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Progress Report for
"A Research Program to Reduce Interior Noise
in General Aviation Airplanes"
(NASA Cooperative Agreement NCCI-6)

MEASUREMENT OF TRANSMISSION LOSS CHARACTERISTICS
USING ACOUSTIC INTENSITY TECHNIQUES
AT THE KU-FRL ACOUSTIC TEST FACILITY

KU-FRL-417-22

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SUMMARY

In this report, the work carried out at the University of Kansas Flight Research Laboratory (KU-FRL) to measure the transmission loss characteristics of panels using the acoustic intensity technique is presented. The report describes the theoretical formulation, installation of hardware, modifications to the test facility, and development of computer programs and test procedures. A listing of all the programs is also provided.

The initial test results indicate that the acoustic intensity technique can be easily adapted at the KU-FRL test facility to measure transmission loss characteristics of panels. Use of this method will give average transmission loss values. The fixtures developed to position the microphones along the grid points are very useful in plotting the intensity maps of vibrating panels.

Based on the experience gained so far, several improvements to the test facility and test procedures are also identified.

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LIST OF SYMBOLS

Symbol	Definition	Dimension
A	Area	m^2
A	Maximum input range of the analyzer	volts
C	Confidence interval	-
E	Energy flux	Joules
E{ }	Expected value function	-
f	Frequency	Hz
F	Force	Newton
$\mathscr{F}$	Fourier transform	-
G	One-sided spectrum	-
H	Transfer function	-
i	Integer	-
I	Intensity	watt/mass
j	$\sqrt{-1}$	-
k	Integer	-
k	Wave number	-
K	Calibration constant	-
n	Integer	-
n	Number of ensemble averages	-
N	Number of ensemble averages	-
N	Array size of the analyzer	-
p	Pressure	pascal
P	Pressure	pascal
r	Distance	m
R	Correlation function	-

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Symbol	Definition	Dimension
S	Spectrum	—
t	Time	sec
u	Particle velocity	m/sec
U	Particle velocity	m/sec
V	Output from the analyzer	—
x	Sample mean	—
z	Test statistic	—
Z	Statistic	—

(Greek)

Symbol	Definition	Dimension
δ	Difference between test mean and population mean	—
δr	Incremental distance	—
Δf	Incremental frequency	Hz
τ	Time increment	sec
ω	Circular frequency	rad/sec
γ	Square root of coherence	—
ϕ	Phase difference	rad
ϵ	Relative statistical error $= \left(\dfrac{\text{var}(I)^{1/2}}{I}\right)$	—
σ	Standard deviation	—
μ_0	Population mean	—
ρ	Density	kg/m^3

Symbol	Definition	Dimension
(Subscript)		
A	Location A	
av	Average	
B	Location B	
c	Calibration	
cal	Calibration	
d	Test or sample	
i	Integer	
p	Pressure	
v	Particle velocity	
α	Probability of commiting Type I error	
β	Probability of committing Type II error	
(Superscript)		
s	Switched	
*	Conjugate	

LIST OF ABBREVIATIONS

Abbreviation	Definition
KU-FRL	University of Kansas Flight Research Laboratory
MPD	Microphone positioning device
NR	Noise reduction
TL	Transmission loss
TV	True value
VAR	Variance

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

This report i. a continuation of the documentation of the research accomplished under continuing NASA Cooperative Agreement NCCI-6. The progress of the research accomplished during the period November 1982 through April 1983 of the previous project year (May 1, 1982, through April 30, 1983) was included in the previous report, KU-FRL-417-21 (Reference 1).

The present report covers the period from May 1, 1983, through November 30, 1983. In this reporting period, the measurement of transmission loss characteristics of panels using acoustic intensity techniques is being investigated. The characteristics and the limitations of the present measurement techniques are described in Reference 2. Most of the limitations mentioned in Reference 2 are due to the small size of source and receiver sections of this test facility and the use of acoustic pressure levels instead of acoustic sound power levels as a measure of sound power. Also, in the present method, the sound pressure levels are measured at only one location. Even though this location had been chosen after a careful experimental study, it is possible that this location may not be ideal for some cases. Measurement of the sound power by the integration of the acoustic intensity levels over the entire panel will eliminate a few of these limitations. The direct measurement of the acoustic intensity has now been made possible by the development of the two-microphone, cross-spectral method. This report describes the adoption

of this measurement technique at this test facility to measure panel transmission loss values.

Theoretical developments for the calculation of the acoustic intensity from the pressure measurements by two microphones separated by a known distance is given in Chapter 2. In the same chapter, some of the limitations of this method and ways to reduce some of the errors encountered are also described. The present test set-up had to be changed to introduce the intensity method at this test facility. The modified test set-up is presented in Chapter 3. Also presented in this chapter is the description of the computer programs and the modified test procedures. A typical test result from this test facility obtained using the acoustic intensity technique is given in Chapter 4. The comparison of the present test results with the previous results, and the modifications that will be required to improve test time and memory requirements are presented in Chapter 5.

CHAPTER 2

THEORETICAL ANALYSIS

2.1 ACOUSTIC INTENSITY

The acoustic intensity at any point is defined as the rate of acoustic energy flow across a surface of unit area (Reference 3). By definition:

$$I_{r,inst} = \frac{\delta_{E_r}}{\delta_t \delta_A} \tag{2.1}.$$

This energy flux, δ_{E_r}, is equal to the amount of work done upon the area A in the direction r due to the total force, F_r; i.e.,

$$\delta_{E_r} = F_r \cdot \delta r = p_t \delta_A \cdot \delta r \tag{2.2},$$

where p_t is the total pressure comprising the ambient pressure p_a and the sound (perturbed) pressure ϕ. This gives

$$I_{r,inst} = p_a u + pu \tag{2.3},$$

where $u = dr/dt$ is the particle velocity in the direction r. Both the sound pressure and the particle velocity are functions of spatial coordinates and time. For sinusoidal processes, the time-averaged value of the first term is zero if the averaging time is an integral number of half periods. For other processes, it well be zero if the averaging time is sufficiently long. If the processes are stationary random, the same result can be obtained by

$$E\{I_r\} = E\{p_a \cdot u_r\} + E\{pu_r\}$$

$$= p_a E\{u_r\} + E\{pu_r\}$$

$$= p_a u_{r_{mean}} + E\{pu_r\} \tag{2.4}.$$

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If the mean flow is zero, then

$$E\{I_r\} = E\{pu_r\} \qquad (2.5).$$

Direct measurement of intensity using pressure-velocity product
has proved very difficult in field conditions (Reference 4). An
indirect measurement, wherein two microphones are used to measure the
acoustic intensity, has gained wide attention in recent years
(Reference 4). In the next section, equations required for the
measurement of acoustic intensity using this method will be derived.

2.2 ESTIMATION OF ACOUSTIC INTENSITY USING TWO-MICROPHONE METHOD

With zero mean flow of the medium, the time-averaged intensity is
given by Equation (2.5). For ease of calculation, let us consider both
$p(r,t)$ and $u(r,t)$ to be stationary random processes. Fourier transforms
of stationary random processes exist if their autocorrelations and cross
correlation are aperiodic (Reference 6). In such cases the Fourier
transforms of $p(r,t)$ and $u(r,t)$ are defined as

$$P(r,\omega) = - \int_{-\infty}^{\infty} p(r,t)e^{-j\omega t}dt \qquad (2.6)$$

$$U(r,\omega) = - \int_{-\infty}^{\infty} u(r,t)e^{j\omega t}dt \qquad (2.7).$$

From Euler's equation (Reference 3), the relationship between
the particle acceleration and the pressure is obtained as

$$\rho \frac{\partial u}{\partial t} = -\text{grad } p \qquad (2.8).$$

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In one direction, namely r,

$$\rho \frac{\partial u_r}{\partial t} = - \frac{\partial p}{\partial r} \qquad (2.9).$$

In subsequent discussions, it is assumed that the particle velocity is in the direction r, and hence the subscript r will be dropped. The particle velocity is obtained by integrating Equation (2.9):

$$u = - \frac{1}{\rho} \int_0^t \frac{\partial p}{\partial r} \, dt \qquad (2.10).$$

To measure intensity using two microphones, an intensity measurement apparatus as shown in Figure 2.1 is used. In practice, the pressure at the center of closely spaced points A and B can be approximated by taking the mean of p_A and p_B. The pressure gradient, to a first order, can be calculated by dividing the difference in pressures at p_A and p_B by the separation distance, δr. These approximations give the following estimates for $p(r,t)$ and $u(r,t)$:

$$p(r,t) = \frac{1}{2} \{p_A(r,t) + p_B(r,t)\}$$

$$\qquad (2.11).$$

$$u(r,t) = - \frac{1}{\rho \delta r} \int_0^t (p_B - p_A) dt$$

This approximation can be considered valid as long as the separation is small compared to the wavelength, λ (Reference 5). Following Laplace Transform procedures, the time integral of the transform can be replaced by

$$\mathscr{F}[\int u \, dt] = \frac{U(\omega)}{j\omega} \qquad (2.12).$$

Reference 5 states that even though this procedure is mathematically incorrect, it gives valid results in practice. Hence Fourier transforms of $p(r,t)$ and $u(r,t)$ can be written as

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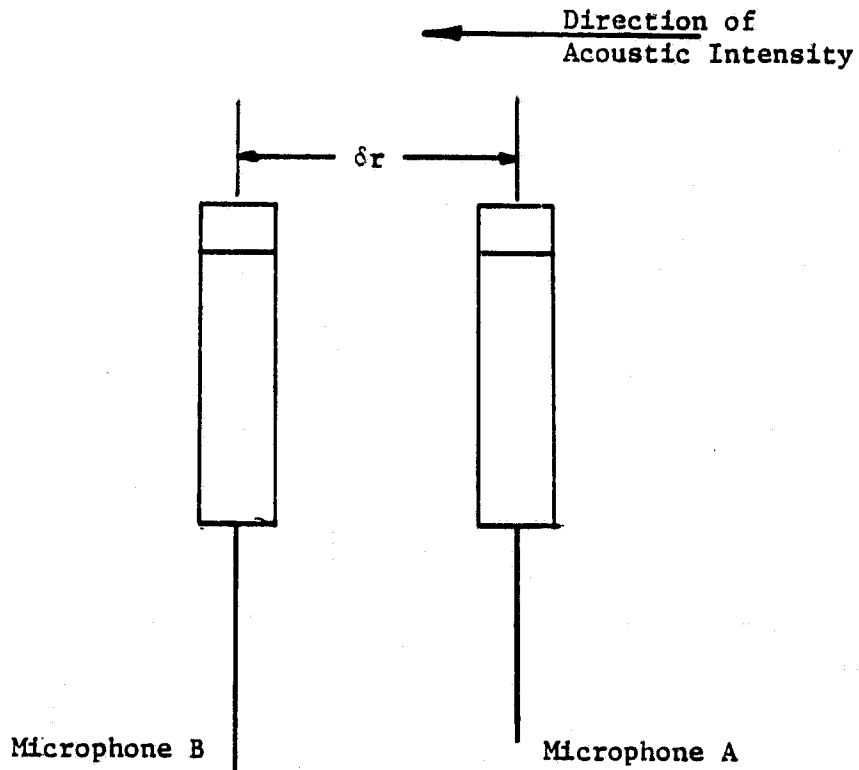
Figure 2.1: Acoustic Intensity Measurement Apparatus

$$P(r,\omega) = \frac{1}{2} \{P_A(r,\omega) + P_B(r,\omega)\} \qquad (2.13)$$

$$U(r,\omega) = -\frac{1}{j\omega\delta r\rho} \{P_B(r,\omega) - P_A(r,\omega)\} \qquad (2.14).$$

From Equation (2.5):

$$I_{r,av} = E\{p(r,t)u(r,t)\} \qquad (2.15).$$

Both p and u are functions of the spatial coordinates of r. The cross correlation function of p and u is defined by (Reference 6):

$$R_{pu}(t_1 t_2) = E\{p(t_1)u(t_2)\} \qquad (2.16).$$

Because of the stationarity, this equation can be written as

$$R_{pu}(\tau) = E\{p(t)u(t + \tau)\} \qquad (2.17).$$

At $\tau = 0$,

$$R_{pu}(0) = E\{p(t)u(t)\} \qquad (2.18).$$

The right hand side of the equation is equal to the averaged intensity. Therefore,

$$I_{r,av} = R_{pu}(0) \qquad (2.19).$$

By definition, the cross-spectrum of these two processes is given by (Reference 6)

$$S_{pu}(r,\omega) = \int_{-\infty}^{\infty} R_{pu}(\tau)e^{-j\omega\tau}d\tau \qquad (2.20),$$

and its inverse Fourier transform is

$$R_{pu}(\tau) = \frac{1}{2\pi} \int_{-\infty}^{\infty} S_{pu}(\omega)e^{j\omega\tau}d\omega \qquad (2.21).$$

With $\tau = 0$,

$$R_{pu}(0) = \frac{1}{2\pi} \int_{-\infty}^{\infty} S_{pu}(\omega)d\omega = \int_{-\infty}^{\infty} S_{pu}(f)df \qquad (2.22)$$

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and

$$R_{pu}(0) = R_{up}(0).$$

If the Fourier transform of $p(t)$ and $u(t)$ exist, the cross spectrum can be written as (Reference 6)

$$S_{p_u} = E\{P(f)U*(f)\} \qquad (2.23).$$

Substituting the values for $P(f)$ and $U(f)$ from Equations (2.13) and (2.14),

$$E\{PU*\} = E\{[\frac{1}{2} (P_A + P_B)][- \frac{1}{j\omega\delta r\rho} (P_B - P_A)]*\} \qquad (2.24).$$

Simplifying this equation,

$$E\{PU*\} = - \frac{j}{2\omega\delta r\rho} [E\{P_B P_B*\} - E\{P_A P_A*\} + E\{P_A P_B*\} - E\{P_B P_A*\}] \qquad (2.25).$$

By definition,

$E\{P_B P_B*\}$ = Power spectrum of pressure at A = S_{AA},

$E\{P_A P_A*\}$ = Power spectrum of pressure at A = S_{BB},

$E\{P_A P_B*\}$ = Cross power spectrum between pressure at B and A = S_{AB},

$E\{P_B P_A*\}$ = Cross power spectrum between pressure at B and A = S_{BA}.

Because $S_{BA} = S_{AB}*$,

$$j (S_{AB} - S_{BA}) = +2Im(S_{BA}).$$

Substituting these relations in the equation,

$$E\{PU*\} = \frac{1}{2\omega\delta r\rho} \{j (S_B - S_{AA}) + 2Im(S_{BA})\} \qquad (2.26).$$

If the cross correlation is real, which normally is the case, the real part of the cross spectrum will be even and the imaginary part of the cross spectrum will be odd. Hence, when integrated from $-\infty$ to $+\infty$, the odd part integrates to zero. Using only the real part,

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$$I_{r,av} = -\int_{-\infty}^{\infty} \frac{1}{\omega\delta r\rho} \text{Im}(S_{BA})d\omega \qquad (2.27).$$

Fourier analyzers use only one-sided spectrum. The values on the positive frequency side are doubled to keep the energy the same. One-sided cross spectrum is normally denoted by G_{BA}.

$$I_{r,av} = -\int_{0}^{\infty} \frac{1}{\omega\delta r\rho} \text{Im}(G_{BA})d\omega \qquad (2.28).$$

The negative sign in the equation can be avoided if the microphone closest to the source is connected to channel B of the analyzer (see Equation 2.11). For this case, the intensity can be written as

$$I_{r,av} = \int_{0}^{\infty} \frac{1}{\omega\delta r\rho} \text{Im}(G_{AB})d\omega \qquad (2.29).$$

In practice, the digital form of the estimate will be used:

$$I_{r,av} = \frac{1}{\rho\delta r} \sum_{n=1}^{N/2} \frac{\text{Im} G_{AB}(n\Delta f)}{n\Delta f} \qquad (2.30),$$

where Δf is the calculation bandwidth and N is the block size of the analyzer. Intensity as a function of frequency is

$$I_r(n\Delta f) = \frac{1}{\rho\delta r} \frac{\text{Im} G_{AB}(n\Delta f)}{n\Delta f} \qquad (2.31).$$

2.3 LIMITATIONS

References 3 through 5 discuss the inherent limitations of the two-microphone cross-spectral method to estimate the acoustic intensity. The limitations arise due to two types of error that occur: a) a systematic error and b) a statistical error. The systematic error is due to the finite difference approximation used in the formulation

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of acoustic intensity. The statistical errors are due to the random source excitation and other random variations in measurement. In addition there are some more limitations that are specific to the KU-FRL acoustic test facility. All these limitations are discussed below.

2.3.1 High Frequency Limitation

At the KU-FRL acoustic test facility there are two possible sources of error in the high frequency region. The first limitation is due to the finite difference approximation for pressure and pressure gradient. This produces a systematic error in the estimation of these two quantities. The approximations used are (Equation 2.11)

$$p = \frac{p_A + p_B}{2} \tag{2.32}$$

$$\frac{\partial p}{\partial r} = \frac{p_B - p_A}{\delta r} \tag{2.33}.$$

By the mean value theorem, these approximations tend to the actual values only when the separation distance tends to zero. Otherwise, they produce a systematic error in the entire frequency range. However, the error is most severe in the high frequency range. For a plane sinusoidal wave, the estimate of the intensity, using this approximate method, is related to the actual intensity by (Reference 5)

$$\frac{\hat{I}}{I_r} = \frac{\sin(k\delta r)}{k\delta r}$$

where $\hat{I}_r$ = actual intensity,

I_r = calculated intensity,

k = wave number (w/c).

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(Sin x/x) tends to 1 when x tends to zero. Otherwise, it is less than 1. Hence at high frequency (high k) and large separation distance, the acoustic intensity will be underestimated. At the KU-FRL acoustic test facility, this is minimized by limiting the separation distance to 25 mm (1") at frequencies above 500 hz.

The second limitation is due to the band pass characteristics of microphones. Because low frequency noise reduction is the major concern in aircraft noise reduction, microphones with higher sensitivity in this region are preferred. Because only the low frequency region is important in aircraft noise control applications, 1/2" B&K microphones were chosen for the measurement of transmission loss of panels at the KU-FRL acoustic test facility. These microphones are accurate only up to 4000 hz. With 1" separation and up to 400 hz, the error due to the approximation will be less than 3 dB for a plane with sinusoidal wave. However, because this is a systematic error, similar error occurs with and without the panel. Hence, when the transmission loss is calculated, these errors tend to cancel each other out.

2.3.2 Low Frequency Limitations

According to Reference 4, there is no evidence of any low frequency limit due to the approximation errors. Reference 5 shows that the estimation of the particle velocity results in the estimation of the phase angle difference between the two microphones. The term "kδr" in Equation (2.34) is the phase difference between the microphones. This term is very small at low frequencies because k is small. Hence, at

low frequencies, the measurement error of the phase angle becomes significant. The measurement error is due to the channel mismatch between the two microphone channels. This error can be eliminated (or reduced) either by using phase-matched microphones or by correcting for the difference in the phase angles when both the microphone channels are exposed to the same sound field. While the use of phase-matched microphones will make measurement easier, it cannot account for the phase mismatch in the rest of the measurement channels (like signal amplifier, etc.). Because of this, a phase calibration procedure is being adopted at the KU-FRL acoustic test facility. These procedures are discussed in detail in Chapter 3.

2.3.3 Near Field Limitations

The third limitation occurs when this method is used in cases where the intensity changes rapidly along the probe. When this occurs, the intensity is very different at the two microphone locations. A similar situation arises when the measurements are made in near field. Several expressions have been derived to estimate the effect of near field for simple sources such as monopole, dipole, and quadrupole. Table 2.1, taken from Reference 5, gives the following criteria for limiting this error.

Source type	Proximity error less than 1 dB if source is away by
Monopole	$> 1.1 \, \delta r$
Dipole	$> 1.6 \, \delta r$
Quadrupole	$> 2.3 \, \delta r.$

While these results will not be valid for a complex source such as a thin panel, they do provide some guidance in using the acoustic intensity techniques near the sound sources.

2.3.4 Limitations Due to Statistical Errors

Because of the random excitation, an estimate of $G_{AB}(f)$ is made. This estimation gives an additional error due to the variance of the quantity being measured. Reference 7 gives the normalized random error, $\varepsilon(I) = (Var(I)^{1/2}/I)$, in this type of measurement as

$$\varepsilon(I) = (n_d)^{-1/2}[1/\gamma^2 + \cot^2\phi_{AB}(1 - \gamma^2)/2\gamma^2]^{1/2} \qquad (2.35),$$

where n_d is the number of ensemble averages for cross spectrum, and γ^2 is the coherence between the acoustic pressure at the two measurement points.

As can be seen, the statistical error can be minimized by selecting a large number of ensemble averages and making sure that the coherence level is high. Since the tests are conducted inside a closed cavity where no other sources exist, the measured coherence values are normally very high. In the KU-FRL acoustic test facility an ensemble average of 256 and acceptable coherence of above .8 are used. For an assumed phase difference of .18 rad, with these values for ensemble averages and coherence, the statistical error ($\varepsilon(I)$) will be less than .194. For a plane wave, a phase angle difference of .18 rad corresponds to 100 Hz at 4" microphone separation.

2.4 CORRECTIONS FOR PHASE MISMATCH

As discussed in Section 2.3, phase mismatch between the two
microphones can be minimized either by using phase-matched microphones
or by correcting for the error. One of the disadvantages of using the
phase-matched microphone is the error due to phase mismatch of the
rest of the measurement channel cannot be corrected. At times these
errors may become significant. Hence at the KU-FRL acoustic test
facility, phase correction by prior calibration of microphones is
used. A literature search was conducted. Based on the results, four
promising methods were chosen (References 4, 5, and 8).

2.4.1 Phase Angle Correction

In this method the phase difference between the two measurement
channels (including microphones) is measured when the microphones are
subjected to the same sound field. The phase angles of the cross
spectrum measured during the intensity tests are corrected for this
difference. The magnitude correction is done separately. If the
same sound field is applied to both the microphones, shown in Figure
2.2, the measured cross spectrum is given by

$$S_{AB} = S_{P_1 P_2} \cdot H_A^* \cdot H_B \qquad (2.36),$$

where $S_{P_1 P_2}$ is the cross spectrum of the sound field at the position
of the two microphones, S_{AB} is the measured cross spectrum, and H_A
and H_B are the transfer functions of the two measuring channels.
The phase angle of the measurement channels is the phase angle of the
transfer function.

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This is one of the methods chosen at the KU-FRL to correct for the phase angle difference. This method is useful at low frequencies. The exact realization is discussed in the next chapter. The magnitude calibration is done separately using B&K Pistonphone 4220.

2.4.2 Transfer Function Method

Reference 5 shows that when two microphones are exposed to the sound field, both magnitude and phase correction for channel mismatch can be done using the relation:

$$S_{P_1P_2} = \frac{S_{AB}}{(H_A)^2 \cdot H_{ab}} \qquad (2.37),$$

where H_{AB} is the transfer function between the measurement channels. Since this method is very similar to the previous method, this was not tried.

2.3.4 Microphone Switching Method

Chung, et al. (Reference 4), originally proposed this method for correcting phase mismatch. In this method, tests are done twice. Tests are first performed with the microphones in normal locations; tests are then repeated with the microphones interchanged. Under these conditions Reference 4 gives the actual cross spectrum as

$$Im = \{[G_{AB}^S \cdot G_{AB}]^{1/2}\}/\rho \delta r \omega \cdot |H_A| \cdot |H_B| \qquad (2.38),$$

where G_{AB} = cross spectrum between microphones,

G_{AB}^S = cross spectrum with microphones switched,

$|H_A|$, $|H_B|$ = gain factors, microphones A and B.

