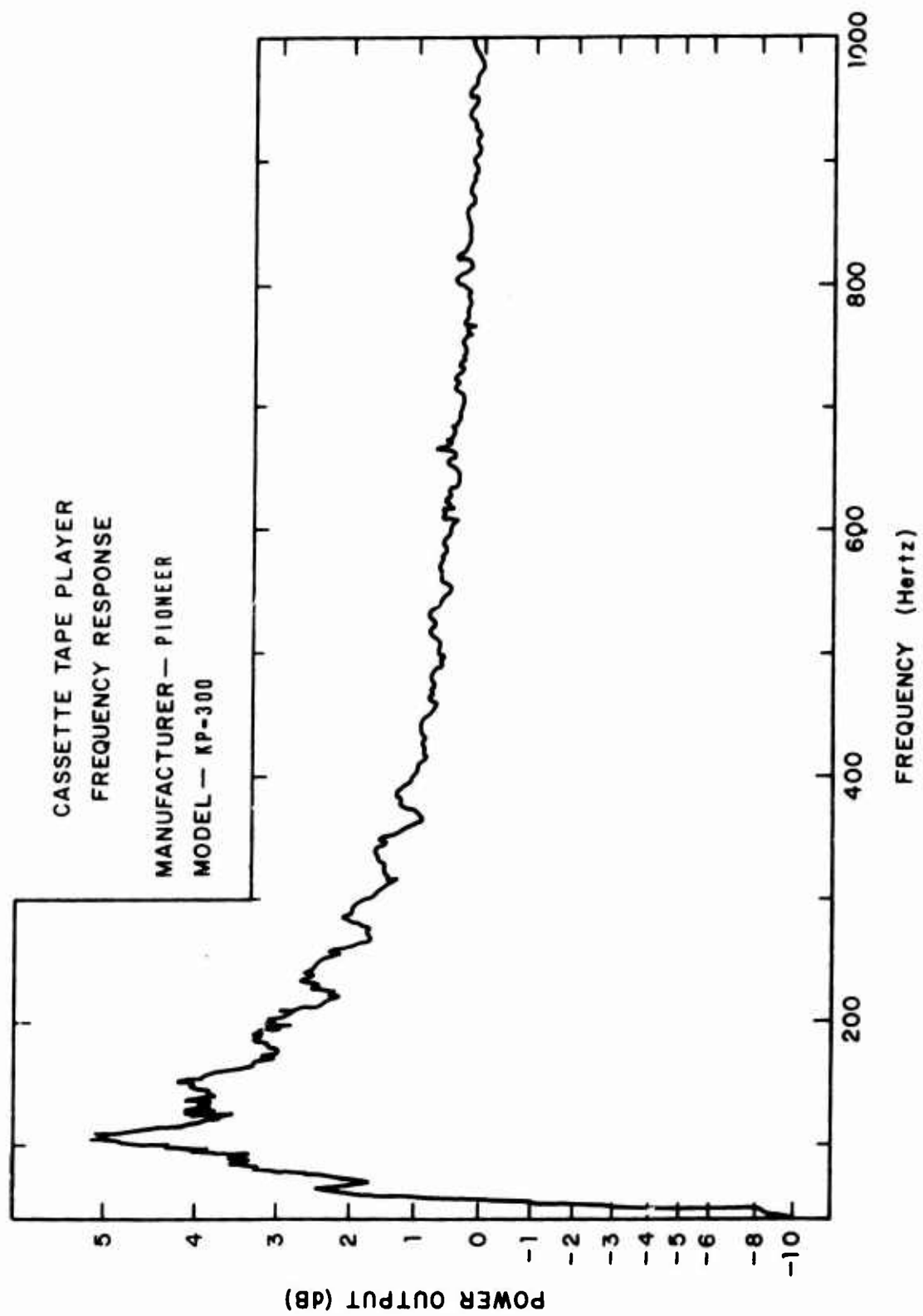




CASSETTE TAPE PLAYER
FREQUENCY RESPONSE

MANUFACTURER — PIONEER
