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PROPELLER ACOUSTICS TEST FACILITY (CAPABILITY DESCRIPTION).(U)
AUG 77 P A SHAHADY, S W KIZIRNIS

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**PROPELLER ACOUSTICS TEST FACILITY
(Capability Description)**

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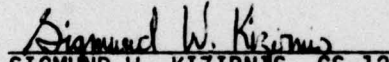
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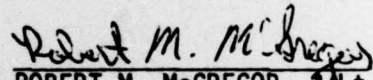
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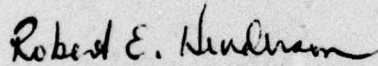
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report describes the development of a research facility to investigate fan and propeller noise generation mechanisms. A 3500 horsepower electric whirl rig was modified to allow both near and far-field acoustic testing. The rig is located in a large building with acoustically-treated walls. Reverberation time and sound pressure level measurements were conducted to determine the acoustic characteristics of the building. Acoustic data is acquired using a portable analog FM multichannel tape recorder system. The resultant data is frequency analyzed in one-third octave or narrow bands. A series of data presentation programs have been developed to cross plot key performance and acoustic parameters.		

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FOREWORD

This report contains the description of a propeller acoustics test facility utilized to conduct a number of propeller performance and acoustic tests over the period from 1970 to 1976. The facility was developed by the Turbine Engine Division and the Technical Facilities Division of the Air Force Aero-Propulsion Laboratory, Wright-Patterson AFB, Ohio, under Project 3066, Task 12, Work Unit 02. The effort was conducted by Paul A. Shahady, AFAPL/TBC, and Sigmund W. Kizirnis, AFAPL/TFE during the period of 1 January 1970 to 31 October 1976. 2/Lt Robert M. McGregor provided major computer support to the project.

Special appreciation is extended to Raymond Allen for providing outstanding instrumentation support to the facility. Appreciation is also given to George Medisch, foreman of the facility test crew during most of the testing period, to Wellington Steel, William Howerton, Harold Crouch, Walt Stebel, and Harold Lee, members of the facility test crew and to Joseph Simmons for his support to the acoustic tests.

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I. INTRODUCTION

The purpose of this report is to describe the development of a research facility to investigate fan and propeller noise generation mechanisms. Over the past several decades, a considerable amount of propeller noise experimental data has been obtained. Much of this data was acquired using simplified test rigs employing reciprocating or gas turbine engines as the means for driving the propeller. Noise from these drive systems seriously contaminated much of the measured propeller noise under certain operating conditions. The more recently constructed turbine engine fan test facilities have alleviated the drive noise contamination problem by properly suppressing drive system noise. However, most of the facilities capable of large-scale acoustic testing are located outdoors and are subject to weather conditions. Therefore, a program was initiated to develop an all-weather test capability to measure near- and far-field propeller and fan noise free of contamination from excessive background noise.

A 3500-horsepower electric whirl rig, located in Building 20A at Wright-Patterson AFB, was modified to allow both near- and far-field acoustic testing. The rig is located in a large building with acoustically treated walls. Reverberation time and sound pressure level measurements were conducted to determine the acoustic characteristics of the building. Acoustic data was acquired using a 12-channel portable data acquisition system consisting of microphone stands, microphones, lead lines, signal conditioning equipment, a multi-channel analog FM tape recorder, and associated calibration equipment. Acoustic data is frequency analyzed into one-third octave or narrow bands and automatically plotted using a computerized dynamic analysis system located in the Air Force Flight Dynamics Laboratory at Wright-Patterson Air Force Base. A series of data presentation programs have been developed to cross plot a number of key performance and acoustic parameters.

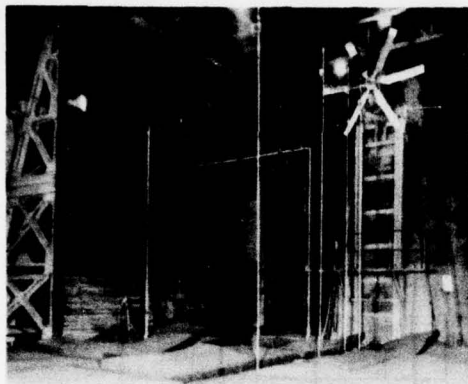
II. FACILITY DESCRIPTION AND PERFORMANCE MEASUREMENT SYSTEM

The 3500-horsepower electric whirl rig consists of a large concrete pier which houses the electric drive motor, thrust and RPM measuring equipment, and various accessory drives. The pier rises about 25 feet off the floor of a large open building. The facility side walls and floor were covered with six-inch thick Coustic TM polyurethane foam to minimize acoustic reflections. The control room is located under the pier and the propeller may be observed via a periscope and strobe light arrangement. Closed circuit TV cameras are also used to monitor the facility. Various parts of the facility are shown in Figure 1. The following technical summary of the performance measurement system is taken from Reference 1. The input power to the propeller is calculated from measuring the armature voltage and amperage at the electric drive motor. Predetermined correction factors are then applied to allow for the copper and field winding losses. The resultant watts are then converted to horsepower and an atmospheric correction factor is used to adjust the data to standard day conditions. These calculations are made with an electronic desk calculator during the course of the test so that field curves can be drawn to check for obvious data discrepancies. The system is calibrated against a well documented test propeller whose characteristics have been accurately set and locked into place. No-load losses are determined by motoring the rig at various RPM settings without a propeller attached.

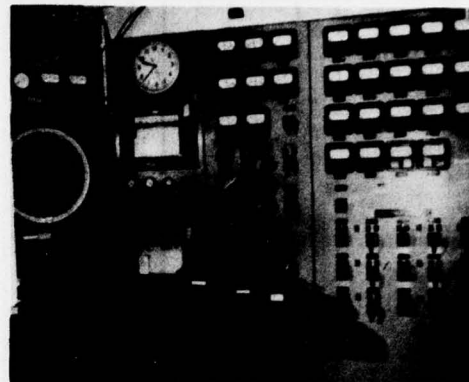
The thrust is measured by converting the movement of the propeller shaft to hydraulic pressure via a hydraulic diaphragm. The pressure signal is then directly converted to pounds thrust with a precalibrated Emery-Tate load indicator and then corrected to standard day conditions. The thrust system is calibrated statically by applying a known load (lead weights) to the propeller shaft. Accurate shaft RPM was obtained from a magnetic pickup which receives impulses from the drive motor shaft. These impulses are then presented on a digital display in the control room as propeller RPM.

All of the previously mentioned performance data, horsepower, thrust, and RPM, is taken directly from the instrumentation in the control room. This data is then corrected for the various loss and atmospheric effects by employing pre-determined correction factors. The data is tabulated on the form shown in Figure 2 and turned over to the project engineer for reduction. This is accomplished by using a computer program entitled "Computer Program for Reducing Static Propeller Test Data" (Reference 2). The following explanation of the program generally follows that of Chopin (Reference 3).

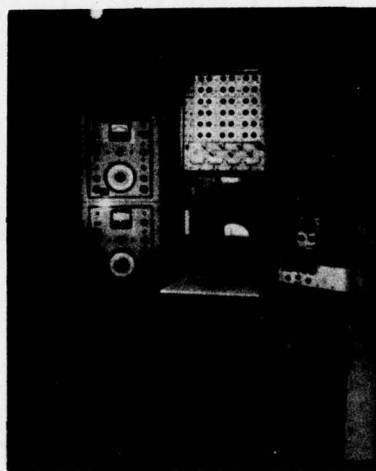
The program accepts whirl rig data in the format in which it is taken from the rig by the test crew. This is then reduced by the computer into power coefficients (C_p), thrust coefficients (C_t),



a) 3500 HP Whirl Rig



b) Performance Data Acquisition System



c) Acoustic Data Acquisition System

Figure 1: Propeller Acoustics Test Facility at Wright-Patterson AFB, Ohio

PROPELLER WHIRL TEST DATA SHEET										
DATE	RIG	HUB DWG NO.	ENGINEER	TEMP						
12-20-72	2			+30						
MFR	ADAPTER	HUB SERIAL NO. <td>CREW CHIEF</td> <td>BAROMETER</td> <td colspan="6"></td>	CREW CHIEF	BAROMETER						
	With Foam Rubber on	6 Blades Equal Spaced		29.16						
PROJ. NO.	BAFFLES	BLADE DWG NO. <td>TEST CREW</td> <td>AIR FACTOR</td> <td colspan="6"></td>	TEST CREW	AIR FACTOR						
30661208	Floor	Hi Tail Rotor Blades	Stebel	1.0169						
WHIRL TEST NO.	T.T.	BLADE SERIAL NO. <td>Howerton</td> <td>RIG FACTOR</td> <td colspan="6"></td>	Howerton	RIG FACTOR						
3026	3.25		Steele	1.006						
SHEET NO.				TH FACTOR						
				1.023						
ANGLE	10°									
RPM	601	752	900	1050	1201	1299	1402			
COR HP	26	37	56	85	121	152	189			
COR TH	188	298	430	601	786	928	1080			
ARM VOLTS	40	50	60	70	79	85	94			
MULTIPLIER	4	X20								
ARM AMPS	2.76	.6	.7	.83	.96	1.06	1.17			
MULTIPLIER	240	X600				X1200				
ARM WATTS	185	106	147	203	269	161	193			
CU LOSS						1	1			
F W I LOSS	34	47	61	76	92	103	118			
GEAR LOSS										
TOTAL HP	60	85	118	163	216	259	310			
TOTAL LOSS	34	47	61	76	92	104	118			
NET HP	26	38	57	87	124	155	192			
TH SCALE	193	305	440	615	805	950	1105			
BAL THRUST							0			
ACTUAL TH										
START	09:13									
STOP	09:45									
TEST TIME	:32									
START										
STOP										
RIG TIME										
REMARKS	<p>Total Time 3 hrs. 57 min. Blade Angle Checked 1. 9.90 4. 10° 2. 9.90 5. 9.9° 3. 100 6. 10°</p>									

Figure 2: Performance Data Sheet

C_t/C_D , figure of merit (F.M.), thrust/horsepower (Th/HP), and propeller tip Mach number. The output format of the program is shown in Table 1. The symbols presented in Table 1 are defined as follows:

PROPELLER CHARACTERISTICS

- BETA - Test blade angle
- AF - Blade activity factor
- DIA - Propeller diameter in feet
- NBL - Number of blades
- TEMPC - Ambient temperature in degrees Centigrade
- TEMPR - Ambient temperature in degrees Rankine
- SIGMA - Density ratio

RAW DATA POINTS

- RPM - Propeller rpm
- HP - Corrected horsepower
- TH - Corrected thrust
- TMACH - Propeller tip Mach number
- RCT - Raw thrust coefficient
- RCP - Raw power coefficient
- RCT/CP - Ratio of raw thrust to raw power coefficient
- RFM - Raw figure of merit
- RTH/HP - Ratio of raw corrected thrust to corrected horsepower

FITTED CURVE DATA FOR CONSTANT MACH NUMBER INCREMENTS

- MACH - Selected Mach number increment
- HP - Horsepower at Mach increment
- TH - Thrust at Mach increment
- TIPS - Propeller tip speed in ft/sec corresponding to Mach increment
- RPM - Propeller rpm at Mach increment
- CT - Thrust coefficient at Mach increment
- CP - Power coefficient at Mach increment
- CT/CP - Ratio of thrust coefficient to power coefficient at Mach increment
- RM - Figure of merit at Mach increment
- TH/HP - Ratio of thrust to horsepower at Mach increment

TABLE 1: PROPELLER PERFORMANCE DATA OUTPUT FORMAT

STATIC PROP PERFORMANCE

RUN ___ TITLE OF TEST

BETA= ___ AF= ___ DIA= ___ NBL= ___ TEMPC= ___ TEMPR= ___ SIGMA= ___

*** RAW DATA POINTS ***

RPM	HP	TH	TMACH	RCT	RCP	RCT/CP	RFM	RTH/HP
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—

*** FITTED CURVE DATA FOR CONSTANT MACH NUMBER INCREMENTS ***

MACH	HP	TH	TIPS	RPM	CT	CP	CT/CP	FM	TH/HP
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—

III. ACOUSTIC DATA ACQUISITION SYSTEM

The acoustic data acquisition system consists of Bruel and Kjaer half-inch microphones and cathode followers and in-house designed line drive amplifiers mounted on portable microphone stands. The microphones are located 23 feet above the floor in a horizontal plane through the propeller centerline. A typical microphone array used for several test programs is shown in Figure 3.

The data signals are carried by 250-foot land lines to an instrumentation control room located below the rig. The signals were conditioned through variable gain amplifiers and recorded on a 14-channel AMPEX FR 1300 tape unit for later analysis. A data flow schematic of the acoustic data acquisition system is shown in Figure 4. The two symbols for the tape recorder represent the data flow in the record mode and in the reproduce mode respectively. Gain and attenuator adjustments are accessible at various points in the system. Phase and gain controls are located at the line drive amplifier for system calibration adjustments. A zero to twenty dB attenuation is available at the junction box. Final adjustments are made at the variable gain amplifiers before the signals are input to the tape recorder. The data signals can be monitored at various points in the system. A signal output BNC is located at the line drive amplifier and at the junction box. Individual channel scopes are used to monitor either the tape recorder input signals or the reproduced output signals. A signal selector circuit is used to provide any of the tape recorder input signals for detailed analysis. These signals are recorded on the loop recorder for on-line frequency analysis. These various monitor outputs allow the signal to be evaluated on the output side of each major component from the line drive amplifier to the tape recorder. The total system is calibrated at the beginning and end of each tape and at the beginning and end of each test day. An NBS traceable piston phone provides a 124 dB pressure signal at 250 Hertz to the microphone diaphragm. This signal is recorded on tape for each microphone channel. Gains for the various data acquisition system components are recorded manually on data log sheets.

The data acquisition system is primarily comprised of off-the-shelf general purpose instrumentation. However, four of the components, the line drive amplifier, junction box, signal selector, and audio monitor system were designed in-house. Detailed schematics of these components are presented in Appendix A.

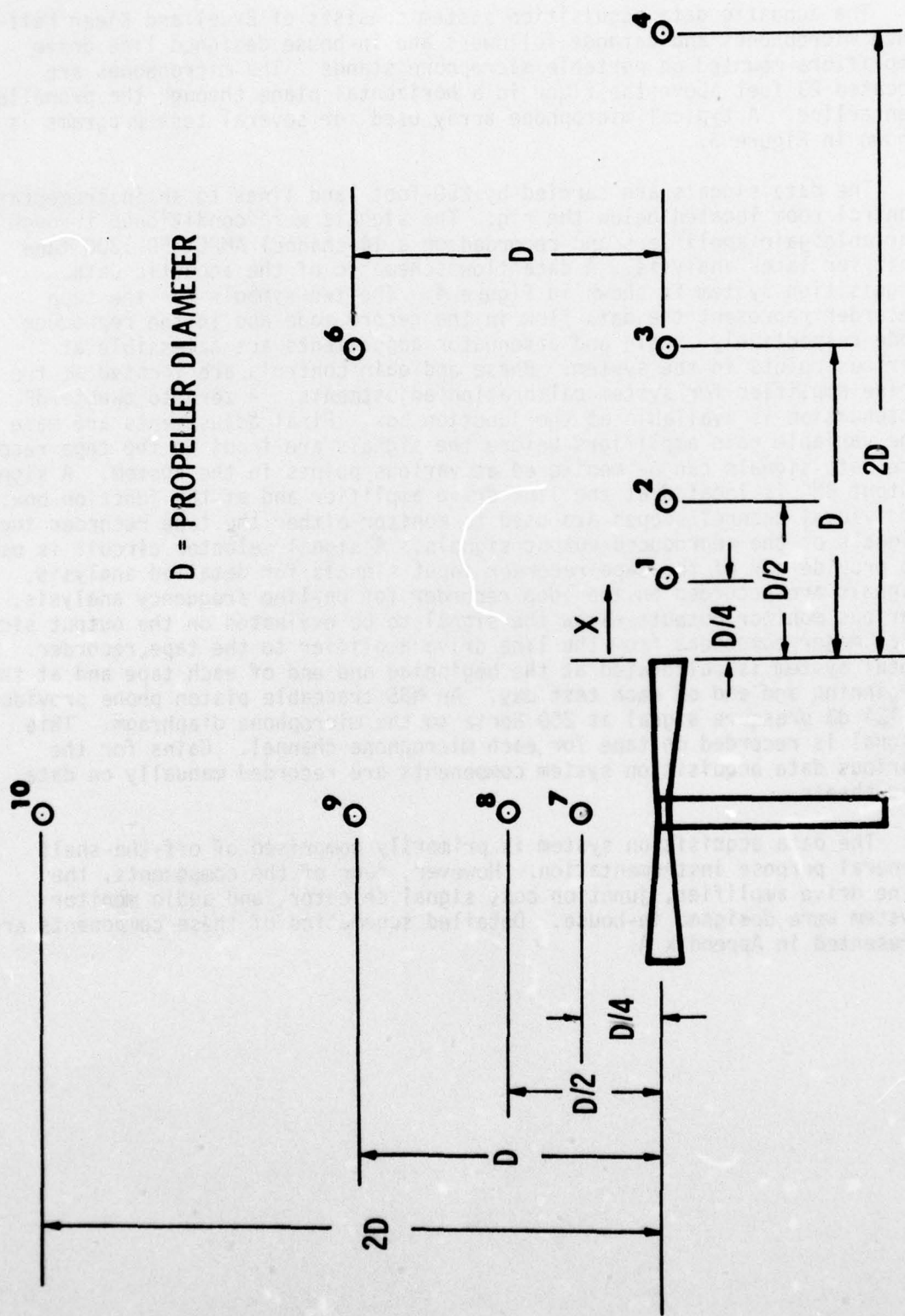


FIGURE 3:
TYPICAL MICROPHONE ARRAY FOR
PROPELLER ACOUSTICS TESTING

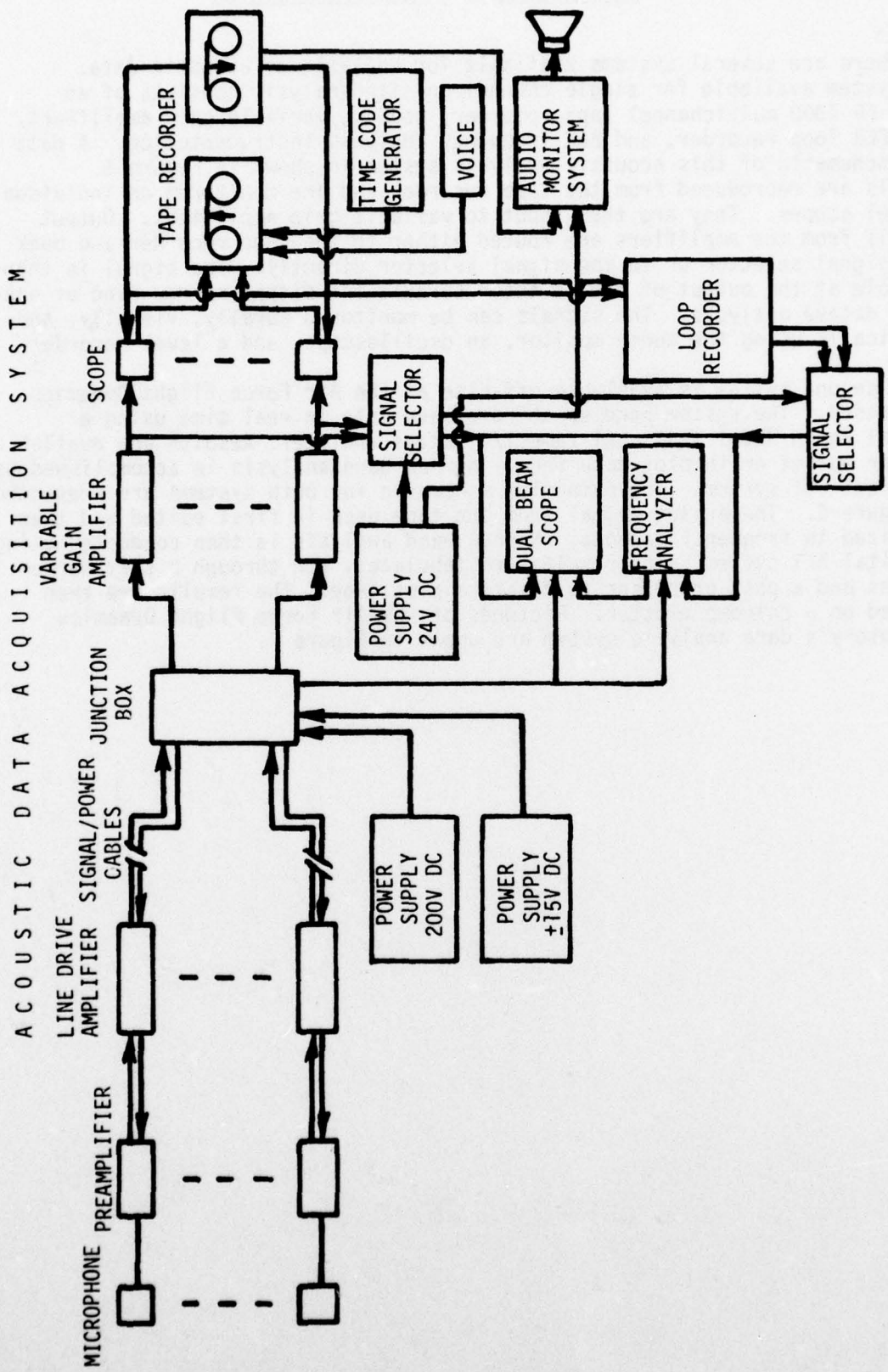


FIGURE 4: DATA FLOW SCHEMATIC FOR ACOUSTIC DATA ACQUISITION

IV. ACOUSTIC DATA ANALYSIS SYSTEM

There are several systems available for analysis of acoustic data. One system available for single channel on-site analysis consists of an AMPEX FR 1300 multichannel tape recorder, scopes, variable gain amplifiers, an AMPEX loop recorder, and B&K frequency analysis instrumentation. A data flow schematic of this acoustic analysis system is shown in Figure 5. Signals are reproduced from the tape recorder and are monitored on individual channel scopes. They are then input to variable gain amplifiers. Output signals from the amplifiers are routed either to the loop recorder and back to a signal selector or to the signal selector directly. The signal is then available at the output of the selector circuit for either narrow band or one-third octave analysis. The signals can be monitored aurally, visually, and graphically using the audio monitor, an oscilloscope, and a level recorder.

A second system is available off-site at the Air Force Flight Dynamics Laboratory. The system handles third-octave data in real time using a General Radio Model 1933 real time 1/3 octave analyzer. Results are available in tabular output or in plot tape form. Narrow band analysis is accomplished using a digital FFT system. The data flow schematic for both systems are presented in Figure 6. The analog signal from the tape deck is first edited and then digitized in frequency decades. Narrow band analysis is then conducted using a digital FFT system. The results are tabulated, run through a sort/merge process and a post processor to create a plot tape. The results are then plotted on a calcomp plotter. Pictures of the Air Force Flight Dynamics Laboratory's data analysis system are shown in Figure 7.