In this method every test has to be done twice; also, therefore, the test section has to be opened for every measurement. For these reasons this method is not being used at the KU-FRL acoustic test facility.

2.4.4 Modified Microphone Switching Technique

This method is a combination of the transfer function method and the microphone switching method. In this method, before the start of the tests, the microphones are exposed to a sound field and the cross spectrum (G_{AB}) is measured. Now the microphones are switched, the measuring system is exposed to the same sound field, and once again the cross spectrum is measured (G_{AB}^S). From Reference 8, we get

$$e^{i\phi} = \sqrt{\frac{G_{AB}^*(\omega)}{G_{AB}(\omega)}} \tag{2.39},$$

where ϕ is the phase angle between the measurement channel. By assuming that the magnitudes are the same, the complex root computation is avoided. The phase angle is calculated by dividing the phase angle of the cross spectral division by 2.

This error is used to correct the measured intensity values during the actual tests. The implementation of this method at the KU-FRL acoustic test facility is discussed in the next chapter. The advantages of this method are 1) the microphones need not be exposed to the same sound field, 2) tests need not be performed twice,

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3) the method is valid even at high frequencies. The only requirement is that the sound field should be stationary.

CHAPTER 3

EXPERIMENTAL SET-UP

3.1 HARDWARE DESCRIPTION

3.1.1 General Test Set-Up Description

The general arrangement of the acoustic intensity test set-up
is shown schematically in Figure 3.1. The system shown was designed
to take and process data as quickly and efficiently as possible. Since
each TL test requires 324 intensity spectra at 402 frequency values
each (325 spectra = 81 points for high and low frequency tests for both
the source and receiver side), the need for speed in data processing
and efficiency in data storage becomes obvious. The operation of the
system is described below.

The heart of the system is the Nicolet 660B dual channel FFT
analyzer. The analyzer provides temporary data storage and performs
all required FFT calculations. It is controlled by a Zenith Z-100
microcomputer which provides data reduction and permanent data storage
capability. The 660B and Z-100 are linked through their respective
RS-232C ports at a 9,600 baud rate. At present, the communication
software used to transfer data from the 660B to the Z-100 is written
in a high-level language and represents one of the limitations to the
speed of testing. The development of an assembly language communication
program (a future project) will, however, decrease the test time.

In addition to its data acquisition role, the Nicolet 660B also
provides the excitation signal that drives the speakers in the Beranek
tube. This excitation signal is a band-limited binary white noise
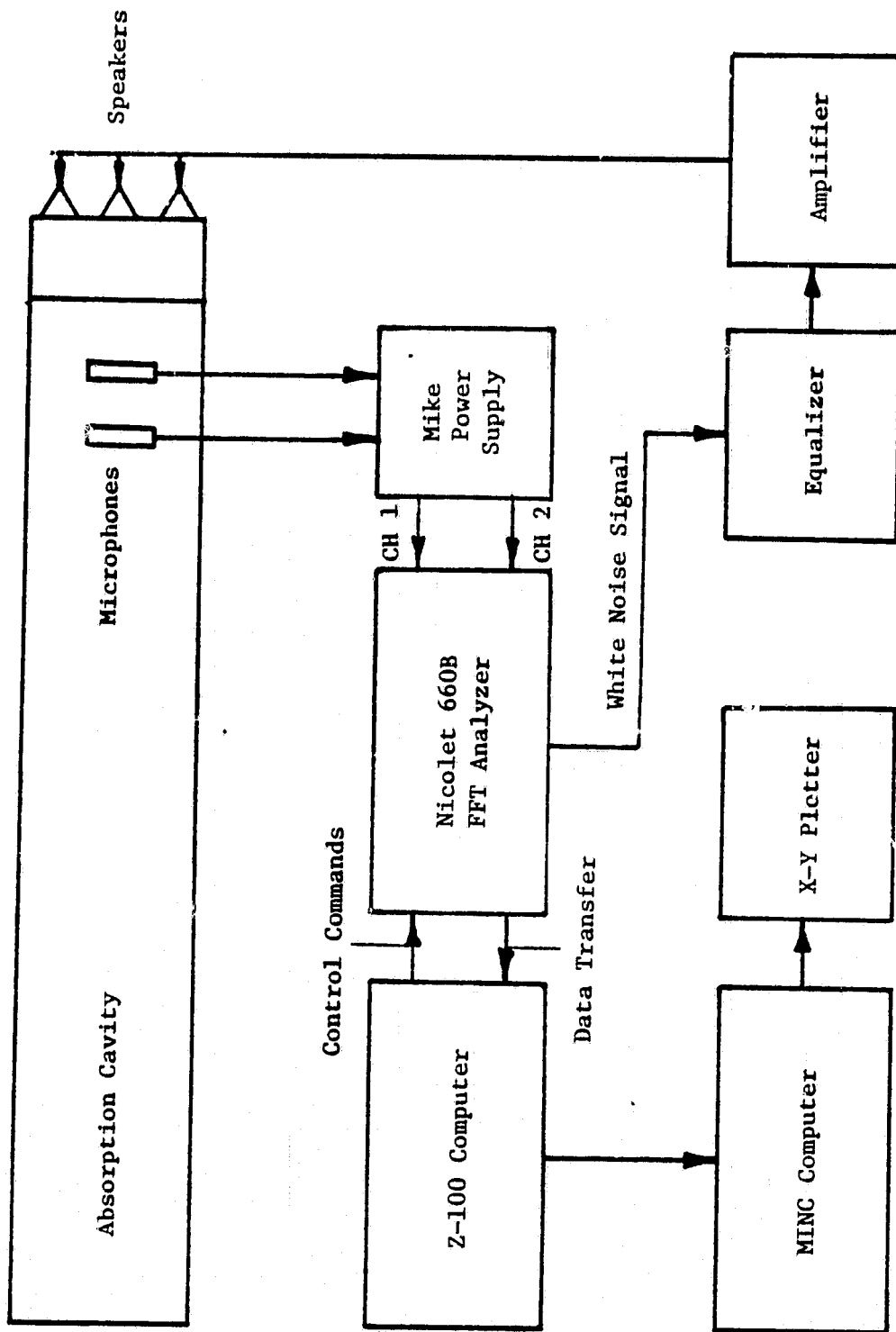
Figure 3.1: General Arrangement of the Acoustic Intensity Test Set-Up

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output from the analyzer's rear panel. It is passed through a TAPCO 2200 equalizer for purposed of modifying the speaker inputs to achieve a flat speaker output. The equalizer output is gained up through a Crown D-150 power amplifier to drive the nine Altec 405-8G loudspeakers. It may, however, be necessary to insert a high pass filter between the analyzer and the equalizer when testing panels with large transmission losses. This would be required to avoid overloading the analyzer inputs in the low frequency range when attempting to gain up the microphone outputs in the high frequency range. As yet, this had not become necessary.

Two B&K 4165 microphones with B&K 2618 preamps are positioned in the Beranek tube by the microphone positioning device (MPD--described in the next section). The microphone preamplifier outputs are fed into the two channels of the 660B FFT analyzer (although tests involving panels with very high transmission losses may require additional amplification of microphone signals--such as the KU-FRL Nagra SJS tape recorder--between the microphone power supply and the analyzer). From the analyzer, the cross spectrum of the two microphones is transferred to the Z-100 microcomputer where it is stored on 5 1/4 inch disks. Data transferred to the Z-100 are cataloged in files by microphone location, analysis (frequency) range, and source or receiver spectra so that batch processing of data is simplified. Data reduction routines are run on the Z-100 to generate point intensity values and overall panel transmission loss. These data are transferred to a Digital MINC computer for plotting on a Hewlett-Packard Model 7225B X-Y plotter.

3.1.2 Microphone Positioning Device (MPD) Description

The microphone positioning device was designed and built at the KU-FRL for the purpose of accurately positioning the microphones within the Beranek tube. The design requirements specified that the MPD be able to position two microphones anywhere in a 16 inch by 16 inch plane parallel to and directly behind the test panel without opening the tube. Movement of the mikes had to be done easily and accurately from the outside. In addition, provisions for varying the spacing between the microphones had to be made, and "blockage" due to the device (interference with the sound paths within the tube) had to be kept to a minimum. A later requirement that the MPD provide for easy time-area averaging could not be met, as construction had already progressed too far at that time.

The MPD is shown in Figure 3.2. It is an extension tube constructed of particle board into which the positioning mechanism is built. Vertical and horizontal motion is provided by a system of cross beams. A Lucite block is attached to the vertical and horizontal beams at their intersection and is allowed to slide freely on both. The block is therefore constrained by the cross beams (guide rods) such that when the rods are moved, the Lucite block maintains its porition at their intersection. The microphones are attached to the Lucite block through an aluminum beam protruding from it (see Detail A). The microphones can be positioned at different locations along the beam to provide for different microphone spacings.
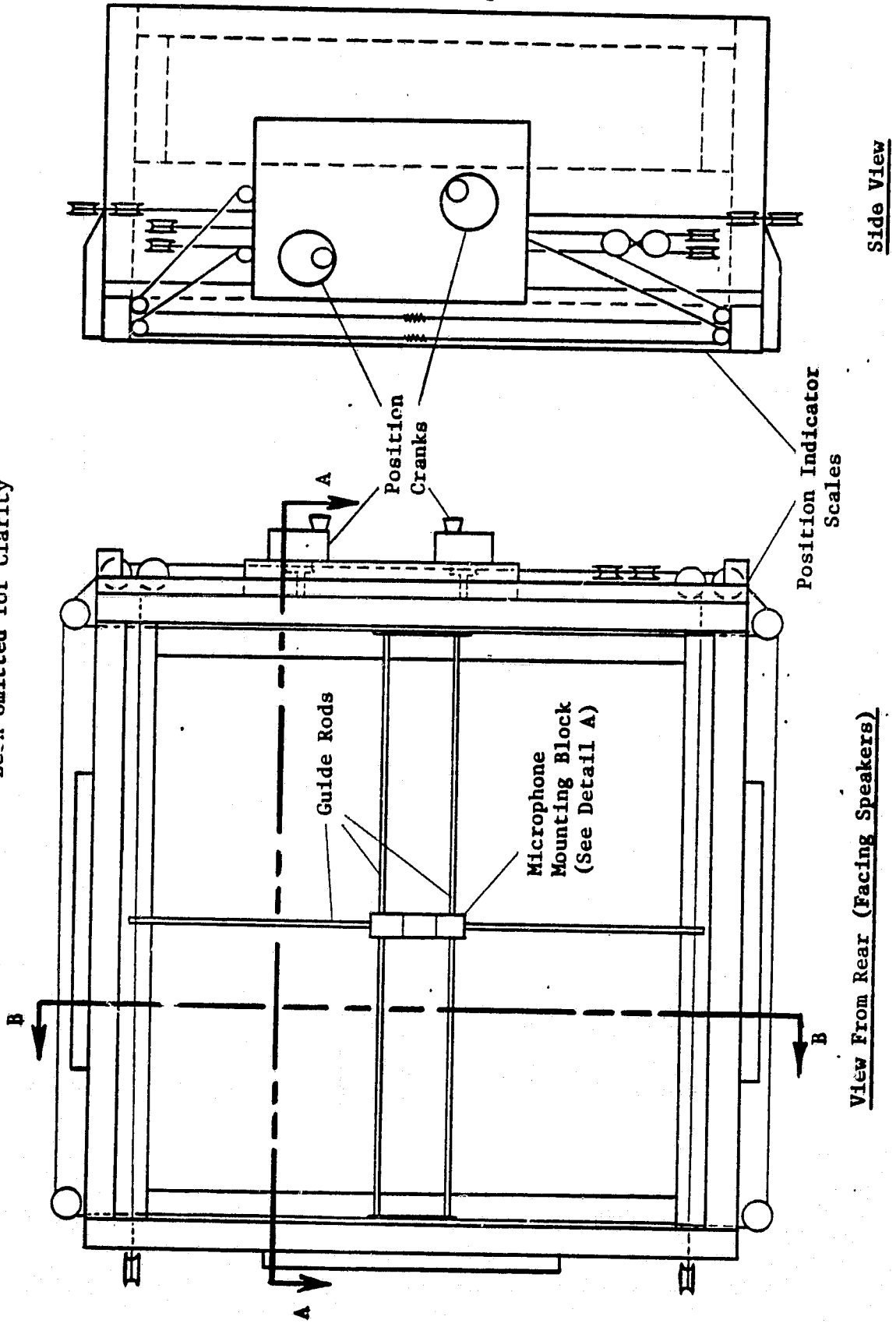
Figure 3.2: Description of Microphone Positioning Device

Section B-B

Mike Mounting Block
(See Detail A)

MPD/Beranek Tube
Mounting Flanges

Guide Trolley

Guide Rods

Microphone Clamps

Microphones

Mounting Beam

Position Indicator Scales

Guide Trolley

Section A-A

Position Crank

Lucite Mounting Block

Guide Rods

Detail A
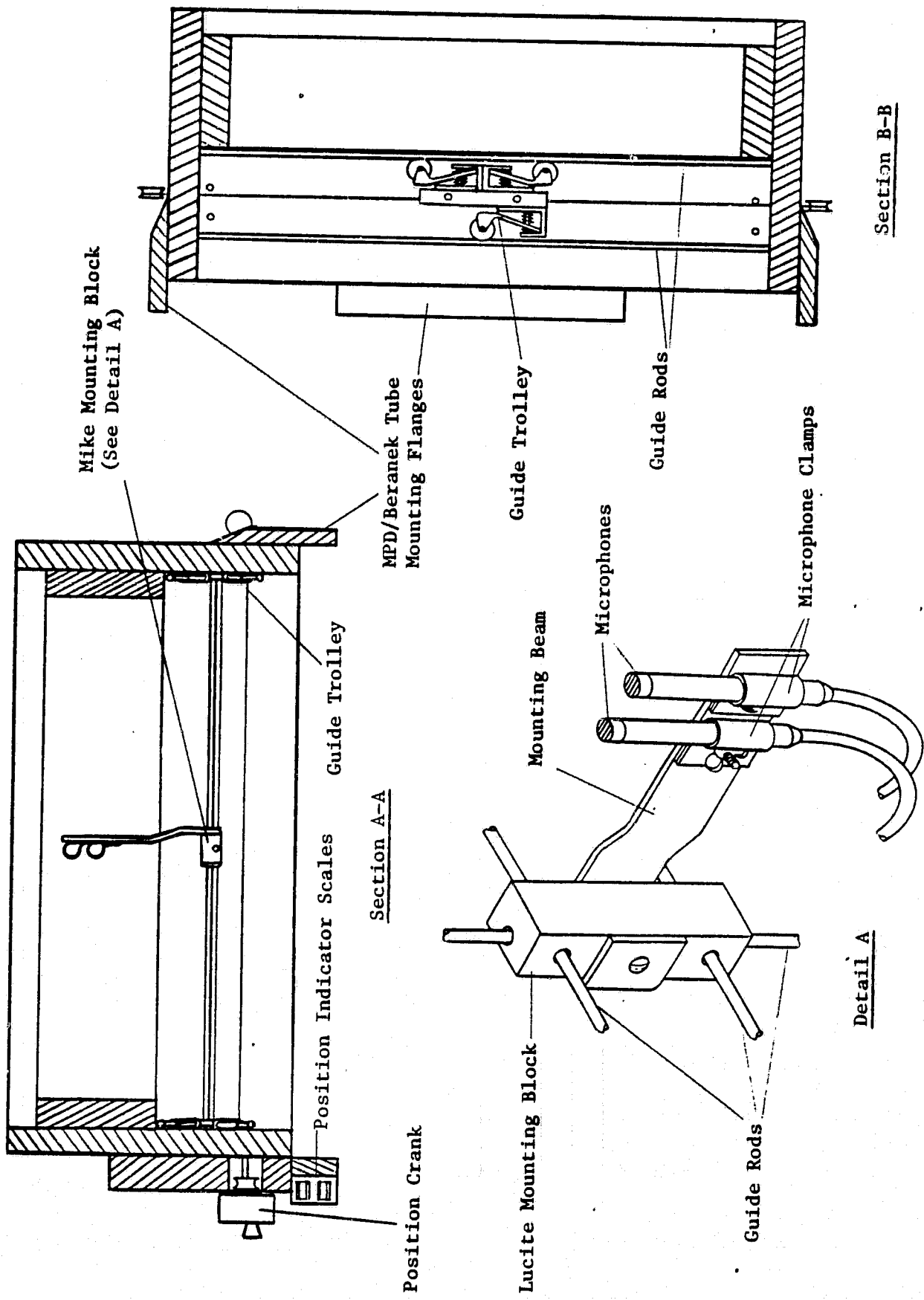
Figure 3.2:   (continued)

The guide rods in the MPD are controlled externally by a cable
and manual crank system. Position information is displayed on scales
by a secondary cable system driven off the cranks.

The MPD operates smoothly and positions the microphones with
reasonable accuracy. However, due to interference of the microphone
cables with the bottom of the MPD at low positions, it is not possible
to cover the entire 16 inch by 16 inch sweep area. The solution to
this problem is to turn the microphones face down when they are
positioned near the bottom of the MPD. This, however, requires that
the Beranek tube be opened midway through a test. While this is not
a significant problem, it increased testing time.

3.2 SOFTWARE DEVELOPMENT

Because of the large amount of data that will have to be processed,
using this method, the computer program had to be split into many
subparts before it could be handled by the Z-100 computer. Depending
upon the ease of programming and the amount of calculations involved,
either Fortran or Basic language was chosen to write these programs.
The Flow diagram shown in Figure 3.3 describes the steps involved. The
individual steps and the relevant equations are described in subsequent
sections.

3.2.1 Magnitude Calibration

A B&K "Pistonphone" is used to calibrate the microphones. Because
the 660B outputs unscaled values, the actual output from calibration

```
                    ┌──────────────┐
                    │    START     │
                    └──────┬───────┘
                           │
          ┌────────────────┴────────────────────┐
          │      MAGNITUDE CALIBRATION           │
          │  TRANSFER PROGRAM:  PSP660           │
          │  ANALYSIS PROGRAM:  MAGCAL           │
          └──────────────────┬──────────────────┘
                             │
        ┌────────────────────┴──────────────────────────┐
        │                                                │
┌───────┴───────────────────┐            ┌───────────────┴─────────────┐
│     PHASE CALIBRATION      │            │      PHASE CALIBRATION       │
│ DETERMINATION: TRUE VALUES │            │  TRANSFER PROGRAM:  INT660   │
│ TRANSFER PROGRAM:  TFN660  │            │  ANALYSIS PROGRAM:  INTCAL   │
│ ANALYSIS PROGRAM: STAT.BAS │            └──────────────┬──────────────┘
└───────────┬────────────────┘                           │
            │                                             │
┌───────────┴────────────────┐                           │
│     DAILY CALIBRATION       │                          │
│ TRANSFER PROGRAM:  TFN660   │                          │
│ ANALYSIS PROGRAM:  CALII    │                          │
└───────────┬─────────────────┘                          │
            └────────────────────┬────────────────────────┘
                                 │
                 ┌───────────────┴────────────────┐
                 │     INTENSITY MEASUREMENT        │
                 │  TRANSFER PROGRAM:  INT660       │
                 │  ANALYSIS PROGRAM:  INTSTY       │
                 └───────────────┬────────────────┘
                                 │
        ┌────────────────────────┴────────────────────┐
        │                                              │
┌───────┴───────────────┐                ┌─────────────┴────────────────┐
│   TRANSMISSION LOSS    │                │       INTENSITY MAP           │
│ TRANSFER PROGRAM:  CPS │                │ ANALYSIS PROGRAM:  INTVAL     │
└───────────┬───────────┘                │ TRANSFER PROGRAM:  CPS        │
            │                            └─────────────┬────────────────┘
┌───────────┴───────────┐                              │
│         PLOT          │                 ┌────────────┴───────────┐
│  PROGRAM:  ZPLOT      │                 │       ANALYSIS          │
└───────────┬───────────┘                │  PROGRAM:  INTMAP       │
            │                            └────────────┬───────────┘
┌───────────┴───────────┐                             │
│         END           │                ┌────────────┴───────────┐
└───────────────────────┘                │        PLOT             │
                                         │  PROGRAM:  MAPPLT       │
                                         └────────────┬───────────┘
                                                      │
                                         ┌────────────┴───────────┐
                                         │         END            │
                                         └────────────────────────┘
```
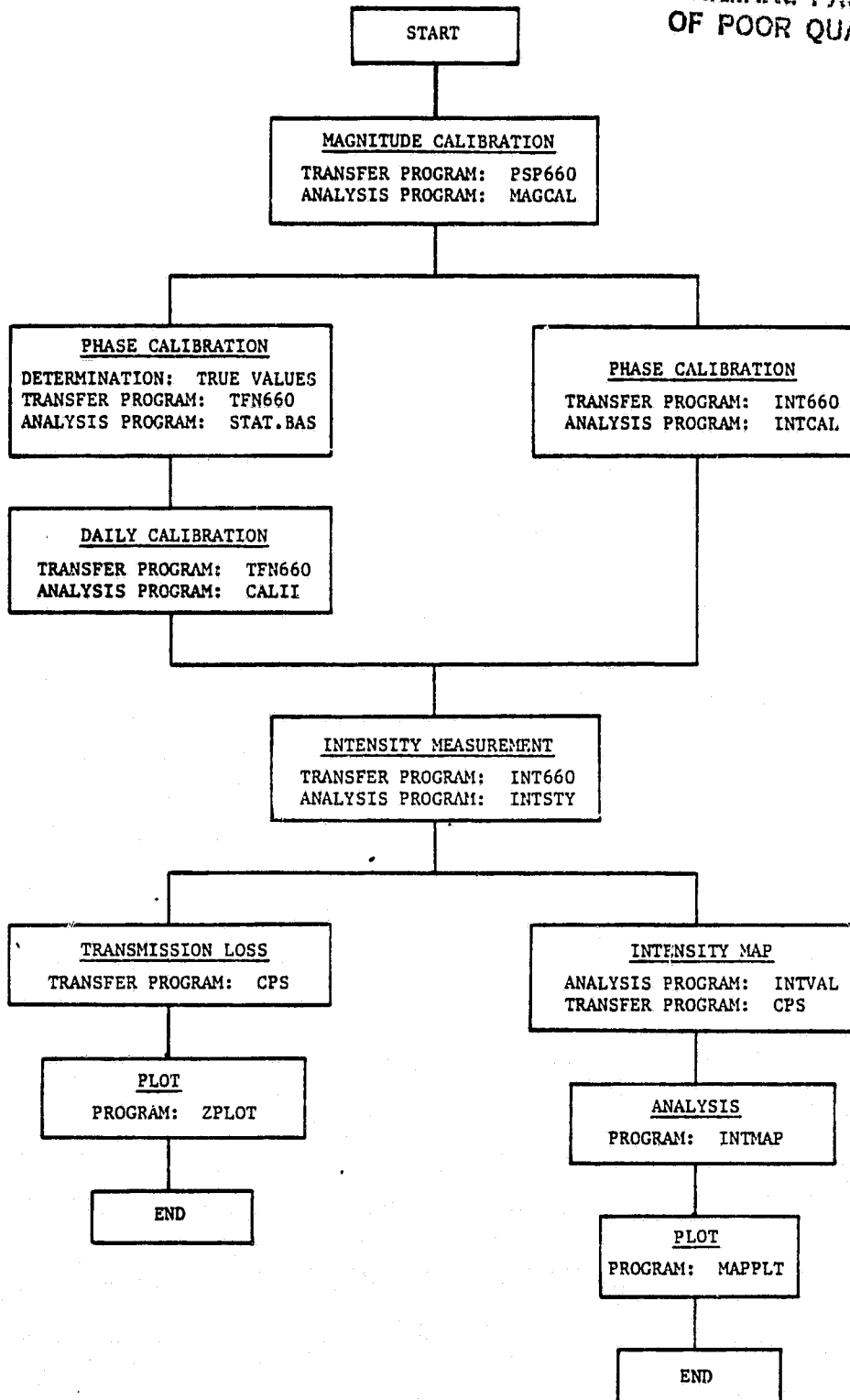
Figure 3.3: Test and Analysis Flow Diagram

tests is a function not only of the pressure but also of the input max amplitude setting and number of ensemble averages. In converting the output of the 660B to the actual BNC input volt level and then to pressure, these two additional variables will have to be considered. The B&K 4220 Pistonphone outputs calibrated sound pressure level 124 dB re 20 micro pascals at 250 hz. Hence,

$$20 \ \log(\frac{P_{cal}}{P_{ref}}) = 124 \ dB$$

$$P_{cal} = 10^{(\frac{124}{20})} P_{ref} \qquad (3.1),$$

where P_{cal} = pressure corresponding to pressure level of 124 dB

P_{ref} = reference pressure (20 micro pascals).