MODEL — KP-300

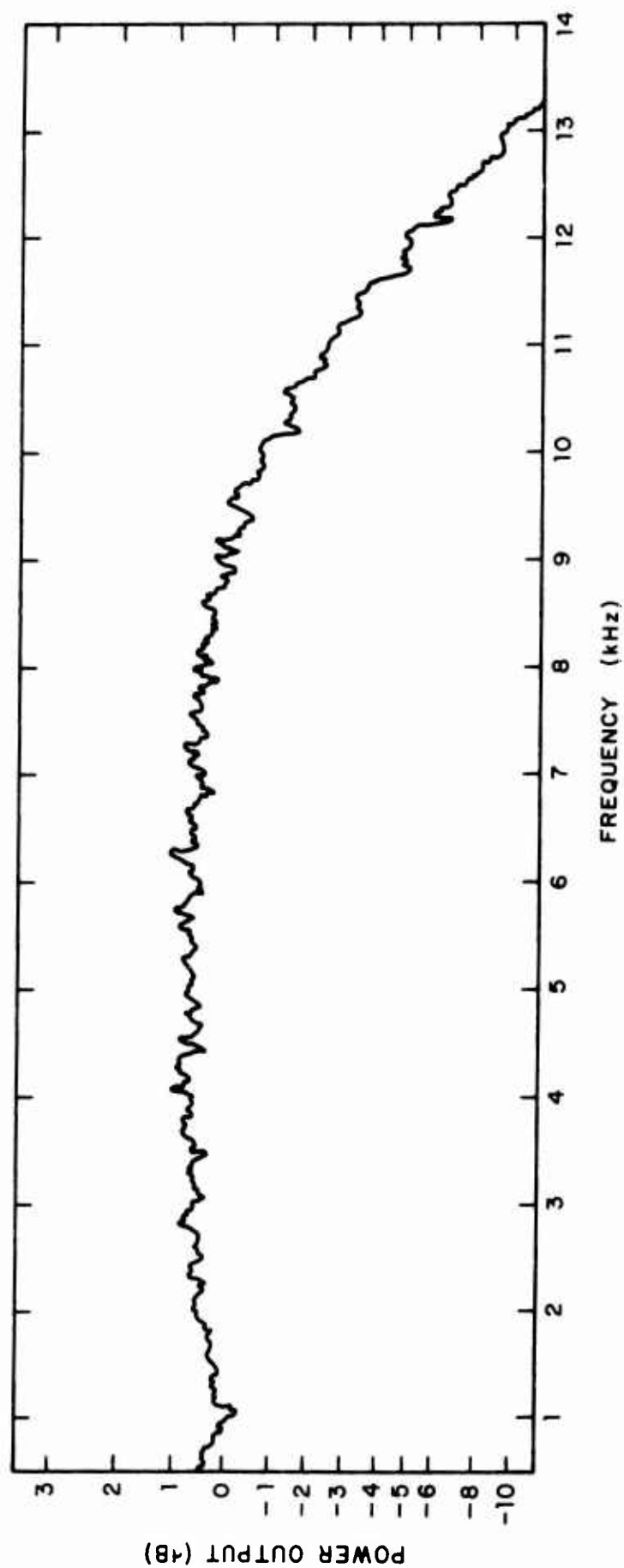


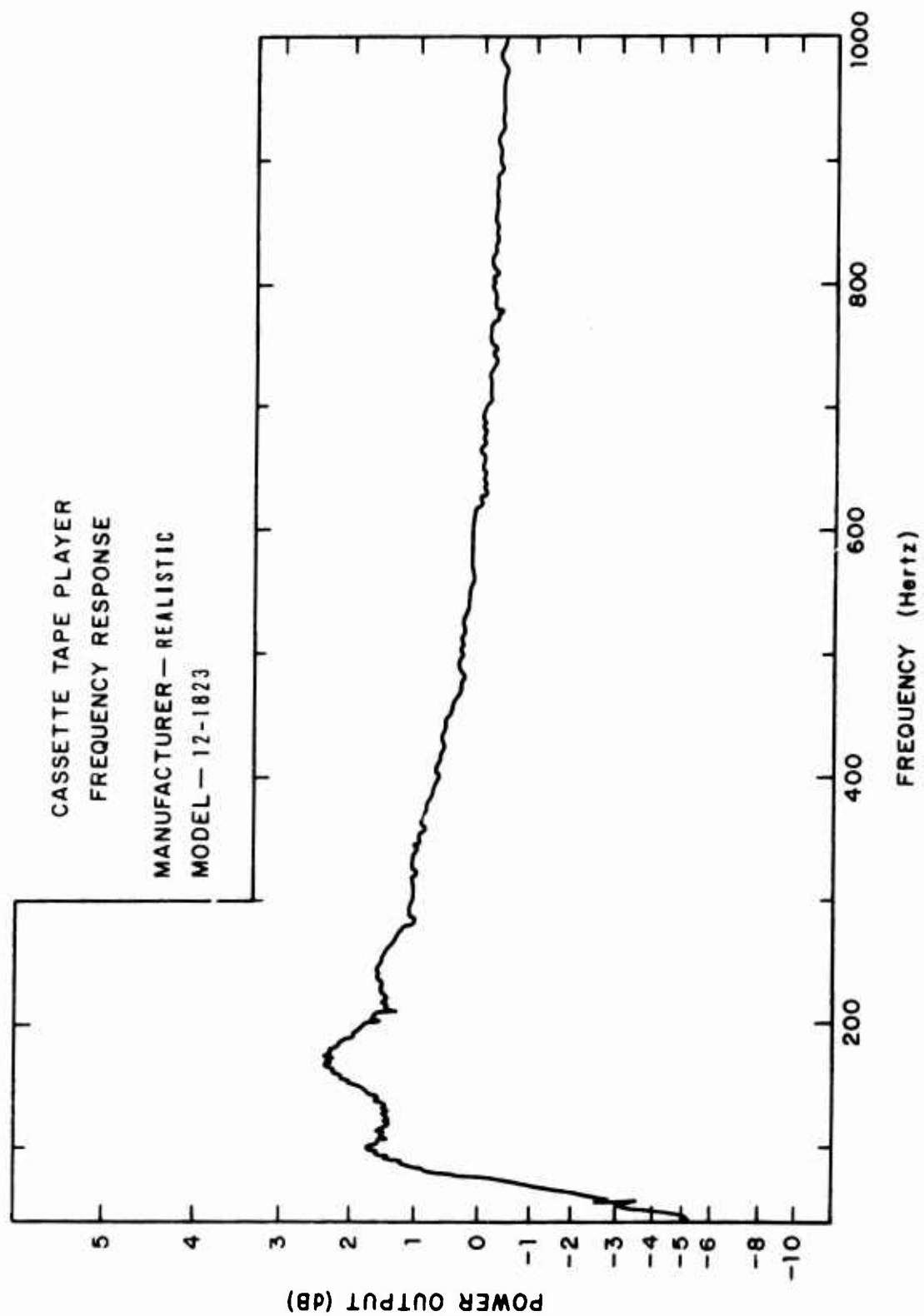