ACOUSTIC DATA ANALYSIS SYSTEM

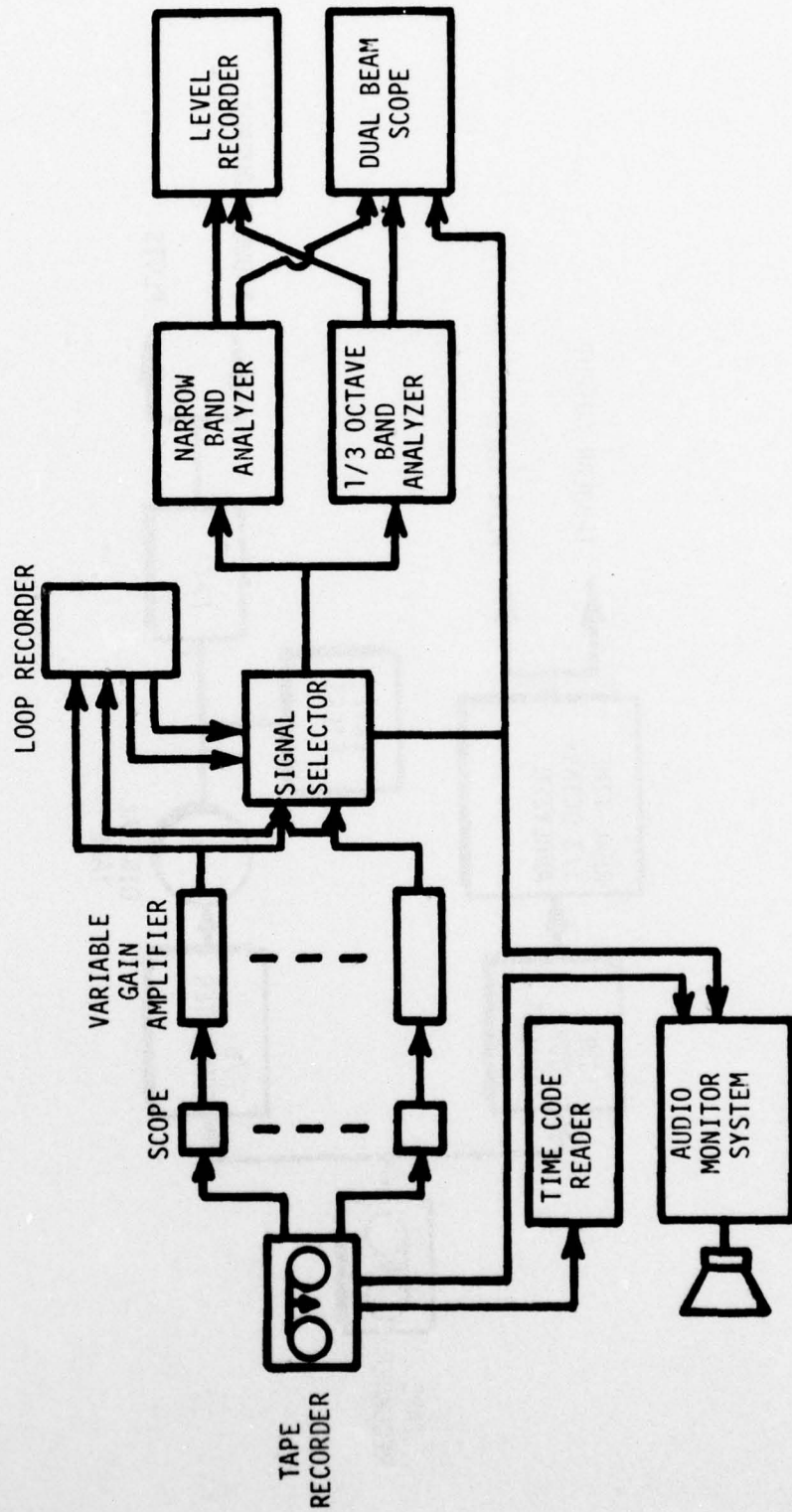


FIGURE 5: DATA FLOW SCHEMATIC FOR ON-LINE ACOUSTIC DATA ANALYSIS

ACOUSTIC DATA ANALYSIS SYSTEM

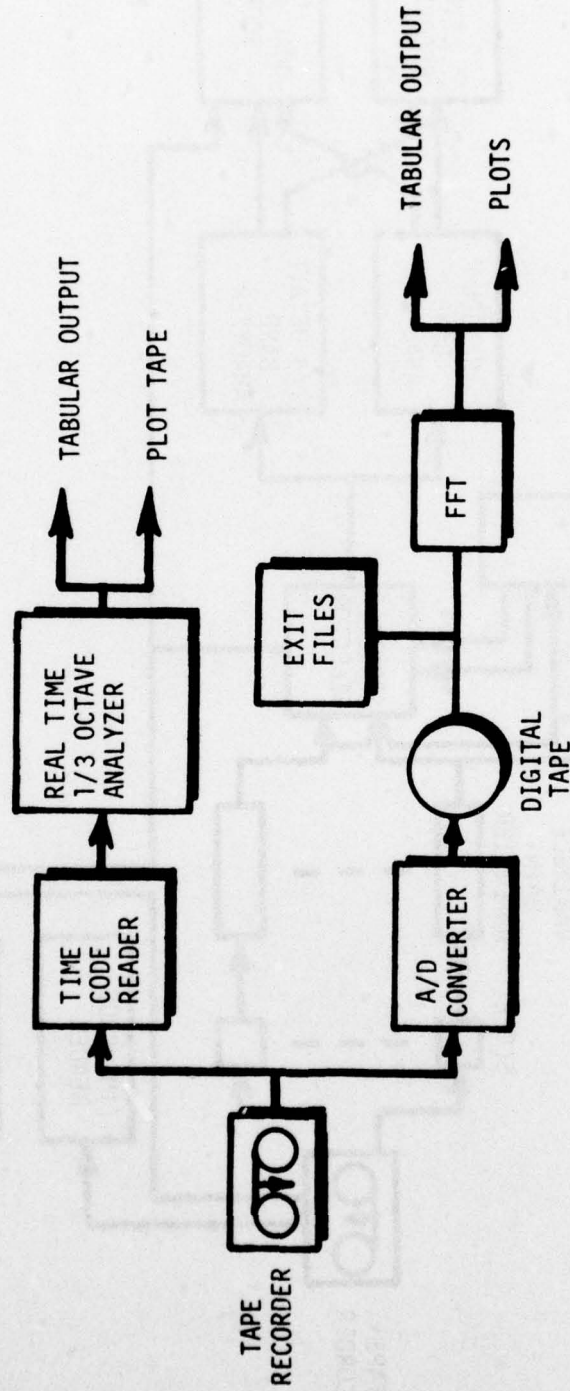
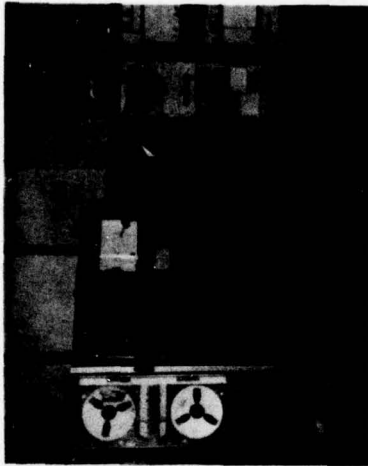


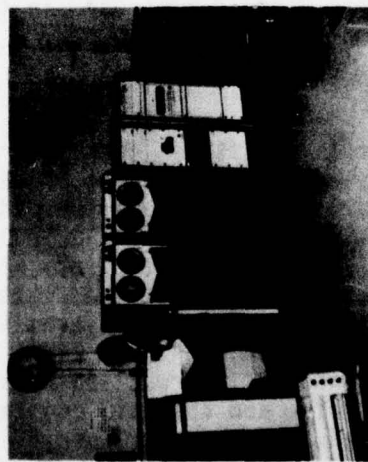
FIGURE 6: DATA FLOW SCHEMATIC FOR OFF-LINE ACOUSTIC DATA ANALYSIS



a) Data Recovery and Editing



b) Analog-to-Digital Conversion



c) Digital Analysis



d) Data Presentation

Figure 7: Dynamic Data Analysis System at the Flight Dynamics Laboratory

V. ACOUSTIC DATA PRESENTATION SYSTEM

Several computer programs were written to reduce and plot propeller performance and acoustic test data. The data comes in two basic forms: Propeller Whirl Test Data Sheets (AFAPL Form 14A), and digitized sound spectra computer cards.

Data from the test rig sheets must first be coded onto computer cards as shown in Figure 8. In this format it is compatible with programs written for data reduction programs in ASD-TR-68-19, "Computer Program for Reducing Static Propeller Test Data." Not all data on these cards will be required by each individual program, but with commonality, the number of cards and the time spent punching them is reduced.

The digitized spectra data cards were obtained from a General Radio 1933 Real Time third-octave band analyzer, and come in two formats. The first format covers the frequencies from 3.15 Hz through 20,000 Hz, while the second covers 20 Hz through 20,000 Hz. Each block of data consists of four cards, the first containing the run and microphone channel identification numbers. The last number on the last card is the overall sound pressure level (OASPL) in dB for that block. All other numbers represent the SPL's for their respective third-octave bands. Figure 8.a. shows data sets for three microphones (4, 5, 6) during run number six of a particular configuration.

The basic coded rig data and spectra data are used by five programs: HORSE, THORSE, NOISY1, NOISY2, and DBA. Each program is written in FORTRAN IV-Extended for the CDC 6600 computer, and with the exception of DBA, requires a CALCOMP plotter and associated software. DBA requires a peripheral card punch. References 2 and 4 were used in the development of these programs.

HORSE

Program HORSE plots thrust vs. horsepower for any configuration. Several parameters which control the output format have been preset within the main program body. Changes should be made using a NAMELIST card. Input may include 600, 750, 900, 1050, and 1200 RPM data or 600, 900, and 1200 RPM data. If five points are entered, all five will be used. Likewise, if three are entered, three will be plotted. Setting the Namelist variable IORPM = 2 gives three-point output even if five points are entered. Three blade angles are required for each RPM. Spline-fitted curves through all points are standard. Thrust and horsepower limits are preset at 1600 and 240 respectively, and are held constant for easy comparison between plots. If desired, the user may specify his own limits. Different limits need only be set once for any number of plots generated during a single program run. If changes are required, however, 99999 in columns 1 - 5 alerts the program to a new \$INPUT card. A program listing with sample input cards and output plots is found in Appendix B.1.

PROPELLER WHIRL TEST DATA SHEET												
DATE	12-20-72		RIG	2		HUB DWG NO.			ENGINEER	C	TEMP	+30
PROJ NO.	30661208		ADAPTER	With Foam Rubber on		HUB SERIAL NO.	6 Blades Equal Spaced		CREW CHIEF		BAROMETER	29.16
WHIRL TEST NO.	3026		BAFFLES	Floor		BLADE DWG NO.	Hi Tail Rotor Blades		TEST CREW	D	AIR FACTOR	1.0169
SHEET NO.	7		T.T.	3.25		BLADE SERIAL NO.			Howerton		RIG FACTOR	1.006
									Steele		TH FACTOR	1.023
ANGLE	10°											
RPM	E	601	752	900	1050	1201	1299	1402				
COR HP	F	26	37	56	85	121	152	189				
COR TH	G	188	298	430	601	786	928	1080				
ARM VOLTS	40 50 60 70 79 85 94											
MULTIPLIER	4 X20											
ARM AMPS	2.76 .6 .7 .85 .96 1.06 1.17											
MULTIPLIER	240 X600											
ARM WATTS	185 106 147 203 269 161 193											
CU LOSS	1 1											
F W I LOSS	34 47 61 76 92 103 118											
GEAR LOSS												
TOTAL HP	60 85 118 163 216 259 310											
TOTAL LOSS	34 47 61 76 92 104 118											
NET HP	26 38 57 87 124 155 192											
TH SCALE	193 305 440 615 805 950 1105											
BAL THRUST	0											
ACTUAL TH												
START	09:13											
STOP	09:45											
TEST TIME	:32											
START												
STOP												
RIG TIME												
REMARKS	<p>Total Time 3 hrs. 57 min. Blade Angle Checked 1. 9.9° 4. 10° 2. 9.9° 5. 9.9° 3. 10° 6. 10°</p>											

- A** Number of Blades
- B** Blade Pitch Angle
- C** Temperature (°C)
- D** Air Factor
- E** Propellor RPM
- F** Horsepower
- G** Thrust

AFAPL FORM 14a
DEC 67

A		B		C		D	
6		116.75		9.33		10.0	
3.0		1.0169					
601		26		188			
Blade Diameter (ft)		Activity Factor					
ONE		TWO		THREE		FOUR	
FIVE		SIX		SEVEN		EIGHT	
Figure 8: Computerized Performance Input Data							

THORSE

Program THORSE is a derivative of HORSE, and plots the ratio of thrust to horsepower versus horsepower. Input cards are exactly the same as those for HORSE. Any section of a plot which falls below the X-axis is automatically eliminated. This is not true for values exceeding the Y-axis maximum (preset at 11.) where the user risks running the plotter into the travel stops, and throwing all remaining points out of place. A program listing with sample input cards and output plots is found in Appendix B.2.

NOISY1

Program NOISY1 plots SPL (dB) versus third-octave band frequency. The user may select any range between 20 Hz and 10,000 Hz for plotting. The overall SPL for the selected range is plotted separately on the right of the graph. The user may elect to have the A-weighted spectra plotted along with the dB spectra. Any number of spectra may be put on the same axes as long as they are from the same microphone channel. As in the previous programs, plotting parameters are preset but may be changed using the standard NAMEDLIST format. A blank card at the end of a block of data signals an end to plotting on that set of axes. The user then has three options: (1) end that session of plotting with an ENDDATA card, (2) start another plot with a new set of data cards or, (3) change the output NAMEDLIST parameters using a NEWPARAM card. Following the NEWPARAM card should be a new set of data. The program listing, sample input cards and output plots are found in Appendix B.3.

NOISY2

Program NOISY2 is a derivative of NOISY1. NOISY2 plots the spectra of several microphones on the same axes as long as the RPM remains constant. This differs from NOISY1 where the RPM varied for a single microphone. A program listing with sample input cards and output plots is found in Appendix B.4.

DBA

Program DBA reduces the digitized spectra data to dB and dBA sound pressure levels. The program sorts through each run of the basic data, stopping at user-specified microphone numbers. Over any given spectra range, the program will then calculate the overall SPL in both dB and dBA. The data are then punched on cards with the corresponding identification numbers and calculation range indices. If cards are not desired, the user may set IPUNCH = 0 and receive only the printout. Punched cards from DBA are used by program NEWCITY. A program listing with sample input cards and an output listing are found in Appendix B.5.

NEWCITY

The final data presentation program is NEWCITY. Using both the basic rig data and the SPL data cards from DBA, NEWCITY will plot SPL vs. thrust and SPL vs. horsepower. Several options for presentation are open to the user. The user may elect to receive either the thrust or horsepower

plots or both. The legend block may be eliminated. Three or five RPM values may be used, depending on the input data. Output curves may be in either dB or dBA, with spline or up to 6th-order polynomial-fitted curves. If the number of points is too few for the requested polynomial fit, NEWCITY will default to the highest possible polynomial. A program listing with sample input cards and an output listing are found in Appendix B.6.

VI. FACILITY ACOUSTIC CHARACTERISTICS

Ideally, we would like to be able to measure noise characteristics in a free-field environment uncontaminated by acoustic reflections, room mode interactions, reverberation, background noise, etc. Unfortunately, we are faced with all these problems when we attempt to evaluate acoustic sources in an enclosure. We must, therefore, either minimize these problems or carefully define their effect on the acoustic characteristics of the source.

Acoustic Reflections

The problem of acoustic reflections contaminating data measured on propeller whirl rig #2 has been minimized by the use of high absorption acoustic treatment on the near walls and the floor of the test rig. Six-inch thick pads of Custifoam were used to eliminate all reflections above five hundred Hertz and minimize reflections in the 100 to 500 Hertz range.

Room Mode Interactions

The acoustic power output of a source depends on the impedance presented to it by the surrounding medium. Reverberant room modes may increase or decrease this impedance depending on the location of the source and on its frequency relative to the room mode frequencies. If the room is very large in comparison with the acoustic wavelength, there will be so many modes at any given frequency that the effects of the individual modes are likely to cancel out. The total number of room resonances occurring in a rectangular room in the frequency range from 0 to f is given by the expression.

$$Q = \frac{4\pi V}{3} \times \left(\frac{f}{c}\right)^3 + \frac{\pi S}{4} \times \left(\frac{f}{c}\right)^2 + \frac{L}{2} \times \left(\frac{f}{c}\right) \quad (1)$$

Where:

- $V \equiv$ room volume (m^3)
- $S \equiv$ room surface (m^2)
- $L \equiv$ room edges, $l_x + l_y + l_z$ (m)
- $c \equiv$ velocity of sound (m/sec)

In a narrow frequency band ($\Delta f = f_2 - f_1$) around f the number of resonances are

$$\Delta Q = Q_{f_2} - Q_{f_1} \quad (2)$$

For Building 20A, $V = 69,859 m^3$, $S = 13,012 m^2$ and $L = 170 m$

Figure 9 gives the number of room resonances for the propeller test facility for one-third octave bands at octave band center frequencies from 63 Hertz to 8 KHz. Figure 10 shows the uncertainty of the power output at a single arbitrary source position for a simple source for both pure tones and bands of noise. This shows that the expected error can be neglected if the room is large enough assuming that the source is more than a wavelength from a wall (Reference 5). For the propeller rigs, the near walls and the floor adversely affect the data below 60 Hertz.

Reverberation

The reverberation characteristics of the facility were evaluated using the Norris-Eyring Formula (Reference 6) where the reverberation time in seconds is given by the expression

$$T = \frac{0.161V}{S[-2.3 \log_{10} (1-\bar{\alpha})]} \quad (3)$$

Where: $V \equiv$ volume of room, m^3
 $S \equiv$ area of bounding surface, m^2
 $\bar{\alpha} \equiv$ average absorption coefficient of the room

The average absorption coefficient is therefore given by

$$\bar{\alpha} = 1 - 10^{-.07V/ST} \quad (4)$$

The room constant, R_T , is given by the expression

$$R_T = \frac{S \bar{\alpha}}{1-\bar{\alpha}} \quad (5)$$

Reverberation time measurements were made in the facility using a rifle as the sound source. A number of shots were recorded on magnetic tape at various locations in the facility. The data was then analyzed in one-third octave frequency bands at octave band center frequencies. Plots of amplitude versus time for these bands were used to determine the reverberation time. The reverberation time, average absorption coefficient, and room constant are given as a function of third-octave bands at octave band center frequencies in Table 2. Figure 11 gives the relative sound pressure level as a function of distance from the acoustic center of a non-directional source for Building 20A. Relative sound pressure level is given by the expression

$$SPL-PWL = 10 \log_{10} \left(\frac{Q}{4\pi r^2} + \frac{4}{R_T} \right) \quad (6)$$

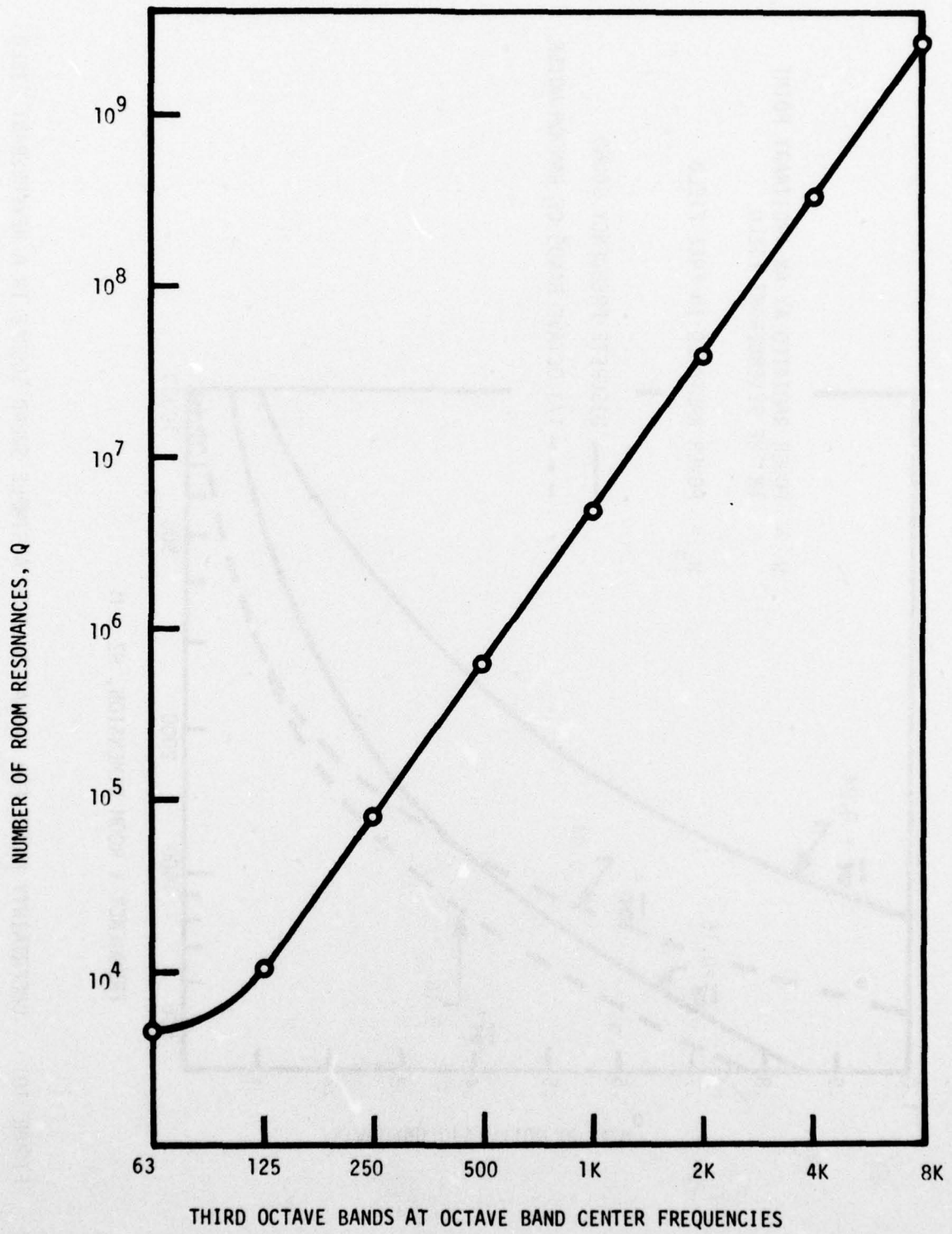


FIGURE 9: ROOM RESONANCES IN THIRD OCTAVE BANDS AROUND OCTAVE BAND CENTER FREQUENCIES

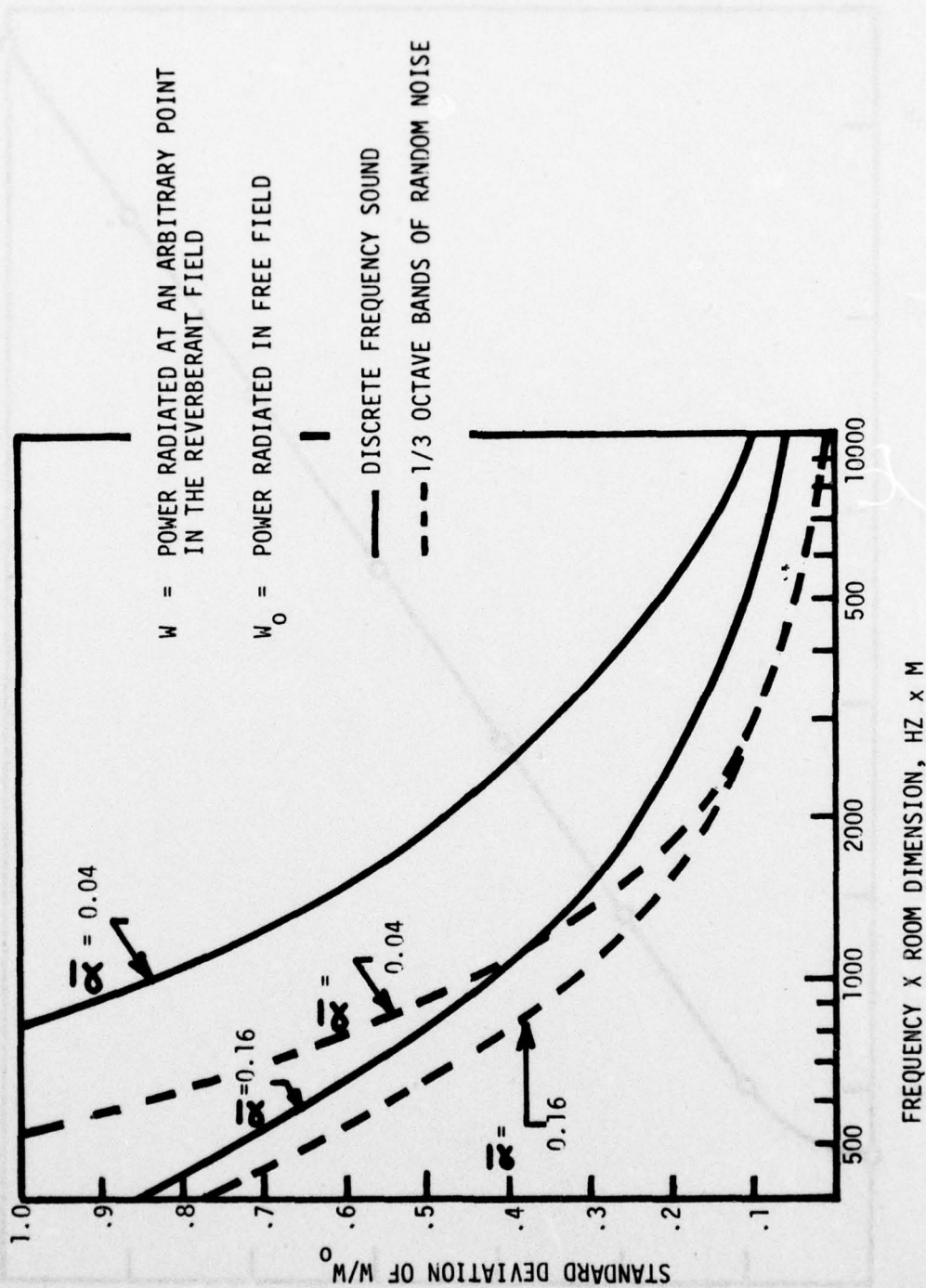
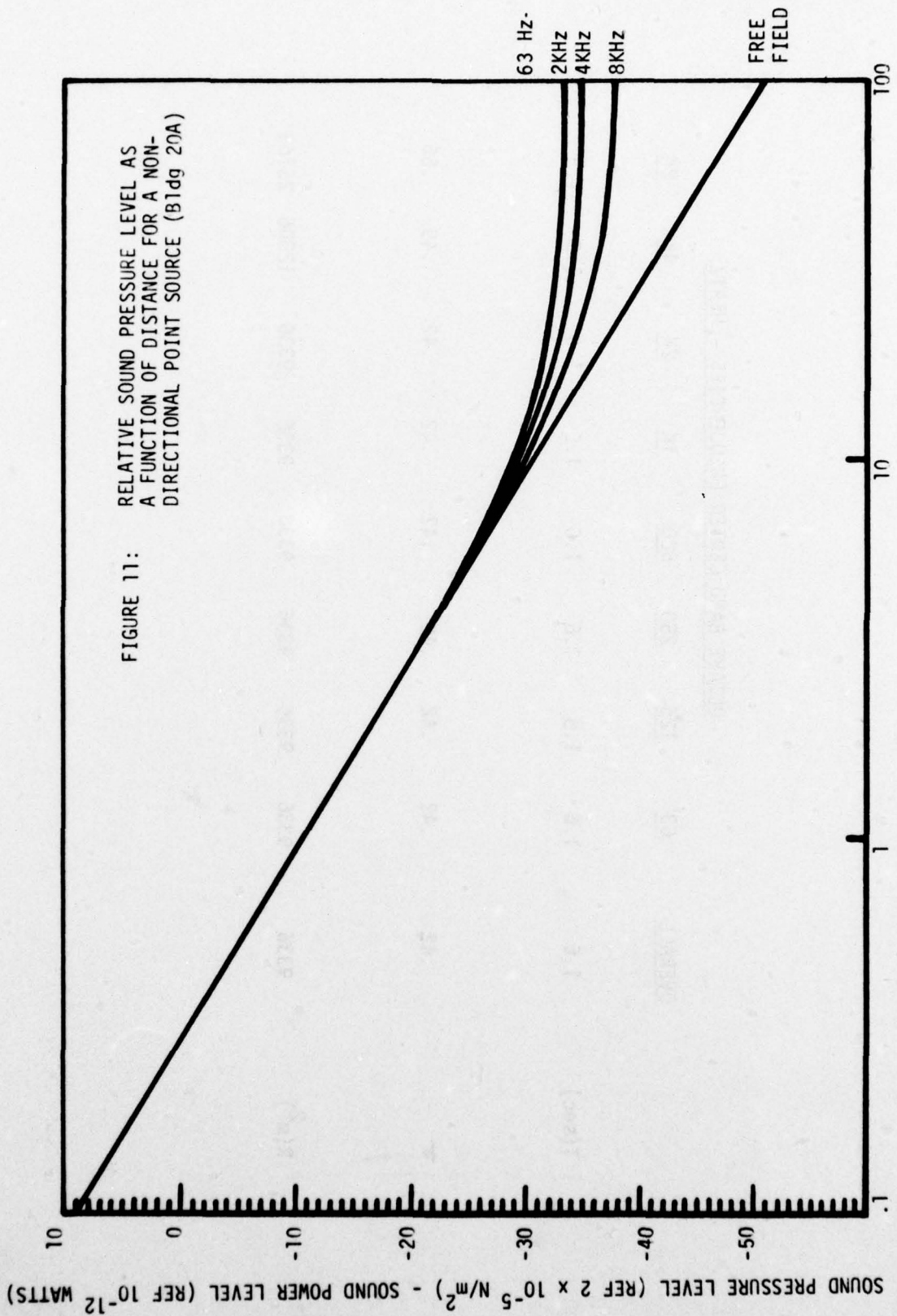


FIGURE 10: UNCERTAINTY RANGE FOR RADIATION FROM A SIMPLE SOUND SOURCE IN A REVERBERANT FIELD

TABLE 2: Reverberation Time, Average Absorption Coefficients, and Room Constants in Octave Bands for Building 20A

	<u>OCTAVE BAND CENTER FREQUENCIES - HERTZ</u>							
	<u>63</u>	<u>125</u>	<u>250</u>	<u>500</u>	<u>1K</u>	<u>2K</u>	<u>4K</u>	<u>8K</u>
<u>T(sec)</u>	1.6	1.6	1.6	1.6	1.6	1.6	1.3	1.8
$\bar{\alpha}$.42	.42	.42	.42	.42	.42	.49	.66
<u>R(m²)</u>	9336	9336	9336	9336	9336	9336	12306	25369



Where: R_T is the room constant in m^2
 r is the distance in m
 Q is a directivity factor (equal to 1 for propeller test rigs)

Since the room constants for Building 20A are the same for all frequency bands between 63 Hertz and 2 KHz, this range is represented by the top curve in Figure 11. The straight line shows the variation of relative sound pressure level with distance for a free-field environment (no reflections, reverberations, etc.).

