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Investigation of Ground Reflection and Impedance from Flyover Noise Measurements

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16. Abstract
In October 1974, an extensive series of flyover noise tests was conducted at the Fresno Air Terminal for the primary purpose of studying meteorological effects on propagation of aircraft noise. The test airplane, a DC-9-10, flew several level-flight passes at various heights over a taxiway. Two microphone stations, separated by 595 m, were located under the flight path. At each station, there was a microphone at a height of 1.2 m above the concrete taxiway, a microphone at a height of 1.2 m at the center of a 3-m-dia region of randomly spaded soil, and a microphone mounted flush in a plywood board on the ground. A total of 37 runs was selected for analysis and processed to obtain a consistent set of 1/3-octave-band sound pressure levels at half-second intervals. The goal of the present study was to use the flyover noise data to deduce acoustical reflection coefficients and hence acoustical impedances.

Direct determination of the reflection coefficients (or acoustical impedances) was prevented by the generally small differences between sound pressure levels measured over the concrete and spaded-soil surfaces. Therefore, an indirect procedure was adopted in which physically reasonable assumptions for acoustical impedances were made and differences between sound pressure levels over the two surfaces were calculated using ground reflection theory. Good agreement between calculated and measured differences was obtained when the impedance of concrete was assumed to be infinite and that of spaded soil was assumed to be that previously measured for grass-covered soil. Fair agreement was also obtained when the impedance model for the spaded soil was varied widely, thereby verifying the relative insensitivity of reflection coefficients to large changes in ground-surface impedance. Spectral anomalies were observed at shallow sound propagation angles and were partially explainable by ground-reflection theory.

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INVESTIGATION OF GROUND REFLECTION AND IMPEDANCE FROM FLYOVER NOISE MEASUREMENTS

Robert L. Chapkis and Alan H. Marsh

INTRODUCTION

All outdoor measurements of sound pressures from a stationary or a moving source will be affected by sound waves reflected from the ground surfaces. The reflected waves interfere, constructively and destructively, with the sound waves traveling directly from the source to the microphone. The magnitude and frequency of the interference effects are functions of the geometrical relationships between the source, microphone, and ground plane; of the speed (or Mach number) of the source if it is moving; and the specific acoustical impedance of the ground surface (i.e., the complex ratio of the sound pressure to the particle velocity of a sound wave at a point on the surface).

For aircraft noise, ground reflection and ground impedance phenomena are an important consideration because of the effects of the interference patterns on measurements or predictions of the spectrum of the signal. Indeed, the size of noise exposure contours around airports is critically dependent on the assumed ground attenuation factor which is related to the specific acoustical impedance of the local terrain where the sound waves are reflected.

Ground reflection effects are not, of course, the only phenomenon influencing the measurements of aircraft noise. As the sound waves propagate from the source(s) of noise on an airplane, the acoustical energy is reduced by atmospheric absorption effects — effects that are a function of the temperature, pressure, and humidity of the air and the frequency of the sound. The path of a sound wave will be diffracted (bent) by temperature and wind gradients. Sound waves can also be scattered in various directions by the velocity and temperature fluctuations associated with atmospheric turbulence.

During 1974, the Federal Aviation Administration (FAA) became concerned about the affects of sound propagation phenomena on measurements of aircraft flyover noise. The FAA arranged to obtain measurements of aircraft flyover noise levels in an extensive series of tests in October and November 1974. The October tests were conducted at Fresno Air Terminal in Fresno, California. The November tests were conducted at Yuma International Airport in Yuma, Arizona. McCollough and True, reference 1, and True, reference 2, describe the FAA program and report results of studies of atmospheric absorption phenomena.

The NASA Langley Research Center assisted the FAA in conducting the tests by providing instruments and test personnel. NASA personnel decided to enrich the FAA program by installing additional microphones to acquire data that could be used to study ground reflection phenomena in noise measured by microphones at different heights above different ground surfaces. A total of six microphones were used. NASA personnel have studied some of the test data and have presented results concerned with the effects of atmospheric absorption and microphone height on the measured noise levels, see Hosier and Hilton, reference 3.

Data were available from the six microphones at 0.5-second intervals throughout the duration of each aircraft flyover. A total of approximately 270 runs was made on various days with a variety of meteorological conditions. A representative set of data was selected from the large sample of available data for the analyses described in this report.

Some ground-surface acoustical impedance data have been obtained with an impedance tube or by probing the sound field in front of a loudspeaker aimed at the ground, see Dickinson, references 4 and 5. Ventres, Myles, and Ver, reference 6, used a correlation technique in their studies of the acoustical impedance of ground surfaces. In 1974 and 1975, the A-21 Committee of the Society of Automotive Engineers reviewed the available data and theories and developed an Aerospace Information Report, reference 7, with a recommended procedure for assessing ground reflection effects from stationary noise sources. Embleton, Piercy, and Olson, reference 8, present the results of analytical and experimental studies of outdoor sound propagation over surfaces with finite acoustical impedance. Norum and Liu, reference 9, conducted an experiment with a moving acoustic monopole source and compared their measurements with calculations made with a wide range of assumed values for ground impedance. Two recent reviews of the state of the art in ground impedance and reflection effects are given in papers by Oncley, reference 10, and by Piercy, Embleton, and Sutherland, reference 11. Knowledge of the acoustical impedance of the ground surface is a common requirement in application of any of the theoretical models to practical problems of outdoor sound propagation. Most of the available data only provide impedance values over a limited range of frequency.

The goal of the study described in this report was to deduce the acoustical impedances of the concrete and spaded soil surfaces beneath four of the six microphones by examining the spectra from all six microphones on the basis of ground reflection theory. As will be shown later in the report, the measured data and the analyses showed that aircraft flyover noise spectra are rather insensitive to changes in ground impedance for the sound propagation angles for which data were obtained. Nevertheless, by incorporating reasonable impedance models, ground reflection theory was able to explain many of the observed differences between sound pressure levels measured by the different microphones at most of the times throughout the duration of the flyover. In the remainder of this report we describe the tests that were conducted and the data that were available to study. The analytical basis for the investigations is presented followed by a discussion of the results.

SYMBOLS

[All dimensional quantities have SI units]

c	speed of sound
Ci	cosine integral
f	frequency
f_i	geometric mean frequency of 1/3-octave band
Δf	bandwidth of 1/3-octave band
FL	focal length of camera used to photograph test airplane
h	microphone height
H	airplane height
i	$\sqrt{-1}$
IL	image length in photograph of test airplane
IRIG	Inter-Range Instrumentation Group
ℓ	distance from point on the ground below the microphone to the point where the incident sound wave reflects from the ground
M	airplane Mach number, V/c
ΔN	difference between the sound pressure level measured above a reflecting surface and the free-field level at the same location (equation 3)
OL	object length or true length of aircraft component in photographs to determine height overhead
p	sound pressure
p_{mic}	sound pressure at microphone
Q	complex reflection coefficient; $Q = \|Q\| e^{i\delta}$
$\|Q\|$	absolute magnitude of the reflection coefficient
r	path length of direct ray from a stationary sound source (figure 7)
r'	path length of reflected ray from a stationary sound noise (figure 7)
Δr	for a stationary sound source, the difference between reflected-ray path length and direct-ray path length (figure 7); $\Delta r = r' - r$

R	real part of complex impedance; also the path length of the direct ray from the position of a moving sound source at the retarded time t - (R/c) to the microphone (figure 10)
R'	path length of the direct ray from the position of a moving image sound source at the retarded time t - (R'/c) to the microphone (figure 10)
s	for a stationary sound source, the ratio of path length of direct ray to path length of reflected ray; s = r/r'
S	For a moving sound source, the ratio defined by $(R/R')[(1-M \cos \theta)/(1-M \cos \theta')]$
Si	sine integral
t	time
t_e	retarded time for emission of sound from the source; $t_e = t - (R/c)$
t_e'	retarded time for emission from the image source; $t_e' = t - (R'/c)$
T	time after IRIG start time
V	airplane speed
W(f)	spectral density of mean-squared sound pressure
x	horizontal distance from source to microphone (figure 10)
Z	complex impedance; $Z = R + i\chi$
α	constant in equation 3; $\alpha = 0.7275$ for 1/3-octave-band analysis
β	constant in equation 3; $\beta = 6.3252$ for 1/3-octave-band analysis
δ	phase of reflection coefficient
θ	angle between the horizontal and the direct ray from the source at the retarded time t - (R/c) (figure 10)
θ'	angle between the horizontal and the ray from the image source at the retarded time t - (R'/c) (figure 10)
λ	wavelength of sound
ρ	density of air
χ	imaginary part of complex impedance
ψ	incident-ray grazing angle at the ground surface (figure 7)
<>	time average or mean value

TEST ARRANGEMENTS AND GENERAL PROCEDURES

As mentioned in the Introduction, attempts were made to record noise data for a total of approximately 270 runs at the Fresno and Yuma test sites. To limit somewhat the choices for the data to be analyzed, it was decided to select runs only from those recorded at Fresno.

At Yuma, the tests were all conducted at night or in the early morning hours (2200 to 0600 hours) because a test objective was to acquire data when there was a nocturnal wind shear aloft. Since airplane tracking was by means of polaroid photographs, there was larger inherent error in the height data from Yuma because of the requirement to scale the distance between the streak left by the wingtip lights. Furthermore, the microphones 'over the runway' were along the edge of the runway in line with the runway lights. The winds were higher at Yuma than at Fresno where the wind was generally calm. At Fresno, the 'over-the-runway' microphones were on the centerline of a 15.2-m-wide concrete taxiway so that the surface under the microphone was uniquely defined and the same for all reflected waves impinging on the microphone.

The general layout of the Fresno Air Terminal is shown in figure 1. The airport is located about 11 km northeast of downtown Fresno. It is at a field elevation of approximately 101 m above mean sea level. The airport serves the central San Joaquin valley. Commercial air-carrier jet transports, business jets, and the California Air National Guard use the 2932-m-long by 46-m-wide paved and lighted runway 11L/29R. General-aviation aircraft use the 904-m-long by 23-m-wide paved and lighted runway 11R/29L.

The flyover noise tests were conducted by flying over the centerline of the essentially unused taxiway B to the north of the active runways. A series of nominally level flights was flown in a racetrack or figure 8 pattern. The prevailing wind, when there is wind, is from the northwest (i.e., from a compass heading of 290 degrees). There were no lights along the taxiway and no asphalt or macadam shoulder along the edge of the concrete. The ground surface along the edge of the taxiway had been scraped clear of weeds and was relatively smooth and flat. The ground was rather hard and compact. The soil was a sandy loam with an unknown moisture content although it was probably quite dry after a typical long, hot summer with little or no rain.

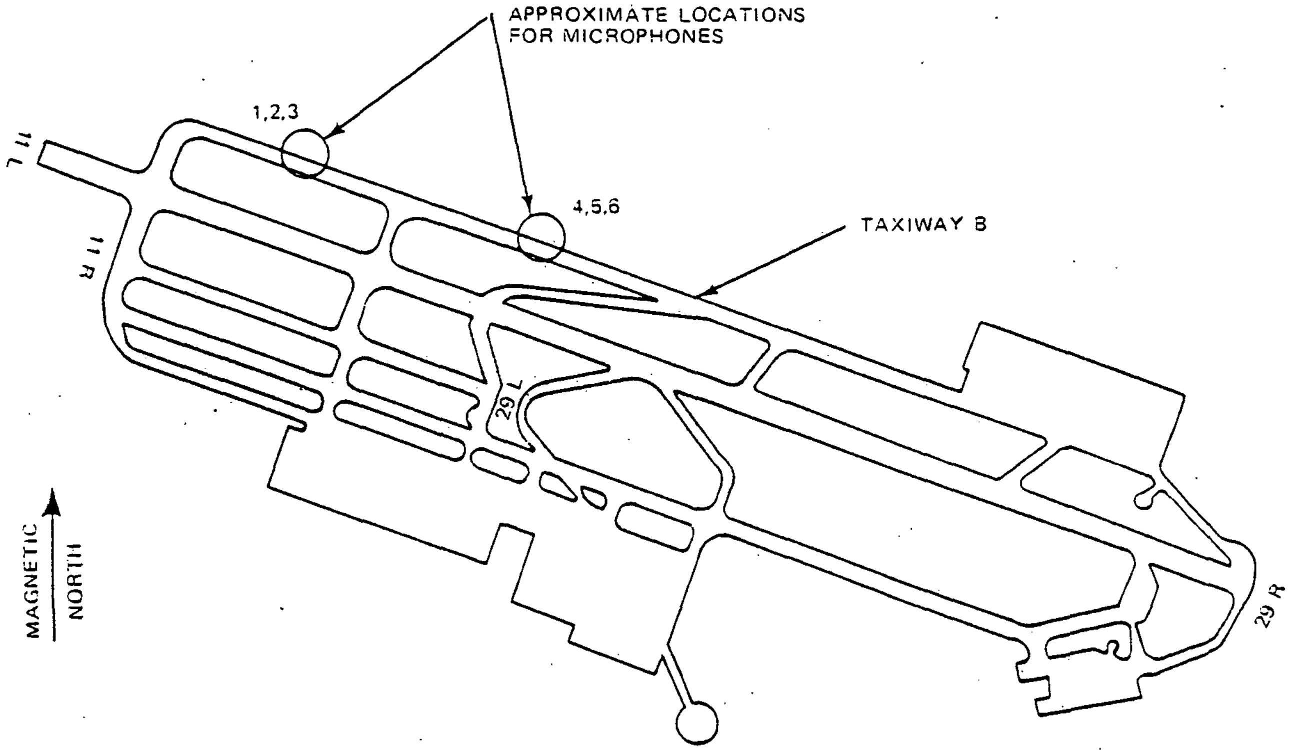


Figure 1.- General layout of Fresno Air Terminal.

The six microphones were placed in two groups of three on, and to the north of, the taxiway as indicated by the circled regions in figure 1. Microphones 1, 2, and 3 were in one group; microphones 4, 5, and 6 were in the other group.

The FAA test plan involved two different test airplanes, a McDonnell Douglas series 10 DC-9 and a McDonnell Douglas model 61 DC-8. Only a relatively few runs were recorded using the DC-8 and it was decided to further limit the selection to only the data recorded using the DC-9-10 test airplane. Moreover, it was decided to omit runs where the DC-9 was deliberately flown over the turbulence in the wake of the DC-8. Additional culling of the available data was performed by FAA and NASA personnel in their previous analyses of the Fresno/Yuma data. The process of limiting the analyses to the best samples of DC-9 flyovers at Fresno resulted in a set of 92 runs, out of the 270, from which a subset of data was selected for the analyses in this report.

Figure 2 shows a 3-view of a DC-9-10 airplane. The principal dimensions are indicated. The wingspan was the dimension usually used in calculating airplane height because it was seen in true perspective when the photograph was taken at the time when the airplane was overhead and the airplane actually was flying in level flight along the taxiway centerline. The fuselage length was available as an alternative to the wingspan, but was seldom used because of the foreshortening produced by the nose-up or nose-down attitude during most of the flyovers.

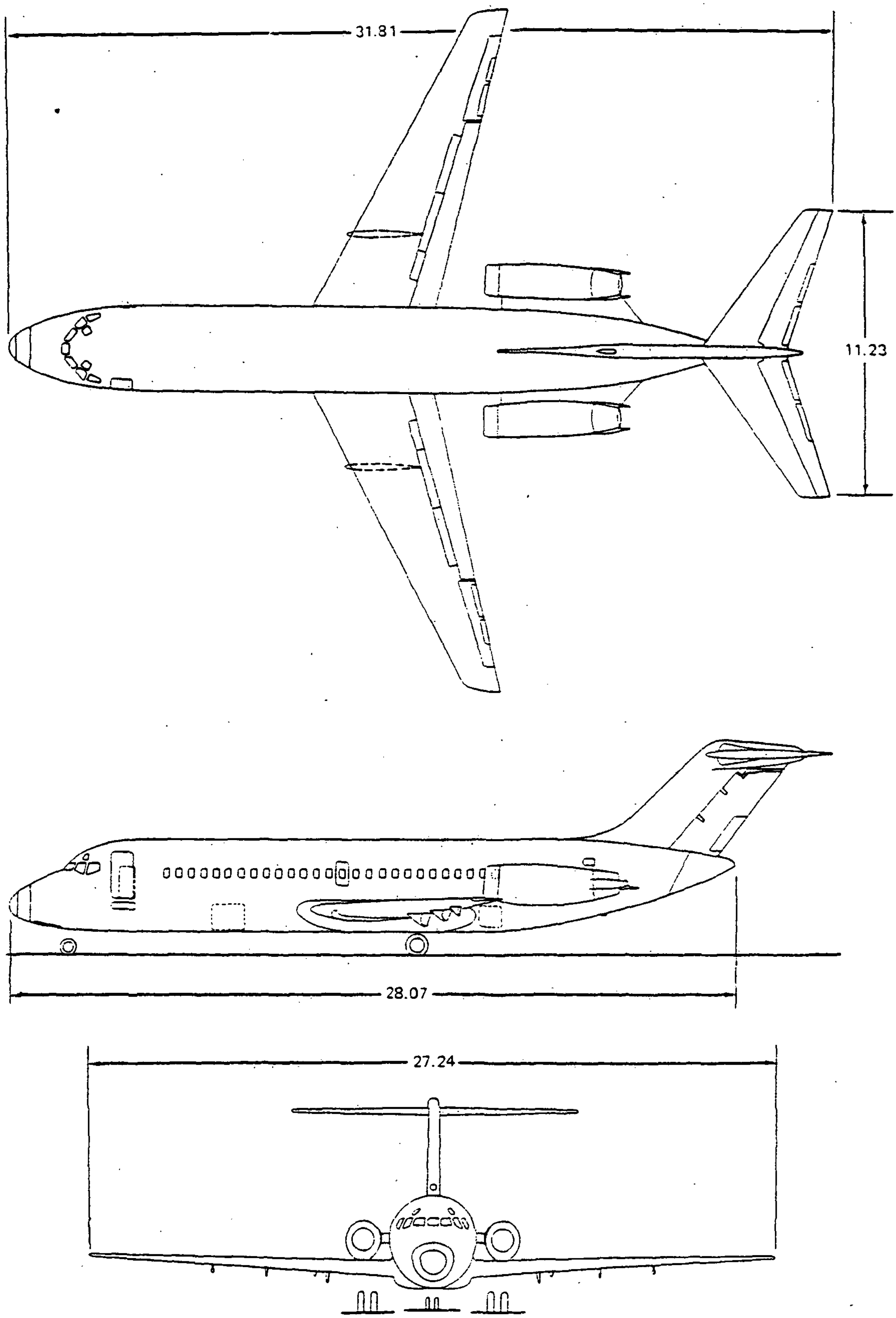
DATA ACQUISITION

Microphones

The six microphones were located on, and to the north side of, taxiway B according to the arrangement shown in figure 3. The two microphone stations were separated by a distance of approximately 595 m. Microphones 1 and 4 were at a height of 1.2 m and on the centerline of the concrete taxiway. Microphones 2 and 5 were flush in a 1-m-sq painted plywood groundboard. Microphones 3 and 6 were at a height of 1.2 m in the center of a 6-m-dia circle of spaded soil. The data from microphones 1 and 4 and 3 and 6 contain the effects of ground reflections in the measured spectra and were the data of most interest. The data from the flush-mounted microphones were used to determine the spectral shape of free field sound pressure levels. Note that microphones 2 and 5 and 3 and 6 were not quite symmetrically placed relative to the distance from the taxiway centerline. Photographic views of the three types of microphone locations are given in figure 4.

The microphones were 1/2-inch-diameter air-dielectric capacitor types. The centerline microphones and the two microphones over spaded soil were oriented for grazing incidence throughout the flyovers under the assumption that the airplane always flew along the taxiway centerline with no lateral deviation for the duration of the airplane noise signal.

Table 1 lists general test information for the test airplane and the microphones. The coordinate system used to define the microphone locations has the origin at the point on the taxiway below microphone 1. Note that all heights are above ground level.



DIMENSIONS IN METERS

Figure 2.-3-view of DC-9-10

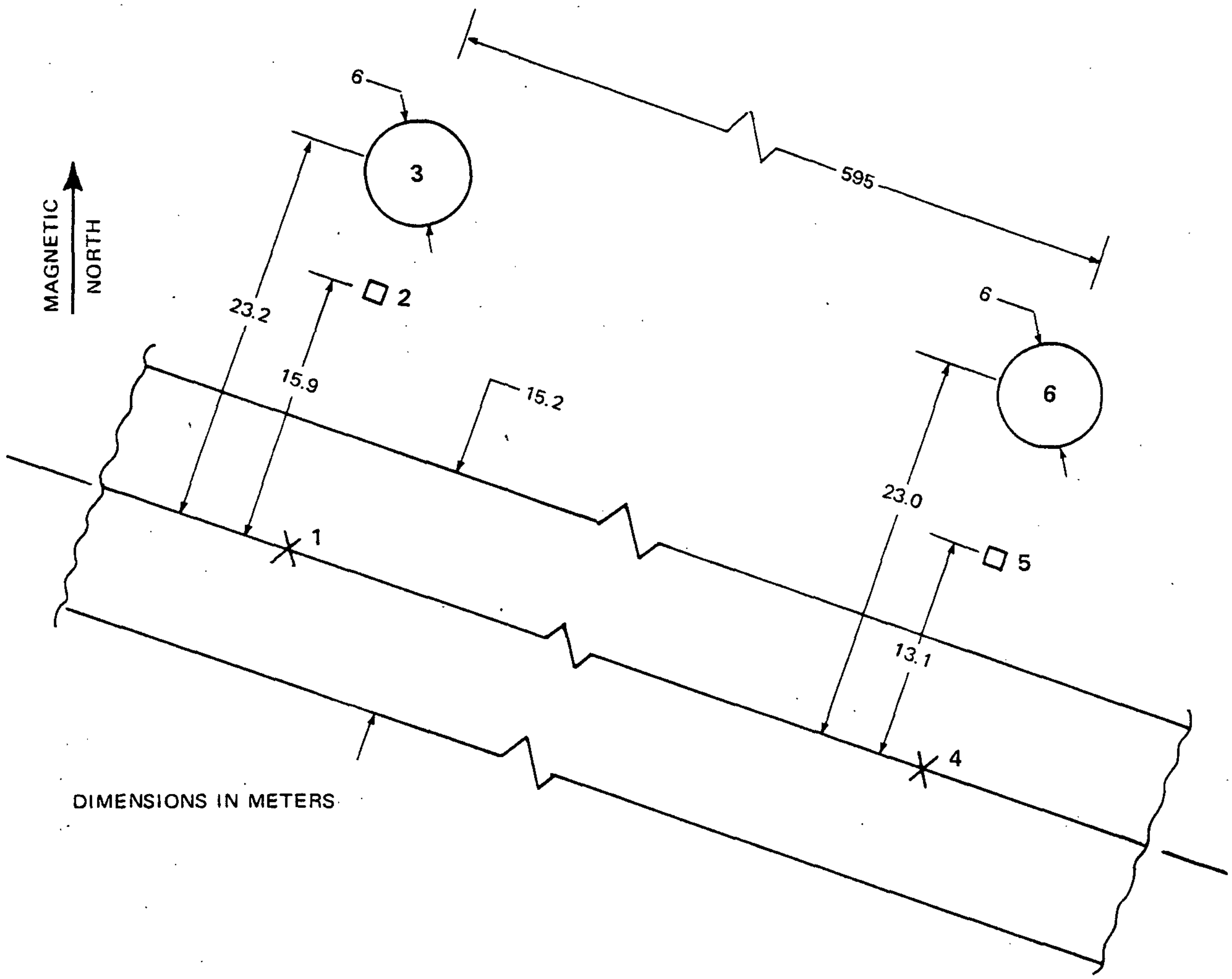


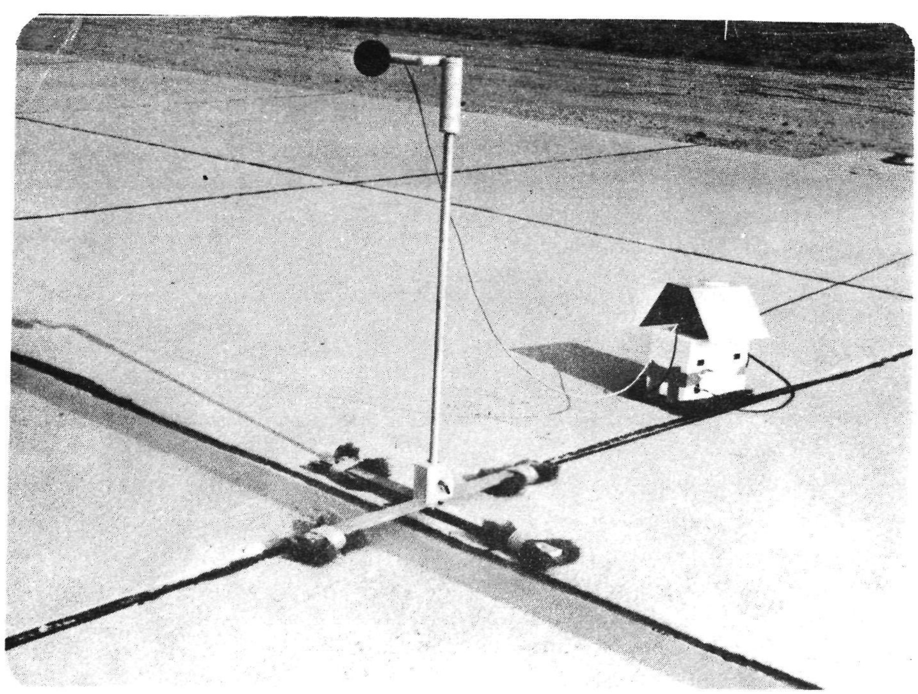
Figure 3.-Microphone locations on and to the side of taxiway B.

Windscreens were placed around the microphones at all times. Reticulated polyurethane foam balls were used around microphones 1, 3, 4, and 6. Special cheesecloth windscreens were used around the flush microphones at locations 2 and 5.

Data Recording System

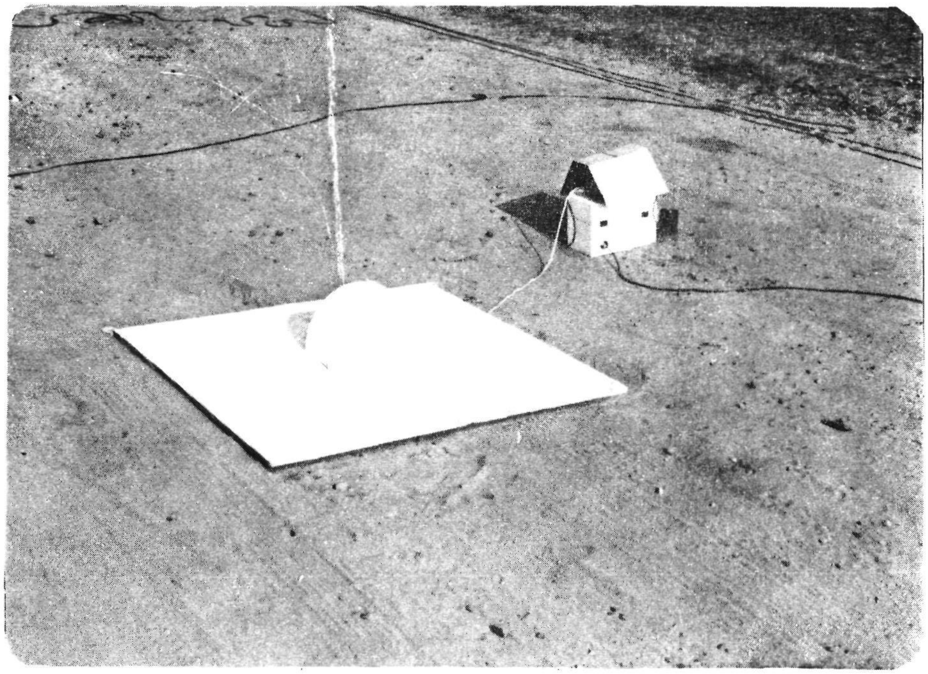
The signals from the six microphones were recorded simultaneously on one 14-channel FM instrumentation-grade magnetic tape recorder. Operational amplifiers were used after the cathode-follower microphone preamplifiers and the microphone power supplies to provide sufficient current to drive the

(a) OVERALL VIEW OF ONE SET OF THREE MICROPHONES



(b) 1.2m OVER CONCRETE TAXIWAY

Figure 4.- Views of microphone locations.



(c) FLUSH IN 1-m-SQ PLYWOOD BOARD

(d) 1.2m OVER RANDOMLY SPADED SOIL

Figure 4.-Concluded.

Table 1. - General Test Information

NASA/FAA DC-9 FLYOVER NOISE TESTS AT FRESNO AIR TERMINAL IN OCTOBER 1974

AIRPLANE: DC-9-10; REGISTRY NO.: N119; ENGINES: P&WA JT8D-1; NACELLE ACOUSTICAL TREATMENT: NONE

FLIGHT TYPE: NOMINAL LEVEL FLIGHTS OVER TAXIWAY B: HEADINGS: 110 TO SE, 290 TO NW

COORDINATE SYSTEM: X AXIS IN GROUND PLANE ALONG TAXIWAY CENTERLINE AND POSITIVE FROM NORTHWEST TO TO SOUTHEAST (COMPASS HEADING 110).

Y AXIS IN GROUND PLANE PERPENDICULAR TO TAXIWAY CENTERLINE AND POSITIVE TO NORTHEAST (COMPASS HEADING 020).

Z AXIS PERPENDICULAR TO GROUND PLANE AND POSITIVE UP.

ORIGIN AT MICROPHONE LOCATION 1.

MICROPHONE COORDINATES: 1 (0,0, 1.2); 2 (0, 15.9, 0); 3 (0, 23.2, 1.2); 4 (595, 0, 1.2); 5 (595, 13.1, 0); 6 (595, 23.0, 1.2) [DIMENSIONS IN METERS]

DESCRIPTION OF GROUND SURFACES AT MICROPHONES: 1 AND 4 WERE 1.2m ABOVE CONCRETE TAXIWAY: 2 AND 5 WERE FLUSH IN CENTER OF 1-m-SQUARE, 12-mm-THICK PLYWOOD GROUNDBOARD: 3 AND 6 WERE 1.2m ABOVE CENTER OF 6-m-DIA AREA OF LOOSE SPADED DIRT.

MICROPHONE ORIENTATION: 1 AND 4 HAD MIC AXIS PARALLEL TO TAXIWAY, POINTED AWAY FROM LOCATIONS 2 AND 3, AND 5 AND 6, RESPECTIVELY (GRAZING INCIDENCE). 3 AND 6 HAD MIC AXIS PARALLEL TO GROUND PLANE POINTED TOWARD TAXIWAY (NOMINALLY GRAZING INCIDENCE). 2 AND 5 WERE POINTED UP AND FLUSH WITH SURFACE OF GROUNDBOARD (RANDOM INCIDENCE ASSUMED).

microphone signal cables. The cables were as long as 457 m.

The tape recorder complied with the standards of the Inter-Range Instrumentation Group (IRIG) and used 25.4-mm-wide tape on 36.56-cm-diameter reels operated at 76.2 cm/s with IRIG intermediate-band electronics.

Table 2 lists the principal components of the acoustical data-acquisition system. The quartz coating on the diaphragms of the microphones provided increased protection against arcing noise when the moisture content in the air was high, at the expense of reduced sensitivity.

Acoustical sensitivity checks were made at a frequency of 250 Hz using a pistonphone producing a nominal sound pressure level of 124 dB re 20 μPa.

Checks of the frequency response of the data system after the microphone were made by recording the output of a random noise generator producing a pink noise spectrum, i.e., one with a pressure spectrum level slope of -1 dB per 1/3-octave band or a flat sound pressure level spectrum after analysis in 1/3-octave bands.

Recordings of ambient noise were obtained by starting the tape recorder in advance of the initial increase of the airplane noise signal above the ambient level.

A time code was recorded on one of the data channels for use in data processing and to permit determination of airplane groundspeed.

Note that all acoustical data were recorded without any pre-emphasis boost of the high-frequency signals before the recorder. The recording system gain was set to yield an optimum recording level, safely below the distortion limit, for the maximum signal strength. The lack of pre-emphasis, the use of 1/2-inch microphones, and the available signal-to-noise ratio of the recorder limited the amount of high-frequency data at all times throughout the flyover and the amount of low-level data at any frequency at times before or after the time of the maximum signal.

Table 2. - Components of Acoustical Data-Acquisition System

B&K TYPE UA 0237 FOAM-BALL WINDSCREENS AROUND TRIPOD-MOUNTED MICROPHONES AT LOCATIONS 1, 3, 4, AND 6.

NASA CHEESECLOTH WINDSCREENS OVER FLUSH GROUNDBOARD MICROPHONES AT LOCATIONS 2 AND 5.

B&K TYPE 4134/S MICROPHONES (QUARTZ COATING ON DIAPHRAGMS).

B&K TYPE 2619 PREAMPLIFIERS.

B&K TYPE 2804 MICROPHONE POWER SUPPLIES.

NASA OPERATIONAL AMPLIFIER FOR CURRENT GAIN TO DRIVE 457m SIGNAL CABLE.

B&K TYPE 140 USED AS VARIABLE-GAIN VOLTAGE AMPLIFIER.

BELL & HOWELL MODEL VR 3300, S/N 136961, FM TAPE RECORDER

B&K TYPE 4220 (124 dB AT 250 Hz) ACOUSTIC CALIBRATOR.

GEN RAD MODEL 1382 PINK NOISE GENERATOR FOR SYSTEM FREQUENCY RESPONSE CHECKS.

SYSTRON DONNER MODEL 8120 TIME CODE GENERATOR.

SERIAL NUMBERS BY COMPONENT AT MICROPHONE LOCATIONS (REPLACEMENTS THAT OCCURRED DURING THE TEST ARE NOTED).

LOC	1	2	3	4	5	6
MIC	478824	478811	478825	478819	478817	478812+
PREAMP	504130	503905*	418471	327343†	503793	386632
PWR SUP	455327	455315	488638	488688	488663	488630

*REPLACED BY 340301 REPLACED BY 340361

†REPLACED BY 503964

+REPLACED BY 478814

Airplane Position Data

Polaroid cameras of known focal length were mounted on stands on the taxiway centerline and near microphones 1 and 4. The cameras were pointed straight up. The plane of the film was approximately 1 m above the ground plane and thus gave airplane heights approximately equal to the height over microphones 1 and 4 at the time of closest approach, which was usually the overhead position because runs were selected where the image of the airplane was as close as possible to the center of the picture in order to eliminate runs with lateral deviation from the nominal straight flight path.

Photographs were taken by an operator who watched the airplane and triggered the shutter when he judged the airplane to be at the point of closest approach. Triggering the shutter also activated an electric signal which was recorded as a direct-current pulse on the magnetic tape recorder. The accuracy and reliability of this system proved to be adequate although some problems were noted with pictures being taken too early, or too late, or not at all. Also, the operator occasionally was unable to, or failed to, coat the print with the gel and the image faded and became badly scratched. For some runs, one, or both, of the pulse trigger signals was not activated and time synchronization was lost. Some photographs were not properly or adequately identified. Fortunately, several repeat runs were made for each nominal test condition and a valid sample of useful data was easily obtained.

Airplane heights were scaled from the pictures by NASA personnel by measuring the image length for the longest dimension seen in true perspective, usually the wingspan as noted earlier. The airplane height above the plane of the film, or above the height of microphones 1 and 4, was then found from

$$H = (FL \times OL)/IL$$

where H is airplane height in meters, OL is the object length in meters (27.24 m for the wingspan of the DC-9-10), FL is the focal length of the camera (when set at infinity) in mm, and IL is the image length in mm of the object in the photograph. The focal length of the cameras was 152.4 mm. Since two photographs were taken for each run, there were several hundred pictures to catalog and read.

Engine and Airplane Data

No on-board system was used for automatic and continuous recording of time-synchronized engine and airplane data. It was considered adequate to have a cockpit observer monitor and note on a daily log sheet the readings of various cockpit instruments.

The test procedure was for the pilot to align the airplane with the taxiway, set the throttle, airspeed, and airplane configuration to the nominal or target values for the run, and then make no further adjustments until well past the second microphone. Thus, assuming the flight was actually level and straight, the use of hand-annotated cockpit logs should have provided adequate records, which they did for most cases. Examination of several log sheets revealed the benefit of experience as the tests proceeded and the records became more complete and more detailed.

The engine and airplane data available from the cockpit logs consisted of: the airplane heading, the nominal altitude from the radio altimeter, airplane pitch angle, flap deflection angle, landing gear position (up or down), takeoff gross weight, initial fuel weight, weight of the fuel remaining, ram (total) air temperature, and the indicated values of engine pressure ratio, exhaust gas temperature, and low-pressure shaft rotational speed for each engine. Engine thrust was, of course, not measured but could be estimated from manufacturer-supplied power setting curves for the indicated engine pressure ratio, air temperature, and airspeed. Knowledge of engine thrust was not required for this study and was therefore not estimated.

