MOUNT HOPE NOISE SURVEY

MOUNT HOPE NOISE SURVEY:

PRESENT LEVELS AND PREDICTED INCREASES WITH EXPANSION.

by

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SCOPE AND CONTENTS:

This study deals with applied research in the field of environmental noise problems, specifically the measuring of noise patterns near Mount Hope Airport originating from subsonic jet aircraft using the present runway facilities. Based on actual measurements the results have been analyzed and reduced to simple contour lines.

An attempt has been made in this study to relate the concept of community noise in the vicinity of the airport to specific runway configurations, traffic density and patterns, and to provide a comparison between the noise levels due to the existing operations and those which may result due to the proposed expansion. Versatile computer programs have been developed in this study to simulate an airport model, compute and construct the noise contours for any combination of design requirements such as runway orientation, flight procedure, type of aircraft, etc.

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ABBREVIATIONS

ATC	Air Traffic Control
CTOL	Conventional Take-off and Landing
CNR	Composite Noise Rating
dB	Decibels
EPNL	Effective Perceived Noise Level
EPNdB	Effective Perceived Noise Decibels
FM	Frequency Modulation
FAA	Federal Aviation Administration, U.S.A.
GSA	Glide Slope Angle
ILS	Instrument Landing System
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
NEF	Noise Exposure Forecast
NNI	Noise and Number Index
NPL	Noise Pollution Level
PNL	Perceived Noise Level
PNdB	Perceived Noise Decibels
$PNdB_t$	Tone-Corrected Perceived Noise Decibels
RMS	Root Mean Square
SLM	Sound Level Meter
SPL	Sound Pressure Level

SAE	Society of Automotive Engineers
SST	Super Sonic Transport
VTOL	Vertical Take-off and Landing
VFR	Visual Flight Rules

CHAPTER 1

INTRODUCTION

1.1 Civil Aviation Growth

The impact of civil aviation growth on the environment is evident in the public concern regarding noise, air pollution, esthetics and ecological disturbances. Of these effects noise is judged to be one of the most important and a critical constraint to the future growth of civil aviation. This constraint is already manifested in the inability to site and construct new airports or expand an existing airport facility in locations required to meet demand and in the reduction of existing airport capacities by noise restrictions and operational limitations. Public pressure is increasing daily against the airlines, aircraft manufacturers, and local airport authorities to reduce aircraft-generated noise in airport communities. This increasing awareness and pressure can be expected at the very time these operations should increase significantly to meet the growing travel and transportation demands. The decision-making process in a democratic society as applied to the site selection of a new airport or further development of an existing airport operations is a complex task. Its complexity arises from the many conflicting and interfering factors which govern the design objectives of the airport and the site. The final selection of the site is therefore, ideally, finding an optimum solution, bringing all these factors into account such as construction costs, environmental impact, surface access, rural land use, urbanization, operation of airlines, etc.

1.2 Objectives - Scope of the Study

This study deals with applied research in the field of environmental noise problems, specifically the measuring of noise patterns near Mount Hope Airport originating from subsonic conventional takeoff and landing aircraft (CTOL) using the present runway facilities.

The results and conclusions presented in this study hopefully will assist urban planners, both at the local and federal level, in planning zoning regulations, establishing noise standards and assessing the severity of aircraft noise on the airport community due to the proposed expansion of the airport to a regional airport.

Based on actual measurements the results have been analyzed and reduced to simple contour lines. This study is neither intended to be a noise certification of a particular aircraft, nor a noise survey due to the operations of a particular commercial aircarrier.

An attempt has also been made in this report to relate the concept of community noise in the vicinity of the airport to specific runway configurations, traffic density and patterns and to provide a comparison between the noise levels due to the existing operations and those which may result due to the proposed expansion.

It should be noted that all the earlier reports [1], [2], [3] including that given by the Ministry of Transport were based on sound surveys carried out in the U.S.A. These sound surveys were then computerized for different types of aircraft, traffic densities, etc. and the computer programs applied directly to the runway configurations for the proposed expansion of Mount Hope Airport to provide estimated sound contours. The present study, on the other hand, contains actual measurements taken at Mount Hope Airport.

An experimental investigation has also been carried out to correlate the calculated PNL in PNdB and the simple dB(A) measured directly by a sound level meter for both cases takeoff and landing.

Several computer programs were also devised which enables a very complex and complete analysis of sound contours to be constructed for an airport model.

CHAPTER 2

PHYSICAL EVALUATION OF AIRCRAFT NOISE LEVEL

2.1 Introduction

Acoustic noise is defined as any undesired sound and sound is, physically speaking, mechanical vibrations in gaseous, liquid or solid media. Such vibrations are characterized by their frequency, their amplitude and their phase.

Not all mechanical vibrations can be perceived by the hearing mechanism of the human ear. Firstly, the vibrations have to be of a certain magnitude to be audible and secondly the frequency has to be within certain limits. Audible vibrations are found within a certain magnitude versus frequency region, called the hearing range. This region varies from person to person and will also depend on the persons age, possible hearing loss, physiological conditions, etc.

The lowest frequency of sound that has a pitch-like quality is about 20 Hz and the upper frequency audible to the average adult is about 10,000 Hz, however, typical frequency limits of the ear could be as low as 2Hz and with an upper frequency of about 20,000 Hz. The simplest vibration is a pure tone which consists of a sinusoid, but most sounds met within daily life are not purely sinusoidal vibrations. Very often they vary with time, both in frequency and amplitude and simple mathematical relationships between the various characteristic values do not exist for such complex signals.

2.2 The Physical Level Scale for Noise. The Decibel.

The quantity normally measured when dealing with acoustic noise is the

RMS sound pressure because it has a direct relationship to the energy content of the signal over a certain period or increment. Because the weakest sound pressure that is perceived by a person is a very small quantity, use has conveniently been made of the CGS-system in scaling sound pressures. Thus, as the sound pressure is the force per unit area caused by the sound wave the unit is dyne/cm^2 = microbar (μ bar).

Now, even though the weakest sound pressure perceived as sound is a small quantity, the range of sound pressure perceived as sound is extremely large. The weakest sound pressure to be detected by an average person at 1,000 Hz has been found to be 0.0002 μ bar (2×10^{-5} Newton/m^2). On the other hand, the largest sound pressure perceived without pain is of the order of 1,000 μ bar, i.e. the scale of sound pressures covers a dynamic range of approximately 1,000,000:1. The use of the unit of μ bars to measure sound pressure is obviously not very convenient because of the length of scale. It is also a fact that the hearing mechanism responds to changes in sound pressures in a relative rather than in an absolute manner. Therefore it was found more convenient and practical to use a relative scale of sound pressure than the absolute scale. Such a scale is the decibel scale (dB-scale). The decibel is defined as ten times the logarithm to the base ten* of the ratio between two quantities of power. As the sound power is related to the square of the sound pressure, a convenient scale for sound (noise) measurement was defined as:

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* In this study the base 10 will be used for all the logarithms unless otherwise specified.

$$\text{Sound Pressure Level (SPL)} = 10 \log \left(\frac{P}{Po}\right)^2 \quad \text{dB} \qquad (2.1)$$

or
$$SPL = 20 \log \left(\frac{P}{Po}\right) \quad \text{dB} \qquad (2.2)$$

Where P is the sound pressure being measured and Po is a reference sound pressure, normally taken to be 0.0002 μ bar. The term level as shown in equation (2.1) indicates that the given quantity has a certain level above a certain reference quantity.

In this study the reference RMS pressure of 0.0002 μ bar will be used as the reference value Po in sound pressure measurements, unless otherwise indicated.

2.3 Frequency Content of Noise

A pure tone resulting from a surface vibrating in simple harmonic motion has the form of a sine wave. In practice noise contains many different frequencies and the waveform departs from that of the pure tone. Little can be gained from detailed study of the waveform, except in very special circumstances, but a great deal can be learned about the likely effects of a noise from a frequency analysis of the noise. Means are available for measuring the frequency content of a noise and assessing the contributions of the different parts of the frequency scale towards the over-all sound level. Frequency selective filters are used, each filter responding only to one part of the frequency scale. For example, one may choose a filter which responds only to sound in the frequency band 56 to 71 Hz and the next band will respond to frequencies in the range 71 to 90 Hz. Thus the whole frequency scale can be divided into separate bands, one band cutting off as the next band takes over. For example, an octave band analysis has been found suitable in some applications such as noise control in machine shops, measurement of noise emitted by machine tools, ratings of sound insulating materials, etc. The centre frequency of one octave band is, by definition, one half that of the centre frequency of the band above it. For finer analysis, as in aircraft noise measurement, one third octave band analysis is very often used, and for certain applications even discrete frequency analyses could be made.

The frequency specifications for band filters have been standardized by the ISO and are shown on Figure 2.1.

A frequency analysis has the advantage of indicating the frequency content or character of a noise and because of the variation in the sensitivity of the ear at different frequencies, such a knowledge is necessary to estimate the subjective effects of a particular noise.

2.4 Frequency - Weighting Curves

Since the response of the human ear varies with both frequency and intensity there are certain difficulties in obtaining direct measurements with instruments which will give information as to the human perception of the noise under examination. The simplest solution is to produce an instrument with characteristics similar to those of the human ear. These characteristics are obtained by using frequency-weighting curves and they modify the frequency response of the instrument in such a way as to resemble the response of the ear in an approximate form. These weighting curves are termed A, B, C and D.

PREFERRED FREQUENCIES

1 The frequencies preferred for acoustical measurements are given in the table below. The type of printing indicates the degree of preference.

2 The table may be extended indefinitely in either direction by successive multiplication or division by 1000. In other words, the frequencies in the table may be taken if required, as millihertz (mHz), kilohertz (kHz), megahertz (MHz), etc.