Background Noise

Background noise during testing in the Building 20A facility is not a significant problem. Figure 12 shows a plot of background noise without the facility drive motors operating. Figure 13 shows the background noise as a function of RPM for a rotating propeller hub without blades. Neither case results in significant background noise when compared to the noise generated by a typical propeller. The measurements were made at a typical microphone position approximately 3 meters from the source. During each propeller test program, ambient and drive motor background levels are recorded as a function of RPM for each microphone position. In this way the source noise levels can be compared directly with the background noise to ensure that the signal-to-noise ratio is adequate. Generally, we require that the signal be at least 10 dB above the background noise in each third-octave band of interest.

We have now evaluated several problem areas relative to acoustic testing in Building 20A--acoustic reflections, room mode interactions, reverberation, and background noise. One other area should be investigated to properly understand the acoustic data obtained during propeller testing. Since acoustic propagation characteristics with distance change depending on the source, we should know what to expect in terms of noise level variation with distance from the propeller. It is beyond the scope of this report to discuss all of the noise generation and propagation theories applicable to propellers. An excellent review of propeller noise theory is contained in Reference 7. It is sufficient to point out that the broadband characteristics of a propeller can best be evaluated from noise measurements made along the axis of the propeller. Along the axis there is no Doppler effect. Also, the acoustic spectrum measured on the axis is generated entirely by fluctuating loads on the blade and is simply related to their integrated spectrum. Measurements made in the plane of rotation involve predominantly rotational noise due to harmonics of the blade passage frequency.

Reference 8 provides the basis for a preliminary analysis of noise propagation with distance from a propeller. In our application, we use a slightly modified version of Maekawa's result for circular plane noise

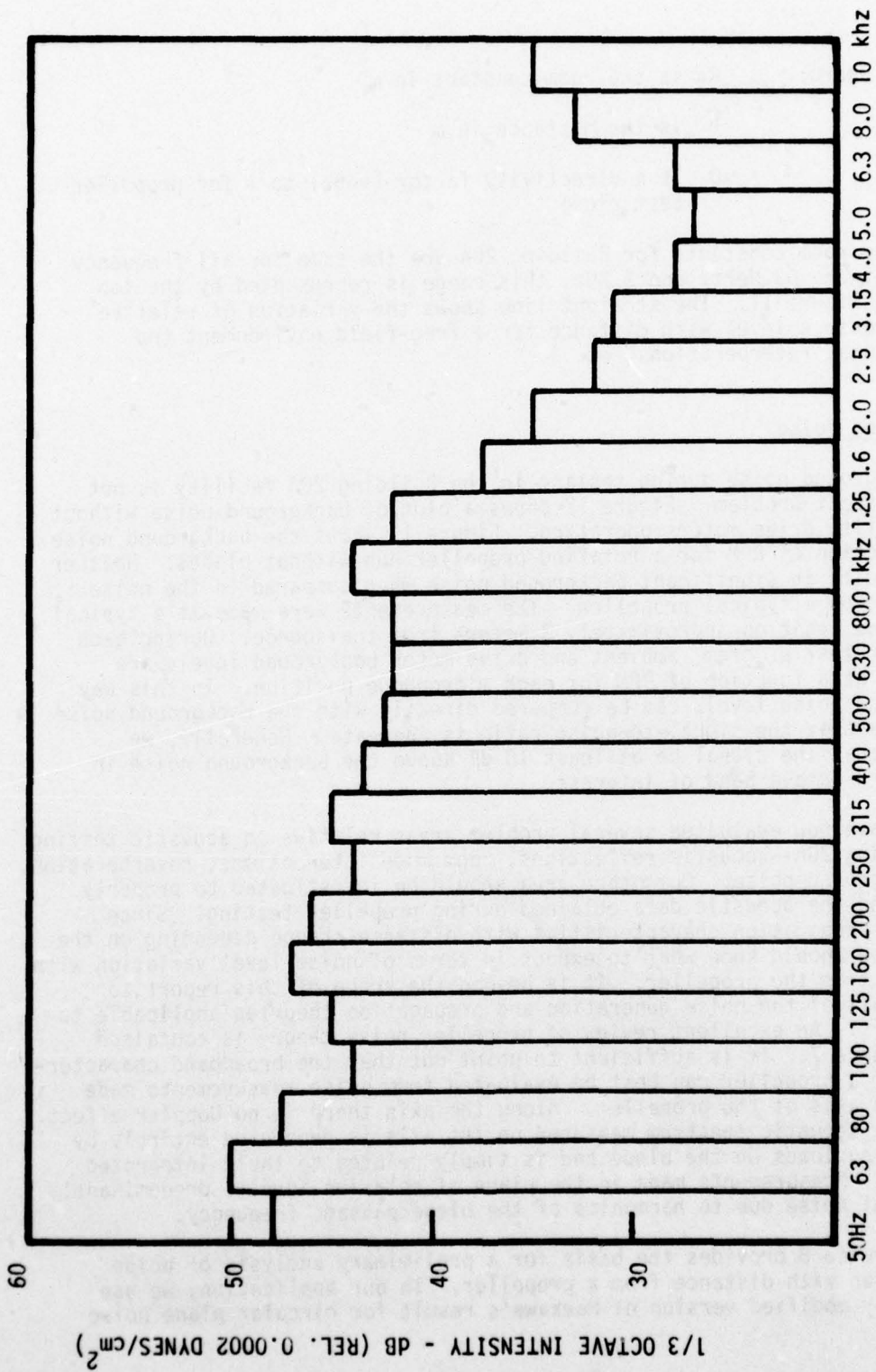


FIGURE 12: BUILDING 20A AMBIENT NOISE LEVELS

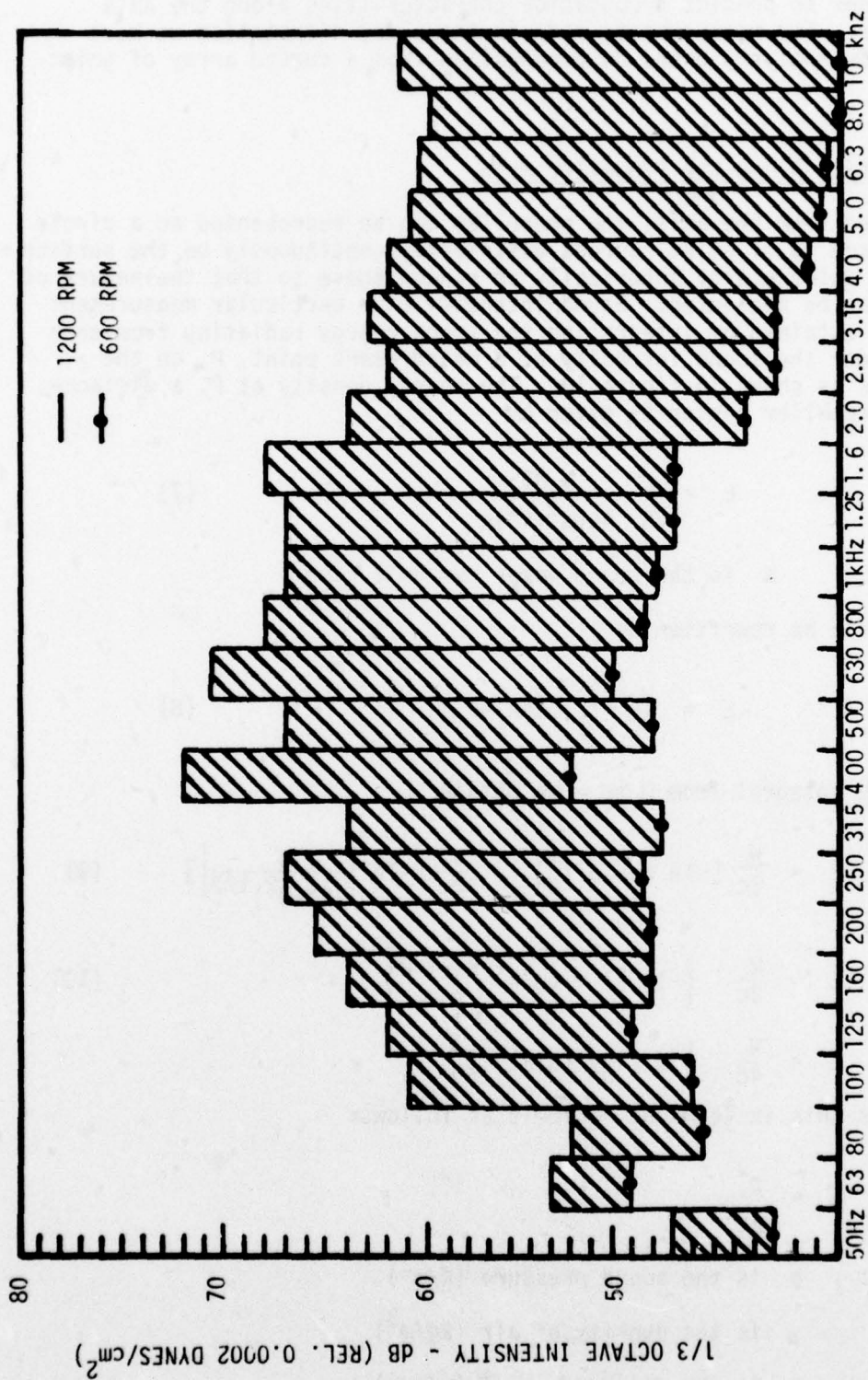


FIGURE 13: RIG #2 BACKGROUND NOISE FOR DRIVE MOTOR AND PROPELLER HUB WITHOUT BLADES

sources in order to predict propagation characteristics along the axis of a propeller. For measurements made in the plane of rotation we have developed a new analysis based on propagation from a curved array of point sources.

Noise Propagation Along the Propeller Axis

When viewed from the axis, the propeller can be represented as a circle of radius R made up of point sources distributed continuously on the surface and radiating noise energy spherically in random phase so that the nature of wave motion can be neglected. Sound intensity at a particular measurement point will be obtained by integrating the sound energy radiating from each point. Consider the sound intensity at a measurement point, P, on the propeller axis as shown in Figure 14. The energy density at P, a distance, d, from the propeller center is given by

$$E = \int_S \frac{W dS}{4\pi(d^2+x^2)c} \quad (7)$$

Where: W is the sound power per unit area

Equation (7) can be rewritten as

$$E = \frac{W}{2c} \int_0^\infty \tan\theta d\theta \quad (8)$$

Evaluating the integral from 0 to ∞ we obtain

$$E = \frac{W}{2c} [-\ln \cos \theta \Big|_0^\infty] = \frac{W}{2c} \left[-\ln \left| \frac{d}{(R^2+d^2)^{1/2}} \right| \right] \quad (9)$$

$$E = \frac{W}{2c} \left\{ -\ln [1 + (d/R)^{-2}]^{-1/2} \right\} \quad (10)$$

$$E = \frac{W}{4c} \left\{ \ln [1 + (d/R)^{-2}] \right\}$$

We can express this in terms of decibels as follows:

$$E = \frac{p^2}{\rho c^2}$$

Where: p is the sound pressure (N/m²)

ρ is the density of air (kg/m³)

c is the speed of sound (m/sec)

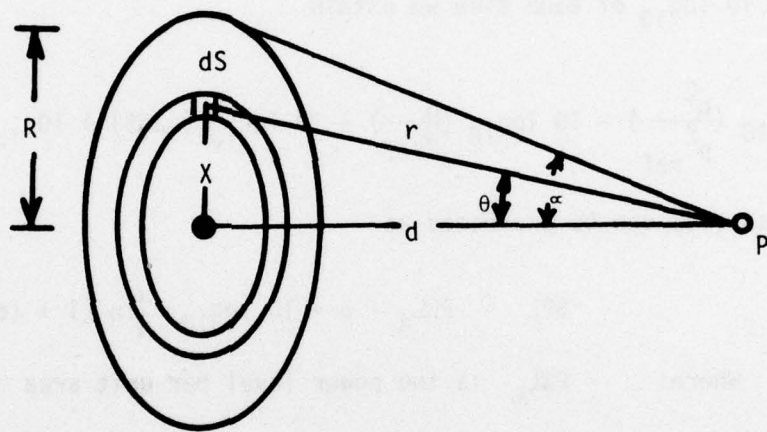


FIGURE 14: GEOMETRY FOR A PROPELLER AS VIEWED FROM A MEASUREMENT POINT, P, ON THE AXIS

$$p^2 = W \left(\frac{\rho c}{4}\right) \left\{ \ln [1 + (d/R)^{-2}] \right\} \quad (12)$$

By referencing the pressure to .00002 N/m² and the power to 10⁻¹² watts we obtain

$$\frac{p^2}{p_{\text{ref}}^2} = \frac{W}{W_{\text{ref}}} \left(\frac{\rho c}{4}\right) \left[\frac{10^{-12}}{(.00002)^2} \right] \left\{ \ln [1 + (d/R)^{-2}] \right\} \quad (13)$$

Where: $\rho c = 408 \text{ kg/m}^2/\text{sec}$ for air

Taking $10 \log_{10}$ of each side we obtain

$$10 \log_{10} \left(\frac{p^2}{p_{\text{ref}}^2} \right) = 10 \log_{10} \left(\frac{W}{W_{\text{ref}}} \right) + 10 \log_{10} (.255) + 10 \log_{10} \left\{ \ln [1 + (d/R)^{-2}] \right\} \quad (14)$$

Equation (14) can be expressed as

$$\text{SPL} = \text{PWL}_A - 6 + 10 \log_{10} \left\{ \ln [1 + (d/R)^{-2}] \right\} \quad (15)$$

Where: PWL_A is the power level per unit area

Figure 15 is a plot of the third expression in equation (15) as a function of d/R . The plot shows that in a free-field environment, the noise level should drop off at 6dB per doubling of distance for all points along the axis greater than approximately one diameter ($2R$) away.

Equation (15) was developed by assuming that source elements on the surface of the propeller radiate omnidirectionally. A similar equation can be developed by considering that each surface element on the plane noise source has some directivity of its own. A directional radiation power can be given by the expression:

$$J_{\theta} = J_0 \cos^n \theta \quad (16)$$

Where: J_0 is the radiation power to the normal of a surface element given in the units watt/m²/sterad.

θ is the angle between J_{θ} and the normal to the surface.

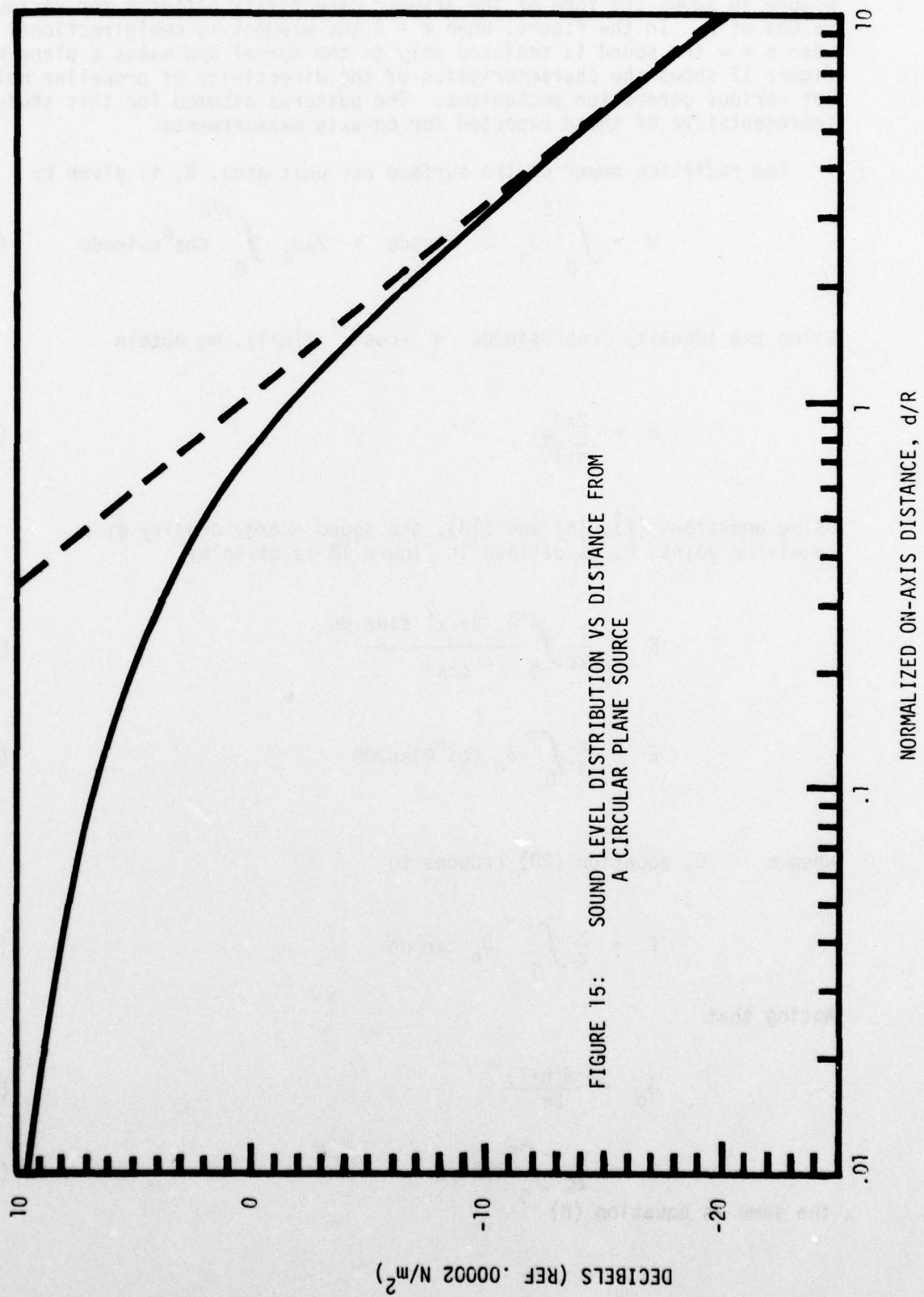


FIGURE 15: SOUND LEVEL DISTRIBUTION VS DISTANCE FROM A CIRCULAR PLANE SOURCE

Figure 16 shows the form of the assumed directivity patterns for various values of n . In the figure, when $n = 0$ the element is omnidirectional and when $n = \infty$ the sound is radiated only to the normal and makes a plane wave. Figure 17 shows the characteristics of the directivity of propeller noise for various generation mechanisms. The patterns assumed for this study are representative of those expected for on-axis measurements.

The radiation power of the surface per unit area, W , is given by

$$W = \int_0^{\pi/2} J_\theta \cdot 2\pi \sin\theta d\theta = 2\pi J_0 \int_0^{\pi/2} \cos^n\theta \sin\theta d\theta \quad (17)$$

Using the identity $\int \cos^n\theta \sin\theta d\theta = -\cos^{n+1}\theta / (n+1)$, we obtain

$$W = \frac{2\pi J_0}{n+1} \quad (18)$$

Using equations (7), (8) and (18), the sound energy density at a receiving point, P , as defined in Figure 18 is given by

$$E = \frac{1}{2c} \int_0^\infty \frac{J_\theta \cdot 2\pi x^2 \sin\theta d\theta}{x^2 \cos\theta} \quad (19)$$

$$E = \frac{\pi}{c} \int_0^\infty J_0 \cos^n\theta \tan\theta d\theta \quad (20)$$

When $n = 0$, equation (20) reduces to

$$E = \frac{\pi}{c} \int_0^\infty J_0 \tan\theta d\theta \quad (21)$$

Noting that

$$J_0 = \frac{W(n+1)}{2\pi} \quad (22)$$

$$E = \frac{W}{2c} \int_0^\infty \tan\theta d\theta \quad (23)$$

the same as equation (8)

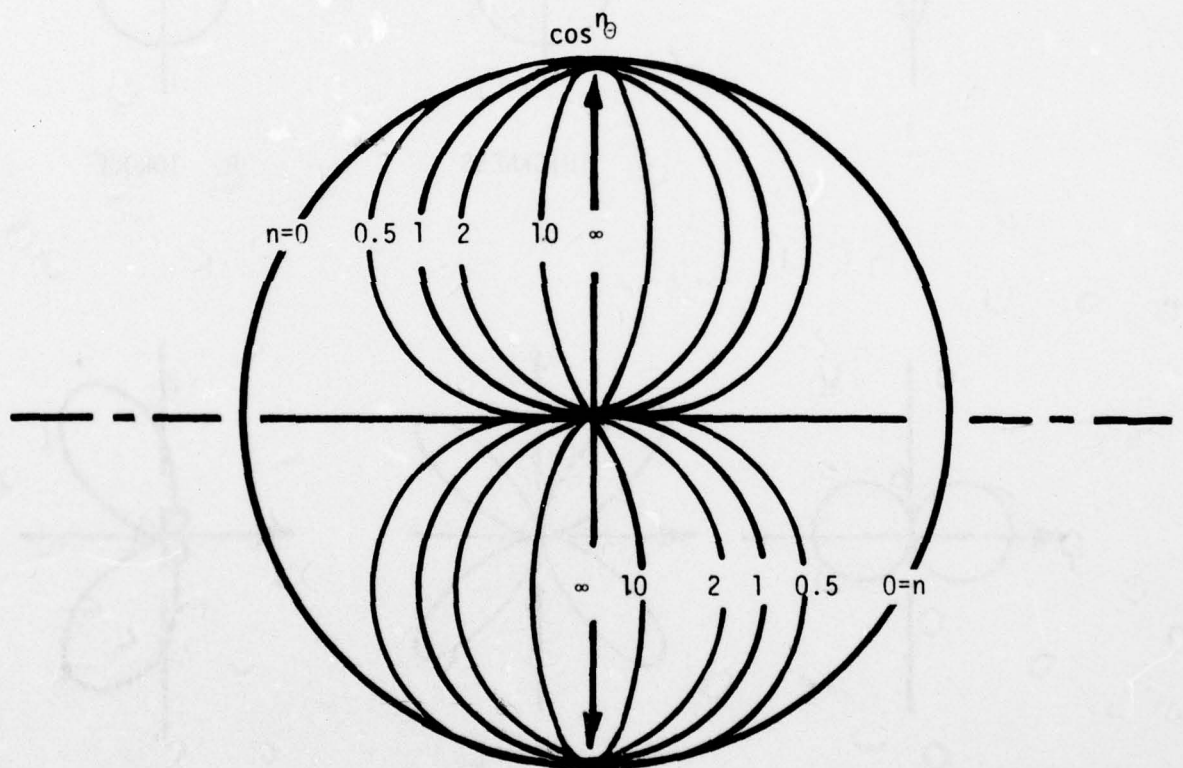


FIGURE 16: ASSUMED DIRECTIVITY PATTERN FOR SOUND RADIATION FROM ELEMENTAL SOURCES DISTRIBUTED

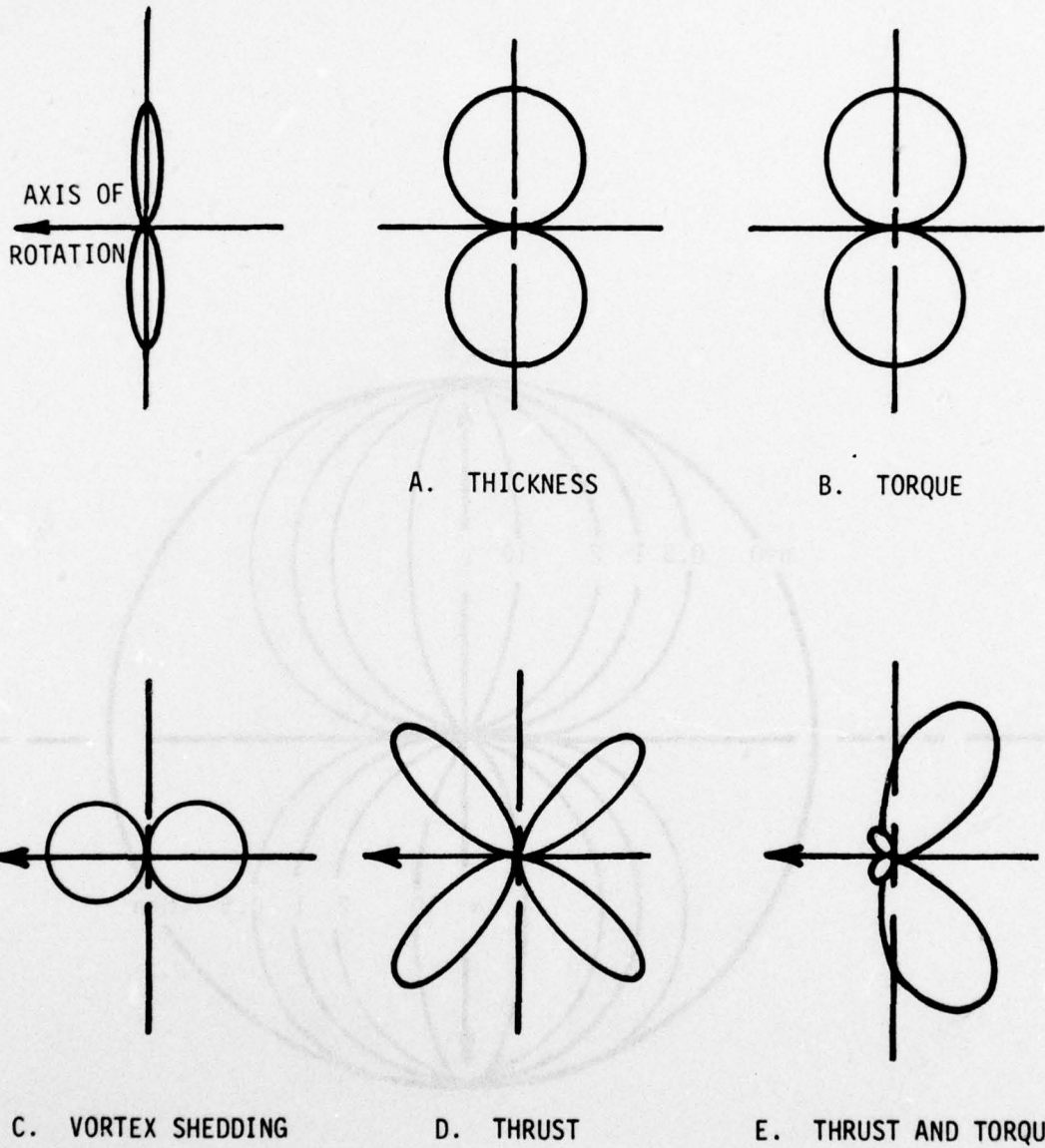


FIGURE 17: THEORETICAL NOISE PATTERNS FOR PROPELLER NOISE (REFERENCE 9)

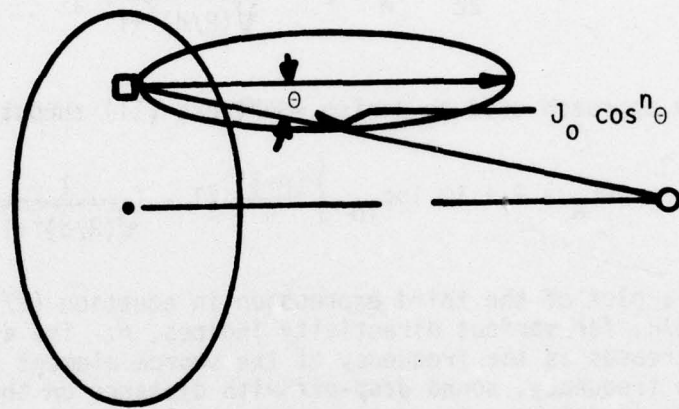


FIGURE 18: GEOMETRY FOR AN ASSUMED ELEMENTAL SOURCE DIRECTIVITY PATTERN AS VIEWED FROM A MEASUREMENT POINT, P, ON THE AXIS.