CASSETTE TAPE PLAYER
FREQUENCY RESPONSE

MANUFACTURER — REALISTIC

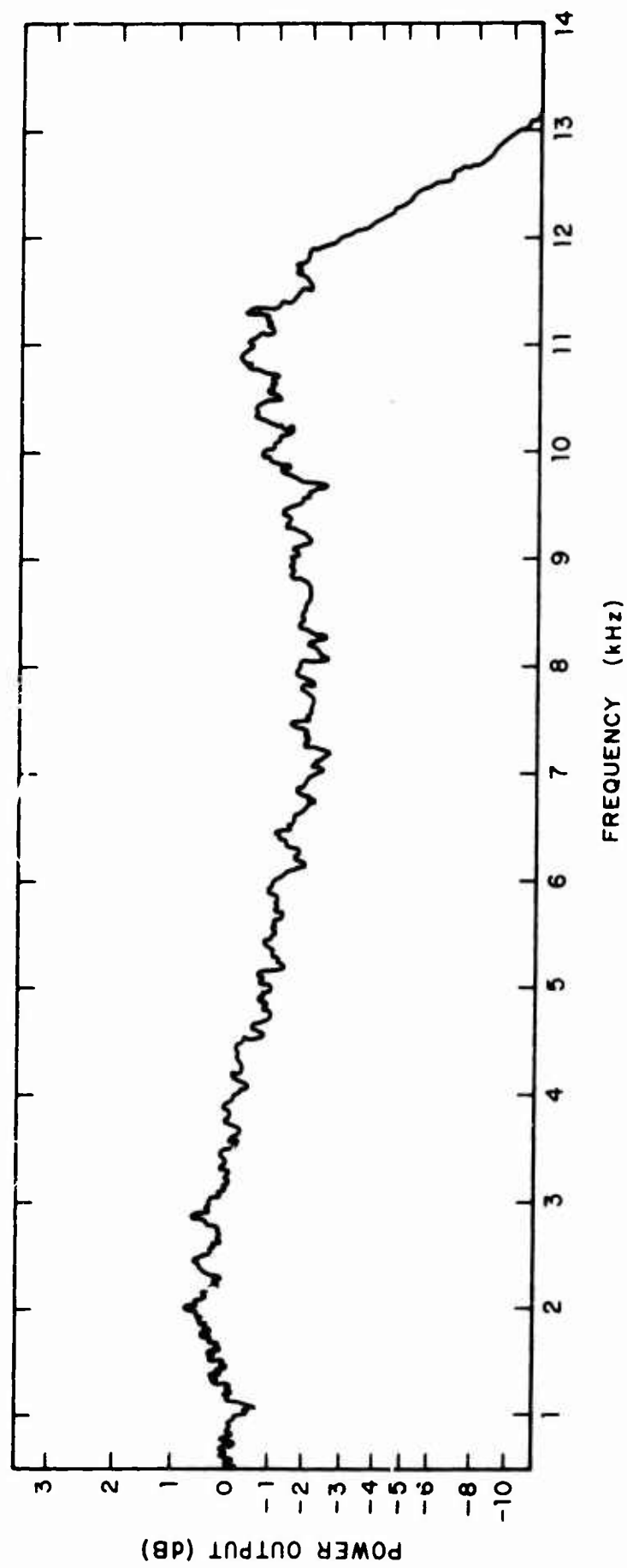
MODEL — 12-1823