3 In case octave intervals are desired, the preferred frequencies are 500, 1000, 2000 Hz (c/s), etc., as indicated by crosses in the octave column. If the intervals are 1/2 or 1/3 octave, the preferred frequencies are those indicated by crosses in the appropriate column.

RANGE OF APPLICATION OF FREQUENCIES

When electro-acoustical devices are to be constructed, or when data are to be given at discrete frequencies, these discrete frequencies should be selected from the table in accordance with the particular interval chosen.

In the case of bandpass filters or bands of sound, the frequencies listed in the table should be the geometric centre frequencies of the bands.

TABLE OF PREFERRED FREQUENCIES IN HERTZ (c/s) FOR ACOUSTICAL MEASUREMENTS AND FOR GEOMETRIC CENTRE FREQUENCIES OF FILTER PASS BANDS

Preferred frequencies	1/1 oct.	1/2 oct.	1/3 oct.	Preferred frequencies	1/1 oct.	1/2 oct.	1/3 oct.	Preferred frequencies	1/1 oct.	1/2 oct.	1/3 oct.
16	×	×	×	160			×	1600			×
18				180		×		1800			
20			×	200			×	**2000**	×	×	×
22.4		×		224				2240			
25			×	**250**	×	×	×	2500			×
28				280				2800		×	
31.5	×	×	×	315			×	3150			×
35.5				355		×		3550			
40			×	400			×	**4000**	×	×	×
45		×		450				4500			
50			×	**500**	×	×	×	5000			×
56				560				5600		×	
63	×	×	×	630			×	6300			×
71				710		×		7100			
80			×	800			×	**8000**	×	×	×
90		×		900				9000			
100			×	**1000**	×	×	×	10 000			×
112				1120				11 200		×	
125	×	×	×	1250			×	12 500			×
140				1400		×		14 000			
160			×	1600			×	**16 000**	×	×	×

Fig.(2.1)

From Reference (8)

Each of the curves A, B and C were originally used for a particular range of SPL. However, the A-weighting curve is now by far the most widely used. The D curve has recently been introduced for measuring jet aircraft noise. Measurement results are usually reported in the form dB(A) with the weighting scale used shown in brackets. Figure 2.2 illustrates the four frequency weighting curves.

2.5 Perceived Noisiness (Annoyance)

The perceived loudness of pure tones of differing frequencies and intensities has been studied quite extensively and is well understood. However, it has been recognized that an accurate determination of the judged loudness of a complex noise signal such as produced by jet aircraft is somewhat more difficult. Although the use of a sound level meter (SLM) with, say, the A-weighting network, provides a reasonably good approximation it must be recognized that the shape of the frequency-response curves as shown on Figure 2.2 vary with intensity and also, that these curves have been based on psychoacoustical studies involving the use of pure tone only.

In an effort to establish a method of determining the perceived loudness of complex noise signals, researchers have turned to an analysis of the signal in terms of the SPL's in each octave or one-third octave band. Two significant studies have been conducted in this regard, by Stevens in 1956 [5] and by Kryter in 1959[6].

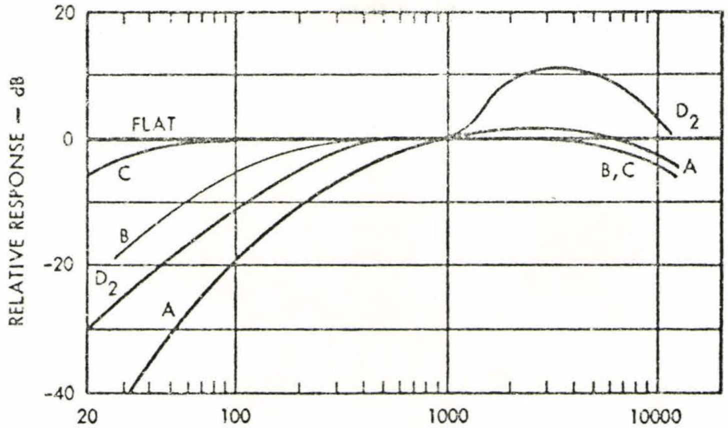
The Kryter study, which resulted in the definition of the perceived noise decibel unit (PNdB) is of more interest with respect to aircraft noise.

The results and the method developed in 1959 by Kryter were refined and modified in 1963 [7]. This method along with various restrictions and extensions, has been internationally recommended by the I.S.O. Recommendations No. 507 [8] and No. R1761 [9].

The curves developed by Kryter [6] were named equal noisiness contours and were used in conjunction with the summation formula developed by Stevens [5] for calculating the loudness of a complex sound. To distinguish noisiness from loudness, it was proposed that the subjective unit of noisiness be called the "noy" which parallels the use of the "Sone" for loudness. As an example a sound of 2 noys was said to be subjectively twice as noisy as a sound of 1 noy, 4 noys was assigned to the sound four times as noisy as a sound of 1 noy, etc. The "noy" was defined as the noisiness of the one-third octave band or full octave band centred at 1,000 Hz and having a SPL of 40 dB. The resulting scale of noisiness illustrated in Figure 2.4, is somewhat analogous to the equal loudness scale for pure tones as illustrated in Figure 2.3.

Kryter's method for determining the PNdB unit for a particular noise signal involved the determination of the SPL's for each octave or one-third octave band. Noy values for each band were then determined from Figure 2.4 or an equivalent table of values. (See Figure A.1 in Appendix A). Finally, these individual noy values were combined by means of a summation equation to a quantity known as the total perceived noisiness which was then converted to a PNdB unit.

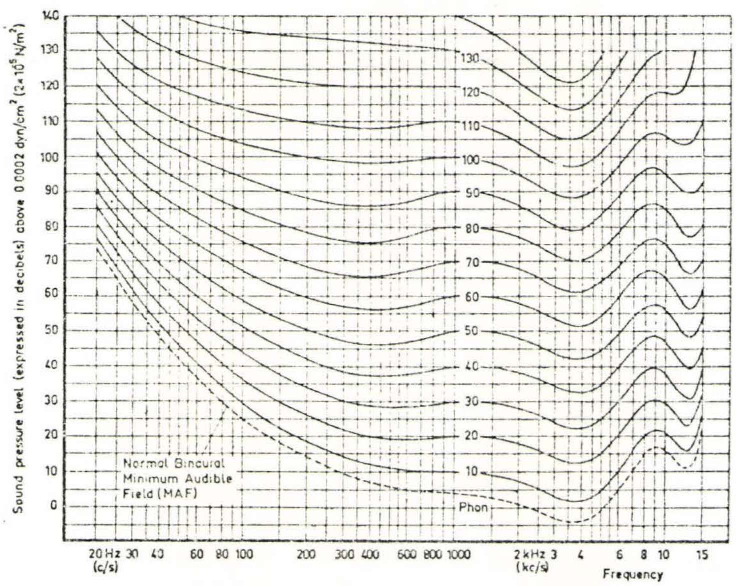
It should be noted that the equations and the corrections applied to arrive at the final PNdB value will be presented in greater detail in Chapter 4.



Frequency in Hz

Fig.(2.2) Frequency weighting curves for sound level meters

From Reference (10)



Normal equal loudness contours for pure tones. They can be applied when:

a) The source of sound is directly ahead of the listener.
b) The sound reaches the listener in the form of a free progressive plane wave.
c) The sound pressure level is measured in the absence of the listener.
d) The listening is binaural.
e) The listeners are otologically normal persons in the age group 18 to 25 years inclusive.

Fig.(2.3) Normal equal loudness contours for pure tones

From Reference (23)