When $n > 0$, equation (20) becomes

$$E = \frac{W(n+1)}{2c} \int_0^\alpha \cos^n \theta \tan \theta \, d\theta \quad (24)$$

Using the identity $\int \cos^n \theta \tan \theta \, d\theta = -\cos^n \theta / n$, we obtain

$$E = \frac{W}{2c} \frac{(n+1)}{n} [1 - (\cos \alpha)^n] \quad (25)$$

Replacing $\cos \alpha$ with the proper rectilinear coordinates yields

$$E = \frac{W}{2c} \frac{(n+1)}{n} \left[1 - \left(\frac{1}{\sqrt{(R/d)^2 + 1}} \right)^n \right] \quad (26)$$

Repeating the approach used to derive equations (11) through (15), we obtain

$$\text{SPL} = \text{PWL}_A - 3 + 10 \log_{10} \left\{ \frac{(n+1)}{n} \left[1 - \left(\frac{1}{\sqrt{(R/d)^2 + 1}} \right)^n \right] \right\} \quad (27)$$

Figure 19 is a plot of the third expression in equation (27) as a function of d/R , for various directivity indices, n . The directivity index, n , increases as the frequency of the source element increases. Therefore, at high frequency, sound drop-off with distance on the center axis is gradual. This is not true for measurement points out of the center axis.

In order to compare equations (15) and (27) with equation (6), the equations must be converted to total power level equations where the total power level, PWL , is given by

$$\text{PWL} = \text{PWL}_A + 10 \log_{10} \pi R^2 \quad (28)$$

Therefore, equations (15) and (27) can be expressed as follows:

For $n = 0$

$$\text{SPL-PWL} = -6 - 10 \log_{10} \pi R^2 + 10 \log_{10} \left\{ \ln[1+(d/R)^{-2}] \right\} \quad (29)$$

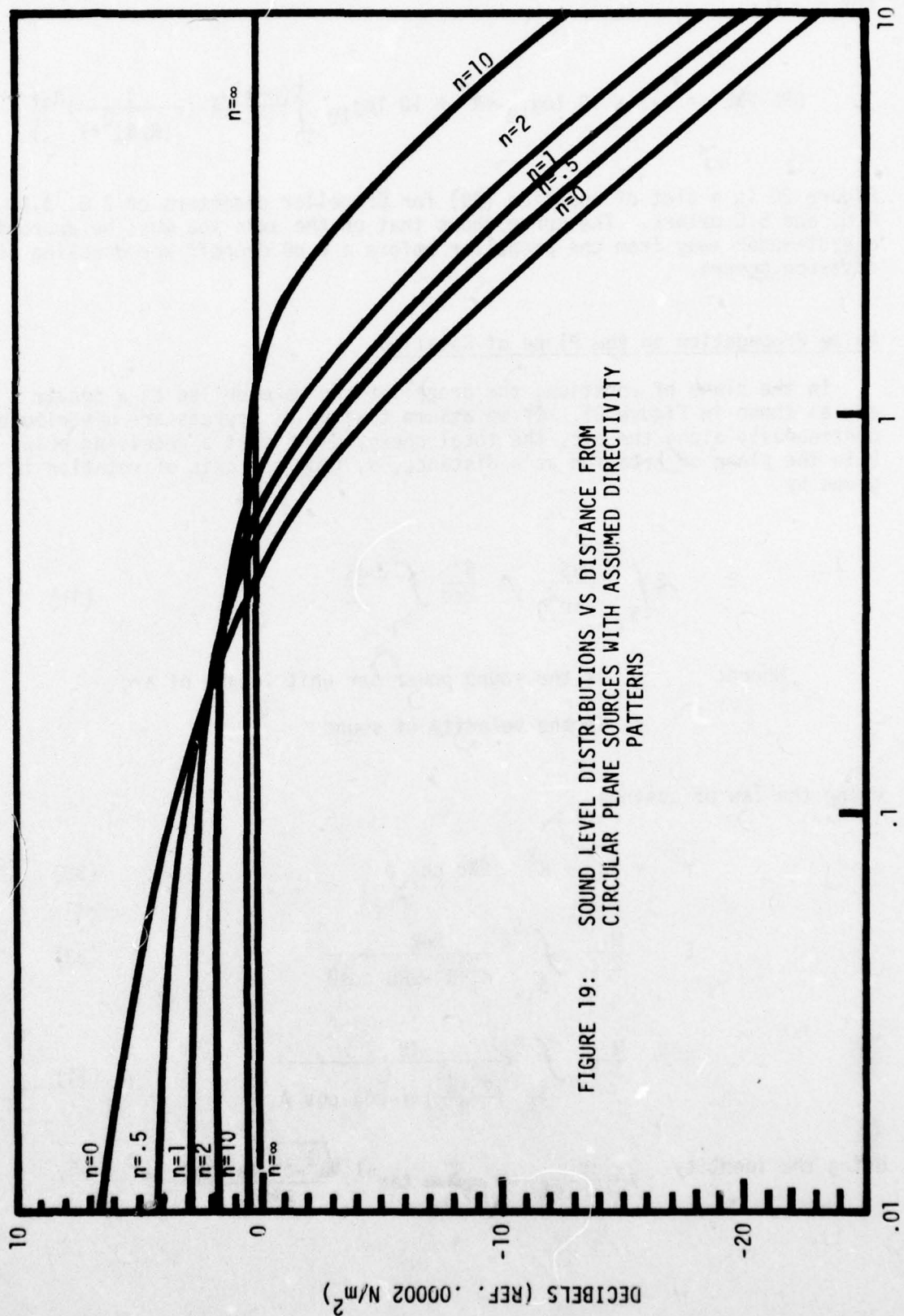


FIGURE 19: SOUND LEVEL DISTRIBUTIONS VS DISTANCE FROM CIRCULAR PLANE SOURCES WITH ASSUMED DIRECTIVITY PATTERNS

For $n > 0$

$$\text{SPL-PWL} = -3 - 10 \log_{10} \pi R^2 + 10 \log_{10} \left\{ \frac{(n+1)}{n} \left[1 - \left(\frac{1}{(R/d)^2 + 1} \right)^n \right] \right\} \quad (30)$$

Figure 20 is a plot of equation (29) for propeller diameters of 2.0, 3.0, 4.0, and 5.0 meters. The curve shows that on the axis you must be approximately one diameter away from the propeller before a 6 dB dropoff per doubling of distance occurs.

Noise Propagation in the Plane of Rotation

In the plane of rotation, the propeller can be modelled as a convex arc as shown in Figure 21. If we assume that point sources are distributed continuously along the arc, the total energy density at a receiving point P in the plane of rotation at a distance, d, from the axis of rotation is given by

$$E = 2 \int_{S_1}^{S_2} \frac{W dS}{4\pi r^2 c} = \frac{W}{2\pi c} \int_{S_1}^{S_2} \frac{dS}{r^2} \quad (31)$$

Where: W is the sound power per unit length of arc
 c is the velocity of sound

Using the law of cosines

$$r^2 = d^2 + R^2 - 2Rd \cos \theta \quad (32)$$

$$E = \frac{W}{2\pi c} \int_{S_1}^{S_2} \frac{R d\theta}{d^2 + R^2 - 2Rd \cos \theta} \quad (33)$$

$$E = \frac{W}{2\pi c} \int_{S_1}^{S_2} \frac{d\theta}{\left(\frac{d^2 + R^2}{R} \right) + (-2d) \cos \theta} \quad (34)$$

Using the identity $\int \frac{d\theta}{a + b \cos \theta} = \frac{2}{\sqrt{a^2 - b^2}} \tan^{-1} \frac{\sqrt{a^2 - b^2} \tan \theta/2}{a + b}$ $a^2 > b^2$,

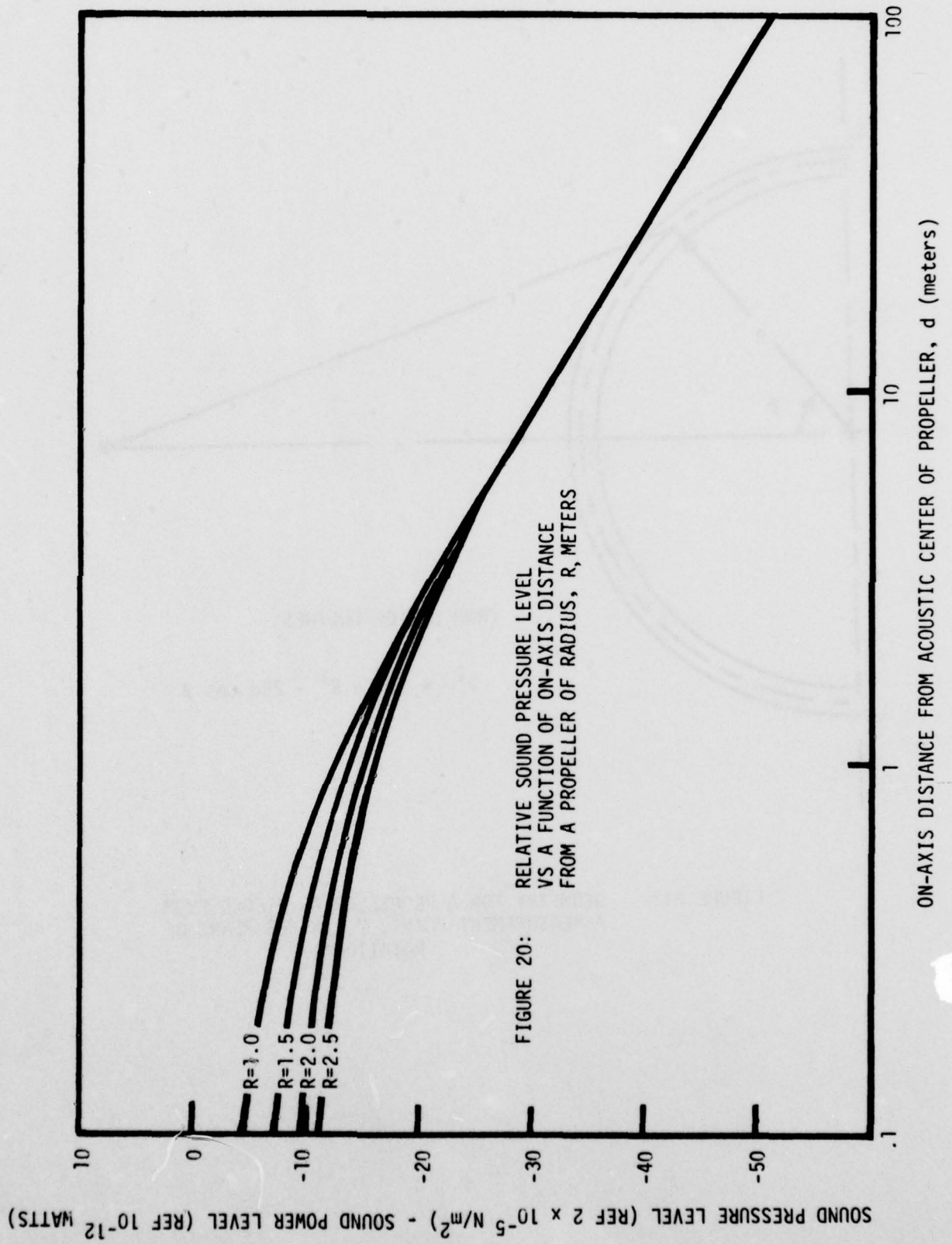


FIGURE 20: RELATIVE SOUND PRESSURE LEVEL VS A FUNCTION OF ON-AXIS DISTANCE FROM A PROPELLER OF RADIUS, R, METERS

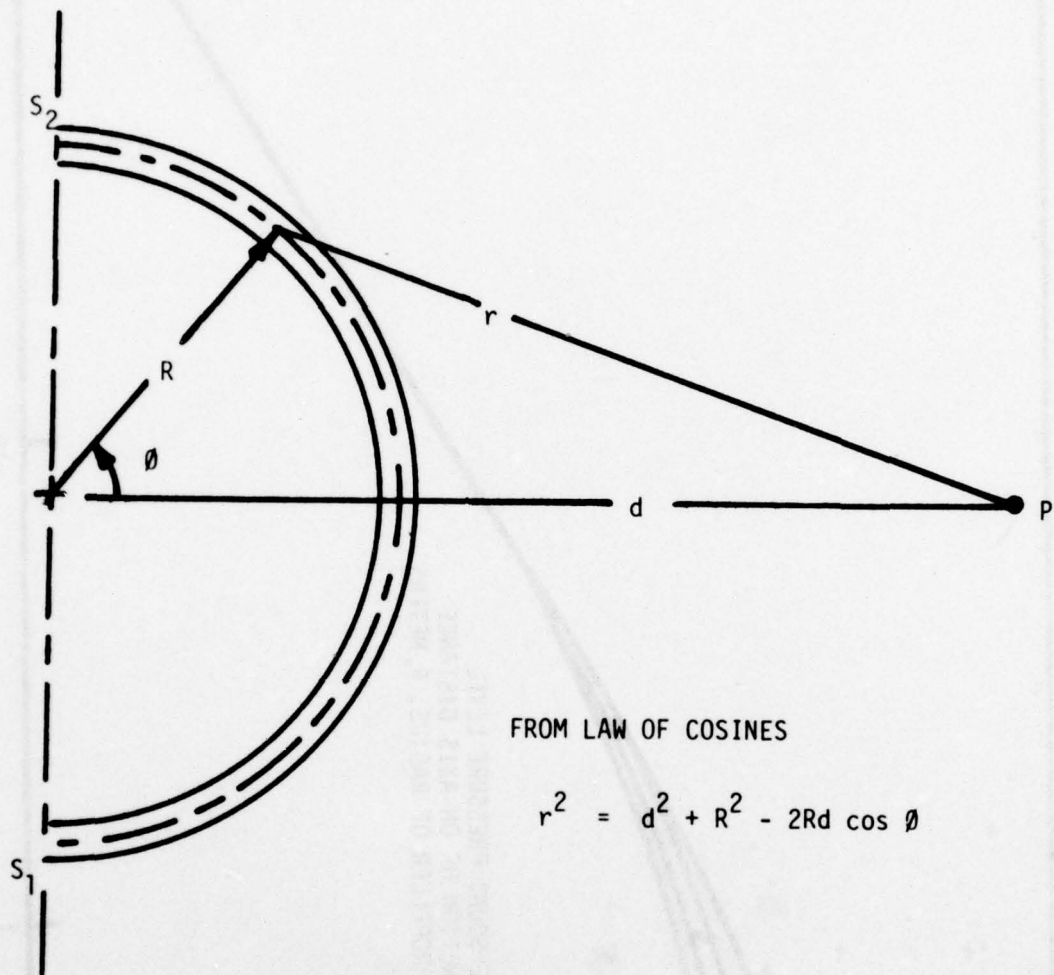


FIGURE 21: GEOMETRY FOR A PROPELLER AS VIEWED FROM A MEASUREMENT POINT, P, IN THE PLANE OF ROTATION

we obtain

$$E = \frac{W}{\pi C} \left[\frac{1}{\sqrt{a^2 - b^2}} \tan^{-1} \left(\frac{\sqrt{a^2 - b^2}}{a+b} \tan \theta/2 \right) \right]_{\theta = -\pi/2}^{\theta = \pi/2} \quad (35)$$

$$E = \frac{W}{\pi C} \left[\frac{1}{\sqrt{a^2 - b^2}} \tan^{-1} \left(\frac{\sqrt{a^2 - b^2}}{a+b} (+1) \right) - \frac{1}{\sqrt{a^2 - b^2}} \tan^{-1} \left(\frac{\sqrt{a^2 - b^2}}{a+b} (-1) \right) \right] \quad (36)$$

$$E = \frac{2W}{\pi C} \left[\frac{1}{\sqrt{a^2 - b^2}} \tan^{-1} \left(\frac{\sqrt{a^2 - b^2}}{a+b} \right) \right] \quad (37)$$

$$E = \frac{2W}{\pi C} \left[\frac{1}{\sqrt{\left(\frac{d^2 + R^2}{R}\right)^2 - 4d^2}} \tan^{-1} \left(\frac{\sqrt{\left(\frac{d^2 + R^2}{R}\right)^2 - 4d^2}}{\frac{d^2 + R^2}{R} - 2d} \right) \right] \quad (38)$$

$$E = \frac{2W}{\pi C} \left[\frac{1}{\sqrt{\frac{\left(\frac{d^2 + R^2}{R}\right)^2 - 4d^2 R^2}{R^2}}} \tan^{-1} \left(\frac{\sqrt{\frac{\left(\frac{d^2 + R^2}{R}\right)^2 - 4d^2 R^2}{R^2}}}{\frac{\left(\frac{d^2 + R^2}{R}\right) - 2dR}{R}} \right) \right] \quad (39)$$

$$E = \frac{2W}{\pi C} \left[\frac{R}{d^2 - R^2} \tan^{-1} \left(\frac{d+R}{d-R} \right) \right] \quad (40)$$

$$E = \frac{2W}{\pi C R} \left[\frac{1}{\left(\frac{d}{R}\right)^2 - 1} \tan^{-1} \left(\frac{d/R+1}{d/R-1} \right) \right] \quad (41)$$

Repeating the approach used to derive equations (11) through (15), we obtain

$$\text{SPL} = \text{PWL}_L + 3 - 10 \log_{10} \pi R + 10 \log_{10} \left[\frac{1}{\left(\frac{d}{R}\right)^2 - 1} \tan^{-1} \left(\frac{d/R+1}{d/R-1} \right) \right] \quad (42)$$

Where: PWL_L is the power level per unit length

If we assume that the length of radiating arc is equal to the propeller circumference, we obtain the following expression for total power level

$$PWL = PWL_L + 10 \log_{10} 2\pi R \quad (43)$$

Therefore,

$$SPL - PWL = -20 \log_{10} \pi R + 10 \log_{10} \left[\frac{1}{(d/R)^2 - 1} \tan^{-1} \left(\frac{d/R + 1}{d/R - 1} \right) \right] \quad (44)$$

Figure 22 is a plot of the third expression of equation (44) as a function of d/R . The curve shows that the plane of rotation measurement points must be approximately 3 diameters from the propeller blade tip before a true 6 dB per doubling of distance is obtained. Figure 23 is a plot of equation (44) as a function of measurement distance, d , and propeller radius, R , in meters. This result can be directly compared with the result from equation (6) as plotted in Figure 11 to determine the effects of reverberation and source geometry on the noise propagation characteristics.

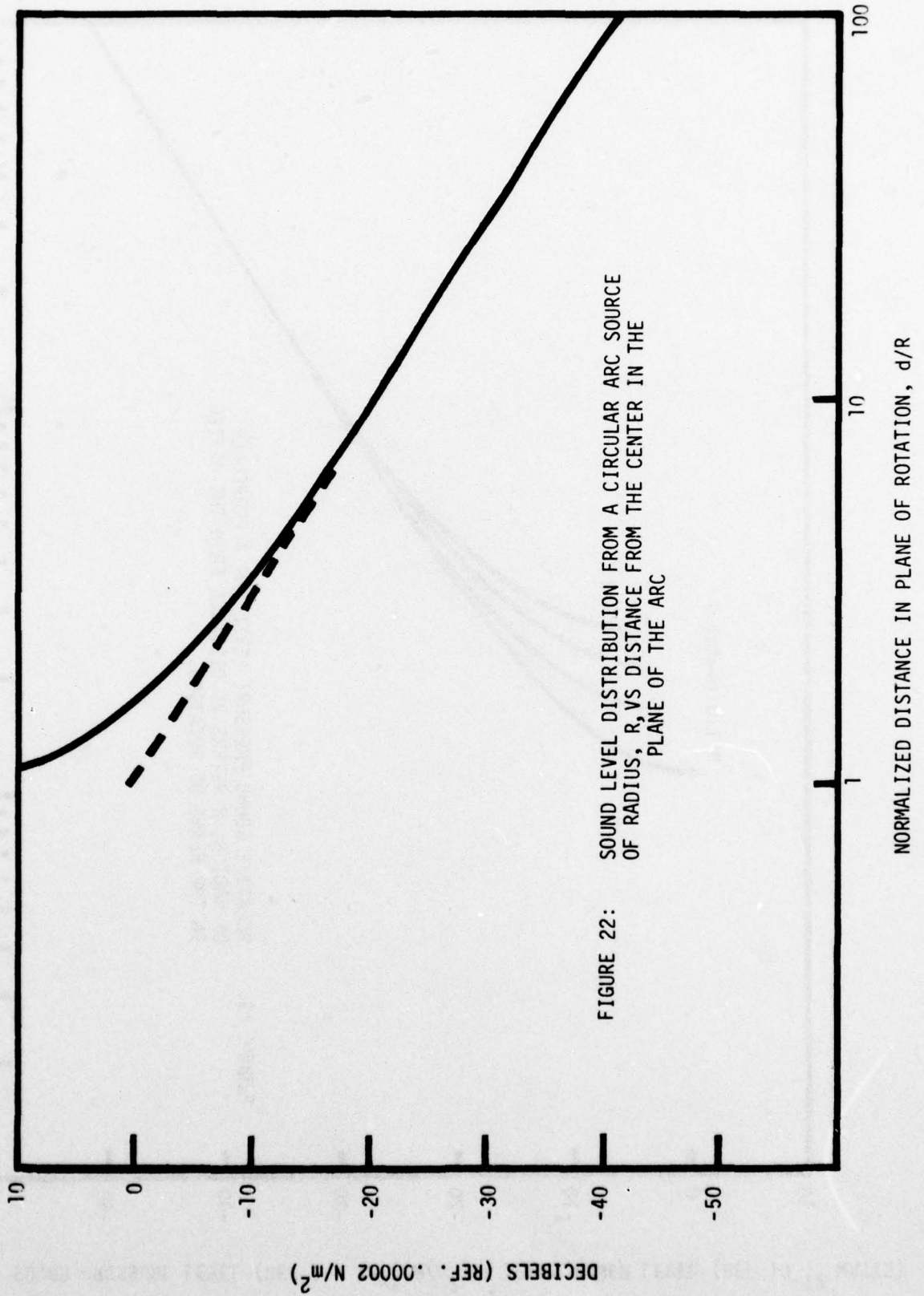


FIGURE 22: SOUND LEVEL DISTRIBUTION FROM A CIRCULAR ARC SOURCE OF RADIUS, R, VS DISTANCE FROM THE CENTER IN THE PLANE OF THE ARC

DECIBELS (REF. .00002 N/m²)

SOUND PRESSURE LEVEL (REF $2 \times 10^{-5} \text{ N/m}^2$) - SOUND POWER LEVEL (REF 10^{-12} WATTS)

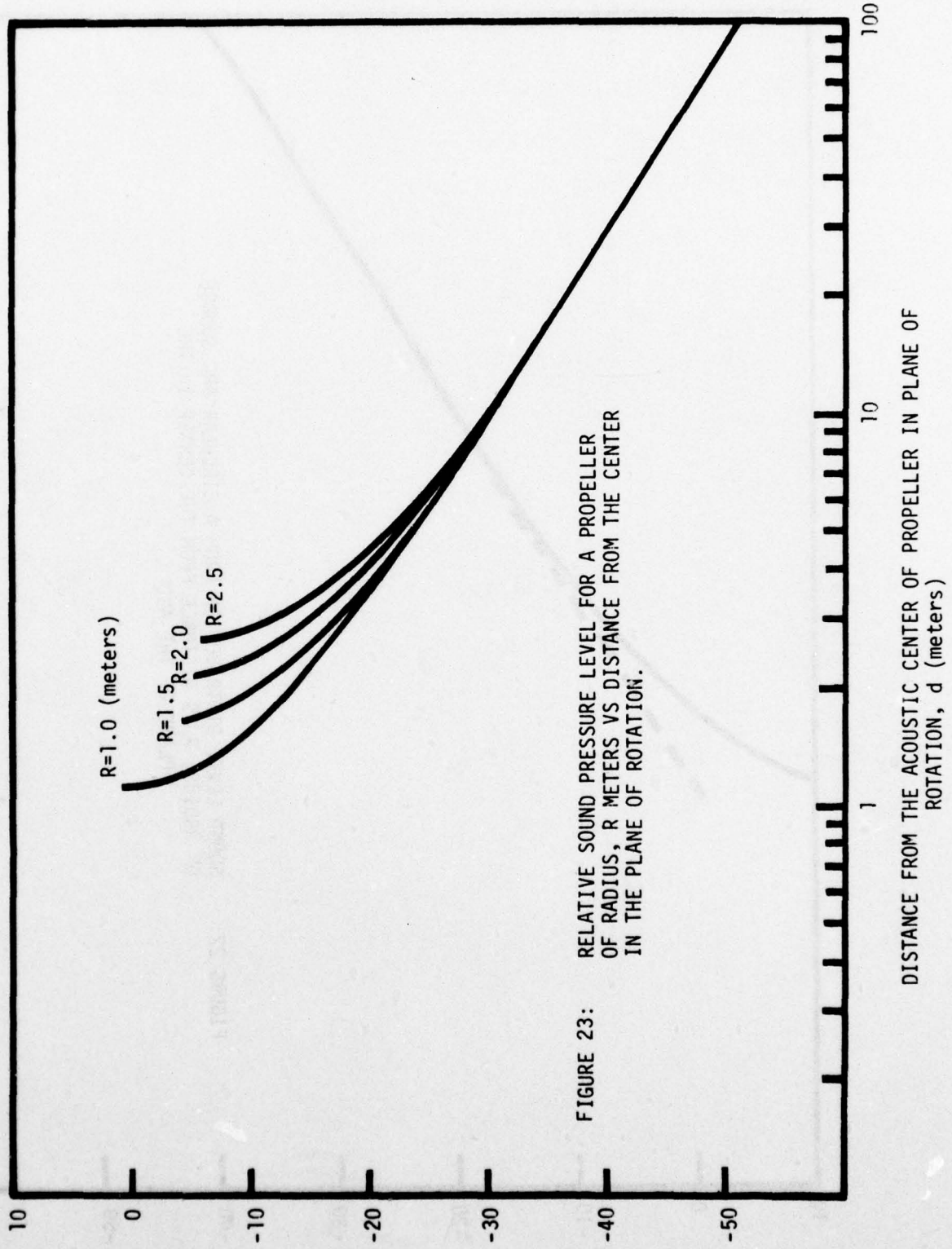


FIGURE 23: RELATIVE SOUND PRESSURE LEVEL FOR A PROPELLER OF RADIUS, R METERS VS DISTANCE FROM THE CENTER IN THE PLANE OF ROTATION.