Since airspeed is an important parameter in the analysis, the airplane's speed was calculated using the time interval between the leading edges of the pulses recorded on the tape recorder when the photographs were triggered. The speed (groundspeed) was calculated by dividing the distance (595 m) by the time interval. Airplane Mach number was calculated by assuming that the groundspeed and the airspeed were equal (the winds were calm to negligible at the ground and aloft during the noise testing) and determining the speed of sound at the nominal height of the airplane from the air temperature measured by the meteorological test airplane and interpolated to the nominal time of the flyover noise test.

To control airspeed, all flights were flown with the landing gear extended. Flaps were deflected as required.

Meteorological Data

Meteorological data (air temperature and relative humidity) were measured at a height of 1.2 m by stationary instruments. A propeller-powered light aircraft was used to sample the air temperature and relative humidity as a function of height above ground level starting at a height of 30.5 m and continuing to a height of 915 m at increments of 30.5 m.

Meteorological data were sampled periodically throughout the day at times close to the times of the flyover noise tests. Linear interpolation was used to estimate data at the time of the noise tests.

Station barometric pressure was read hourly by National Weather Service personnel at the Fresno Air Terminal. No vertical profiles of air pressure were measured. Linear interpolation was also used to estimate the pressure at the time of the noise tests.

Measurements of air temperature, relative humidity, and air pressure were obtained in order to provide a general indication of the atmospheric conditions. The meteorological conditions of the atmosphere have important effects on sound propagation from the source to the receiver. However, except for the possible effects of freezing or baking and the resulting hardening or drying out of the soil under microphones 3 and 6 and for thermal gradients and temperature fluctuations in the layer of air near the ground surface where wave reflections occur, it was not considered necessary to do more than to note the availability of the meteorological data. The air temperature was always above 0°C and the weather was generally warm and dry.

Wind data were not available. During any test, the wind speed was always negligible.

DATA SELECTION

The Fresno flight tests were conducted in the period from 14 to 25 October 1974. The initial efforts to screen and select runs for analysis resulted in a list of 92 runs as mentioned earlier. The listing of the 92 runs is given in table 3 according to weather condition. The primary variables are the nominal or target height of the test airplane, the nominal or target value of referred thrust per engine, the nominal or target airspeed, and the weather. The descriptions of the weather and the nominal airplane/engine parameters were taken from reference 1. The description of 'baseline' in table 3 signifies a near-standard temperature lapse rate, air temperature and relative humidity within the limits of Part 36 of the Federal Aviation Regulations, and calm wind at any height from the ground to a height greater than the height of the test airplane. The Fresno tests were run during the day and in the evening from 0700 to 2300 hours.

Since it was not feasible or necessary to examine more than a fraction of the available data, the following ground rules were used to select the runs to be studied.

- From inspection of the polaroid airplane-positioning photographs, eliminate those runs where the airplane was significantly left or right of the taxiway centerline.

- Eliminate runs where data from any of the six acoustic data channels were missing or suspected of being poor quality.

- Concentrate on runs with baseline meteorological conditions in order to avoid the refraction effects occurring as the sound waves propagate through temperature inversions.

- Concentrate on runs made well after sunrise and before sunset to avoid the scattering and refraction problems associated with the thermal gradients at these times.

- Omit any runs made after sunset.

- Concentrate on runs at the nominal heights of 152 and 335 m and at the higher engine power settings in order to have data with the best signal-to-noise ratio over as wide a range as possible of frequency and angle of incidence.

Table 3. - Available flyover noise tests at Fresno by weather condition

Item	Nominal airplane height, m	Nominal referred thrust, F_n/δ_{am}, kN	Nominal indicated airspeed, $m.s^{-1}$	Number of runs available	Run numbers	Weather
1	152	13.7	77	5	321-326	baseline (no run 323)
2		26.7	77	5	375-379	
3	152	49	89.5	4	292-295	
4	335	13.3	77	7	327-333	
5		26.7	77	4	371-374	
6	335	49	89.5	5	315-319	
7	610	26.7	77	5	365-369	
8	610	49	89.5	5	341-345	baseline
9	335	26.7	77	5	118-123	hot and dry, no inversion (no run 120)
10	610			6	112-117	hot and dry, no inversion
11	335			6	171-178	strong low inversion, very hot and dry above$^{\Delta}$
12	335			5	211-215	strong low inversion, P36 window above and below
13	610			5	216-220	strong low inversion, P36 window above and below
14	335			5	237-241	weak low inversion, hot and dry
15	610			5	242-246	weak low inversion, hot and dry
16	152			5	354-359	high inversion (knee at 335m), cool and moist†
17	335			5	360-364	high inversion (knee at 335m), cool and moist
18	152	26.7	77	5	272-276	high inversion
				92		

$^{\Delta}$no runs 172 or 173; †no run 357

- Favor runs at the lower airspeed in order to minimize moving source effects.

- Eliminate runs where the data logs and other test records indicated there was a good possibility of interfering noise signals from the operation of other aircraft such as commercial jets, helicopters, and Air National Guard F-106 airplanes.

- Eliminate runs where a photograph was missing or where other important test parameters were not available.

- Include some repeat runs to help establish a measure of confidence in the results.

- Favor runs where valid pre- and post-acoustical sensitivity and system frequency response calibrations were available. Eliminate runs where neither pre- or post-run calibrations were available.

The result of applying these groundrules or guidelines to the set of 92 runs in table 3 was the selection of the 39 runs shown in table 4. For each grouping of data there were two, three, or four runs. There were five groups at the nominal height of 152 m, five at 335 m, and three at 610 m. Ten of the thirteen groups were for the mid power setting, two at the highest, and one at the lowest. Eleven of the thirteen groups were at the lower airspeed, two at the higher airspeed. Most of the tests occurred in the late morning or early afternoon hours. Low inversions were present for only two of the thirteen groups.

To appreciate the scope of the data provided by the 39 runs in table 4, assume that the desired coverage of propagation angles requires a set of twenty four 1/3-octave-band sound pressure levels every 0.5 second from each of the six microphones locations for a duration of 30 seconds [60 time samples] for the 152-m flyovers, of 55 seconds [110 time samples] for the 335-m flyovers, and of 75 seconds [150 time samples] for the 610-m flyovers. This arithmetic gives 300 samples of 1/3-octave-band data from the 152-m flyovers, 550 samples from the 335-m flyovers, and 450 samples from the 610-m flyovers — or 1300 samples per microphone. For the six microphones, the total set of data would be 7800 samples or a grand total of approximately 187,200 sound pressure level

Table 4. - Test runs selected for data processing

Item	Test date in Oct. 74	Nominal airplane height, m	Nominal referred net thrust, F_n/δ_{am}, kN	Nominal indicated airspeed, m/s	Run Number	Nominal time of day, hours	Weather
1	14	610	26.7	77	112, 113, 115, 117	1220-1255	hot and dry, no inversion
2	14	335	26.7	77	118, 121, 122, 123	1300-1330	hot and dry, no inversion
3	17	335	26.7	77	211, 212, 214, 215	0745-0825	strong low inversion
4	17	610	26.7	77	216, 218, 219	0825-0855	strong low inversion
5	21	152	26.7	77	272, 274, 275	0910-0940	high inversion
6	22	152	49	89.5	292, 295	1200-1230	baseline
7	24	335	49	89.5	315, 316, 319	1030-1105	baseline
8	24	152	13.3	77	321, 322, 326	1110-1150	baseline
9	25	152	26.7	77	358,359	0725-0735	high inversion
10	25	335	26.7	77	360, 361, 362	0745-0800	high inversion
11	25	610	26.7	77	365, 366	1040-1100	baseline
12	25	335	26.7	77	371, 373, 374	1130-1155	baseline
13	25	152	26.7	77	376, 378, 379	1200-1230	baseline
					Total: 39 runs		

values. There would be even more numbers if overall or A-weighted levels were to be included. Even though considerable data loss was anticipated because of interference from ambient or background noise, there still was more than enough information available from the runs listed in table 4 to conduct the intended study of ground reflection and impedance.

DATA PROCESSING

Discussions of the availability of consistent and reliable flyover noise data from the Fresno/Yuma tests were held with NASA and FAA personnel prior to initiating this study of ground reflection and ground impedance. Although some data had been analyzed and processed for the objectives of the tests (see references 1, 2, and 3), the consensus of opinion was that re-analysis and re-processing of selected runs was mandatory to obtain a complete set of consistent data. The Noise Technology Laboratory of The Boeing Company in Seattle, Washington was selected to analyze and process the analog tape recordings under subcontract.

The original analog tape recordings containing the flyover noise signals, time code signals, overhead timing pulses from the polaroid cameras, and acoustic sensitivity and system frequency response calibrations were obtained from NASA along with information on windscreen and microphone frequency-response corrections. NASA personnel also provided guidance on which of the pre-run or post-run calibrations should be used for each of the 39 data runs. Airplane position data, copies of the cockpit log records for engine and airplane performance data, and meteorological data were also provided by NASA.

Microphone and system frequency response corrections used in processing the data are given in Appendix A.

A schematic diagram of the major components in the Boeing data-reduction/data-processing system is given in figure 5. Table 5 lists the particular instruments used to accomplish the functions in figure 5. The objective of the data processing was to produce 24 1/3-octave-band sound pressure levels (50 to 10,000 Hz) at half-second intervals over the duration of the aircraft noise signal for each of the six microphones from each of the 39 runs of table 4. The sound pressure levels were to be referenced to 20 micropascals

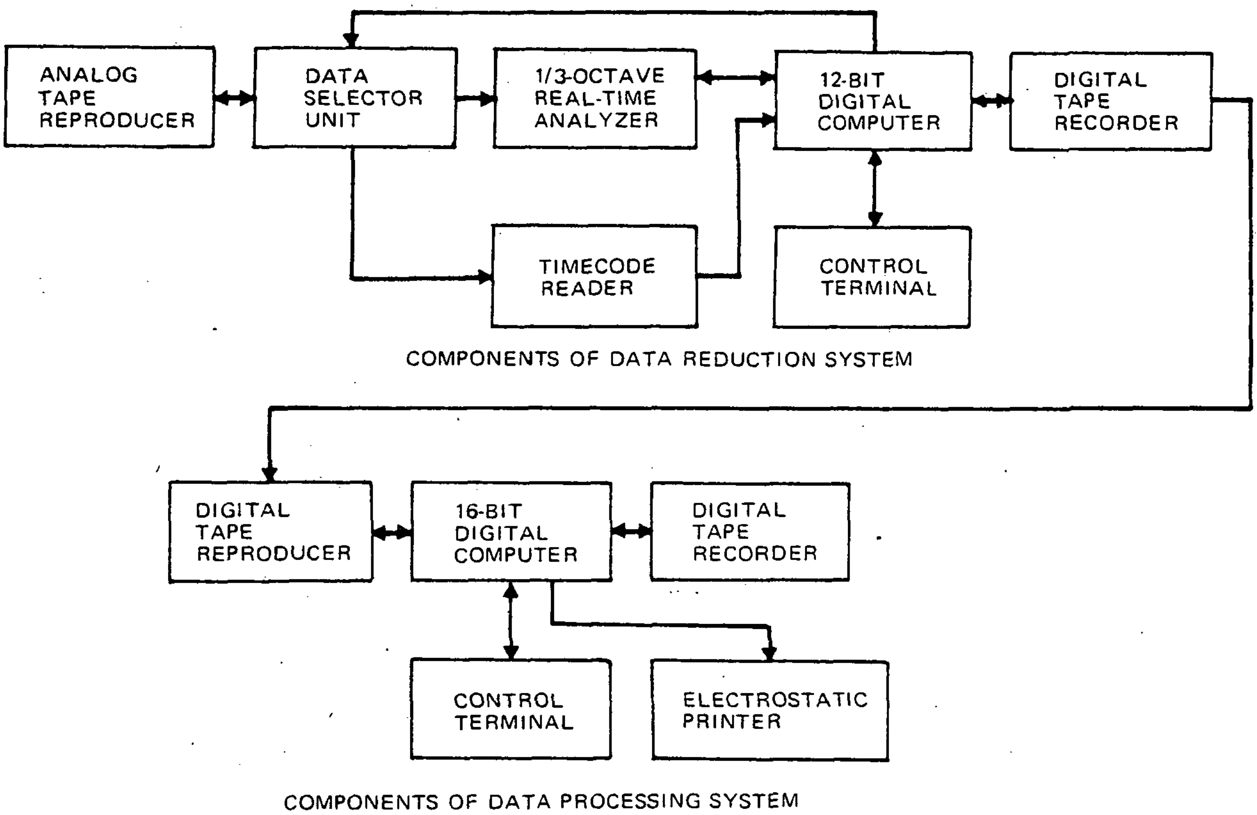


Figure 5.-System components for reduction and processing of flyover noise data.

Table 5. - Components of systems for reduction and processing of flyover noise data

DATA REDUCTION

BELL & HOWELL MODEL VR 3400 ANALOG FM TAPE REPRODUCER

BOEING DATA SELECTOR AND TAPE CONTROL UNIT

GEN RAD MODEL 1921 1/3-OCTAVE-BAND REAL-TIME ANALYZER

ASTRODATA MODEL 5400 TIMECODE READER

DIGITAL EQUIPMENT CORP. MODEL PDP 8/1 12-BIT DIGITAL COMPUTER

ASR-35 TELETYPE TERMINAL FOR SYSTEM CONTROL

DIGITAL EQUIPMENT CORP. MODEL DEC TU20 DIGITAL TAPE RECORDER

DATA PROCESSING

PERTEC MODEL 8840-8-45 DIGITAL TAPE REPRODUCER/RECORDER

PRIME MODEL 400 16-BIT DIGITAL COMPUTER

TEKTRONIX MODEL 4014 TERMINAL FOR SYSTEM CONTROL

GOULD MODEL 5000 ELECTROSTATIC PRINTER

and corrected for all known sources of error.

The computer that controlled the data-reduction system required specification of the IRIG time code at the desired instant for beginning the digitization. The IRIG start time for digitization (in hours, minutes, and seconds) was determined from the IRIG time for the overhead timing marks and an estimate of the time of occurrence of the sound signal at a selected sound propagation angle prior to the overhead time. The desired duration of the data sample was calculated from the time for a selected sound propagation angle after overhead. The calculated start and stop times assumed that the tape recording had been started well before the beginning of the airplane noise signal and had continued well after the airplane had passed overhead.

The IRIG times associated with the leading edges of the overhead event pulses were determined by displaying the recorded time code and event pulse signals on a dual-channel oscillograph. A total of 78 overhead times (two for each of the 39 runs) was determined in this way.

From the geometry of the tests, figure 6, the time when a sound signal is received at a microphone under the flight path can be related to the sound emission or sound propagation angle θ. The angle γ denotes the position of the airplane on the flight path at the time the sound emitted at an earlier time (angle θ) reaches the microphone. The airplane is considered to be a point sound source moving with speed V and subsonic Mach number M along the level flight path at a height H above the microphone. Angles are measured from the nose of the airplane relative to the flight path (or to the horizontal).

The time is assumed to be equal to zero when the airplane is directly overhead, i.e., when $\gamma = 90°$. The time is positive for $\gamma > 90°$ and negative for $\gamma < 90°$.

For the geometry in figure 6, it is readily shown that the relation between airplane position angle and sound emission angle is given by

$$\tan \gamma = (\cot \theta - M \csc \theta)^{-1} \tag{1}$$

from which it follows that the relation between sound reception time and

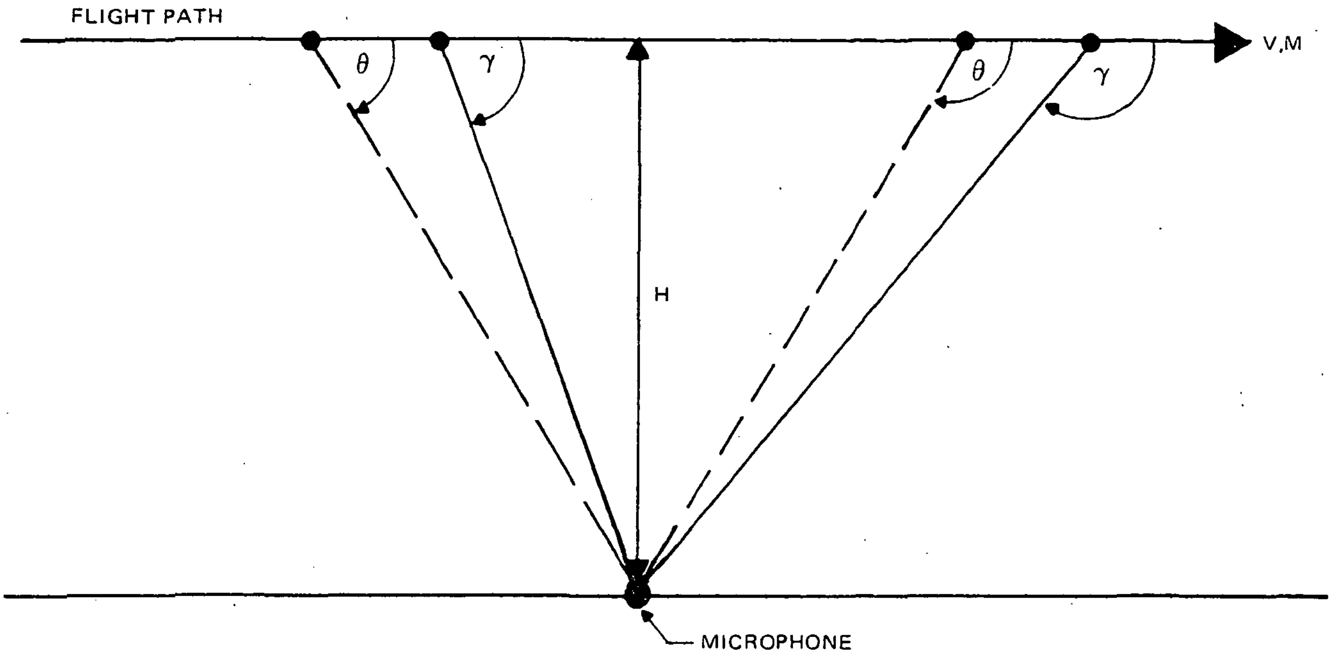


Figure 6.-Geometrical relationships for relating sound emission angle θ to sound reception time at the microphone.

sound emission angle is

$$t = (H/V)\ (M \csc \theta - \cot \theta). \tag{2}$$

When $\gamma = 90°$ and $t = 0$, then $\theta = \cos^{-1} M$.

In order to determine in advance what the desired IRIG start times and digitizing durations should be, it was arbitrarily decided to attempt to obtain data between sound emission angles of 10° and 170°, assuming valid data were on the tape for this range of angles or recording times. Airplane speeds were calculated from the 595-m distance between the microphones or cameras and the duration between event markers on the oscillograph traces. Airplane heights were supplied by NASA. Airplane Mach numbers were determined from the calculated airplane speeds and an assumed speed of sound of 342 m/s.

The results of these calculations are shown below.

Run numbers	Start time relative to IRIG time at overhead, sec	Duration, sec
112, 113, 115, 117, 216, 218, 219, 365, 366	-40	100
118, 121, 122, 123, 211, 212, 214, 215, 315, 316, 319, 360, 361, 362, 371, 373, 374	-30	70
376, 378, 379	-15	35
272, 274, 275, 292, 295, 321, 322, 326, 358, 359,	-10	25

In practice, it turned out that most of the recordings were either started too late or cut off too soon to adhere to the calculated start and stop times shown above. While the Boeing personnel attempted to comply with the desired start and duration times, the actual times were significantly different, especially for the runs at the nominal 335-m and 610-m heights. Contamination of the data by high ambient noise levels also plagued many of the data samples at times before or after overhead.

Once the operator had made a judgment of the best IRIG start time and digitizing duration for a particular run, the digital computer in the data reduction system (see figure 5) automatically started the analysis at the beginning of the first half-second sample. Digitizing times on the Boeing system always began at the start of each half-second data sample. The actual integration or averaging period was 495 ms; a period of 5 ms was required to read out the set of 24 sound pressure levels to the digital magnetic tape recorder and to get set to digitize another set of 24 levels.

The digital magnetic tape recording resulting from the data reduction step contained the indicated 1/3-octave-band sound pressure at the half-second intervals, the system frequency-response correction factors, the correction for acoustical sensitivity (i.e., the difference between 124.0 dB and the indicated band level for the 250-Hz tone), recording gain settings for the data and the acoustic calibration, and event identification such as run number and IRIG start time.

Ambient noise levels were digitized from a sample of the recording prior to the IRIG start time for the beginning of the aircraft noise signal. The ambient noise levels (as well as the 124-dB, 250-Hz calibration tone) were integrated (time averaged) for an 8-second period.

During the data-reduction process, it became necessary to abort the attempt to acquire data for runs 365 and 366. For both of these runs the original analog tape recording was started when the airplane was almost overhead. There was no usable sample of ambient noise and most of the before-overhead data was lost. Thus, data were obtained for only 37 of the 39 runs in table 4.

In processing the data, the operator entered, via the computer control terminal, the commands to read a set of data from the digital magnetic tape, to adjust the indicated levels for differences in gain and level of the 250-Hz calibration tone, and to incorporate the frequency-response correction factors. Overall sound pressure levels and A-weighted sound levels were calculated for each half-second set of 1/3-octave-band sound pressure levels. The computer also read the 1/3-octave-band sound pressure levels for the ambient noise recording and determined adjustments for ambient noise interference for each set of data. Additional identifying information was also entered at the control terminal. The computer then controlled the output to a second digital magnetic tape recording and to a tabulation on the electrostatic printer.

No additional smoothing or averaging of the data, beyond that incorporated in the 495-ms period of digital integration by the Gen Rad 1921 real time analyzer in the data reduction system, was included during data processing. No running average of two or three half-second data samples was used to simulate a highly damped meter. For the objective of the present study, it was considered appropriate that each half-second data sample represent just data in that half-second for optimum correlation with the position of the airplane at the midpoint of the half-second period.

The procedure used to adjust the data for ambient noise interference was to subtract the mean-square pressure of the ambient noise level from the mean-square pressure of the contaminated noise signal when the indicated sound pressure level for the data was between 5 and 10 dB more than the corresponding level of ambient noise. For levels less than 5 dB above the corresponding ambient noise levels, it was not felt that any reliable ambient noise adjustment could be made and the output in that band was set to a predetermined negligible level.

No pre-emphasis adjustments were included because none were used during data acquisition.

The output data were provided to the precision of the nearest tenth of a decibel. The accuracy of each sound pressure level value, however, is estimated to be approximately ± 0.5 to ± 1.0 dB. The resolution of the Gen Rad analyzer is ± 0.25 dB. The accuracy of the pistonphone calibrator is at best ± 0.2 dB. The repeatability and internal consistency of the data for the 37 runs, however, are considered to be very good as confirmed by the analyses presented in subsequent sections.

The digital output data tape was 12.7-mm-wide with 9 data tracks, a packing density of 800 bits per inch, and odd parity. The information was stored on the tape using the character set defined by the EBCDIC (extended binary coded decimal interchange code) system. This format is compatible with the tape drives of most large-scale digital computers.

The tabulated output was printed on 8 1/2 x 11 inch paper by the electrostatic printer. A sample of data for one microphone from run 295 is given in table 6. Note the value of -350.0 dB chosen for the negligible sound pressure level when the level of ambient noise contamination was too high. Appendix B contains the associated airplane, engine, and meteorological data for each of the 37 runs that were finally processed. Table B20 gives the data corresponding to the sound pressure levels in table 6.

Table 6. - Sample of output data from run 295

DC-9-10/JT8D-1 FLYOVER NOISE LEVELS

NASA/FAA FLIGHTS OVER TAXIWAY B AT FRESNO AIR TERMINAL
RUN NO.:295; DATA TAPE NO.: 110487 ; MIC LOC: 1 ; TEST DATE: 22 OC 74
IRIG TIME AT OVERHEAD: 12-27-38.6 ; HEIGHT AT OVERHEAD: 167.00 M
AIRSPEED AT OVERHEAD: 85.00 M/S; GROUND SURFACE AROUND MIC: CONCRETE

MEASURED TEST DAY 1/3-OCTAVE BAND SOUND PRESSURE LEVELS, DB RE 20 MICROPASCALS

GMF	AMB	TIME AFTER IRIG START TIME 12-27-28													
HZ	SPL	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5
50	53.4	63.5	63.5	62.4	62.9	58.8	64.0	66.4	65.9	68.5	68.3	69.0	70.5	72.3	71.8
63	55.9	66.0	63.2	63.7	60.0	61.7	65.4	66.9	65.2	66.9	70.0	70.0	69.5	72.6	74.3
80	58.2	62.5	64.5	62.3	62.3	62.3	66.0	63.2	66.3	71.2	71.7	69.6	69.9	71.2	72.5
100	56.6	61.1	61.7	63.6	63.9	61.7	-350.0	61.7	66.7	69.7	72.5	71.5	68.6	69.7	72.3
125	59.2	64.9	63.9	62.8	-350.0	62.8	-350.0	63.3	67.8	71.4	70.9	69.5	70.9	69.5	71.1
160	55.1	63.7	63.7	62.6	61.7	63.7	62.4	63.5	67.3	71.7	71.5	70.2	68.4	70.2	68.6
200	54.8	62.1	59.9	59.3	61.8	62.4	-350.0	62.1	67.9	70.5	70.2	66.3	64.9	61.8	59.3
250	54.5	59.9	-350.0	-350.0	-350.0	-350.0	-350.0	58.8	62.9	65.9	62.3	58.6	-350.0	-350.0	63.1
315	55.7	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	62.1	-350.0	-350.0	63.0	64.5	69.3
400	54.1	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	59.8	66.3	69.5	69.2	72.2
500	53.4	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	64.9	66.7	69.8	71.1	69.8	71.1
630	54.9	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	62.4	71.3	70.5	73.3	70.0	66.6	66.6
800	51.6	56.1	60.4	56.1	-350.0	-350.0	-350.0	61.1	64.9	71.4	69.5	69.5	65.2	65.9	71.9
1000	47.9	54.3	56.9	52.4	54.5	-350.0	-350.0	56.1	62.0	67.9	63.1	69.4	70.2	68.4	68.7
1250	51.1	-350.0	55.2	-350.0	-350.0	-350.0	-350.0	-350.0	57.1	63.3	66.0	71.3	67.7	64.9	68.2
1600	54.1	59.1	62.7	63.1	58.2	-350.0	-350.0	60.1	63.9	70.5	71.7	73.2	73.8	69.2	67.1
2000	44.0	49.4	50.0	49.4	53.9	53.0	50.4	52.4	55.7	60.4	61.2	65.8	65.5	61.7	63.5
2500	43.5	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	49.2	54.1	55.4	64.0	60.9	58.1	60.1
3150	44.7	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	53.1	53.5	60.9	58.8	52.3	58.0
4000	45.8	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	51.8	50.1	-350.0	51.5
5000	48.6	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0
6300	51.7	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0
8000	57.8	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0
10000	59.5	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0
OVERALL		72.8	72.6	71.9	70.5	70.7	70.7	73.5	76.6	81.2	81.4	82.1	81.5	81.1	82.6
AL		63.5	66.6	65.4	62.2	57.7	54.1	65.4	70.3	76.9	76.8	79.5	78.7	75.9	77.6

Table 6. - Continued

DC-9-10/JT8D-1 FLYOVER NOISE LEVELS

NASA/FAA FLIGHTS OVER TAXIWAY B AT FRESNO AIR TERMINAL
RUN NO.:295; DATA TAPE NO.: 110487 ; MIC LOC: 1 ; TEST DATE: 22 OC 74
IRIG TIME AT OVERHEAD: 12-27-38.6 ; HEIGHT AT OVERHEAD: 167.00 M
AIRSPEED AT OVERHEAD: 85.00 M/S; GROUND SURFACE AROUND MIC: CONCRETE

MEASURED TEST DAY 1/3-OCTAVE BAND SOUND PRESSURE LEVELS, DB RE 20 MICROPASCALS

GMF HZ	AMB SPL	TIME AFTER IRIG START TIME 12-27-28 7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5
50	53.4	71.8	71.0	71.5	74.9	76.9	80.6	79.4	77.4	76.6	76.9	77.1	85.4	86.4	87.6
63	55.9	72.8	73.6	73.8	75.4	75.9	71.8	74.1	73.3	69.2	70.8	80.4	84.2	88.7	89.9
80	58.2	72.5	74.1	75.6	74.8	70.1	69.9	70.4	73.6	76.3	73.3	72.0	77.9	80.9	89.4
100	56.6	73.3	72.5	72.5	72.8	66.1	72.5	80.1	83.1	83.1	84.9	83.4	83.9	79.4	81.6
125	59.2	70.6	68.4	68.4	65.2	75.6	78.9	84.9	87.7	87.2	91.9	90.2	90.7	89.2	84.9
160	55.1	62.9	64.1	69.4	76.1	79.8	83.6	87.8	86.6	88.8	91.3	93.8	95.6	94.6	93.6
200	54.8	59.9	70.7	73.2	80.6	81.8	85.1	83.6	79.1	83.1	87.3	92.6	95.6	94.8	93.8
250	54.5	67.0	74.7	78.7	81.5	81.2	80.2	82.7	87.2	88.7	88.7	86.5	88.0	91.5	92.2
315	55.7	73.6	77.2	79.0	78.0	76.0	84.0	88.5	88.5	89.5	90.0	93.2	92.7	87.7	85.5
400	54.1	75.6	73.8	74.8	78.6	83.8	85.3	84.6	88.6	89.6	90.8	86.3	93.1	92.6	89.6
500	53.4	70.6	70.1	79.9	83.4	79.7	84.7	86.9	88.4	87.7	90.4	90.7	91.2	86.2	86.9
630	54.9	73.5	79.4	79.1	80.9	83.1	83.9	87.1	88.4	90.4	90.4	89.9	90.6	89.6	86.1
800	51.6	71.6	73.1	78.1	80.9	82.9	84.9	85.4	88.1	89.4	90.9	89.9	90.9	88.4	83.6
1000	47.9	67.9	73.4	77.7	78.9	81.7	82.9	85.7	86.7	88.7	89.9	88.9	89.2	86.9	83.7
1250	51.1	67.0	71.1	76.6	78.3	80.8	84.6	85.1	86.8	87.1	89.3	87.8	87.1	85.1	81.6
1600	54.1	67.6	71.5	75.6	77.6	78.8	83.1	82.1	85.3	86.1	88.8	84.6	87.1	83.6	80.8
2000	44.0	62.7	67.0	73.8	75.0	79.8	81.3	82.3	84.3	84.0	87.3	85.3	85.5	82.3	79.5
2500	43.5	60.6	64.2	70.5	72.5	76.5	80.5	80.5	82.5	83.7	86.0	84.5	83.5	79.5	77.5
3150	44.7	58.5	61.4	67.5	70.0	74.0	78.5	80.7	83.2	85.7	89.0	85.5	83.7	80.2	77.5
4000	45.8	53.3	55.6	63.4	66.8	71.8	77.5	80.0	81.8	84.5	86.3	82.0	79.8	75.3	71.5
5000	48.6	-350.0	-350.0	60.0	62.9	69.3	73.8	74.1	77.3	80.6	83.3	79.6	77.3	73.1	67.5
6300	51.7	-350.0	-350.0	-350.0	-350.0	57.7	63.9	68.3	72.2	75.2	77.4	72.2	68.8	65.0	59.0
8000	57.8	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	62.1	66.4	68.4	70.6	64.4	-350.0	-350.0	-350.0
10000	59.5	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0
OVERALL		83.5	85.8	88.7	91.1	92.6	95.3	97.2	98.8	99.9	101.8	101.7	103.1	101.9	100.9
AL		78.7	82.3	86.1	88.3	90.4	93.2	94.5	96.4	97.7	99.6	98.1	98.7	96.4	93.9

Table 6. - Continued

DC-9-10/JT8D-1 FLYOVER NOISE LEVELS

NASA/FAA FLIGHTS OVER TAXIWAY B AT FRESNO AIR TERMINAL
RUN NO.:295; DATA TAPE NO.: 110487 ; MIC LOC: 1 ; TEST DATE: 22 OC 74
IRIG TIME AT OVERHEAD: 12-27-38.6 ; HEIGHT AT OVERHEAD: 167.00 M
AIRSPEED AT OVERHEAD: 85.00 M/S; GROUND SURFACE AROUND MIC: CONCRETE

MEASURED TEST DAY 1/3-OCTAVE BAND SOUND PRESSURE LEVELS, DB RE 20 MICROPASCALS

GMF	AMB	TIME AFTER IRIG START TIME 12-27-28													
HZ	SPL	14.0	14.5	15.0	15.5	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5	20.0	20.5
50	53.4	91.1	90.9	92.6	93.1	89.1	90.4	84.6	85.9	84.6	84.6	82.1	80.1	79.4	80.4
63	55.9	91.2	91.2	94.2	91.7	92.9	90.2	91.9	91.7	86.9	88.9	85.9	86.2	86.9	84.9
80	58.2	91.4	94.4	90.9	95.2	92.4	93.4	92.7	92.7	87.9	89.9	86.2	84.9	88.2	85.4
100	56.6	82.4	88.4	88.9	92.4	94.4	91.1	93.1	91.4	91.1	87.9	87.6	86.4	86.1	86.4
125	59.2	80.7	79.2	80.9	86.4	88.4	90.2	90.9	91.9	88.7	86.9	84.7	83.9	86.7	85.2
160	55.1	92.3	86.8	76.6	74.0	77.1	81.1	82.8	84.8	84.1	82.1	84.6	82.8	80.6	80.8
200	54.8	93.1	95.8	87.1	80.1	76.6	72.2	72.0	73.7	76.8	72.5	74.3	77.6	73.5	76.1
250	54.5	91.7	95.5	92.7	88.5	82.2	81.5	77.0	74.7	68.3	66.7	65.4	65.9	66.2	67.5
315	55.7	89.5	92.5	90.2	92.5	87.7	87.5	85.2	82.5	78.5	72.9	67.9	65.0	63.0	-350.0
400	54.1	86.3	83.8	84.1	87.6	83.6	86.1	86.1	83.6	83.1	81.1	78.8	75.8	74.8	71.7
500	53.4	89.9	87.7	84.9	81.2	76.7	82.2	81.9	81.2	78.9	79.4	79.2	80.2	76.4	75.4
630	54.9	83.1	84.6	87.4	84.9	81.1	79.4	75.1	74.4	74.4	74.0	75.9	76.9	75.1	74.9
800	51.6	84.9	84.1	81.1	79.9	77.6	80.9	80.1	78.4	75.4	68.5	70.3	69.3	70.8	70.3
1000	47.9	82.4	80.7	80.7	81.7	75.9	75.2	75.7	75.7	75.4	72.4	73.2	71.4	69.9	65.6
1250	51.1	81.1	80.6	82.1	79.1	73.6	75.6	77.1	74.8	71.8	68.2	69.5	71.3	71.3	69.0
1600	54.1	79.8	77.8	79.3	75.8	71.7	74.8	72.5	72.2	70.5	68.1	67.9	65.5	66.3	61.6
2000	44.0	78.0	75.3	77.8	72.5	70.0	72.3	69.3	69.8	68.8	65.0	64.0	62.4	63.5	61.9
2500	43.5	76.5	74.2	75.5	71.5	67.5	69.7	67.0	66.7	64.5	59.9	60.4	59.9	59.9	57.3
3150	44.7	76.0	72.5	73.5	69.2	65.5	68.0	64.7	63.6	61.1	57.3	56.2	55.9	54.6	52.9
4000	45.8	71.0	67.5	67.8	63.4	58.8	61.2	57.2	56.4	52.4	-350.0	-350.0	-350.0	-350.0	-350.0
5000	48.6	66.5	62.4	61.6	56.7	-350.0	54.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0
6300	51.7	57.1	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0
8000	57.8	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0
10000	59.5	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0
OVERALL		101.1	102.4	100.7	101.2	99.7	99.3	99.2	98.9	96.3	95.6	93.8	93.0	93.8	92.6
AL		93.6	93.9	92.6	91.6	87.5	88.7	87.9	86.6	84.8	82.7	82.5	82.2	81.0	79.7

Table 6. - Concluded

DC-9-10/JT8D-1 FLYOVER NOISE LEVELS

NASA/FAA FLIGHTS OVER TAXIWAY B AT FRESNO AIR TERMINAL
RUN NO.:295; DATA TAPE NO.: 110487 ; MIC LOC: 1 ; TEST DATE: 22 OC 74
IRIG TIME AT OVERHEAD: 12-27-38.6 ; HEIGHT AT OVERHEAD: 167.00 M
AIRSPEED AT OVERHEAD: 85.00 M/S; GROUND SURFACE AROUND MIC: CONCRETE

MEASURED TEST DAY 1/3-OCTAVE BAND SOUND PRESSURE LEVELS, DB RE 20 MICROPASCALS

GMF	AMB	TIME AFTER IRIG START TIME 12-27-28							
HZ	SPL	21.0	21.5	22.0	22.5	23.0	23.5	24.0	24.5
50	53.4	78.6	81.9	80.4	78.4	80.1	75.9	75.6	74.1
63	55.9	79.7	80.9	79.2	79.9	81.9	77.2	78.7	75.9
80	58.2	83.7	82.9	81.7	77.1	79.9	79.7	80.2	78.7
100	56.6	84.4	83.1	84.9	80.9	79.1	81.4	78.1	77.9
125	59.2	84.9	84.2	83.4	82.2	80.9	78.7	78.7	76.3
160	55.1	81.1	78.8	80.8	80.8	79.6	80.8	76.8	75.8
200	54.8	78.3	77.6	76.3	77.3	73.0	74.6	72.0	73.2
250	54.5	69.1	71.1	71.9	74.7	68.3	67.0	70.4	69.4
315	55.7	-350.0	60.8	66.1	67.7	66.1	65.8	65.2	65.0
400	54.1	67.9	65.5	62.2	61.6	60.1	63.9	65.8	63.9
500	53.4	72.6	74.2	71.8	70.3	65.6	59.2	61.8	60.7
630	54.9	75.1	76.4	74.9	77.6	72.0	67.4	67.9	67.7
800	51.6	69.8	71.1	71.4	77.4	73.4	70.0	70.5	72.6
1000	47.9	62.8	63.3	64.3	71.7	68.9	68.2	72.4	71.4
1250	51.1	68.5	68.0	66.5	66.5	62.0	61.7	69.7	69.5
1600	54.1	60.4	62.5	60.4	65.5	-350.0	-350.0	60.7	59.8
2000	44.0	59.4	60.9	59.4	55.7	53.0	55.0	59.7	57.6
2500	43.5	52.7	53.6	53.3	52.7	49.5	48.9	55.7	52.7
3150	44.7	49.8	49.4	48.8	-350.0	-350.0	-350.0	-350.0	-350.0
4000	45.8	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0
5000	48.6	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0
6300	51.7	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0
8000	57.8	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0
10000	59.5	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0	-350.0
OVERALL		91.0	90.7	90.5	89.4	88.6	87.6	86.8	85.6
AL		78.9	79.4	78.6	81.3	77.2	75.5	77.5	77.3

THEORY OF GROUND REFLECTION EFFECTS

In order to interpret the ground reflection effects in the DC-9 flyover noise measurements it was necessary to use results from ground reflection theory. Theoretical predictions of ground reflection effects for static noise sources have been rather well developed, at least for idealized situations. However, few theoretical investigations have been conducted for moving noise sources above a reflecting surface. In the following sections we review results from ground reflection theory for static noise sources and then present new analyses of the effects of source motion on ground reflection phenomena.