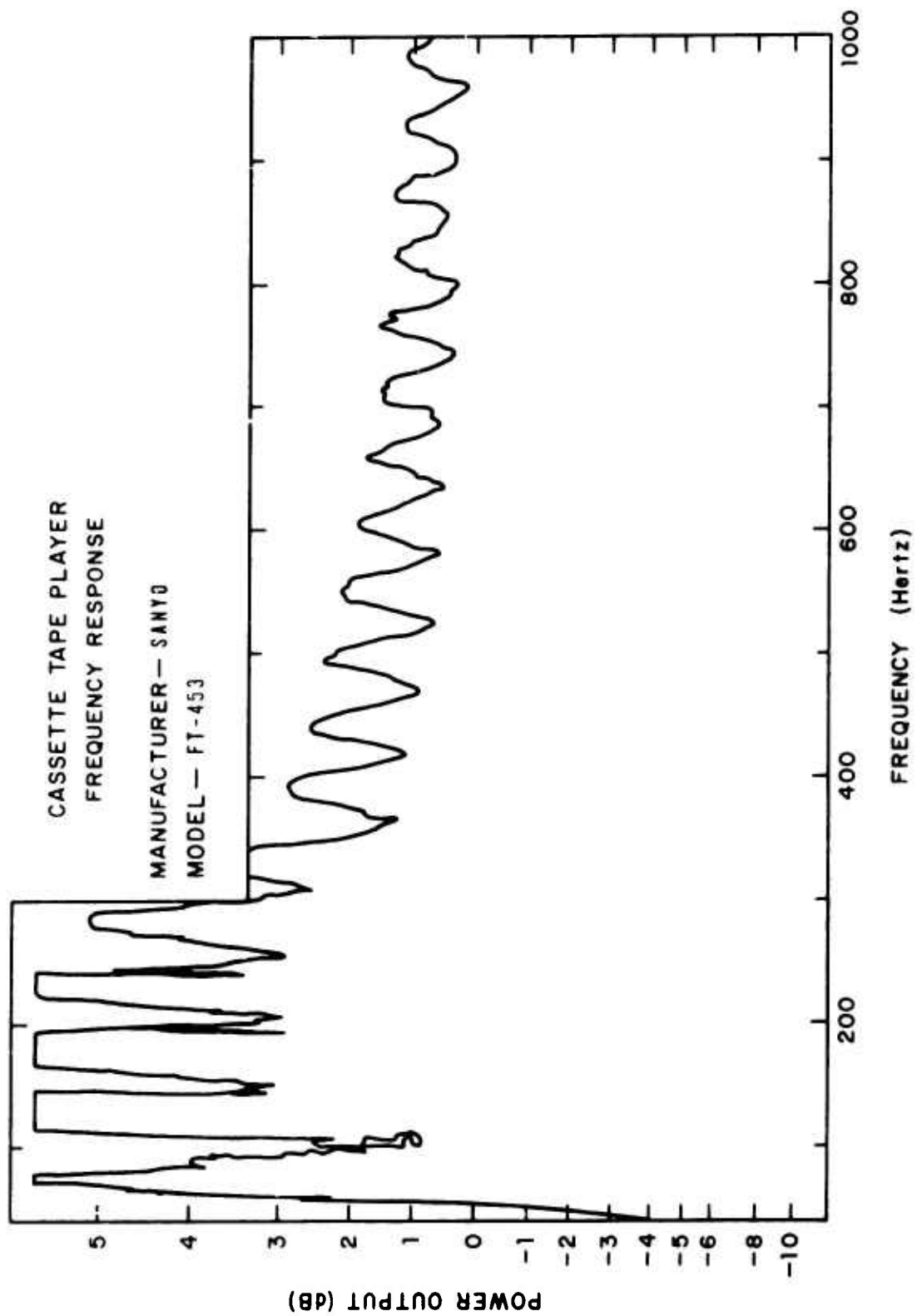




CASSETTE TAPE PLAYER
FREQUENCY RESPONSE