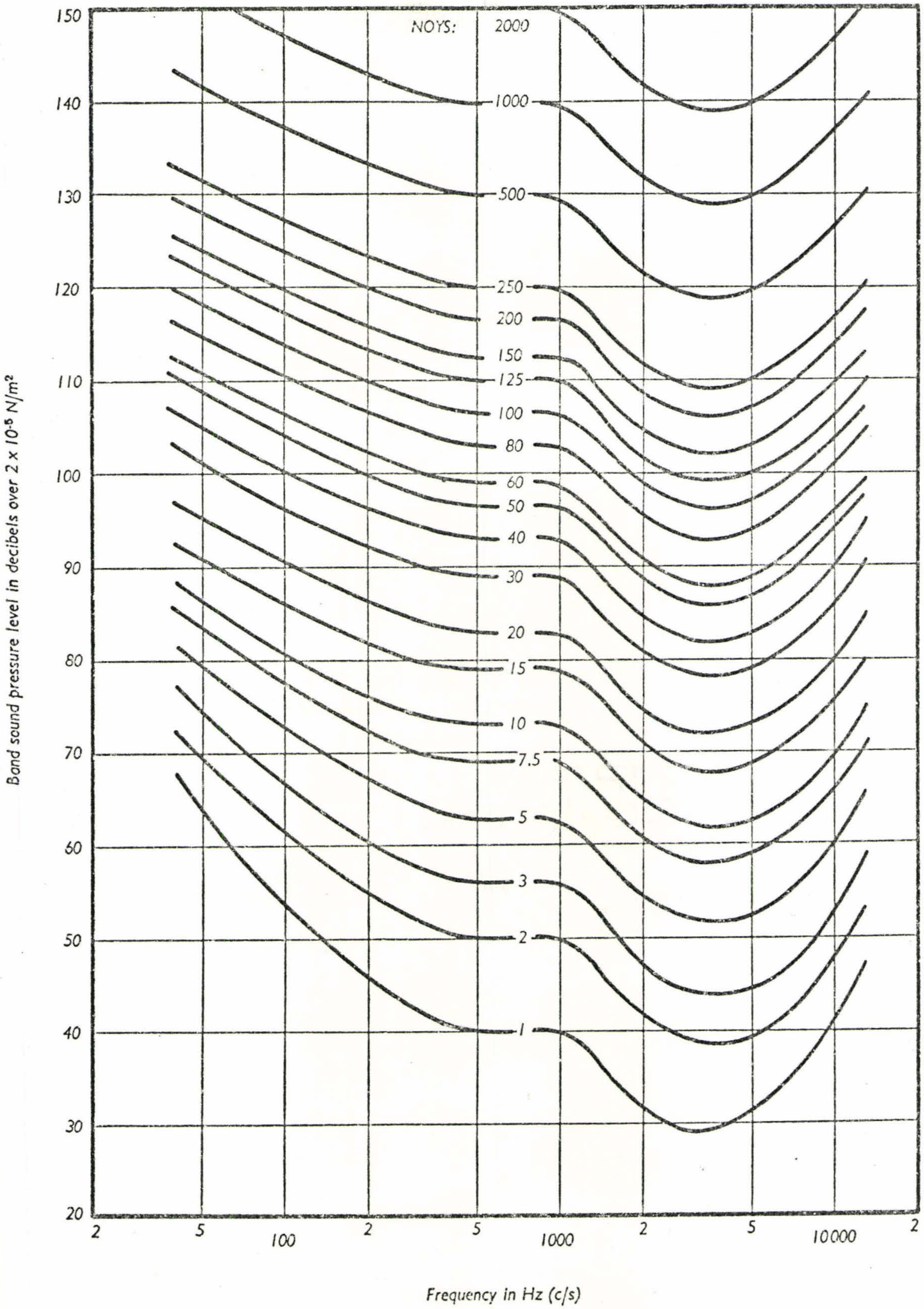


Fig.(2.4) Contours of perceived noisiness

From Reference (8)

2.6 Further Developments in the Perceived Noisiness Concept

Measurements taken during an aircraft flypast may be analyzed to determine the maximum PNdB value at a certain location. The resulting number is then a measurement of the maximum noisiness reaching that point, with due consideration for sound intensity and the variable response of the human ear to the various frequency components of the noise. However, it should be pointed out that certain subjectively annoying elements of the sound event have not been considered in calculating the PNdB values. Psychoacoustical experimentation has indicated that the addition of relatively high concentrations of energy in narrow bands to the overall broad band spectrum produces high value of "perceived noisiness" when compared to a similar broad band spectrum having the same overall energy level (without the high concentrations).

For this purpose, correction factors were developed by researchers and applied to the measured SPL in the various bands that exceed adjacent band levels.

In addition to this, further studies have led to the development of the effective perceived noise in decibels (EPNdB) which takes into account the duration of the noise and the shape of the time history of flypast noise. A more detailed treatment of this analysis will be presented in Chapter 4.

2.7 Recent Developments in Aircraft Noise Annoyance Rating Systems

The above mentioned units relate to the measurement of the noisiness or annoyance of an individual aircraft flypast. However, community disturbance resulting from aircraft noise must include the effects of numerous other factors such as the number of aircraft movements and the time of day at which they occur. The noise exposure forecast (NEF) system as discussed in Chapter 5 included considerations of these factors. [It should be noted that the NEF is a calculated quantity and cannot be measured directly with a sound level meter.]

CHAPTER 3

MOUNT HOPE AIRPORT COMMUNITY NOISE SURVEY

Measurements of noise due to jet aircraft on the community surrounding Mount Hope Airport started at the beginning of September 1972. For this purpose a station wagon was equipped with sound measuring and recording equipment. During the measurements data was recorded on magnetic tapes and later analyzed in the dynamics laboratory of the Department of Mechanical Engineering. Over 110 measurements were recorded at various locations, carefully selected to obtain as wide a coverage as possible. Of these approximately 65 were selected for the analysis to follow.

The noise patterns at Mount Hope Airport were recorded only for the takeoff and landing operations of the Boeing 737-200 series powered by 2 turbofan engines.*

3.1 Measurement Locations

Figure 3.1 illustrates the approximate location of measurements in the vicinity of the airport. Forty-five measurement locations are shown on the map and at each one of these locations recordings were taken for both landing and takeoff noise, depending on the runway used (06 or 24).**

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* Pratt and Whitney JT809

** Runways are normally designated by the first 2 figures of their orientations according to the compass rose, i.e. 06 stands for 060 or 60° from the north.

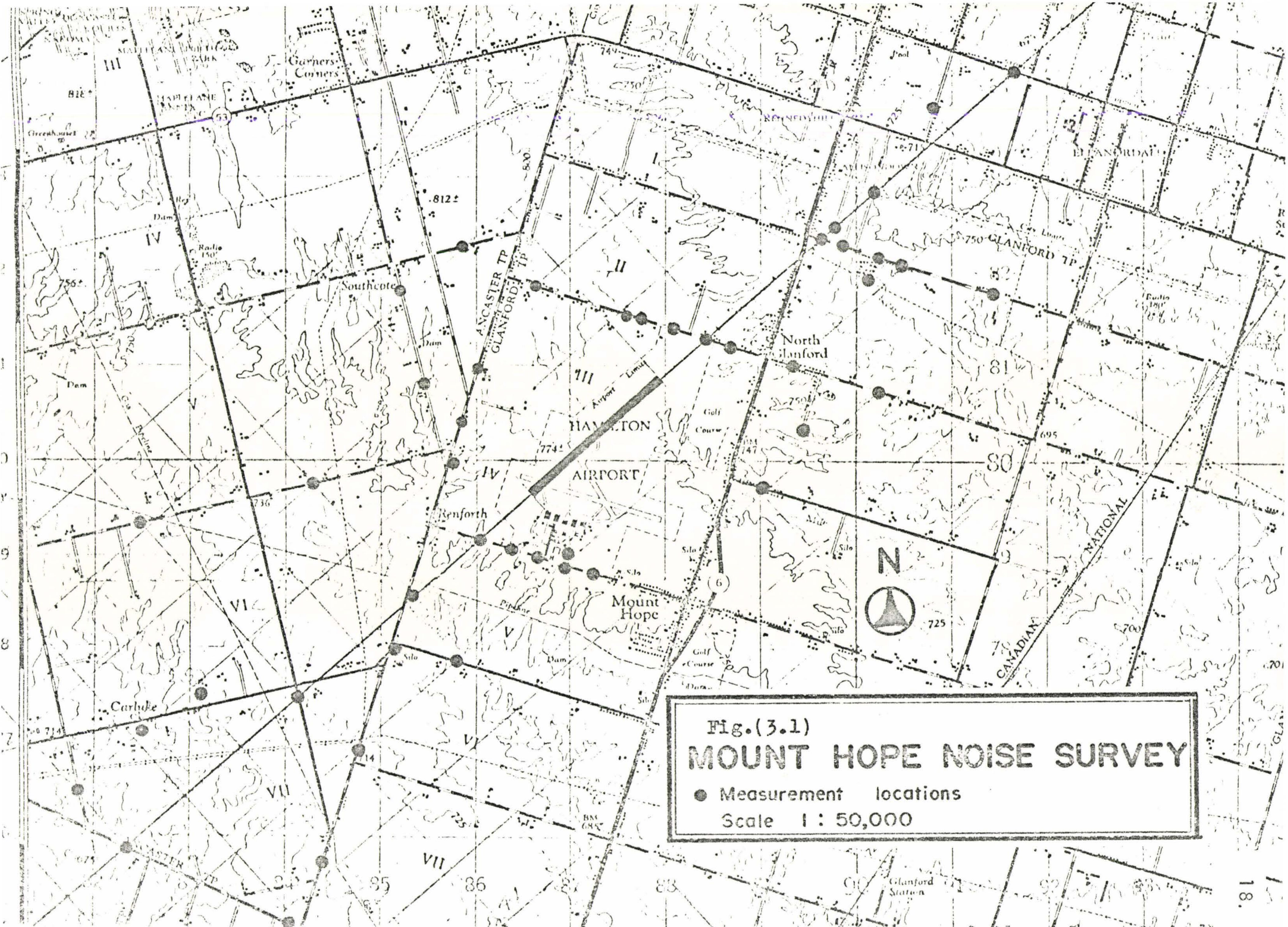

Fig.(3.1)
MOUNT HOPE NOISE SURVEY
● Measurement locations
Scale 1 : 50,000

The farthest location surveyed was about 3-1/2 miles to the south of the end of runway 06 along the centre line of the runway strip, and the farthest location surveyed off to the side of the runway was about 1-1/2 miles.

It should be noted that 9 locations were located directly under the flight path; provided that the aircraft followed a straight line flight path during approach and climb-out.

In the following paragraphs a brief discussion will be presented to illustrate the merits and advantages of some of the chosen measurement locations.

(i) Locations close to the end of the runway (less than about 1-1/2 miles) and located off to the side of the flight path with the added proviso that the elevation angle was greater than 10 degrees: upon moving further from the flight path to the side, differences in aircraft altitude became less important in determining the total distance from the aircraft to the observer. At great distances to the side, aircraft altitude effects were negligible and as a consequence takeoff gross weight changes did not alter the perceived noise level.

(ii) Locations close to the end of the runways and situated at great distance off to the side with the added proviso that the elevation angle was less than 10 degrees: at these locations ground attenuation and the terrain introduced excessive reductions in the perceived noise level due to absorption characteristics as produced by some trees, tall grass, buildings, hills, ... etc., consequently, typical ground attenuation values were estimated for the Mount Hope area.

(iii) Locations situated at great distances from aircraft flight path provided that the elevation angle was greater than 10^{o}: these measurement locations assisted in the investigation of the frequency content and noise spectrum at such great distances in the community due to the absorption and scattering of sound energy by the atmosphere, and also assessing the difference between the PNdB and dB(A) measurements in view of the reduced high frequency noise components in the energy spectrum.