Static Noise Sources

The importance of ground reflection effects in the analysis of sound measurements has been recognized for some time. A number of theoretical studies have investigated various aspects of the problem such as effects of finite ground impedance and near-grazing wave-incidence angles. A good list of references related to these studies is given in reference 10. Reference 7 also has an extensive bibliography of related studies. The studies (all for static sound sources) showed that large distortions of the free-field sound spectra can be caused by ground reflections. The magnitude of the distortions depends on the heights of the source and receiver, the distance between the two, the acoustical characteristics of the reflecting surface, and the frequency of the sound.

The spectral distortions can be analyzed by considering the signal received by a microphone as the summation of a direct wave from the sound source plus a wave reflected from the surface. The geometrical relationships are shown in figure 7. The mean square pressure at the microphone depends on the parameters $\Delta r/\lambda$, $s = r/r'$, and a reflection coefficient Q according to the following equation

$$\Delta N = 10 \log_{10} \left[1 + (s|Q|)^2 + 2\,(s|Q|)\,\frac{\sin\left(\alpha\frac{\Delta r}{\lambda}\right)}{\left(\alpha\frac{\Delta r}{\lambda}\right)}\cos\left(\beta\frac{\Delta r}{\lambda} - \delta\right)\right]. \qquad (3)$$

The equation gives the difference ΔN between the sound pressure level measured above a reflecting surface (i.e., the direct plus the reflected signals) and

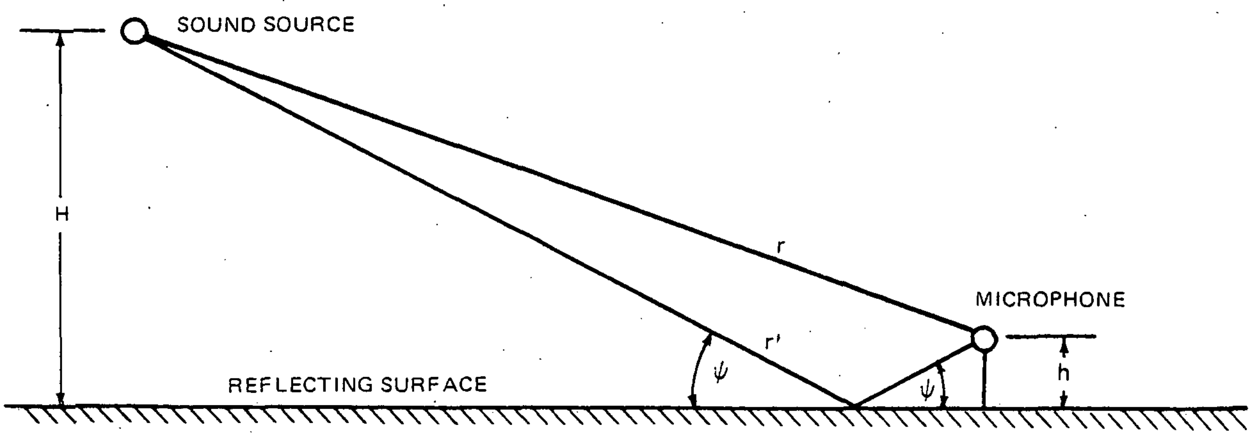


Figure 7.- Geometry for ground reflection analysis for stationary source.

the free-field level at the same location with no reflecting surface (i.e., the direct signal alone).

The constants α and β have the following definitions for constant-percentage-bandwidth filters

$$\alpha = 2\pi\ \Delta f/2f_i;\ \beta = 2\pi\ [1 + (\Delta f/2f_i)^2]^{1/2}$$

where Δf is the bandwidth of an ideal filter and f_i is its geometric mean frequency.

For ideal 1/3-octave-bands, $\Delta f/f_i = 2^{1/6} - 2^{-1/6}$ and α and β have the following values

$$\alpha = 0.7275;\ \beta = 6.3252.$$

The wavelength of the sound is λ, the quantity Δr is the difference r'-r between the reflected and the direct path lengths, and the reflection coefficient $Q = |Q|e^{i\delta}$ is related to the acoustical impedance Z of the ground surface.

The magnitude of Q is the ratio of the magnitude of the reflected wave to that of the incident wave at the point of reflection. The phase δ is the difference in the phases of the reflected and incident waves. The relation between the reflection coefficient Q and the specific acoustical impedance Z of the reflecting surface is given by the following expression which is valid for a locally reacting surface and an incident plane wave

$$Q = |Q|e^{i\delta} = (Z \sin \psi - \rho c)/(Z \sin \psi + \rho c) \tag{4}$$

where $Z = R+i\chi$ and R is the resistive and χ the reactive part of the impedance, $i = \sqrt{-1}$, ρ is the density of air, c is the speed of sound, and the product ρc is the characteristic impedance of the air.

Experimentally determined values of the impedance of grass-covered flat ground have been reported by Embleton, Piercy and Olson (ref. 8). Their data serve as a useful gauge which can be used to measure and help interpret the results of the present program. In order to make their impedance data convenient to use in calculations, the following equations were fitted to the data in figure 8 of reference 8

$$R/\rho c = 1 + 16\ (100/f)^{0.6}$$
$$\chi/\rho c = -25\ (100/f)^{0.6} \tag{5}$$

Plots of the normalized resistance and reactance as determined from equation 5 are given in figure 8. Absolute value and phase of the reflection coefficient were calculated from equation 4 and are plotted in figure 9. Note that because of the assumption that the ground surface is 'locally reacting', the impedance Z is not a function of grazing angle ψ while the reflection coefficient Q is.

Knowledge of the reflection coefficient together with sound-source height and microphone height and distance from the source is sufficient information for calculating spectral distortions due to ground reflection using equation 3.

Moving Noise Sources

Since the sound source for these experiments was a moving DC-9 airplane, it was desirable to consider the effects of sound source motion on ground reflection phenomena. Sound source motion affects the measured sound pressure level for two reasons. First of all, since sound travels with a finite speed, the sound received at a microphone at a time t was emitted from a different location than the instantaneous location of the source at the time t, see figure 6. Retarded time effects must be taken into account for moving-source ground-reflection problems.

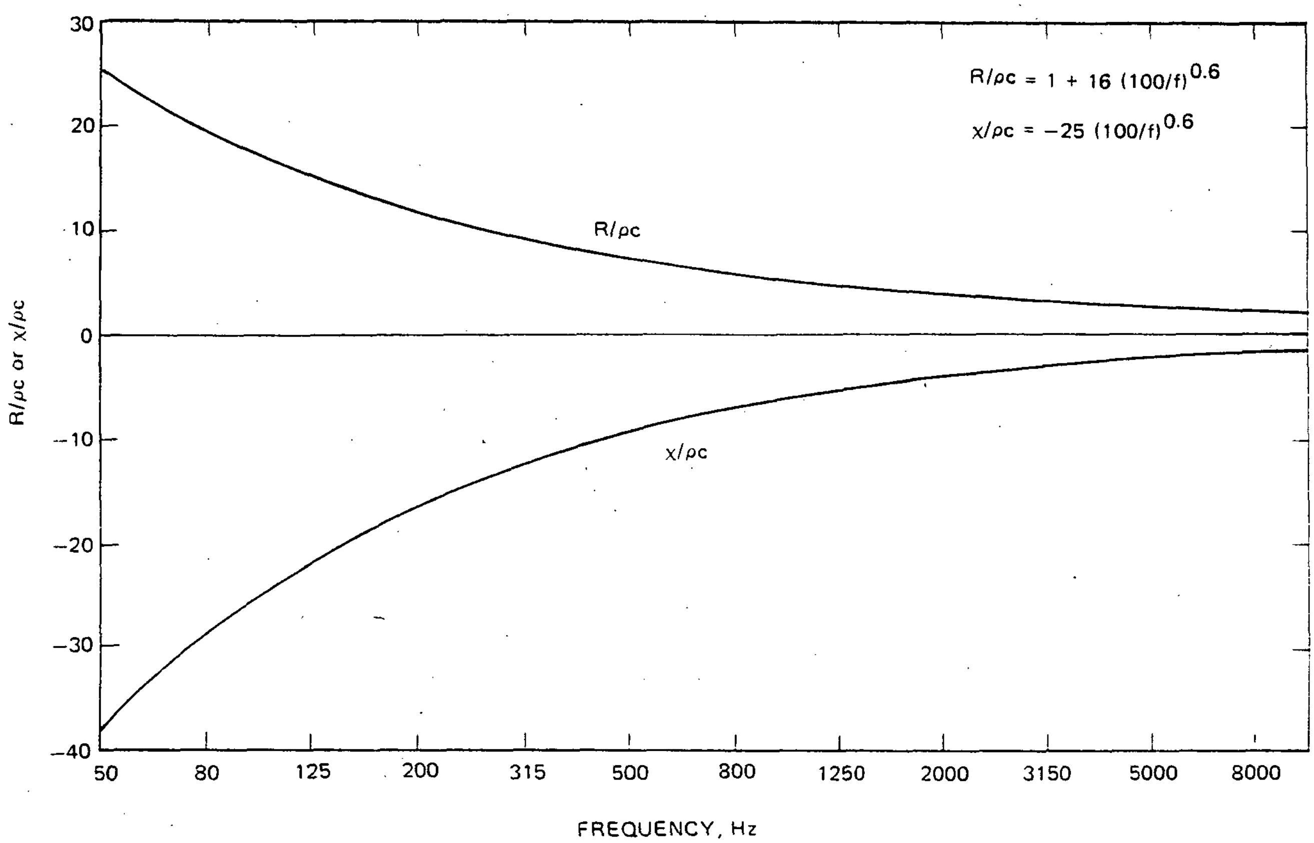


Figure 8.- Model ground impedance used for calculations.

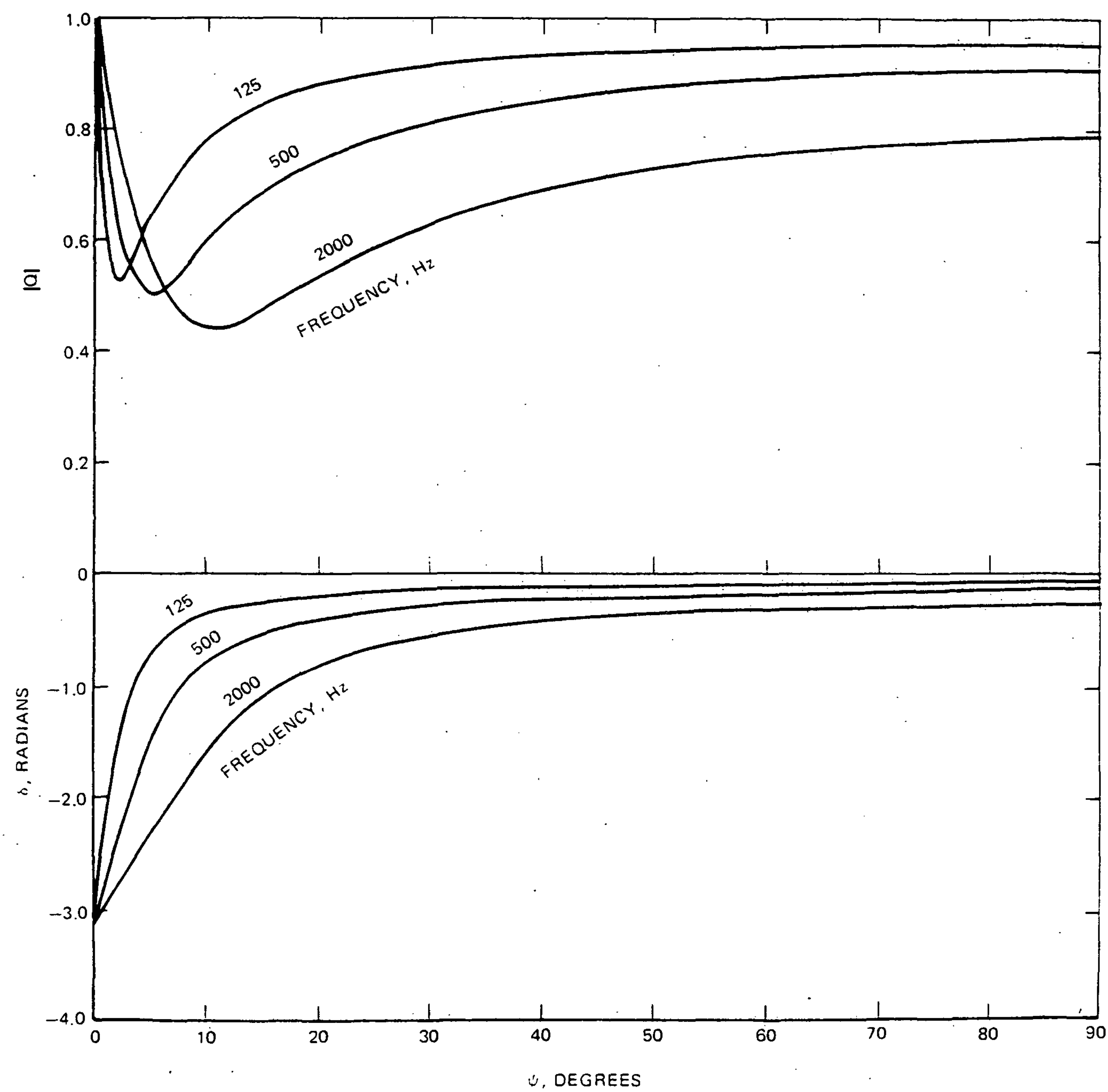


Figure 9.-Magnitude and phase of reflection coefficient for ground impedance of figure 8.

The second effect of source motion on ground reflection phenomena is caused by the fact that the pressure signal received at a microphone must be time averaged in order to obtain sound pressure levels. For long averaging times or high source speeds, the source may move a significant distance during the time used for the averaging period. Therefore the geometrical relationships between the source and microphones which determine the sound pressure level also change. Those effects must also be considered for ground reflection problems.

We will now consider how retarded time effects influence ground reflection phenomena.

In order to see some of the basic features of the problem we shall consider the least complicated problem of a monopole source moving with a constant speed V at a fixed height H above a perfectly reflecting surface. For that case, the reflecting surface can be replaced by an image source also moving with a speed V or Mach number $M = V/c$, where c is the speed of sound in the atmosphere (see figure 10).

The sound pressure measured with a microphone located a distance h above the surface at a time t is given by the sum of the sound pressures due to the real source and the image source. However, we must account for the fact that the signal received at the microphone at time t was emitted by the real source at the retarded emission time $t_e = t - (R/c)$ and by the image source at the retarded emission time $t_e' = t - (R'/c)$ where R and R' are the slant distances between the microphone and the source and image source, respectively, at the respective retarded times. From figure 10, these distances are given by

$$R = \{Mx \pm \sqrt{x^2 + (1-M^2)\ (H-h)^2}\}/(1-M^2) \qquad (6)$$

and

$$R' = \{Mx \pm \sqrt{x^2 + (1-M^2)\ (H+h)^2}\}/(1-M^2) \qquad (7)$$

For subsonic source Mach numbers, only the plus sign in front of the square root is allowable. For supersonic Mach numbers, both signs are allowable. Only subsonic cases are considered here because the most-urgent need is for a method applicable to noise measurements made during takeoff and landing when airplanes would by flying subsonically. Supersonic Mach numbers

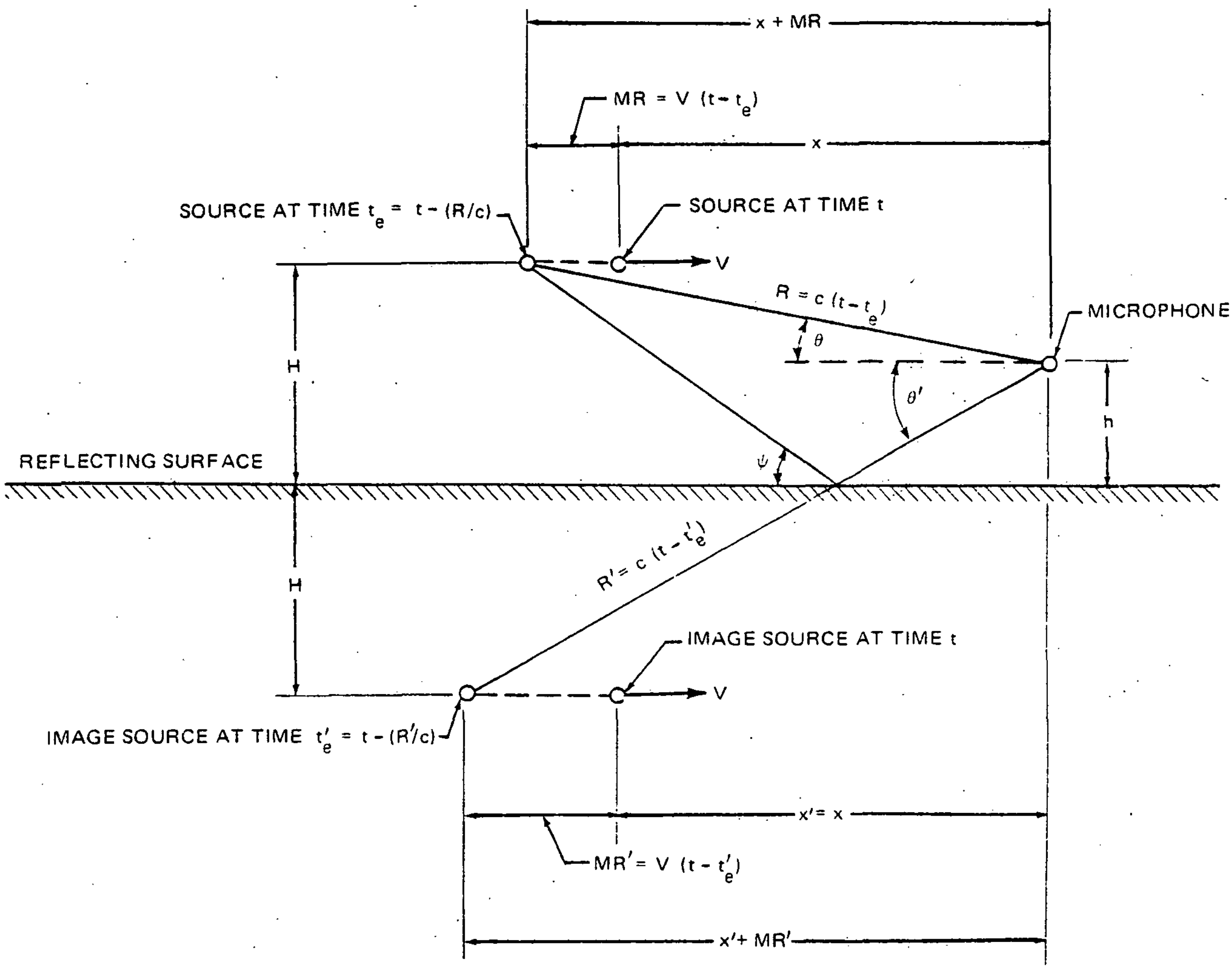


Figure 10.-Geometry for analysis of ground reflection phenomena for moving source.

would be applicable, for example, to a sound source convected at supersonic speeds in the exhaust of an afterburning engine for a supersonic jet transport and for engine test stand measurements of jet noise.

The sound pressure at the microphone is given by the following expression:

$$p_{mic}(t) = \frac{p\ (t - (R/c))}{R\ (1-M \cos \theta)^2} + \frac{p\ (t - (R'/c))}{R'\ (1-M \cos \theta')^2} \qquad (8)$$

where p (t - (R/c)) and p (t - (R'/c)) are the strengths of the source and image source, respectively, at the respective retarded times, and c is assumed constant. The factors $(1-M \cos \theta)^2$ and $(1-M \cos \theta')^2$ account for the effects of "convective amplification" due to the fact that the sources are moving, see reference 12.

The mean-square pressure is obtained by squaring the expression for $p_{mic}(t)$ and taking the time average. Denoting time averages by <> and performing the calculation yields

$$< p_{mic}^2\ (t) > = < \frac{p^2\ (t - (R/c))}{R^2\ (1-M \cos \theta)^4} > + < \frac{p^2\ (t - (R'/c))}{R'^2\ (1-M \cos \theta')^4} >$$

$$+ 2 < \frac{p\ (t - (R/c))\ p\ (t - (R'/c))}{RR'\ (1-M \cos \theta)^2\ (1-M \cos \theta')^2} > \qquad (9)$$

Equation 9 poses the problem of defining a time average when R, R', θ, and θ' are all functions of time. This problem deserves further study. However, for the present let us assume that R, R', θ, and θ' can be taken to be approximately constant over the averaging period, and that the sound source strength is statistically stationary. The mean-square pressure at the microphone then becomes

$$< p_{mic}^2(t) > = \frac{< p^2(t) >}{R^2\ (1-M \cos \theta)^4} + \frac{< p^2(t) >}{R'^2\ (1-M \cos \theta')^4}$$

$$+ 2\ \frac{< p\ (t)\ p\ (t - [(R'-R)/c]) >}{RR'\ (1-M \cos \theta)^2\ (1-M \cos \theta')^2} \qquad (10)$$

The first term in equation 10 is the free-field mean-square pressure at the location of the microphone. The ratio of the mean-square pressure at the microphone to the free-field mean-square pressure is

$$<p^2_{mic}(t)>/\frac{< p^2(t) >}{R^2 (1-M \cos \theta)^4} = 1 + S^2 + 2S <p(t)\ p\ (t-\tau)>/<p^2(t)> \qquad (11)$$

where $S = \frac{R}{R'}\ (\frac{1-M \cos \theta}{1-M \cos \theta'})^2$, $\tau = \frac{R'-R}{c}$, $\frac{< p(t)\ p\ (t-\tau)>}{< p^2(t) >} = \frac{{}_0\int^\infty W(f) \cos 2\pi\tau f\ df}{{}_0\int^\infty W(f)\ df}$

and W(f) is the spectral density of the mean squared sound pressure.

The important parameter $\tau = (R'-R)/c$ can be determined from the following expression from equations 6 and 7

$$R'-R = \frac{\sqrt{x^2 + (1-M^2)\ (H+h)^2} - \sqrt{x^2 + (1-M^2)\ (H-h)^2}}{1-M^2} \qquad (12)$$

For M = 0, the expression for R'-R reduces to the result for a static source at the position defined in figure 10 for time t

$$R'-R = \sqrt{x^2 + (H+h)^2} - \sqrt{x^2 + (H-h)^2}. \qquad (13)$$

When the sound source is located at a shallow angle with respect to a microphone, the quantity $(1-M^2)\ (\frac{H+h}{x})^2$ will be much less than unity. Then from equation 12 the expression for R'-R can be approximated by

$$R'-R \simeq 2hH/x \qquad (14)$$

independent of Mach number!

Furthermore, for shallow propagation angles θ the quantity S is approximately equal to unity. Also, if W(f) is taken to be a constant, implying a white noise spectra, then equation 11 depends only on the quantity (R'-R)/λ where λ is the wavelength of the sound. Thus, equation 11 is itself independent of Mach number and depends only on source height, microphone height, and the instantaneous location of the source at the horizontal distance x from the microphone.

The latter result is surprising since one might intuitively expect that, if a static-source theory were to be used to compute, approximately, ground reflection effects for a moving source, the static source should be located at the position where it was at the retarded time $t - (R/c)$ and not at the instantaneous position at time t. The expression for R'-R obtained by locating a static source at the position of the moving source at the retarded time $t - (R/c)$ instead of at the instantaneous position of the moving source at time t is, from figure 10 and equation 14 with distance x replaced by x + MR,

$$R'-R \simeq 2hH/(x+MR) \simeq 2hH/[(1+M)x] \simeq (1-M)(2hH)/x. \qquad (15)$$

Although this analysis indicates that for shallow angles the "correct" expression for R'-R is given by equation 14 rather than equation 15, the experimental data show that better results are obtained by locating the source at the retarded-time position rather than the instantaneous-time position when calculating values for ΔN.

We will now consider the effect caused by the changing of source position during the time period during which the sound pressure signal is averaged. That effect will be considered separately from the retarded time effects by considering the problem of a source moving at a very low Mach number — low enough such that retarded time effects are negligible. The averaging time for the pressure signal, however, is assumed to be large enough so that the source has moved a significant distance during that time. Refering to figure 11, position A is the position of the source at the end of a time interval. If the source were not moving at all, and located at position A, then the change in the sound pressure level from the free-field value would be given by equation 3 where the path length difference Δr is the value at position A, i.e., $\Delta r = (\Delta r)_A$. The effects of the source position changing with time are determined from the time-averaged value of ΔN in equation 3 as the source moves from A to B. To simplify the determination of the time-averaged ΔN, we first make the approximations that the ratio s is equal to unity (generally an excellent approximation) and that the magnitude $|Q|$ and phase δ of the reflection coefficient are constant, i.e., they do not change as the source moves over the path from A to B. Then from equation 3 the average value of ΔN is given by the following equation:

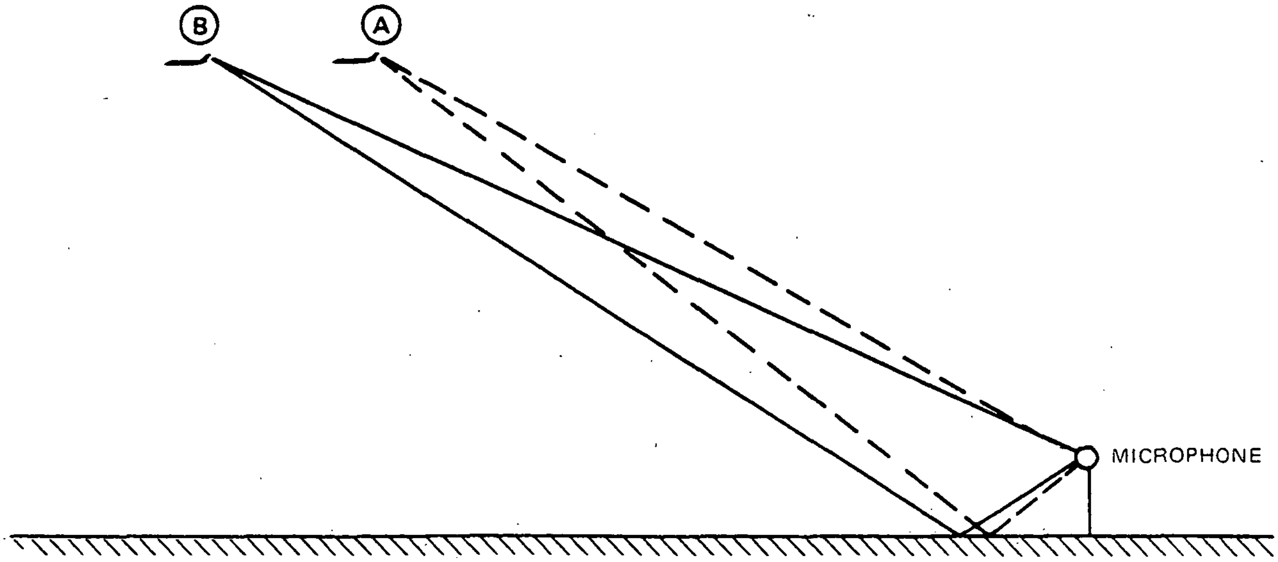


Figure 11.-Change in position of moving source during time interval over which soung pressure signal is averaged.

$$\langle \Delta N \rangle = 10 \log_{10} \left[1 + |Q|^2 + \frac{2\,|Q|}{(\Delta r/\lambda)_B - (\Delta r/\lambda)_A}\, I \right] \tag{16}$$

$$\text{where } I = \int_{(\Delta r/\lambda)_A}^{(\Delta r/\lambda)_B} \frac{\sin(\alpha \Delta r/\lambda)}{(\alpha \Delta r/\lambda)} \cos\left[(\beta \Delta r/\lambda) - \delta\right] d(\Delta r/\lambda)$$

After expanding the cosine term, the integral can be evaluated in closed form in terms of sine and cosine integrals Si and Ci, see reference 13. The resulting expression is

$$I = \frac{\cos\delta}{2\alpha}\left\{Si\left[(\beta+\alpha)\left(\frac{\Delta r}{\lambda}\right)_B\right] - Si\left[(\beta+\alpha)\left(\frac{\Delta r}{\lambda}\right)_A\right] - Si\left[(\beta-\alpha)\left(\frac{\Delta r}{\lambda}\right)_B\right] + Si\left[(\beta-\alpha)\left(\frac{\Delta r}{\lambda}\right)_A\right]\right\}$$
$$+ \frac{\sin\delta}{2\alpha}\left\{Ci\left[(\beta+\alpha)\left(\frac{\Delta r}{\lambda}\right)_B\right] - Ci\left[(\beta+\alpha)\left(\frac{\Delta r}{\lambda}\right)_A\right] - Ci\left[(\beta-\alpha)\left(\frac{\Delta r}{\lambda}\right)_B\right] + Ci\left[(\beta-\alpha)\left(\frac{\Delta r}{\lambda}\right)_A\right]\right\} \tag{17}$$

Sample calculations were made using equations 16 and 17 for an airplane sound source on the flight path and moving with the velocity appropriate to run 272. For half-second averaging time, values of $\langle \Delta N \rangle$ calculated using equation 16 and 17 agreed within 0.2 dB with values of ΔN calculated from equation 3 for the midpoint of the half-second interval, However, significant differences would be found for 1 1/2-second averaging times. For the longer averaging time, source motion damps out the pattern of spectral peaks and valleys produced by ground reflections, particularly at high frequencies.

DETERMINATION OF GROUND IMPEDANCE

One method of determining the acoustical impedance of the spaded ground beneath microphones 3 and 6 would be to use the procedure presented in reference 7. That method finds the phase angle δ of the reflection coefficient by determining, from the measured spectra, the frequencies at which spectral peaks and valleys occur due to constructive and destructive interference between the incident and reflected waves. According to equation 3 the minima occur, to an excellent approximation, when $\cos[(\beta\Delta r/\lambda - \delta] = -1$ or $[(\beta\Delta r/\lambda) - \delta] = n\pi$, where $n = 1, 3, 5 \cdots$. Similarly, reflection peaks occur when $[(\beta\Delta r/\lambda) - \delta] = 2m\pi$, where $m = 0, 1, 2, \cdots$. Those relations and the measured spectra determine the reflection coefficient as a function of frequency. For example, the first null in a measured spectrum due to ground reflection occurs for $n = 1$ or for $[(\beta\Delta r/\lambda) - \delta] = \pi$. Since Δr is determined completely by the aircraft location and the microphone height and the value of λ corresponding to the center frequency of the band containing the first null can be obtained by inspection of the measured spectrum, the value of δ can be determined at the center frequency of the band containing the first null. By repeating the process for the second and third nulls, for the first, second and third peaks, and for other aircraft locations (other values of Δr), values of δ would be obtained at a number of frequencies. A plot of δ versus frequency could thus be obtained for the particular reflecting surface around the microphone.

Having obtained δ, the magnitude of the reflection coefficient $|Q|$ as a function of frequency would be obtained by comparing the spectra measured with the microphone over concrete with the spectra measured with the microphone over spaded ground.

The calculations would proceed as follows. For a microphone over a perfect reflector (concrete) the phase δ is zero for all frequencies and the magnitude of the reflection coefficient $|Q|$ is unity, by definition. Therefore, from equation 3 for the microphone over concrete, the sound pressure level difference is

$$\Delta N_c = 10 \log_{10} \{1 + s^2 + 2s \{[\sin (\alpha\Delta r/\lambda)]/(\alpha\Delta r/\lambda)\} \cos (\beta\Delta r/\lambda)\} \tag{18}$$

and for the microphone over spaded soil the difference is

$$\Delta N_{ss} = 10 \log \{1 + (|Q_{ss}|s)^2 + (2 |Q_{ss}|s) \{[\sin (\alpha\Delta r/\lambda)]/(\alpha\Delta r/\lambda)\} \cos [(\beta\Delta r/\lambda) - \delta_{ss}]\} \tag{19}$$

where $|Q_{ss}|$ is the magnitude of the reflection coefficient and δ_{ss} the phase change at the spaded soil surface. Subtracting equation 19 from equation 18 yields

$$\begin{aligned}\Delta N_c - \Delta N_{ss} = {} & 10 \log_{10} \{1 + s^2 + 2s \{[\sin (\alpha\Delta r/\lambda)]/(\alpha\Delta r/\lambda)\} \cos (\beta\Delta r/\lambda)\} \\ & - 10 \log \{1 + (|Q_{ss}|s)^2 \\ & + (2|Q_{ss}|) \{[\sin (\alpha\Delta r/\lambda)]/(\alpha\Delta r/\lambda)\} \cos [(\beta\Delta r/\lambda) - \delta_{ss}]\}\end{aligned} \tag{20}$$

The only unknown in equation 20 is $|Q_{ss}|$ since δ_{ss} has been obtained previously, Δr is known from the position of the airplane and the microphone height, and the sound pressure levels at the two microphones are available from the measured data to determine $\Delta N_c - \Delta N_{ss}$. Thus, equation 20 would, theoretically, enable one to calculate $|Q_{ss}|$ for the spaded soil beneath the microphone as a function of frequency. The impedance Z would then be calculated using equation 4.

Although the procedure described above for determining $|Q_{ss}|$ and δ_{ss} appeared useful, an examination of the measured data showed that the method would not work in practice. For the accuracy with which the noise produced by the complex and moving aircraft noise source was measured, the measured differences in sound pressure level were generally too small for reliable and repeatable calculations by the above method. As an example of the problems encountered, the measured sound pressure level differences were consistently not the same at the same grazing angle prior to and after overhead. As another example, the 1/3-octave-band spectra from microphones 3 and 6 over spaded soil and microphones 1 and 4 over concrete were not consistently the same for the same grazing angle in a given flyover.

Furthermore, it turned out that the changes in spectra caused by ground reflections were insensitive to large changes in ground impedance. The insensitivity became apparent from calculations of the expected differences between the sound pressure levels measured by the microphones over concrete and those measured by the microphones over spaded soil. The results of the calculations are shown later in this report. The calculations were made using different assumed impedance models for spaded soil which differed from each other by a factor of about 16 for the resistance and a factor of 3.6 for the reactance.