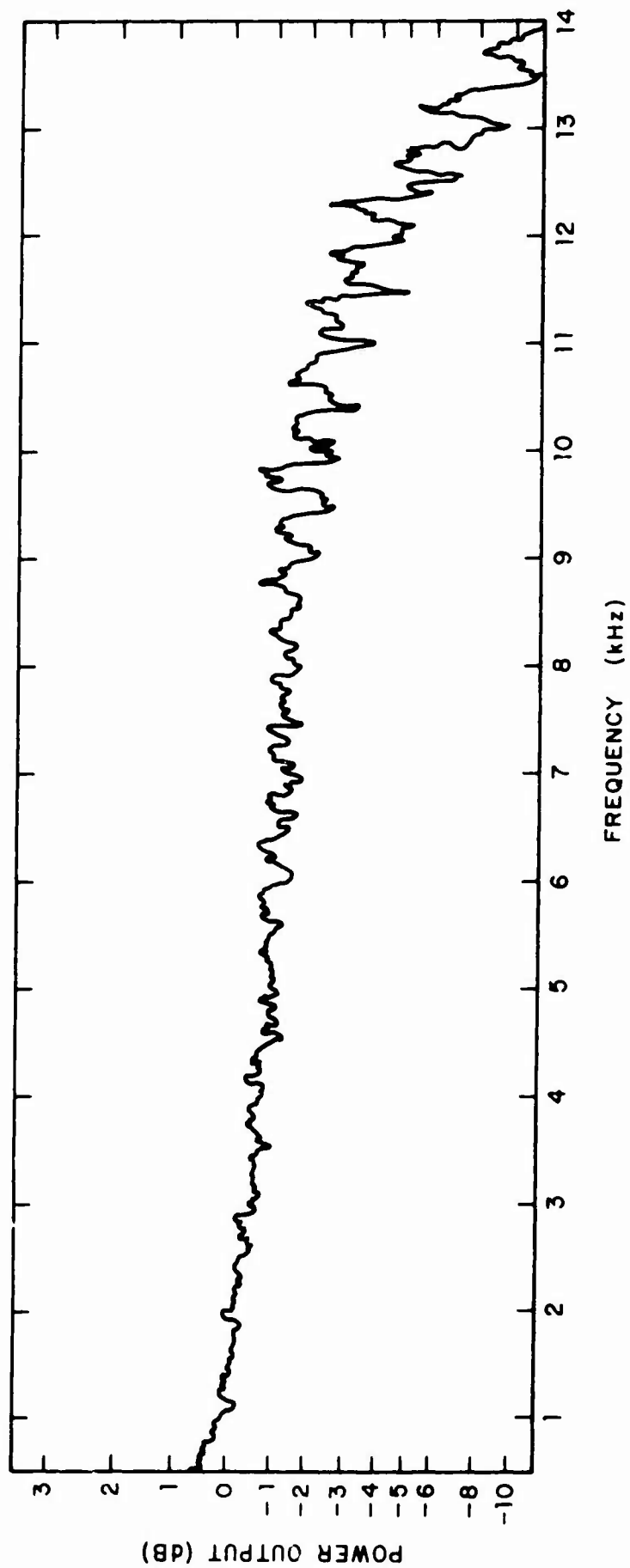
MANUFACTURER — SANYO
MODEL — FT-453

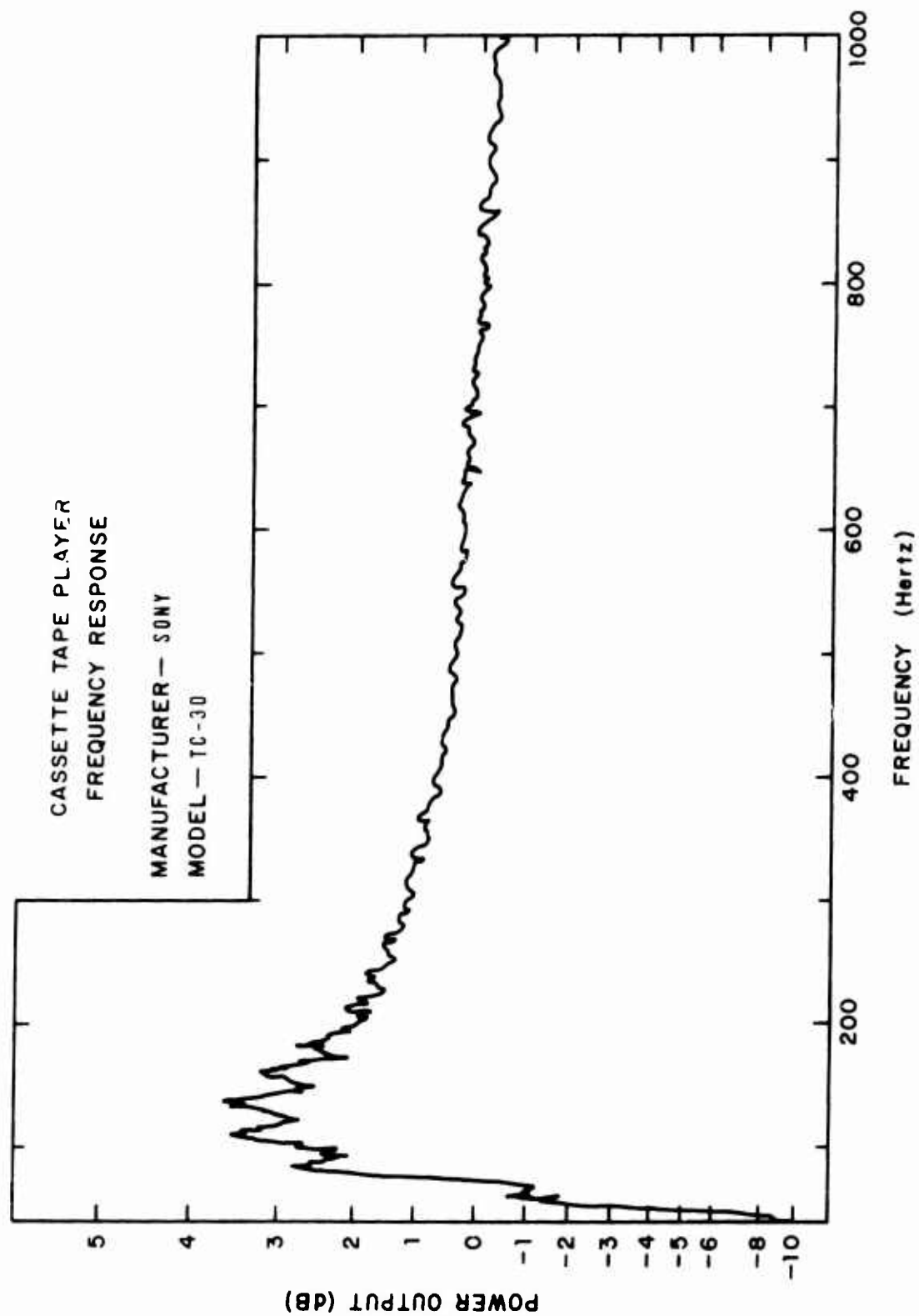