At a given input channel maximum amplitude setting and for a given number of ensemble average, at any cell location of 660B, the pressure (p_i) will be proportional to the value output by the 660B (v_i).

$$p_i \propto v_i$$

or

$$p_i = Kv_i \qquad (3.2),$$

where K is the calibration constant. The Pistonphone outputs 125 dB sound level at 250 hz. There is a small tolerance about 250 hz. Also, spectral leakage always exists in digital signal processing. Whenever the energy is concentrated at a discrete frequency which is in between two adjacent cell (filter) locations, the energy is smeared across the neighboring cells. See Reference 9 for discussion on spectral leakage. In order to minimize the effect of spectral leakage during calibration, the power-spectral values of three adjacent cells

on either side are summed to obtain the total energy. The calibrated
pressure can be equated to

$$\sum_{i=i_0-3}^{i_0+3} p_i^2 = K\sum v_i^2 \tag{3.3}$$

$$p_{cal}^2 = K\sum_{i=i_0-3}^{i_0+3} v_i^2 \tag{3.4},$$

where i_0 is the filter location corresponding to 250 h_z, and v_i is
the value output by the 660B at a given maximum amplitude setting
and for a given number of ensemble averages, the calibration constant
K can be calculated. This needs to be done for both channels. The
functional relationship between the output and the ensemble averages
and the maximum amplitude setting is given in Reference 10. Based
on these relationships, the relationship between the true value and
the value output from the analyzer 660B during any one test was
derived as follows.

RMS spectrum of channel A:

$$TV = K_A \cdot V_t \cdot \frac{A_t}{A_c} \cdot \sqrt{N_c/N_t} \tag{3.5};$$

Power spectrum of channel A:

$$TV \cdot K_A \cdot V_t \cdot (\frac{A_t}{A_c})^2 \cdot \frac{N_c}{N_t} \tag{3.6};$$

Cross spectrum:

$$TV = K_A K_B V_t \frac{(A_{A,t} \cdot A_{B,t})}{(A_{A,c} \cdot A_{B,c})} \cdot \frac{N_c}{N_t} \tag{3.7};$$

where TV = true value,

  V = value output,

  A = maximum input amplitude setting,

  N = number of ensemble averages,

  K = calibration constants defined in Equation (3.3),

and the subscripts t, c, A and B correspond to test, calibration,
channel A and channel B, respectively. These relationships were
confirmed by experimentation. They are used in obtaining calibration
constants. The actual test and analysis procedure developed, based
on the above equations, is described in Appendix A. The listings of
programs PSP660 and MAGCAL, used for the determination of magnitude
calibration constants, are given in Appendix B. The output from these
programs are stored in a file named CALDAT.DAT. It stores calibration
factor, number of averages, and maximum amplitude setting for both
channels. This file is accessed by other routines to convert the test
values into true values.

3.2.2 Phase Calibration

As described in Chapter 2, two different calibration techniques
are used at the KU-FRL acoustic test facility. Method 1 calculates
the phase angle difference between the two microphone channels when
both the microphones are exposed to the same field. Method 2 uses the
modified transfer function method described in Chapter 2.

3.2.2.1 Method 1

In this method both the microphones are exposed to the same field, and any difference in the phase angle me ⁓ired is due to the difference in the channels. Subsequent tests can then be corrected for this difference in phase angle. Figure 3.4 shows the schematic diagram for the microphone phase calibration system. In this method, the two microphones are inserted into a long tube with faces of the microphone parallel. A random noise is generated at the other end. Hence both the microphones are exposed to the same sound field. Only the cavity resonance effects affect the actual sound field incident at the microphone. By the tube diameter of two inches, the fundamental circumferential resonance frequency is made to occur at a frequency greater than 5000 hz, which is the maximum frequency of interest. Thus the effect of circumferential resonance frequency is avoided. The effect of longitudinal resonance frequency could not be eliminated fully, but it is minimized by having absorptive fiberglass materials on the ends of the calibration tube.

During the initial determination of the phase angles, it was noticed that a certain amount of scatter was unavoidable in the phase angle differences measured. Since this scatter may affect the results during daily calibration, a statistical approach was taken to minimize the effects of this scatter. It was decided to perform tests many times to cover the entire range of parameters that cannot be controlled exactly during any test. These parameters involve the humidity, temperature, amount of time the calibration speaker has been on, etc.

Two 1/2" Microphones (4165)
with Preamplifiers (2619)

Calibration Tube

Speaker

Nicolet 660B
Fourier
Analyzer

White
Noise

Equalizer

Amplifier
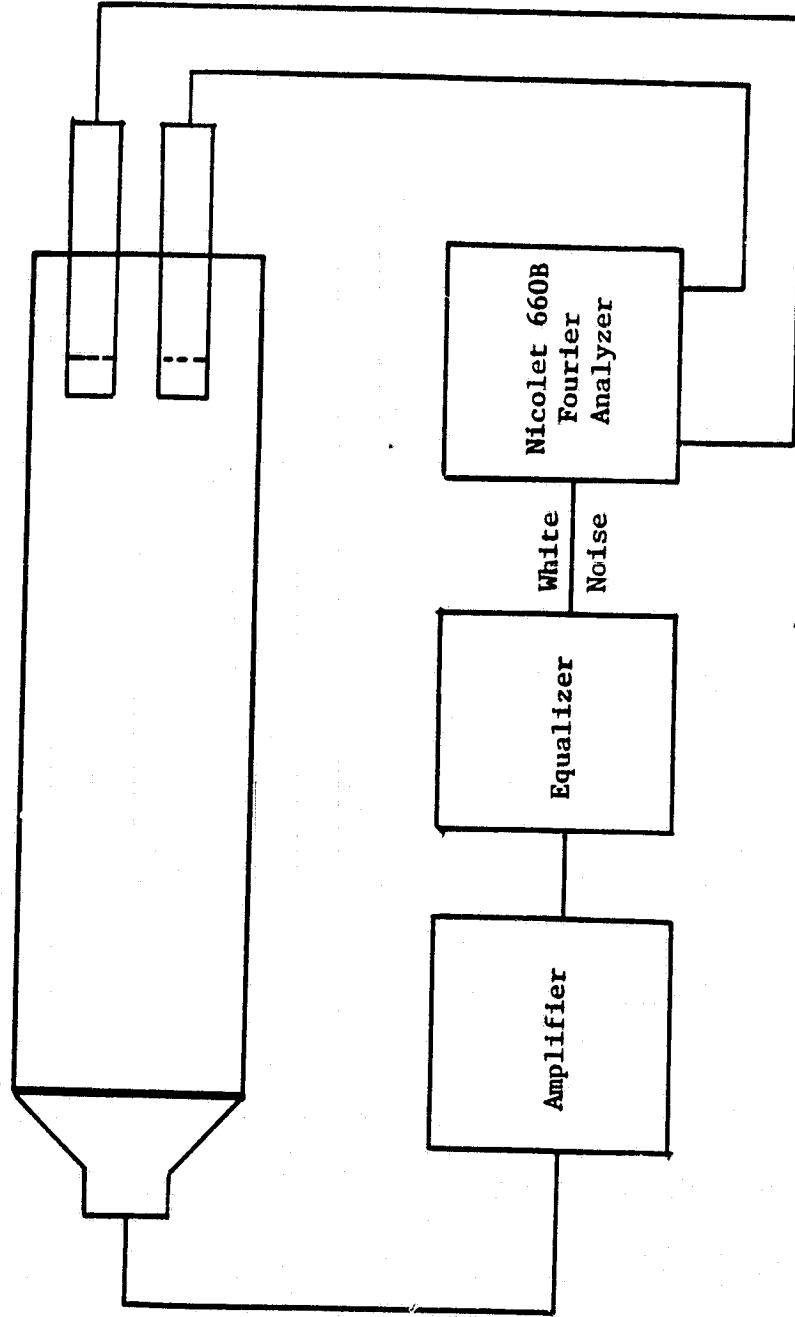
Figure 3.4:   General Arrangement of Microphone Phase Calibration Set-Up

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Thirty tests were conducted to cover the range of variables. A mean of the results of these thirty tests can be considered to be a good estimate of the mean of the population of all possible phase angle measurements (see Reference 11). However, thirty calibration tests every day to cover all possible random combinations is not practicable. Hence it was decided to use significance testing to obtain acceptable calibration values. In this procedure, the population mean and standard deviation are first determined only once. Thereafter, only a small number of tests need to be done every day. The mean values of these tests are compared with the population mean values, and the significance tests are used to accept or reject the new values.

An estimate of population mean can be obtained by taking a mean of a large number of tests. If the number of samples is greater than thirty, it can be assumed that the mean and the standard deviation of the sample are equal to the mean and the standard deviation of the population (Reference 11). Hence, thirty tests that are conducted in the beginning of a test series can be assumed to be a very good estimate of the population mean and the standard deviation. Daily calibration values are then compared with these values for acceptability.

Acceptability or rejection of a test sample (in this case daily calibration results) is based on the significance testing. The aim is to minimize both type I and type II errors. A type I error is committed if the null hypothesis is rejected when it is true. A type II error is committed if the null hypothesis is accepted when it is not true. In this case, the null hypothesis will be that the sample mean (x) is equal to the population mean (μ_0); i.e.,

$$HO: \quad x = \mu_0 \qquad \text{(both means are the same)} \qquad (3.8).$$

The alternate hypothesis is given by

$$H1: \quad x \neq \mu_0 \qquad \text{(che mean of the sample is not equal to the population mean)} \qquad (3.9).$$

The test statistic is given by

$$z_0 = \frac{x - \mu_0}{\sigma/\sqrt{n_2}} \qquad (3.10),$$

where n_2 is the number of averages of the test sample (during daily calibration) and σ is the standard deviation.

	HO is true	HO is false
Accept HO	Correct decision	Type II error
Reject HO	Type I error	Correct decision

Specifically in this case, while committing type I error can be tolerated, committing type II error should be avoided. The probability of committing type II is denoted by "β." The probability of committing type I error is denoted by α. This is also known as the level of significance. When the alternate hypothesis is nonspecific, as in this case, it is not possible to compute the probability of computing type II error (Reference 11). However, with higher sample size, both α and β can be reduced. Reference 11 also gives the following equation for the two-tailed test to obtain the power $(1 - \beta)$ for a specified alternative as

$$n_2 \approx \frac{(z_{\alpha/2} + z_\beta)^2 \sigma^2}{\delta^2} \qquad (3.11),$$

where n_2 is the number of observations required, σ is the standard deviation, and δ is the difference between the sample mean and the

population mean. For .05 level of significance (α), $z_{\alpha/2}$ is 1.96 for normal distribution, and for .05 probability of computing type II error (β), $z_k \approx 1.645$. Using Equation (3.11) as a guide and by trial and error, n = 5 was observed to be adequate for our calculations.

These equations have been modelled into the computer program. At the beginning of a series of tests, the calibration is performed 30 times, varying the uncontrollable parameters (such as temperature, humidity, etc.) as much as possible. Then a basic program, STAT.BAS, is run. These tests are performed once for low frequency range and again for high frequency range. The outputs (the population mean and the confidence interval at 95% confidence level) are stored into two files. For t distribution, the standard deviation (σ) and confidence interval (c) are related at 95% confidence level by

$$\sigma = \frac{c * \sqrt{n_1}}{2.02} \tag{3.11},$$

where n_1 is the number of tests.

During the day of the tests, calibration is done only five times. The analysis program, CALII.EAE, is run to perform the significance tests. During the running of this test, the operator will be asked whether to accept or reject the calibration if the z statistic (Equation 3.10) exceeds 1.96. At this z statistic, the level of significance is 5% and the power is about 95%. Very high values of z statistic should be rejected and the calibration redone. This has to be done for both frequency ranges. The output file from this program is called CALII.DLO, or CALII.DHI. These files contain the cosine and sine of the phase angle correction at each filler. These files are accessed by other routines to correct for phase angles.

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3.2.2.2 Method 2

The second method for phase correction uses the modified microphone switching technique described in Section 2.4.4. Equation (2.39) is used to obtain the correction. In this method, the tests are done only at the beginning of a test. First, the microphones are clamped in normal location in the MPD and the cross spectrum is measured. Then the microphones are switched and the switched cross spectrum is measured. From these two cross spectra, the phase angle correction as a function of frequency is obtained using Equation 2.39. The test procedure is described in Appendix A; and the listing of the program INTCAL, which performs the calculations, is given in Appendix B.

3.2.3 Intensity Tests

The test procedure for measuring acoustic intensity values at the KU-FRL acoustic test facility is given in Appendix A. The intensity is calculated from the measured cross-spectral values by Equation (2.31). The program INTSTY performs this calculation. It also performs relevant magnitude and phase corrections. At present, the intensity values are calculated at 81 grid points on an 18-inch-by-18-inch cross sectional area. These intensity values can be made use of to plot either an intensity map or transmission loss. The relevant programs are identified in Figure 3.3. The listing of programs is given in Appendix B.

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3.2.4 Plotting

At present, no plotter is available for the Z-100 microcomputer.
Hence the plotting is done on a MINC-11 computer with a HP 7225B
plotter. Therefore the data values have to be transferred from the
Z-100 to the MINC-11 computer. This is achieved through modem
communication. The data values are then plotted using plot programs
ZPLOT and PLOT (for transmission loss and intensity maps, respectively).
The listings of these plot programs are given in Appendix B.

CHAPTER 4

TEST RESULTS

This chapter describes the tests conducted to check out the acoustic intensity procedures developed at the KU-FRL acoustic test facility. At the time of preparation of this progress report, this activity has not yet been completed. The tests described in this chapter are in addition to the tests conducted to verify the accuracy of the programs. In all cases, phase corrections were performed.

4.1 SOURCE INTENSITY MAP

One of the important aspects of the plane wave tube is the behavior of the speaker array. It is desirable for all speakers to produce identical outputs with the same phase angle. Also the spectrum produced by the speakers should be flat for a random white noise excitation. During the initial calibration tests of the test facility, it was concluded (Reference 2) that the incident wave can be considered plane only up to 800 Hz. With the acoustic intensity technique, this aspect can be easily verified. To determine the sound field characteristics of the test facility, an acoustic intensity survey was carried out along the cross section of the plane wave tube. The test facility has a cross section of 18 inches by 18 inches. Tests were conducted to measure intensity every two inches, using the procedures outlined in Appendix A. This gave intensity values of 81 grid points. During these tests, the gain values at the frequency ranges of the equalizer were set to zero.

The results of the tests are plotted in Figure 4.1 and 4.2, for 300 Hz and 1000 Hz, respectively. The results are also available for every 1.25 Hz up to 500 Hz, and for every 12.5 Hz from 500 Hz up to 5000 Hz. The software programs developed seem to work well for the type of analysis being done. From the tests, it was found that the number of grid points needs to be increased at high frequencies to obtain a good quality intensity map.

From Figure 4.1, it can be seen that two speakers (#2 and #6) are producing less power (10 dB lower than the other speakers). This phenomenon was seen at frequencies from 250 to 4000 Hz. Thereafter, these speakers behaved normally. But for these two areas, the result was reasonably flat. At 1000 Hz, the variations were much more severe. This could be due to the cavity resonances present in the test facility. In general, the intensity was higher around the edges than at the center. The reason for this is not fully understood. However, based on this test, it is concluded that the KU-FRL acoustic test facility cannot be considered a plane wave facility above 1000 Hz.

4.2 INTENSITY MAP WITH ALUMINUM PANEL

At the KU-FRL test facility, a 0.032" aluminum panel is used as the standard panel. The transmission loss (or noise reduction) values obtained with this panel are used for calibration. To determine the acoustic intensity characteristics of this panel, an intensity survey was carried out at the same 81 grid points as before, this time with the 0.032" aluminum panel installed between the source and the

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SOURCE INTENSITY MAP
KU-FRL TEST #001
FREQUENCY = 300 HZ
DATE: 12-5-83

□ = 65 DB
△ = 70 DB
▽ = 75 DB
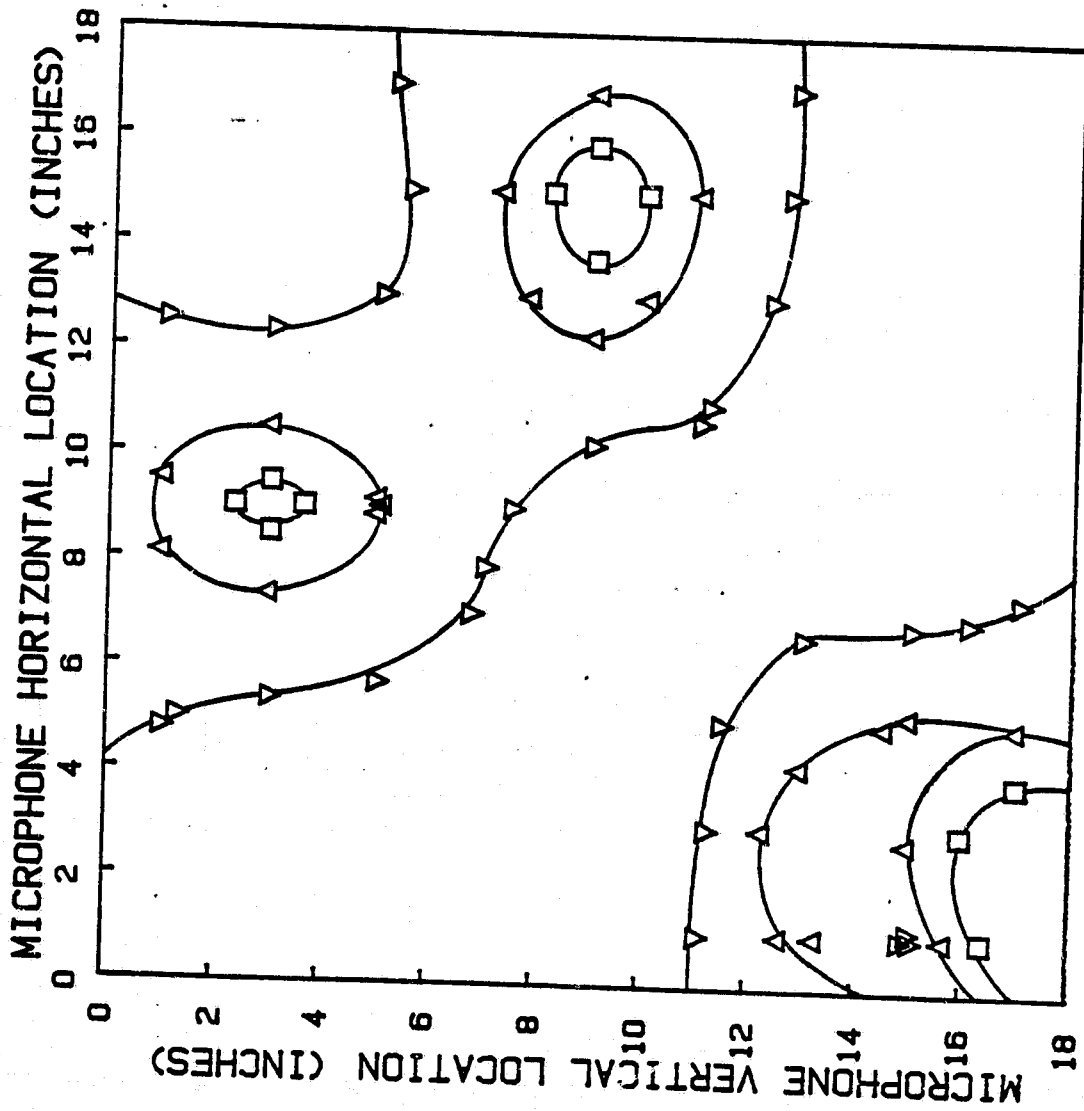
Figure 4.1: Source Intensity Map at 300 Hz

SOURCE INTENSITY MAP
KU-FRL TEST #100
FREQUENCY = 1000 HZ
DATE: 12-5-83

□ = 50 DB
△ = 55 DB
▽ = 60 DB
○ = 65 DB
◇ = 70 DB
▽ = 75 DB
○ = 80 DB
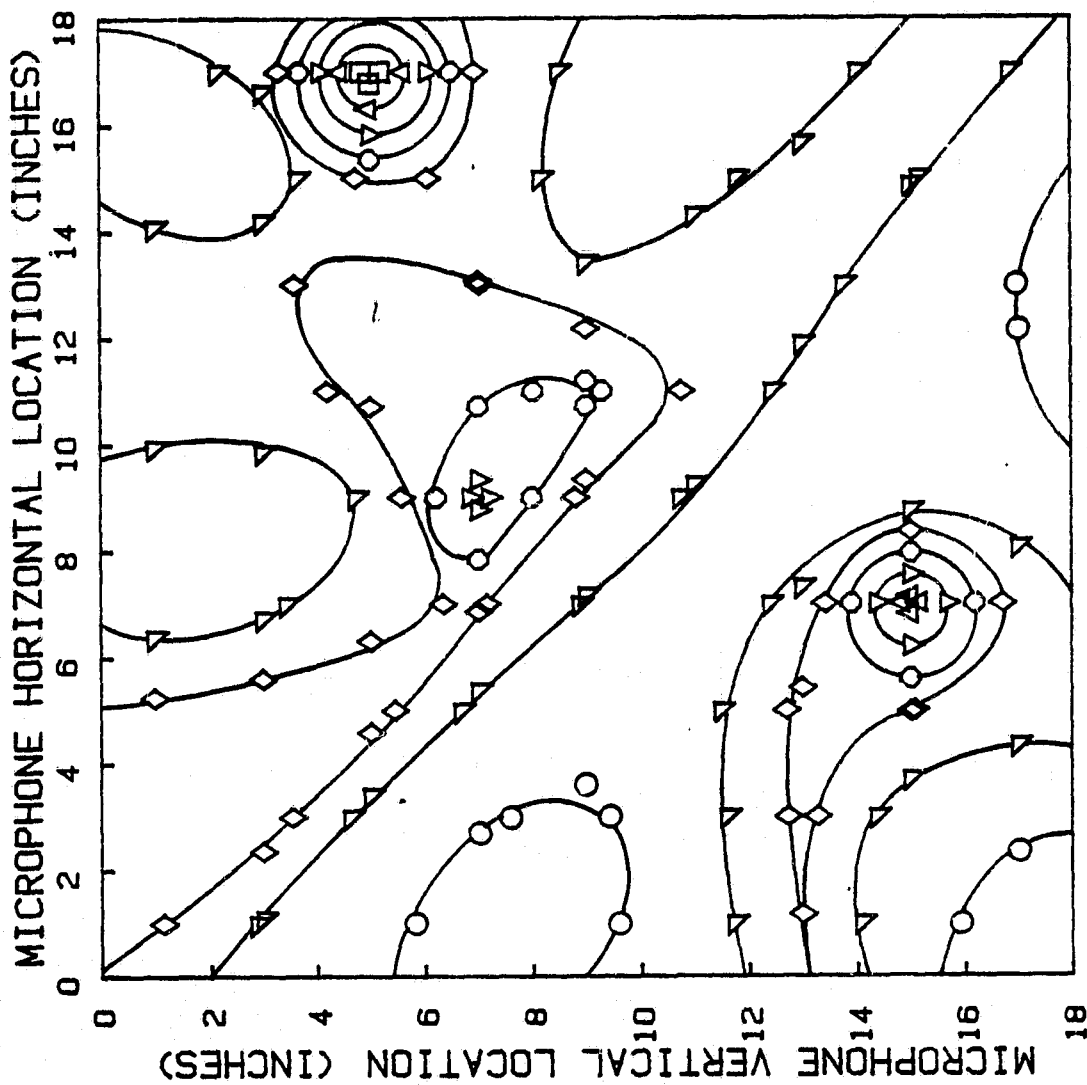
Figure 4.2: Source Intensity Map at 1000 Hz

MICROPHONE HORIZONTAL LOCATION (INCHES)

MICROPHONE VERTICAL LOCATION (INCHES)

microphones. Figures 4.3 and 4.4 show the results at 300 Hz and 1000 Hz, respectively. At 300 Hz, the intensity variation was within 10 dB at all points. At 1000 Hz, while the maximum variation was only 20 dB, the actual intensity value was 40 dB. It is anticipated that this low value of transmitted intensity may pose problems in accurate estimation of the intensity, especially if the panel exhibits higher transmission loss characteristics. This aspect was expected. At higher frequencies, the transmission loss will be higher because of the mass law. Several methods are being studied to overcome this problem. They are installation of amplifier in the measurement channel, increasing the input signal strength, and finally filtering away the low frequency in the excitation signal using high-pass filters and then amplifying the signal. The third method will involve performing each test twice: once at low frequency, say up to 500 Hz; and the second time, from 500 Hz to 5000 Hz. This was how the tests were being done with the old measurement procedures.