As an example of the problem caused by this insensitivity to large changes in the acoustical impedance of the ground surfaces, there was no apparent difference between the frequencies of the interference nulls in the spectra from the microphones over concrete and over spaded soil. Therefore, it was impossible to obtain the plot of δ_{ss} versus frequency that is required to apply the method described above.

As an alternative to attempting to apply the method of reference 7 as described above, we investigated the idea of choosing an impedance model, calculating the expected behavior of a microphone over a surface of that impedance, and then comparing the results with the measured data. This idea was ultimately adopted for analysis of the data. As will be shown later in this report, the insensitivity to changes in the ground impedance made it impossible to deduce precise values of ground impedance by the method of comparing calculations based on various impedance models against experimental results. It was shown, however, that calculations based on an impedance model appropriate for grass-covered ground (figure 8) agreed well in general with the measurements.

SELECTION OF RUNS FOR DETAILED ANALYSIS

The 37 flyover-noise runs processed for this study can be categorized into three groups according to the nominally constant height of the flyovers. Seven of the runs were flown at an actual height above ground level of about 625 m. Seventeen runs were flown at a height of about 350 m, and the remaining 13 were flown at a height of about 160 m.

It was important for the purposes of this study to have data for a wide angular range of the airplane. However only the lowest height runs had a high enough signal-to-noise ratio to provide useful data at shallow angles. Therefore, the analysis efforts were concentrated on the group of 13 lowest-height runs.

In order to analyze the large amount of available data, a computer program was written to produce line-printer plots of the sound pressure level spectra from the six microphones. Data from three microphones were plotted on each page. Thus, spectra from microphones 1, 2, and 3 were plotted together and spectra from microphones 4, 5, and 6 were plotted together. Plots were obtained for each half-second time interval for every one of the thirteen runs, a total of about 1300 plots.

Since each page contained three plots — one for a microphone over the concrete taxiway, one for a microphone over spaded ground, and one for a ground-level microphone on a plywood board — it was easy to spot trends and relationships among the three spectra. For example, inspection of the spectral plots revealed that the microphone 1 and microphone 3 spectra were generally close to each other as were the spectra from microphones 4 and 6. Thus, although the general trend from examination of all 1300 spectral comparison plots was that the microphones over concrete measured slightly higher sound pressure levels than the microphones over spaded ground, the differences were insufficient to make an accurate determination of the impedance of the spaded ground as noted in the previous section. Nevertheless, as will be shown later, the general trends were consistent with predictions of ground reflection theory based on the impedance model described in the section of this report on theory of ground reflection effects.

However, in some instances there were large differences between the spectra measured with the microphones over concrete and those measured with the microphones over spaded ground. The largest differences occurred primarily for times when the airplane was at a shallow angle with respect to the microphones and in the high frequency region of the spectra. The magnitude of the differences in sound pressure level often changed drastically from one half-second time interval to another.

Because it would be impractical, and not especially useful, to present all of the data from all thirteen of the runs here, we instead will present typical data to illustrate the main conclusions. A typical set of data is that from run 272. Most of the data shown will be from that run, but data from other runs will illustrate some of the shallow-angle, high-frequency anomalies that the data sometimes exhibited.

ANALYSIS AND RESULTS

Geometrical Relationships

Before looking at the flyover noise data, it is useful to first point out some important geometrical parameters of the tests. The geometry connected with a flyover above the taxiway centerline is shown in figure 12. The base of the 1.2-m-high microphone stand is at the center of a spaded-ground circle. The center is at a distance $d_M \approx 23$ m from the taxiway centerline. The ground around the microphone was spaded within a circular region having a radius of 3 m. An important geometrical parameter is the location of the point where the incident wave reflects off of the ground. The distance ℓ from the center of the spaded dirt circle to that point is given by the following equation

$$\ell = h \cot \psi \tag{21}$$

For a microphone height h = 1.2 m and for a distance ℓ = 3 m (the radius of the spaded-ground circle) the value of the grazing angle ψ is about ψ = 22 degrees. Thus for positions of the airplane such that ψ is less than 22 degrees, the incident wave reflects off of the unspaded surface outside the spaded circle.

The distance d_R of the reflection point from the centerline of the taxiway is also of interest. The surprising result was that d_R is given by the following equation

$$d_R = [H/(H+h)]\ d_M \tag{22}$$

independent of the angle ψ! Since the height H of the airplane is much greater than the microphone height h, the distance d_R is almost equal to the distance d_M.

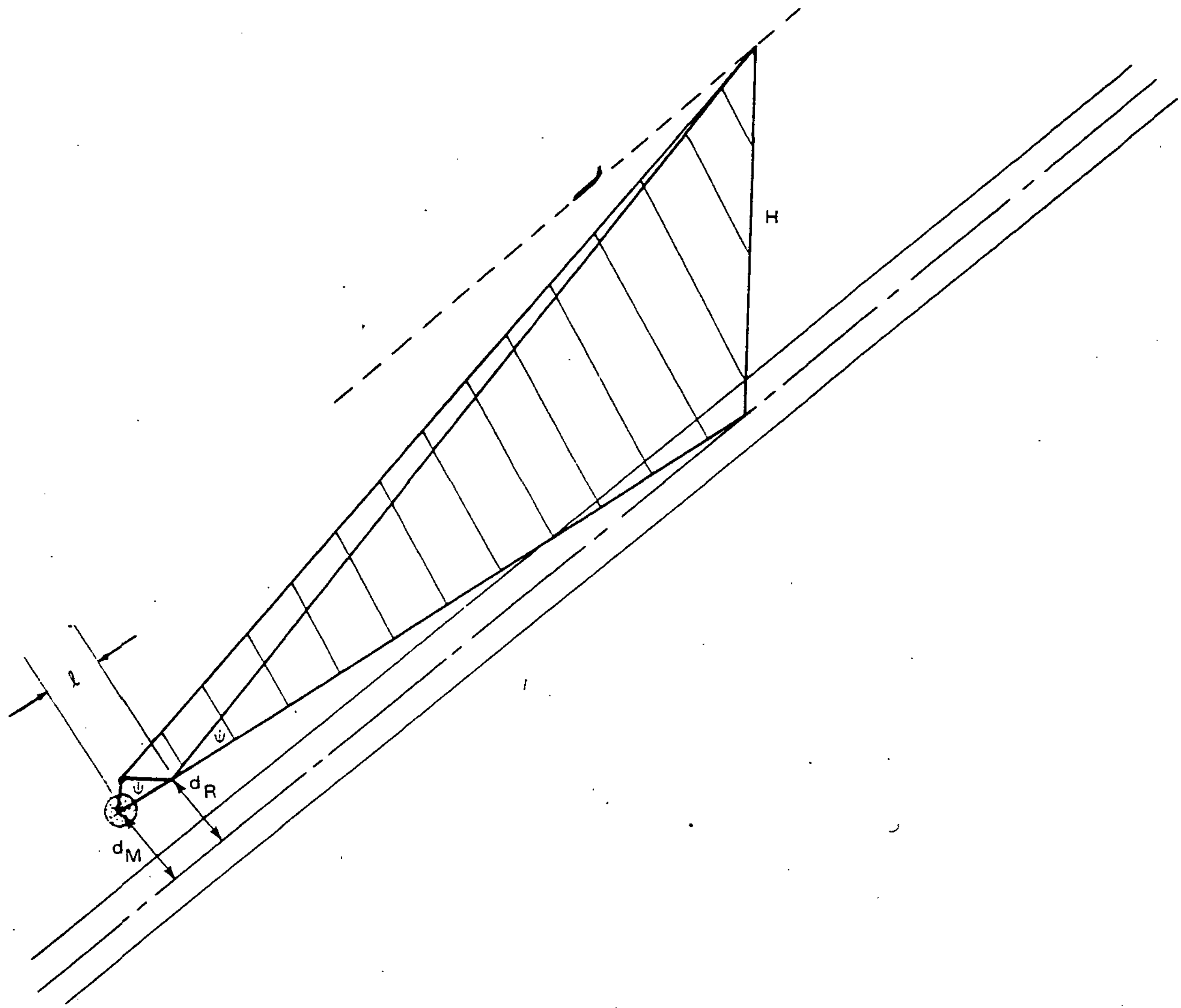


Figure 12.-Geometry of ground reflection phenomena for off-axis microphones.

In the discussions that follow, the location of the airplane is described by the grazing angle ψ. Unless otherwise stated, the angle ψ is the grazing angle at the retarded time t - (R/c) and not at the time t. For run 272, the variation of ψ with time is shown in figure 13. The other important geometrical parameter for ground reflection effects is the pathlength difference. For run 272, the variation of the pathlength difference with time is shown in figure 14. Again, the pathlength difference is determined for the position of the airplane at the retarded time t - (R/c) and not at the instantaneous time t. Note that the reflected wave hits within the spaded-soil region around microphones 3 or 6 only for times after IRIG start of between 6 and 17 seconds. Outside of that time range for the conditions of run 272, the angle ψ is less

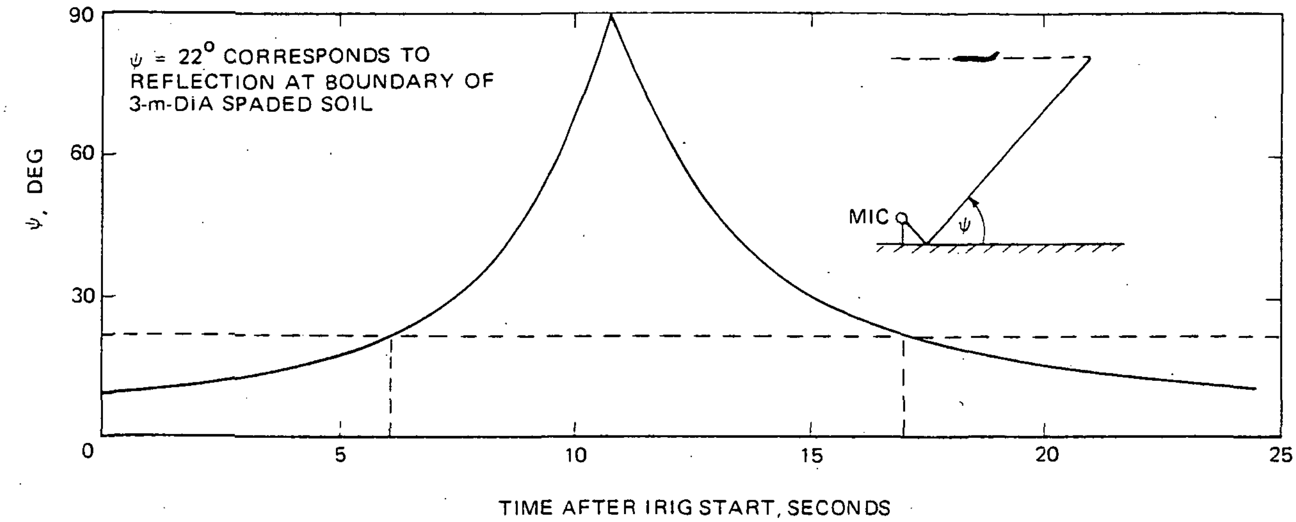


Figure 13.-Variation of grazing angle with time for run 272.

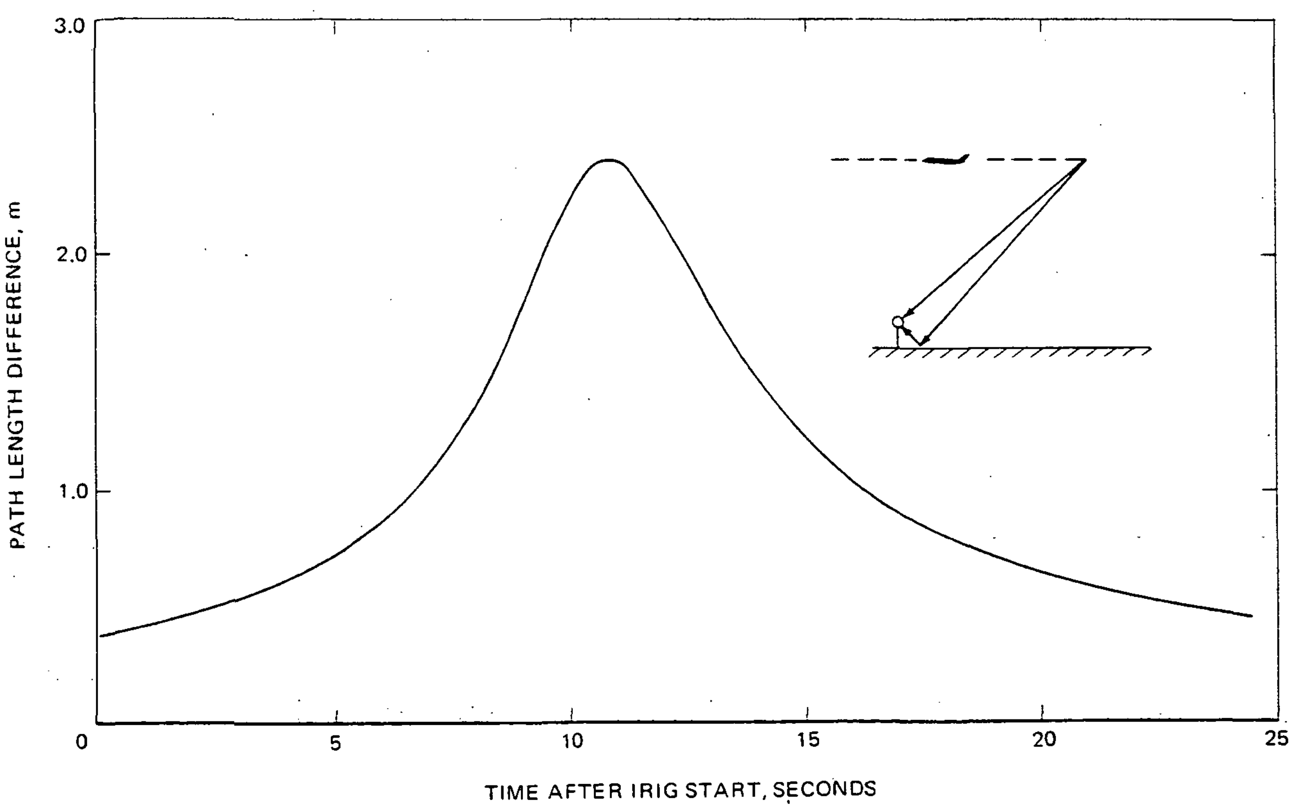


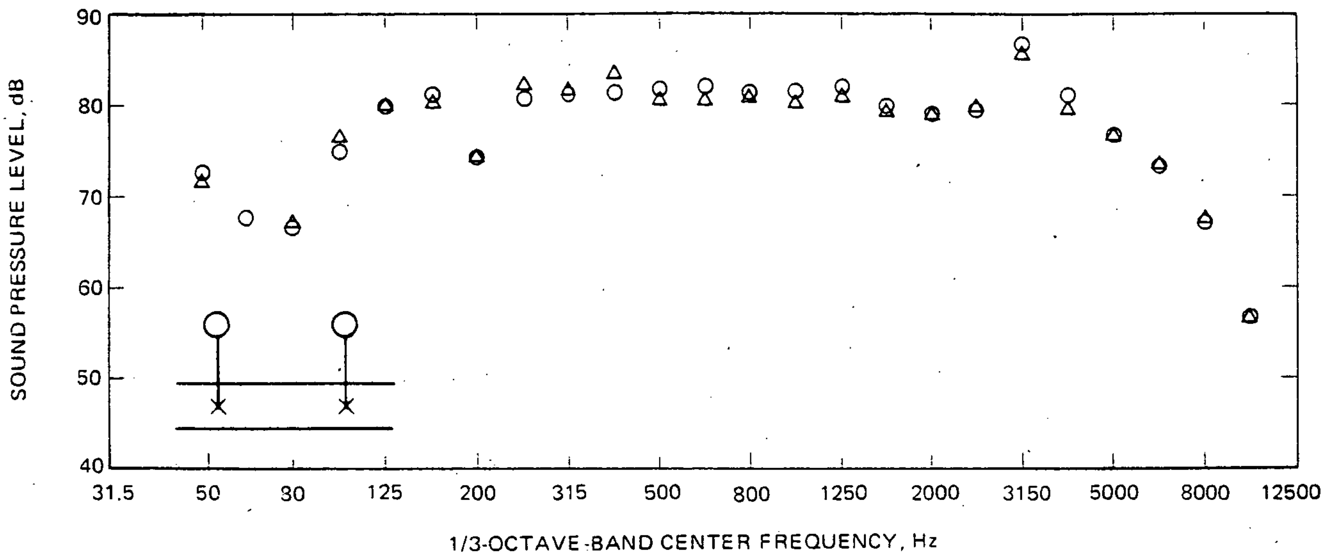
Figure 14.-Variation of path length difference between reflected and direct rays with time for run 272.

than 22 degrees and the wave reflects from the unspaded ground outside the 3-m-radius circle.

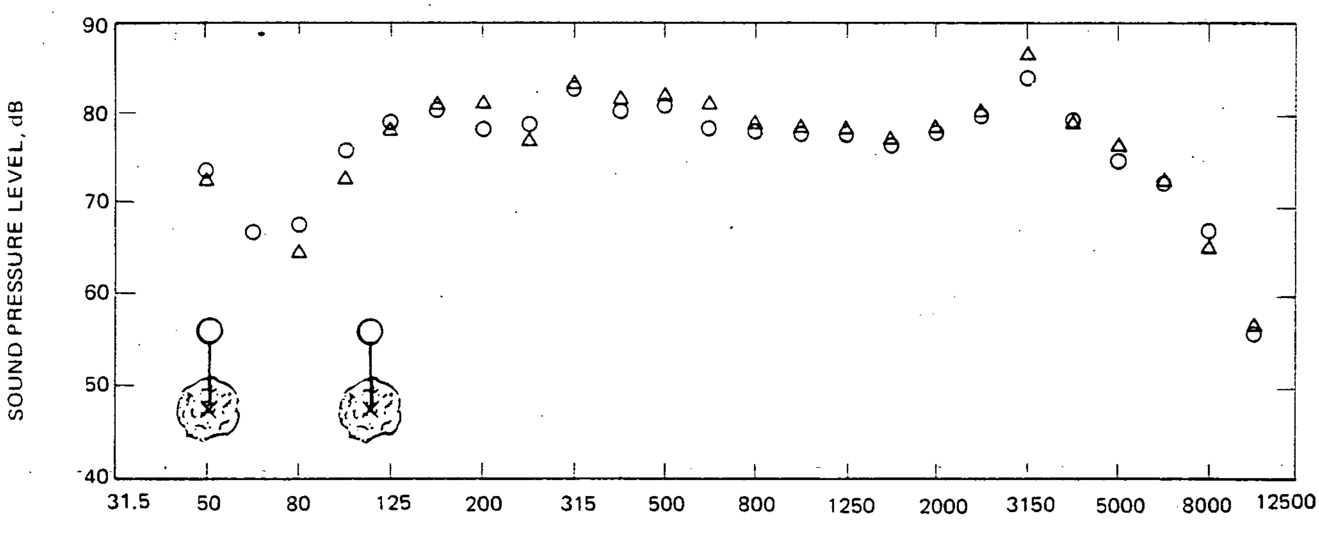
Typical Measured Spectra

In order to determine the consistency of the flyover noise data, comparisons were made between spectra measured at the two sets of microphones located 595 m apart. Figure 15 illustrates such a comparison. The microphone symbols on these and subsequent plots illustrate the surface under the microphone. The two spectra in each plot were determined from measurements made at two different relative times T for two different microphones during a single run. The relative times were chosen so that the airplane was in approximately the same position with respect to the two microphones at the two times, i.e., for approximately the same grazing angle. For example, figure 15(a) shows two spectra. One was obtained from measurements made at microphone 1 when the airplane position was such that the grazing angle ψ with respect to the microphone 1 location was 82 degrees. The second spectrum was obtained from measurements made with microphone 4, which was 595 m away from microphone 1, during the same run. However, the time when the measurements were made at microphone 4 was such that the grazing angle with respect to the microphone 4 location was 90 degrees. It was not possible to obtain spectra for exactly the same grazing angles since data were only available at half-second time intervals.

It can be seen from figure 15 that generally the data from the two sets of microphones were quire consistent, both for microphones 1 and 4 (the microphones over concrete) and for microphones 3 and 6 (the microphones over spaded soil). There were, however, exceptional cases. For example, figure 15(g) shows large differences in the sound pressure levels, in a number of bands, between microphones 1 and 4. But figure 15(h) shows that, at the same relative time, the spectra from microphones 3 and 6 were close together, except for the levels in the 80 Hz band. The large differences did not occur if the microphone 4 spectra used for comparison were taken 0.5 s later, as seen by comparing figures 15(e) and 15(g). The improvement was not as noticeable for the comparisons using the microphone 6 spectra, see figures 15(f) and 15(h).

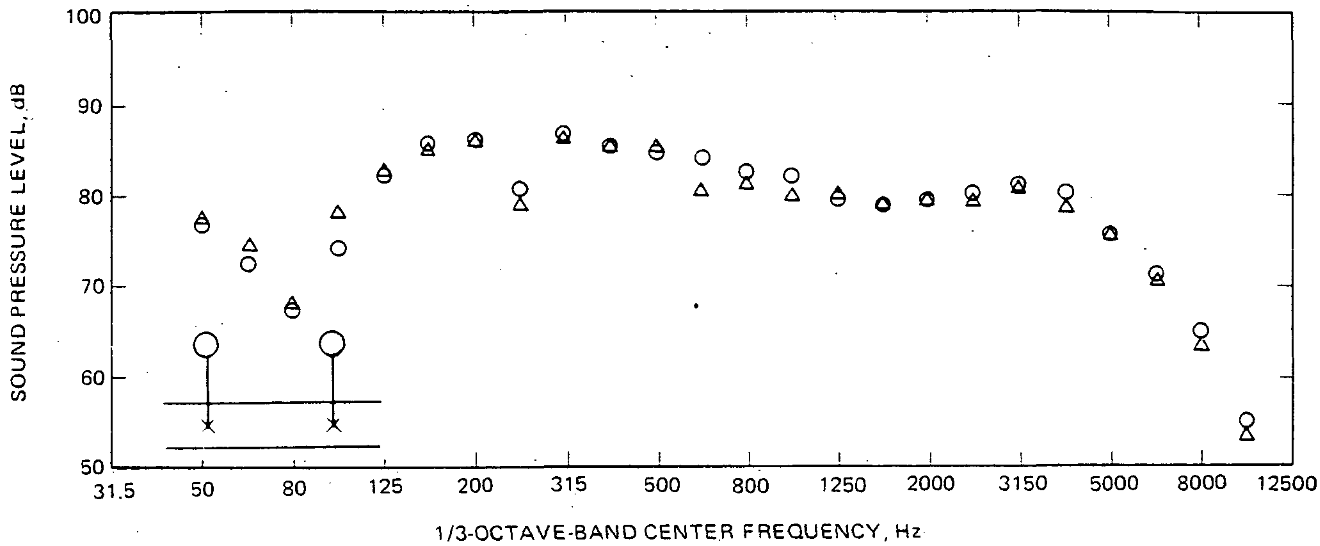


(a) ○ MIC 1, T = 10.5 s, ψ = 82 DEG
△ MIC 4, T = 10.5 s, ψ = 90 DEG

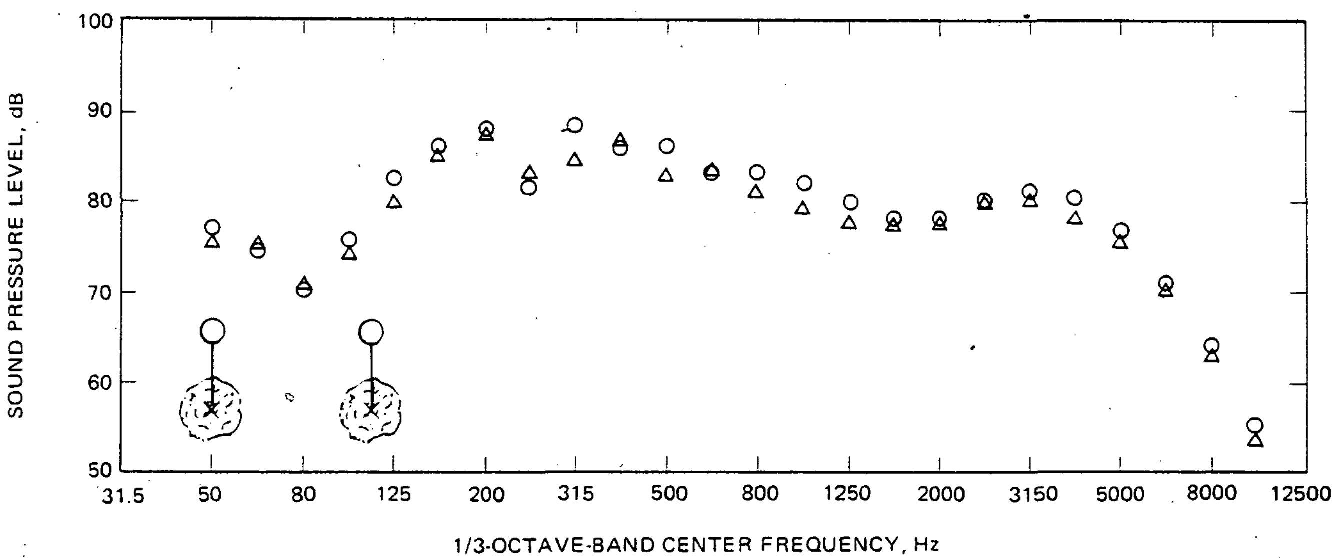


(b) ○ MIC 3, T = 10.5 s, ψ = 82 DEG
△ MIC 6, T = 10.5 s, ψ = 90 DEG

Figure 15.-Comparison of spectra measured with microphones 595m apart but for different times such that the airplane is approximately in the same relative position with respect to each microphone; run 272.

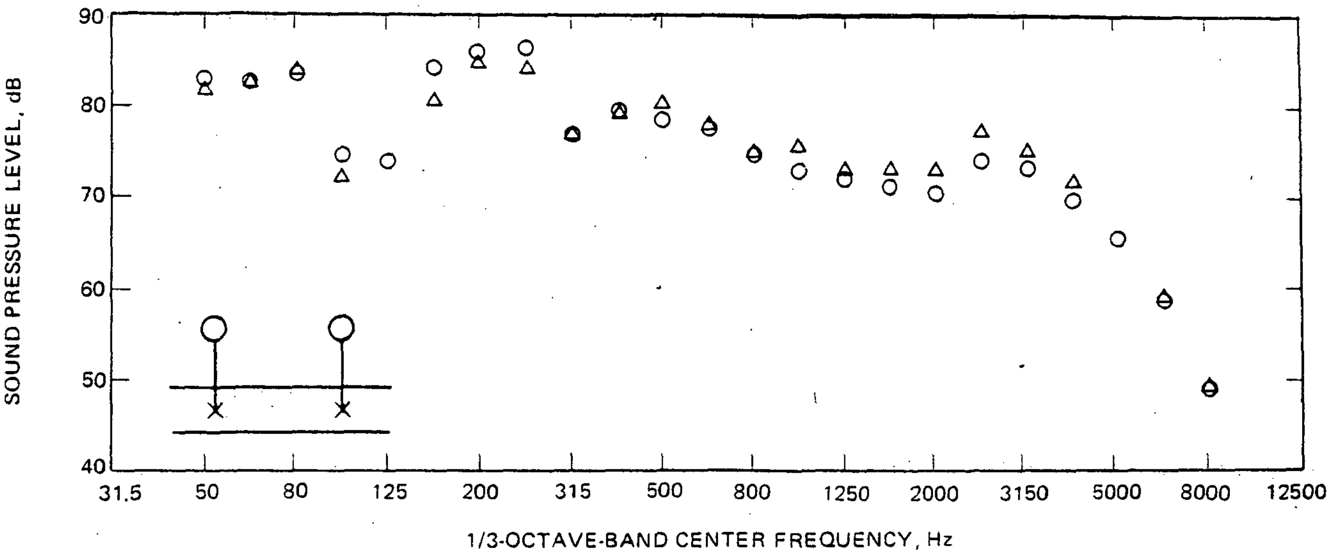


(c) ○MIC 1, T = 12.5 s, ψ = 54 DEG
△MIC 4, T = 12.5 s, ψ = 50 DEG



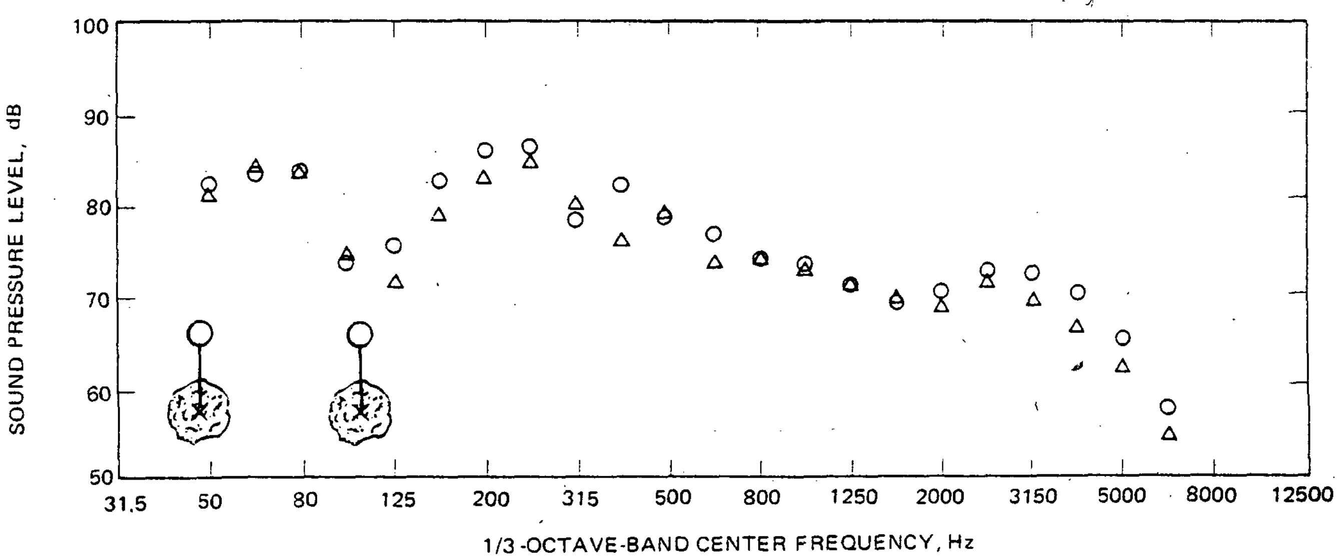
(d) ○MIC 3, T = 12.5 s, ψ = 54 DEG
△MIC 6, T = 12.5 s, ψ = 50 DEG

Figure 15.-Continued.



(e) ○MIC 1, T = 14.0 s, ψ = 37 DEG

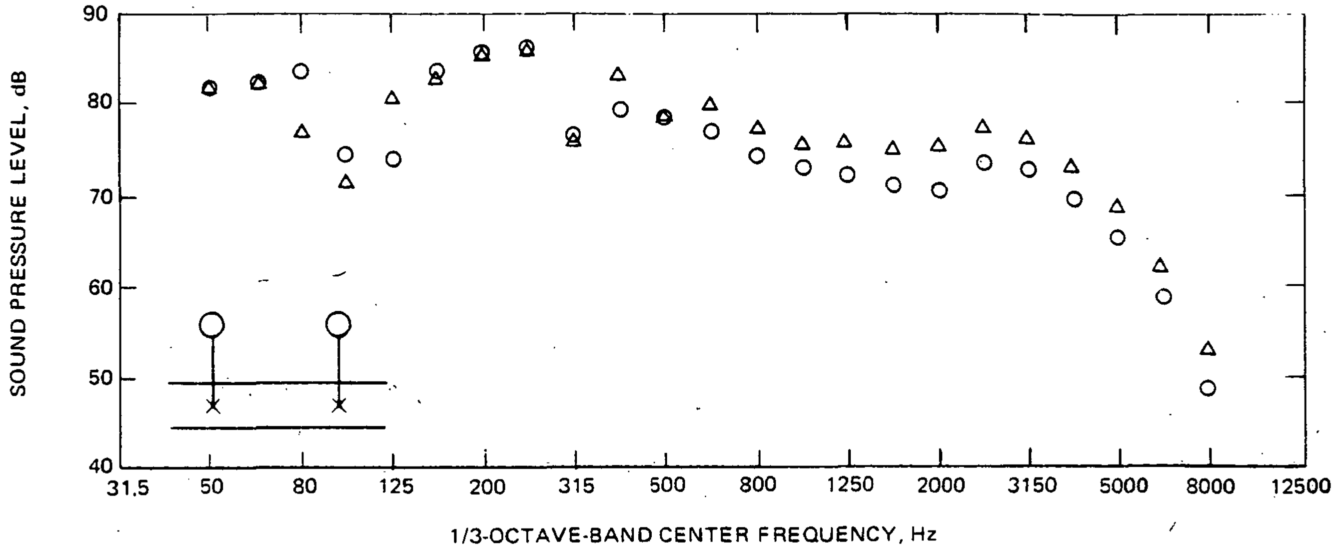
△MIC 4, T = 14.0 s, ψ = 35 DEG



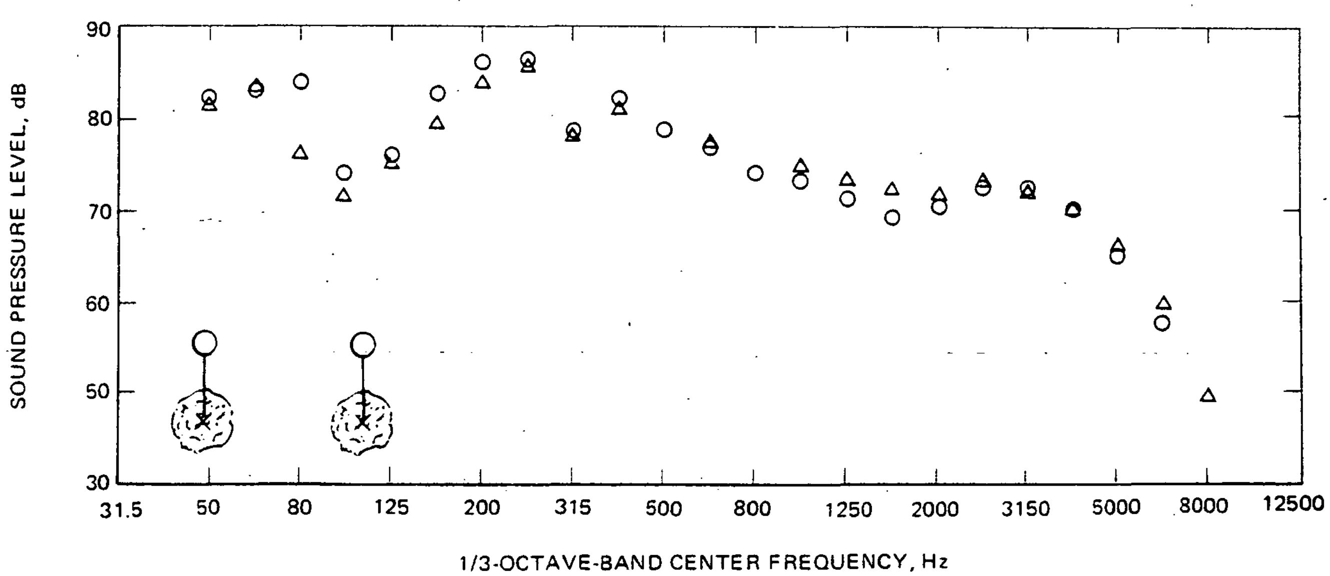
(f) ○MIC 3, T = 14.0s, ψ = 37 DEG

△MIC 6, T = 14.0 s, ψ = 35 DEG

Figure 15.-Continued.