VII. CONCLUSIONS AND RECOMMENDATIONS

This report has described the development of an indoor acoustic test facility for static testing of fans and propellers. The performance measurement system has been used for many years with demonstrated accuracy and dependability. The acoustic characteristics of the facility have been thoroughly studied and documented. The problem of data contamination due to acoustic reflections has been minimized by the use of high absorption acoustic treatment on the near walls and the floor of the test rig. Room mode interactions are not considered significant above 60 Hertz due to the large size of the room. Reverberation characteristics for the facility have been thoroughly evaluated and can be used to correct measured data where necessary. Finally, background noise has been assessed and is not considered a problem for most propeller and fan configurations. However, background noise measurements are made an integral part of each test program to ensure that the test data is not contaminated in the frequency range of interest.

In Section six of this report, a brief study was made to assess acoustic propagation characteristics with distance in the plane of rotation and along the propeller axis. Characteristic curves for on-axis propagation (Figure 20) and plane of rotation propagation (Figure 22) should be developed for the propeller under test. These curves, together with the facility reverberation curves can then be used to select optimum microphone measurement arrays. For propellers in the diameter range of 2 to 4 meters, the optimum location for far-field measurements in this facility falls between one and two diameters from the propeller center in the plane of rotation. The farthest microphone point is limited by wall effects and reverberation while the nearest microphone position is limited by the extent of the propeller near field. The propeller near field is generally defined as the space within one propeller diameter from the blade tips. Measurements in this area are generally free from interference by reflection, reverberation, and background noise, but do not show the directivity patterns characteristic of far-field noise. Near-field noise does not exhibit radial variation in sound pressure in accordance with the far-field "inverse square law" where the level drops 6 dB per doubling of distance (Reference 9).

A number of useful data presentation programs have been developed to aid in assessing noise/performance tradeoffs for the articles under test. These programs were described in Section V and detailed listings with sample plots are shown in Appendix B. This plotting capability coupled with the performance and acoustic measurement systems provides a very versatile tool for conducting static propeller/fan performance and acoustic tests and for conducting noise/performance trade studies.

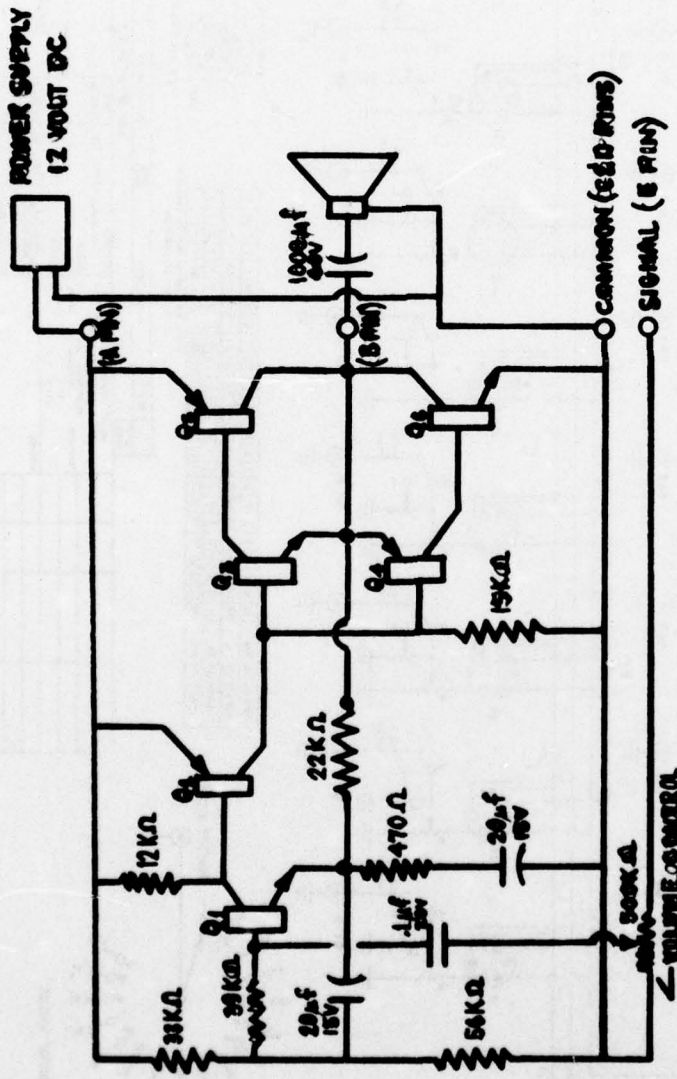
VIII. REFERENCES

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4. Berger, R., and Winemiller, G., "XYZPLT - A Computer Plotting Routine for Engineering Applications," ASD Technical Report 73-50, Aeronautical Systems Division, Wright-Patterson AFB, Ohio, February 1974.
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9. Anon., "A Study of Propeller Noise Research," Hamilton Standard Division of United Aircraft Corporation, SP 67148, Revision A, November 1967.

APPENDIX A

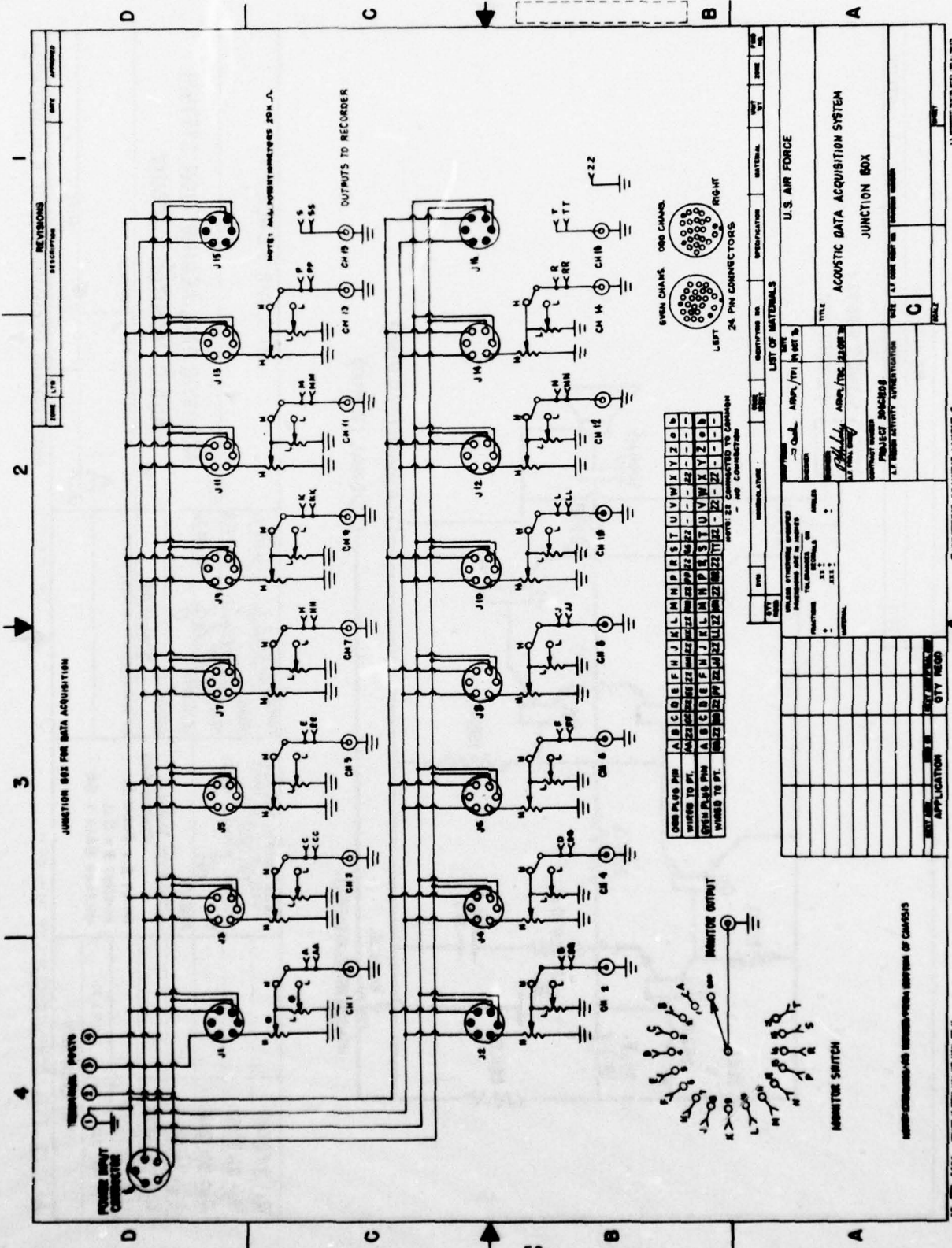
DETAILED SCHEMATICS - ACOUSTIC DATA SYSTEM

REVISIONS		DATE	APPROVAL
LTR	DESCRIPTION		



Q1 = 2N5704	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES FRACTIONS DECIMALS ANGLES	DATE 26 OCT 74	U. S. AIR FORCE
Q2 = 2N3702	± .010 ± .015	26 OCT 74	ACQUSTIC DATA ACQUISITION SYSTEM AUDIO MONITOR CIRCUIT
Q3 = 2N1502	± .010 ± .015	26 OCT 74	
Q4 = 2N1505	3.7 WATTES 50-75 CONTROLS	DATE	SIZE A
Q5 = 2N3922	IMPED 8 ± 500K Ω	CONTINUT IN 3006-1208	SCALE
Q6 = 2N3380	IMPED 2 ± 8 Ω	FILE DESIGN ACTIVITY AUTHORIZATION	SHEET
RETT ASSY	VOLTAGE GAIN ± 50		
APPLICATION			
AF FORM 1651 1651 REPLACES AF FORM 1651 AND 1651A, DEC 61. SEP 65 WHICH ARE OBSOLETE			

ENGINEERING DRAWING LAYOUT A HORIZONTAL



REVISIONS

NO.	DATE	BY	APPROVED
1			

JUNCTION BOX FOR DATA ACQUISITION

SEVEN CHANNEL ORG CHARS.

ORG CHAR	1	2	3	4	5	6	7
LEFT	1	2	3	4	5	6	7
RIGHT	8	9	10	11	12	13	14

24 PIN CONNECTORS

U.S. AIR FORCE

ACoustic DATA ACQUISITION SYSTEM

JUNCTION BOX

DATE: 15 FEB 64 BY: [Signature]

DESIGNED BY: [Signature]

APPROVED BY: [Signature]

REVISIONS

NO.	DATE	BY	APPROVED
1			

LIST OF MATERIALS

QTY	DESCRIPTION	UNIT	DATE

APPLICATION

QTY REQD

REVISIONS

DATE: 15 FEB 64 BY: [Signature]

DESIGNED BY: [Signature]

APPROVED BY: [Signature]

APPENDIX B

DATA PRESENTATION PROGRAMS

APPENDIX B-1

PROGRAM HORSE

R45, STCSA, C477777, T20, I20. P720119 MCGREGOR 52744
 FTN, R=3.
 MAP, PART.
 ATTACH, CCAUX, CCAUX, ID=X654321.
 LIBRARY, CCAUX.
 LGO.

" END OF RECORD
 PROGRAM HORSE (INPUT, OUTPUT, TAPE5=INPUT, TAPE6=OUTPUT, PLOT)
 C *** PROGRAM HORSE IS USED TO PLOT THRUST VS HORSEPOWER FOR VARIOUS
 C QUIET PROPELLER CONFIGURATIONS. IT WILL ACCEPT DATA WITH 3 OR 5
 C RPM RUNS.
 C
 C PRESET PARAMETERS (NAMELIST):
 C IORPM = (1) .. ALL AVAILABLE DATA USED IN PLOTS
 C 2 .. 3 RPM VALUES USED REGARDLESS OF DATA INPUT
 C MINIMUM THRUST (YMIN) = 0.
 C MAXIMUM THRUST (YMAX) = 1600.
 C MINIMUM HORSEPOWER (XMIN) = 0.
 C MAXIMUM HORSEPOWER (XMAX) = 240.
 C RPM DATA POINTS (WRPM(1-5)) = 600., 750., 900., 1050., 1200.
 C
 C * CHANGES TO THESE PARAMETERS SHOULD BE MADE USING THE STANDARD
 C NAMELIST FORMAT (EXAMPLE: \$INPUT YMIN=10., XMIN=100.\$)
 C

INTEGER HEAD
 DIMENSION HEAD(40), BETA(3), X(2,3,5), CX(7), CY(7), WRPM(5)
 NAMELIST/INPUT/ WRPM, IORPM, YMIN, YMAX, XMIN, XMAX
 DATA WRPM/600., 750., 900., 1050., 1200./
 IORPM=1 \$ YMIN=0. \$ YMAX=1600. \$ XMIN=0. \$ XMAX=240.
 CALL PLOT (0., 1., -3)
 1 READ(5, INPUT)
 YSTEP=(YMAX-YMIN)/8.0
 XSTEP=(XMAX-XMIN)/6.0
 C ** READ IN NUMBER OF RPM RUNS
 2 READ (5, 8) NRPM
 IF(NRPM.EQ.99999) GO TO 1
 IF (NRPM.EQ.0) GO TO 7
 CALL READER(HEAD, BETA, X, Y, NRPM, 0, IORPM, NSIZ, 0)
 CALL CENTER (HEAD, 40)
 C ** SET UP AXIS FOR PLOTTING
 CALL AXIS (0., 0., 21HTHRUST (POUNDS FORCE), 21, 8., 90., YMIN, YSTEP)
 CALL AXIS (0., 0., 10HHORSEPOWER, -10, 6.5, 0., XMIN, XSTEP)
 ENCODE(40, 100, HEAD) HEAD
 100 FORMAT(40A1)
 CALL SYMBOL (0.25, 8.35, 0.15, HEAD, 0., 40)
 C ** SET UP DATA ARRAY FOR CONSTANT BLADE ANGLES
 DO 4 I=1, 3
 DO 3 J=1, NSIZ
 CX(J)=X(1, I, J)
 3 CY(J)=X(2, I, J)
 CX(NSIZ+1)=XMIN
 CX(NSIZ+2)=XSTEP
 CY(NSIZ+1)=YMIN
 CY(NSIZ+2)=YSTEP
 C ** PLOT POINTS AND DRAW A SMOOTH CURVE
 CALL FLIN (CX, CY, -NSIZ, 1, 1, (I-1))

```

C ** DRAW LEGEND BY END OF LINE
  CALL WLINE (CX,CY,(NSIZ+2),0.,XL,YL)
  CALL SYMBOL ((XL+.1),YL,.08,22H--      DEG. BLADE ANGLE,0.,22)
  4 CALL NUMBER ((XL+.34),YL,0.08,BETA(I),0.,-1)
C ** SET UP DATA ARRAY FOR CONSTANT RPM'S
  DO 6 J=1,NSIZ
  DO 5 I=1,3
  CX(I)=X(1,I,J)
  5 CY(I)=X(2,I,J)
  CX(4)=XMIN
  CX(5)=XSTEP
  CY(4)=YMIN
  CY(5)=YSTEP
C ** PLOT POINTS AND DRAW A SMOOTH CURVE
  CALL FLINE (CX,CY,-3,1,1,(J-1))
C ** DRAW LEGEND BY END OF LINE
  CALL WLINE (CX,CY,5,90.,XL,YL)
  CALL SYMBOL (XL,(YL+.1),.08,11H--      RPM,90.,11)
C ** COMPUTE DESIRED INDEX FOR TITLE'S RPM VALUE
  LABEL=IFIX(FLOAT(J)*(5.0/FLOAT(NSIZ))+.001)
  6 CALL NUMBER (XL,(YL+.34),.08,WRPM(LABEL),90.,-1)
  CALL PLOT (9.5,0.,-3)
  GO TO 2
  7 CONTINUE
  CALL PLOTE
  STOP
C
  8 FORMAT (10I5)
  END

```

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```

SUBROUTINE READER (HEAD, BETA, X, Y, NRPM, NMIKE, IORPM, NSIZ, IOJBA)
DIMENSION HEAD(40), X(2,3,5), Y(4,3,5), BETA(3)
INTEGER HEAD
READ (5,14) HEAD
IF (IORPM.EQ.1) GO TO 9
IF (IORPM.EQ.2.AND.NRPM.EQ.3) GO TO 9
C ** READ 3 POINTS IF 5 ARE AVAILABLE
DO 2 I=1,3
  READ (5,15) BETA(I)
  DO 1 J=1,2
    READ (5,16) RPM,X(1,I,J),X(2,I,J)
  1 READ (5,17) TRASH
  2 READ (5,16) RPM,X(1,I,3),X(2,I,3)
  3 NSIZ=3
  GO TO 13
C ** READ ALL AVAILABLE DATA
  9 DO 10 I=1,3
    READ (5,15) BETA(I)
    DO 10 J=1,NRPM
      10 READ (5,16) RPM,X(1,I,J),X(2,I,J)
      NSIZ=NRPM
  13 RETURN
C
  14 FORMAT (40A1)
  15 FORMAT (30X,F10.3)
  16 FORMAT (3F10.3)
  17 FORMAT (F10.3)
END

```

```

SUBROUTINE CENTER (HEAD,LENGTH)
C *** SUBROUTINE CENTER IS USED TO CENTER A HEADING WITHIN A VARIABLE-
C LENGTH TITLE LINE
INTEGER HEAD
DIMENSION HEAD(LENGTH)
INK=0
C ** COUNT THE RIGHT-HAND BLANKS
  1 LOC=LENGTH-INK
  IF (HEAD(LOC).NE.1H ) GO TO 2
  INK=INK+1
  GO TO 1
C ** PLACE HALF THE DETECTED BLANKS ON THE HEADING'S LEFT SIDE
  2 MOVE=IFIX(((FLOAT(INK))/2)+.001)
  IF(MOVE.EQ.0) RETURN
  DO 4 I=1,MOVE
    N=LENGTH-1
    IPOS=LENGTH+1
    DO 3 J=1,N
      3 HEAD(IPOS-J)=HEAD(LENGTH-J)
    4 HEAD(I)=1H
  RETURN
END

```

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```

SUBROUTINE WLINE (X,Y,N,WCH,XL,YL)
C *** SUBROUTINE WLINE ARRANGES DATA SETS IN DECREASING ORDER RESPECTIVE
C TO EITHER X OR Y. IT THEN RETURNS THE PHYSICAL PAGE COORDINATES
C OF THE DATA SET FOUND GREATEST RELATIVE TO THE OTHERS.
DIMENSION X(N), Y(N)
IP2=N-3
IP3=N-2
DO 3 I=1,IP2
IP1=I+1
DO 3 J=IP1,IP3
IF (WCH.EQ.90.) GO TO 1
C ** COMPARE "X" VALUES
IF (X(I).GE.X(J)) GO TO 3
GO TO 2
C ** COMPARE "Y" VALUES
1 IF (Y(I).GE.Y(J)) GO TO 3
C ** INTERCHANGE THE OUT-OF-ORDER X-Y DATA SETS
2 TEMP=X(I)
X(I)=X(J)
X(J)=TEMP
TEMP=Y(I)
Y(I)=Y(J)
Y(J)=TEMP
3 CONTINUE
C ** COMPUTE THE PHYSICAL PAGE COORDINATES
YL=(Y(1)-Y(N-1))/Y(N)
XL=(X(1)-X(N-1))/X(N)
RETURN
END
** END OF RECORD

```

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\$INPUT IORPM=2\$

5

6 BLADES, STANDARD

6	116.75	9.33	5.0	4.0	1.0133
602.	13.	58.			
750.	22.	93.			
901.	30.	134.			
1050.	39.	186.			
1200.	54.	245.			
6	116.75	9.33	10.0	4.0	1.0133
601.	26.	188.			
752.	37.	298.			
900.	56.	430.			
1050.	85.	601.			
1201.	121.	786.			
6	116.75	9.33	15.0	4.0	1.0133
600.	36.	342.			
751.	61.	537.			
900.	104.	785.			
1051.	162.	1081.			
1200.	240.	1430.			

99999

\$INPUT XMAX=120., YMAX=800.\$

3

2 SETS (6"SHRT,3"SHRT,NORM)

6			1.0		
630.	8.	2.			
902.	21.	5.			
1200.	39.	11.			
6			5.0		
599.	9.	52.			
899.	25.	117.			
1200.	49.	217.			
6			10.0		
599.	14.	155.			
899.	45.	358.			
1200.	98.	658.			

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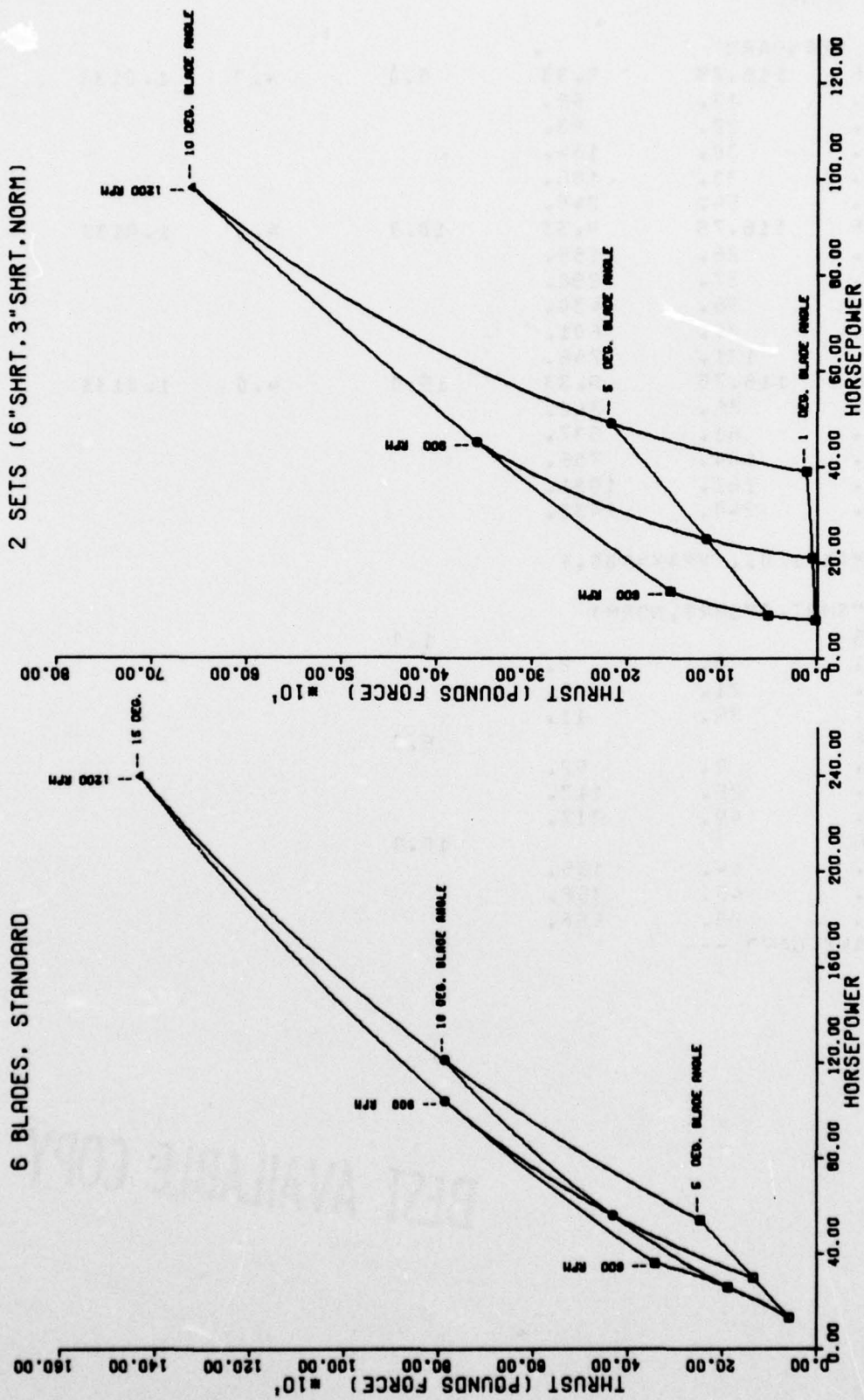


Figure B1-1: Plots From Sample HORSE Input Data Cards

APPENDIX B-2

PROGRAM THORSE

R46,STCSA,CM77777,T40,I080. P720119 MCGREGOR 55421

FTN,R=3.