4.3 TRANSMISSION LOSS OF PANELS

To compare the values of the measured transmission loss values obtained using this procedure with theoretical values, two panel were tested: a 0.032" aluminum panel and 40 oz/sq yd leaded vinyl. These specimens were tested at the KU-FRL acoustic test facility using the test procedures outlined in Appendix A. The resulting transmission loss characteristics are compared with the mass law. The behavior of the test panels is illustrated in Figures 4.5 and 4.6.

Figure 4.3: Intensity Map with 0.032" Aluminum Panel at 300 Hz

RECEIVER INTENSITY MAP
KU-FRL TEST #002
0.032" 2024-T3 ALUMINUM PANEL
PANEL WEIGHT: 1.53 LB
FREQUENCY = 1000 HZ
DATE: 12-5-83

□ = 40 DB
△ = 45 DB
▽ = 50 DB
○ = 55 DB
◇ = 60 DB
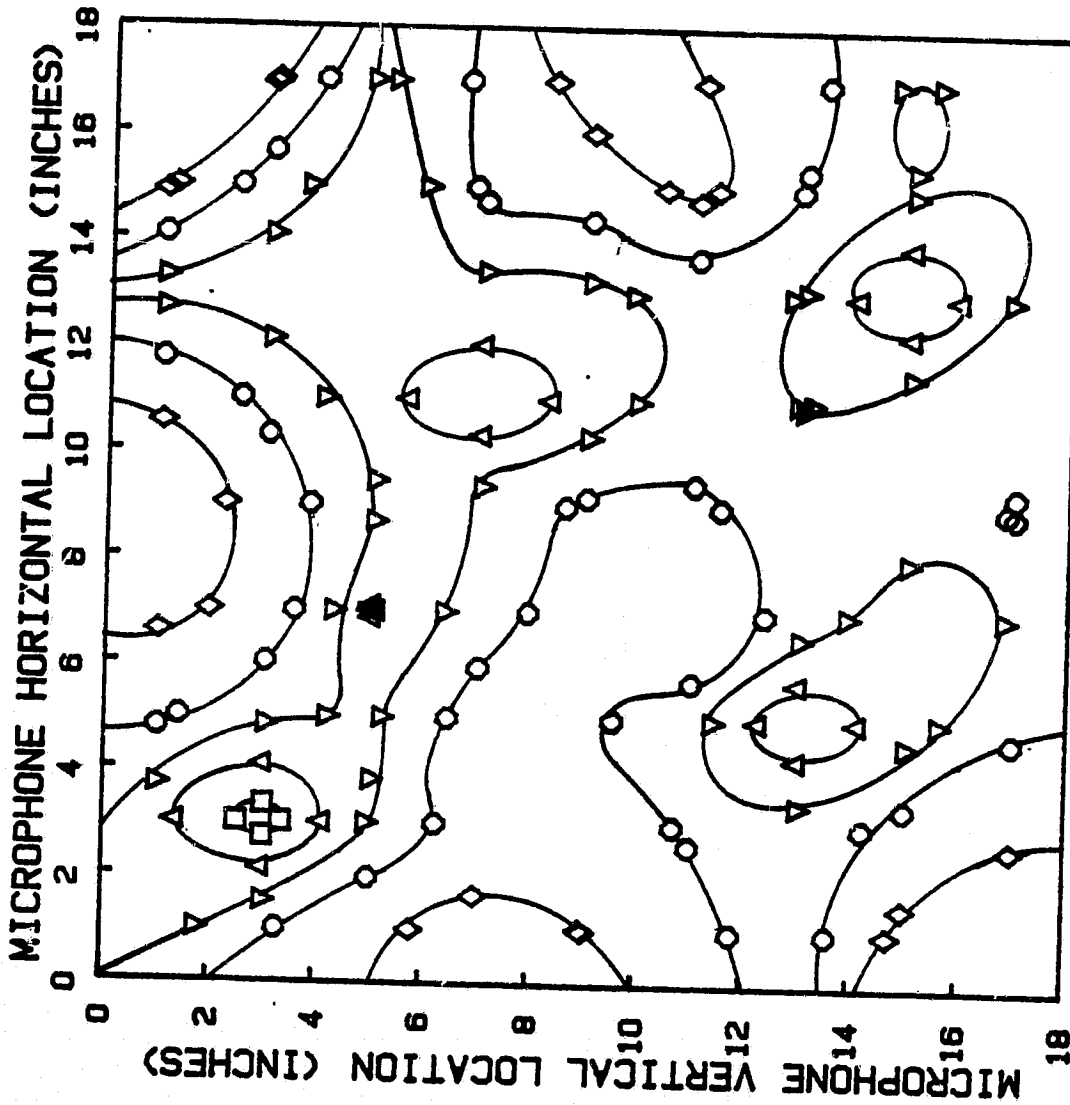
Figure 4.4: Intensity Map with 0.032" Aluminum Panel at 1000 Hz
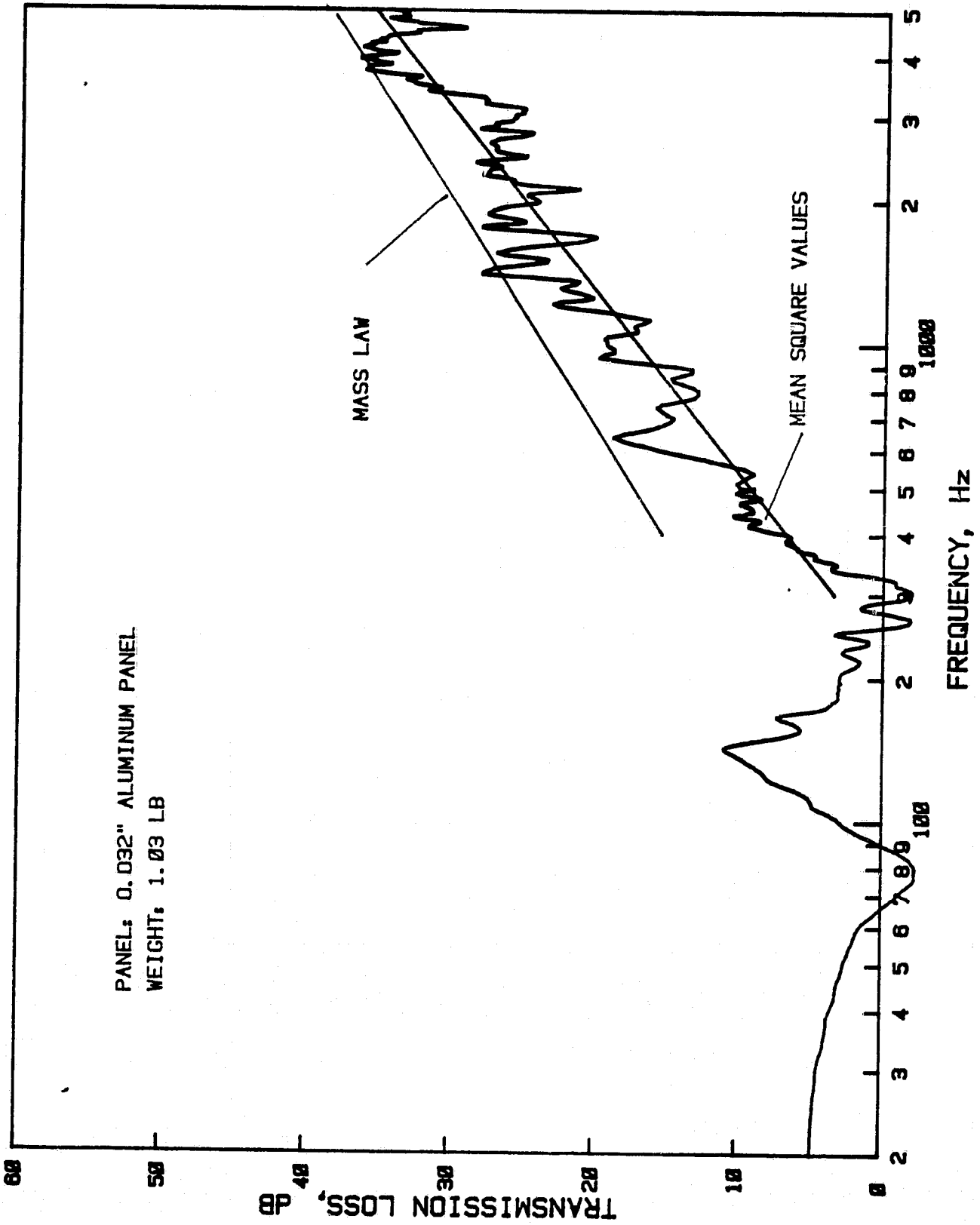
Figure 4.5: Transmission Loss Characteristics of 0.032" Aluminum Panel
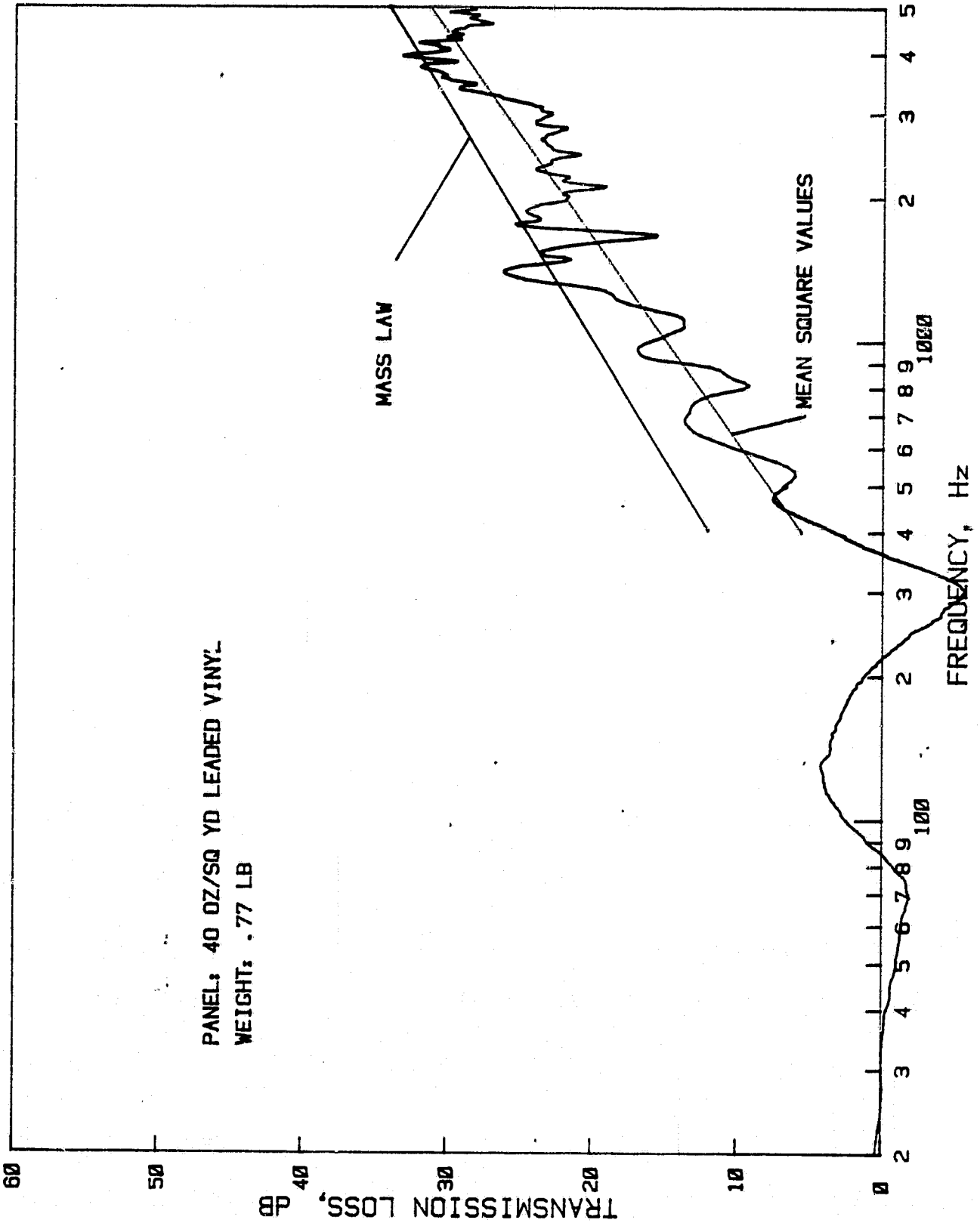
Figure 4.6: Transmission Loss Characteristics of 40 oz/sq yd Leaded Vinyl

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The transmission loss (TL) curve for a particular panel is obtained in the following manner. An intensity level survey is conducted without any panel. The intensity level is integrated over the entire panel area, and the incident sound power level is estimated. Then the tests are repeated with the panel installed between the source and the microphones, and the transmitted sound power level is estimated. The difference in sound power level between these two measurements will give the transmission loss. This test procedure is similar to the measurement of insertion loss. However, because the intensity is measured close to the source and the panel is thin, the difference between this procedure and the two-room transmission loss measurement method is expected to be small. This procedure had to be adopted because the measurement of incident intensity alone on the source side is not possible with this technique. The reflected intensity from the test specimen will affect the intensity being measured. This problem existed even in the old procedure. However, no correction was made for this; and the resulting measurements were termed noise reduction (and not transmission loss).

Mass law values are also plotted in Figures 4.5 and 4.6. The mean square transmission loss measured in each case is approximately 2 to 5 dB lower at 5000 Hz. The integration of the several intensity values for both with and without panels, used in this procedure, is expected to yeidl an average transmission loss value. This is in comparison to the use of just one microphone situated close to both source and receiving side, which will result in position-dependent transmission loss values. Hence a difference between the two

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measurements was anticipated. The results with the old test procedure gave up to 6 dB higher noise reduction than the calculated noise reduction values. Hence, one-to-one comparison between the present procedure and the old single-microphone procedure is not considered valid.

In addition to the lower-than-mass-law values observed at 5000 Hz, another aspect that will have to be studied is the near-zero transmission loss observed around 300 Hz. The reasons for this are not fully understood and are currently being investigated. The tests will be performed after modifications have been made to the MPD and the receiver cavity. These modifications include filling up the cavities with loose foam, moving wire gauze closer to the MPD, and installation of the microphone in the MPD in such a way as to reduce the reflections from the support rod. Also, increasing the signal strength at high frequencies is expected to increase the dynamic range of measurements.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

In this report, the development of a method to measure the transmission loss characteristics of panels using the acoustic intensity technique is presented. This report also describes the theoretical formulation, installation of the hardware, modifications to the test facility, and development of computer programs and test procedures. Initial test results are also presented. Based on the tests conducted so far, the following conclusions have been reached.

- The acoustic intensity technique can be adapted to measure the transmission loss characteristics of panels. Use of this method will give average transmission loss values as opposed to the position-dependent values obtained from single-microphone measurements.

- The same technique and installation can also be used to plot the intensity maps of vibrating panels. Use of the microphone-positioning device greatly simplifies correct grid positioning.

- The acoustic intensity programs can easily be written on a microcomputer. (Total cost of the microcomputer is less than $2500.)

- The initial results indicate that transmission loss values measured using this method are lower than theoretically predicted values.

- This facility cannot be considered a plane wave facility at high frequencies above 800 Hz.

Based on the experience gained so far in using this technique, the following recommendations are made:

- The computer programs should be optimized to lessen the test time and the memory storage requirements. This may require programming in assembly language or in higher level languages like "C."

- The test facility should be modified to eliminate possible reflections from the microphone holding device.

- The test procedure should be modified to increase the dynamic range at high frequency. This can be achieved by performing the tests twice, once at low frequency ($\sim$500 Hz) and the second time at high frequency ($\sim$5000 Hz). During the high frequency testing, the low frequency component should be eliminated by filtering.

- At present, no spatial averaging is possible. The microphone positioning device can easily be modified to have spatial averaging.

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APPENDIX A

ACOUSTIC INTENSITY TEST OPERATOR'S MANUAL

A.1 INTRODUCTION

In this appendix the procedures for performing an acoustic intensity test are presented. All pertinent data are included for calibrating equipment, performing a test, and reducing the resulting data. However, at the time of this writing, the testing procedures are still being developed, and the following is not expected to be the final procedure. This manual will be updated as testing procedures are refined.

The sections presented below are arranged in the order in which they have to be performed, although not all the sections will be required for every test. (For instance, the "infrequent" phase calibration tests are only required when daily calibrations using method #I do not agree with previous infrequent calibration test results.) The manual presents the procedures in a checklist format and does not dwell on why certain steps are required, as this would require an intimate knowledge of the system (which at this time is not fully developed). The manual is intended to serve as a quick reference guide during testing.

A.2 INFREQUENT MICROPHONE PHASE CALIBRATION PROCEDURE

This section describes the procedures for performing an "infrequent" calibration test of the intensity test set-up for purposes of statistical assurance. That is, the daily calibration tests are compared to the results of an infrequent calibration test to determine the statistical

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validity of the daily calibrations. To do this, a large, random sample
of calibration tests is required to estimate the calibration values of
the population. The sample size required by the STAT.BAS statistics
program is thirty tests. It is therefore necessary to generate thirty
calibration tests as described below.

1.   Connect the 2-inch calibration speaker to the metal calibration
     test tube with masking tape.

2.   Remove the red speaker wires (2) from the speaker panel and
     attach them to the black wires on the 2-inch speaker.

3.   Insert microphone #1 into slot #1 in the wooden microphone
     support block, and microphone #2 into slot #2 in the block.

4.   Insert microphone #1 into slot #1 in the Plexiglas microphone
     support ring, and microphone #2 into slot #2 in the ring.

5.   Insert the Plexiglas ring into the metal test tube. Line up
     the markings on the ring and the tube, and secure together
     with masking tape.

6.   Attach a cable to the binary noise-out (A) post on the FFT
     analyzer.

7.   Connect the cable from the FFT to the speaker switch cable.

8.   Connect the cable from output 1 on the microphone power supply
     to channel A on the FFT analyzer.

9.   Connect the cable from output 2 on the microphone power supply
     to channel B on the FFT analyzer.

10. Boot the Z-100 with the system/testing disk in drive A, and
     a working disk in B.

11. Turn on the following equipment:

a. 660B,

b. mike power supply,

c. equalizer,

d. amplifier.

Allow equipment to warm up for approximately 10 minutes.

12. While the system is warming up, do the following:

a. On Z-100:

   1) Type ZBASIC <ret>,

   2) Press F3 and when 'LOAD"' appears, type CAL660 <ret>,

   3) When 'OK' appears on the screen, type RUN <ret>.

   The computer will then ask for a file name. Don't answer

   this question yet.

b. On 660B: Make sure that the following lights are on.

   1) mode: Dual 1K,

   2) function: TF,

   3) average: SUM,

   4) display: XPROP, φMAG,

   5) capture control: CONT,

   6) amplitude units: V/ABS,

   7) scales: AMPL-LOG.

13. Set the number of averages using the following sequence:

a. 1-2-8,

b. SET/STORE,

c. AVGN.

Check to see if 128 AVGN appears on the screen of the 660B.

If it does, press CLEAR and repeat step 13. You are now ready

to begin testing.

14. On the Z-100, type in the file name in the following format.
Do not hit return.

Denotes Drive B   File Name   Test number (01 to 30)

B:CALPXX.D(LO or HI)

D for Data   HI for High Frequency Calibrations
                                (Up to 5000. Hz)
LO for Low Frequency Calibrations
(Up to 500. Hz)

15. On the 660B:

    a. Set desired frequency range (500 = LO, 5000 = HI).

    b. Turn on the speakers by putting the speaker switch in
the "SO" position. (Note: speakers may be turned off
whenever data are not being taken.)

    c. Adjust the analyzer channel amplitudes to maximum
without overloading.

    d. Press START.

    e. Press RECALL and then AVGN.

    f. When the test is done, the START light will go out.
Turn off the speakers by returning the speaker switch
to OFF.

16. Press RETURN on the Z-100. This will initiate the transfer
of data from the 660B to the Z-100. The transfer is completed
when the Z-100 asks for a new file name.

17. On the 660B, press RCL D so that the function light goes out.

18. Begin the next test by following the steps from step 14 onward.

19. When finished, turn off:

    a. microphone power supply,

    b. amplifier,

  c. equalizer,

  d. 660B.

20. On the Z-100, type E <ret>. They type SYSTEM <ret>.

21. Turn off the Z-100 and its monitor.

22. Remove disks.

23. Disconnect all cables and reconnect the speaker wires to the speaker panel.

A.3 PROCEDURE FOR RUNNING STAT.BAS: A PROGRAM TO REDUCE PHASE CALIBRATION DATA USED FOR STATISTICAL ASSURANCE

This section describes the operation of the statistical analysis program STAT.BAS. This program calculates the sample mean and a confidence interval about the mean of thirty tests. The calculations are done such that the probability of the population mean falling within the confidence interval is 95 percent. The program is designed to operate on data files of arbitrary length up to 403 values (that is, thirty files, each up to 403 values in length).

The following is a description of the preparation required to run STAT.BAS.

Thirty calibration tests are required for both the low frequency (0-500 Hz) and high frequency (0-5000 Hz) tests. All thirty of these tests for either high or low ranges will fit on one disk. File names must be sequential, although it is not necessary to have them arranged in order. File name format must be as described in the previous section.