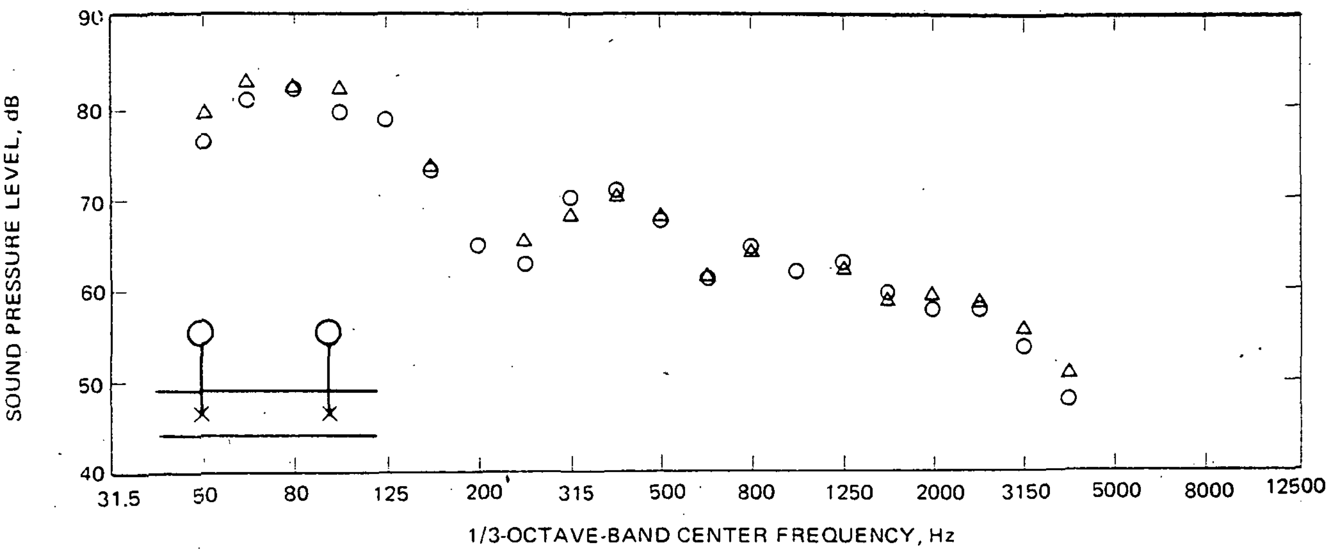


(g) ○MIC 1, T = 14.0 s, ψ = 37 DEG
△MIC 4, T = 13.5 s, ψ = 39 DEG

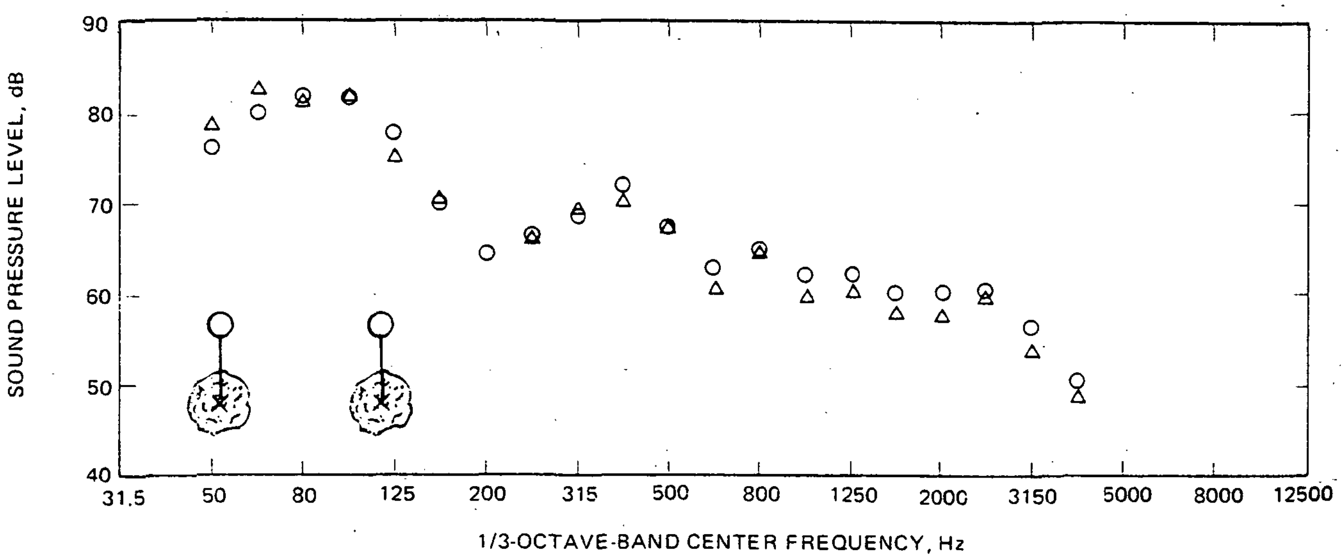


(h) ○MIC 3, T = 14.0 s, ψ = 37 DEG
△MIC 6, T = 13.5 s, ψ = 39 DEG

Figure 15.-Continued.

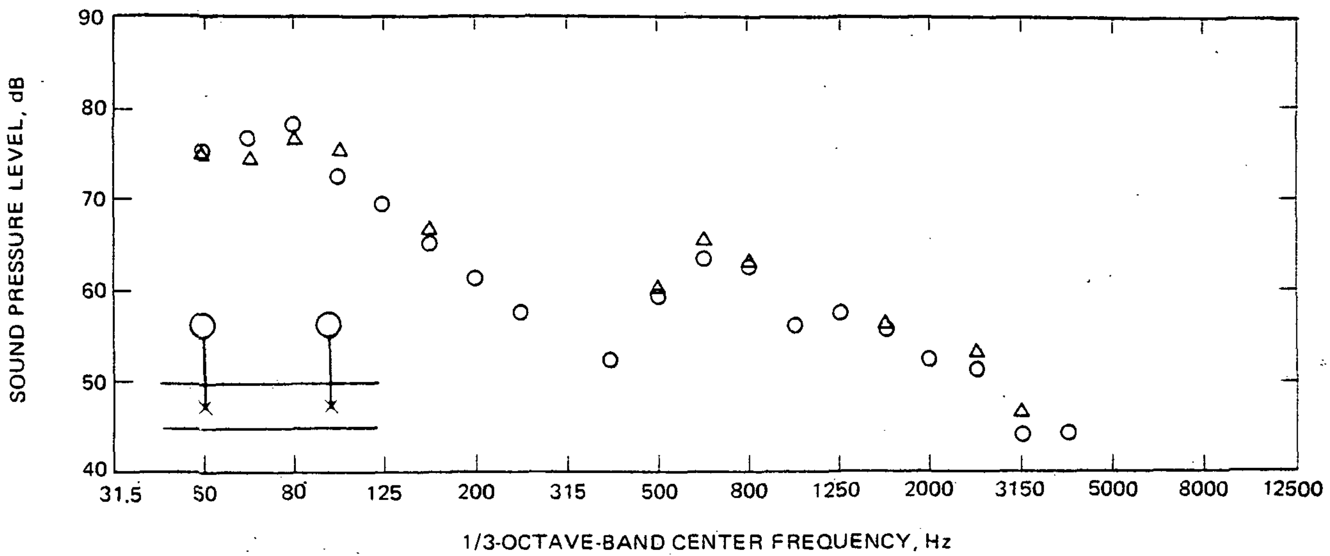


(i) ○ MIC 1, T = 18.5 s, ψ = 18 DEG
△ MIC 4, T = 18.0 s, ψ = 19 DEG



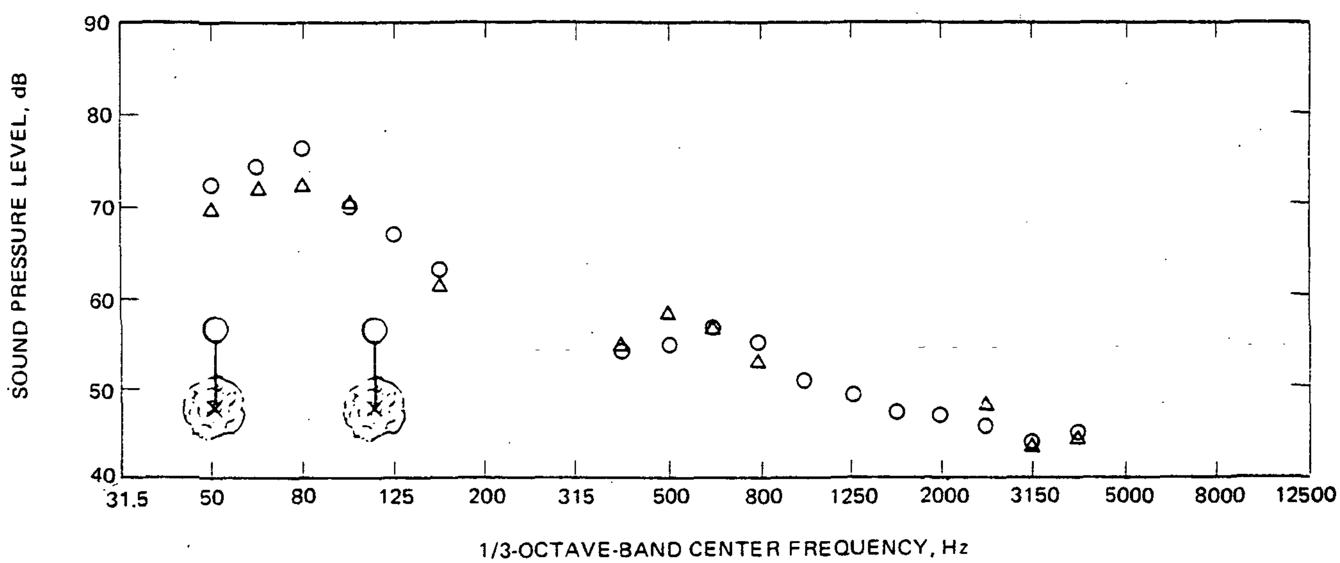
(j) ○ MIC 3, T = 18.5 s, ψ = 18 DEG
△ MIC 6, T = 18.0 s, ψ = 19 DEG

Figure 15.- Continued.



(k) ○ MIC 1, T = 24.5 s, ψ = 11 DEG

△ MIC 4, T = 24.0 s, ψ = 11 DEG



(l) ○ MIC 3, T = 24.5 s, ψ = 11 DEG

△ MIC 6, T = 24.0 s, ψ = 11 DEG

Figure 15.-Concluded.

In order to compare the spectra from the microphones over concrete with the spectra from the microphones over spaded soil, data from all four 1.2-m-high microphones are plotted together in figure 16. The plots generally show only small differences between the spectra from the microphones over concrete and from the microphones over spaded dirt. In fact, even for the small-angle case shown in figure 16(e) there was little difference between the two sets of spectra. Note that for that case, the angle ψ was less than 22 degrees so the reflected wave hit the ground outside of the spaded region. For the smallest angle case, shown in figure 16(f), however, there were large differences between the spectra for the two sets of microphones, especially in the higher frequency bands.

Comparison of Measured and Calculated Spectra

According to ground reflection theory (equation 3) the ground-level microphones mounted on the plywood boards should measure sound pressure levels that are about 6 dB above the free-field levels for all frequency bands. (That result is of course an idealization for a infinitely large plywood board of infinite impedance.) Furthermore, ground reflection theory can be used to calculate the difference between the free-field spectra and the spectra actually measured by 1.2-m-high microphones, provided the impedance of the surface beneath the microphones is known. Furthermore, the spectral measurements shown previously indicated that the impedance does not have a large effect on the spectral behavior even for rather shallow grazing angles.

As a test of the practicality of obtaining free-field data from measurements made with a microphone above a reflecting surface, calculations were made using equation 3. An infinite impedance reflecting surface was assumed for the calculations and the differences between the free-field sound pressure levels and sound pressure levels at microphone 1 were calculated. Then, using the assumption that the board mounted microphones actually did measure sound pressure levels 6 dB above the free-field values, the sound pressure levels from microphone 2 were calculated. Comparisons of the calculated and measured spectra are shown in figure 17. The calculated spectra agreed well with the measured spectra for a large range of grazing angles.

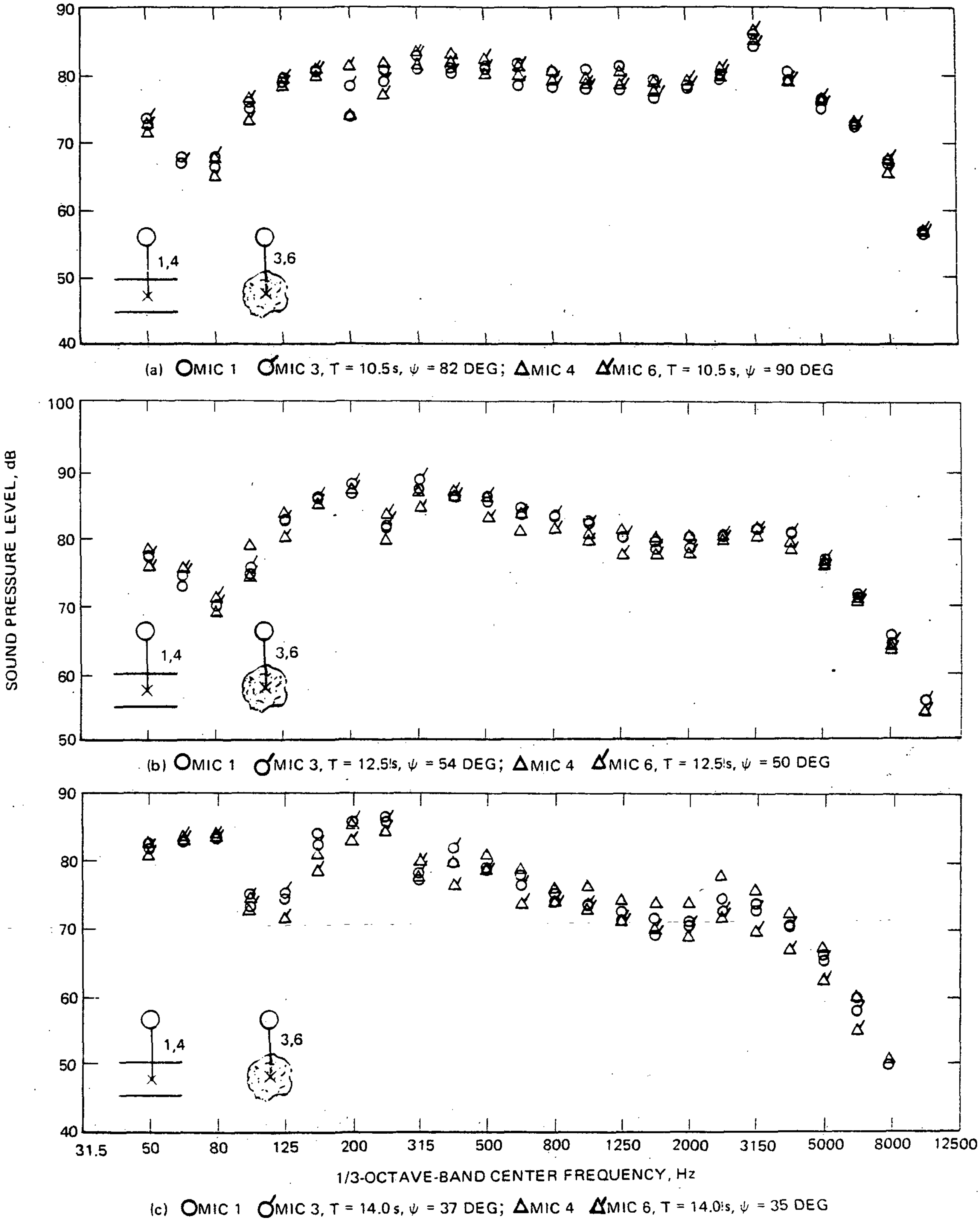


Figure 16.-Comparison of spectra measured with microphones over concrete and over spaded soil; run 272.

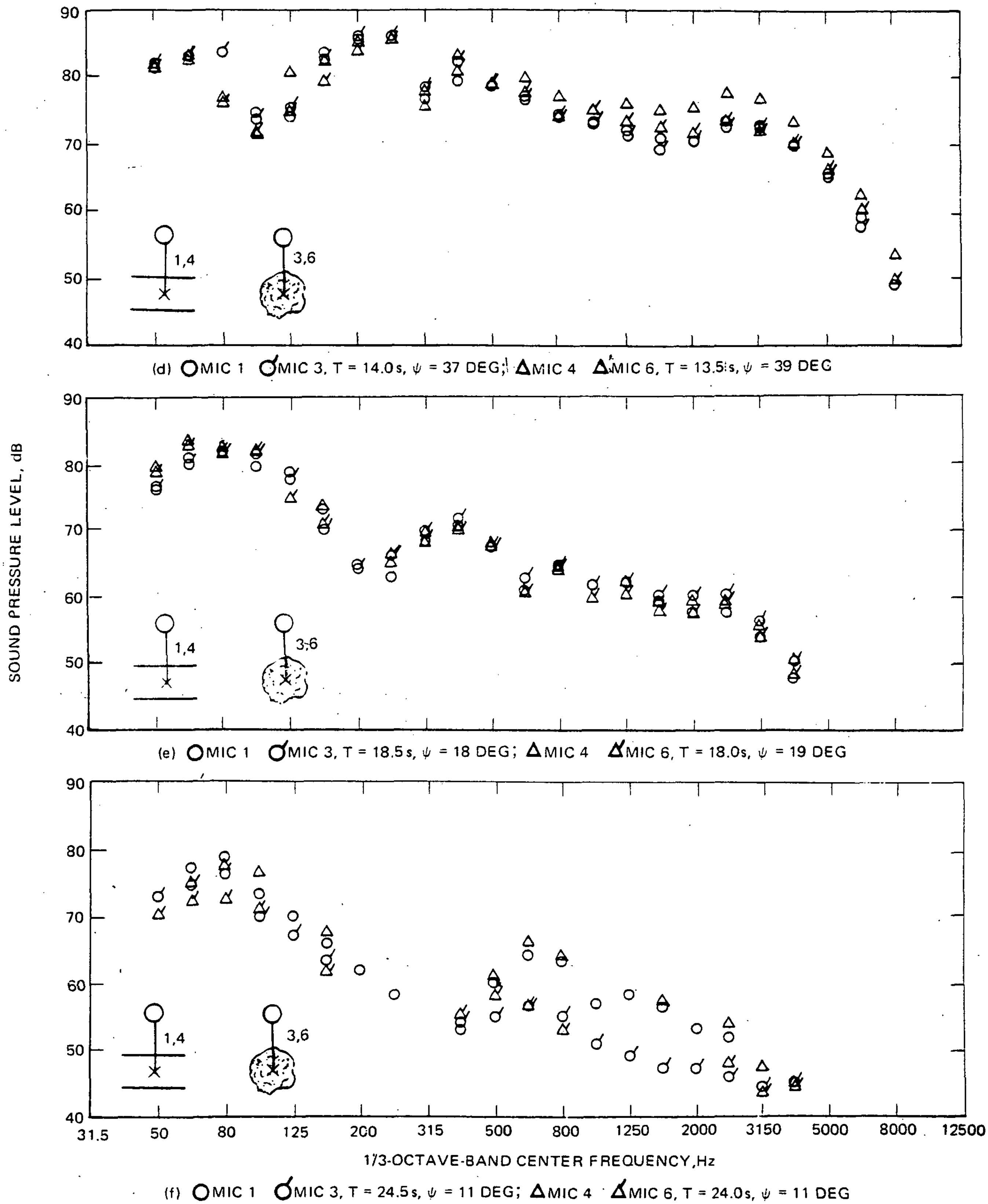


Figure 16.-Concluded.

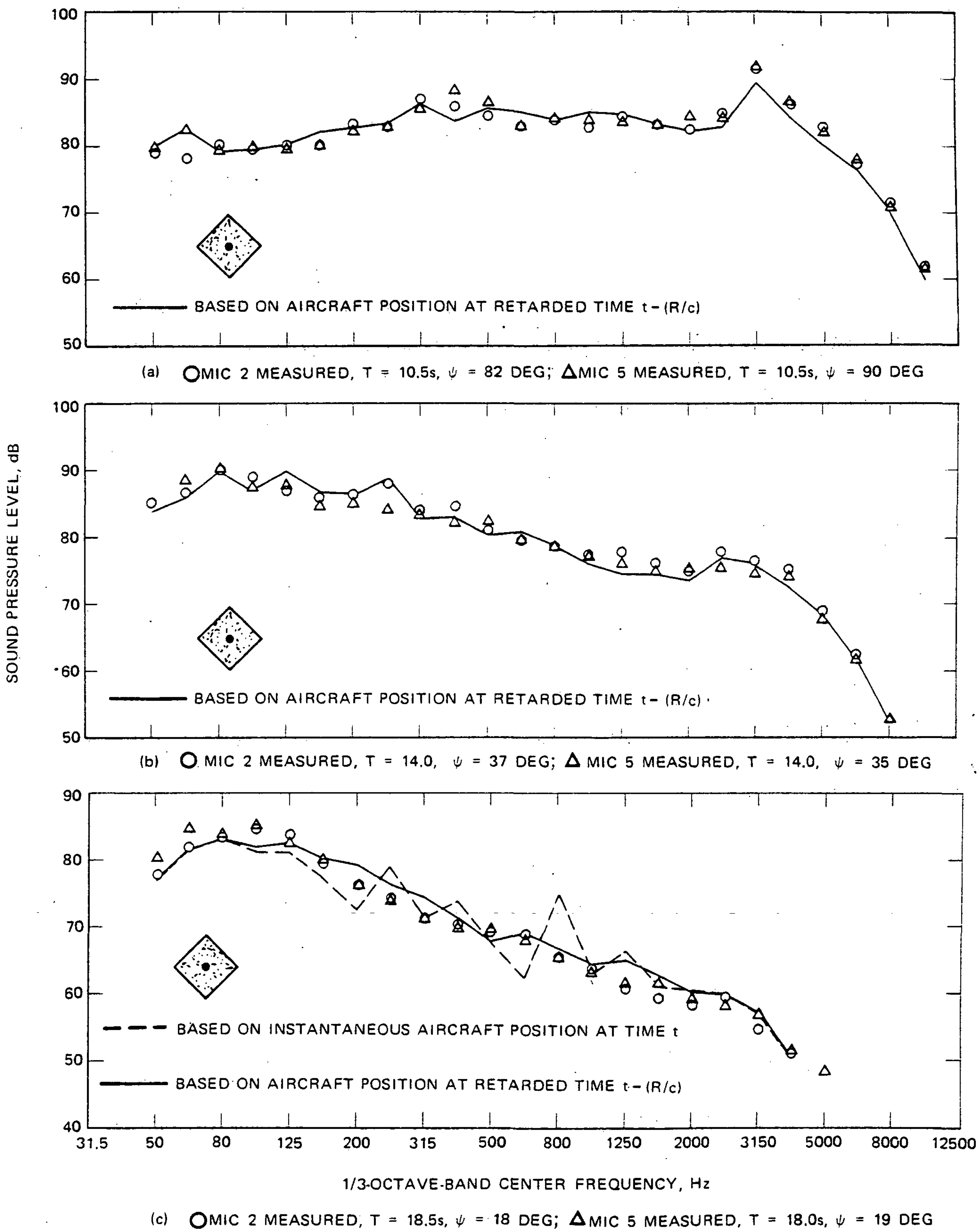


Figure 17.-Comparison of measured spectra from ground level microphones with spectra calculated from SPLs measured at 1.2m over concrete (mic 1); run 272.

The geometrical parameters used in equation 3 for the calculations were based on the position of the airplane at the retarded time t - (R/c), and not on the instantaneous position of the airplane. The calculated spectrum shown in figure 17(c), which was done for parameters based on the instantaneous position of the airplane, did not agree as well with the measurements. This latter result is contrary to what would be expected on the basis of the moving source analysis described previously. The reason for the discrepancy is not known.

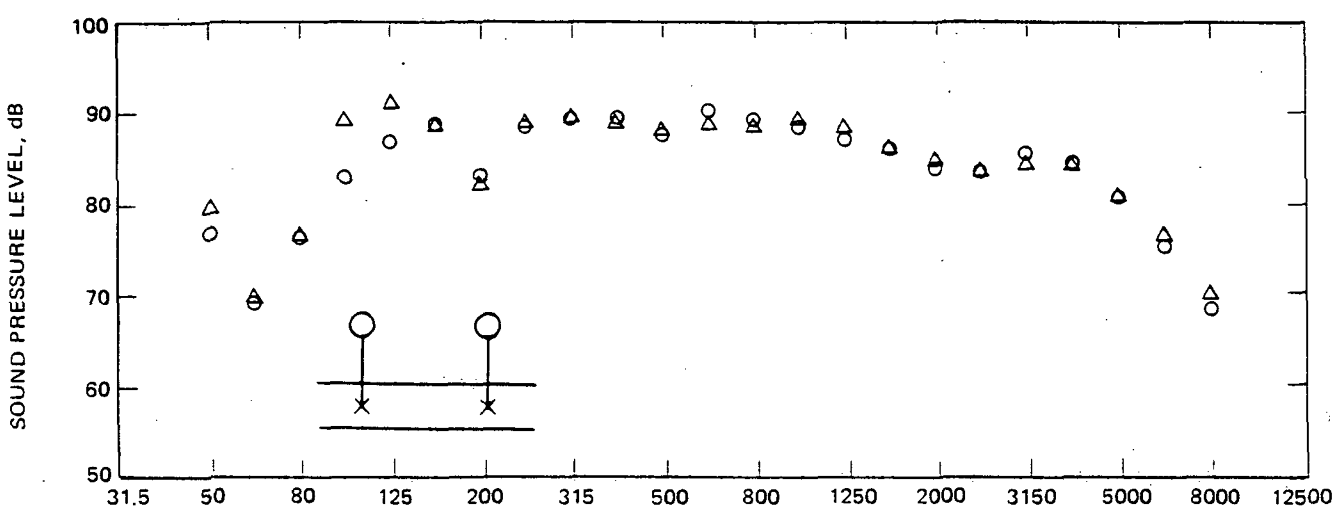
Other Measured Spectra

Although the majority of the measured spectra from the thirteen runs were consistent in the sense described earlier, and although the majority of the data showed only small differences between the microphone 1 and 4 data and the microphone 3 and 6 data, there were a large number of exceptions. We will now show some examples of "exceptional" data.

Figure 18 shows the same type of spectral comparison for run 295 as was shown in figure 15 for run 272. It can be seen that there were some fairly large differences between the spectra from microphones 3 and 6 especially for the shallow-angle case shown in figures 18(c) and 18(d). A possible explanation for the differences is the inaccuracy of the airplane positioning data. The airplane may not really have been at the same relative location with respect to the two sets of microphones when the comparisons were made. Indeed, if the microphone 4 and microphone 6 spectra used for comparison with the microphone 1 and microphone 3 spectra were for times one half-second later than for the comparison of figure 18, better agreement was obtained for the shallow-angle case as seen by comparing the spectra in figures 19(a) and 19(b) with those in figures 18(c) and 18(d). However, the agreement became worse for the more-nearly-overhead case — compare figures 19(c) and 19(d) with figures 18(a) and 18(b).

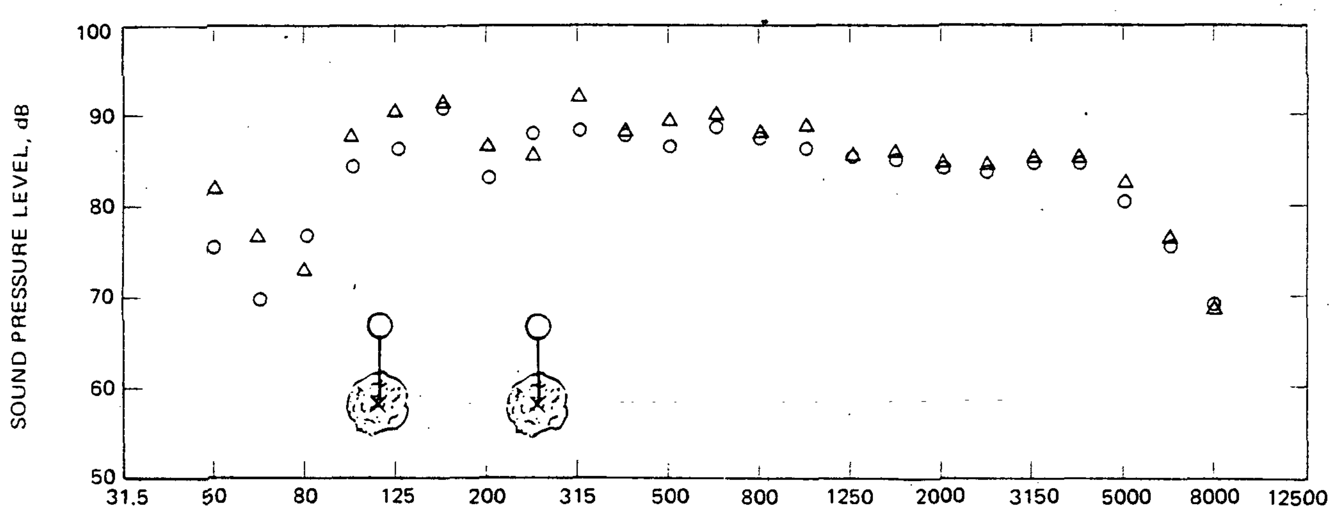
Time Variation of Spectral Differences

Rapid variations with time sometimes occurred for the differences between the sound pressure levels at microphones 1 and 3 and between those at microphones 4 and 6. The rapid variations usually occurred for shallow



(a) ○ MIC 1, T = 11.0s, ψ = 86 DEG

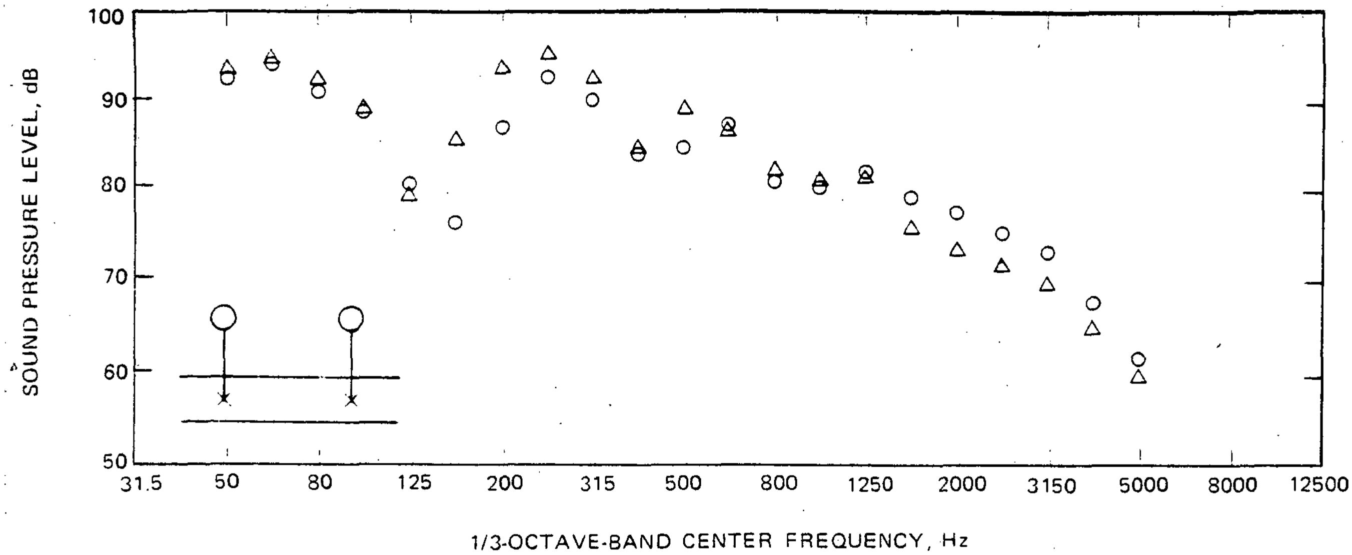
△ MIC 4, T = 2.0s, ψ = 86 DEG



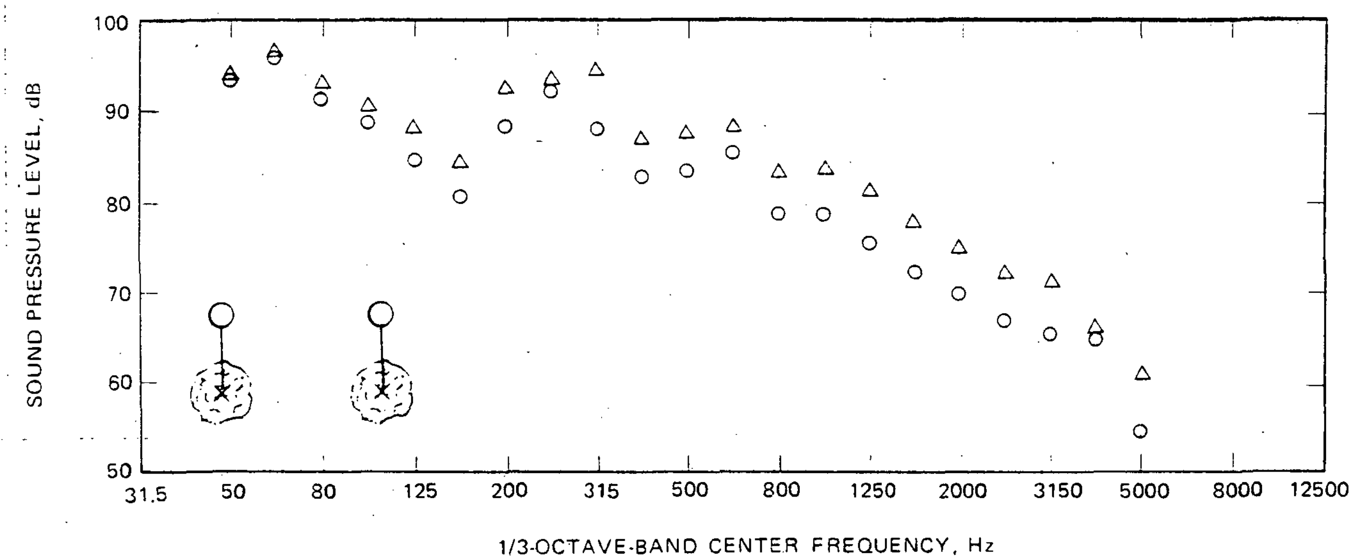
(b) ○ MIC 3, T = 11.0s, ψ = 86 DEG

△ MIC 6, T = 2.0s, ψ = 86 DEG

Figure 18.- Comparison of spectra measured with microphones 595m apart but for different times such that the airplane is approximately in the same relative position with respect to each microphone; run 295.

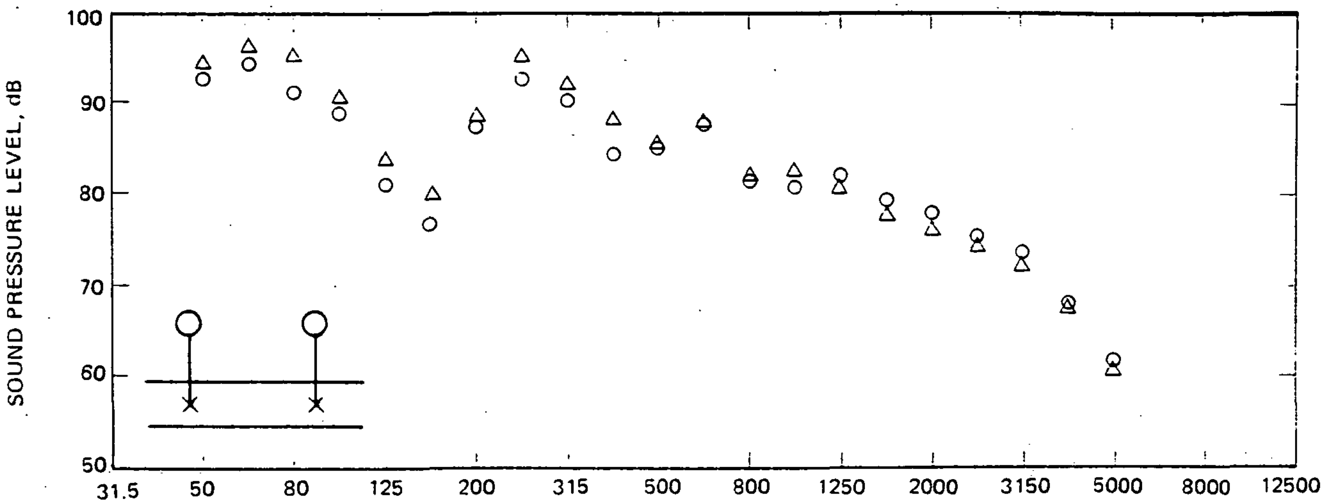


(c) ○ MIC 1, T = 15.0s, ψ = 29 DEG
△ MIC 4, T = 6.0s, ψ = 29 DEG



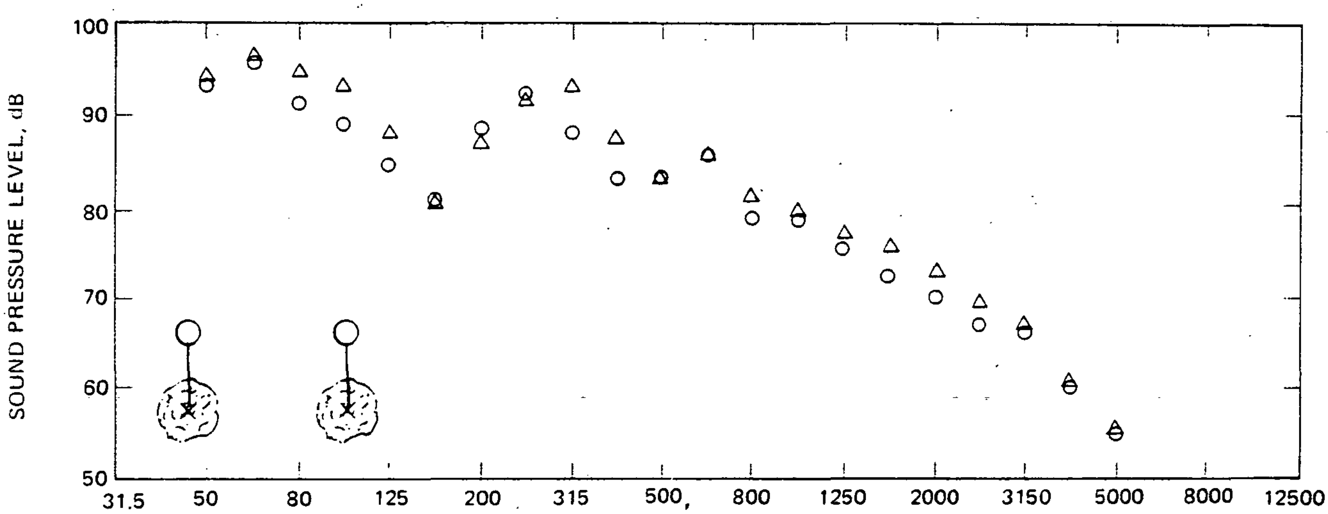
(d) ○ MIC 3, T = 15.0s, ψ = 29 DEG
△ MIC 6, T = 6.0s, ψ = 29 DEG

Figure 18.-Concluded.