MAP,PART.

ATTACH,PLOTLIB,OGIVEFILE,CY=2,IO=1740030,SN=ASD.

ATTACH,CCAUX,CCAUX,IO=X654321.

LIBRARY,CCAUX.

LOAD,LGO.

SATISFY.

LDSET,LIB=PLOTLIB.

SATISFY,PLOTLIB.

EXECUTE.

" END OF RECORD

PROGRAM THORSE(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,PLOT)

C *** THORSE IS USED TO PLOT THRUST/HORSEPOWER VS. HORSEPOWER FOR
C VARIOUS QUIET PROPELLOR CONFIGURATIONS. IT WILL ACCEPT DATA
C WITH 3 OR 5 RPM POINTS. ALL OR PART OF THE DATA MAY BE USED.

C PRESET PARAMETERS (NAMELIST):

C IORPM = (1) .. ALL AVAILABLE DATA USED IN PLOTS

C 2 .. 3 RPM VALUES USED REGARDLESS OF DATA INPUT

C YMIN = (3.) .. MINIMUM THRUST/HORSEPOWER FOR PLOT

C YMAX = (11.) .. MAXIMUM THRUST/HORSEPOWER FOR PLOT

C XMIN = (0.) .. MINIMUM HORSEPOWER FOR PLOT

C XMAX = (240.) .. MAXIMUM HORSEPOWER FOR PLOT

C RPM DATA POINTS (WRPM(1-5)) = 500.,750.,900.,1050.,1200.

C * CHANGES TO THESE PARAMETERS SHOULD BE MADE USING THE STANDARD
C NAMELIST FORMAT. (EXAMPLE: INPUT YMIN=6.,YMAX=24.)

C INTEGER HEAD,ORD

C DIMENSION HEAD(40), BETA(3), X(2,3,5), CX(7), CY(7), WRPM(5)

C 1,XC(102), YC(102), ORD(6), COEF(7)

C NAMELIST/INPUT/ WRPM,IORPM,YMIN,YMAX,XMIN,XMAX

C DATA WRPM/500.,750.,900.,1050.,1200./

C IORPM=1 : YMIN=3. \$ YMAX=11. \$ XMIN=0. \$ XMAX=240.

C CALL PLOT (0.,1.,-3)

C 1 READ(5,INPUT)

C YSTEP=(YMAX-YMIN)/8.0

C XSTEP=(XMAX-XMIN)/6.0

C ** READ IN NUMBER OF RPM RUNS

C 2 READ (5,8) NRPM

C IF (NRPM.EQ.0) GO TO 7

C IF(NRPM.EQ.99999) GO TO 1

C CALL READER (HEAD,BETA,X,Y,NRPM,0, IORPM,NSIZ,0)

C CALL CENTER (HEAD,40)

C ** SET UP AXIS FOR PLOTTING

C CALL AXIS (0.,0.,17HTHRUST/HORSEPOWER,17,3.,90.,YMIN, YSTEP)

C CALL AXIS (0.,0.,10HHORSEPOWER,-11,6.5,0.,XMIN,XSTEP)

C ENCODE(40,100,HEAD) HEAD

C 100 FORMAT(40A1)

C CALL SYMBOL (0.50,8.35,0.15,HEAD,0.,40)

C ** SET UP DATA ARRAY FOR CONSTANT BLADE ANGLES

C DO 4 I=1,3

C DO 3 J=1,NSIZ

C CX(J)=X(1,I,J)

```

3 CY(J)=X(2,I,J)/CX(J)
  IF(CY(NSIZ).LT.YMIN) GO TO 4
C ** DRAW A SMOOTH CURVE AND/OR DATA POINTS
  CALL CURVFT(CX,CY,NSIZ,XMIN,XSTEP,YMIN,YSTEP,-2,1,(I-1),1.,0.)
C ** DRAW LEGEND BY END OF LINE
  XL=(CX(NSIZ)-XMIN)/XSTEP
  YL=(CY(NSIZ)-YMIN)/YSTEP
  CALL SYMBOL ((XL+.1),YL,.08,22H--      DEG. BLADE ANGLE,0.,22)
  CALL NUMBER ((XL+.34),YL,0.08,BETA(I),0.,-1)
4 CONTINUE
C ** SET UP DATA ARRAY FOR CONSTANT RPM'S
  DO 6 J=1,NSIZ
  DO 5 I=1,3
  CX(I)=X(1,I,J)
  5 CY(I)=X(2,I,J)/CX(I)
  M=3
  IF(CY(1).GE.YMIN) GO TO 50
  DO 40 K=1,4
  CX(K)=CX(K+1)
  40 CY(K)=CY(K+1)
  CX(3)=0.
  CY(3)=0.
  M=2
C ** PLOT POINTS AND DRAW A SMOOTH CURVE
  50 CALL CURVFT(CX,CY,M,XMIN,XSTEP,YMIN,YSTEP,-2,1,(J-1),1.,0.)
C ** DRAW LEGEND BY END OF LINE
  XL=(CX(M)-XMIN)/XSTEP
  YL=(CY(M)-YMIN)/YSTEP
  CALL SYMBOL (XL,(YL+.1),.08,11H--      RPM,90.,11)
C ** COMPUTE DESIRED INDEX FOR TITLE'S RPM VALUE
  LABEL=IFIX(FLOAT(J)*(5.0/FLOAT(NSIZ))+.001)
  6 CALL NUMBER (XL,(YL+.34),.08,WRPM(LABEL),90.,-1)
  CALL PLOT (9.5,0.,-3)
  GO TO 2
7 CONTINUE
  CALL PLOTE
  STOP
C
  8 FORMAT (10I5)
  END

```

BEST AVAILABLE COPY

```

SUBROUTINE READER (HEAD,BETA,X,Y,NRPM,NMIKE,IORPM,NSIZ,I003A)
DIMENSION HEAD(40), X(2,3,5), BETA(3)
INTEGER HEAD
READ (5,14) HEAD
IF (IORPM.EQ.1) GO TO 9
IF (IORPM.EQ.2.AND.NRPM.EQ.3) GO TO 9
C ** READ 3 POINTS IF 5 ARE AVAILABLE
DO 2 I=1,3
READ (5,15) BETA(I)
DO 1 J=1,2
READ (5,16) RPM,X(1,I,J),X(2,I,J)
1 READ (5,16) TRASH
2 READ (5,16) RPM,X(1,I,3),X(2,I,3)
NSIZ=3
GO TO 13
C ** READ ALL AVAILABLE DATA
9 DO 10 I=1,3
READ (5,15) BETA(I)
DO 10 J=1,NRPM
10 READ (5,16) RPM,X(1,I,J),X(2,I,J)
NSIZ=NRPM
13 RETURN
C
14 FORMAT (40A1)
15 FORMAT (30%,F10.3)
16 FORMAT (3F10.3)
END

```

```

SUBROUTINE CENTER (HEAD,LENGTH)
C *** SUBROUTINE CENTER IS USED TO CENTER A HEADING WITHIN A VARIABLE-
C LENGTH TITLE LINE
INTEGER HEAD
DIMENSION HEAD(LENGTH)
INK=0
C ** COUNT THE RIGHT-HAND BLANKS
1 LOC=LENGTH-INK
IF (HEAD(LOC).NE.1H ) GO TO 2
INK=INK+1
GO TO 1
C ** PLACE HALF THE DETECTED BLANKS ON THE HEADING'S LEFT SIDE
2 MOVE=IFIX(((FLOAT(INK))/2)+.001)
IF(MOVE.EQ.0) RETURN
DO 4 I=1,MOVE
N=LENGTH-1
IPOS=LENGTH+1
DO 3 J=1,N
3 HEAD(IPOS-J)=HEAD(LENGTH-J)
4 HEAD(I)=1H
RETURN
END
** END OF RECORD

```

BEST AVAILABLE COPY

```

$INPUT $
5
5 BLADES, STANDARD
  6      116.75    9.33    5.0    4.0    1.0133
  602.    13.     58.
  750.    22.     93.
  901.    30.    134.
  1050.   38.    186.
  1200.   54.    245.
  6      116.75    9.33    10.0   4.0    1.0133
  601.    26.    188.
  752.    37.    298.
  900.    56.    430.
  1050.   85.    601.
  1201.  121.    786.
  6      116.75    9.33    15.0   4.0    1.0133
  600.    36.    342.
  751.    61.    537.
  900.   104.    785.
  1051.  162.   1081.
  1200.  240.   1430.

```

99999

\$INPUT XMAX=120.9

3

2 SETS (6"SHRT, 3"SHRT, NORM)

```

  6      1.0
  630.    8.     2.
  902.   21.     5.
  1200.  39.    11.
  6      5.0
  599.    9.     52.
  899.   25.    117.
  1200.  49.    217.
  6      10.0
  599.   14.    155.
  899.   45.    358.
  1200.  98.    658.

```

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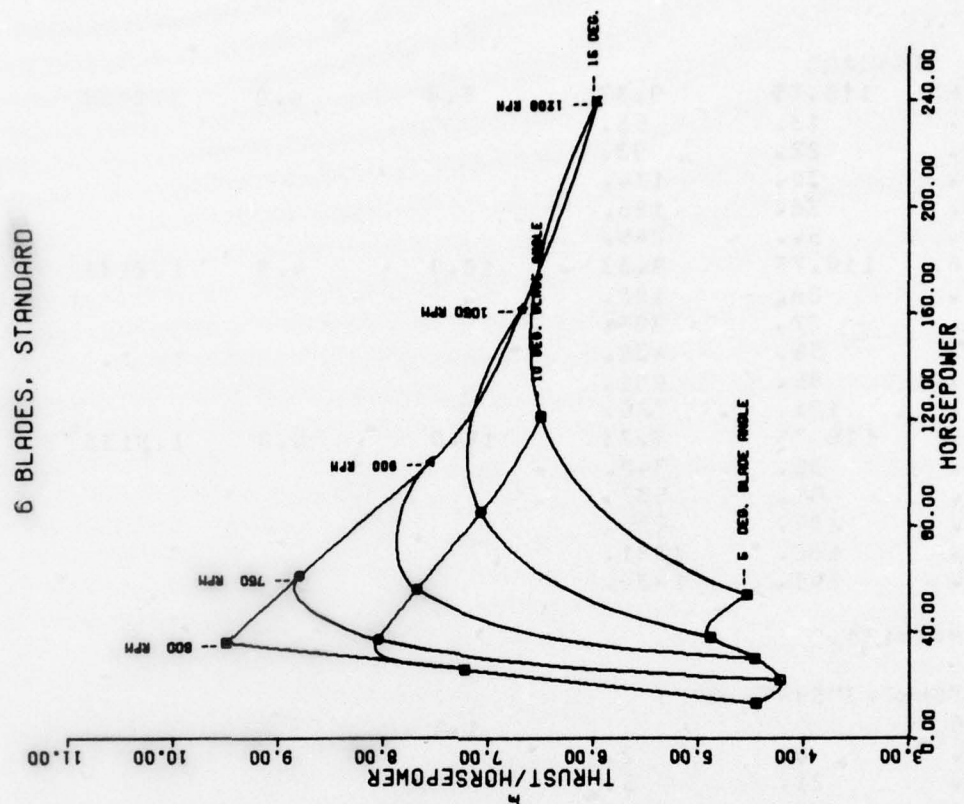
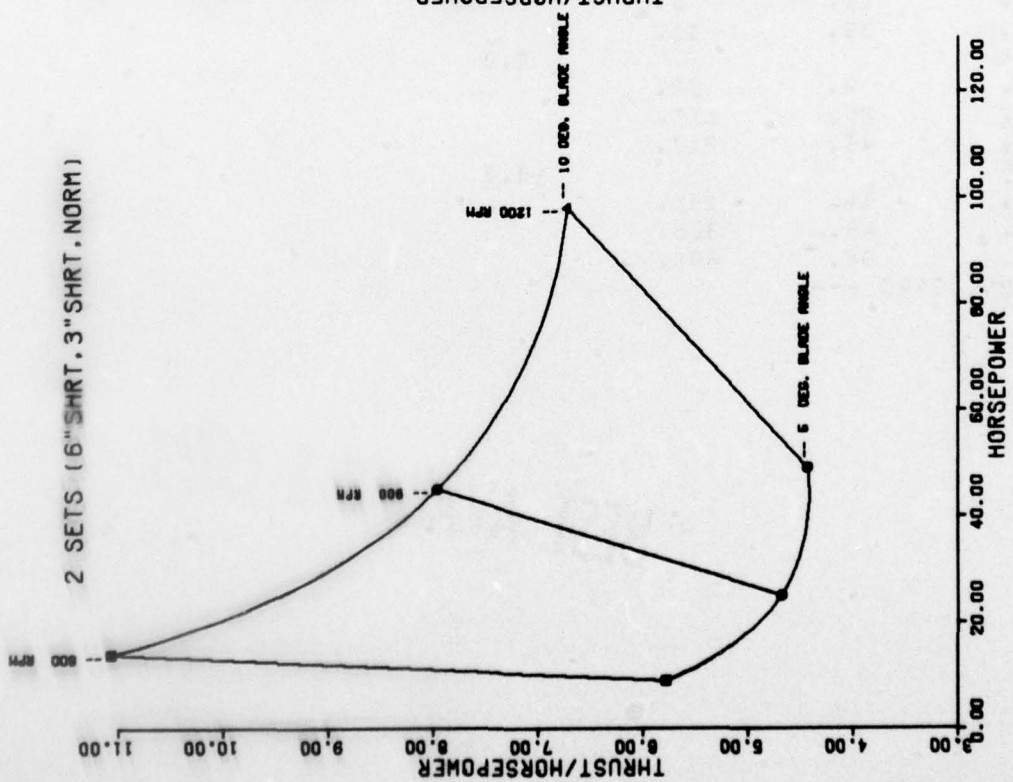
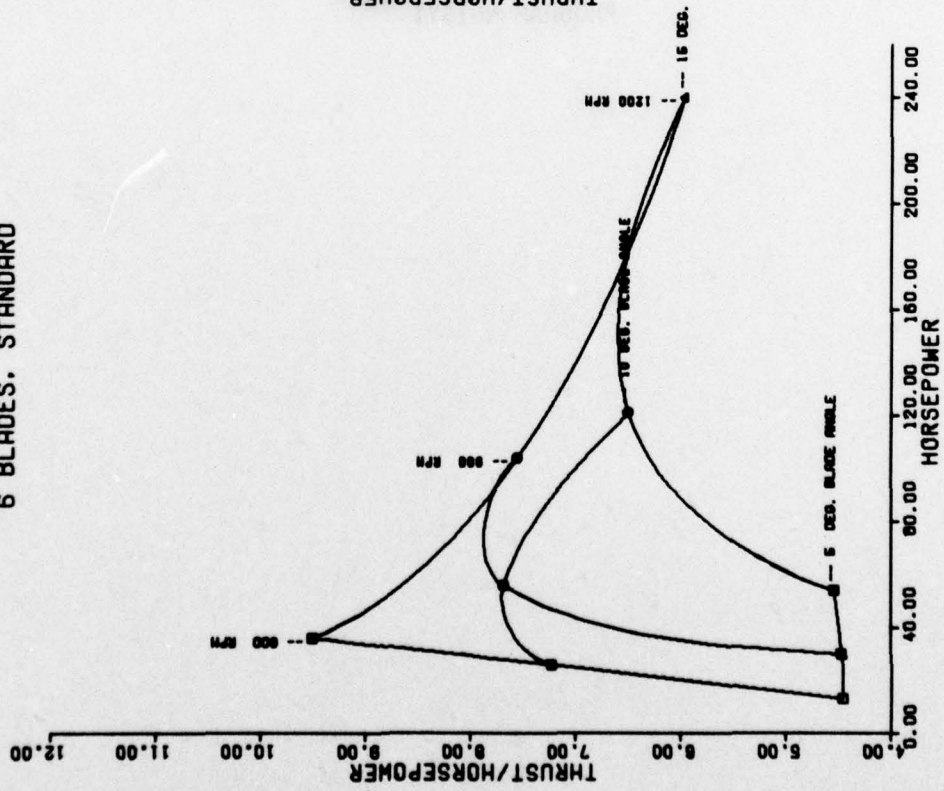


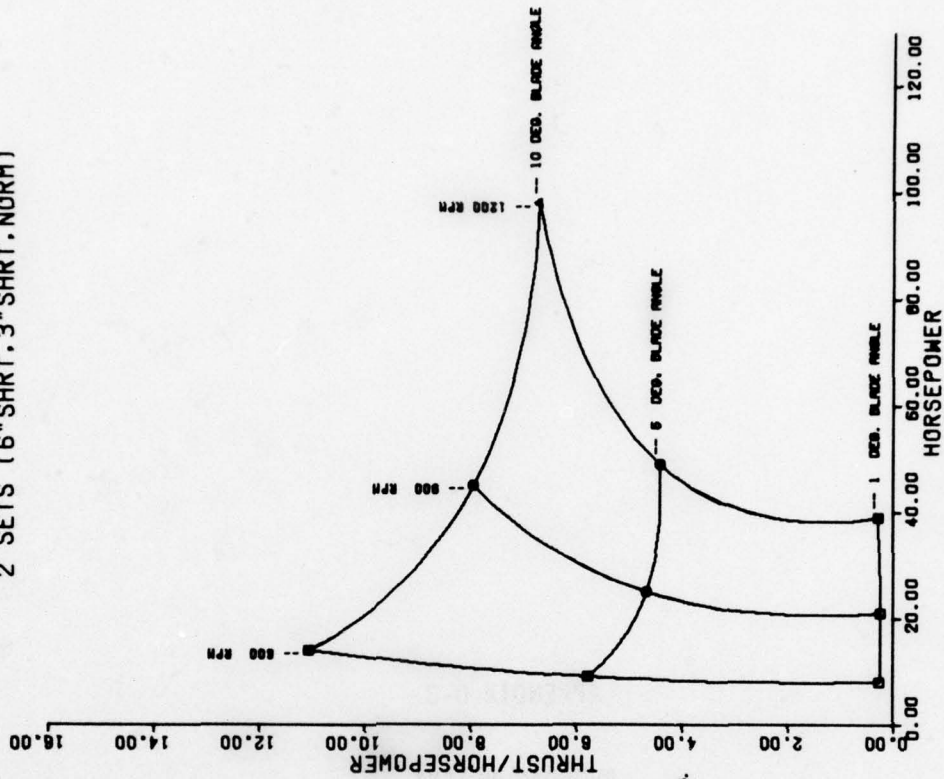
Figure B2-1: Plots From Sample THORSE Input Data Cards

6 BLADES. STANDARD



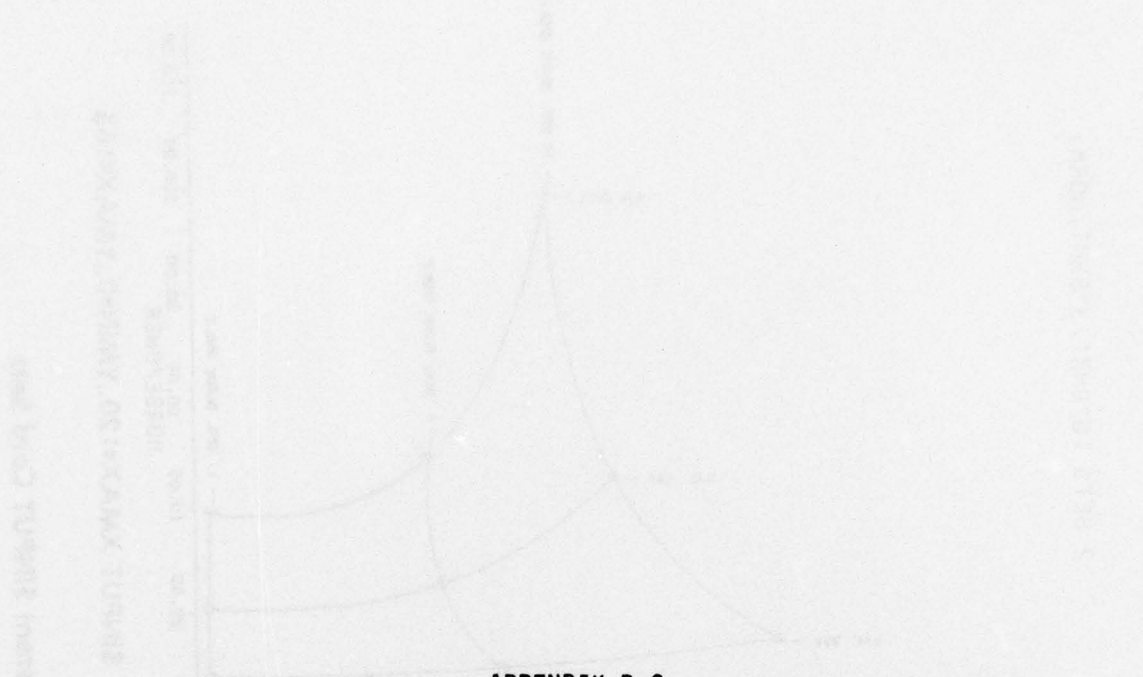
\$INPUT YMIN=4., YMAX=12., IORPM=2\$

2 SETS (6" SHRT., 3" SHRT., NORM)



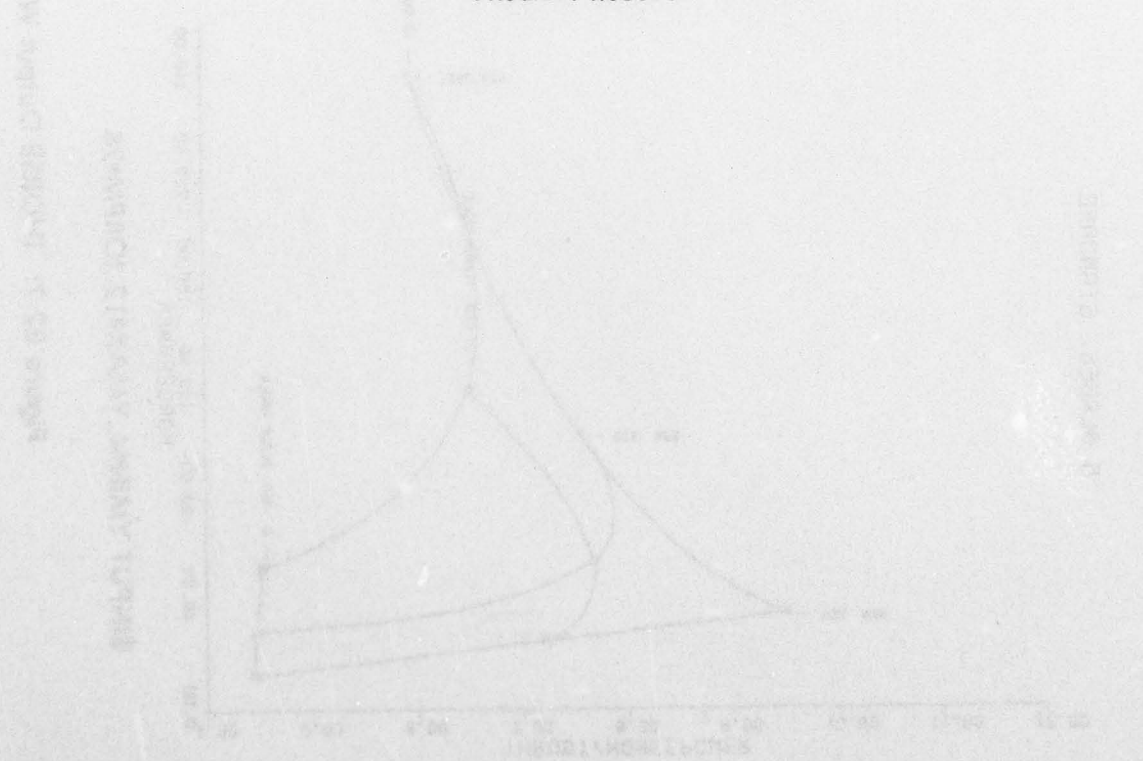
\$INPUT XMAX=120., YMIN=0., YMAX=16\$

Figure B2-2: THORSE Output With Different \$INPUT Card Sets



APPENDIX B-3

PROGRAM NOISY1



RM1,STCSA,CM55000,T20,I020. P720119 MCGREGOR. 52744
 FTN,R=3.
 MAP,PART.
 ATTACH,CCAUX,CCAUX,IO=X654321.
 LIBRARY,CCAUX.
 LGO.