Program STAT.BAS requires a catalog file containing the names of all the calibration tests. For the low frequency tests, this catalog file is FILCAT.LFR; and it must reside on the same disk as the low frequency calibration tests. For the high frequency tests, the catalog file name is FILCAT.HFR; and it must reside on the high frequency test disk.

FILCAT.LFR and FILCAT.HFR are most easily generated by running simple utility programs called CAT1.BAS and CAT2.BAS. CAT1.BAS generates 30 low frequency file names within the FILCAT.LFR file. These take the form

                    B:CALP01.DLO
                    B:CALP02.DLO
                    B:CALP03.DLO
                         .
                         .
                         .
                    B:CALP30.DLO

Similar file names are generated under FILCAT:HFR for the high frequency tests.

STAT.BAS will open a FILCAT file and read in the calibration file names. STAT.BAS will open each calibration file in turn and read in the data in each file. When finished, the results will be written to a user-defined file in the form

                         .
                         .
                         .
                    1.093   0.023
                    1.110   0.023
                    1.023   0.019
                    0.913   0.006
                         .
                         .
                         .

The first column represents the mean phase difference between the two microphones (mike #1 with respect to mike #2). The second column represents the confidence interval (the interval is the mean +/- confidence interval value). Each row corresponds to a different frequency. For low frequency tests, the difference between two consecutive rows is 1.25 Hz. For the high frequency tests, the difference is 12.5 Hz. Four hundred two (402) values are stored, starting at 0 Hz.

The following is a step-by-step description of how to run STAT.BAS.

1. Boot Z-100 with the system/testing disk in drive A, and the low frequency calibration test disk in B.

2. Type ZBASIC <ret>.

3. When Z-100 responds with 'OK,' type LOAD"CAT1 <ret>.

4. When Z-100 responds with 'OK,' type RUN <ret>.

5. Z-100 will print 30 file names. When it is finished, type NEW <ret>.

6. Replace the disk in drive B with the disk containing the high frequency tests.

7. Type LOAD"CAT2" <ret>.

8. When Z-100 responds with 'OK,' type RUN <ret>.

9. Z-100 will print 30 file names. When it is finished, type NEW <ret>. The FILCAT files have now been created on their respective disks.

10. Type LOAD"STAT" <ret>.

11. When Z-100 responds with 'OK,' type RUN <ret>.

12. Z-100 will ask 'ENTER NAME OF INPUT FILE CATALOG?' Type B:FILCAT.HFR <ret>.

13. Z-100 will ask 'ENTER OUTPUT FILE NAME?'

    Type STATHI.DAT <ret>.

14. Z-100 will ask 'ENTER ANALYSIS RANGE?'

    Type 5000 <ret>.

15. Z-100 will now be busy for approximately 20 minutes. As

    each file is opened, its name will be printed on the monitor.

    When finished, Z-100 will beep three times.

16. When Z-100 is finished, replace the disk in drive B with

    the disk containing the low frequency calibration tests.

    Type RUN <ret>.

17. The answers to the three Z-100 questions asked in steps

    12, 13, and 14 are, respectively,

                   B:FILCAT.LFT

                   STATLO.DAT

                   500.

18. When Z-100 is finished, type SYSTEM <ret>.

19. The high and low frequency statistical data now reside on

    the disk in drive A under the file names STATHI.DAT and

    STATLO.DAT, respectively.

20. Copy files STATHI.DAT and STATLO.DAT to Data Disk #1.

    Do this using the following steps.

    a.   Insert Data Disk #1 in drive B.

    b.   Type STATHI.DAT B:*.* <ret>.

    c.   Type STATLODAT B:*.* <ret> when Z-100 answers with 'A:'.

21. Turn off Z-100 and its monitor.

22. Remove all disks.

A.4 DAILY MICROPHONE PHASE CALIBRATION PROCEDURE: METHOD I

This section describes the procedures for performing a daily calibration test of the two B & K microphones. The procedure should be followed in the order given. Two tests are required: a low frequency test, and a high frequency test. Note that this phase calibration procedure is one of two procedures that may be used.

1. Connect the 2-inch speaker to the test tube with masking tape.

2. Remove the red speaker wires (2) from the speaker panel and attach them to the black wires on the 2-inch speaker.

3. Insert microphone #1 into slot #1 in the wooden microphone support block, and microphone #2 into slot #2 in the block.

4. Insert microphone #1 into slot #1 in the Plexiglas microphone support ring, and microphone #2 into slot #2 in the ring.

5. Insert the Plexiglas ring into the metal test tube. Line up the markings on the Plexiglas ring with those on the tube. Secure the ring and tube together with masking tape.

6. Attach a cable to the binary noise-out (A) post on the FFT analyzer.

7. Connect the cable from the FFT to the speaker switch cable.

8. Connect the cable from output 1 on the microphone power supply to channel A on the FFT analyzer.

9. Connect the cable from output 2 on the microphone power supply to channel B on the FFT analyzer.

10. Boot Z-100 with the system/testing disk in drive A, and Data Disk #1 in drive B.

11. Turn on the following equipment:

    a. 660B,

    b. mike power supply,

    c. equalizer,

    d. amplifier.

    Allow equipment to warm up for approximately 10 minutes.

12. While the system is warming up, do the following:

    a. On Z-100:

        1) Type ZBASIC <ret>,

        2) Press F3 and when 'LOAD"' appears, type CAL660 <ret>.

        3) When 'OK' appears on the screen, type RUN <ret>.

        The computer will then ask for a file name. Don't answer

        this question yet.

    b. On 660B: Make sure that the following lights are on.

        1) mode: Dual 1K,

        2) function: TF,

        3) average: SUM,

        4) display: XPROP, ϕMAG,

        5) capture control: CONT,

        6) amplitude units: V/ABS,

        7) scales: AMPL-LOG.

13. Set the number of averages using the following sequence:

    a. 6-4-0,

    b. SET/STORE,

    c. AVGN.

    Check to see if 640 AVGN appears on the scrreen of the 660B.

If it does not, press CLEAR and repeat step 13. You are now ready to begin testing.

14. On the Z-100: Type in the file name in the following format. Do not hit return.

Denotes Drive B   File Name (Transfer Function Calibration)

B:TFNCAL.D(LO or HI)

D for Data   HI for High Frequency Calibrations
                    (Up to 5000. Hz)
LO for Low Frequency
Calibrations (Up to 500. Hz)

15. On the 660B:

    a.   Set desired frequency range (500 = LO, 5000 = HI).

    b.   Turn on the speakers by putting the speaker switch in the "SO" position. (Note: Speakers may be turned off whenever data are not being taken.)

    c.   Adjust the analyzer channel amplitudes to maximum without overloading.

    d.   Press START.

    e.   Press RECALL and then AVGN.

    f.   When the display reads 128 AVGN, press STOP.

    g.   At this point, disassemble the microphone/block combination and repeat steps 3 to 5.

    h.   After completing 15a to 15g, press CONT on the 660B.

    i.   When the display reads 256 AVGN, press STOP, and repeat 15g to 15h. Do this for 384 AVGN and 512 AVGN also.

    j.   When the test is done, the START light will go out. Turn off the speakers by returning the speaker switch to OFF.

16. Press RETURN on the Z-100. The transfer is completed when the Z-100 asks for a new file name.

17. On the 660B, press RCL D so that the function light goes out.

18. Begin the next test by following the steps from step 14 onward.

19. When finished, turn off:

   a. microphone power supply,

   b. amplifier,

   c. equalizer,

   d. 660B.

20. On the Z-100, type E <ret>. Then type SYSTEM <ret>.

21. Type CALII <ret>. When Z-100 asks for the frequency range, type 500. <ret>.

22. Z-100 will now do a statistical comparison of the phase values determined in the daily calibration with those from the infrequent calibration tests. Whenever a value is found to be outside accepted limits, the Z-100 will give the frequency value and the value of the test statistic. Accept the calibration value with a <ret> if one of the following conditions is satisfied:

   a. Frequency value is less than 60 Hz or greater than 4000 Hz,

   b. The test statistic is close to 2.0 (within, say, five percent),

   c. The test statistic is less than 2.5 for less than five consecutuve frequency values,

   d. The test statistic is considerably greater than 2.0 but is an isolated excursion; that is, a single event, rather than a string of excursions greater than 2.0.

If the test statistic fails, then the calibration will have
to be repeated. If a satisfactory calibration test cannot
be made within three or four trials, then Section
should be redone.

23. If the values are acceptable, repeat steps .1 and 22 but for
frequency value 5000. Hz.

A.5 MICROPHONE CALIBRATION USING SWITCHING TECHNIQUE TEST PROCEDURE CALIBRATION METHOD II

This section describes the procedures for microphone channel
calibration using the switching technique.

1. Place the microphone positioning device (MPD) between the
Beranek tube and the speaker wall.

2. Insert the two microphones through the hole in the top of
the MPD.

3. Clamp the microphones into their respective holders (#2 mike
closest to the speakers) with a one-inch spacing for high
frequency tests, and a four-inch spacing for low frequency
tests. The microphones should be inserted so that they are
upright in their holder.

4. Position the mikes in the upper left hand side (when facing
the speakers) of the MPD, somewhere in the center of the
cross section. The exact location is not important; but
once it is in place, the MPD should not be moved.

5. Place putty into the hole in the MPD around the microphone
cables.

6. Leave the panel space empty. Close the tube and secure the MPD in place with the four "hook" bolts.

7. Attach a cable to the binary noise-out (A) post on the FFT analyzer.

8. Connect the cable from the FFT to the speaker switch cable.

9. Connect the cable from output 1 on the microphone power supply to channel A on the FFT analyzer.

10. Connect the cable from output 2 on the microphone power supply to channel B on the FFT analyzer.

11. Boot Z-100 with the system/testing disk in drive A, and Data Disk #1 in drive B.

12. Turn on the following equipment:

   a. 660B,

   b. mike power supply,

   c. equalizer,

   d. amplifier.

   Allow equipment to warm up for approximately 10 minutes.

13. While the system is warming up, do the following:

   a. On Z-100:

      1) Type ZBASIC <ret>,

      2) Hit F3 and when 'LOAD"' appears, type INT660 <ret>,

      3) When 'OK' appears on the screen, type RUN <ret>,

      4) The computer will then ask for a file name. Do not answer this question yet.

   b. On 660B: Make sure that the following lights are on.

1) mode: DUAL 1K,

2) function: XSPEC,

3) average: SUM,

4) display: XPROP, ϕMAG,

5) capture control: CONT,

6) amplitude units: V/ABS,

7) scales: AMPL-LOG.

14. Punch the following buttons on the 660B in the order given:

a. 2-5-6,

b. SET/STORE,

c. AVGN.

Check and see if 256 AVGN appears on the screen of the 660B.

If it does not, hit CLEAR and redo the above sequence.

You are now ready to begin testing.

15. On the Z-100: Type in the file name in the following format.

Do not hit return.

Denotes Drive B

B:XSNORM.D(LO or HI)

XS for Cross-Spectrum   Low or High Frequency Calibration
                               (LO = 500. Hz, HI = 5000. Hz)

16. On the 660B:

a. Set desired frequency range (500 or 5000 Hz).

b. Turn on the speakers by putting the speaker switch in

the "SO" position.

c. Adjust the analyzer channel amplitudes to maximum without

overloading.

  d. Press START.

  e. Press RECALL and then AVGN.

  f. Note in the testing log the input channel maximum

    amplitude settings, microphone spacing, number of

    averages.

17. When the test is done, the START light will go out. Turn

   off the speakers by returning the speaker switch to OFF.

18. Press RETURN on the Z-100. This will initiate the transfer

   of data from 660B to the Z-100. The transfer is completed

   when the Z-100 asks for a new file name.

19. On the 660B, press RCL D so that the function light goes out.

20. Unscrew the 4 holding bolts. Without changing the position

   of the MPD, switch the location of the microphones. After

   switching, #1 microphone should be closer to the source.

21. On the Z-100, type file name:

      B:XSSWCH.D(LO or HI)

   Do not hit return. Repeat steps 16-19.

22. Repeat test for the other frequency range (steps 16-21).

23. Type E <ret> and SYSTEM <ret> on the Z-100, and turn off the

   following equipment:

  a. microphone power supply,

  b. amplifier,

  c. equalizer,

  d. 660B.

24. Type INTCAL <ret>. When Z-100 asks for the frequency range,

   type 500. <ret>.

25. Z-100 will now calculate the phase correction values and store the result in B:INTCAL.D(LO or HI).

26. Repeat step 24 for frequency range value of 5000. Hz.

A.6 DAILY MICROPHONE MAGNITUDE CALIBRATION TEST PROCEDURE

This section describes the procedures for performing a daily magnitude calibration test of the two B & K microphones. The steps should be followed in the order given. Special note: Microphone #1 corresponds to analyzer channel A, and microphone #2 corresponds to analyzer channel B.

1. Remove the microphone connected to channel A from the MPD.

2. Place the microphone into the connecting ring of the "Pistonphone."*

3. Boot Z-100 with the system/testing disk in drive A, and Data Disk #1 in drive B.

4. Turn on the 660B.

5. Turn on the microphone power supply.

6. Allow the system to warm up for approximately 10 minutes.

7. While the system is warming up, do the following:

    a.   On the Z-100:

        1)   Type ZBASIC <ret>.

        2)   Press F3, and when 'LOAD"' appears, type PSP660 <ret>.

        3)   When 'OK' appears, type RUN.

    The computer will then ask for a file name. Do not answer this question yet.

---

*Brüel & Kjaer, Type 4220

    b.   On 660B: Make sure that the following lights are on.

        1)   mode: DUAL 1K,

        b)   function: PWR SPEC,

        c)   average: SUM,

        d)   display: MAG (either A or B),

        e)   capture control: CONT,

        f)   amplitued units: V,ABS,

        g)   scales: AMPL-LOG.

8.   Set the number of averages using the following sequence:

    a.   2-5-6,

    b.   SET/STORE,

    c.   AVGN.

Check and see if 256 AVGN appears on the screen of the 660B.

If it does not, press CLEAR and redo the above sequence.

9.   You are now ready to begin testing. Do the following:

    a.   On the Z-100: The Z-100 will ask 'FILE NAME FOR

        CHANNEL A?'. Type in the file name A:CALA.DAT.

        Do not enter a return yet.

    b.   On 660B: Set the frequency range to 500 and press RECALL

        and then AVGN.

10.   Turn on the Pistonphone.

11.   Hit the START button on the 660B.

12.   When the test is done, the START light will go out. When

this happens, turn off the Pistonphone.

13.   Hit RETURN on the Z-100.

14.   The transfer is complete when the Z-100 asks for a new file name.

15. On the 660B, hit RCL D so that the light goes out.

16. Replace microphone A with microphone B in the Pistonphone, and output from microphone B should be connected to channel B on 660B.

17. Begin the next test by following the steps from step 9a onward. This time the file name will be A:CALB.DAT.

18. Type SYSTEM <ret>. When A: appears, type MAGCAL <ret>.

19. The computer will then ask a series of questions. Answer each of them with the appropriate answer.

20. When A: appears on the screen, type COPY A:CALDAT.DAT B:CALDAT.DAT <ret>.

21. Turn off:

    a. microphone power supply,

    b. 660B,

    c. Z-100 and its monitor.

22. Remove the disks.

23. Place the microphone back in the MPD and put away the Pistonphone.

A.7 ACOUSTIC INTENSITY TESTING PROCEDURE

This section describes the procedures for running an intensity test. Follow these steps in the order given. Note: Each disk will hold only 35 files. You will need several data disks for these tests.

1. Place the microphone positioning device (MPD) between the Beranek tube and the speaker wall.

2.   Insert the two microphones through the hole in the top of the MPD.

3.   Clamp the microphones into their respective holders (#2 mike closest to the speakers) with a one-inch spacing for high frequency tests, and a four-inch spacing for low frequency tests. The microphones should be inserted so that they are upright in their holder.

4.   Position the mikes in the upper left-hand side (when facing the speakers) of the MPD, one inch from the left side and top side of the inner surfaces. This represents position (1,1). While holding the positioning cranks fixed, move the position indicators (springs) so that they are centered over the indicator scales at the value (1,1).

5.   Place putty into the hole in the MPD around the microphone cables.

6.   If a "receiver side" test is to be done, place the panel to be tested in the MPD. If a "source side" test is to be done, leave the panel space empty. Close the tube and secure the MPD in place with the four "hook" bolts.

7.   Attach a cable to the binary noise-out (A) post on the FFT analyzer.

8.   Connect the cable from the FFT to the speaker switch cable.

9.   Connect the cable from output 1 on the microphone power supply to channel A on the FFT analyzer.

10. Connect the cable from output 2 on the microphone power supply to channel B on the FFT analyzer.

11. Boot Z-100 with the system/testing disk in drive A, and an empty working disk in B.

12. Turn on the following equipment:

    a.   660B,

    b.   mike power supply,

    c.   equalizer,

    d.   amplifier.

    Allow equipment to warm up for approximately 10 minutes.

13. While the system is warming up, do the following:

    a.   On the Z-100:

        1)   Type ZBASIC <ret>;

        2)   Hit F3 and when 'LOAD"' appears, type INT660 <ret>;

        3)   When 'OK' appears on the screen, type RUN <ret>,

        4)   The computer will then ask for a file name. Do not answer this question yet.

    b.   On 660B: Make sure that the following lights are on.

        1)   mode: DUAL 1K,

        2)   function: XSPEC,

        3)   average: SUM,

        4)   display: XPROP, φMAG,

        5)   capture control: CONT,

        6)   amplitude units: V/ABS,

        7)   scales: AMPL-LOG.

14. Punch the following buttons on the 660B in the order given:

    a.   2-5-6,

    .b.   SET/STORE,

    c.   AVGN.

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Check and see if 256 AVGN appears on the screen of the 660B.

If it does not, hit CLEAR and redo the above sequences.

You are now ready to begin testing.

15. On the Z-100: Type in the file name in the following format.
Do not hit return.

```
Denotes Drive B          Source or Receiver Side
          ↓          ⤹
        B:XS(S or R)XX(L or H).XXX  ←————— Test number
           ↑         ↑  ⌣
XS for Cross-Spectrum |   Low or High Frequency Test
                      |   (L = 500 Hz, H = 5000 Hz)
                      ↑
                  Mike Position
```

    Examples: B:XSS31L.012 or B:XSS78H.005

16. Begin the test by moving the cranks on the MPD so that it
reads (1,1). The tests will need to be done in the following
order: (1,1) - (1,9), (2,1) - (2,9), etc. After test (6,9),
consult the special instructions listed at the end of this
section.

17. On the 660B:

    a. Set desired frequency range.

    b. Turn on the speakers by putting the speaker switch
       in the "SO" position.

    c. Adjust the analyzer channel amplitudes to maximum
       without overloading.

    d. Press START.

    e. Press RECALL and then AVGN.

    f. For each position, note in the testing log the input
       channel maximum amplitued settings, microphone spacing,
       number of averages, and the number of the disk used.

18. When the test is done, the START light will go out. Turn off the speakers by returning the speaker switch to OFF.

19. Press RETURN on the Z-100. This will initiate the transfer of data from the 660B to the Z-100. The transfer is completed when the Z-100 asks for a new file name.

20. On the 660B, press RCL D so that the function light goes out.

21. Begin the next test by repositioning the microphones to the next testing location and repeating steps 15 to 21. Remember that upon reaching position (6,9), the special instructions must be followed.

22. After reaching position (9,9), and if no more testing is to be done, type E <ret> and SYSTEM <ret> on the Z-100, and turn off the following equipment:

a. microphone power supply,

b. amplifier,

c. equalizer,

d. 660B,

e. Z-100 and its monitor. (Remove all disks.)

*** Special Instructions ***

These instructions are necessary at the time the microphones are moved past position (6,9). Beyond this location the preamp cables in the MPD begin to interfere with the operation of the device, and the microphones themselves obstruct further progress. To avoid this, the microphones are turned over so that they face down. This operation is described below:

1. Turn off the microphone power supply.

2. Remove the "hook" bolts from the MPD and slide the tube back.

3. Remove the aluminum beam to which the microphones are fastened by removing the bolt that fixes it to the Lucite mount.

4. Turn the mikes face down and reattach the aluminum beam to its mount with the bolt. Make sure the arrangement of the mike cables allows for freedom of movement of the mikes.

5. Position the microphones in the (9,1) position by carefully measuring one inch from the bottom and left side.

6. While keeping the positioning cranks fixed, move the position indicators (springs) so that they are centered over (9,1) on the scales.