1/3-OCTAVE-BAND CENTER FREQUENCY, Hz

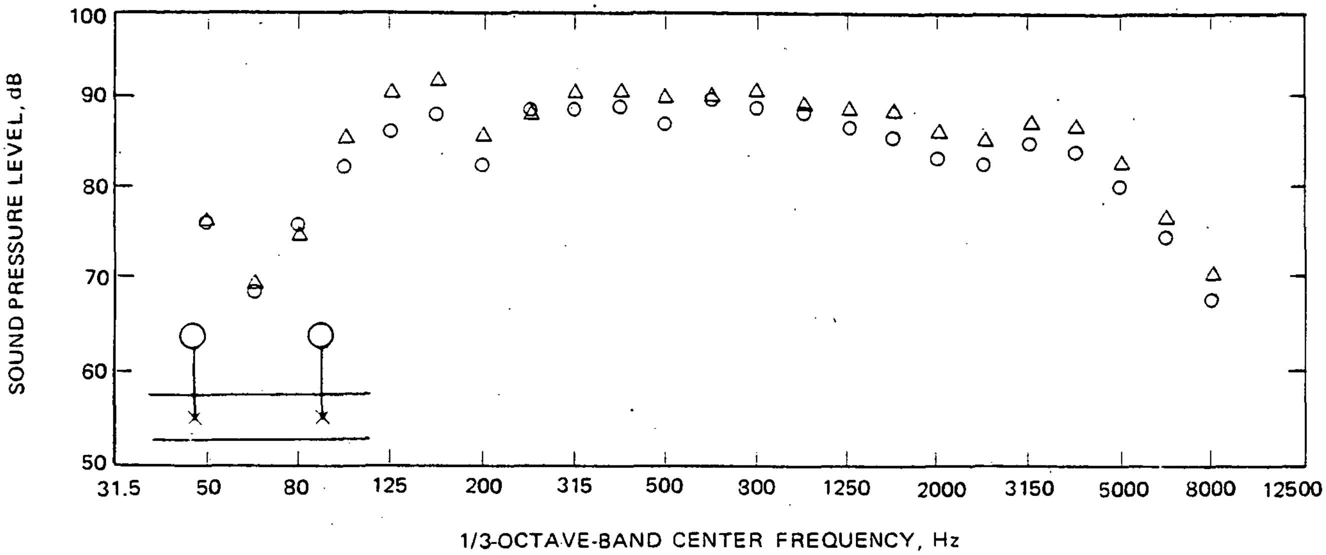
(a) ○ MIC 1, T = 15.0s, ψ = 29 DEG
△ MIC 4, T = 6.5s, ψ = 26 DEG



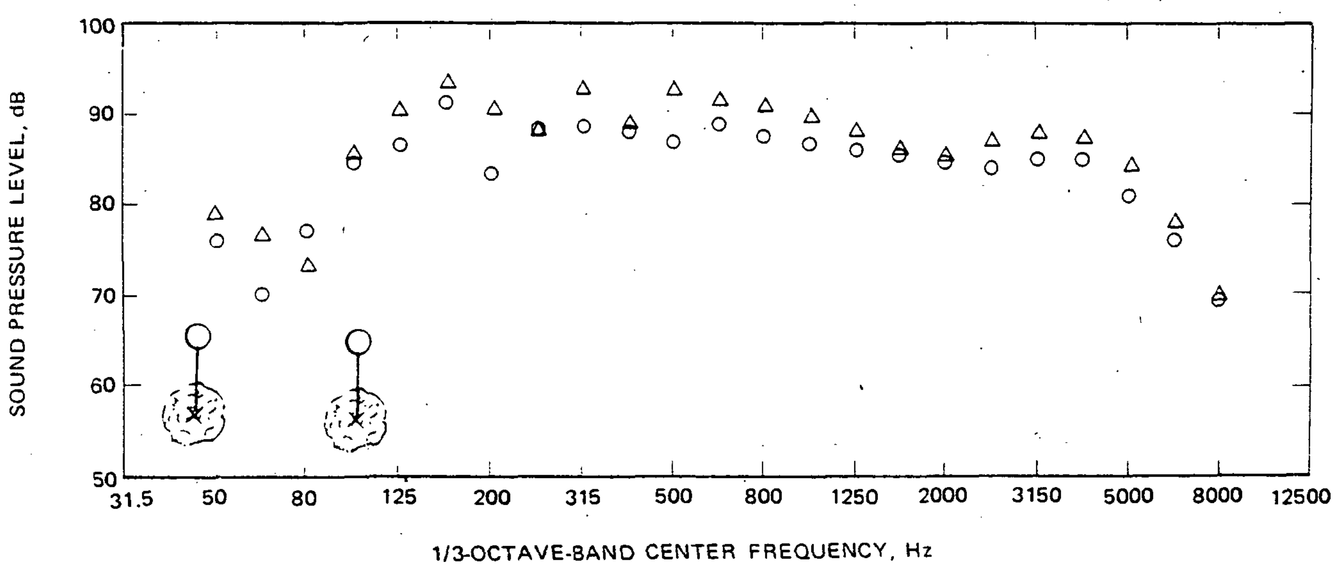
1/3-OCTAVE-BAND CENTER FREQUENCY, Hz

(b) ○ MIC 3, T = 15.0s, ψ = 29 DEG
△ MIC 6, T = 6.5s, ψ = 26 DEG

Figure 19.-Same spectral comparison as in figure 18 but the mic 4 and mic 6 spectra plotted here are for times 0.5s later than for the corresponding spectra plotted in figure 18.



(c) O MIC 1, T = 11.0s, ψ = 86 DEG
Δ MIC 4, T = 2.5s, ψ = 72 DEG



(d) O MIC 3, T = 11.0s, ψ = 86 DEG
Δ MIC 6, T = 2.5s, ψ = 72 DEG

Figure 19.-Concluded.

grazing angles. Figure 20 illustrates the type of changes that occurred over a period of three successive half-second time intervals. These data are from a third run of the set of thirteen low-height runs, i.e., run 379.

In order to more thoroughly investigate the time variation of sound pressure level differences during a run, individual 1/3-octave bands were chosen for detailed analysis. The differences between the sound pressure levels measured at microphones 1 and 3 were calculated for 1/3-octave band center frequencies of 125, 250, 500, 1000, and 2000 Hz for each half-second sample of data from run 272. In addition, calculations of the differences, based on the impedance model in figure 8, were made using equation 3. The calculations were made by the following procedure: first, the geometrical parameters ψ and Δr were calculated at the midpoint of each half-second time interval. Next, equation 3 used to calculate ΔN for a microphone over an infinite impedance surface. Equation 3 was then used again to calculate ΔN for a microphone over a surface having an impedance given by equation 5. The differences between the two sets of values of ΔN were the final results desired.

Plots of the measured differences in sound pressure level and the calculated differences are given in figure 21. The circles indicate the experimental data points and the solid lines the calculated results. In interpreting the data, it should be kept in mind that, in actuality, the impedance of the surface relevant to microphone 3 was not uniform. That was because the ground around microphone 3 was spaded in a 3-m-radius circular region, and the rest of the ground was undisturbed. As pointed out earlier, the reflected wave was inside the spaded-ground region only for times after IRIG start of between 6 and 17 seconds. Nevertheless, the calculations showed that ground reflection effects can account for some of the rapid changes in differences between the sound pressure levels measured at microphones 1 and 3, see, for example, the agreement between calculated and measured changes for the time between 17 and 24 seconds for the 250-Hz data in figure 21(b) and for the time between 0 and 4 seconds for the 1000-Hz data in figure 21(d). However, there were also large oscillations in the differences that did not appear to be caused by impedance differences. Atmospheric turbulence near the ground may have a significant effect on the measured differences for shallow-angle sound propagation, since thermally induced turbulence over the concrete taxiway might be quite different

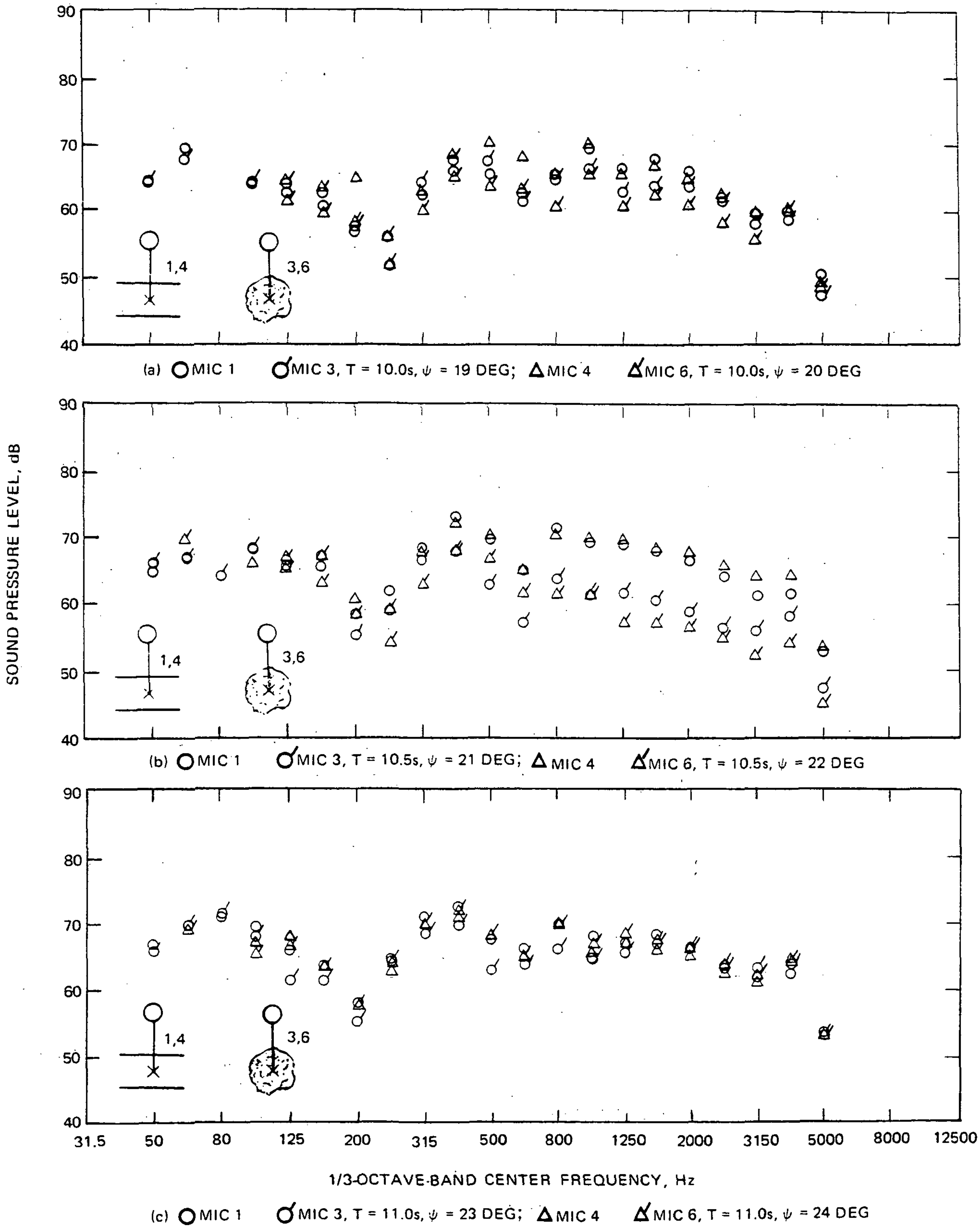


Figure 20.- Spectra measured at successive 0.5s time intervals illustrating rapid changes with time of differences between SPLs recorded by microphone pairs 1,4 and 3,6; run 379.

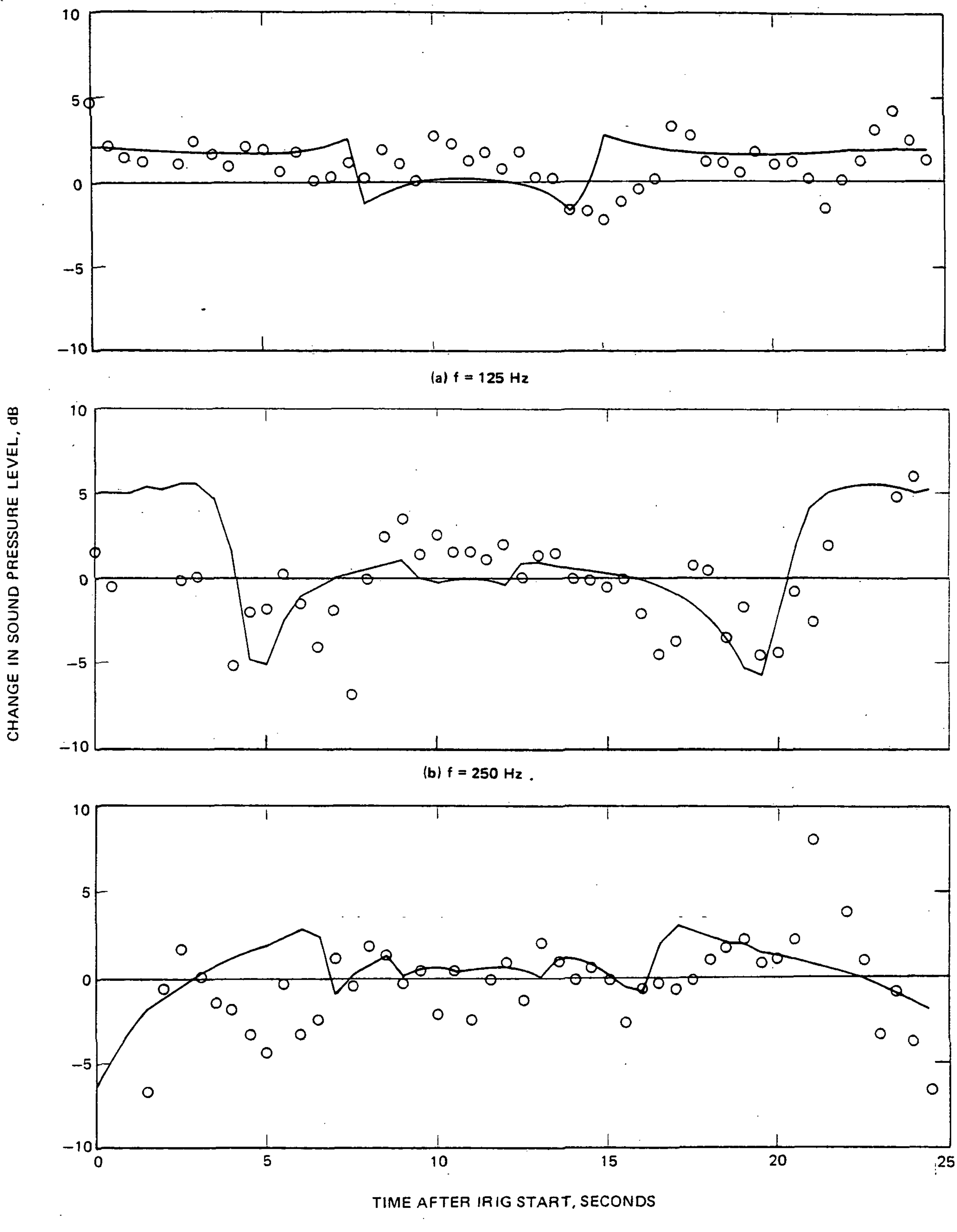
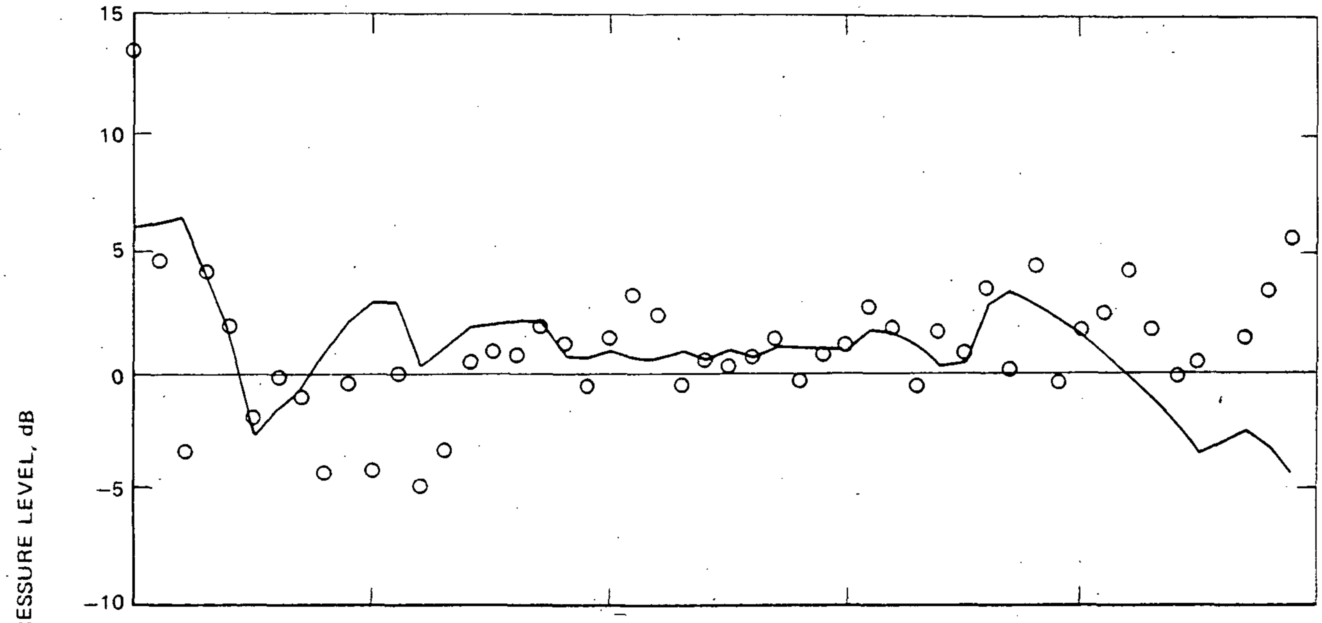
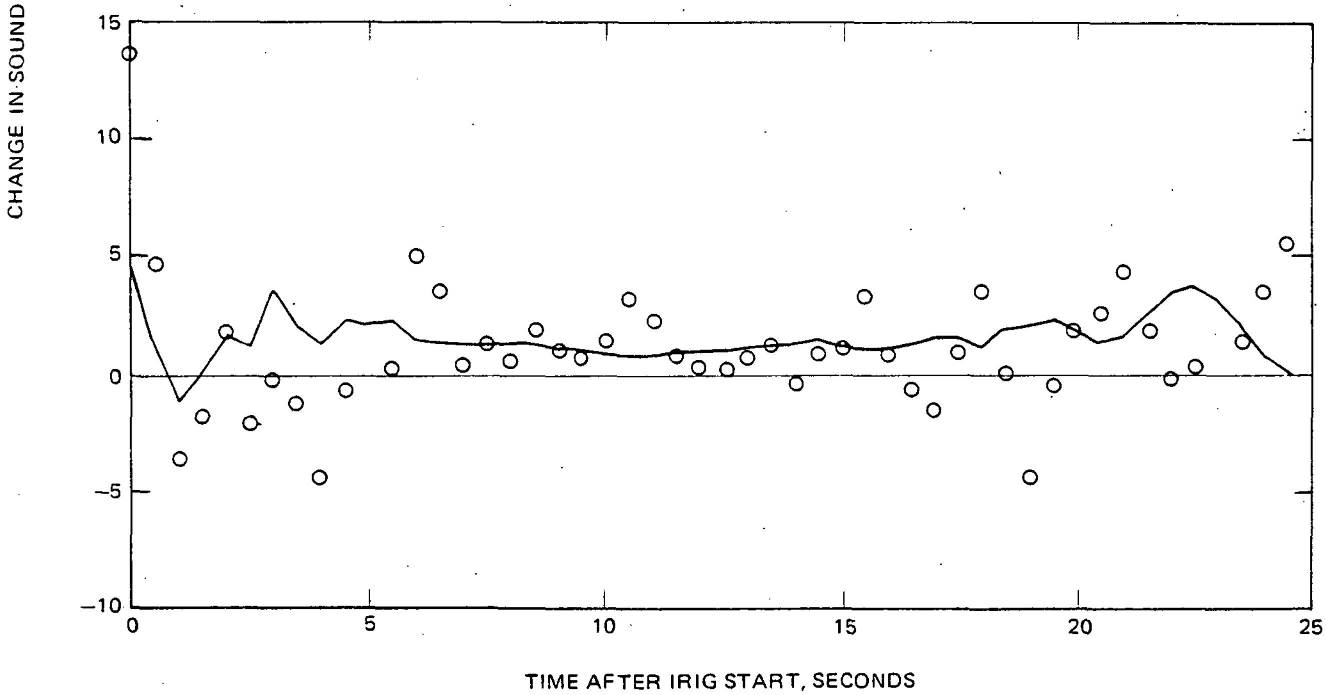


Figure 21.-Variation with time of the difference:mic 1 SPL minus mic 3 SPL; run 272.



(d) f = 1000 Hz



(e) f = 2000 Hz

Figure 21.-Concluded.

than that over the ground surface around microphone 3. Additional research is required to quantify the potential role of turbulence.

Sensitivity of Spectral Differences to Ground Impedance

To illustrate the sensitivity — or insensitivity — of ground reflection effects to changes in the complex ground impedance, calculations of spectral differences were done using a model ground impedance greatly different from the model ground impedance shown in figure 8.

As pointed out by Piercy, Embleton, and Sutherland (reference 11), measurements of the acoustical impedance of ground surfaces are scarce. A substantial amount of impedance data are available only for grass-covered ground. Other surfaces such as a stubble field and the ground under a pine plantation appear to have impedances similar to that of grass.

Those observations led to our choosing the model ground impedance shown in figure 8. As mentioned earlier, that impedance model was based on measurements of the impedance of grass-covered ground.

The lowest value of normalized ground impedance reported in the literature is $Z/\rho c = 0.5 - 3.5i$ at a frequency of 300 Hz. That value was deduced by Aylor (reference 14) from his measurements of the excess attenuation of sound propagated over disced soil. We now specify an impedance model which was constructed to yield Aylor's measured value of the impedance of disced soil at 300 Hz. The normalized resistance and reactance were calculated according to the following equations

$$R/\rho c = (100/f)^{0.6}$$

$$\chi/\rho c = -7\ (100/f)^{0.6} \tag{23}$$

Equation 23 yields much smaller absolute values of resistance and reactance than does equation 5, as can be seen from the plots in figure 22.

Based on the impedance model of equation 23, calculations were made of the expected differences between the sound pressure levels measured by microphone 1 and microphone 3. The calculated curves are shown in figure 23,

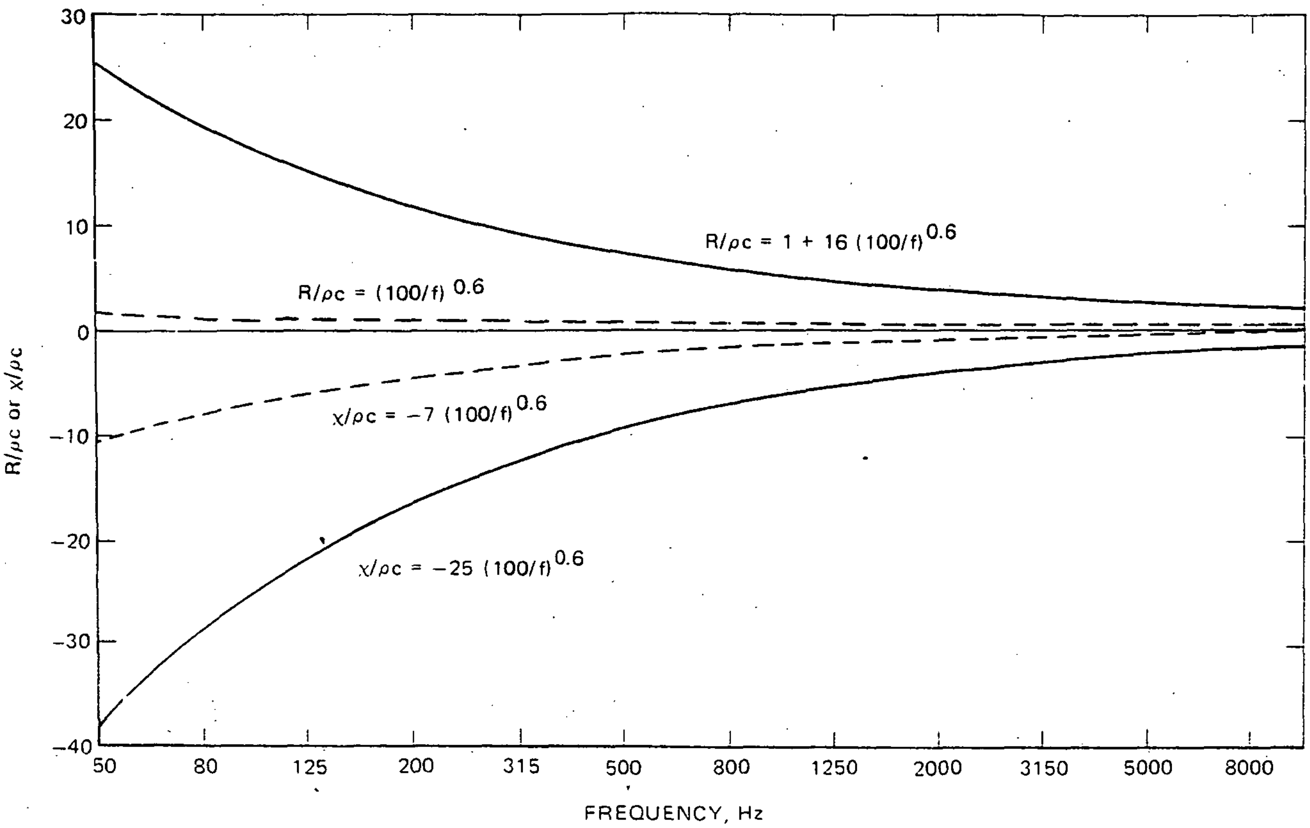


Figure 22.-Analytical models of ground impedance.

——— Fit to data of ref. 8

– – – – Approximation fitting 300-Hz data of ref. 14

along with the measured differences. Comparison of the two calculated curves with the data shows that the impedance model of equation 5 gave results that agreed better with measured values than did the impedance model of equation 23. However, it must be kept in mind that the reflected waves only impinged on the spaded ground region around microphone 3 for times aftter IRIG start of between 6 and 17 seconds. Restricting the comparisons to that time interval, we find that, except for the 125-Hz band, the impedance model of equation 5 is only marginally superior to that of equation 23. Thus, calculations using widely different values of impedance, showed only small differences in sound pressure levels, particularly for the high frequencies (i.e., large values of $\Delta r/\lambda$). Norum and Liu (reference 9) also found from their experiments that the relative insensitivity of ground reflection phenomena to surface impedance precluded a quantitative determination of impedance.

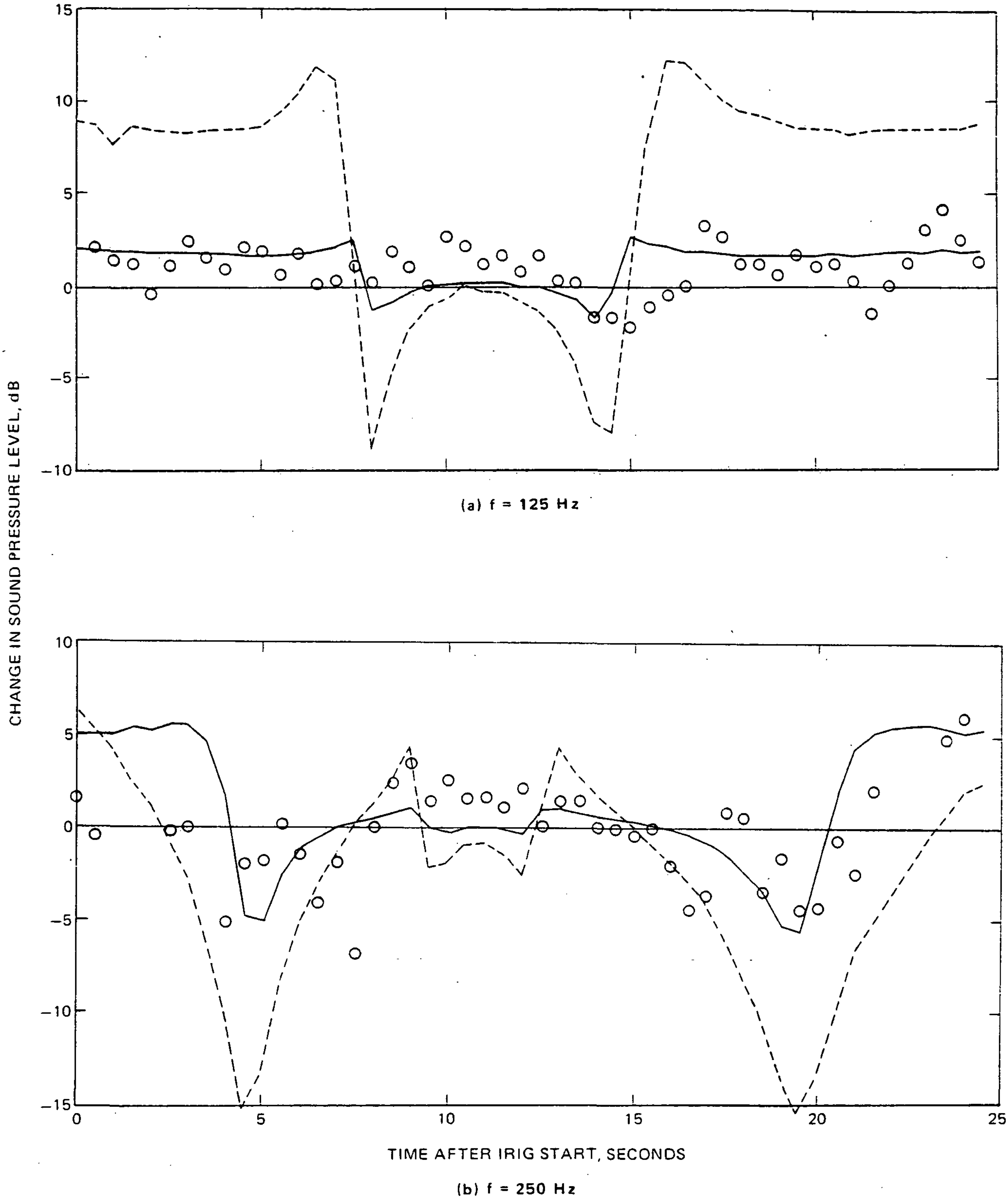


Figure 23.- Experimental and calculated variations of SPL with time during a flyover; SPL at mic 1 minus SPL at mic 3 from run 272.

——— Using analytical expression fitting data of ref. 8

– – – – Using analytical expression approximating 300-Hz data of ref. 14

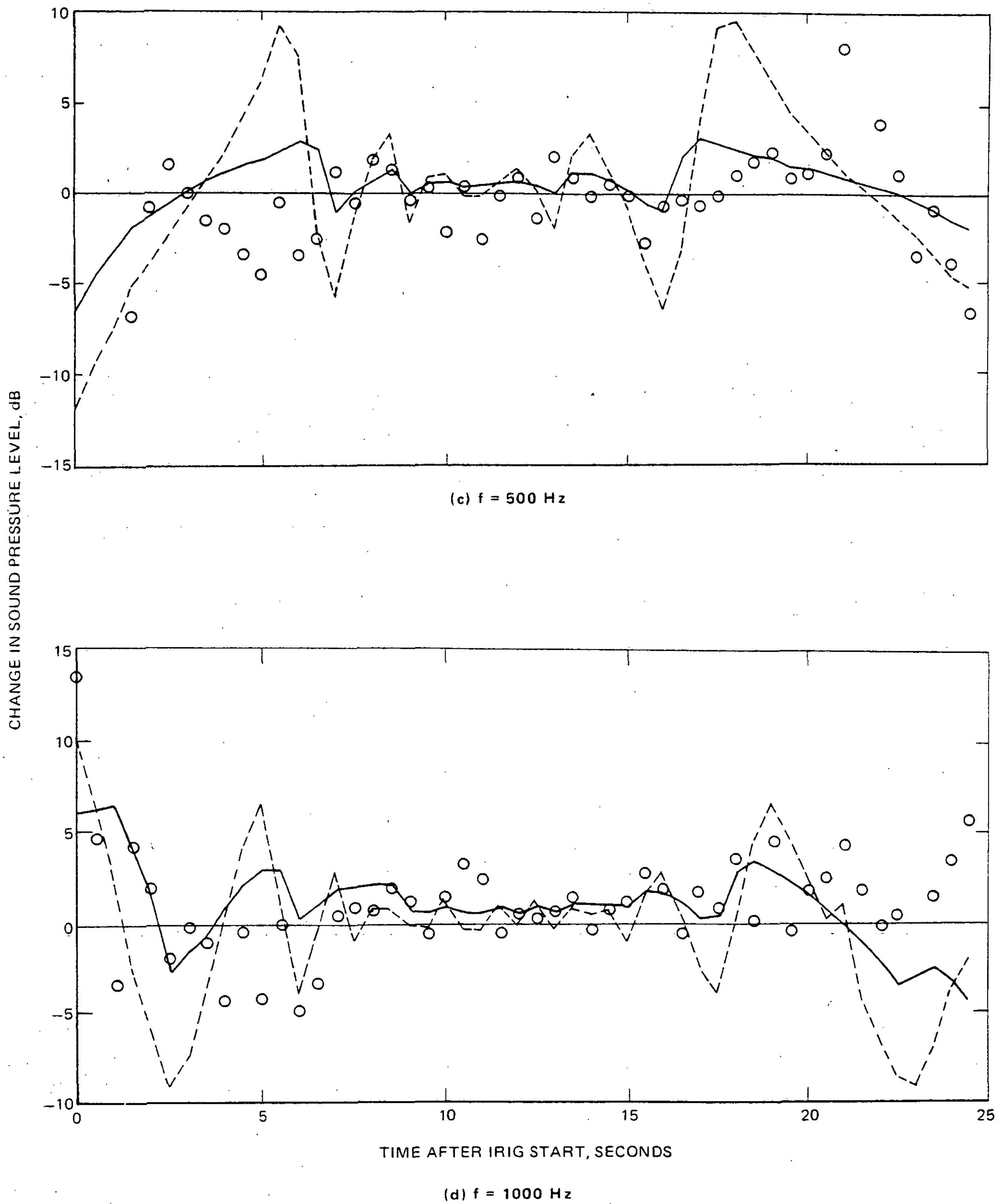
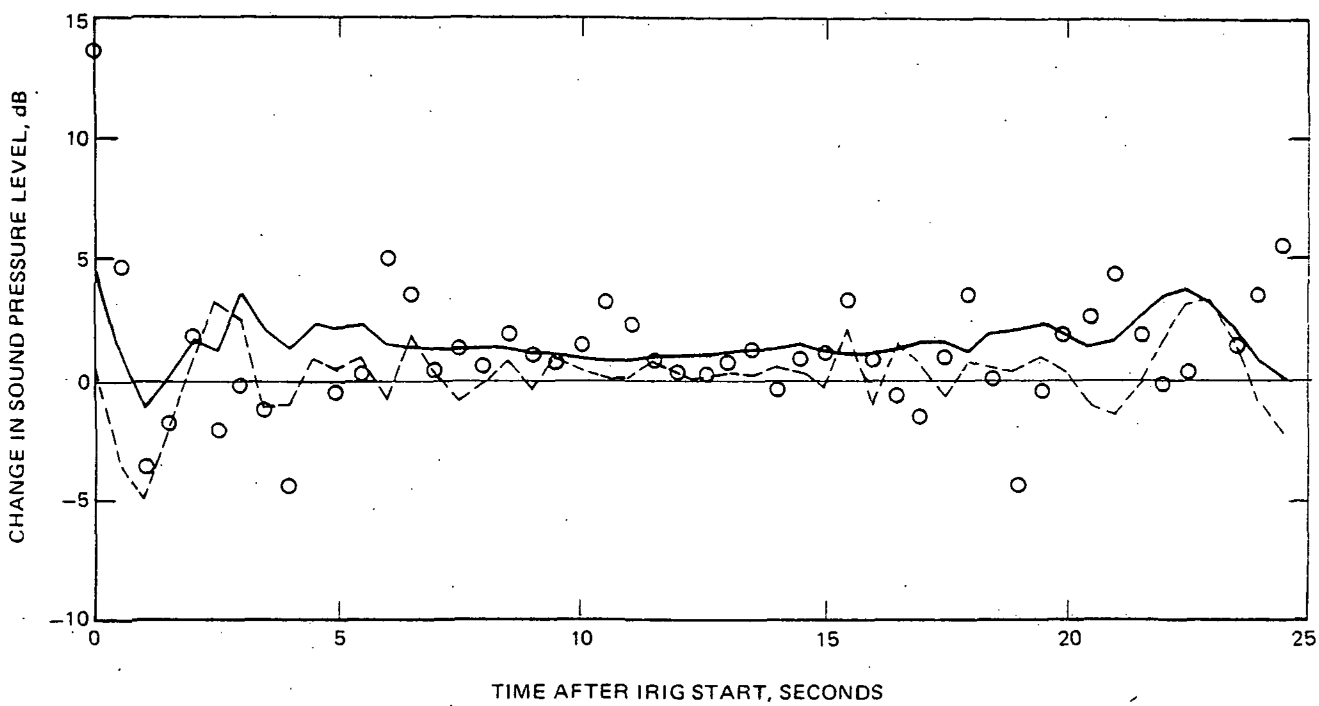


Figure 23.- Continued.