3.2 Background Noise

In selecting the measurement locations the background noise was considered as one of the major factors. Generally it is recommended that the background noise level be at least 10 dB lower than the total noise level. However, if the difference is between 3 to 10 dB a correction factor can be used. If the difference is less than 3 dB the measurement should be rejected.

3.3 Acoustical Instrumentation

The principal instruments employed for acoustical measurements and laboratory analysis were standard in range and response. Very briefly the acoustical instrumentation included the following:

(a) A precision sound level meter *(1) covering the frequency range 20 to 20,000 Hz. with specified tolerances. This portable

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*(1) B & K type 2203, serial no. 209871.

sound level meter is a highly accurate instrument designed for outdoor use and complies with International Electro-technical Commission (IEC) and American Standards Association (ASA) requirements.

(b) An instrumentation magnetic tape recorder *(2) covering the frequency range 0 to 10,000 Hz., ± 0.5 dB at 30 ips tape speed and using an FM recording playback system. Signal to noise ratio at 30 ips was better than 44 dB.

(c) A 1/3 octave band-pass filter set *(3) designed for analysis, selective measurements and selection of noise signals in 1/3 octave bands covering the frequency range 22 to 45,000 Hz.

(d) A graphic level recorder *(4) designed for accurate recording of signal levels in the frequency range 2 to 200,000 Hz, the recorder has a frequency response of 2 to 200 Hz and 50 dB dynamic range.

(e) A portable high precision acoustic calibrator *(5), designed to enable quick and accurate overall calibration of the sound measuring and recording equipment. The calibrator produces a sound pressure level of 124 dB at the microphone diaphragm, at a frequency of 250 Hz and has a calibration accuracy of ± 0.2 dB.

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*(2) Philips ANA-LOG 7, EL1020/07, serial no. 2691
*(3) B & K type 1612, serial no. 223202.
*(4) B & K type 2305, serial no. 205241.
*(5) B & K type 4220, serial no. 221356.

(f) A microphone amplifier for data reduction in the laboratory in conjunction with other instrumentation.

3.4 Measurement Procedures and Techniques

(i) Effects of Reflections and Background Noise: Any object the physical dimensions of which are of the order of the wavelength of the sound will reflect the sound waves and thus cause a disturbance of the field. The amount of disturbance depends furthermore upon the sound reflecting properties of the object, its shape and the angle of the incident sound wave. Experiments have shown that the maximum sound reflections from a human body will occur in the frequency range around 400 Hz, and if the person operating the noise measurement equipment stands close to the microphone a maximum uncertainty of around 6 dB may be obtained in this frequency range. At frequencies above 1,000 Hz approximately, reflections from the SLM may also upset the measured results.

In order to minimize undesired effects of reflection in the course of measurements, the microphone was mounted on an extension connector as shown in Figure 3.2, the operator position was maintained at a position of about 4 ft. from the microphone, the magnetic tape recorder was located about 15 ft. away from the SLM and obstructions between the microphone and the aircraft in flight were carefully avoided.

CAPTION TO FIGURE (3.2)

Acoustical Instrumentations Used In Field Measurements

1. Condenser Microphone Fitted with Windscreen.
2. B & K Sound Level Meter, Type 2203.
3. Philips Instrumentation Magnetic Tape Recorder.
4. Earphones.
5. B & K Acoustical Calibrator, Type 4220.

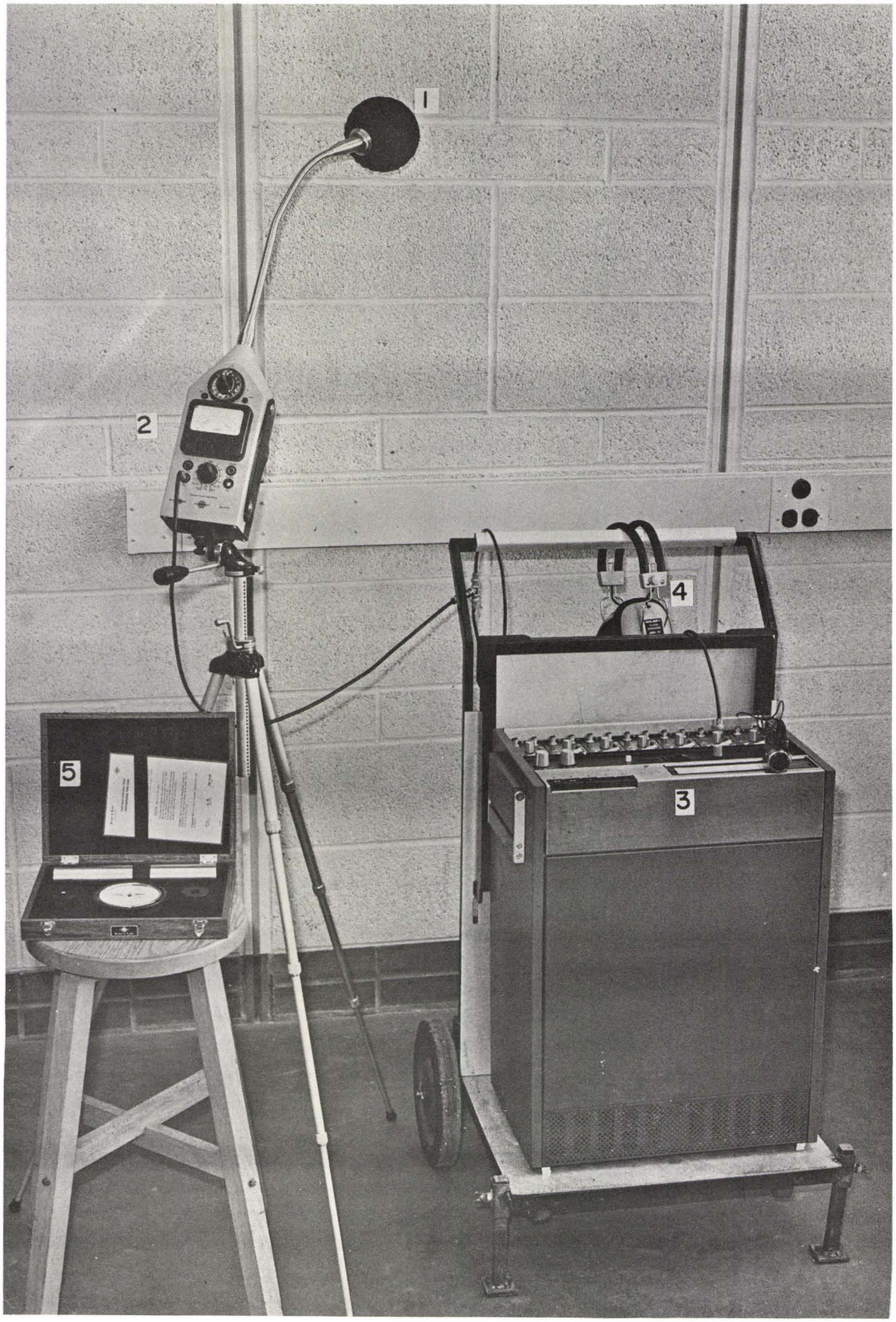

Fig.(3.2) ACOUSTICAL INSTRUMENTATIONS USED IN FIELD MEASUREMENTS

Background noise was measured before each recording and in order to avoid further complications in adding a correction factor for background noise, measurements were generally taken for locations exhibiting a level of 10 dB lower than the anticipated total level.

(ii) Microphone Location and Direction: Generally the frequency response of a microphone depends upon the angle between the direction of travel of the sound wave and the microphone diaphragm (Angle of incidence). The microphone used in measurements * has a calibrated linear frequency response in the frequence range 20 to 15,000 Hz in free field measurements and 0° angle of incidence. Accordingly, for measurements on an aircraft in flight the microphone was continuously oriented so that the maximum sound received arrives roughly on a 0° angle of incidence. As a standard practice [8] the microphone was located approximately 4 ft. above ground level.

(iii) Field Calibration: The tape recorder and the SLM were individually calibrated before each recording was taken. The tape recorded was calibrated and checked for the zero adjustment by an internal reference signal built in the recording system while the SLM was calibrated by an external acoustical calibrator which produces a constant SPL of 124 dB at 250 Hz.

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* B & K condenser microphone, type 4131, serial no. 205752.

The entire measuring set up including connectors, cables, etc., was also acoustically calibrated and a reference signal* was recorded at least once on each magnetic tape. The reference signal was used in the subsequent analysis of the noise recordings to adjust the zero level.

(iv) Recording: A VHF receiver was used to indicate the approximate location of the aircraft and the recording time was dependent on the distance from the measurement location to the aircraft. The input attenuation to the recorder was kept constant while the SLM input attenuation was continuously adjusted in steps of 10 dB in order to obtain the best signal/noise ratio and to avoid overloading the input circuits to the measuring equipment. It should be noted that the SLM was switched for operation "Lin 20 - 20,000 Hz" on the "fast" response scale and the microphone was fitted with a windscreen** designed and recommended for outdoor measurements. Figure 3.2 shows the windscreen as fitted to the microphone.

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* A pure tone of 250 Hz, with a SPL of 124 dB (RMS) re 0.000 μ bar.

** B & K type UA0082 (note: Attenuation values for the windscreen were included in the analysis as a correction factor).

CHAPTER 4

ANALYSIS OF NOISE MEASUREMENTS AND THE THEORETICAL PREDICTION OF AIRCRAFT NOISE

4.1 General

In this chapter the necessary steps will be presented to explain how the measurements recorded on magnetic tapes were analyzed in order to obtain the EPNdB vs. distance curves.