7. Crank the mikes into the (7,1) position.

8. Close the tube and bolt it together with the four "hook" bolts.

9. Turn on the mike power supply.

10. Proceed with testing from step 15.

APPENDIX B

LISTING OF COMPUTER PROGRAMS

```
5 REM PSP660
10 SCREEN 0,0
20 DEFINT I-N
30 KEY OFF:CLS:CLOSE
40 LOCATE 25,1
50 C$="ZZZOA31SY251SY261SY272SWAJ6F1E0=8"
60 PRINT STRING$(60," ")
70 SYN$=CHR$(22)
80 LOCATE 1,1
90 SPEED$="9600"
100 COMFIL$="COM1:"+SPEED$+",E,7,1"
110 OPEN COMFIL$ AS #1
120 OPEN "SCRN:" FOR OUTPUT AS #2
130 LOCATE 25,1:PRINT "660B MAGNITUDE CAL TRANSFER PROGRAM";
140 LOCATE 1,1:PRINT STRING$(60," "):LOCATE 1,1
141 JC=1
150 IF JC=1 THEN LINE INPUT "FILE NAME FOR CHANNEL A? < E TO EXIT > :";DSKFIL$
151 IF JC=2 THEN LINE INPUT "FILE NAME FOR CHANNEL B? < E TO EXIT > :";DSKFIL$
152 IF JC=2 THEN MID$(C$,33)="9"
153 IF JC=2 THEN MID$(C$,29)="2"
160 IF DSKFIL$="E" THEN 500
170 LOCATE 1,1:PRINT STRING$(60," "):LOCATE 1,1
180 OPEN DSKFIL$ FOR OUTPUT AS #3
190 FIELD#1, 3 AS H1$,6 AS F1$,3 AS E1$,3 AS H2$,6 AS F2$,3 AS E2$,3 AS H3$,6
AS F3$,3 AS E3$,3 AS H4$,6 AS F4$,3 AS E4$,3 AS H5$,6 AS F5$,3 AS E5$,3 AS
H6$,6 AS F6$,3 AS E6$
200 FOR IC=1 TO 33
210 D$=MID$(C$,IC,1)
220 GOSUB 340
222 FOR IK=1 TO 75
224 NEXT IK
230 NEXT IC
240 REM CONTINUE
250 LOCATE 1,1
260 GOSUB 370
320 CLOSE#3:JC=JC+1
330 IF JC =2 THEN GOTO 150 ELSE GOTO 500
340 PRINT #1,D$;
350 IF LOC(1)=0 THEN 350
360 A$=INPUT$(1,#1):IF ASC(A$)=6 THEN RETURN ELSE PRINT #2,"ERROR SENDING DATA"
:STOP
370 J=0
380 FOR IC=1 TO 86
390 PRINT #1;SYN$;
400 J=J+1
410 IF LOC(1)<72 THEN 410
420 GET #1,72
430 A$=F1$+"E"+E1$+","+F2$+"E"+E2$+","+F3$+"E"+E3$+","+F4$+"E"+E4$+","+F5$+"E"
+E5$+","+F6$+"E"+E6$
440 IF J>67 THEN GOTO 460
450 PRINT #3,A$
460 NEXT IC
470 IF LOC(1)<>2 THEN 470
```

```
480 A$=INPUT$(2,#1)
490 RETURN
500 CLOSE :KEY ON:KEY OFF
```

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                                 C
C                   MAGNITUDE CALIBRATION PROGRAM                 C
C                                                                 C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C
C
C
C
C############# PROGRAMMER : R.NAVANEETHAN
C#############       DATE : SEPT,1 83
C#############    VERSION : 1                    ####################
C
C
C234567
      IMPLICIT REAL(O-Z)
      IMPLICIT REAL(A-F)
      IMPLICIT INTEGER*2 (I-N)
      DIMENSION CHA(402),CHB(402)
      CHARACTER *1 HA,HB
      DATA HA/'A'/
      DATA HB/'B'/
      IF (IOREAD(6,2,0,'A:CALA.DAT')) GO TO 10
      IF (IOREAD(7,2,0,'A:CALB.DAT')) GO TO 11
      J=1
      DO 1 I=1,67
      READ (6,100) (CHA(J1), J1=J,J+5)
      READ (7,100) (CHB(J1), J1=J,J+5)
      J=J+6
1     CONTINUE
100   FORMAT(6(E0.0))
      IF (IOCLOS(6)) STOP
      IF (IOCLOS(7)) STOP
      YMCHA = CHA(1)
      YMCHB = CHB(1)
      DO 2 I=5,400
      IF (YMCHA.GE.CHA(I)) GOTO 3
      YMCHA=CHA(I)
      IAMAX=I
3     CONTINUE
      IF (YMCHB.GE.CHB(I)) GOTO 2
      YMCHB=CHB(I)
      IBMAX=I
2     CONTINUE
      YA=0.
      DO 4 I=IAMAX-3,IAMAX+3
4     YA=YA+CHA(I)
      YB=0.
      DO 5 I=IBMAX-3,IBMAX+3
5     YB=YB+CHB(I)
      PCAL=10.**(124./20.)*.00002
      AKCHA=PCAL/SQRT(YA)
      AKCHB=PCAL/SQRT(YB)
```

78

```
      WRITE(1,200)
200   FORMAT(' ','CHANNEL A DETAILS')
      WRITE(1,201)
201   FORMAT(' ','ENTER MAX AMPLITUDE SETTING : '$)
      READ(1,300) AMPCHA
300   FORMAT(F0,0)
      WRITE(1,202)
202   FORMAT(' ','ENTER # OF AVERAGES : '$)
      READ(1,301) NAVGA
301   FORMAT(I0)
      WRITE(1,203)
203   FORMAT(' ','CHANNEL B DETAILS')
      WRITE(1,201)
      READ(1,300) AMPCHB
      WRITE(1,202)
      READ(1,301) NAVGB
      IF (IOWRIT (8,2,0,'CALDAT.DAT')) STOP
      WRITE (8,205) AKCHA,AKCHB
205   FORMAT(' ',2E15.5)
      WRITE(8,205) AMPCHA,AMPCHB
      WRITE(8,206) NAVGA,NAVGB
206   FORMAT(' ',2I5)
      IF (IOCLOS(8)) STOP
      GOTO 6
10    WRITE(1,500) HA
500   FORMAT(' ','ERROR OPENING DATA FILE OF CHANNEL ',A1)
      GO TO 6
11    WRITE(1,500) HB
6     CONTINUE
      STOP
      END
```

79

```
5 REM TFN660.BAS
10 SCREEN 0,0
20 DEFINT I-N
30 KEY OFF:CLS:CLOSE
40 LOCATE 25,1
50 C$="ZZZOA31SY251SY261SY272SWAJ3E0E4ZZZ=8"
60 PRINT STRING$(60," ")
70 SYN$=CHR$(22)
80 LOCATE 1,1
90 SPEED$="9600"
100 COMFIL$="COM1:"+SPEED$+",E,7,1"
110 OPEN COMFIL$ AS #1
120 OPEN "SCRN:" FOR OUTPUT AS #2
130 LOCATE 25,1:PRINT "660B TRANSFER PROGRAM";
140 LOCATE 1,1:PRINT STRING$(60," "):LOCATE 1,1
150 LINE INPUT "INPUT FILE? <TYPE E TO EXIT > :";DSKFIL$
160 IF DSKFIL$="E" THEN 500
170 LOCATE 1,1:PRINT STRING$(60," "):LOCATE 1,1
180 OPEN DSKFIL$ FOR OUTPUT AS #3
190 FIELD#1, 3 AS H1$,6 AS F1$,3 AS E1$,3 AS H2$,6 AS F2$,3 AS E2$,3 AS H3$,6
AS F3$,3 AS E3$,3 AS H4$,6 AS F4$,3 AS E4$,3 AS H5$,6 AS F5$,3 AS E5$,3 AS
H6$,6 AS F6$,3 AS E6$
200 FOR IC=1 TO 36
210 D$=MID$(C$,IC,1)
220 GOSUB 340
222 FOR IK=1 TO 75
224 NEXT IK
230 NEXT IC
240 REM CONTINUE
250 LOCATE 1,1
260 GOSUB 370
270 D$="Z":GOSUB 340
280 D$="Z":GOSUB 340
290 D$="=":GOSUB 340
300 D$="9":GOSUB 340
310 GOSUB 370
320 CLOSE #3:CLS
330 GOTO 130
340 PRINT #1,D$;
350 IF LOC(1)=0 THEN 350
360 A$=INPUT$(1,#1):IF ASC(A$)=6 THEN RETURN ELSE PRINT #2,"ERROR SENDING DATA"
:STOP
370 J=0
380 FOR IC=1 TO 86
390 PRINT #1,SYN$;
400 J=J+1
410 IF LOC(1)<72 THEN 410
420 GET #1,72
430 A$=F1$+"E"+E1$+","+F2$+"E"+E2$+","+F3$+"E"+E3$+","+F4$+"E"+E4$+","+F5$+"E"
+E5$+","+F6$+"E"+E6$
440 IF J>67 THEN GOTO 460
450 PRINT #3,A$
460 NEXT IC
```

```
470 IF LOC(1)<>2 THEN 470
480 A$=INPUT$(2,#1)
490 RETURN
500 CLOSE :KEY ON:KEY OFF
```

```
10 CLS
20 OPTION BASE 1
30 DIM X(513),X2(513),AVMAG(513),VAR(513),TAV(31),CI(513)
40 FOR I=1 TO 31
50 READ TAV(I)
60 NEXT I
70 DATA 12.71,4.303,3.182,2.776,2.571,2.447,2.365,2.306
80 DATA 2.262,2.228,2.201,2.179,2.160,2.145,2.131,2.12,2.11,2.101
90 DATA 2.093,2.086,2.08,2.074,2.069,2.064,2.06,2.056,2.052,2.048
100 DATA 2.045,2.042,2.02
110 N=0
120 INPUT 'ENTER NAME OF INPUT FILE CATALOG ';A$
130 OPEN 'I',#1,A$
140 INPUT 'ENTER OUTPUT FILE NAME ';B$
150 INPUT 'ENTER SPECTRAL LINE SPACING ';LS
160 IF EOF(1) THEN  GOTO 390
170 N=N+1
180 INPUT#1, N$
190 PRINT N$
200 OPEN 'I',#2, N$
210 INPUT#1, M$
220 PRINT M$
230 OPEN 'I',#3, M$
240 I=0
250 IF EOF(2) THEN GOTO 360
260 I=I+1
270 INPUT#2,A
280 INPUT#3,B
290 DEG=ATN(B/A)*(180/3.14159)
300 IF(A<0)AND(B>0) THEN DEG=DEG+180
310 IF(A<0)AND(B<0) THEN DEG=DEG-180
320 X(I)=X(I)+DEG
330 X2(I)=X2(I)+DEG^2
340 PRINT I*LS-LS;DEG;X(I);X2(I)
350 GOTO 250
360 CLOSE #3
370 CLOSE #2
380 GOTO 160
390 CLOSE #1
400 OPEN 'O',#1,B$
410 K=N
420 IF N>31 THEN K=31
430 FOR J=1 TO I
440 VAR(J)=(N*X2(J)-X(J)^2)/(N*(N-1))
450 X(J)=X(J)/N
460 CI(J)=TAV(K)*(VAR(J)/N)^2
470 PRINT J*LS-LS;X(J);VAR(J);CI(J)
480 PRINT#1,USING'#####.### ';J*LS-LS,X(J),CI(J)
490 NEXT
500 CLOSE #1
510 FOR I=1 TO 3
520 BEEP
530 FOR J=1 TO 200
```

```
540 NEXT
550 NEXT
560 END
```

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                                  C
C               PHASE CALIBRATION PROGRAM FOR INTENSITY            C
C                     TRANSFER FUNCTION METHOD                     C
C                            TYPE I.                               C
C                                                                  C
C                                                                  C
C              VERSION : 1                                         C
C           PROGRAMMER : R.NAVANEETHAN                             C
C                 DATE : 20-MAY-83                                 C
C                                                                  C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C234567
C
C#########   CHANGE DIMENSION STATEMENTS DEPENDING UPON THE ANALYSER
C
      COMPLEX CALA (512)
      COMPLEX CMPLX
      CHARACTER *15 NAMET,NAME1,NAME2,NAME3,NAME4,NAMEC
      CHARACTER *1 AR
      REAL X(512),Y(512)
      REAL ABIB(4)
      DATA ABIB/4*0./
      DATA NAME1/"B:TFNCAL.DLO"/
      DATA NAME2/"B:TFNCAL.DHI"/
      DATA NAME3/"B:CALII.DLO"/
      DATA NAME4/"B:CALII.DHI"/
      RAD=180./3.1415962
      WRITE(1,600)
600   FORMAT(' ENTER FREQUENCY RANGE : '$)
      READ(1,601) SFREQ
601   FORMAT(F0.0)
      IFLAG=1
      NAMET=NAME1
      NAMEC=NAME3
      IF (SFREQ.GT.1000.) IFLAG=2
      IF (IFLAG.NE.2) GOTO 112
      NAMET=NAME2
      NAMEC=NAME4
112   CONTINUE
C
C###########  CHANGE N DEPENDING UPON THE ANALYSER
C
      N=402
C
C##########   OPEN DATA FILE CONTAINING TRANSFER FUNCTION DATA
C
      IF(IOREAD(8,2,0,NAMET)) STOP
      J=1
      DO 1 I=1,67
      READ(8,100) (X(J1), J1=J,J+5)
      J=J+6
1     CONTINUE
```

```
        J=1
        DO 11 I=1,67
        READ(8,100) (Y(J1), J1=J,J+5)
        J=J+6
11      CONTINUE
C
C********** CHANGE FORMAT STATEMENT DEPENDING UPON THE ANALYSER
C
100     FORMAT(6E0.0)
        IF(IOCLOS(8)) STOP
        NAMET='A:STATLO.DAT'
        IF (IFLAG.EQ.2) NAMET='A:STATHI.DAT'
        IF(IOREAD(6,2,0,NAMET)) STOP
        READ(6,114) FREQ
 114    FORMAT(F0.0)
        IF(FREQ.NE.SFREQ) GOTO 999
        BW=SFREQ*2.56/1024.
        DO 3 I=1,N
        READ(6,110) AMEAN,ALVL
110     FORMAT(F9.3,1X,F9.3)
        IF(ALVL.LT..1) ALVL=.1
        THETA1=ATAN2(Y(I),X(I))*RAD
        IF((IFLAG.EQ.2).AND.(I.GT.280)) GOTO 4
        IF(I.EQ.1) THETA1=0.0
        SIGMA=ALVL*SQRT(30.)
        ZSTAT=(AMEAN-THETA1)/(SIGMA*SQRT(1./30.+1./5.))
987     FORMAT(' ',F15.2,2F15.3)
        IF(ABS(ZSTAT).LE.1.96) GO TO 4
        WRITE(1,990)
990     FORMAT('      FREQUENCY      CAL VALUE      ZSTAT          ')
        FRQ=FLOAT(I-1)*BW
        WRITE(1,987) FRQ,THETA1,ZSTAT
989     WRITE(1,113)
113     FORMAT(' VALUES NOT WITHIN LIMITS! ACCEPT OR REJECT <A/R> : '$)
        READ(1,988) AR
988     FORMAT(A0)
        IF((AR.NE.'A').AND.(AR.NE.'R')) GOTO 989
        IF(AR.EQ.'R') GO TO 998
4       CONTINUE
        THETA1=-THETA1/RAD
        CALA(I)=CMPLX(COS(THETA1),SIN(THETA1))
3       CONTINUE
C
C********** OPEN PHASE CAL DATA FILE
C
        IF(IOWRIT(10,2,0,NAMEC)) STOP
        ABIB(1)=SFREQ
        ABIB(2)=2.
        WRITE(10,102)(ABIB(J),J=1,4)
102     FORMAT(' ',4F15.5)
        DO 2 I=1,N
        WRITE(10,101) CALA(I)
101     FORMAT(' ',2E15.5)
```

```
2       CONTINUE
        IF(IOCLOS(1,0)) STOP
        GOTO 9999
999     WRITE(1,700)
700     FORMAT(' FREQUENCY MIS-MATCH')
        GO TO 9999
998     CONTINUE
9999    CONTINUE
        STOP
        END
```

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```
5 REM INT660.BAS
10 SCREEN 0,0
20 DEFINT I-N
30 KEY OFF:CLS:CLOSE
40 LOCATE 25,1
50 C$='ZZZOA31SY251SY261SY272SWAJ2E0E4ZZZ=8'
60 PRINT STRING$(60,' ')
70 SYN$=CHR$(22)
80 LOCATE 1,1
90 SPEED$='9600'
100 COMFIL$='COM1:'+SPEED$+',E,7,1'
110 OPEN COMFIL$ AS #1
120 OPEN 'SCRN:' FOR OUTPUT AS #2
130 LOCATE 25,1:PRINT '660B TRANSFER PROGRAM';
140 LOCATE 1,1:PRINT STRING$(60,' '):LOCATE 1,1
150 LINE INPUT 'INPUT FILE? <TYPE E TO EXIT > ';DSKFIL$
160 IF DSKFIL$='E' THEN 500
170 LOCATE 1,1:PRINT STRING$(60,' '):LOCATE 1,1
180 OPEN DSKFIL$ FOR OUTPUT AS #3
190 FIELD#1, 3 AS H1$,6 AS F1$,3 AS E1$,3 AS H2$,6 AS F2$,3 AS E2$,3 AS H3$,6
AS F3$,3 AS E3$,3 AS H4$,6 AS F4$,3 AS E4$,3 AS H5$,6 AS F5$,3 AS E5$,3 AS
H6$,6 AS F6$,3 AS E6$
200 FOR IC=1 TO 36
210 D$=MID$(C$,IC,1)
220 GOSUB 340
222 FOR IK=1 TO 75
224 NEXT IK
230 NEXT IC
240 REM CONTINUE
250 LOCATE 1,1
260 GOSUB 370
270 D$='Z':GOSUB 340
280 D$='Z':GOSUB 340
290 D$='=':GOSUB 340
300 D$='9':GOSUB 340
310 GOSUB 370
320 CLOSE #3:CLS
330 GOTO 130
340 PRINT #1,D$;
350 IF LOC(1)=0 THEN 350
360 A$=INPUT$(1,#1):IF ASC(A$)=6 THEN RETURN ELSE PRINT #2,'ERROR SENDING DATA'
:STOP
370 J=0
380 FOR IC=1 TO 86
390 PRINT #1,SYN$;
400 J=J+1
410 IF LOC(1)<72 THEN 410
420 GET #1,72
430 A$=F1$+'E'+E1$+','+F2$+'E'+E2$+','+F3$+'E'+E3$+','+F4$+'E'+E4$+','+F5$+'E'
+E5$+','+F6$+'E'+E6$
440 IF J>67 THEN GOTO 460
450 PRINT #3,A$
460 NEXT IC
```

```
470 IF LOC(1)<>2 THEN 470
480 A$=INPUT$(2,#1)
490 RETURN
500 CLOSE :KEY ON:KEY OFF
```

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                                    C
C            PHASE CALIBRATION PROGRAM FOR INTENSITY                 C
C                                                                    C
C                                                                    C
C            VERSION : 1                                             C
C          PROGRAMMER : R.NAVANEETHAN                                C
C              DATE : 02-SEP-83                                      C
C                                                                    C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C234567
C
C
C
C#########   THIS PROGRAM CALCULATES THE PHASE CALIBRATION USING
C#########   THE METHOD DESCRIBED IN 'THE APPLICATION OF ACOUSTIC
C#########   INTENSITY FOR ENGINE NOISE REDUCTION' BY M.D. CROKER ET AL
C#########   PRESENTED AT THE INTERNATIONAL CONF. ON RECENT ADVANCES IN ACOU
C#########   ACOUSTIC INTENSITY METHODS, SENLIS, FRANCE, OCT 1981
C
C
C#########   IN THIS AND OTHER PROGRAMS ON ACOUSTIC INTENSITY PROGRAMS
C#########   THE CROSS-SPECTRAL AND INTENSITY DATA ARE STORED IN TWO
C#########   ARRAYS :
C#########            A. DATA ARRAY IN WHICH DATA VALUES ARE STORED.
C#########            B. IDENTIFICATION ARRAY IN WHICH THE SAMPLING
C#########               FREQUENCY, DISTANCE BETWEEN MICS ETC ARE STORED.
C
C
C
C
C#########   DIMENSION STATEMENTS
C
C
C#########   DEPENDING UPON THE FFT ANALYSER CHARACTERISTICS THE
C#########   DIMENSION VALUES NEED TO BE CHANGED.
C
C
C
      COMPLEX CALA(402),CALB(402),C1
C
C#####  THE FOLLOWING STATEMENT IS PECULIAR TO SUPERSOFT FORTRAN AND
C#####  SHOULD BE OMITTED FOR OTHER FORTRAN COMPILER
C
      COMPLEX CMPLX
      REAL X(402),Y(402)
      REAL ABIB(4),BBIB(4)
      CHARACTER *12 NAME1,NAME2,NAME3
      CHARACTER*2 STR1
      DATA NAME1/'B:XSNORM.DLO'/
      DATA NAME2/'B:XSSWCH.DLO'/
      DATA NAME3/'B:INTCAL.DLO'/
      DATA STR1/'HI'/
```

C-2

89

```
      DATA ABIB/4*0./
      DATA BBIB/4*0./
C
C########## READ DATA FROM X-SPECTRUM DATA FROM THE FFT ANALYZER
C########## STORED IN THE DISC
C########## THIS FORMAT FOR OPENING THE DISC FILE IS PECULIAR
C########## TO SUPER SOFT COMPILER
C
      WRITE(1,700)
700   FORMAT(' ENTER FREQUENCY RANGE OF ANALYSIS : '$)
      READ(1,800) SFREQ
800   FORMAT(F0.0)
      IFLAG=1
      IF(SFREQ.LT.1001.) GO TO 87
      IFLAG=2
      CALL PUTCHR(NAME1,11,KHAR(STR1,1))
      CALL PUTCHR(NAME1,12,KHAR(STR1,2))
      CALL PUTCHR(NAME2,11,KHAR(STR1,1))
      CALL PUTCHR(NAME2,12,KHAR(STR1,2))
      CALL PUTCHR(NAME3,11,KHAR(STR1,1))
      CALL PUTCHR(NAME3,12,KHAR(STR1,2))
87    CONTINUE
      IF (IOREAD(6,2,0,NAME1)) STOP
C
C########## CHANGE N DEPENDING UPON THE ANALYSER
C
      N=402
      J=1
      DO 1 I=1,67
      READ(6,100) (X(J1), J1=J,J+5)
      J=J+6
1     CONTINUE
      J=1
      DO 10 I=1,67
      READ(6,100) (Y(J1), J1=J,J+5)
      J=J+6
10    CONTINUE
      IF (IOCLOS(6)) STOP
C
C########## THE FOLLOWING FORMAT IS PECULIAR TO SUPER SOFT
C########## FOR FREE FORMAT INPUTS SEPARATED BY COMMAS.
C
100   FORMAT(6E0.0)
C
      DO 12 I=1,402
      Y(I)= -Y(I)
      CALA(I) = CMPLX(X(I),Y(I))
12    CONTINUE
C
      IF(IOREAD(9,2,0,NAME2)) STOP
      J=1
      DO 2 I=1,67
      READ (9,100) (X(J1), J1=J,J+5)
```

90

```fortran
        J=J+6
2       CONTINUE
        J=1
        DO 20 I=1,67
        READ (9,100) (Y(J1), J1=J,J+5)
        J=J+6
20      CONTINUE
        IF(IOCLOS(9)) STOP
        DO 3 I=1,N
3       CALB(I)=CMPLX(X(I),Y(I))
C
C###### END OF DATA READ
C
        IF(IOWRIT(10,2,0,NAME3)) STOP
        ABIB(1)=SFREQ
        BBIB(1)=SFREQ
        ABIB(2)=2.
        BBIB(2)=2.
        WRITE(10,102)(ABIB(J),J=1,4)
102     FORMAT(' ',4E15.5)
C
C###### FOR MORE DETAILS SEE REF ABOVE
C
        DO 21 I=1,N
C
C######### SEE REPORT KU-FRL-417-22 FOR DETAILS OF THIS REPORT.
C
        C1 = CALA(I)/CALB(I)
        THETA = ATAN2(AIMAG(C1)/REAL(C1))/2.
        CALA(I)=CMPLX(COS(THETA),SIN(THETA))
C
C######## WRITE TO DISC NEW PHASE CAL VALUES
C
        WRITE(10,101) CALA(I)
101     FORMAT(' ',2E15.5)
21      CONTINUE
        IF(IOCLOS(10)) STOP
        STOP
        END
```

91

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```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                                 C
C                                                                 C
C                                                                 C
C            PROGRAM TO CALCULATE THE INTENSITY SPECTRUM          C
C                                                                 C
C                                                                 C
C                                                                 C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C
C
C#############         VERSION    : 1           #################
C#############         PROGRAMMER : R.NAVANEETHAN  #################
C#############            DATE    : 13-SEP-83    #################
C
C
C############# A WORD ABOUT THE WAY THIS PROGRAM IS WRITTEN !!!!!!!!!!
C#############
C#############      EACH SPECTRAL DATA ARRAY IS ASSOCIATED WITH AN
C#############      ADDITIONAL ARRAY WHICH DEFINES THE RELEVANT PARA
C#############      METERS ASSOCIATED WITH THE ARRAY.  FOR INTENSITY
C#############      SPECTRUM THESE ARE SAMPLING FREQUENCY (ANALYSIS
C#############      FREQUENCY RANGE), MIC SPACING AND AREA ASSOCITAED
C#############      WITH THE MEASUREMENTS.  ADDITIONALLY, ONE MORE SPEC
C#############      CAN ALSO BE INCLUDED.  THESE FOUR VALUES ARE STORED
C#############      IN THE BEGINNING OF EACH INTENSITY SPECTRUM DATA
C#############      ON THE DISK. THE UNIT OF INTENSITY VALUES STORED
C#############      IS WATT/M^2.
C
C234567
C
C######  DIMENSION STATEMENTS
C
      COMPLEX AXPS(402),CAL(402)
      COMPLEX CMPLX
      REAL BBIB(4),BINT(402),X(402),Y(402),SPL(402)
      REAL SFREQ(100),AIN(100),BIN(100),AVG(100),SPAC(100),AREA(100)
      CHARACTER*1 ANS
      CHARACTER*15 INAME(100),NAME
      CHARACTER *3 IN
      CHARACTER *5 OUT
      DATA OUT/'ASP00'/
      DATA IN/'AIN'/
      DATA NAME/'B:XSS00L.000'/
      DATA SPL/402*0.0/
C
C###### READ MAG CAL FACTORS
C
      IF(IOREAD(6,2,0,'A:CALDAT.DAT'))  GOTO 421
      GO TO 422
421 · CONTINUE
      WRITE(1,423)
423   FORMAT(' ERROR OPENING FILE A:CALDAT.DAT')
```