" END OF RECORD
 PROGRAM NOISY1 (INPUT,OUTPUT,TAPES=INPUT,TAPES=OUTPUT,PLOT)

C
 C PROGRAM NOISY1 WILL PLOT THE SOUND PRESSURE LEVEL VS. FREQUENCY
 C PLUS THE OVERALL FOR ANY PROPELLOR RUNS. THE USER MAY SPECIFY
 C THE DATA CARD FORMAT, THE OUTPUT PLOT RANGE, AND WHETHER OR NOT
 C HE DESIRES A DBA CURVE FOR EACH SPECTRA PLOTTED. DEFAULT VALUES
 C ARE LISTED BELOW WITH INSTRUCTIONS FOR THEIR CHANGE. DATA WILL
 C BE VARYING RPM RUNS FROM A SINGLE MICROPHONE. (FOR A SINGLE
 C RPM FROM SEVERAL MICROPHONES, USE NOISY2)

C **** PRESET PARAMETERS (NAMELIST)

C DTFORM = (0) .. 3.15 THROUGH 20K PLUS OVERALL
 C 1 .. 20 THROUGH 20K PLUS OVERALL

C IOBAST = (0) .. NORMAL PLOTS, NO ADDITIONAL DBA CURVE
 C 1 .. ADDITIONAL DBA CURVE DESIRED

C SPLMIN = (20.) .. MINIMUM SPL VALUE FOR PLOT
 C SPLMAX = (120.) .. MAXIMUM SPL VALUE FOR PLOT

C START = (1) .. STARTING FREQUENCY INDEX
 C FINISH = (28) .. CLOSING FREQUENCY INDEX

C INDEX TABLE

I	HZ	I	HZ	I	HZ	I	HZ	I	HZ	I	HZ
1	20	6	63	11	200	16	630	21	2000	26	6300
2	25	7	80	12	250	17	800	22	2500	27	8000
3	32	8	100	13	315	18	1000	23	3150	28	10000
4	40	9	125	14	400	19	1250	24	4000		
5	50	10	150	15	500	20	1600	25	5000		

C * CHANGES TO THESE PARAMETERS SHOULD BE MADE USING THE STANDARD
 C NAMELIST FORMAT (EXAMPLE: \$INPUT FINISH=15, IOBAST=15)

C INTEGER DTFORM,START,FINISH
 C DIMENSION XFR(31)
 C DIMENSION TITLX(4),TITLY(-),A(31),FR(30),TITLE(4),UNX(4),UNY(4)
 C NAMELIST/INPUT/ DTFORM,IOBAST,START,FINISH,SPLMAX,SPLMIN
 C DATA TITLX/10MONE THIRU ,10HOCTAVE CEN,10HTER FREQUE,
 C 110HNCY IN HZ /,TITLY/10HSOUND LEVE,10HLS IN DB R,10HE 0.0002 M,
 C 210MICROBAR /,FR/20.,25.,31.5,40.,50.,63.,80.0,100.0,125.0,150.,
 C 3200.,250.,315.,400.,500.,630.,800.,1000.,1250.,1600.,2000.,2500.,
 C 43150.,4000.,5000.,6300.,8000.,10000.,10.,0.491/
 C 5,UNX/4.0,5.25,0.,1./,UNY/1.75,1.75,0.,1./
 C DTFORM=0 \$ IOBAST=0 \$ START=1 \$ FINISH=28 \$ SPLMAX=120.
 C SPLMIN=20.
 C CALL PLOT(0.,1.,-3)
 C 5 READ(5,INPUT)

```

10 READ(5,1000)TITLE,ICHNO
1001 FORMAT(4A10,I10)
IF(TITLE(1).EQ.10HNEWPARAM ) GO TO 5
IF(TITLE(1).EQ.10HENDATA )GO TO 999
MM=START
NN=FINISH
CHNO=ICHNO
SPLSTEP=(SPLMAX-SPLMIN)/8.0
II=0
YLOC=1.55
NUMPTS=NN-MM+1
C**DRAW AND LABEL AXES
CALL AXIS(0.,0.,TITLEY,40,8.,90.,SPLMIN,SPLSTEP)
TINC=5.5/FLOAT(NUMPTS-1)
TICK=0
CALL PLOT(6.0,0.0,3)
CALL PLOT(0.0,0.0,2)
N=1
DO 100 IPT=MM,NN
IF(IPT.GT.2)N=-1
CALL PLOT(TICK,-0.1,2)
CALL NUMBER(TICK,-0.1,0.07,FF(IPT),-60.0,N)
TICK=TICK+TINC
100 CALL PLOT(TICK,0.0,3)
CALL PLOT(6.0,0.0,3)
CALL PLOT(6.0,-0.1,2)
CALL SYMBOL(5.85,-0.2,0.1,3HQ/A,0.0,3)
CALL SYMBOL(.75,-.6,.1,44HONE-THIRD OCTAVE BAND CENTER FREQUENCY I
2N HZ,0.0,44)
CALL SYMBOL(1.35,8.35,0.1,TITLE,0.,40)
CALL SYMBOL(2.05,8.5,0.15,11HMIKE NUMBER,0.,11)
CALL NUMBER(3.85,8.5,0.15,CHNO,0.,-1)
CALL SYMBOL(4.5,1.775,0.1,3HRPM,0.,3)
CALL LINE(UNX,UNY,2,1,0,0)
C**PUT DATA IN A ARRAY
200 READ(5,1001)IRUNNO
RUNNO=IRUNNO
IDBA>IDBAST
1001 FORMAT(I10)
IF(IRUNNO.EQ.0)GO TO 899
CALL GETIN(DTFORM,IRUNNO,ICHNO,A,MM,NN)
C**PUT IN SYMBOL FOR OVERALL SPL
1002 OALL=OVERAL(A,MM,NN)
WRITE(6,2000)OALL
2000 FORMAT(F10.4)
OALL=(OALL-SPLMIN)/SPLSTEP
CALL SYMBOL(6.00,OALL,0.1,II,0.0,-1)
CALL SYMBOL(4.35,YLOC+.05,0.1,II,0.,-1)
CALL NUMBER(4.7,YLOC,0.1,RUNNO,0.,-1)
IF>IDBAST.EQ.0.OR>IDBA.EQ.1) GO TO 249
CALL SYMBOL(5.25,YLOC,0.1,5H(DBA),0.,5)
C**REMOVE OUT-OF RANGE-POINTS
249 DO 300 JJ=1,NUMPTS
IF (A(JJ).GE.SPLMIN) GO TO 250
A(JJ)=3.125+SPLMIN
250 IF (A(JJ).LE.SPLMAX) GO TO 300

```

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```

      A(JJ)=SPLMAX-3.125
300 CONTINUE
C**DRAW EACH LINE
      A(NUMPTS+1)=SPLMIN
      A(NUMPTS+2)=SPLSIEP
      XFR(NUMPTS+1)=0
      XFR(NUMPTS+2)=1.
      JJ=MM
      DO 201 I=1,NUMPTS
      XFR(I)=TINC*FLOAT(I-1)
201  CONTINUE
      CALL LINE(XFR,A,NUMPTS,1,1,II)
      YLOC=YLOC-0.15
      II=II+1
      IF (IDBA.NE.1) GO TO 799
      CALL D3ALIN(A,MM,NN)
      IDBA=IDBA-1
      GO TO 1002
799  CONTINUE
      GO TO 200
899  CALL PLOT(8.5,0.0,-3)
      GO TO 10
999  CONTINUE
      CALL PLOTE
      STOP
      END

```

```

SUBROUTINE GETIN(K,IRUNNO,ICHNO,A,MM,NN)
DIMENSION A(31)
IF (K.EQ.1) GO TO 50
READ(5,1000)(A(L),L=1,2)
READ(5,1001)(A(L),L=3,12)
READ(5,1001)(A(L),L=13,22)
READ(5,1003)(A(L),L=23,28)
1000 FORMAT(62X,2F6.1)
1001 FORMAT(10F6.1)
1003 FORMAT(6F6.1)
GO TO 75
50  READ(5,2000)(A(L),L=1,10)
    READ(5,1001)(A(L),L=11,20)
    READ(5,2001)(A(L),L=21,26)
    READ(5,2002) GARBAGE
2000 FORMAT(16X,10F6.1)
2001 FORMAT(8F6.1)
2002 FORMAT(F6.1)
75  WRITE(6,200)
    WRITE(6,100)(A(L),L=MM,NN)
100  FORMAT(11,10E12.2)
200  FORMAT(2X,10HDR *****)
RETURN
END

```

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```

SUBROUTINE DBALIN(A,MM,NN)
DIMENSION A(31),DBAWT(28)
DATA DBAWT/-50.5,
A-44.7,-33.4,-34.6,-30.2,-26.2,-22.5,-19.1,-16.1,-13.4,-10.9,-8.6,
B-6.6,-4.8,-3.2,-1.9,-0.8,0.0,0.6,1.0,1.2,1.3,1.2,1.0,0.5,-0.1,
C-1.1,-2.5/
DO 100 I=1,28
100 A(I)=A(I)+DBAWT(I)
WRITE (6,200)
WRITE (6,300) (A(L),L=MM,NN)
200 FORMAT (2X,10HD3A *****)
300 FORMAT (1H ,10E12.2)
RETURN
END
" END OF RECORD

```

```

FUNCTION OVERAL(A,MM,NN)
DIMENSION A(31)
SUM=0.0
DO 100 I=MM,NN
100 SUM=SUM+(10.0**(A(I)/10.0))
OVERAL=10.0*ALOG10(SUM)
RETURN
END

```

```

$INPUT DTFORM=1, IDBAST=19
6 BLADE BASELINE - 15 DEGREE PITCH 3
900
ID: %R003 C003: 050.7 054.5 057.5 062.2 064.7 068.2 079.2 082.5 068.2 073.0
075.7 075.5 074.2 079.5 079.5 081.0 090.5 080.5 081.5 090.7
081.2 081.5 084.0 083.0 081.7 084.0 084.7 089.0 062.5 048.7
044.0 094.5
--- BLANK CARD ---
ENDDATA

```

MIKE NUMBER 3
6 BLADE BASELINE - 15 DEGREE PITCH

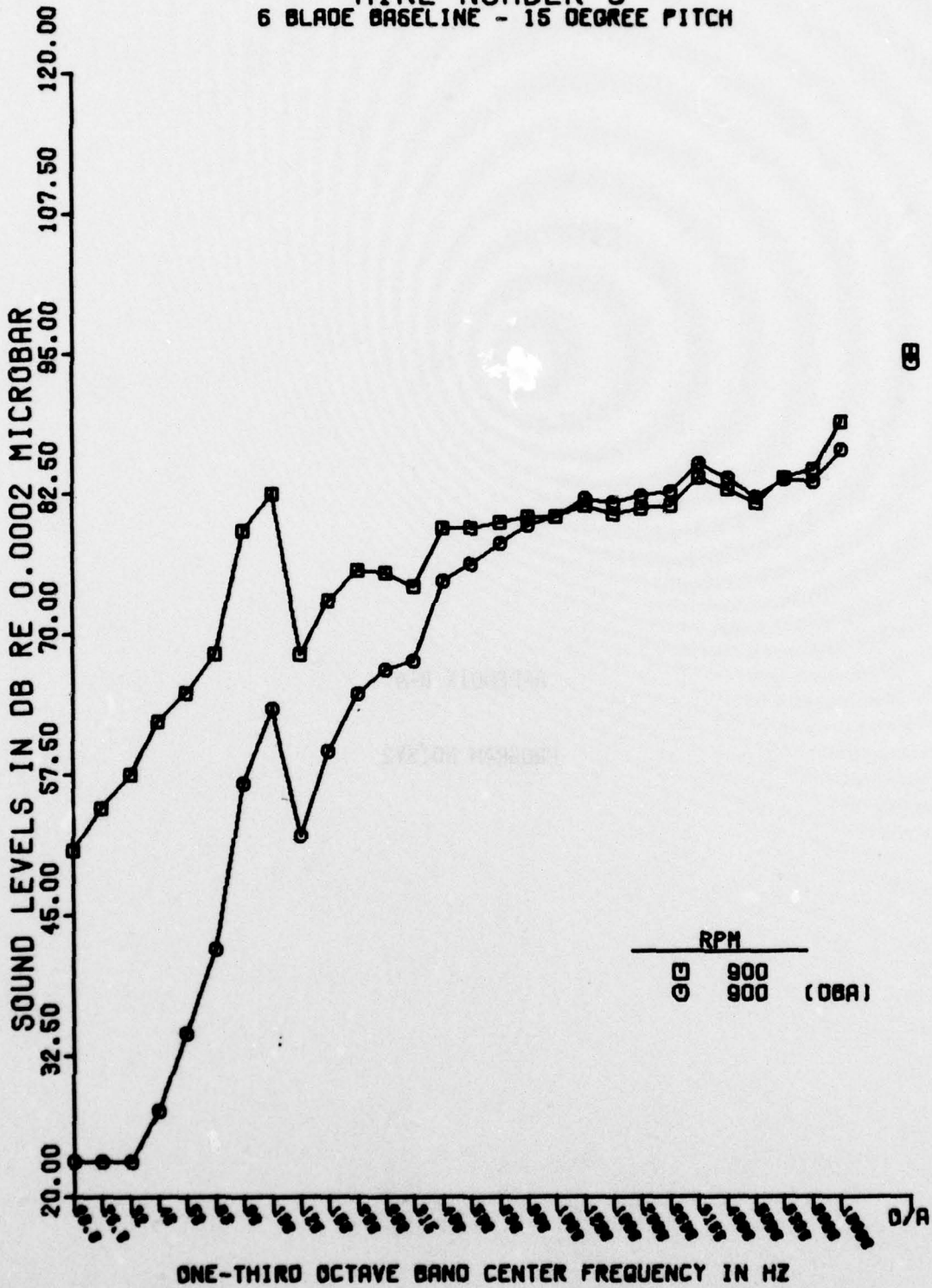


Figure B3-1: Plot From Sample NOISY1 Input Data Cards

MAC,STCSA,C460000,T40,I090. P720119 MCGREGOR 55421
 FTN.
 ATTACH,CCAUX,CCAUX,IO=X654321.
 LIBRARY,CCAJX.
 LGO.

" END OF RECORD

PROGRAM NOISY2(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,PLOT)

C
 C PROGRAM NOISY2 WILL PLOT THE SOUND PRESSURE LEVEL VS. FREQUENCY
 C PLUS THE OVERALL FOR ANY PROPELLOR RUNS. THE USER MAY SPECIFY
 C THE DATA CARD FORMAT, THE OUTPUT PLOT RANGE, AND WHETHER OR NOT
 C HE DESIRES A DBA CURVE FOR EACH SPECTRA PLOTTED. DEFAULT VALUES
 C ARE LISTED BELOW WITH INSTRUCTIONS FOR THEIR CHANGE. DATA WILL
 C BE A CONSTANT PPM FROM ANY NUMBER OF MICROPHONES. (FOR A
 C SINGLE MICROPHONE AND VARYING RPM'S, USE NOISY1)

C **** PRESET PARAMETERS (NAMELIST)

C DTFORM = (0) .. 3.15 THROUGH 20K PLUS OVERALL
 C 1 .. 20 THROUGH 20K PLUS OVERALL

C IDBAST = (0) .. NORMAL PLOTS, NO ADDITIONAL DBA CURVE
 C 1 .. ADDITIONAL DBA CURVE DESIRED

C SPLMIN = (20.) .. MINIMUM SPL VALUE FOR PLOT
 C SPLMAX = (120.) .. MAXIMUM SPL VALUE FOR PLOT

C START = (1) .. STARTING FREQUENCY INDEX
 C FINISH = (28) .. CLOSING FREQUENCY INDEX

C INDEX TABLE

I	HZ	I	HZ	I	HZ	I	HZ	I	HZ
1	20	6	63	11	200	16	630	21	2000
2	25	7	80	12	250	17	800	22	2500
3	32	8	100	13	315	18	1000	23	3150
4	40	9	125	14	400	19	1250	24	4000
5	50	10	150	15	500	20	1600	25	5000

C * CHANGES TO THESE PARAMETERS SHOULD BE MADE USING THE STANDARD
 C NAMELIST FORMAT (EXAMPLE: \$INPUT FINISH=18, IDBAST=1)

C INTEGER DTFORM,START,FINISH
 C DIMENSION XFR(31)

C DIMENSION TITLX(4),TITLY(4),A(31),FR(30),TITLE(4),UNX(4),UNY(4)

C NAMELIST/INPUT/ DTFORM,IDBAST,START,FINISH,SPLMAX,SPLMIN

C DATA TITLX/10HONE THIRD ,10HOCTAVE GEN,10HTER FREQUE,

C 110HNCY IN HZ /,TITLY/10HSOUND LEVE,10HLS IN DB R,10HE 0.0002 M,
 C 210MICROBAR /,FR/20.,25.,31.5,40.,50.,63.,80.0,100.0,125.0,150.,
 C 3200.,250.,315.,400.,500.,630.,800.,1000.,1250.,1600.,2000.,2500.,
 C 43150.,4000.,5000.,6300.,8000.,10000.,10.,0.491/

C *,UNX/3.9,5.65,0.,1./,UNY/8.0,8.0,0.,1./

C DTFORM=0 \$ IDBAST=0 \$ START=1 \$ FINISH=28 \$ SPLMAX=120.

C SPLMIN=20.

C CALL PLOT(0.,1.,-3)

C 5 READ(5,INPUT)

C 10 READ(5,1000)TITLX,IRPMO

```

1000 FORMAT (4A10,I10)
      IF(TITLE(1).EQ.10HNEWPARAM ) GO TO 5
      IF(TITLE(1).EQ.10HENDDATA )GO TO 999
      RPMO=IRPMO
      IDBA=IDB /ST
      II=0
      YLOC=7.75
      MM=START
      NN=FINISH
      NUMPTS=NN-MM+1
C**DRAW AND LABEL AXES
      SPLSTEP=(SPLMAX-SPLMIN)/8.0
      CALL AXIS(0.,0.,TITLEY,40,8.,90.,SPLMIN,SPLSTEP)
      TINC=5.5/FLOAT(NUMPTS-1)
      TICK=0
      CALL PLOT(6.0,0.0,3)
      CALL PLOT(0.0,0.0,2)
      N=1
      DO 100 IPT=MM,NN
      IF(IPT.GT.2)N=-1
      CALL PLOT(TICK,-0.1,2)
      CALL NUMBER(TICK,-0.1,0.07,FR(IPT),-60.0,N)
      TICK=TICK+TINC
100  CALL PLOT(TICK,0.0,3)
      CALL PLOT(6.0,0.0,3)
      CALL PLOT(6.0,-0.1,2)
      CALL SYMBOL(5.85,-0.2,0.1,3HO/A,0.0,3)
      CALL SYMBOL(.75,-.6,.1,44HONE-THIRD OCTAVE BAND CENTER FREQUENCY I
2N HZ,0.0,44)
      CALL SYMBOL(0.0,8.5,0.15,TITLE,0.0,40 )
      CALL SYMBOL(3.9,7.75,0.10,11HMIKE NUMBER,0.0,11)
      CALL SYMBOL(4.875,8.025,0.1,3HRPM,0.,3)
      CALL NUMBER(4.375,8.025,0.1,RPMO,0.,-1)
      CALL LINE(UNX,UNY,2,1,0,0)
C**PUT DATA IN A ARRAY
200  READ(5,1001)IMIKO
      XMIKO=IMIKO
1001  FORMAT(I10)
      IF(IMIKO.EQ.0) GO TO 899
      CALL GETIN(DTFORM,IRUNNO,ICHNO,A,MM,NN)
C**PUT IN SYMBOL FOR OVERALL SPL
1002  OALL=OVERAL(A,MM,NN)
      WRITE(6,2000)OALL
2000  FORMAT(F10.4)
      OALL=(OALL-SPLMIN)/SPLSTEP
      CALL SYMBOL(6.00,OALL,0.1,II,0.0,-1)
      CALL SYMBOL(5.5,YLOC+.05,0.10,II,0.0,-1)
      CALL NUMBER(5.1,YLOC,0.10,XMIKO,0.0,-1)
      IF(IDBAST.EQ.0.OR.IDBA.EQ.1) GO TO 249
      CALL SYMBOL(5.75,YLOC,0.1,5H(DBA),0.,5)
C**REMOVE OUT-OF RANGE-POINTS
249  DO 300 JJ=1,NUMPTS
      IF (A(JJ).GE.SPLMTN) GO TO 250
      A(JJ)=3.125+SPLMIN
250  IF (A(JJ).LE.SPLMAX) GO TO 300
      A(JJ)=SPLMAX-3.125

```

```

300 CONTINUE
C**DRAW EACH LINE
  A(NUMPTS+1)=SPLMIN
  A(NUMPTS+2)=SPLSTEF
  XFR(NUMPTS+1)=0
  XFR(NUMPTS+2)=1.
  JJ=MM
  DO 201 I=1,NUMPTS
201  CONTINUE
  CALL LINE(XFR,A,NUMPTS,1,1,II)
  YLOC=YLOC-0.15
  II=II+1
  IF (IDBA.NE.1) GO TO 799
  CALL DRALIN(A,MM,NN)
  IDBA=IDBA-1
  GO TO 1002
799  CONTINUE
  GO TO 200
899  CALL PLOT(8.5,0.0,-3)
  GO TO 10
999  CONTINUE
  CALL PLOTE
  STOP
  END

```

```

SUBROUTINE GETIN(K,IRUNNO,ICHNO,A,MM,NN)
  DIMENSION A(31)
  IF (K.EQ.1) GO TO 50
  READ(5,1000) (A(L),L=1,2)
  READ(5,1101) (A(L),L=7,12)
  READ(5,1001) (A(L),L=17,22)
  READ(5,1003) (A(L),L=23,28)
1000  FORMAT(62X,2F6.1)
1001  FORMAT(10F6.1)
1003  FORMAT(5F6.1)
  GO TO 75
  50  READ (5,2000) (A(L),L=1,10)
  READ (5,1001) (A(L),L=11,20)
  READ (5,2001) (A(L),L=21,28)
  READ (5,2002) GARBAGE
2000  FORMAT (16X,10F6.1)
2001  FORMAT (8F6.1)
2002  FORMAT(F5.1)
  75  WRITE (6,200)
  WRITE(6,100) (A(L),L=MM,NN)
  100  FORMAT(14 ,10E12.2)
  200  FORMAT (2X,10HDR ***** )
  RETURN
  END

```

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```

FUNCTION OVERAL(A,MM,NN)
DIMENSION A(31)
SUM=0.0
DO 100 I=MM,NN
100 SUM=SUM+(10.0**(A(I)/10.0))
OVERAL=10.0*ALOG10(SUM)
RETURN
END

```

```

SUBROUTINE DBALIN(A,MM,NN)
DIMENSION A(31),DBAWT(28)
DATA DBAWT/-50.5,
A-44.7,-33.4,-34.6,-30.2,-26.2,-22.5,-19.1,-16.1,-13.4,-10.9,-8.6,
B-6.6,-4.3,-3.2,-1.9,-0.3,0.0,0.6,1.0,1.2,1.3,1.2,1.0,0.5,-0.1,
C-1.1,-2.5/
DO 100 I=1,28
100 A(I)=A(I)+DBAWT(I)
WRITE (6,200)
WRITE (6,300) (A(L),L=MM,NN)
200 FORMAT (2X,10HPDA *****)
300 FORMAT (1H,10F12.2)
RETURN
END
** END OF RECORD

```

```

$INPUT SPLMIN=40., FTNISH=25$
6 BLADE, 10% MOD - 10 DEGREE PITCH 900
3
T01 R013 C003$ 044.0 044.0 044.0 044.0 044.0 044.0 044.0 044.0 044.0 048.0 048.5
049.7 051.0 055.0 062.7 076.5 079.0 064.2 072.7 075.0 074.0
075.0 075.7 076.2 076.7 075.7 075.7 076.2 076.2 076.5 076.5
078.7 079.7 033.5 086.7 087.0 089.7 054.7 044.0 044.0 094.2
0
T01 R013 C009$ 049.0 049.0 049.0 049.0 049.0 049.0 049.0 049.0 049.0 050.0 050.2
051.0 053.2 056.7 064.2 078.0 081.2 073.5 084.2 083.7 084.5
087.5 090.0 090.1 090.2 088.5 088.2 087.5 085.0 084.7 084.7
087.2 091.5 094.2 094.7 099.5 095.0 052.5 049.0 049.0 103.7
--- BLANK CARD ---
ENDDATA

```

6 BLADE, 10% MOD - 10 DEGREE PITCH

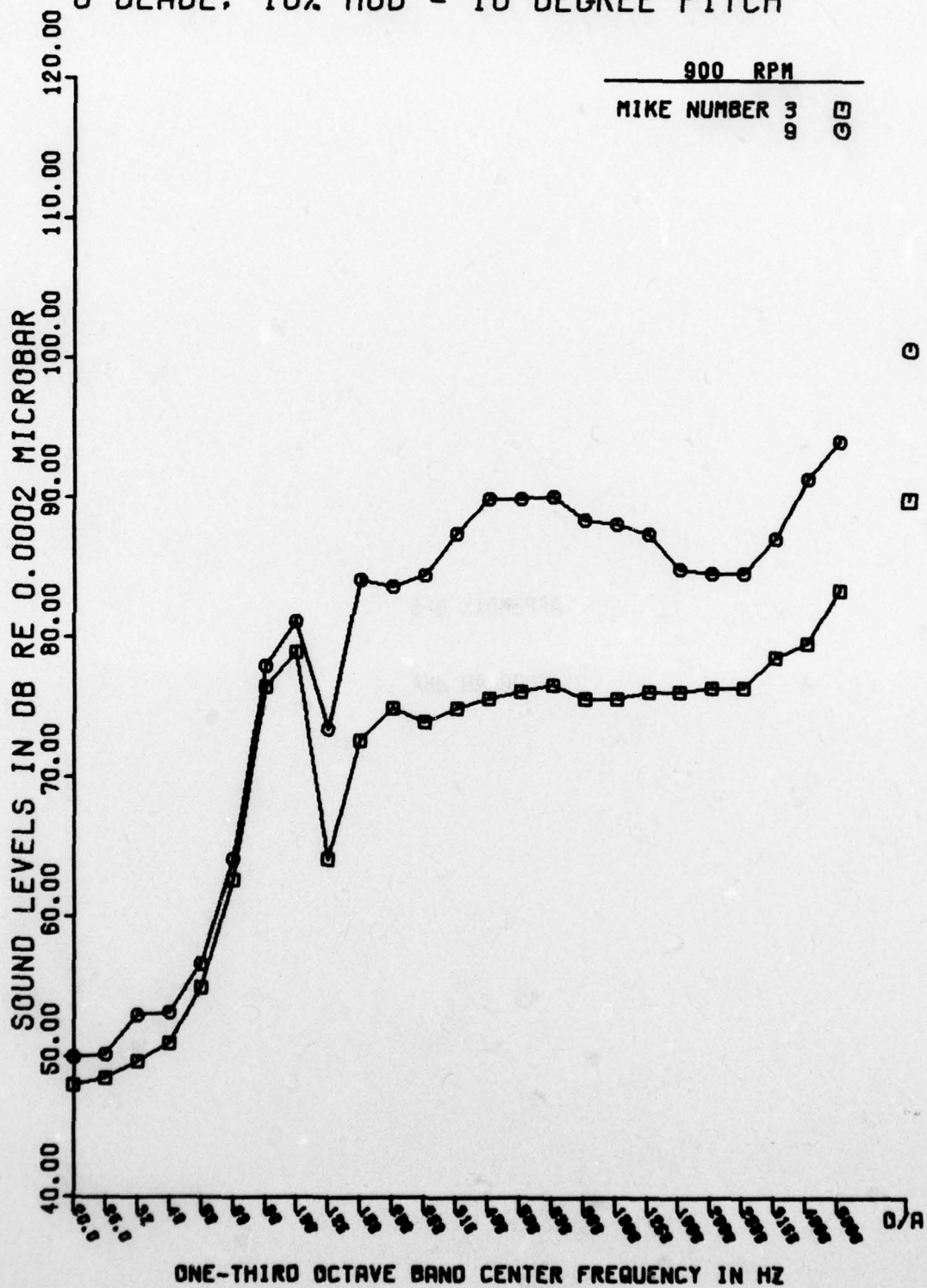


Figure B4-1: Plot From Sample NOISY2 Input Data Cards

RM8,STCSA,CM60000,T40,I030. P720119 MCGREGOR 55421
FTN.
LGO.

.. END OF RECORD
PROGRAM DBA (INPUT,OUTPUT,PUNCH,TAPE5=INPUT,TAPE6=OUTPUT,TAPE7=PUN
1CH)
INTEGER INFO,FRQRNG
REAL JUNK
DIMENSION INFO(8), DBAWT(39), DB(2,40), IMIKE(12)
NAMelist/INPUT/ IPUNCH
DATA DBAWT/-80.0,-80.0,-80.0,-80.0,-80.0,-70.4,-63.4,-56.7,-50.5,-
144.7,-39.4,-34.0,-30.2,-26.2,-22.5,-19.1,-16.1,-13.4,-10.9,-8.8,-6
2.6,-4.8,-3.2,-1.9,-0.8,0.0,0.6,1.0,1.2,1.3,1.2,1.0,0.5,-0.1,-1.1,-
32.5,-4.3,-6.6,-9.3/

1 CONTINUE

C PROGRAM DBA IS USED TO CALCULATE BOTH DB AND DBA WEIGHTED SOUND
C LEVELS FOR ANY SET OF DATA TAKEN ON THE QUIET PROPELLER RUNS.
C THE USER MUST SPECIFY THE NUMBER OF RPM RUNS PER CONFIGURATION AND
C THE NUMBER OF MICROPHONES INCLUDED IN THE DATA. TWO DATA FORMATS
C MAY BE READ, DEPENDING ON THE ORIGINAL PUNCHED CARDS. THE MAIN
C OPTIONS INCLUDE CONSIDERATION OF ONLY DESIRED MICROPHONES, AND
C THEN ONLY OVER THE SPECIFIED RANGE OF FREQUENCIES. THE USER MAY
C SPECIFY THE INTERNAL PROGRAM OPTION, IPUNCH, TO GIVE ONLY THE
C PRINTOUT AND NO CARDS. CARDS PRODUCED BY THIS PROGRAM WILL CONTAIN
C THE DB AND DBA LEVELS, THE RUN IDENTIFICATION, AND THE RANGE
C CONSIDERED IN THE CALCULATIONS. DATA CARD ORDERING IS GIVEN BELOW
C

*** SPECIFICATION DATA CARDS ***

C NRUN = NUMBER OF DIFFERENT RPMs/CONFIGURATION 15
C NCHANL = NUMBER OF MICROPHONE CHANNELS/RPM RUN 15
C NMIKE = TOTAL NUMBER OF DESIRED MICROPHONES 15
C IMIKE = MICROPHONE IDENTIFICATION NUMBERS 1015
C FRQRNG = DATA CARD FREQUENCY RANGE CODE 15
C 1 .. 3.15 HZ TO 20K HZ
C 2 .. 20 HZ TO 20K HZ
C NN,MM = RANGE TO BE CONSIDERED IN CALCULATIONS 215
C NN = 8 + INDEX OF STARTING FREQUENCY
C MM = 8 + INDEX OF FINAL FREQUENCY

INDEX TABLE

I	HZ	I	HZ	I	HZ	I	HZ	I	HZ	I	HZ
1	20	6	63	11	200	16	630	21	2000	26	6300
2	25	7	80	12	250	17	800	22	2500	27	8000
3	32	8	100	13	315	18	1000	23	3150	28	10000
4	40	9	125	14	400	19	1250	24	4000		
5	50	10	150	15	500	20	1600	25	5000		

C **** PRESET PARAMETERS (NAMelist)
C IPUNCH = 0 .. NO PUNCHED DATA DESIRED
C (1) .. PUNCHED DATA DESIRED

C * CHANGES TO THESE PARAMETERS SHOULD BE MADE USING THE STANDARD
C NAMelist FORMAT (EXAMPLE: \$INPUT IPUNCH=0\$)

IPUNCH=1
READ(5,INPUT)
READ(5,19)NRUN