The EPNL due to aircraft noise has been selected as a unit for this analysis since it has been adopted by both the ISO and SAE, and has been selected as a unit for noise certification requirements for aircraft by the FAA.

The overall effective value of a noise environment to which a person is subjected will be expressed in terms of the NEF index.

However, the basic data for determining NEF contours consists of EPNL vs. distance information for various aircraft types, along with generalized aircraft performance data. Thus in calculating the NEF at a specific location the contribution in EPNdB from each aircraft operating from each runway is calculated by considering the distance from the point in question to the aircraft, and then obtaining EPNdB values from the appropriate EPNdB vs. distance curve; as represented by the equations developed in this chapter.

In describing the aircraft noise in the airport vicinity various methods may be employed depending on the ultimate use of the results and the degree of sophistication required. The following paragraphs summarize the available methods.

(i) Monitoring aircraft noise around the airport at preselected positions. Monitoring is understood to be a routine measurement of noise levels created by the various aircraft operating from an airport. This routine involves a large number of measurements per day, from which an immediate indication of the noise level is required. Monitoring can be carried out either with mobile equipment, often using only a sound level meter, or with permanently installed equipment incorporating one or more microphones with amplifiers located at different positions in the field with a data transmission system linking the microphones to a central recording installation. The sound levels measured are approximations of the perceived noise level in PNdB and the SLM with the A-weighting curve goes some way to meeting this approximate procedure. This practice is based on the experience that for take-off noise, the difference between the PNdB value and the sound level as measured in dB(A) is roughly the same for other aircraft of the same class at about the same distance from the start of the take-off roll, i.e.:

$$\text{PNdB} \simeq \text{dB(A)} + k$$

where k= a constant which depends on aircraft class, type of operation, distance to aircraft and frequency spectrum of noise.

(ii) The second method is to determine the noise characteristics received on ground from a certain type of aircraft operating under various conditions such as different loads, different take-off or landing profiles, etc. Then from the measured data sets of noise "contours" are constructed which the aircraft will produce around a particular airport. When such noise contours are estimated for all types of aircraft operating from the airport in question a more reliable estimate of the total noise nuisance produced in nearby areas may be made. The analysis of measurements in this case could be made in 1/3-octave bands or by the approximate method outlined in clause (i).

(iii) Measuring and analyzing the noise at a large number of different points around the airfield over a period of time and from the results the contours of equal levels are mapped.

The method used in this study is basically divided into two parts

1. Analysis of Actual Measurements

Ten measurements were selected for a detailed 1/3-octave band analysis and the final results obtained are EPNdB values. From the detailed analysis of the 10 measurements two experimental linear equations were developed to better approximate the relationship between PNdB and dB(A) levels for take-off and landing of a typical 2-engine turbofan aircraft. The approximate relations derived were then applied to the other 55 measurements in order to convert the simple "max. dB(A)" levels to "max. PNdB" values.

2. Theoretical Prediction of Aircraft Noise

On the basis of some fundamental data and actual measurements of aircraft flyover noise at a specific location, the noise level in different areas was estimated theoretically. The results of such calculations were then compared with the actual measurements.

4.2 Analysis of Actual Measurements

Figure 4.1 illustrates the arrangements used for field measurements and laboratory analysis of the recorded acoustical data. The output from the tape recorder was fed to the band-pass filter set, the filtered signal was amplified using the amplifier stage and the signals were then displayed graphically on the graphic level recorder and also displayed on the oscilloscope screen. A photograph of the acoustical instrumentations used in laboratory analysis is shown on Figure 4.2

The effective perceived noise levels in decibels (EPNdB) were calculated according to the following procedure

1. The reference signal* previously recorded on the tape during field calibration of the acoustical equipment was used to calibrate and adjust the zero level of the data reduction equipment.
2. An analysis of the recorded data was made using the method of "sequential filtering" and the results were recorded on a graphic, logarithmic level recorder. The analysis was made using 1/3 –

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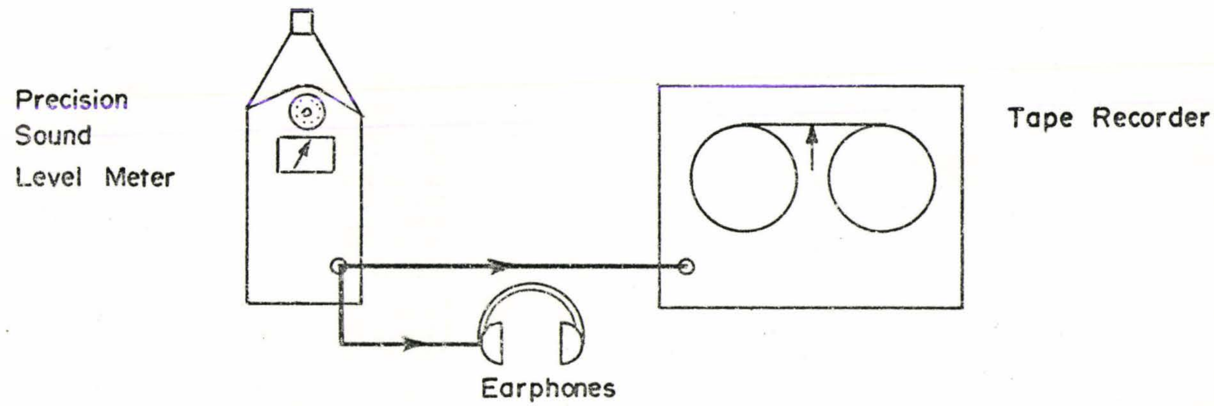
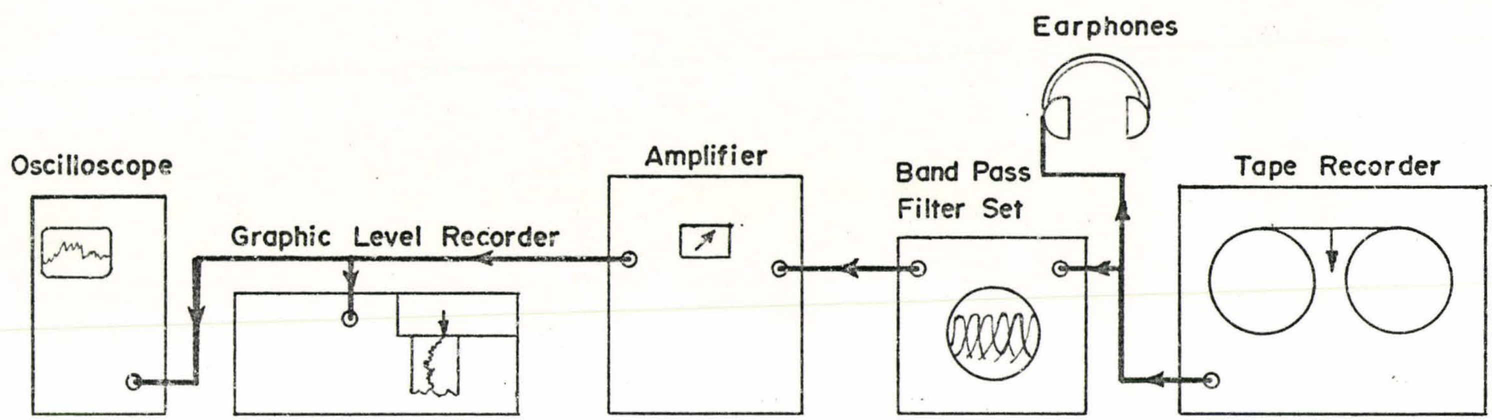
* A pure tone of 250 Hz, with a SPL of 124 dB(RMS)



Measuring arrangement used to record aircraft noise in the tield



Arrangement used for laboratory analysis of data recorded

Fig.(4.1)

CAPTION TO FIGURE (4.2)

Acoustical Instrumentations Used In Laboratory Analysis

1. Philips Instrumentation Magnetic Tape Recorder, Type ANA-LOG7, EL1020/07.
2. B & K 1/3 Octave Band-Pass Filter Set, Type 1612.
3. B & K Frequency Analyzer and Amplifying Stage, Type 2107.
4. B & K Graphic Level Recorder, Type 2305.
5. Tektronix Storage Oscilloscope, Type 564.
6. B & K Acoustical Calibrator, Type 4220.
7. Earphones.