```
        STOP
422     CONTINUE
        READ(6,700) ACAL,BCAL
        READ(6,700) ARAN,BRAN
        READ(6,701) NAVGA,NAVGB
700     FORMAT(2E15.5)
701     FORMAT(2I5)
        IF (IOCLOS(6)) STOP
C
C###### READ XPS FILENAME AND TEST DETAILS
C
        IF (IOREAD(6,2,0,'A:XPSCAT.DAT')) GOTO 671
        GO TO 672
671     WRITE(1,673)
673     FORMAT(' ERROR OPENING FILE A:XPSCAT.DAT')
        STOP
672     CONTINUE
        J=1
322     CONTINUE
        READ(6,323,ENDFILE=324)INAME(J),SFREQ(J),AIN(J),BIN(J),AVG(J)
     &,SPAC(J),AREA(J)
        J=J+1
        GO TO 322
323     FORMAT(A12,1X,6F0.0)
324     JFILE=J-1
        CONTINUE
        IF (IOCLOS(6)) STOP
C
C####### READ PHASE CAL VALUES
C
        NAME='A:CALII.DLO'
        IF (SFREQ(1).GT.1001) NAME='A:CALII.DHI'
        IF(IOREAD(9,2,0,NAME)) GOTO 961
        GOTO 962
961     WRITE(1,963)
963     FORMAT(' ERROR OPENING A:CALII.DLO OR A:CALII.DHI FILE')
        STOP
962     CONTINUE
        READ(9,103) A1,A2,A3,A4
103     FORMAT(4F15.5)
        DO 120 I=1,402
        READ(9,121) CAL(I)
121     FORMAT(2E15.5)
120     CONTINUE
        IF (IOCLOS(9)) STOP
C
C####### CHANGE DISK FOR OUTPUT FILES
C
        WRITE(1,800)
800     FORMAT(' REMOVE PROGRAM DISK IN DRIVE A:; INSERT
     &OUTPUT DISK AND HIT RETURN'$)
        PAUSE
        CONTINUE
```

```
      IFILE=1
C
C######  CHANGE N DEPENDING ON THE ANALYSER SPEC
C
      N=402
C
C#######  MAIN LOOP FOR FILES
C
      DO 900 IC=1,JFILE
      IF (IFIX(SFREQ(IC)+.05).NE.IFIX(A1+.05)) GO TO 1000
752   CONTINUE
      IF(IOREAD(9,2,0,INAME(IC))) GO TO 750
      GO TO 751
750   CONTINUE
      WRITE(1,780)
780   FORMAT(' CHANGE INPUT FILE DISK IN DRIVE B: AND HIT RETURN'$)
      PAUSE
      GO TO 752
751   CONTINUE
      WRITE(1,798) INAME(IC)
798   FORMAT(' ',A0)
      J=1
      DO 1 I=1,67
      READ (9,100) (X(J1),J1=J,J+5)
C
C######  FORMAT STATEMENT DEPENDS ON THE ANALYSER SPEC
C
100   FORMAT(6E0.0)
C
C######  NEXT STATEMENT DEPENDS ON THE ANALYSER OUTPUT SPEC
C
      J=J+6
1     CONTINUE
      J=1
      DO 10 I=1,67
      READ(9,100) (Y(J1),J1=J,J+5)
      J=J+6
10    CONTINUE
      IF(IOCLOS(9)) STOP
      BBIB(1)=SFREQ(IC)
      BBIB(2)=2.
      BBIB(3)=SPAC(IC)*.0254
      BBIB(4)=AREA(IC)*.0254*.0254
C
C######   DATA FOR OUTPUT FILE SPEC
C
      NAME=INAME(IC)
      CALL PUTCHR(NAME,1,KHAR(IN,1))
      CALL PUTCHR(NAME,3,KHAR(IN,2))
      CALL PUTCHR(NAME,4,KHAR(IN,3))
C
C######  CORRECT FOR MAG AND PHASE CALIBRATION IN DATA CHANNELS
C
```

94

```
      TEMP=ACAL*BCAL*(AIN(IC)*BIN(IC))/(ARAN*BRAN)/(AVG(IC)
     &/FLOAT(NAVGA))
      DO 111 I=1,402
      X(I)=X(I)*TEMP
      Y(I)=Y(I)*TEMP
      AXPS(I)=CMPLX(X(I),Y(I))
111   CONTINUE
      DO 4 I=1,N
      AXPS(I)=AXPS(I)*CAL(I)
4     CONTINUE
C
C###### OPEN & WRITE OUTPUT FILE
C
      IF(IFILE.LE.41) GOTO 775
      WRITE(1,776)
776   FORMAT(' REMOVE OUTPUT DISK IN DRIVE A: AND INSERT
     & INITIALIZED DISK AND HIT RETURN'$)
      PAUSE
      IFILE=1
775   CONTINUE
758   CONTINUE
      IF(IOWRIT(10,2,0,NAME)) GO TO 755
      GOTO 756
755   WRITE(1,757)
757   FORMAT(' CHANGE OUTPUT DISK IN DRIVE A: AND HIT RETURN'$)
      PAUSE
      GO TO 758
756   CONTINUE
      IFILE=IFILE+1
      WRITE(10,123) (BBIB(I),I=1,4)
123   FORMAT(1X,4E15.5)
C
C
C######  CALCULATE INTENSITY
C
C
      DO 5 I=1,N
      BINT(I)=AIMAG(AXPS(I))
C
C###### STD SEA LEVEL VALUE FOR DENSITY OF AIR WAS ASSUMED. FOR
C###### BETTER ACCURACY BOTH PRESSURE AND TEMPERATURE MAY BE INPUT
C###### RHO CALCULATED.
C
      RHO=1.225
      BINT(I)=BINT(I)/(1.225*BBIB(3))
C
C###### THE FOLLOWING STATEMENTS NEEDS TO CHECKED WITH ANALYSER SPEC
C
      OMEGA=2.*3.1415962*FLOAT(I)*BBIB(1)*2.56/1024.
      BINT(I)=BINT(I)/OMEGA
      WRITE(10,104) BINT(I)
104   FORMAT(' ',E15.5)
5     CONTINUE
```

95

```
      IF(IOCLOS(10)) STOP
      DO 6 I=1,402
      SPL(I)=SPL(I)+BINT(I)*BBIB(4)
6     CONTINUE
900   CONTINUE
      NAME=INAME(1)
      CALL PUTCHR(NAME,1,KHAR(OUT,1))
      CALL PUTCHR(NAME,3,KHAR(OUT,2))
      CALL PUTCHR(NAME,4,KHAR(OUT,3))
      CALL PUTCHR(NAME,6,KHAR(OUT,4))
      CALL PUTCHR(NAME,7,KHAR(OUT,5))
      WRITE(1,790)
790   FORMAT(' REMOVE OUTPUT DISK IN DRIVE A: AND INSERT SPL DISK'$)
      PAUSE
      CONTINUE
      IF (IOWRIT(9,2,0,NAME)) STOP
      DO 791 I=1,402
      FR=FLOAT(I-1)*SFREQ(1)*2.56/1024.
      WRITE(9,792) FR,SPL(I)
791   CONTINUE
792   FORMAT(' ',2E15.5)
      IF (IOCLOS(9)) STOP
      GO TO 999
1000  CONTINUE
      WRITE(1,764)
764   FORMAT(' ERROR IN THE ANALYSIS RANGE SPEC')
999   CONTINUE
      STOP
      END
```

```
C234567
      DIMENSION AINT(402)
      CHARACTER*12 NAME,NAME1
      CHARACTER*1 CHRA,CHRB
      WRITE(1,100)
2     CONTINUE
100   FORMAT(' ENTER FREQUENCY VALUE OF INTEREST')
      READ(1,101) FREQ
101   FORMAT(F0.0)
1     CONTINUE
      ICOUNT = FREQ/1.25+1
      IF (FREQ.GT.500.05) ICOUNT =FREQ/12.5+1
      IF(FREQ.LE.500.) CHRB = 'L'
      IF(FREQ.GT.500.05) CHRB = 'H'
      WRITE(1,103)
103   FORMAT(' ENTER CATALOG FILE NAME CONTAINING INTENSITY DATA
     $FILE NAMES')
      READ(1,104) NAME
104   FORMAT(A0)
      WRITE(1,105)
105   FORMAT(' INSERT FIRST DATA DISK IN DRIVE B:')
      PAUSE
3     CONTINUE
      JC=0
      IF (IOREAD(6,2,0,NAME)) STOP
4     CONTINUE
      READ(6,106,ENDFILE=5) NAME1
106   FORMAT(A0)
      WRITE(1,130) NAME1
130   FORMAT(' ',A12)
      CALL PUTCHR(CHRA,1,KHAR(NAME1,8))
      JC=JC+1
      IF(CHRA.NE.CHRB) GO TO 999
10    CONTINUE
      IF(IOREAD(7,2,0,NAME1)) GO TO 8
      GO TO 9
8     CONTINUE
      WRITE(1,107)
107   FORMAT(' INSERT 2ND DATA DISK DRIVE IN DRIVE B:'$)
      PAUSE
      GO TO 10
9     CONTINUE
      READ(7,120) B1,B2,B3,B4
120   FORMAT(4E15.5)
      DO 11 I=1,ICOUNT
      READ(7,108) BINT
108   FORMAT(E15.5)
11    CONTINUE
      IF (BINT.LE.0.) BINT=1.E-12
      AINT(JC)=10.*(ALOG10(BINT/1.E-12))
      IF (IOCLOS(7)) STOP
      GO TO 4
5     CONTINUE
```

```
       IF (IOCLOS(6)) STOP
       JK=JC
       WRITE(1,109)
109    FORMAT(' ENTER NAME FOR OUTPUT FILE')
       READ(1,110) NAME
110    FORMAT(A0)
       IF (IOWRIT(10,2,0,NAME)) STOP
       DO 12 I=1,JK
       WRITE(10,111) AINT(I)
111    FORMAT(' ',F15.5)
12     CONTINUE
       IF (IOCLOS(10)) STOP
       GO TO 1000
999    WRITE(1,200)
200    FORMAT(' SOMETHING IS WRONG IN FILE NAMES!!!')
1000   CONTINUE
       STOP
       END
```

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                                  C
C                   TRANSMISSION LOSS PLOT PROGRAM                 C
C                                                                  C
C       PROGRAMMER : R. NAVANEETHAN          VERSION 1   11-17-83  C
C                                                                  C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C       THIS PROGRAM READS THE SOUND POWER  DATA FILES TRANSMITTED FROM
C       Z 100 COMPUTER AND PLOTS. THE TL VS FREQUENCY.THIS
C       PROGRAM IS DEVELOPED ON MINC-11 COMPUTER SYSTEM AND MAKES EXTENSIVE
C       USE OF USER WRITTEN (KU-FLIGHT RESEARCH LAB) PLOTTER SUBROUTINES.
C       MINC COMPUTER HAS RT-11 OPERATING SYSTEM AND THE FORTRAN USED IS
C       PDP-FORTRAN.  MINC HAS EXTENSIVE FORTRAN CALLABLE IEEE-488
C       IB SUB-ROUTINES. THESE SUBROUTINES HAVE BEEN USED IN THIS PROGRAM
C            THE FOLLOWING SUBPROGRAMS ARE REQUIRED:
C                      TLTEST (SOURCE LISTING GIVEN BELOW)
C                    O:PLTLIB (WRITTEN AT KU-FRL)
C                    O:IBLIB  (SUPPLIED BY DEC)
        PROGRAM TLTEST
C       DIMENSION STATEMENTS
C            MAX NUMBER OF POINTS 804
C            TL OR NR      = NR(I)
C            FREQUENCY(Hz)= FRE(I)
        DIMENSION ARRAY(9),ARAY(9),ARRA(4),VAX(6),FRE(804)
        REAL NR(804),J,I
        BYTE NAME(20)
        COMMON /ONE/ FRE,NR
        CONTINUE
        DATA ARRAY /'2  ','3  ','4  ','5  ','6  ','7  ','8  ','9  ',
       .'100'/
        DATA ARAY /'2   ','3   ','4   ','5   ','6   ','7   ','8   ',
       .'9   ','1000'/
        DATA ARRA /'2','3','4','5'/
        DATA VAX /'  0','  20','40','60','80','100'/
        TYPE *,'      '
        TYPE *,'TURN ON PLOTTER, PLACE PAPER ON PLOTTER,'
        TYPE *,'INSERT DESIRED PEN, RETURN WHEN READY.'
        PAUSE
        CALL PSC(5)
        CALL PCLR
        CALL IBSEND('IP 1543,1488,9559,7520;',-1,5)
        CALL SCL (ALOG10(20.),ALOG10(5000.),0.,100.)
      4 TYPE 1
      1 FORMAT('$','DO YOU WANT AXES DRAWN? (YES=1  NO=2)  ')
        ACCEPT *,KL
        CALL CSIZ(1.5,1.5,0,0)
        IF(KL.NE.1) GO TO 21
        CALL PLT (ALOG10(20.),0.,-2)
        CALL PLT (ALOG10(5000.),0.,2)
        CALL PLT (ALOG10(5000.),100.,2)
        CALL PLT (ALOG10(20.),100.,2)
```

```fortran
      CALL PLT (ALOG10(20.),0.,-1)
      J = 1.
5 DO 10 II=2,10
        I=II*1.
        CALL PLT (ALOG10(I*10.*J),0.,0)
        CALL IPLT (0.,0.,-2)
        IF(I.NE.10) CALL IPLT (0.,1.5,-1)
        IF(I.EQ.10) CALL IPLT (0.,3.,-1)
        IF(I.NE.10)CALL CPLT(-.4,-1.6)
        IF(I.EQ.10)CALL CPLT(-(ALOG10(J*100.)/2.),-2.8)
        IF(J.EQ.1) ENCODE (3,6,GN) ARRAY(I-1)
6     FORMAT(A3)
        IF(J.EQ.10) ENCODE (4,7,GS) ARAY(I-1)
7     FORMAT(A4)
        IF(J.EQ.100) ENCODE (1,8,COR) ARRA(I-1)
8     FORMAT(A1)
        IF(J.EQ.1) CALL LBL(GN)
        IF(J.EQ.10) CALL LBL(GS)
        IF(J.EQ.100) CALL LBL(COR)
        IF(J.EQ.100 .AND. I.EQ.5) GO TO 20
10 CONTINUE
      J = J * 10.
      GO TO 5
20 CALL PLT (ALOG10(300.),0.,1)
      CALL IPLT(0.,-6.5,1)
      CALL CPLT(-7.,-1.5)
      CALL CSIZ (2.0,1.5,0,0)
      CALL LBL('FREQUENCY, Hz')
      CALL PLT (ALOG10(20.),0.,1)
      CALL CSIZ(1.5,1.5,0,0)
      DO 30 II=0,100,5
        I=II*1.
C       PUT TIC MARKS ON VERTICAL AXIS NOW
        CALL PLT(ALOG10(20.),I*1.,1)
        CALL IPLT(ALOG10(1.07),0.,2)
        K=7
        IF(I.EQ.0)K=1
        IF(I.EQ.20)K=2
        IF(I.EQ.40)K=3
        IF(I.EQ.60)K=4
        IF(I.EQ.80)K=5
        IF(I.EQ.100)K=6
        IF(K.EQ.7) GO TO 29
        CALL PEN
        CALL CPLT(-4.,-.3)
        VLBL=VAX(K)
        CALL LBL(VLBL)
29      CALL PLT(ALOG10(20.),I*1.,1)
30 CONTINUE
      CALL PLT(ALOG10(20.),50.,1)
      CALL IPLT(-ALOG10(1.45),0.,1)
```

```
      CALL CSIZ(2.0,1.5,90.,,0)
      CALL CPLT(-10.,,0.)
      CALL LBL('TRANSMISSION LOSS, dB')
   21 CONTINUE
      TYPE 122
  122 FORMAT(' LOW FREQ DATA')
      KIMAX=1
      IFLG=1
      CALL DATRED(KIMAX,IFLG)
      KIMAX=KIMAX+0
      IFLG=2
      TYPE 123
  123 FORMAT(' HI FREQ DATA')
      CALL DATRED(KIMAX,IFLG)
      KIMAX=KIMAX-1
   27    CONTINUE
       DO 34 II=1,KIMAX
          X=FRE(II)
          Y=NR(II)
          IF(II.EQ.1)CALL PLOT1(X,Y)
          IF(II.NE.1)CALL PLOT2(X,Y)
   34 CONTINUE
      CALL PEN
      TYPE*,'WANT LEAST SQUARE LINE? 1= YES'
      ACCEPT*,ILSL
      IF (ILSL .NE.1) GO TO 42
      TYPE *,'ENTER MIN FREQUENCY FOR LEAST SQUARE LINE?'
      ACCEPT*,AMF
      SUMX=0.
      SUMY=0.
      SUMX2=0.
      SUMY2=0.
      N1=0
      DO 118 II=1,KIMAX
      IF(FRE(II) .LT. AMF) GO TO 118
      T1=ALOG10(FRE(II))
      N1=N1+1
      SUMX=SUMX+T1
      SUMY=SUMY+NR(II)
      SUMX2=SUMX2+T1**2
      SUMXY=SUMXY+T1*NR(II)
  118 CONTINUE
      SLOP=(SUMXY-SUMX*SUMY/N1)/(SUMX2-SUMX**2/N1)
      YINT=(SUMY-SLOP*SUMX)/N1
      TYPE*,SLOP,YINT
      X=ALOG10(AMF)
      Y=SLOP*X+YINT
      TYPE*,'CHANGE PEN '
      PAUSE
      CALL PLT(X,Y,3)
      X=ALOG10(5000.)
```

```
      Y=SLOP*X+YINT
      CALL PLT(X,Y,2)
      CALL PEN
117.  CONTINUE
   42 TYPE 41
   41 FORMAT('$','MORE CURVES PLOTTED? (YES=1 NO=2)   ')
      ACCEPT *,MC
      IF(MC.EQ.1) GO TO 4
      STOP
      END
C
      SUBROUTINE PLOT1(X,Y)
        CALL PLT (ALOG10(X),Y,3)
      RETURN
      END
C
      SUBROUTINE PLOT2(X,Y)
        CALL PLT (ALOG10(X),Y,2)
      RETURN
      END
C
      SUBROUTINE LABEL
C
      BYTE LABEL(80)
      DATA LABEL/80*' '/
C
      TYPE *,'LABEL DESIRED? YES = 1'
      ACCEPT *,IL
      IF (IL.NE.1) GO TO 10
      TYPE *,'ENTER LABEL (LESS THAN 80 CHARACTERS)'
      ACCEPT 5,(LABEL(II),II=1,80)
    5 FORMAT(80A1)
      TYPE *,'MOVE PEN TO DESIRED LOCATION OF LABEL'
      TYPE *,'HIT RETURN WHEN SATISFIED'
      PAUSE
      CALL CSIZ (1.5,1.5,0,0)
      CALL LBL(LABEL)
   10 RETURN
      END
C
C
CC
C
      SUBROUTINE DATRED (KIMAX,IFLG)
      COMMON /ONE/ FRE,TL
      REAL TL(804),FRE(804)
      BYTE INAME1(11),INAME2(11)
87    CONTINUE
      TYPE 222
  222 FORMAT('$',/,' ENTER THE NAME OF DATA FILE (TEST W/OUT PANEL? ')
      ACCEPT 23,(INAME1(II),II=1,10)
```

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```
   23 FORMAT(10(A1))
      OPEN (UNIT=8,NAME=INAME1,TYPE='OLD',ACCESS='SEQUENTIAL',
     2       FORM='FORMATTED',ERR=87,RECORDSIZE=1026)
  387 CONTINUE
      TYPE 322
  322 FORMAT('$',/,' ENTER THE NAME OF DATA FILE (TEST WITH PANEL)? ')
      ACCEPT 23,(INAME2(II),II=1,10)
      OPEN (UNIT=9,NAME=INAME2,TYPE='OLD',ACCESS='SEQUENTIAL',
     2       FORM='FORMATTED',ERR=387,RECORDSIZE=1026)
      K=KIMAX
      K1=17
      K2=401
      IF(IFLG.EQ.2) K1=41
      DO 41 I= 1,402
      READ(8,100) X1,Y1
      READ(9,100) X2,Y2
  100 FORMAT(2E15.5)
      IF ((I.LT.K1).OR.(I.GT.K2)) GO TO 41
      TL(K)=10*ALOG10(Y1)-10.*ALOG10(Y2)
      IF(IFLG.EQ.1) FRE(K)= FLOAT(I-1)*1.25
      IF(IFLG.EQ.2) FRE(K)= FLOAT(I-1)*12.5
      K=K+1
   41 CONTINUE
      CLOSE (UNIT=8)
      CLOSE (UNIT=9)
      KIMAX=K
      RETURN
      END
```

103

ORIGINAL PAGE IS
OF POOR QUALITY

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                                      C
C                                                                      C
C                     INTENSITY MAP INTERPOLATION PROGRAM              C
C                                                                      C
C                                                                      C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C
C
C                     VERSION: 2
C                     PROGRAMMER: MIKE GRAHAM,   R. NAVANEETHAN
C                     DATE: 22-NOVEMBER-83
C
C
C
C
C     DIMENSION STATEMENTS
C
      DIMENSION A(9,9),AX(9),AY(9)
      DIMENSION B1(810),B2(810),IB3(810),IC(810)
      BYTE INAME(15),ONAME(15)
      DATA INAME,ONAME/30*' '/
      TYPE*,'ENTER INPUT FILE NAME'
      ACCEPT 122,(INAME(II),II=1,14)
122   FORMAT(14(A1))
      TYPE*,'ENTER OUTPUT FILE NAME'
      ACCEPT 122,(ONAME(II),II=1,14)
123   TYPE*,'ENTER CONTOUR INTERVAL IN dB (10. OR 5. OR 2. OR 1.)'
      ACCEPT*,CONINT
      IF(.NOT.((CONINT.EQ.10.).OR.(CONINT.EQ.5.).OR.(CONINT.EQ.2.)
     &.OR.(CONINT.EQ.1))) GO TO 123
      IF(CONINT.EQ.10.) ICON=1
      IF(CONINT.EQ.5.)  ICON = 2
      IF(CONINT.EQ.2.)  ICON = 3
      IF(CONINT.EQ.1) ICON=4
C        THE FOLLOWING LOOPS ASSIGN THE VALUES FROM THE INTENSITY TESTS
C        TO AN ARRAY WHICH REPRESENTS THE TEST GRID.
C
      OPEN (UNIT=8,NAME=INAME,TYPE='OLD')
      DO 10 J=1,9
      DO 10 I=1,9
      READ (8,300) A(I,J)
  300 FORMAT (F15.5)
   10 CONTINUE
C
C        THE FOLLOWING LOOPS TRANSLATE GRID LOCATIONS INTO LOCATIONS
C        DEFINED BY THE DISTANCE FROM THE MPD EDGE.
C
      DO 11 I=1,9
      AX(I) = 1 + 2.*FLOAT(I-1)
      AY(I) = 1 + 2.*FLOAT(I-1)
```