CASSETTE TAPE PLAYER
FREQUENCY RESPONSE

MANUFACTURER — SONY
MODEL — TC-30

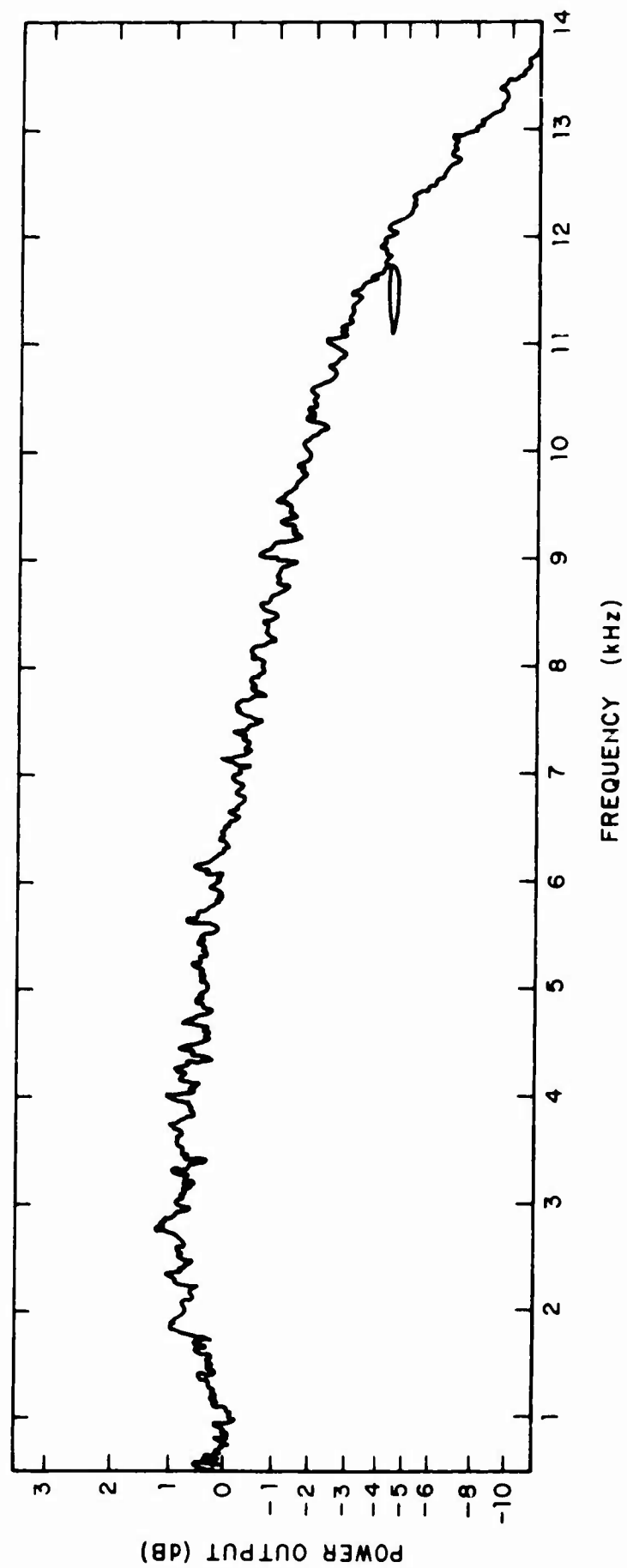