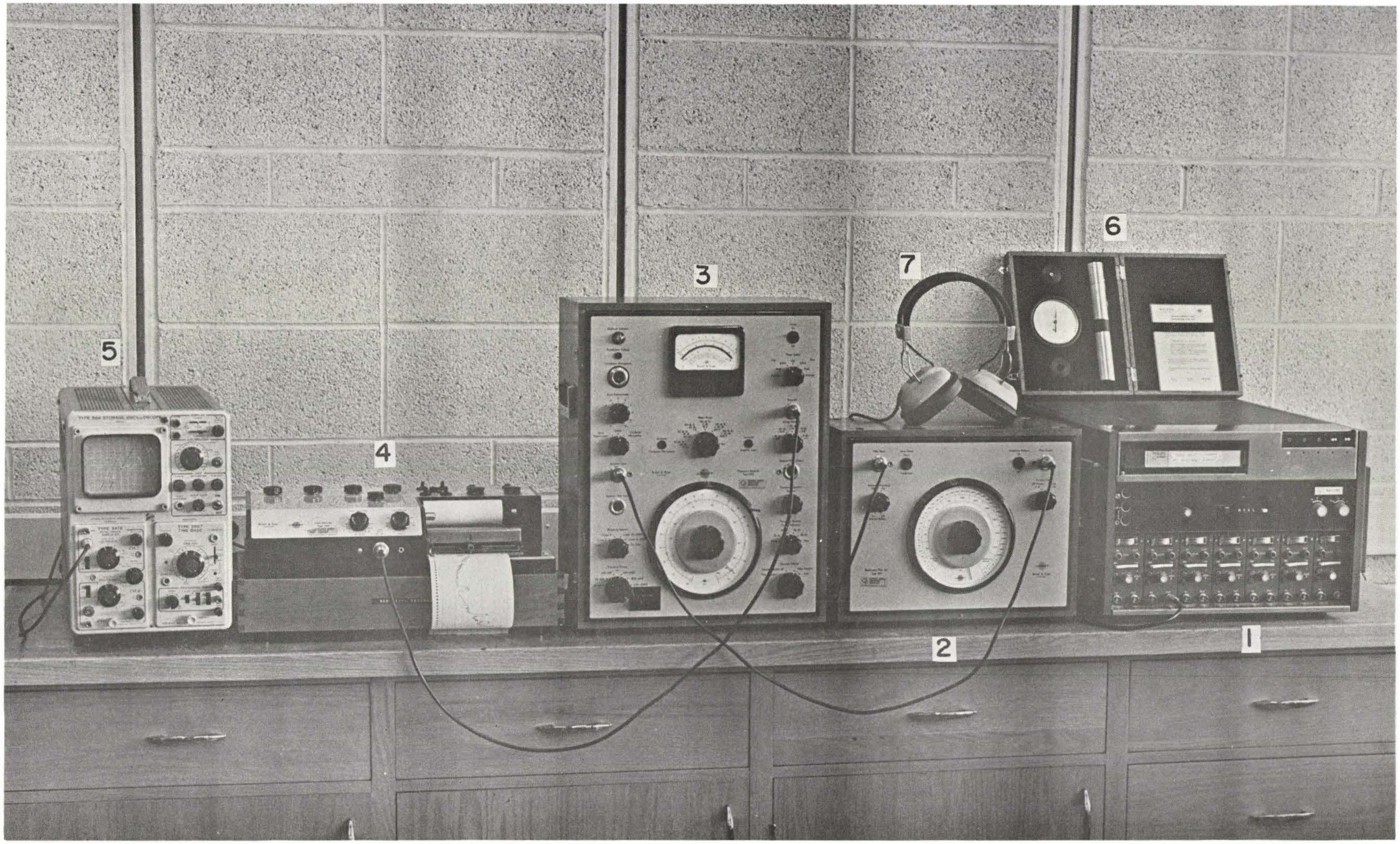


Fig.(4.2) ACOUSTICAL INSTRUMENTATIONS USED IN LABORATORY ANALYSIS octave bands and the output from each 1/3-octave filter was recorded as a function of time. The analysis of each field measurement resulted in 24 charts of the flyover noise history for the specified centre frequency of the band from 50 to 10,000 Hz. Figure 4.3 illustrates two examples of the flyover noise time history for two centre frequencies.

3. The charts obtained in step 2 were then digitized using a high-precision X-Y digitizer.* The signals were logged every half second of the flyover time and then recorded on computer magnetic tapes.

4. A computer program was developed to decode the digital data recorded on the tape, add instrumentation correction factors to the SPL (such as potentiometer adjustments, tape recorder response, wind screen response, etc.) and to perform the subsequent calculations.

Since the perceived noisiness was greater for sounds that contain within a broadband spectrum relatively high concentrations of energy in narrow bands as discussed in Chapter 2, correction factors were added to the SPL of bands that exceeded adjacent bands.

If any band above 400 Hz was abutted above and below by bands that were both less intense than the in-between band, a

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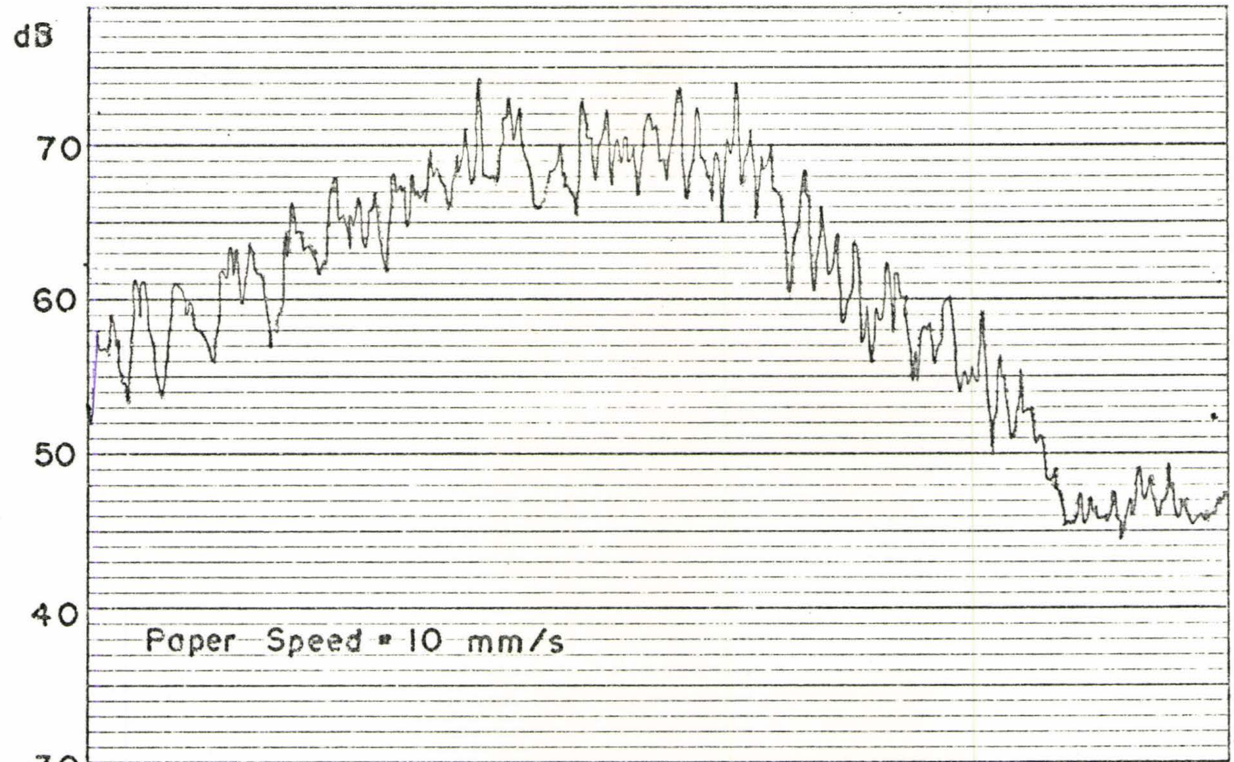
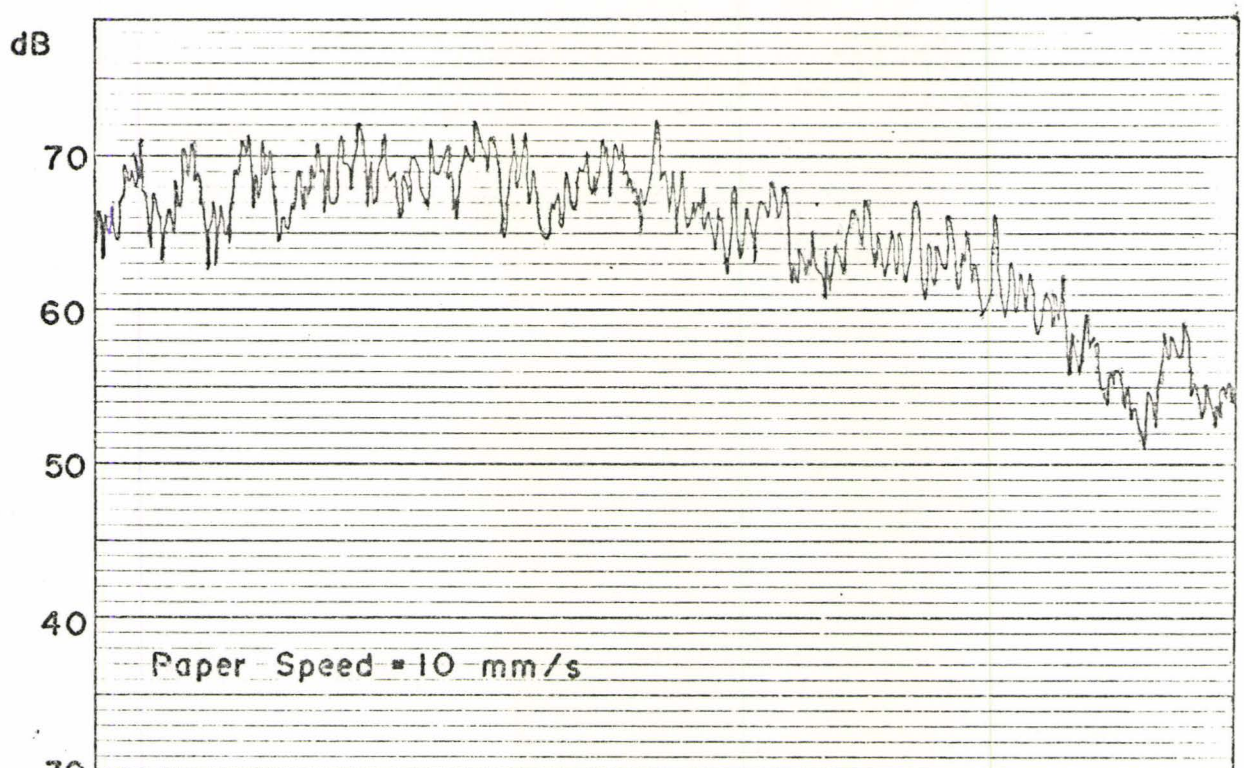
* Ruscom Logic Digitizer, model 11.



Centre freq. = 4000 Hz.



Centre freq. = 1000 Hz.