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```
   11 CONTINUE
      CLOSE(UNIT=8)
C
C        THE FOLLOWING LOOPS DO THE INTERPOLATION BETWEEN POINTS IN
C        A HORIZONTAL DIRECTION.  THE LOCATION OF EACH DIVISION OF 10
C        DECIBELS BETWEEN THE POINTS WILL BE FOUND FOR MAPPING PURPOSES.
C
      OPEN(UNIT=10,NAME='INT1.TMP',TYPE='NEW')
      DO 20 J=1,9
      DO 20 I=1,8
      Y2 = A((I+1),J)
      Y1 = A(I,J)
      X2 = AX(I+1)
      X1 = AX(I)
      IF(Y2.EQ.Y1) GO TO 20
C
C        THESE STATEMENTS ENSURE THAT Y2 IS ALWAYS GREATER THAN Y1.
C
      IF (Y2.GE.Y1) GO TO 23
      X1TEMP = X1
      Y1TEMP = Y1
      Y1=Y2
      Y2=Y1TEMP
      X1=X2
      X2=X1TEMP
   23 CONTINUE
      SLOPE = (X2 - X1)/(Y2 - Y1)
      CALL INVAL(Y1,Y2,ZCAL,ICON)
   21 CONTINUE
      IF (ZCAL.GT.Y2) GO TO 22
      XLOC = (SLOPE*(ZCAL - Y1)) + X1
      WRITE (10,100) XLOC,AY(J),INT(ZCAL)
      ZCAL = ZCAL + CONINT
      GO TO 21
   22 CONTINUE
   20 CONTINUE
C
C        THE FOLLOWING LOOPS DO THE INTERPOLATION BETWEEN POINTS IN A
C        VERTICAL DIRECTION.  THE LOCATION OF EACH DIVISION OF 10
C        DECIBELS BETWEEN POINTS WILL BE FOUND FOR MAPPING PURPOSES.
C
      DO 30 I=1,9
      DO 30 J=1,8
      Y2 = A(I,(J+1))
      Y1 = A(I,J)
      X2 = AY(J+1)
      X1 = AY(J)
      IF(Y2.EQ.Y1) GO TO 30
C
C        THESE STATEMENTS ENSURE THAT Y2 IS ALWAYS GREATER THAN Y1.
C
```

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```
      IF (Y2.GE.Y1) GO TO 33
      X1TEMP = X1
      Y1TEMP = Y1
      Y1 = Y2
      Y2 = Y1TEMP
      X1 = X2
      X2 = X1TEMP
   33 CONTINUE
      SLOPE = (X2 - X1)/(Y2 - Y1)
      CALL INVAL(Y1,Y2,ZCAL,ICON)
   31 CONTINUE
      IF (ZCAL.GT.Y2) GO TO 32
      YLOC = (SLOPE*(ZCAL - Y1)) + X1
      WRITE (10,100) AX(I),YLOC,INT(ZCAL)
      ZCAL = ZCAL + CONINT
      GO TO 31
   32 CONTINUE
   30 CONTINUE
      CLOSE(UNIT=10)
  100 FORMAT (1X,F6.2,1X,F6.2,1X,I3)
C
C         SORTING OF DATA INTO SEQUENTIAL DIVISIONS OF 10 DECIBELS
C
      OPEN(UNIT=9,NAME='INT1.TMP',TYPE='OLD')
      I = 1
   40 CONTINUE
      READ(9,200,END=45) B1(I),B2(I),IB3(I)
  200 FORMAT (1X,F6.2,1X,F6.2,1X,I3)
      I = I + 1
      GO TO 40
   41 CONTINUE
   45 NS = I - 1
      CLOSE(UNIT=9)
      CALL SORT (NS,IB3,IC)
      OPEN(UNIT=11,NAME=ONAME,TYPE='NEW')
      DO 42 J=1,NS
      J2 = IC(J)
      WRITE(11,100) B1(J2),B2(J2),IB3(J2)
   42 CONTINUE
      STOP
      END
C
C         THE FOLLOWING IS A MODIFIED BUBBLE SORT WRITTEN BY
C         R. NAVANEETHAN.
C
      SUBROUTINE SORT(NS,IA,IC)
      DIMENSION IA(810),KSORT(810),IC(810)
      DO 1 IS=1,NS
      IC(IS) = IS
      KSORT(IS) = IA(IS)
    1 CONTINUE
```

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```
      DO 3 IS=1,NS-1
      DO 2 JS=1,NS-IS
      IF(KSORT(JS).LE.KSORT(JS+1)) GO TO 2
      IT = KSORT(JS)
      ITC = IC(JS)
      KSORT(JS) = KSORT(JS+1)
      IC(JS) = IC(JS+1)
      KSORT(JS+1) = IT
      IC(JS+1) = ITC
    2 CONTINUE
    3 CONTINUE
      RETURN
      END
C
C
      SUBROUTINE INVAL(Y1,Y2,ZCAL,ICONT)
      IF(ICONT.NE.1) GO TO 1
      ZCAL=FLOAT(INT(Y1/10.)*10)+10.
      GO TO 4
    1 CONTINUE
      IF(ICONT.NE.2) GO TO 2
      DEC=(Y1-FLOAT(INT(Y1/10.0)*10))/10.
      IF (DEC.LT.0.5) ZCAL= FLOAT(INT(Y1/10.))*10.+5.
      IF (DEC.GE.0.5) ZCAL = FLOAT(INT((Y1 + 10.)/10.)*10.)
      GO TO 4
    2 CONTINUE
      IF(ICONT.NE.3) GO TO 5
      IDEC=MOD(INT(Y1),2)
      IF(IDEC.EQ.1) ZCAL=FLOAT(INT(Y1))+1.
      IF(IDEC.EQ.0) ZCAL=FLOAT(INT(Y1))+2.
      GO TO 4
    5 CONTINUE
      ZCAL=INT(Y1)+1.
    4 CONTINUE
      RETURN
      END
```

107

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C
C
C        ************************************************************
C        *                                                        *
C        *                INTENSITY MAP PROGRAM                    *
C        *                                                        *
C        ************************************************************
C
C
C        PROGRAMMER : BRIAN QUAYLE
C        VERSION 1    11-15-83
C
C        THIS PROGRAM PLOTS INTENSITY MAPS USING DATA GENERATED IN
C        THE KU-FRL ACOUSTIC TEST FACILITY.
C
C        MORE INFORMATION ABOUT THE PROGRAM CAN BE OBTAINED AT
C        THE PROJECT MANAGER OF THE NOISE PROJECT.
C
C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C
        PROGRAM PLOT
        BYTE XLBL(39),INAME(11),YLBL(37)
        DATA XLBL/'M','I','C','R','O','P','H','O','N','E',' ',
       .'H','O','R','I','Z','O','N','T','A','L',' ','L','O','C',
       .'A','T','I','O','N',' ','(','I','N','C','H','E','S',')'/
        DATA YLBL/'M','I','C','R','O','P','H','O','N','E',' ',
       .'V','E','R','T','I','C','A','L',' ','L','O','C',
       .'A','T','I','O','N',' ','(','I','N','C','H','E','S',')'/
        TYPE *,' '
        TYPE *,'TURN ON PLOTTER, LOAD PAPER, AND SET P1 AND P2.'
        TYPE *,'RETURN WHEN READY'
        PAUSE
        CALL PSC(5)
        CALL PCLR
        CALL PEN
        CALL SCL(0.,9.,0.,9.)
        CALL CSIZ(2.,1.5,0.,0.)
        TYPE*,'ENTER PEN VELOCITY 1 = 1 CM/SEC ; 2 = NORMAL'
        ACCEPT*,IPNVEL
        IF(IPNVEL.EQ.1)CALL PENVEL
    8   TYPE*,'DO YOU WANT AN AXIS DRAWN? (YES=1)'
        ACCEPT*, AXDRAW
        IF(AXDRAW.NE.1) GOTO 30
        P1=9.
        P2=9.
        PX3=0.
        PY3=0.
        PX4=9.
        PY4=0.
```

```fortran
      P5=9.
      PX6=0.
      PY6=18.
      PX7=2.
      PY7=-2.
      P8=1.
      PX9=1.
      PY9=-1.
      CALL XAXX(P1,P2,PX3,PX4,P5,PX6,PX7,P8,PX9,XLBL)
      CALL YAXX(P1,P2,PY3,PY4,P5,PY6,PY7,P8,PY9,YLBL)
   30 IF(IPNVEL.NE.1)CALL PNVELN
      TYPE *,'WHAT IS THE NAME OF THE INPUT FILE?'
      ACCEPT 97,(INAME(I),I=1,10)
   97 FORMAT(10(A1))
 1267 FORMAT(1X,F6.2,1X,F6.2,1X,I3)
      OPEN (UNIT=9,NAME=INAME,TYPE='OLD',ACCESS='SEQUENTIAL',
     .FORM='FORMATTED',ERR=30)
      ISYM=0
      INT=-999
      CALL SCL(0.,18.,18.,0.)
   56 READ(9,1267,END=57) XPOS,YPOS,INTSTY
      IF(INT.EQ.-999) IVFRST=INTSTY
      IF(INT.NE.INTSTY) ISYM=ISYM+1
      IF(INT.NE.INTSTY) PAUSE
      INT=INTSTY
      CALL PLT(XPOS,YPOS,1)
      CALL PEN
      CALL SYMB(ISYM)
      GOTO 56
   57 IVLAST=INTSTY
      TYPE*,'DO YOU WANT TO LABEL? (YES=1)'
      ACCEPT*, LAB
      IF(LAB.EQ.1) CALL IDENTC(IVFRST,IVLAST,ISYM)
  667 TYPE*,'DO YOU WANT TO PLOT ANOTHER MAP? (YES=1)'
      ACCEPT*,MAP
      IF(MAP.EQ.1) GOTO 8
      STOP
      END
C
C
C
      SUBROUTINE IDENTC(IVFRST,IVLAST,ISYM)
      DIMENSION NUM(3)
      BYTE NAME(81),NUM
      DATA NAME/81*' '/
      DATA NUM/3*' '/
  100 TYPE *,'ENTER LABEL (LESS THAN 80 CHARACTERS)'
      TYPE *,'ENTER 'ZZZ' IF FINISHED'
      ACCEPT 30,(NAME(J),J=1,80)
      IF((NAME(1).EQ.'Z').AND.(NAME(2).EQ.'Z').AND.(NAME(3).EQ.'Z'))
     .GOTO 66
```

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```fortran
      TYPE *,' '
      TYPE *,'USE PLOTTER PEN CONTROL TO POSITION LABEL'
      TYPE *,'RETURN WHEN SATISFIED'
      PAUSE
      CALL CSIZ(1.5,1.5,0.,0)
  20  CALL LBL(NAME)
      DO 50 I=1,80
      J=81-I
      IF(NAME(J).NE.' ') GOTO 60
  50  CONTINUE
  60  CONTINUE
      CALL CPLT(FLOAT(-J),-1.2)
      GOTO 100
  66  INCRMT=(IVLAST-IVFRST)/(ISYM-1)
      IVFRST=IVFRST-INCRMT
      CALL CPLT(3,-2.2)
      DO 112 I=1,ISYM
      IV=I
      INUM=IVFRST+INCRMT
      IVAR=INUM
      ENCODE(3,13,NUM) INUM
  13  FORMAT(I3)
      CALL SYMB(IV)
      CALL CPLT(1,.4)
      CALL LBL('=')
      CALL CPLT(1,0)
      CALL LBL(NUM)
      CALL CPLT(1,0)
      CALL LBL('DB')
      IF(IVAR.LT.100) CALL CPLT(-9,-1.2)
      IF(IVAR.GE.100) CALL CPLT(-10,-1.2)
 112  CONTINUE
      CALL CSIZ(2.5,1.5,0.,0)
  30  FORMAT(80A1)
      RETURN
      END
C
C
C
      SUBROUTINE XAXX (P1,P2,P3,P4,P5,P6,P7,P8,P9,LABEL)
      COMMON /ADDRES/ INSTR
      COMMON /XYSCLP/ SCLP1,SCLP2,SCLP3,SCLP4
      BYTE ARRAY(10),LABEL(39)
      DATA ARRAY /10*' '/
      P15=-.1*P9
      P11=.1*P9
      P16=0.
      SCLP1=P6-P7*P3
      SCLP2=P6+(P1-P3)*P7
      HGHT=40./P2
      CALL CSIZ(2.,1.5,0.,0.)
```

110

```
      CALL SCL(0.,P1,0.,P2)
      CALL PLT(P1,0.,-2)
      CALL PLT(P1,P2,-1)
      CALL PEN
      XPLT=P3
      YPLT=P4-P11
      CALL PLT(XPLT,YPLT,1)
      JINT=0
      IG3=0
      CALL FINTGR(P6,P7,JINT)
      IF(JINT.EQ.1)GOTO 201
      CALL FINTGR(P6*10.,P7*10.,JINT)
      JINT=JINT+1
      IG3=1
201   CONTINUE
      IF((P6+P7*P16).GT.10000.)JINT=0
   4  CONTINUE
      IF(JINT.EQ.0) GOTO 202
15    FORMAT(1I9)
      IF(JINT.EQ.1)ENCODE(9,15,ARRAY(1)) INT(P6+P16*P7)
      IF(JINT.EQ.2)ENCODE(9,12,ARRAY(1)) P6+P16*P7
      GOTO43
202   CONTINUE
   10 FORMAT(1PE9.2)
   11 FORMAT(1F9.0)
   12 FORMAT(1F9.1)
   13 FORMAT(1F9.2)
   14 FORMAT(1F9.3)
      ENCODE (9,10,ARRAY(1)) P6+P16*P7
      IF(ABS(SCLP1).LT.10000.AND.ABS(SCLP2).LT.10000)
     .ENCODE (9,11,ARRAY(1)) P6+P16*P7
      IF(ABS(SCLP1).LT.1000.AND.ABS(SCLR2).LT.1000)
     .ENCODE (9,12,ARRAY(1)) P6+P16*P7
      IF(ABS(SCLP1).LT.100.AND.ABS(SCLP2).LT.100)
     .ENCODE (9,13,ARRAY(1)) P6+P16*P7
      IF(ABS(SCLP1).LT.10.AND.ABS(SCLP2).LT.10)
     .ENCODE (9,14,ARRAY(1)) P6+P16*P7
   43 CONTINUE
      IF(ARRAY(1).NE.' ') GOTO 44
      DO 45 IC=1,9
      ARRAY(IC)=ARRAY(IC+1)
   45 CONTINUE
      ARRAY(10)= ' '
      GOTO 43
   44 CONTINUE
      ISAV=9
      DO 666 IA=1,9
      IF(ARRAY(10-IA).EQ.' ') GOTO 666
      ISAV=10-IA
      GOTO 667
  666 CONTINUE
```

111

```
    667 CONTINUE
        P18=ISAV
        DO 888 JJ=1,9
        IF(ARRAY(JJ).EQ.'0') ARRAY(JJ)='0'
    888 CONTINUE
        P17=0.
        CALL PEN
        CW=-(P18/2.+.25)
        CH=.75*P9+.2
        CALL CPLT(CW,CH)
        CALL LBL(ARRAY)
        CW=-(P18/2.-.25)
        CH=-.2-.75*P9
        CALL CPLT(CW,CH)
      3 CONTINUE
        P16=P16+1.
        P17=P17+1.
        IF(P16.LE.P5) CALL IPLT(0.,P11,2)
        IF(P16.LE.P5) CALL IPLT(1.,0.,2)
        IF(P16.LE.P5) CALL IPLT(0.,P15,2)
        IF(P17.LT.P8) GOTO 3
        IF(P16.LE.P5) GOTO 4
        DELX=-.5*P5
        DELY=0.
        CALL IPLT(DELX,DELY,1)
        DO 5 I=1,39
        IF(LABEL(40-I).EQ.' ') GOTO 5
        ISAVE=40-I
        GOTO 6
      5 CONTINUE
      6 CONTINUE
        P17=FLOAT(ISAVE)
        CALL CSIZ(2.5,1.5,0.,0.)
        CW=-P17/2.
        CH=(1.75*P9-.25)
        CALL CPLT(CW,CH)
        CALL LBL(LABEL)
        CALL PEN
        IF(SCLP1.LT.SCLP2.AND.SCLP3.LT.SCLP4)
       .CALL SCL(SCLP1,SCLP2,SCLP3,SCLP4)
        RETURN
        END
C
C
C

        SUBROUTINE YAXX(P1,P2,P3,P4,P5,P6,P7,P8,P9,YLABEL)
        COMMON /ADDRES/ INSTR
        COMMON /XYSCLP/ SCLP1,SCLP2,SCLP3,SCLP4
        BYTE ARRAY(10),YLABEL(37)
        DATA ARRAY /10*' '/
        P10=.1*P9
```

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```
      P14=-.1*P9
      P16=0.
      P19=0.
      SCLP3=P6-P7*P4
      SCLP4=P6+(P2-P4)*P7
      CALL CSIZ(2.,1.5,0.,0.)
      CALL SCL(0.,P1,0.,P2)
      CALL PLT(P1,0.,-2)
      CALL PLT(0.,0.,-1)
      CALL PEN
      XPLT=P3-P10
      YPLT=P4
      CALL PLT(XPLT,YPLT,1)
      JINT=0
      IG3=0
      CALL FINTGR(P6,P7,JINT)
      IF(JINT.EQ.1)GOTO 201
      CALL FINTGR(P6*10.,P7*10.,JINT)
      JINT=JINT+1
      IG3=1
201   CONTINUE
      IF((P6+P7*P16).GT.10000.)JINT=0
   4 CONTINUE
      IF(JINT.EQ.0) GOTO 202
15    FORMAT(1I9)
      IF(JINT.EQ.1)ENCODE(9,15,ARRAY(1)) INT(P6+P16*P7)
      IF(JINT.EQ.2)ENCODE(9,12,ARRAY(1)) P6+P16*P7
      GOTO43
202   CONTINUE
   10 FORMAT(1PE9.2)
   11 FORMAT(1F9.0)
   12 FORMAT(1F9.1)
   13 FORMAT(1F9.2)
   14 FORMAT(1F9.3)
      ENCODE (9,10,ARRAY(1)) P6+P16*P7
      IF(ABS(SCLP3).LT.10000.AND.ABS(SCLP4).LT.10000)
     .ENCODE (9,11,ARRAY(1)) P6+P16*P7
      IF(ABS(SCLP3).LT.1000.AND.ABS(SCLP4).LT.1000)
     .ENCODE (9,12,ARRAY(1)) P6+P16*P7
      IF(ABS(SCLP3).LT.100.AND.ABS(SCLP4).LT.100)
     .ENCODE (9,13,ARRAY(1)) P6+P16*P7
      IF(ABS(SCLP3).LT.10.AND.ABS(SCLP4).LT.10)
     .ENCODE (9,14,ARRAY(1)) P6+P16*P7
   43 CONTINUE
      IF(ARRAY(1).NE.' ') GOTO 44
      DO 45 IC=1,9
      ARRAY(IC)=ARRAY(IC+1)
   45 CONTINUE
      ARRAY(10)=' '
      GOTO 43
   44 CONTINUE
```

```
      ISAV=9
      DO 666 IA=1,9
      IF(ARRAY(10-IA).EQ.' ') GOTO 666
      ISAV=10-IA
      GOTO 667
  666 CONTINUE
  667 CONTINUE
      P18=ISAV
      IF(P18.GT.P19) P19=P18
      DO 888 JJ=1,9
      IF(ARRAY(JJ).EQ.'0') ARRAY(JJ)='0'
  888 CONTINUE
      P17=0.
      CALL PEN
      CW=(P9*(P18/2.+2.)-P18/2.)
      CH=-.3
      CALL CPLT(CW,CH)
      CALL LBL(ARRAY)
      CW=-(P18/2.+P9*(P18/2.+2.))
      CH=.3
      CALL CPLT(CW,CH)
    3 CONTINUE
      P16=P16+1.
      P17=P17+1.
      IF(P16.LE.P5) CALL IPLT(P10,0.,2)
      IF(P16.LE.P5) CALL IPLT(0.,1.,2)
      IF(P16.LE.P5) CALL IPLT(P14,0.,2)
      IF(P17.LT.P8) GOTO 3
      IF(P16.LE.P5) GOTO 4
      DELX=0.
      DELY=-.5*P5
      CALL IPLT(DELX,DELY,1)
      DO 5 I=1,37
      IF(YLABEL(38-I).EQ.' ') GOTO 5
      ISAVE=38-I
      GOTO 6
    5 CONTINUE
    6 CONTINUE
      P17=FLOAT(ISAVE)
      CW=P9*(P19+2.)+.5
      CH=0.
      CALL CPLT(CW,CH)
      CALL CPLT(-1.,0.)
      CALL CSIZ(2.5,1.5,90.,0.)
      CW=-P17/2.
      CH=0.
      CALL CPLT(CW,CH)
      CALL LBL(YLABEL)
      IF(SCLP1.LT.SCLP2.AND.SCLP3.LT.SCLP4)
     .CALL SCL(SCLP1,SCLP2,SCLP3,SCLP4)
      RETURN
```

```
      END
C
C
C
      SUBROUTINE SYMB(ISYM)
      COMMON/ADDRES/INSTR
      BYTE MESSAG(80)
      DATA MESSAG/80*0/
      CALL CSIZ(2.5,1.5,0.,0.)
      ENCODE(12,2421,MESSAG(1))'SI,175,.35; '
2421  FORMAT(1A12)
      CALL IBSEND(MESSAGE,11,INSTR)
      IF(ISYM.NE.1)GOTO 1
      ENCODE(42,2424,MESSAG(1))'UC-99,-3,-3,99,6,0,0,6,-6,0,0,-6,
     1-99,3,3; '
2424  FORMAT(1A42)
      CALL IBSEND(MESSAG,41,INSTR)
      GOTO 99
1     CONTINUE
      IF(ISYM.NE.2)GOTO2
      ENCODE(38,2425,MESSAG(1))'UC-99,0,4,99,-3,-6,6,0,-3,6,-99,
     10,-4; '
2425  FORMAT(1A38)
      CALL IBSEND(MESSAG,37,INSTR)
      GO TO 99
2     CONTINUE
      IF(ISYM.NE.3)GOTO3
      ENCODE(39,2426,MESSAG(1))'UC-99,-3,2,99,6,0,-3,-6,-3,6,-99,
     13,-2; '
2426  FORMAT(1A39)
      CALL IBSEND(MESSAG,38,INSTR)
      GO TO 99
3     CONTINUE
      IF(ISYM.NE.4)GOTO 4
      ENCODE(62,2427,MESSAG(1))'UC-99,-1,3 99,-2,-2,0,-2,2,-2,2,
     10,2,2,0,2,-2,2,-2,0,-99,1,-3; '
 2427 FORMAT(1A62)
      CALL IBSEND(MESSAG,61,INSTR)
      GOTO 99
4     CONTINUE
      IF(ISYM.NE.5)GOTO 5
      ENCODE(43,2428,MESSAG(1))'UC-99,3,0,99,-3,4,-3,-4,3,-4,3,
     14,-99,-3,0; '
 2428 FORMAT(1A43)
      CALL IBSEND(MESSAG,42,INSTR)
      GOTO 99
5     CONTINUE
      IF(ISYM.NE.6)GOTO 6
      ENCODE(38,2429,MESSAG(1))'UC-99,2,2,99,-6,0,6,-6,0,6,
     1-99,-2,-2; '
 2429 FORMAT(1A38)
```

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```
        CALL IBSEND(MESSAG,37,INSTR)
        GOTO 99
6       CONTINUE
99      CONTINUE
        RETURN
        END
C
C
C
        SUBROUTINE PENVEL
        COMMON/ADDRES/INSTR
        CALL IBSEND('VS1;',-1,INSTR)
        RETURN
        END
C
C
C
        SUBROUTINE PNVELN
        COMMON/ADDRES/INSTR
        CALL IBSEND('VS;',-1,INSTR)
        RETURN
        END
C
C
C
        SUBROUTINE FINTGR(G1,G2,JINT)
        JINT=0
        IF(((G1-INT(G1)).EQ.0).AND.((G2-INT(G2)).EQ.0)) JINT=1
        RETURN
        END
```