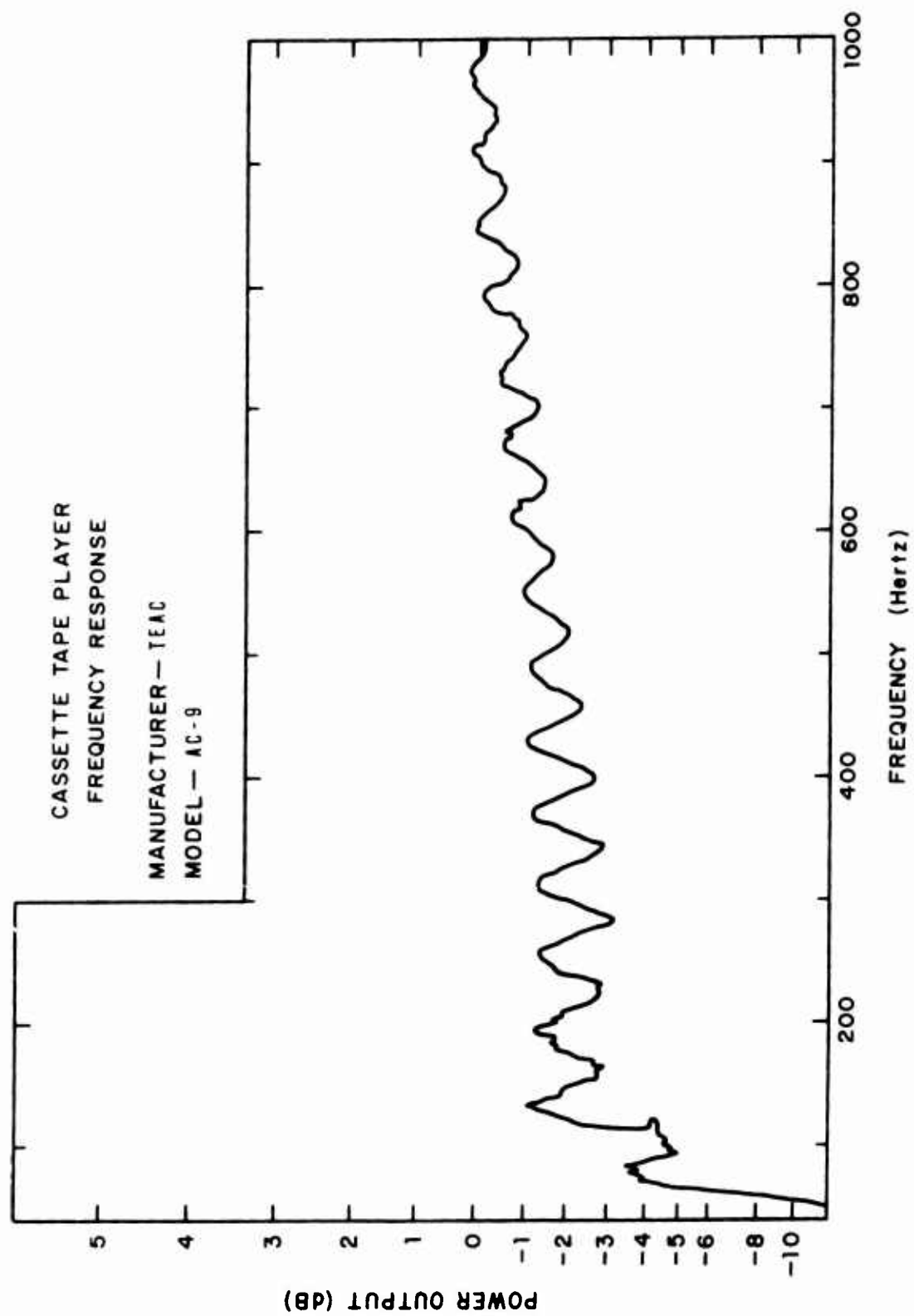


CASSETTE TAPE PLAYER
FREQUENCY RESPONSE

MANUFACTURER — TEAC

MODEL — AC-9





CASSETTE TAPE PLAYER
FREQUENCY RESPONSE

MANUFACTURER — TEAC CASSETTE DECK
MODEL — 450