Fig.(4.3) Aircraft flyover noise time history (1/3 octave bands) correction was determined from the appropriate abscissa on Figure A.2, Appendix A and added to the SPL of the respective bands[10]. In Figure A.2 the abscissa is shown as $L_B - \left[\left(L_{B-1} + L_{B+1}\right) /2\right]$ where L_B is the SPL in dB of band B. (B-1) is the abutted lower frequency band, (B+1) is the abutted higher frequency band. The addition of L_{B-1} to L_{B+1} is arithmetic. The tone correction graph could be used either for octave bands or 1/3-octave band analysis. The result of this step was designated the "tone-corrected SPL".

5. By the use of the table shown in Figure A.3, Appendix A the tone-corrected sound pressure level at each time interval was converted to perceived noisiness values, n, in each 1/3-octave band. The noy values, n, for a given time interval i were then combined using the following formula:

$$N_i = n_{i\ max} + F\ (\Sigma\ n_i - n_{i\ max}) \qquad (4.1)$$

where:

i = 0.5 - sec interval of time.

$n_{i\ max}$ = maximum number of noys in any one band.

F = fractional portion dependent on bandwidth, 0.3 for octave bands, and 0.15 for one-third octave bands.

$\Sigma\ n_i$ = sum of the noy values in all bands.

N_i = perceived noisiness value in noys.

The value Ni was converted into a perceived noise level (PNL), expressed in PNdB rather than dB, using the following formula:

$$PNL_i = 40 + \frac{10}{0.30103} (\log N_i) \qquad (4.2)$$

The result of this step was designated "tone-corrected perceived noise level " [$PNLt_i$] in PNdB.

6. The maximum perceived noise level reached during flyover was then determined from the previous calculations by plotting the values of $PNLt_i$ versus time and determining the maximum value of the faired curve. It should be noted that the time interval i used in this analysis was equal to 0.508 seconds. Figure 4.4 and Figure 4.5 illustrates typical plots of the $PNLt_i$ versus time for a take-off and landing respectively. The slant perpendicular distance to the aircraft flight paths were 300 ft. and 940 ft. for take-off and landing respectively. The result was designated $PNLt_{max}$.

7. The total subjective effect of an aircraft flyover annoyance depended not only on the $PNLt_{max}$, but also on the time history of the noise. To take into account the influence of time, the effective perceived noise level (EPNL) was defined as the algebraic sum of the $PNLt_{max}$ and a duration allowance.

The following equation was used to calculate EPNL:

$$EPNL = 10 \log \frac{1}{To} \int_{t_1}^{t_2} 10^{PNLt/10} \cdot dt \qquad (4.3)$$

Where To was a normalizing constant chosen to be 10 seconds

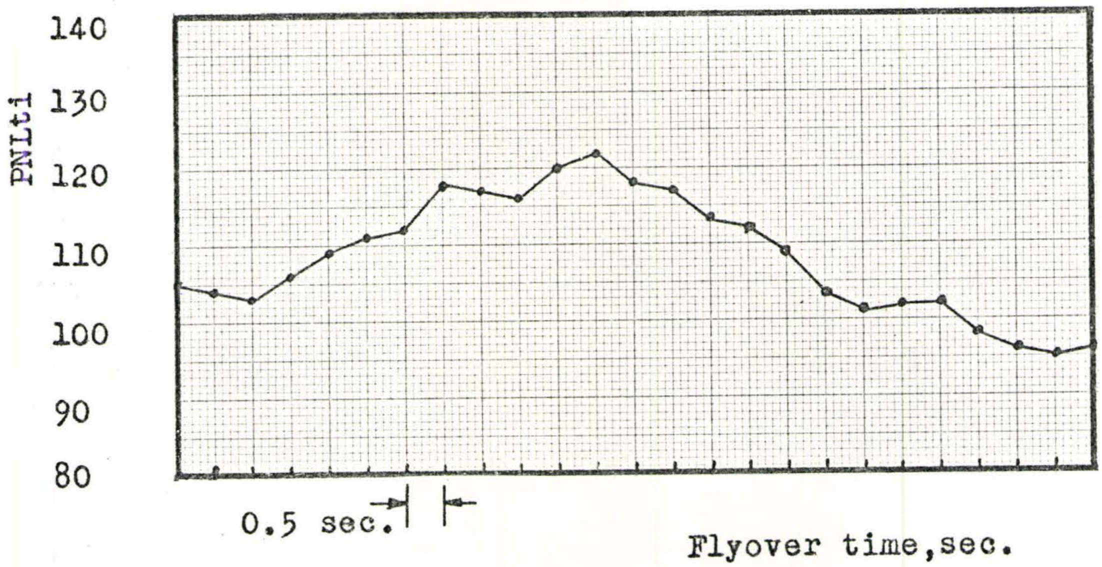


Fig.(4.4) Variation of noise level during takeoff.
(measured at a distance of 300 ft.)

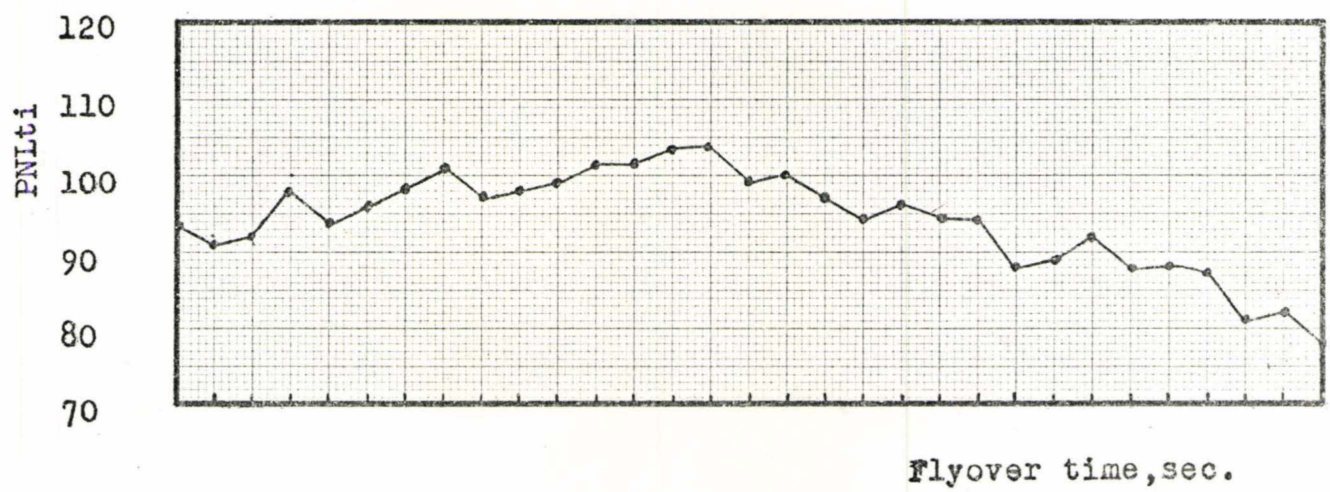


Fig.(4.5) Variation of noise level during landing.
(Measured at a distance of 940 ft.)

and ($t2 - t1$) was the time interval during which the instantaneous value of the PNL_t was within a specified value (not less than 10 dB of the value of the $PNL_{t\ max}$) as illustrated in Figure 4.6.

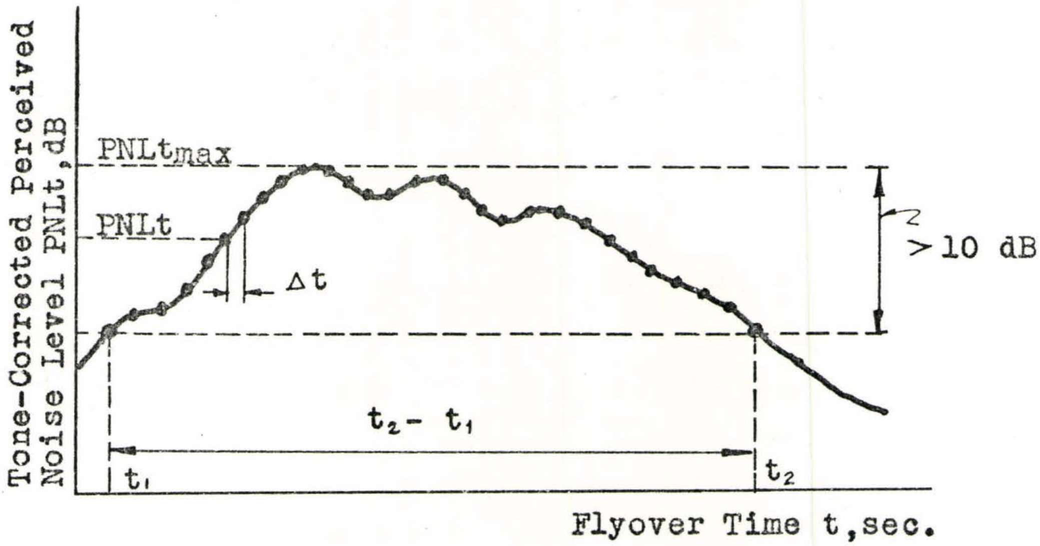


Fig.(4.6) Curve illustrating how the tone-corrected perceived noise level may vary with time.

The integration of Equation 4.3 was performed numerically using Simpson's formula. Figure B.1, Appendix B shows the results obtained for the take-off noise as illustrated on Figure 4.4. In this example the $PNLt_{max}$ was found to be equal to 122 PNdB while the EPNL was found to be equal to 116 EPNdB. The flyover noise in this example was integrated over a period of about 13 seconds (25 time intervals).