(e) f = 2000 Hz

Figure 23.-Concluded.

CONCLUSIONS

Analysis of DC-9-10 flyover noise measurements from microphones at a 1.2-m height over a concrete surface, at a 1.2-m height over spaded soil, and flush in a plywood groundboard led to the following conclusions concerning ground reflection effects on the spectrum of the sound pressure and the acoustical impedance of the concrete and spaded soil surfaces.

1. Classical ground reflection theory (equation 3) for stationary noise sources (with the source located at a position corresponding to the time of sound emission and not the time of sound reception) coupled with physically reasonable assumptions (see conclusions 3 and 4) for the complex acoustical impedance of the ground surface below a microphone can be used to calculate spectral differences between the free field and measured 1/3-octave-band noise levels.

2. Except for data recorded at shallow grazing angles prior to, or after, the time of closest approach, there were no significant and consistent differences between the sound pressure spectra measured over concrete and over the spaded-soil surfaces, a result attributed to the insensitivity of the ground reflection coefficient to large changes in ground impedance.

3. The irregularities caused by ground reflections in the spectra measured by the microphones over concrete were usually calculated within 2 dB (figure 17) by assuming the specific acoustical impedance of concrete to be that of a perfect reflector, i.e., infinite.

4. The irregularities caused by ground reflections in the spectra measured by the microphones over spaded soil were calculated reasonably well (figure 21) by assuming the specific acoustical impedance of the spaded soil to be that of an analytical model developed here for the measured impedance of grass-covered soil, see equation 5.

5. The analytical method used for describing ground reflection effects was successful in removing irregularities caused by ground reflections in the spectra measured by the 1.2-m-high microphones over concrete and spaded soil and producing equivalent free-field spectra that agreed with free-field spectra measured by the flush-mounted groundboard microphones.

6. Two new analyses were developed during this study to describe the effects of source motion on ground reflection phenomena. The first analysis considered the dynamic (Mach number) effects of source motion. The second analysis considered effects caused by relative position changes between the moving source and a microphone during the time averaging period used to obtain sound pressure levels.

7. The first analysis indicated that if a static source theory is used to compute, approximately, ground reflection effects for a moving source the sound path lengths should be calculated assuming the source was located on the airplane flight path at the position corresponding to the time when the sound was received at the microphone and not the time when the sound was emitted. This result was not confirmed by the measured data. The best comparisons between measured and calculated data were obtained when the sound source was located where it would have been at the time the sound was emitted, i.e., at a position behind the instantaneous position of the airplane on the flight path.

8. Relative position changes between source and microphone during the half-second averaging time produced negligible changes in the spectra. If the averaging time had been 1.5 seconds instead of 0.5 seconds, the effects of source translation during the averaging time would have caused significant effects on the measured spectra.

9. The method of determining the phase of the ground-surface reflection coefficient from the frequencies of the maxima and minima of the spectral irregularities introduced by ground reflections could not be applied to these flyover noise measurements because of the usually small differences between the spectra measured over concrete and the spectra measured over the spaded soil. Without knowledge of the phase of the reflection coefficient as a function of frequency, it is not possible to make a direct determination of the acoustical impedance.

10. At shallow propagation angles, large differences between the spectra measured over concrete and over spaded soil were observed. These differences varied rapidly with time. Ground reflection theory could account for some but not all of the observed differences. Additional research is needed to

determine the cause of these large differences.

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Huntington Beach, California
22 February 1978

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APPENDIX A

MICROPHONE AND SYSTEM FREQUENCY-RESPONSE CORRECTIONS

Microphone frequency response corrections at the nominal center frequencies of the 1/3-octave bands between 50 and 10,000 Hz were determined as the algebraic sum of the windscreen correction, the microphone's pressure response correction, and the microphone diffraction correction at the angle of incidence appropriate for the microphone location. Windscreen corrections for the foam-ball windscreens were read from Bruel & Kjaer product information literature. Microphone pressure response corrections were read from recent electrostatic actuator calibration curves for the particular microphone cartridge used at each of the six locations. Microphone diffraction corrections were read from Bruel & Kjaer product information literature for the 1/2-inch-diameter microphones mounted on the 1/2-inch-diameter preamplifiers.

For the special NASA fabricated cheesecloth windscreens used around the flush groundboard microphones at locations 2 and 5, it was assumed that the windscreen correction was negligible at all frequencies in the range of interest. A random incidence diffraction correction was also considered to be appropriate for the flush microphones.

Tables A1 to A6 list the microphone corrections that were developed for the six locations. The corrections are in decibels relative to the response at 250 Hz in the flat region of the microphone frequency curve. The corrections are to be added algebraically to the system frequency response corrections.

The total frequency response corrections for the complete data-acquisition/data-processing system were determined for each of the six channels as the sum of the microphone frequency response corrections from tables A1 to A6, and the applicable system frequency response corrections developed from the pink noise calibrations recorded before and after the data recordings. The pink-noise system frequency response corrections were calculated by examining the indicated 1/3-octave-band sound pressure levels obtained from the real time analyzer for each pink noise calibration. Since there was a 20 to 30-second sample of pink noise data, a 16-second integration time was used for each

1/3-octave band. The correction factors were again read relative to the response at 250 Hz in the flattest portion of the system frequency response. The repeatability of the pink noise system-frequency-response corrections was well within the best that could be expected (namely, $\pm$ 0.5 dB) for all bands except the band centered at 63 Hz.

Inspection of the data tapes and several of the pink noise calibrations revealed that there must have been an anomalous hum problem at the 60-Hz frequency of the 115-volt alternating-current power used at the test site to operate the random noise generator. The hum signal introduced large, spurious negative response corrections in the 63-Hz band for two of the calibration signals that were to be used in the middle of the set of 39 runs. Because of the good repeatability of the response corrections in the other 23 bands, it was decided to develop a single set of system frequency response corrections as the average of four sets of corrections from calibrations made at the beginning, middle, and end of the set of 39 runs. For the 63-Hz band, the average ignored the spurious readings and was determined from corrections from two calibrations.

Tables A7 to A12 list the pink-noise frequency-response corrections, the microphone response corrections, and the total correction factors for the complete data-acquisition/data-processing system. The total response correction factors were stored in the memory of the computer and added algebraically to the indicated sound pressure levels to determine the final values of corrected sound pressure level for the six microphone locations for all runs.

TABLE A1. - RESPONSE CORRECTIONS FOR MICROPHONE AT LOCATION 1

CORRECTIONS ARE RELATIVE TO CORRESPONDING VALUE IN 250-Hz BAND

GMF, Hz	WINDSCREEN CORRECTION, dB	MICROPHONE PRESSURE CORRECTION, dB	MICROPHONE DIFFRACTION CORRECTION,[a] dB	TOTAL MICROPHONE CORRECTION, dB
50	0.0	0.0	0.0	0.0
63				
80				
100				
125				
160				
200				
250				
315				
400	0.0		0.0	
500	-0.1		+0.1	
630	-0.1		+0.1	0.0
800	-0.2		+0.1	-0.1
1000	-0.2		+0.1	-0.1
1250	-0.3		+0.1	-0.2
1600	-0.5		+0.1	-0.4
2000	-0.6		+0.2	-0.4
2500	-0.7		+0.2	-0.5
3150	-0.7	0.0	+0.2	-0.5
4000	-0.2	-0.1	+0.2	-0.1
5000	+0.5	-0.2	+0.3	+0.6
6300	+0.5	-0.5	+0.3	+0.3
8000	+0.3	-0.7	+0.4	0.0
10,000	+0.9	-0.8	+0.4	+0.5

[a] 90°, GRAZING INCIDENCE

TABLE A2. - RESPONSE CORRECTIONS FOR MICROPHONE AT LOCATION 2

CORRECTIONS ARE RELATIVE TO CORRESPONDING VALUE IN 250-Hz BAND

GMF, Hz	WINDSCREEN CORRECTION, dB	MICROPHONE PRESSURE CORRECTION, dB	MICROPHONE DIFFRACTION CORRECTION,[b] dB	TOTAL MICROPHONE CORRECTION, dB
50	0.0	0.0	0.0	0.0
63				
80				
100				
125				
160				
200				
250				
315				
400				
500				
630				
800				
1000				
1250				
1600			0.0	0.0
2000			-0.1	-0.1
2500			-0.1	-0.1
3150			-0.1	-0.1
4000			-0.1	-0.1
5000		0.0	-0.1	-0.1
6300		-0.1	-0.1	-0.2
8000		-0.2	-0.1	-0.3
10,000	0.0	-0.4	-0.2	-0.6

[b] RANDOM INCIDENCE

TABLE A3. - RESPONSE CORRECTIONS FOR MICROPHONE AT LOCATION 3

CORRECTIONS ARE RELATIVE TO CORRESPONDING VALUE IN 250-Hz BAND

GMF, Hz	WINDSCREEN CORRECTION, dB	MICROPHONE PRESSURE CORRECTION, dB	MICROPHONE DIFFRACTION CORRECTION,[a] dB	TOTAL MICROPHONE CORRECTION, dB
50	0.0	0.0	0.0	0.0
63				
80				
100				
125				
160				
200				
250				
315				
400	0.0		0.0	
500	-0.1		+0.1	
630	-0.1		+0.1	0.0
800	-0.2		+0.1	-0.1
1000	-0.2		+0.1	-0.1
1250	-0.3		+0.1	-0.2
1600	-0.5		+0.1	-0.4
2000	-0.6		+0.2	-0.4
2500	-0.7		+0.2	-0.5
3150	-0.7		+0.2	-0.5
4000	-0.2	0.0	+0.2	0.0
5000	+0.5	-0.2	+0.3	+0.6
6300	+0.5	-0.4	+0.3	+0.4
8000	+0.3	-0.5	+0.4	+0.2
10,000	+0.9	-0.7	+0.4	+0.6

[a] 90°, GRAZING INCIDENCE

TABLE A4. - RESPONSE CORRECTIONS FOR MICROPHONE AT LOCATION 4

CORRECTIONS ARE RELATIVE TO CORRESPONDING VALUE IN 250-Hz BAND

GMF, Hz	WINDSCREEN CORRECTION, dB	MICROPHONE PRESSURE CORRECTION, dB	MICROPHONE DIFFRACTION CORRECTION,[a] dB	TOTAL MICROPHONE CORRECTION, dB
50	0.0	0.0	0.0	0.0
63				
80				
100				
125				
160				
200				
250				
315				
400	0.0		0.0	
500	-0.1		+0.1	
630	-0.1		+0.1	0.0
800	-0.2		+0.1	-0.1
1000	-0.2		+0.1	-0.1
1250	-0.3		+0.1	-0.2
1600	-0.5		+0.1	-0.4
2000	-0.6		+0.2	-0.4
2500	-0.7		+0.2	-0.5
3150	-0.7		+0.2	-0.5
4000	-0.2	0.0	+0.2	0.0
5000	+0.5	-0.2	+0.3	+0.6
6300	+0.5	-0.4	+0.3	+0.4
8000	+0.3	-0.6	+0.4	+0.1
10,000	+0.9	-0.9	+0.4	+0.4

[a] 90°, GRAZING INCIDENCE

TABLE A5. - RESPONSE CORRECTIONS FOR MICROPHONE AT LOCATION 5

CORRECTIONS ARE RELATIVE TO CORRESPONDING VALUE IN 250-Hz BAND

GMF, Hz	WINDSCREEN CORRECTION, dB	MICROPHONE PRESSURE CORRECTION, dB	MICROPHONE DIFFRACTION CORRECTION,[b] dB	TOTAL MICROPHONE CORRECTION, dB
50	0.0	0.0	0.0	0.0
63				
80				
100				
125				
160				
200				
250				
315				
400				
500				
630				
800				
1000				
1250				
1600			0.0	0.0
2000			-0.1	-0.1
2500		0.0	-0.1	-0.1
3150		-0.1	-0.1	-0.2
4000		-0.2	-0.1	-0.3
5000		-0.4	-0.1	-0.5
6300		-0.6	-0.1	-0.7
8000		-0.9	-0.1	-1.0
10,000	0.0	-1.3	-0.2	-1.5

[b]RANDOM INCIDENCE

TABLE A6. - RESPONSE CORRECTIONS FOR MICROPHONE AT LOCATION 6

CORRECTIONS ARE RELATIVE TO CORRESPONDING VALUE IN 250-Hz BAND

GMF, Hz	WINDSCREEN CORRECTION, dB	MICROPHONE PRESSURE CORRECTION, dB	MICROPHONE DIFFRACTION CORRECTION,[a] dB	TOTAL MICROPHONE CORRECTION, dB
50	0.0	0.0	0.0	0.0
63				
80				
100				
125				
160				
200				
250				
315				
400	0.0		0.0	
500	-0.1		+0.1	
630	-0.1		+0.1	0.0
800	-0.2		+0.1	-0.1
1000	-0.2		+0.1	-0.1
1250	-0.3		+0.1	-0.2
1600	-0.5		+0.1	-0.4
2000	-0.6		+0.2	-0.4
2500	-0.7		+0.2	-0.5
3150	-0.7	0.0	+0.2	-0.5
4000	-0.2	-0.1	+0.2	-0.1
5000	+0.5	-0.1	+0.3	+0.7
6300	+0.5	-0.2	+0.3	+0.6
8000	+0.3	-0.4	+0.4	+0.3
10,000	+0.9	-0.5	+0.4	+0.8

[a] 90°, GRAZING INCIDENCE

TABLE A7. - SYSTEM FREQUENCY RESPONSE CORRECTIONS FOR MICROPHONE CHANNEL 1

GMF, Hz	RELATIVE RESPONSE CORRECTION TO PINK NOISE CALIBRATION, dB				AVERAGE PINK NOISE CORRECTION, dB	MICROPHONE RESPONSE CORRECTION, dB	TOTAL RESPONSE CORRECTION, dB
	CALIBRATION NUMBER						
	9	13	26	58			
50	0.8	-1.5	-1.0	-0.8	-0.6	0.0	-0.6
63	1.0	-9.8	-9.8	0.7	0.9		0.9
80	0.8	0.0	-0.3	0.2	0.2		0.2
100	0.5	0.2	0.5	0.5	0.4		0.4
125	0.0	0.2	0.2	0.2	0.2		0.2
160	0.3	0.0	0.0	0.0	0.1		0.1
200	0.3	-0.3	0.2	0.2	0.1		0.1
250	0.0	0.0	0.0	0.0	0.0		0.0
315	0.5	0.0	0.0	-0.3	0.1		0.1
400	1.0	0.5	0.2	0.5	0.6		0.6
500	0.5	0.0	0.2	0.2	0.2		0.2
630	0.5	0.2	0.2	0.5	0.4	0.0	0.4
800	0.5	0.5	0.2	0.7	0.5	-0.1	0.4
1000	0.5	0.2	0.0	0.5	0.3	-0.1	0.2
1250	0.8	0.2	0.2	0.0	0.3	-0.2	0.1
1600	0.3	0.2	-0.3	0.0	0.1	-0.4	-0.3
2000	0.3	0.0	0.5	0.0	0.2	-0.4	-0.2
2500	0.3	-0.5	0.0	0.2	0.0	-0.5	-0.5
3150	0.5	0.7	0.5	0.2	0.5	-0.5	0.0
4000	0.5	0.2	0.2	0.5	0.4	-0.1	0.3
5000	0.8	0.5	0.5	0.0	0.5	0.6	1.1
6300	0.8	0.2	0.2	0.2	0.4	0.3	0.7
8000	0.0	0.0	-0.5	-0.3	-0.2	0.0	-0.2
10,000	-0.2	-0.5	-0.8	-0.5	-0.5	0.5	0.0

TABLE A8. - SYSTEM FREQUENCY RESPONSE CORRECTIONS FOR MICROPHONE CHANNEL 2

GMF, Hz	RELATIVE RESPONSE CORRECTION TO PINK NOISE CALIBRATION, dB				AVERAGE PINK NOISE CORRECTION, dB	MICROPHONE RESPONSE CORRECTION, dB	TOTAL RESPONSE CORRECTION, dB
	CALIBRATION NUMBER						
	9	13	26	58			
50	0.5	-1.5	-1.0	0.2	-0.5	0.0	-0.5
63	0.0	-10.2	-9.2	0.5	0.3		0.3
80	0.0	0.3	0.8	0.2	0.3		0.3
100	0.3	0.5	1.0	1.0	0.7		0.7
125	0.0	-0.2	0.5	1.2	0.4		0.4
160	-0.2	-0.7	0.5	-0.3	-0.2		-0.2
200	0.3	0.3	0.5	0.2	0.3		0.3
250	0.0	0.0	0.0	0.0	0.0		0.0
315	-0.2	0.0	0.0	-0.5	-0.2		-0.2
400	0.3	0.0	0.8	0.2	0.3		0.3
500	0.3	-0.2	0.5	-0.3	0.1		0.1
630	0.0	0.5	0.8	0.2	0.4		0.4
800	0.8	0.5	0.8	0.2	0.6		0.6
1000	0.3	0.0	1.3	0.5	0.5		0.5
1250	0.0	0.0	0.8	-0.3	0.1		0.1
1600	0.0	-0.2	0.0	-0.3	-0.1	0.0	-0.1
2000	-0.2	-0.2	0.5	-0.3	-0.1	-0.1	-0.2
2500	-0.2	0.0	0.5	-0.5	-0.1	-0.1	-0.2
3150	0.3	0.5	0.8	0.2	0.5	-0.1	0.4
4000	0.5	0.5	1.0	0.2	0.6	-0.1	0.5
5000	0.3	0.5	1.0	0.0	0.5	-0.1	0.4
6300	0.3	0.3	1.0	1.0	0.7	-0.2	0.5
8000	-0.2	0.0	1.0	0.0	0.2	-0.3	-0.1
10,000	0.0	0.0	0.5	-0.3	0.1	-0.6	-0.5

TABLE A9. - SYSTEM FREQUENCY RESPONSE CORRECTIONS FOR MICROPHONE CHANNEL 3

GMF, Hz	RELATIVE RESPONSE CORRECTION TO PINK NOISE CALIBRATION, dB				AVERAGE PINK NOISE CORRECTION, dB	MICROPHONE RESPONSE CORRECTION, dB	TOTAL RESPONSE CORRECTION, dB
	CALIBRATION NUMBER						
	9	13	26	58			
50	0.5	-1.8	-1.8	0.8	-0.6	0.0	-0.6
63	0.8	-9.8	-9.5	0.8	0.8		0.8
80	0.0	-0.3	0.2	0.5	0.1		0.1
100	0.5	0.2	1.0	0.8	0.6		0.6
125	0.5	-0.3	-0.3	0.0	0.0		0.0
160	-0.2	0.0	0.0	0.0	0.0		0.0
200	0.8	0.0	0.2	0.3	0.3		0.3
250	0.0	0.0	0.0	0.0	0.0		0.0
315	0.0	-0.3	-0.3	0.0	-0.2		-0.2
400	0.5	0.0	0.2	0.8	0.4		0.4
500	0.5	0.0	0.2	0.5	0.3		0.3
630	0.5	0.2	0.2	0.5	0.4	0.0	0.4
800	0.8	0.0	0.2	0.3	0.3	-0.1	0.2
1000	0.8	0.2	0.2	0.3	0.4	-0.1	0.3
1250	0.3	0.0	0.5	0.3	0.3	-0.2	0.1
1600	0.3	0.0	-0.3	0.3	0.1	-0.4	-0.3
2000	0.0	-0.3	0.2	0.0	0.0	-0.4	-0.4
2500	0.0	-0.3	0.2	-0.5	-0.2	-0.5	-0.7
3150	0.5	0.2	0.5	0.0	0.3	-0.5	-0.2
4000	0.8	0.2	0.7	1.0	0.7	0.0	0.7
5000	0.5	0.0	0.7	0.5	0.4	0.6	1.0
6300	0.8	0.2	0.2	0.8	0.5	0.4	0.9
8000	0.5	-0.3	0.2	0.3	0.2	0.2	0.4
10,000	0.0	-0.3	0.0	0.0	-0.1	0.6	0.5

TABLE A10. - SYSTEM FREQUENCY RESPONSE CORRECTIONS FOR MICROPHONE CHANNEL 4

GMF, Hz	RELATIVE RESPONSE CORRECTION TO PINK NOISE CALIBRATION, dB — CALIBRATION NUMBER 9	13	26	58	AVERAGE PINK NOISE CORRECTION, dB	MICROPHONE RESPONSE CORRECTION, dB	TOTAL RESPONSE CORRECTION, dB
50	0.3	0.0	0.0	0.2	0.1	0.0	0.1
63	0.5	-3.8	-4.2	0.2	0.4		0.4
80	0.3	0.7	0.0	0.0	0.3		0.3
100	0.3	0.7	0.8	0.5	0.6		0.6
125	0.5	0.7	0.5	0.2	0.5		0.5
160	0.0	0.2	0.3	0.0	0.1		0.1
200	0.0	0.2	0.5	0.2	0.2		0.2
250	0.0	0.0	0.0	0.0	0.0		0.0
315	0.0	0.0	0.0	0.0	0.0		0.0
400	0.3	0.5	0.5	0.0	0.3		0.3
500	0.3	0.2	0.5	0.0	0.3		0.3
630	0.5	0.2	0.5	0.2	0.4	0.0	0.4
800	0.3	0.0	0.8	-0.3	0.2	-0.1	0.1
1000	0.5	0.7	0.8	0.0	0.5	-0.1	0.4
1250	0.5	0.7	0.5	0.2	0.5	-0.2	0.3
1600	0.0	0.2	-0.2	-0.3	-0.1	-0.4	-0.5
2000	0.0	0.0	0.0	-0.5	-0.1	-0.4	-0.5
2500	0.0	0.2	0.0	-0.5	-0.1	-0.5	-0.6
3150	0.0	0.2	0.3	0.0	0.1	-0.5	-0.4
4000	0.3	0.7	1.0	0.2	0.6	0.0	0.6
5000	0.3	1.0	0.5	0.0	0.5	0.6	1.1
6300	0.3	0.2	0.8	0.2	0.4	0.4	0.8
8000	0.0	0.2	0.0	-0.3	0.0	0.1	0.1
10,000	-0.2	-0.3	0.0	-0.3	-0.2	0.4	0.2

TABLE A11. - SYSTEM FREQUENCY RESPONSE CORRECTIONS FOR MICROPHONE CHANNEL 5

GMF, Hz	RELATIVE RESPONSE CORRECTION TO PINK NOISE CALIBRATION, dB				AVERAGE PINK NOISE CORRECTION, dB	MICROPHONE RESPONSE CORRECTION, dB	TOTAL RESPONSE CORRECTION, dB
	CALIBRATION NUMBER						
	9	13	26	58			
50	0.3	-0.5	-0.7	0.7	-0.1	0.0	-0.1
63	0.5	-5.5	-6.0	1.2	0.9		0.9
80	0.5	0.0	0.0	0.0	0.1		0.1
100	0.0	0.0	0.3	1.0	0.3		0.3
125	-0.2	-0.3	0.0	0.2	-0.1		-0.1
160	-0.2	-0.3	-0.5	0.0	-0.3		-0.3
200	0.0	-0.3	0.0	0.5	0.1		0.1
250	0.0	0.0	0.0	0.0	0.0		0.0
315	-0.2	-0.3	0.0	0.0	-0.1		-0.1
400	0.3	0.0	0.0	0.5	0.2		0.2
500	0.0	0.0	0.3	0.5	0.2		0.2
630	0.5	0.0	0.3	0.5	0.3		0.3
800	0.3	0.0	0.0	0.7	0.3		0.3
1000	0.0	0.2	0.0	0.2	0.1		0.1
1250	0.3	-0.3	0.5	0.5	0.3		0.3
1600	0.0	-0.3	0.0	0.2	0.0	0.0	0.0
2000	0.0	-0.3	-0.2	0.5	0.0	-0.1	-0.1
2500	-0.2	-0.3	0.0	0.5	0.0	-0.1	-0.1
3150	0.0	0.0	0.0	0.2	0.1	-0.2	-0.1
4000	0.5	0.7	0.8	1.0	0.8	-0.3	0.5
5000	0.3	0.0	0.5	0.7	0.4	-0.5	-0.1
6300	0.5	-0.3	0.8	0.7	0.4	-0.7	-0.3
8000	-0.5	-0.3	-0.5	0.2	-0.3	-1.0	-1.3
10,000	0.0	-0.3	-0.2	0.0	-0.1	-1.5	-1.6

TABLE A12. - SYSTEM FREQUENCY RESPONSE CORRECTIONS FOR MICROPHONE CHANNEL 6

GMF, Hz	RELATIVE RESPONSE CORRECTION TO PINK NOISE CALIBRATION, dB — CALIBRATION NUMBER 9	13	26	58	AVERAGE PINK NOISE CORRECTION, dB	MICROPHONE RESPONSE CORRECTION, dB	TOTAL RESPONSE CORRECTION, dB
50	0.5	-0.3	-0.2	0.5	0.1	0.0	0.1
63	0.7	-4.8	-4.7	1.0	0.9		0.9
80	0.7	0.2	-0.2	0.0	0.2		0.2
100	0.5	0.7	0.8	0.5	0.6		0.6
125	0.5	0.2	0.3	0.3	0.3		0.3
160	0.2	0.2	0.0	0.0	0.1		0.1
200	0.2	0.2	0.0	0.3	0.2		0.2
250	0.0	0.0	0.0	0.0	0.0		0.0
315	0.5	-0.3	0.0	0.0	0.1		0.1
400	0.5	0.2	0.3	0.5	0.4		0.4
500	0.5	0.2	0.5	0.0	0.3		0.3
630	1.0	0.2	0.3	0.5	0.5	0.0	0.5
800	0.7	0.2	0.8	0.5	0.6	-0.1	0.5
1000	0.5	0.2	0.5	0.8	0.5	-0.1	0.4
1250	0.5	0.2	0.3	0.0	0.3	-0.2	0.1
1600	0.5	-0.5	0.0	0.0	0.0	-0.4	-0.4
2000	0.0	-0.3	0.0	0.3	0.0	-0.4	-0.4
2500	0.2	0.0	0.3	0.0	0.1	-0.5	-0.4
3150	0.2	0.2	0.5	0.0	0.2	-0.5	-0.3
4000	0.7	0.5	0.5	0.5	0.6	-0.1	0.5
5000	1.0	0.2	0.8	0.5	0.6	0.7	1.3
6300	0.7	0.5	0.5	0.8	0.6	0.6	1.2
8000	0.5	-0.5	0.0	-0.2	-0.1	0.3	0.2
10,000	0.5	0.0	0.0	0.0	0.1	0.8	0.9

APPENDIX B

ENGINE, AIRPLANE, AND METEOROLOGICAL DATA

This appendix contains tabulated values of the engine, airplane, and meteorological data associated with the sound pressure levels for each of the 37 runs.

The value shown for airspeed was determined from the distance between the two cameras located on the taxiway between microphones 1 and 4 and from the time interval between the times when the airplane photographs were taken.

The nominal temperature at the airplane and the nominal temperature and relative humidity at the microphones were determined by interpolating the available meteorological profile data to the time of the flyover noise test and the height of the airplane. The nominal sound speed was determined from the nominal air temperature. The nominal airplane Mach number was calculated from the nominal airspeed and nominal sound speed.

The airplane heights over microphones 1 and 4 were determined from the height data supplied by NASA after adjustment for the correct wingspan of the DC-9-10 airplane.

The other airplane and engine data were read from copies of the cockpit data logs. No engine thrust data were available.

Barometric pressure at a height of 10 m was interpolated to the times of the tests from station pressures supplied by National Weather Service personnel at Fresno Air Terminal and were referenced to a standard atmospheric pressure of 101.325 kPa.

Table B1. - Associated parameter data for run 112

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL — OCTOBER 1974

RUN NO. = 112
TAPE NO. = 110429
TEST DATE = 14 OC 74
DATE DIGITIZED = 5 May 77
NOM. TIME OF DAY OVER MICS = 1226 hr

AIRPLANE HEADING = 110 deg
NOM. AIRSPEED = 94.4 m/s
NOM. RADIO ALT = 594.4 m
PITCH ANGLE = +1 deg
FLAP DEFL = 30 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 24.6 deg C
NOM. SOUND SPEED AT AIRPLANE = 345.9 m/s
NOM. AIRPLANE MACH NO. = 0.27

HEIGHT OVER MIC 1 = 605 m
HEIGHT OVER MIC 4 = 605 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 103.1 kN
FUEL REMAINING = NA . kN
FLYOVER GROSS WEIGHT = NA . kN

RAT OVER MICS = 26 deg C
NOM. AIR TEMP AT MICS = 28.2 deg C
NOM. REL. HUM. at MICS = 27.7 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.44
RIGHT EPR = 1.44
LEFT EGT = 400 deg C
RIGHT EGT = 400 deg C
LEFT N1 = 76.5 PCT
RIGHT N1 = 76.3 PCT

BAROMETRIC PRESSURE = 0.994 ATM

NOTES:

1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B2. - Associated parameter data for run 113

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 113
TAPE NO. = 110429
TEST DATE = 14 OC 74
DATE DIGITIZED = 5 May 77
NOM. TIME OF DAY OVER MICS = 1231 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 82.6 m/s
NOM. RADIO ALT = 588.3 m
PITCH ANGLE = +1 deg
FLAP DEFL = 30 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 24.7 deg C
NOM. SOUND SPEED AT AIRPLANE = 346.0 m/s
NOM. AIRPLANE MACH NO. = 0.24

HEIGHT OVER MIC 1 = 605 m
HEIGHT OVER MIC 4 = 605 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 103.1 kN
FUEL REMAINING = NA . kN
FLYOVER GROSS WEIGHT = NA . kN

RAT OVER MICS = 26 deg C
NOM. AIR TEMP AT MICS = 28.3 deg C
NOM. REL. HUM. at MICS = 27.2 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.44
RIGHT EPR = 1.44
LEFT EGT = 400 deg C
RIGHT EGT = 400 deg C
LEFT N1 = 76.5 PCT
RIGHT N1 = 76.5 PCT

BAROMETRIC PRESSURE = 0.994ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B3. - Associated parameter data for run 115

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL   OCTOBER 1974

RUN NO. = 115
TAPE NO. = 110429
TEST DATE = 14 OC 74
DATE DIGITIZED = 5 May 77
NOM. TIME OF DAY OVER MICS = 1241 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 83.8 m/s
NOM. RADIO ALT = 609.6 m
PITCH ANGLE = +1 deg
FLAP DEFL = 30 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 24.8 deg C
NOM. SOUND SPEED AT AIRPLANE = 346.0 m/s
NOM. AIRPLANE MACH NO. = 0.24

HEIGHT OVER MIC 1 = 628 m
HEIGHT OVER MIC 4 = 628 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 103.1 kN
FUEL REMAINING = NA . kN
FLYOVER GROSS WEIGHT = NA . kN

RAT OVER MICS = 27 deg C
NOM. AIR TEMP AT MICS = 28.7 deg C
NOM. REL. HUM. at MICS = 26.2 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.44
RIGHT EPR = 1.44
LEFT EGT = 400 deg C
RIGHT EGT = 400 deg C
LEFT N1 = 76.5 PCT
RIGHT N1 = 76.8 PCT

BAROMETRIC PRESSURE = 0.993 ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B4. - Associated parameter data for run 117

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL — OCTOBER 1974

RUN NO. = 117
TAPE NO. = 110429
TEST DATE = 14 OC 74
DATE DIGITIZED = 5 May 77
NOM. TIME OF DAY OVER MICS = 1251 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 86.2 m/s
NOM. RADIO ALT = 615.7 m
PITCH ANGLE = +1 deg
FLAP DEFL = 30 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 25.0 deg C
NOM. SOUND SPEED AT AIRPLANE = 346.1 m/s
NOM. AIRPLANE MACH NO. = 0.25

HEIGHT OVER MIC 1 = 628 m
HEIGHT OVER MIC 4 = 628 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 103.1 kN
FUEL REMAINING = NA . kN
FLYOVER GROSS WEIGHT = NA . kN

RAT OVER MICS = 27 deg C
NOM. AIR TEMP AT MICS = 29.0 deg C
NOM. REL. HUM. at MICS = 25.1 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.44
RIGHT EPR = 1.445
LEFT EGT = 400 deg C
RIGHT EGT = 450 deg C
LEFT N1 = 76.6 PCT
RIGHT N1 = 76.3 PCT

BAROMETRIC PRESSURE = 0.993ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B5. - Associated parameter data for run 118

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 118
TAPE NO. = 110430
TEST DATE = 14 OC 74
DATE DIGITIZED = 6 May 77
NOM. TIME OF DAY OVER MICS = 1301 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 90.2 m/s
NOM. RADIO ALT = 335.3 m
PITCH ANGLE = +1 deg
FLAP DEFL = 30 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 26.5 deg C
NOM. SOUND SPEED AT AIRPLANE = 347.0 m/s
NOM. AIRPLANE MACH NO. = 0.26

HEIGHT OVER MIC 1 = 347 m
HEIGHT OVER MIC 4 = 347 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 103.1 kN
FUEL REMAINING = NA . kN
FLYOVER GROSS WEIGHT = NA . kN

RAT OVER MICS = 28 deg C
NOM. AIR TEMP AT MICS = 29.4 deg C
NOM. REL. HUM. at MICS = 24.1 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.435
RIGHT EPR = 1.435
LEFT EGT = 405 deg C
RIGHT EGT = 400 deg C
LEFT N1 = 76.6 PCT
RIGHT N1 = 76.0 PCT

BAROMETRIC PRESSURE = 0.993ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B6. - Associated parameter data for run 121

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 121
TAPE NO. = 110430
TEST DATE = 14 OC 74
DATE DIGITIZED = 6 May 77
NOM. TIME OF DAY OVER MICS = 1318 hr

AIRPLANE HEADING = 110 deg
NOM. AIRSPEED = 78.3 m/s
NOM. RADIO ALT = 335.3 m
PITCH ANGLE = 0 deg
FLAP DEFL = 36 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 26.9 deg C
NOM. SOUND SPEED AT AIRPLANE = 347.3 m/s
NOM. AIRPLANE MACH NO. = 0.23

HEIGHT OVER MIC 1 = 347 m
HEIGHT OVER MIC 4 = 347 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 103.1 kN
FUEL REMAINING = NA . kN
FLYOVER GROSS WEIGHT = NA . kN

RAT OVER MICS = 28 deg C
NOM. AIR TEMP AT MICS = 30.0 deg C
NOM. REL. HUM. at MICS = 22.4 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.44
RIGHT EPR = 1.44
LEFT EGT = 410 deg C
RIGHT EGT = 400 deg C
LEFT N1 = 76.5 PCT
RIGHT N1 = 76.1 PCT

BAROMETRIC PRESSURE = 0.993 ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL's, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B7. - Associated parameter data for run 122