```
READ (5,19) NCHANL
READ (5,19) NMIKE
READ (5,20) (IMIKE(II),II=1,NMIKE)
READ (5,19) FRQRNG
READ (5,21) NN,MM
```

C

```
  NSTRT=NMIKE+1
  DO 2 JJ=NSTRT,12
2  IMIKE(JJ)=99
  TLDBA=0.0
3  READ (5,22) (INFO(II),II=1,8)
  IF (INFO(1).EQ.10HRESTART ) GO TO 1
  WRITE (6,23) (INFO(II),II=1,8)
  IF (IPUNCH.EQ.0) GO TO 4
  WRITE (7,22) (INFO(II),II=1,8)
4  IF (INFO(1).EQ.10H ) STOP
  DO 18 L=1,NRUN
  ISTEP=1
  DO 18 I=1,NCHANL
  IF (FRQRNG.EQ.1) GO TO 6
  DO 5 NMN=1,8
5  DB(NMN)=0.0
  READ (5,25) IDRUN,IDMIKE,(DB(1),N=9,18)
  GO TO 7
6  READ (5,24) IDRUN,IDMIKE,(DB(1,N),N=1,10)
7  CONTINUE
  IF (IDMIKE.EQ.IMIKE(ISTEP)) GO TO 9
  DO 8 JJ=1,3
8  READ (5,26) JUNK
  GO TO 18
9  ISTEP=ISTEP+1
  IF (FRQRNG.EQ.1) GO TO 10
  READ (5,27) (DB(1,N),N=19,28)
  READ (5,27) (DB(1,N),N=29,38)
  READ (5,27) (DB(1,N),N=39,40)
  GO TO 11
10 READ (5,27) (DB(1,N),N=11,20)
  READ (5,27) (DB(1,N),N=21,30)
  READ (5,27) (DB(1,N),N=31,40)
11 CONTINUE
  DO 12 J=NN,MM
12 DB(2,J)=DB(1,J)+DBAWT(J)
  DO 14 K=1,2
  DO 13 J=NN,MM
13 TLDBA=TLDBA+(10.** (DB(K,J)/10.))
  DB(K,40)=10.*(ALOG10(TLDBA))
14 TLDBA=0.0
  IF (FRQRNG.EQ.1) GO TO 15
  WRITE (6,28) DB(1,40),DB(2,40),IDRUN,IDMIKE,NN,MM
  GO TO 16
15 WRITE (6,29) DB(1,40),DB(2,40),IDRUN,IDMIKE,NN,MM
16 IF (IPUNCH.EQ.0) GO TO 18
  IF (FRQRNG.EQ.1) GO TO 17
  WRITE (7,28) DB(1,40),DB(2,40),IDRUN,IDMIKE,NN,MM
  GO TO 18
17 WRITE (7,29) DB(1,40),DB(2,40),IDRUN,IDMIKE,NN,MM
```

18 CONTINUE
GO TO 3

C

19 FORMAT (I5)
20 FORMAT (10I5)
21 FORMAT (2I5)
22 FORMAT (8A10)
23 FORMAT (1H1,///,8A10,/))
24 FORMAT (6X,I2,3X,I2,1X,10F6.1)
25 FORMAT (3X,I2,3X,I2,1X,10F6.1)
26 FORMAT (F6.1)
27 FORMAT (10F6.1)
28 FORMAT (2F10.2,30X,8HID: %R0,I2,3H C0,I2,3H\$,2I5)
29 FORMAT (2F10.2,30X,6HID: R0,I2,3H C0,I2,3H\$,2I5)
END

" END OF RECORD

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INPUT \$
6
10
4
3 4 9 10
2
9 36

***** 6-BLADE BASELINE, 10 DEGREE PITCH *****

ID: %R006 C001\$ 047.7 049.0 054.0 058.2 077.0 090.5 065.7 060.0 079.2 063.2
066.0 067.0 067.2 070.2 070.2 072.0 072.5 072.2 072.0 071.5
073.0 075.0 081.0 086.0 082.7 083.2 085.7 079.7 044.0 044.0
044.0 094.0

ID: %R006 C002\$ 042.5 042.0 047.2 047.2 061.2 074.5 053.0 053.5 061.2 059.0
062.5 064.7 054.7 067.5 067.2 068.7 069.2 069.5 063.2 068.7
069.7 072.0 080.0 083.7 079.7 085.0 084.7 077.2 039.7 038.0
038.0 090.2

ID: %R006 C003\$ 042.5 041.5 048.2 043.2 049.0 057.7 048.5 052.7 061.0 056.0
059.7 062.0 050.7 062.7 063.2 065.0 064.2 064.2 063.2 063.2
064.0 066.5 073.7 079.0 076.2 081.0 078.5 070.7 034.5 034.0
034.0 085.0

ID: %R006 C004\$ 039.2 040.7 052.0 043.0 048.2 057.7 043.2 047.7 055.0 052.7
056.0 057.7 058.7 061.0 059.7 062.5 062.2 062.2 061.2 060.7
061.2 064.2 071.7 076.7 073.0 077.0 074.5 066.0 029.5 029.
029.0 082.0

200 SIMILAR CARDS REMOVED TO SHORTEN LISTING

ID: %R011 C005\$ 060.2 056.0 054.0 057.0 058.5 071.0 054.0 071.7 069.7 077.2
078.5 091.2 082.0 093.2 091.0 091.0 090.2 090.5 090.5 089.5
089.2 088.2 039.2 089.5 092.2 094.7 097.7 100.0 067.5 057.
054.0 104.5

ID: %R011 C006\$ 064.2 059.2 055.0 061.0 060.0 064.0 065.0 073.7 092.5 073.5
078.5 094.0 032.2 091.7 089.0 089.7 089.2 090.5 089.7 089.2
089.2 087.7 088.2 088.5 090.5 093.7 096.7 098.0 065.5 055.7
053.0 103.5

ID: %R011 C007\$ 069.0 069.7 071.7 075.0 075.0 080.0 031.0 088.0 101.0 093.5
093.7 098.2 032.2 105.0 099.7 104.5 101.5 103.5 102.5 101.0
098.7 097.2 098.0 101.0 105.2 106.7 103.0 110.7 073.7 064.0
064.0 115.0

ID: %R011 C008\$ 066.5 065.0 065.5 070.2 068.7 076.2 075.7 083.7 100.2 090.7
089.7 097.2 030.0 103.7 102.2 101.7 101.7 101.7 103.2 098.7
097.2 096.2 037.5 098.0 103.0 107.2 102.5 109.0 079.0 064.0
064.0 114.0

ID: %R011 C009\$ 058.0 058.0 058.0 064.2 062.2 069.7 070.5 079.7 098.5 053.0
085.0 096.7 037.2 099.5 098.7 099.2 097.7 099.5 097.2 096.2
095.2 095.7 096.2 095.0 099.2 104.0 099.2 103.7 074.0 058.0
058.0 110.5

ID: %R011 C010\$ 056.0 056.0 056.0 060.2 058.7 069.0 070.2 074.2 091.7 061.0
080.7 095.2 034.2 095.2 092.7 094.2 094.2 093.5 092.2 092.0
091.7 091.7 091.5 091.0 093.0 093.2 094.0 098.0 067.0 056.0
056.0 105.2

--- BLANK CARD ---

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```

***** 6-BLADE BASELINE, 10 DEGREE PITCH *****
85.80      85.86      ID: %R0 5 C0 35      9      36
82.53      82.73      ID: %R0 6 C0 +3      9      36
93.13      93.22      ID: %R0 5 C0 32      9      36
88.23      88.30      ID: %R0 5 C0105      9      36
91.09      90.59      ID: %R0 7 C0 35      9      36
87.25      86.88      ID: %R0 7 C0 +3      9      36
99.70      99.00      ID: %R0 7 C0 32      9      36
94.95      93.99      ID: %R0 7 C0105      9      36
94.87      94.26      ID: %R0 8 C0 35      9      36
90.71      90.16      ID: %R0 3 C0 +3      9      36
103.53     102.88     ID: %R0 3 C0 35      9      36
97.95      97.39      ID: %R0 5 C0105      9      36
96.67      95.91      ID: %R0 9 C0 35      9      36
93.02      92.37      ID: %R0 9 C0 +3      9      36
107.38     106.47     ID: %R0 9 C0 35      9      36
101.64     100.81     ID: %R0 9 C0105      9      36
100.41      99.24      ID: %R010 C0 35      9      36
96.87      95.84      ID: %R010 C0 +3      9      36
109.93     109.04     ID: %R010 C0 35      9      36
104.42     103.61     ID: %R010 C0105      9      36
103.65     101.55     ID: %R011 C0 35      9      36
99.50      97.82      ID: %R011 C0 +3      9      36
111.27     110.42     ID: %R011 C0 35      9      36
106.30     105.33     ID: %R011 C0105      9      36

```

Figure B5-1: Listing of Output From Sample DBA Input Data Cards

Station	Parameter	Value	Unit
101
102
103
104
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APPENDIX B-6

PROGRAM NEWCITY

Figure B-1: Listing of Output from Sample Data Input Data

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RM3,STCSA,CM55000,T30,I060. P720119 MCGREGOR 55421
FTN,R=3.
MAP,PART.
ATTACH,CCAUX,CCAUX,IO=X654321.
ATTACH,CC6600,IO=X654321.
LIBRARY,CCAUX,CC6600.
LGO.

```
" END OF RECORD
PROGRAM NEWCITY (INPUT,OUTPUT,TAPES=INPUT,TAPE6=OUTPUT,PLOT)

C
C PROGRAM NEWCITY IS DESIGNED TO PLOT SPL VS. HORSEPOWER AND THRUST
C FOR ANY PROPELLER RUNS. THE USER MAY SPECIFY THE USE OF ONLY
C PART OF THE DATA FOR PLOTTING AND MAY RECEIVE THE DATA IN EITHER DB
C OR DBA. CURVES MAY BE EITHER SPLINE FITTED OR UP TO SIXTH ORDER
C POLYNOMIAL FITTED. NAMELISTED PARAMETERS ARE LISTED BELOW ALONG
C WITH INSTRUCTIONS FOR THEIR CHANGE.
C
C ** DATA TO BE READ IN
C SPECIFICATION OF NUMBER OF RPM VALUES IN RUN
C NRPM = RPM VALUES PER RUN
C
C SPECIFICATION OF MICROPHONES IN DATA
C NMIKE=NUMBER OF MIKES
C IDMIKE=MICROPHONE IDENTIFICATION NUMBERS
C
C **** PRESET PARAMETERS (NAMELIST)
C
C NCURVE = (0) .. SPLINE-FIT
C          1 THRU 6 .. NTH ORDER POLYNOMIAL FIT
C
C IOPLT = 1 .. HORSEPOWER ONLY
C         2 .. THRUST ONLY
C         (3) .. BOTH
C
C LEGEND = (1) .. LEGEND BLOCK PRINTED
C          0 .. BLOCK OMITTED
C
C IORPM = (1) .. ALL AVAILABLE DATA USED IN PLOTS
C         2 .. 3 RPM VALUES PLOTTED REGARDLESS OF DATA INPUT
C
C IODBA = (0) .. OUTPUT IN DB
C         1 .. OUTPUT IN DBA
C
C YMIN = (40.) .. MINIMUM DB OR DBA FOR PLOT
C YMAX = (120.) .. MAXIMUM DB OR DBA FOR PLOT
C
C XMINT = (0.) .. MINIMUM THRUST FOR PLOT
C XMAXT = (1625.) .. MAXIMUM THRUST FOR PLOT
C
C XMINH = (0.) .. MINIMUM HORSEPOWER FOR PLOT
C XMAXH = (260.) .. MAXIMUM HORSEPOWER FOR PLOT
C
C * CHANGES TO THESE PARAMETERS SHOULD BE MADE USING THE STANDARD
C NAMELIST FORMAT (EXAMPLE: $INPUT NCURVE=2, XMINT=40.)
```

INTEGER HEAD

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```

DIMENSION HEAD(5), X(2,3,5), Y(4,3,5), XMIKE(10), LMIKE(4), TITLEX
1(2,2), TITLEY(4), TPLBL1(2), BETA(3), XSTEP(2), XDAT(7), YDAT(7),
2IDMIKE(10), CX(103), CY(103), W(5), WORK(100), COEF(7), ORD(6),
3XMIN(2)
NAMELIST/INPUT/ NCURVE, IOPLLOT, LEGEND, IORPM, IODBA, YMIN, YMAX, XMINT,
1XMINH, XMAXT, XMAXH
DATA TITLEY/10HSOUND LEVE, 10HLS IN DB R, 10HE 0.0002 M, 10MICROBAR
1 /, (TITLEX(1,I), I=1,2)/10H HORSE, 10H THRUST/, (TITLEX(2,I), I
2=1,2)/10HPWER , 10H (LBS) /, TPLBL1/10HMIKE NUMBE, 10HR
3 /, ORD/3H1ST, 3H2ND, 3H3RD, 3H4TH, 3H5TH, 3H6TH/
C MOVE PEN TO NEW ORIGIN
CALL PLOT (0.,1.,-3)
NCURVE=0 $ IOPLLOT=3 $ LEGEND=1 $ IORPM=1 $ IODBA=0 $ YMIN=40.
YMAX=120. $ XMINT=0. $ XMINH=0. $ XMAXT=1625. $ XMAXH=260.
1 READ (5,INPUT)
READ (5,28) NRPM
READ (5,28) NMIKE
READ (5,29) (IDMIKE(JJ), JJ=1,NMIKE)
NLINE=1
IF (NCURVE.NE.0) NLINE=-1
DO 2 JJ=1,NMIKE
2 XMIKE(JJ)=FLOAT(IDMIKE(JJ))
YSTEP=(YMAX-YMIN)/8.0
XSTEP(1)=(XMAXH-XMINH)/6.5
XSTEP(2)=(XMAXT-XMINT)/6.5
XMIN(1)=XMINH
XMIN(2)=XMINT
C ** READ IN HORSEPOWER AND THRUST VALUES
3 CALL READER (HEAD,BETA,X,Y,NRPM,NMIKE,IORPM,NSIZ,IODBA)
SUMMA=0.0
LIND=0
IF (HEAD(1).EQ.10H ) GO TO 27
IF (HEAD(1).EQ.10HRESTART ) GO TO 1
IF (IOPLLOT.NE.1.AND.10PLOT.NE.2) GO TO 4
LIND=1
L=IOPLLOT
GO TO 5
4 CONTINUE
L=1
5 CONTINUE
6 DO 26 I=1,NMIKE
C ** DRAW AXIS AND LABELS
IF (IODBA.EQ.1) GO TO 7
CALL AXIS (0.,0.,TITLEY,40,8.,90.,YMIN,YSTEP)
GO TO 8
7 CALL AXIS (0.,0.,38HSOUND LEVELS IN DBA RE 0.0002 MICROBAR,38,8.,9
10.,40.,10.)
8 CALL AXIS (0.,0.,TITLEX(1,L),-20,6.5,0.,XMIN(L),XSTEP(L))
CALL SYMBOL (2.25,8.4,0.15,TPLBL1,0.,20)
CALL NUMBER (4.05,8.4,0.15,XMIKE(I),0.,-1)
CALL SYMBOL (0.85,8.25,0.1,HEAD,0.,50)
IP=0
C ** DRAW CONSTANT BLADE ANGLE CURVES
9 IJ=1
JPOINT=NLINE
IND=0

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```

      J=1
10  CONTINUE
      DO 11 K=1,NSIZ
          YDAT(K)=Y(I,J,K)
11  XDAT(K)=X(L,J,K)
C  ** SKIP 5 DEGREE DUMMY DATA LINES (= 40. DB/D3A)
      TOT=TOTAL(YDAT,NSIZ)
      CUTOFF=40.0*FLOAT(NSIZ)
      IF (TOT.LE.CUTOFF) GO TO 23
      JK=J
      GO TO 15
C  ** DRAW CONSTANT RPM CURVES
12  IJ=2
      JPGINT=0
      IND=1
      K=1
13  CONTINUE
      DO 14 JJ=1,3
          YDAT(JJ)=Y(I,JJ,K)
14  XDAT(JJ)=X(L,JJ,K)
C  ** SKIP ANY DUMMY LINES
      TOT=TOTAL(YDAT,3)
      IF (TOT.LE.120.0) GO TO 23
      JUMP=3
      JK=K
      GO TO 10
15  ISYM=J-1
      JUMP=NSIZ
16  XDAT(JUMP+1)=XMIN(L)
      XDAT(JUMP+2)=XSTEP(L)
      YDAT(JUMP+1)=YMIN
      YDAT(JUMP+2)=YSTEP
C  ** REMOVE 5 DEGREE DUMMY DATA POINTS
      IF (YDAT(2).GT.40.0) GO TO 18
      MOVE=JUMP+1
      DO 17 KI=2,MOVE
          XDAT(KI)=XDAT(KI+1)
17  YDAT(KI)=YDAT(KI+1)
      XDAT(MOVE+1)=0.0
      YDAT(MOVE+1)=0.0
      JUMP=JUMP-1
C  DRAW FITTED CURVE AND/OR DATA POINTS
18  IF (JPOINT.EQ.0.AND.IJ.EQ.2) GO TO 19
      CALL FLINE (XDAT,YDAT,-JUMP,1,JPOINT,ISYM)
      YLOC=0.8-(.15*FLOAT(ISYM))
      IF (LEGEND.EQ.0.OR.IJ.EQ.2) GO TO 19
C  DRAW LEGEND BLOCK FOR PARTICULAR LINE
      CALL SYMBOL (4.20,YLOC,0.1,22H--      DEG. BLADE ANGLE,0.,22)
      CALL SYMBOL (4.0,(YLOC+.05),0.1,ISYM,0.,-1)
      CALL NUMBER (4.5,YLOC,0.1,BETA(JK),0.,-1)
19  IF (NCURVE.EQ.0) GO TO 23
C  CALCULATE AND DRAW LEAST SQUARES FITTED CURVE
      DO 20 II=1,JUMP
          CX(II)=XDAT(II)
20  CY(II)=YDAT(II)
      STEP=(CX(JUMP)-CX(1))/100.

```

```

NCP=NCURVE
ICPR=NCURVE+1
IF (JUMP-.T.ICPR) NCF=JUMP-1
PRINT *,"PASS ",J," THROUGH PLSCF"
CALL PLSCF (CX,CY,-1,JUMP,NCF,NMAX,COEF,0,XD,XO,WORK,IER)
PRINT *, "NCP = ",NCP," ERROR NUMBER = ",IER," NMAX = ",NMAX
PRINT *,"COEFS = ",(COEF(KK),KK=1,7)
LUPEND=NMAX+1
DO 22 JJ=1,101
CX(JJ+1)=CX(JJ)+STEP
DO 21 KK=1,LUPEND
21 SUMMA=SUMMA+(COEF(KK)*(CX(JJ)**(KK-1)))
CY(JJ)=SUMMA
22 SUMMA=0.0
CX(102)=XMIN(L)
CX(103)=XSTEP(L)
CY(102)=YMIN
CY(103)=YSTEP
PRINT *,(CX(KK),KK=1,103)
PRINT *,(CY(KK),KK=1,103)
CALL LINE (CX,CY,101,1,0,ISYM)
PRINT *,"LINE DRAWING COMPLETED"
PRINT *, " "
IF (NCURVE.EQ.0.OR.IP.EQ.1) GO TO 23
CALL SYMBOL (2.5,0.1,0.10,37H** ORDER POLYNOMIAL FITTED CURVES
1,0.,37)
CALL SYMBOL (2.9,0.1,0.1,ORD(NCP),0.,3)
IP=1
23 CONTINUE
IF (IND.EQ.1) GO TO 24
J=J+1
IF (J.LE.3) GO TO 10
GO TO 25
24 CONTINUE
K=K+1
IF (K.LE.NSIZ) GO TO 13
25 CONTINUE
IF (IJ.EQ.1) GO TO 12
MOVE PEN TO NEW ORIGIN
26 CALL PLOT (8.5,0.,-3)
IF (LIND.EQ.1) GO TO 3
L=L+1
LIND=1
GO TO 5
27 CONTINUE
CALL PLOTE
STOP
28 FORMAT (I5)
29 FORMAT (10I5)
END

```

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```

SUBROJTINE READER (HEAD,BETA,X,Y,NRPM,NMIKE,IORPM,NSIZ,IODBA)
DIMENSION HEAD(5), X(2,3,5), Y(4,3,5), BETA(3)
INTEGER HEAD
READ (5,14) HEAD
IF (HEAD(1).EQ.10H .OR.HEAD(1).EQ.10HRESTART ) GO TO 13
IF (IORPM.EQ.1) GO TO 9
IF (IORPM.EQ.2.AND.NRPM.EQ.3) GO TO 9
C ** READ 3 POINTS IF 5 ARE AVAILABLE
DO 2 I=1,3
READ (5,15) BETA(I)
DO 1 J=1,2
READ (5,16) RPM,X(1,I,J),X(2,I,J)
1 READ (5,17) TRASH
2 READ (5,16) RPM,X(1,I,3),X(2,I,3)
IF (IODBA.EQ.1) GO TO 5
C ** READ DB DATA
DO 4 I=1,NMIKE
DO 4 J=1,3
DO 3 K=1,2
READ (5,17) Y(I,J,K)
3 READ (5,17) TRASH
4 READ (5,17) Y(I,J,3)
GO TO 8
C ** READ DBA DATA
5 DO 7 I=1,NMIKE
DO 7 J=1,3
DO 6 K=1,2
READ (5,18) Y(I,J,K)
6 READ (5,18) TRASH
7 READ (5,18) Y(I,J,3)
8 NSIZ=3
GO TO 13
C ** READ ALL AVAILABLE DATA
9 DO 10 I=1,3
READ (5,15) BETA(I)
DO 10 J=1,NRPM
10 READ (5,16) RPM,X(1,I,J),X(2,I,J)
DO 12 I=1,NMIKE
DO 12 J=1,3
DO 12 K=1,NRPM
IF (IODBA.EQ.1) GO TO 11
C ** READ DB DATA
READ (5,17) Y(I,J,K)
GO TO 12
C ** READ DBA DATA
11 READ (5,18) Y(I,J,K)
12 CONTINUE
NSIZ=NRPM
13 RETURN
C
14 FORMAT (8A10)
15 FORMAT (30X,F10.3)
16 FORMAT (3F10.3)
17 FORMAT (F10.3)
18 FORMAT (10X,F10.3)
END

```

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