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 122
TAPE NO. = 110430
TEST DATE = 14 OC 74
DATE DIGITIZED = 6 May 77
NOM. TIME OF DAY OVER MICS = 1323 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 79.3 m/s
NOM. RADIO ALT = 335.3 m
PITCH ANGLE = 0 deg
FLAP DEFL = 36 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 27.1 deg C
NOM. SOUND SPEED AT AIRPLANE = 347.4 m/s
NOM. AIRPLANE MACH NO. = 0.23

HEIGHT OVER MIC 1 = 347 m
HEIGHT OVER MIC 4 = 340 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 103.1 kN
FUEL REMAINING = NA . kN
FLYOVER GROSS WEIGHT = NA . kN

RAT OVER MICS = 29 deg C
NOM. AIR TEMP AT MICS = 30.2 deg C
NOM. REL. HUM. at MICS = 21.9 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.44
RIGHT EPR = 1.44
LEFT EGT = 410 deg C
RIGHT EGT = 400 deg C
LEFT N1 = 76.5 PCT
RIGHT N1 = 76.1 PCT

BAROMETRIC PRESSURE = 0.993 ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B8. - Associated parameter data for run 123

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL · OCTOBER 1974

RUN NO. = 123
TAPE NO. = 110430
TEST DATE = 14 OC 74
DATE DIGITIZED = 6 May 77
NOM. TIME OF DAY OVER MICS = 1328 hr

AIRPLANE HEADING = 110 deg
NOM. AIRSPEED = 81.5 m/s
NOM. RADIO ALT = 335.3 m
PITCH ANGLE = 0 deg
FLAP DEFL = 36 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 27.2 deg C
NOM. SOUND SPEED AT AIRPLANE = 347.5 m/s
NOM. AIRPLANE MACH NO. = 0.23

HEIGHT OVER MIC 1 = 347 m
HEIGHT OVER MIC 4 = 347 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 103.1 kN
FUEL REMAINING = NA . kN
FLYOVER GROSS WEIGHT = NA . kN

RAT OVER MICS = 29 deg C
NOM. AIR TEMP AT MICS = 30.4 deg C
NOM. REL. HUM. at MICS = 21.4 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.44
RIGHT EPR = 1.44
LEFT EGT = 410 deg C
RIGHT EGT = 400 deg C
LEFT N1 = 76.5 PCT
RIGHT N1 = 76.1 PCT

BAROMETRIC PRESSURE = 0.993 ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B9. - Associated parameter data for run 211

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 211
TAPE NO. = 110334
TEST DATE = 17 OC 74
DATE DIGITIZED = 6 May 77
NOM. TIME OF DAY OVER MICS = 0748 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 81.5 m/s
NOM. RADIO ALT = 335.3 m
PITCH ANGLE = +1 deg
FLAP DEFL = 36 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 23.0 deg C
NOM. SOUND SPEED AT AIRPLANE = 345.0 m/s
NOM. AIRPLANE MACH NO. = 0.24

HEIGHT OVER MIC 1 = 340 m
HEIGHT OVER MIC 4 = 347 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 106.2 kN
FUEL REMAINING = 81.1 kN
FLYOVER GROSS WEIGHT = 329.0 kN

RAT OVER MICS = 28.5 deg C
NOM. AIR TEMP AT MICS = 12.9 deg C
NOM. REL. HUM. at MICS = 65.6 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.44
RIGHT EPR = 1.44
LEFT EGT = 403 deg C
RIGHT EGT = 400 deg C
LEFT N1 = 76.5 PCT
RIGHT N1 = 76.3 PCT

BAROMETRIC PRESSURE = 0.995ATM

NOTES:

1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B10. - Associated parameter data for run 212

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 212
TAPE NO. = 110334
TEST DATE = 17 OC 74
DATE DIGITIZED = 6 May 77
NOM. TIME OF DAY OVER MICS = 0756 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 86.2 m/s
NOM. RADIO ALT = 332.2 m
PITCH ANGLE = +1 deg
FLAP DEFL = 35 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 23.1 deg C
NOM. SOUND SPEED AT AIRPLANE = 345.0 m/s
NOM. AIRPLANE MACH NO. = 0.25

HEIGHT OVER MIC 1 = 347 m
HEIGHT OVER MIC 4 = 340 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 106.2 kN
FUEL REMAINING = 76.6 kN
FLYOVER GROSS WEIGHT = 324.5 kN

RAT OVER MICS =28.5deg C
NOM. AIR TEMP AT MICS = 13.0 deg C
NOM. REL. HUM. at MICS = 65.3 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.44
RIGHT EPR = 1.44
LEFT EGT = 403 deg C
RIGHT EGT = 400 deg C
LEFT N1 = 76.6 PCT
RIGHT N1 = 76.3 PCT

BAROMETRIC PRESSURE = 0.995 ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B11. - Associated parameter data for run 214

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 214
TAPE NO. = 110334
TEST DATE = 17 OC 74
DATE DIGITIZED = 6 May 77
NOM. TIME OF DAY OVER MICS = 0810 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 81.5 m/s
NOM. RADIO ALT = 338.3 m
PITCH ANGLE = NA deg
FLAP DEFL = 36 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 23.1 deg C
NOM. SOUND SPEED AT AIRPLANE = 345.0 m/s
NOM. AIRPLANE MACH NO. = 0.24

HEIGHT OVER MIC 1 = 347 m
HEIGHT OVER MIC 4 = 355 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 106.2 kN
FUEL REMAINING = 69.5 kN
FLYOVER GROSS WEIGHT = 317.4 kN

RAT OVER MICS = 28.5 deg C
NOM. AIR TEMP AT MICS = 13.6 deg C
NOM. REL. HUM. at MICS = 63.5 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.44
RIGHT EPR = 1.44
LEFT EGT = 403 deg C
RIGHT EGT = 400 deg C
LEFT N1 = 76.4 PCT
RIGHT N1 = 76.0 PCT

BAROMETRIC PRESSURE = 0.995 ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B12. - Associated parameter data for run 215

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 215
TAPE NO. = 110334
TEST DATE = 17 OC 74
DATE DIGITIZED = 9 May 77
NOM. TIME OF DAY OVER MICS = 0821 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 85.0 m/s
NOM. RADIO ALT = 335.3 m
PITCH ANGLE = 0 deg
FLAP DEFL = 37 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 23.1 deg C
NOM. SOUND SPEED AT AIRPLANE = 345.0 m/s
NOM. AIRPLANE MACH NO. = 0.25

HEIGHT OVER MIC 1 = 340 m
HEIGHT OVER MIC 4 = 347 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 106.2 kN
FUEL REMAINING = 63.6 kN
FLYOVER GROSS WEIGHT = 311.5 kN

RAT OVER MICS = 28 deg C
NOM. AIR TEMP AT MICS = 14.2 deg C
NOM. REL. HUM. at MICS = 61.9 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.44
RIGHT EPR = 1.44
LEFT EGT = 403 deg C
RIGHT EGT = 400 deg C
LEFT N1 = 76.6 PCT
RIGHT N1 = 76.1 PCT

BAROMETRIC PRESSURE = 0.995 ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B13. - Associated parameter data for run 216

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 216
TAPE NO. = 110334
TEST DATE = 17 OC 74
DATE DIGITIZED = 9 May 77
NOM. TIME OF DAY OVER MICS =0828 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 81.5 m/s
NOM. RADIO ALT = 609.6 m
PITCH ANGLE = 0 deg
FLAP DEFL = 35 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 22.6 deg C
NOM. SOUND SPEED AT AIRPLANE = 344.7 m/s
NOM. AIRPLANE MACH NO. = 0.24

HEIGHT OVER MIC 1 = 628 m
HEIGHT OVER MIC 4 = 628 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 106.2 kN
FUEL REMAINING = 60.3 kN
FLYOVER GROSS WEIGHT = 308.2 kN

RAT OVER MICS =27.5deg C
NOM. AIR TEMP AT MICS = 14.5 deg C
NOM. REL. HUM. at MICS = 60.9 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.44
RIGHT EPR = 1.44
LEFT EGT = 403 deg C
RIGHT EGT = 400 deg C
LEFT N1 = 76.4 PCT
RIGHT N1 = 76.0 PCT

BAROMETRIC PRESSURE = 0.995ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B14. - Associated parameter data for run 218

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 218
TAPE NO. = 110334
TEST DATE = 17 OC 74
DATE DIGITIZED = 9 May 77
NOM. TIME OF DAY OVER MICS =0842 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 82.6 m/s
NOM. RADIO ALT = 609.6 m
PITCH ANGLE = -1 deg
FLAP DEFL = 37 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 22.5 deg C
NOM. SOUND SPEED AT AIRPLANE = 344.7 m/s
NOM. AIRPLANE MACH NO. = 0.24

HEIGHT OVER MIC 1 = 628 m
HEIGHT OVER MIC 4 = 628 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 106.2 kN
FUEL REMAINING = 52.2 kN
FLYOVER GROSS WEIGHT = 300.1 kN

RAT OVER MICS =27.5 deg C
NOM. AIR TEMP AT MICS = 15.2 deg C
NOM. REL. HUM. at MICS = 59.0 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.44
RIGHT EPR = 1.44
LEFT EGT = 403 deg C
RIGHT EGT = 400 deg C
LEFT N1 = 76.7 PCT
RIGHT N1 = 76.0 PCT

BAROMETRIC PRESSURE = 0.995 ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B15. - Associated parameter data for run 219

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 219
TAPE NO. = 110334
TEST DATE = 17 OC 74
DATE DIGITIZED = 9 May 77
NOM. TIME OF DAY OVER MICS = 0850 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 82.6 m/s
NOM. RADIO ALT = 609.6 m
PITCH ANGLE = -1 deg
FLAP DEFL = 37 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 22.4 deg C
NOM. SOUND SPEED AT AIRPLANE = 344.6 m/s
NOM. AIRPLANE MACH NO. = 0.24

HEIGHT OVER MIC 1 = 628 m
HEIGHT OVER MIC 4 = N.A.

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 106.2 kN
FUEL REMAINING = 49.3 kN
FLYOVER GROSS WEIGHT = 297.2 kN

RAT OVER MICS = 27.5deg C
NOM. AIR TEMP AT MICS = 15.6 deg C
NOM. REL. HUM. at MICS = 57.8 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.44
RIGHT EPR = 1.44
LEFT EGT = 403 deg C
RIGHT EGT = 400 deg C
LEFT N1 = 76.8 PCT
RIGHT N1 = 76.0 PCT

BAROMETRIC PRESSURE = 0.995 ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B16. - Associated parameter data for run 272

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 272
TAPE NO. = 110373
TEST DATE = 21 OC 74
DATE DIGITIZED = 9 May 77
NOM. TIME OF DAY OVER MICS = 0912 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 71.7 m/s
NOM. RADIO ALT = 152.4 m
PITCH ANGLE = 0 deg
FLAP DEFL = 33 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 10.1 deg C
NOM. SOUND SPEED AT AIRPLANE = 337.4 m/s
NOM. AIRPLANE MACH NO. = 0.21

HEIGHT OVER MIC 1 = 154 m
HEIGHT OVER MIC 4 = 156 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 104.7 kN
FUEL REMAINING = 95.5 kN
FLYOVER GROSS WEIGHT = 344.9 kN

RAT OVER MICS = 15 deg C
NOM. AIR TEMP AT MICS = 11.5 deg C
NOM. REL. HUM. at MICS = 55.0 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.44
RIGHT EPR = 1.44
LEFT EGT = 370 deg C
RIGHT EGT = 375 deg C
LEFT N1 = 75.1 PCT
RIGHT N1 = 75.0 PCT

BAROMETRIC PRESSURE = 0.990 ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B17. - Associated parameter data for run 274

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 274
TAPE NO. = 110373
TEST DATE = 21 OC 74
DATE DIGITIZED = 9 May 77
NOM. TIME OF DAY OVER MICS = 0927 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 73.5 m/s
NOM. RADIO ALT = 149.4 m
PITCH ANGLE = 0 deg
FLAP DEFL = 38 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 10.7 deg C
NOM. SOUND SPEED AT AIRPLANE = 337.7 m/s
NOM. AIRPLANE MACH NO. = 0.22

HEIGHT OVER MIC 1 = 154 m
HEIGHT OVER MIC 4 = 151 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 104.7 kN
FUEL REMAINING = 88.1 kN
FLYOVER GROSS WEIGHT = 337.5 kN

RAT OVER MICS = 15 deg C
NOM. AIR TEMP AT MICS = 12.1 deg C
NOM. REL. HUM. at MICS = 53.1 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.44
RIGHT EPR = 1.435
LEFT EGT = 370 deg C
RIGHT EGT = 375 deg C
LEFT N1 = 75.0 PCT
RIGHT N1 = 74.5 PCT

BAROMETRIC PRESSURE = 0.990 ATM

NOTES:

1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B18. - *Associated parameter data for run 275*

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 275
TAPE NO. = 110373
TEST DATE = 21 OC 74
DATE DIGITIZED = 9 May 77
NOM. TIME OF DAY OVER MICS = 0936 hr

AIRPLANE HEADING = 110 deg
NOM. AIRSPEED = 83.8 m/s
NOM. RADIO ALT = 149.4 m
PITCH ANGLE = 0 deg
FLAP DEFL = 34 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 11.0 deg C
NOM. SOUND SPEED AT AIRPLANE = 337.9 m/s
NOM. AIRPLANE MACH NO. = 0.25

HEIGHT OVER MIC 1 = 146 m
HEIGHT OVER MIC 4 = 146 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 104.7 kN
FUEL REMAINING = 81.8 kN
FLYOVER GROSS WEIGHT = 331.2 kN

RAT OVER MICS = 16 deg C
NOM. AIR TEMP AT MICS = 12.5 deg C
NOM. REL. HUM. at MICS = 51.9 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.44
RIGHT EPR = 1.435
LEFT EGT = 370 deg C
RIGHT EGT = 375 deg C
LEFT N1 = 75.0 PCT
RIGHT N1 = 74.5 PCT

BAROMETRIC PRESSURE = 0.990 ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B19. - Associated parameter data for run 292

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 292
TAPE NO. = 110487
TEST DATE = 22 OC 74
DATE DIGITIZED = 9 May 77
NOM. TIME OF DAY OVER MICS = 1202 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 87.5 m/s
NOM. RADIO ALT = 149.4 m
PITCH ANGLE = -2 deg
FLAP DEFL = 50 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 20.0 deg C
NOM. SOUND SPEED AT AIRPLANE = 343.2 m/s
NOM. AIRPLANE MACH NO. = 0.25

HEIGHT OVER MIC 1 = 163 m
HEIGHT OVER MIC 4 = 151 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 106.2 kN
FUEL REMAINING = 94.6 kN
FLYOVER GROSS WEIGHT = 342.4 kN

RAT OVER MICS = 23 deg C
NOM. AIR TEMP AT MICS = 21.7 deg C
NOM. REL. HUM. at MICS = 40.4 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.85
RIGHT EPR = 1.835
LEFT EGT = 490 deg C
RIGHT EGT = 490 deg C
LEFT N1 = 90.0 PCT
RIGHT N1 = 89.0 PCT

BAROMETRIC PRESSURE = 0.991 ATM

NOTES:

1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B20. - Associated parameter data for run 295

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 295
TAPE NO. = 110487
TEST DATE = 22 OC 74
DATE DIGITIZED = 9 May 77
NOM. TIME OF DAY OVER MICS = 1228 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 85.0 m/s
NOM. RADIO ALT = 158.5 m
PITCH ANGLE = -3 deg
FLAP DEFL = 50 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 21.3 deg C
NOM. SOUND SPEED AT AIRPLANE = 344.0 m/s
NOM. AIRPLANE MACH NO. = 0.25

HEIGHT OVER MIC 1 = 167 m
HEIGHT OVER MIC 4 = 163 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 106.2 kN
FUEL REMAINING = 81.1 kN
FLYOVER GROSS WEIGHT = 329.0 kN

RAT OVER MICS = 23 deg C
NOM. AIR TEMP AT MICS = 23.2 deg C
NOM. REL. HUM. at MICS = 35.5 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.835
RIGHT EPR = 1.835
LEFT EGT = 500 deg C
RIGHT EGT = 500 deg C
LEFT N1 = 89.5 PCT
RIGHT N1 = 89.5 PCT

BAROMETRIC PRESSURE = 0.990 ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B21. - Associated parameter data for run 315

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 315
TAPE NO. = 110489
TEST DATE = 24 OC 74
DATE DIGITIZED = 10 May 77
NOM. TIME OF DAY OVER MICS = 1035 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 91.5 m/s
NOM. RADIO ALT = 335.3 m
PITCH ANGLE = NA deg
FLAP DEFL = 50 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 13.9 deg C
NOM. SOUND SPEED AT AIRPLANE = 339.6 m/s
NOM. AIRPLANE MACH NO. = 0.27

HEIGHT OVER MIC 1 = 340 m
HEIGHT OVER MIC 4 = 340 m

TAKEOFF GROSS WEIGHT = 357.2 kN
INITIAL FUEL WEIGHT = 106.7 kN
FUEL REMAINING = 96.8 kN
FLYOVER GROSS WEIGHT = 347.4 kN

RAT OVER MICS = 18 deg C
NOM. AIR TEMP AT MICS = 15.1 deg C
NOM. REL. HUM. at MICS = 67.8 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.845
RIGHT EPR = 1.845
LEFT EGT = 480 deg C
RIGHT EGT = 480 deg C
LEFT N1 = 99.1 PCT
RIGHT N1 = 99.0 PCT

BAROMETRIC PRESSURE = 0.995 ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B22. - Associated parameter data for run 316

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 316
TAPE NO. = 110489
TEST DATE = 24 OC 74
DATE DIGITIZED = 10 May 77
NOM. TIME OF DAY OVER MICS = 1041 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 93.0 m/s
NOM. RADIO ALT = 329.2 m
PITCH ANGLE = NA deg
FLAP DEFL = 50 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 14.1 deg C
NOM. SOUND SPEED AT AIRPLANE = 339.7 m/s
NOM. AIRPLANE MACH NO. = 0.27

HEIGHT OVER MIC 1 = 347 m
HEIGHT OVER MIC 4 = 333 m

TAKEOFF GROSS WEIGHT = 357.2 kN
INITIAL FUEL WEIGHT = 106.7 kN
FUEL REMAINING = 93.9 kN
FLYOVER GROSS WEIGHT = 344.4 kN

RAT OVER MICS = 18 deg C
NOM. AIR TEMP AT MICS = 15.5 deg C
NOM. REL. HUM. at MICS = 66.1 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.845
RIGHT EPR = 1.82
LEFT EGT = 475 deg C
RIGHT EGT = 480 deg C
LEFT N1 = 99.0 PCT
RIGHT N1 = 89.8 PCT

BAROMETRIC PRESSURE = 0.995 ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B23. - Associated parameter data for run 319

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 319
TAPE NO. = 110489
TEST DATE = 24 OC 74
DATE DIGITIZED = 10 May77
NOM. TIME OF DAY OVER MICS = 1102 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 90.2 m/s
NOM. RADIO ALT = 335.3 m
PITCH ANGLE = -3 deg
FLAP DEFL = 50 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 14.6 deg C
NOM. SOUND SPEED AT AIRPLANE = 340.1 m/s
NOM. AIRPLANE MACH NO. = 0.27

HEIGHT OVER MIC 1 = 347 m
HEIGHT OVER MIC 4 = 347 m

TAKEOFF GROSS WEIGHT = 357.2 kN
INITIAL FUEL WEIGHT = 106.7 kN
FUEL REMAINING = 80.5 kN
FLYOVER GROSS WEIGHT = 331.0 kN

RAT OVER MICS = 18 deg C
NOM. AIR TEMP AT MICS = 16.6 deg C
NOM. REL. HUM. at MICS = 61.5 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.845
RIGHT EPR = 1.845
LEFT EGT = 480 deg C
RIGHT EGT = 480 deg C
LEFT N1 = 99.3 PCT
RIGHT N1 = 99.0 PCT

BAROMETRIC PRESSURE = 0.995 ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B24. - Associated parameter data for run 321

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL   OCTOBER 1974

RUN NO. = 321
TAPE NO. = 110489
TEST DATE = 24 OC 74
DATE DIGITIZED = 10 May 77
NOM. TIME OF DAY OVER MICS = 1114 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 80.4 m/s
NOM. RADIO ALT = 152.4 m
PITCH ANGLE = NA deg
FLAP DEFL = 0 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 16.1 deg C
NOM. SOUND SPEED AT AIRPLANE = 340.9 m/s
NOM. AIRPLANE MACH NO. = 0.24

HEIGHT OVER MIC 1 = 151 m
HEIGHT OVER MIC 4 = 154 m

TAKEOFF GROSS WEIGHT = 357.2 kN
INITIAL FUEL WEIGHT = 106.7 kN
FUEL REMAINING = 75.3 kN
FLYOVER GROSS WEIGHT = 325.8 kN

RAT OVER MICS = 18 deg C
NOM. AIR TEMP AT MICS = 17.1 deg C
NOM. REL. HUM. at MICS = 59.4 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.205
RIGHT EPR = 1.205
LEFT EGT = 315 deg C
RIGHT EGT = 315 deg C
LEFT N1 = 61.5 PCT
RIGHT N1 = 61.0 PCT

BAROMETRIC PRESSURE = 0.995 ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B25. - Associated parameter data for run 322

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 322
TAPE NO. = 110489
TEST DATE = 24 OC 74
DATE DIGITIZED = 10 May 77
NOM. TIME OF DAY OVER MICS = 1122 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 78.3 m/s
NOM. RADIO ALT = 150.9 m
PITCH ANGLE = +9 deg
FLAP DEFL = 0 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 16.5 deg C
NOM. SOUND SPEED AT AIRPLANE = 341.2 m/s
NOM. AIRPLANE MACH NO. = 0.23

HEIGHT OVER MIC 1 = 154 m
HEIGHT OVER MIC 4 = 150 m

TAKEOFF GROSS WEIGHT = 357.2 kN
INITIAL FUEL WEIGHT = 106.7 kN
FUEL REMAINING = 71.5 kN
FLYOVER GROSS WEIGHT = 322.0 kN

RAT OVER MICS = 18 deg C
NOM. AIR TEMP AT MICS = 17.4 deg C
NOM. REL. HUM. at MICS = 58.0 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.205
RIGHT EPR = 1.205
LEFT EGT = 322 deg C
RIGHT EGT = 320 deg C
LEFT N1 = 60.8 PCT
RIGHT N1 = 60.0 PCT

BAROMETRIC PRESSURE = 0.994 ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B26. - Associated parameter data for run 326

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 326
TAPE NO. = 110490
TEST DATE = 24 OC 74
DATE DIGITIZED = 10 May 77
NOM. TIME OF DAY OVER MICS = 1147 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 79.3 m/s
NOM. RADIO ALT = 152.4 m
PITCH ANGLE = +9 deg
FLAP DEFL = 0 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 17.4 deg C
NOM. SOUND SPEED AT AIRPLANE = 341.7 m/s
NOM. AIRPLANE MACH NO. = 0.23

HEIGHT OVER MIC 1 = 154 m
HEIGHT OVER MIC 4 = 153 m

TAKEOFF GROSS WEIGHT = 357.2 kN
INITIAL FUEL WEIGHT = 106.7 kN
FUEL REMAINING = 61.6 kN
FLYOVER GROSS WEIGHT = 312.2 kN

RAT OVER MICS = 19 deg C
NOM. AIR TEMP AT MICS = 18.4 deg C
NOM. REL. HUM. at MICS = 54.0 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.205
RIGHT EPR = 1.205
LEFT EGT = 322 deg C
RIGHT EGT = 321 deg C
LEFT N1 = 61.2 PCT
RIGHT N1 = 60.9 PCT

BAROMETRIC PRESSURE = 0.994 ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B27. - Associated parameter data for run 358

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 358
TAPE NO. = 110492
TEST DATE = 25 OC 74
DATE DIGITIZED = 10 May 77
NOM. TIME OF DAY OVER MICS = 0728 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 74.4 m/s
NOM. RADIO ALT = 150.9 m
PITCH ANGLE = +1 deg
FLAP DEFL = 38 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 13.4 deg C
NOM. SOUND SPEED AT AIRPLANE = 339.4 m/s
NOM. AIRPLANE MACH NO. = 0.22

HEIGHT OVER MIC 1 = 156 m
HEIGHT OVER MIC 4 = 153 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 106.7 kN
FUEL REMAINING = 87.0 kN
FLYOVER GROSS WEIGHT = 334.3 kN

RAT OVER MICS = 17 deg C
NOM. AIR TEMP AT MICS = 9.2 deg C
NOM. REL. HUM. at MICS = 89.4 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.44
RIGHT EPR = 1.44
LEFT EGT = 380 deg C
RIGHT EGT = 380 deg C
LEFT N1 = 75.9 PCT
RIGHT N1 = 75.2 PCT

BAROMETRIC PRESSURE = 0.993 ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B28. - Associated parameter data for run 359

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 359
TAPE NO. = 110492
TEST DATE = 25 OC 74
DATE DIGITIZED = 10 May 77
NOM. TIME OF DAY OVER MICS = 0734 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 75.3 m/s
NOM. RADIO ALT = 152.4 m
PITCH ANGLE = 0 deg
FLAP DEFL = 38 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 13.3 deg C
NOM. SOUND SPEED AT AIRPLANE = 339.2 m/s
NOM. AIRPLANE MACH NO. = 0.22

HEIGHT OVER MIC 1 = 154 m
HEIGHT OVER MIC 4 = 154 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 106.7 kN
FUEL REMAINING = 83.6 kN
FLYOVER GROSS WEIGHT = 331.0 kN

RAT OVER MICS = 17 deg C
NOM. AIR TEMP AT MICS = 9.2 deg C
NOM. REL. HUM. at MICS = 89.4 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.44
RIGHT EPR = 1.44
LEFT EGT = 380 deg C
RIGHT EGT = 378 deg C
LEFT N1 = 75.7 PCT
RIGHT N1 = 75.2 PCT

BAROMETRIC PRESSURE = 0.993 ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B29. - Associated parameter data for run 360

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 360
TAPE NO. = 110492
TEST DATE = 25 OC 74
DATE DIGITIZED = 10 May 77
NOM. TIME OF DAY OVER MICS = 0746 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 74.4 m/s
NOM. RADIO ALT = 335.3 m
PITCH ANGLE = 0 deg
FLAP DEFL = 38 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 15.5 deg C
NOM. SOUND SPEED AT AIRPLANE = 340.6 m/s
NOM. AIRPLANE MACH NO. = 0.22

HEIGHT OVER MIC 1 = 340 m
HEIGHT OVER MIC 4 = 340 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 106.7 kN
FUEL REMAINING = 78.4 kN
FLYOVER GROSS WEIGHT = 325.8 kN

RAT OVER MICS = 19 deg C
NOM. AIR TEMP AT MICS = 9.3 deg C
NOM. REL. HUM. at MICS = 89.4 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.44
RIGHT EPR = 1.44
LEFT EGT = 380 deg C
RIGHT EGT = 385 deg C
LEFT N1 = 76.1 PCT
RIGHT N1 = 75.3 PCT

BAROMETRIC PRESSURE = 0.994 ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B30. - Associated parameter data for run 361

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 361
TAPE NO. = 110492
TEST DATE = 25 OC 74
DATE DIGITIZED = 11 May 77
NOM. TIME OF DAY OVER MICS = 0752 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 74.4 m/s
NOM. RADIO ALT = 335.3 m
PITCH ANGLE = 0 deg
FLAP DEFL = 38 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 15.4 deg C
NOM. SOUND SPEED AT AIRPLANE = 340.5 m/s
NOM. AIRPLANE MACH NO. = 0.22

HEIGHT OVER MIC 1 = 347 m
HEIGHT OVER MIC 4 = 340 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 106.7 kN
FUEL REMAINING = 74.4 kN
FLYOVER GROSS WEIGHT = 321.8 kN

RAT OVER MICS = 20 deg C
NOM. AIR TEMP AT MICS = 9.5 deg C
NOM. REL. HUM. at MICS = 89.2 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.44
RIGHT EPR = 1.44
LEFT EGT = 380 deg C
RIGHT EGT = 385 deg C
LEFT N1 = 76.0 PCT
RIGHT N1 = 75.3 PCT

BAROMETRIC PRESSURE = 0.994 ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table 31. - Associated parameter data for run 362

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 362
TAPE NO. = 110492
TEST DATE = 25 OC 74
DATE DIGITIZED = 11 May 77
NOM. TIME OF DAY OVER MICS = 0758 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 74.4 m/s
NOM. RADIO ALT = 335.3 m
PITCH ANGLE = 0 deg
FLAP DEFL = 38 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 15.3 deg C
NOM. SOUND SPEED AT AIRPLANE = 340.5 m/s
NOM. AIRPLANE MACH NO. = 0.22

HEIGHT OVER MIC 1 = 347 m
HEIGHT OVER MIC 4 = 347 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 106.7 kN
FUEL REMAINING = 72.4 kN
FLYOVER GROSS WEIGHT = 319.8 kN

RAT OVER MICS = 20 deg C
NOM. AIR TEMP AT MICS = 9.6 deg C
NOM. REL. HUM. at MICS = 89.0 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.44
RIGHT EPR = 1.44
LEFT EGT = 390 deg C
RIGHT EGT = 385 deg C
LEFT N1 = 76.0 PCT
RIGHT N1 = 75.3 PCT

BAROMETRIC PRESSURE = 0.994 ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B32. - Associated parameter data for run 371

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 371
TAPE NO. = 110501
TEST DATE = 25 OC 74
DATE DIGITIZED = 11 May 77
NOM. TIME OF DAY OVER MICS = 1132 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 72.6 m/s
NOM. RADIO ALT = 335.3 m
PITCH ANGLE = 0 deg
FLAP DEFL = 37 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 17.2 deg C
NOM. SOUND SPEED AT AIRPLANE = 341.6 m/s
NOM. AIRPLANE MACH NO. = 0.21

HEIGHT OVER MIC 1 = 355 m
HEIGHT OVER MIC 4 = 340 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 106.9 kN
FUEL REMAINING = 77.3 kN
FLYOVER GROSS WEIGHT = 324.5 kN

RAT OVER MICS = 20 deg C
NOM. AIR TEMP AT MICS = 18.8 deg C
NOM. REL. HUM. at MICS = 53.0 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.44
RIGHT EPR = 1.44
LEFT EGT = 390 deg C
RIGHT EGT = 380 deg C
LEFT N1 = 76.0 PCT
RIGHT N1 = 75.2 PCT

BAROMETRIC PRESSURE = 0.992 ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B33. - Associated parameter data for run 373

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 373
TAPE NO. = 110501
TEST DATE = 25 OC 74
DATE DIGITIZED =11 May 77
NOM. TIME OF DAY OVER MICS = 1145 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 77.3 m/s
NOM. RADIO ALT = 335.3 m
PITCH ANGLE = 0 deg
FLAP DEFL = 37 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 17.4 deg C
NOM. SOUND SPEED AT AIRPLANE = 341.7 m/s
NOM. AIRPLANE MACH NO. = 0.23

HEIGHT OVER MIC 1 = 355 m
HEIGHT OVER MIC 4 = 340 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 106.9 kN
FUEL REMAINING = 71.5 kN
FLYOVER GROSS WEIGHT = 318.7 kN

RAT OVER MICS = 20 deg C
NOM. AIR TEMP AT MICS = 19.3 deg C
NOM. REL. HUM. at MICS = 51.4 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.44
RIGHT EPR = 1.44
LEFT EGT = 380 deg C
RIGHT EGT = 380 deg C
LEFT N1 = 75.2 PCT
RIGHT N1 = 75.5 PCT

BAROMETRIC PRESSURE =0.992 ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B34. - Associated parameter data for run 374

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 374
TAPE NO. = 110501
TEST DATE = 25 OC 74
DATE DIGITIZED = 11 May 77
NOM. TIME OF DAY OVER MICS = 1151 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 73.5 m/s
NOM. RADIO ALT = 335.3 m
PITCH ANGLE = -1 deg
FLAP DEFL = 38 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 17.5 deg C
NOM. SOUND SPEED AT AIRPLANE = 341.8 m/s
NOM. AIRPLANE MACH NO. = 0.22

HEIGHT OVER MIC 1 = 347 m
HEIGHT OVER MIC 4 = 340 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 106.9 kN
FUEL REMAINING = 68.6 kN
FLYOVER GROSS WEIGHT = 315.8 kN

RAT OVER MICS = 20 deg C
NOM. AIR TEMP AT MICS = 19.5 deg C
NOM. REL. HUM. at MICS = 50.7 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.44
RIGHT EPR = 1.44
LEFT EGT = 390 deg C
RIGHT EGT = 380 deg C
LEFT N1 = 76.0 PCT
RIGHT N1 = 75.5 PCT

BAROMETRIC PRESSURE =0.992 ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B35. - Associated parameter data for run 376

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL   OCTOBER 1974

RUN NO. = 376
TAPE NO. = 110501
TEST DATE = 25 OC 74
DATE DIGITIZED = 11 May 77
NOM. TIME OF DAY OVER MICS = 1204 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 76.3 m/s
NOM. RADIO ALT = 153.9 m
PITCH ANGLE = -1 deg
FLAP DEFL = 38 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 18.7 deg C
NOM. SOUND SPEED AT AIRPLANE = 342.5 m/s
NOM. AIRPLANE MACH NO. = 0.22

HEIGHT OVER MIC 1 = 162 m
HEIGHT OVER MIC 4 = 160 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 106.9 kN
FUEL REMAINING = 63.4 kN
FLYOVER GROSS WEIGHT = 310.6 kN

RAT OVER MICS = 22 deg C
NOM. AIR TEMP AT MICS = 20.1 deg C
NOM. REL. HUM. at MICS = 49.2 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.44
RIGHT EPR = 1.44
LEFT EGT = 390 deg C
RIGHT EGT = 385 deg C
LEFT N1 = 76.1 PCT
RIGHT N1 = 75.5 PCT

BAROMETRIC PRESSURE = 0.992 ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B36. - Associated parameter data for run 378

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL — OCTOBER 1974

RUN NO. = 378
TAPE NO. = 110501
TEST DATE = 25 OC 74
DATE DIGITIZED = 11 May 77
NOM. TIME OF DAY OVER MICS = 1217 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 72.6 m/s
NOM. RADIO ALT = 155.4 m
PITCH ANGLE = -1 deg
FLAP DEFL = 36 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 19.1 deg C
NOM. SOUND SPEED AT AIRPLANE = 342.8 m/s
NOM. AIRPLANE MACH NO. = 0.21

HEIGHT OVER MIC 1 = 160 m
HEIGHT OVER MIC 4 = 157 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 106.9 kN
FUEL REMAINING = 54.9 kN
FLYOVER GROSS WEIGHT = 302.1 kN

RAT OVER MICS = 22 deg C
NOM. AIR TEMP AT MICS = 20.6 deg C
NOM. REL. HUM. at MICS = 47.7 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.44
RIGHT EPR = 1.44
LEFT EGT = 390 deg C
RIGHT EGT = 385 deg C
LEFT N1 = 76.1 PCT
RIGHT N1 = 75.8 PCT

BAROMETRIC PRESSURE = 0.991 ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.

Table B37. - Associated parameter data for run 379

DC-9-10/JT8D-1 FLYOVER NOISE TESTS

FRESNO AIR TERMINAL OCTOBER 1974

RUN NO. = 379
TAPE NO. = 110501
TEST DATE = 25 OC 74
DATE DIGITIZED = 11 May 77
NOM. TIME OF DAY OVER MICS = 1230 hr

AIRPLANE HEADING = 290 deg
NOM. AIRSPEED = 72.6 m/s
NOM. RADIO ALT = 152.4 m
PITCH ANGLE = -1 deg
FLAP DEFL = 38 deg
GEAR = DOWN

NOM. TEMP. AT AIRPLANE = 19.6 deg C
NOM. SOUND SPEED AT AIRPLANE = 343.0 m/s
NOM. AIRPLANE MACH NO. = 0.21

HEIGHT OVER MIC 1 = 160 m
HEIGHT OVER MIC 4 = 163 m

TAKEOFF GROSS WEIGHT = 354.1 kN
INITIAL FUEL WEIGHT = 106.9 kN
FUEL REMAINING = 50.9 kN
FLYOVER GROSS WEIGHT = 298.1 kN

RAT OVER MICS = 22.5 deg C
NOM. AIR TEMP AT MICS = 21.1 deg C
NOM. REL. HUM. at MICS = 46.1 PCT

NOM. AVER. F_n/δ_{am} OVER MICS = . kN
LEFT EPR = 1.44
RIGHT EPR = 1.44
LEFT EGT = 390 deg C
RIGHT EGT = 385 deg C
LEFT N1 = 76.1 PCT
RIGHT N1 = 75.6 PCT

BAROMETRIC PRESSURE = 0.991 ATM

NOTES:
1. The IRIG start time and the time for each subsequent 1/2-second interval is the time at the beginning of the interval.
2. When the aircraft noise signal was not more than 5 dB above the indicated ambient SPL, the aircraft noise SPL was set equal to -350.0 dB.
3. An 8-second period was used for averaging the digitized samples for the 124 dB, 250-Hz acoustic calibrations, the pink noise system frequency response, and the ambient SPLs.