8. In order to establish an experimental relationship between the PNdB and dB(A) scales, the dB(A) value was computed for each

time interval i during the flyover. First, the instrumentation correction factors were added to the SPL of each 1/3-octave band. The frequency-weighting curve A illustrated earlier in Figure 2.2 was used to adjust the band levels. The band levels were then added to yield the dB(A) value at the specific time interval i. A similar procedure was used to compute the dB(D) value by the use of the frequency-weighting curve D. The values of [PNdB - dB(A)] [and PNdB - dB(D)] were also computed at each time interval and the mean values were estimated. The standard deviations were computed using the formula:

$$\text{standard deviation} = \sqrt{\left(\frac{1}{n}\sum_{i=1}^{n} X_i^{\,2}\right) - \mu^2} \tag{4.4}$$

where:

n = number of intervals.

X_i = [PNdB - dB(A or D)] at the time interval i.

μ = arithmetic mean value of PNdB - dB(A or D)

The preceding detailed analysis was applied to 10 selected measurements and the computer program developed in this study to perform the analysis is included in Appendix D.

4.3 The Experimental Relationship Between PNdB and dB(A)

Inspection of the frequency spectrums produced by the specific type of aircraft surveyed showed a great dependence of the frequency content and frequency distribution on two major factors as briefly outlined below.

(i) Type of Operation

Figure 4.7 and Figure 4.8 illustrates typical frequency spectrums at the maximum level reached during landing and take-off respectively. It is evident that in landing generally the acoustic energy is concentrated in the higher frequency range while during take-off the acoustic energy exhibits less differences between the higher and lower frequency bands.

V. I. The jet-engine noise is mainly generated by the roar of the jet-exhaust resulting from the turbulent mixing of high velocity exhaust gases with the ambient air and by the turbomachinery noise associated with the turbulence produced by rotating blades within the engine. Jet-exhaust noise, being broadband, distributes the sound energy over a wide band of frequencies. On the other hand turbomachinery produce broadband noise, but in addition usually produce discrete frequency tones where a substantial amount of energy is concentrated. The energy from these sources is usually at much higher frequencies than the jet-exhaust noise and the discrete frequency tones are heard as a whistle, whine, or screech.

Therefore, it was expected that the subjective evaluation of aircraft noise considering the shape of the frequency spectrum, will be different for landing than that generated during take-off.

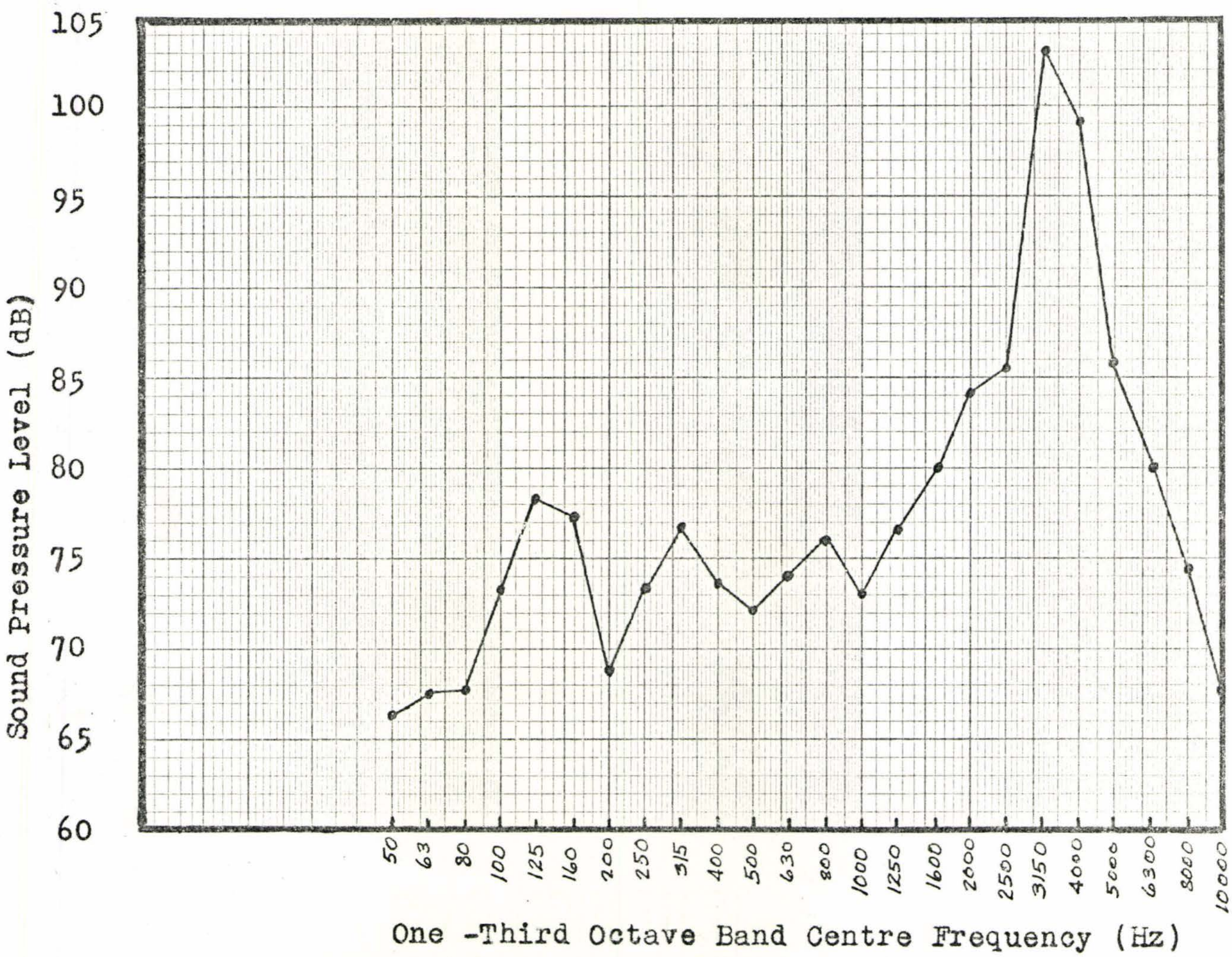


Fig.(4.7) Typical landing noise spectrum measured at a distance of approx. 400 ft. from the aircraft.

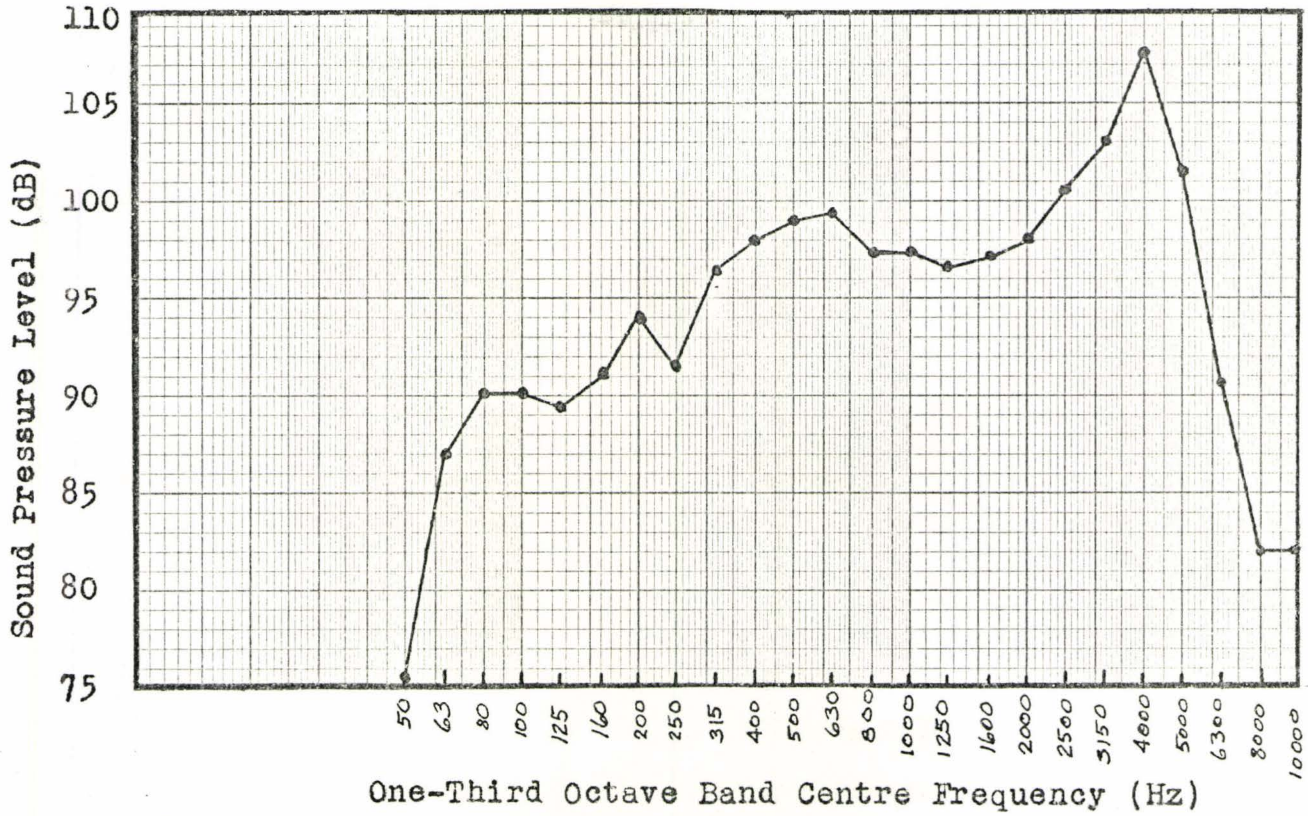


Fig.(4.8) Typical takeoff noise spectrum measured at a distance of approx. 300 ft. from the aircraft.

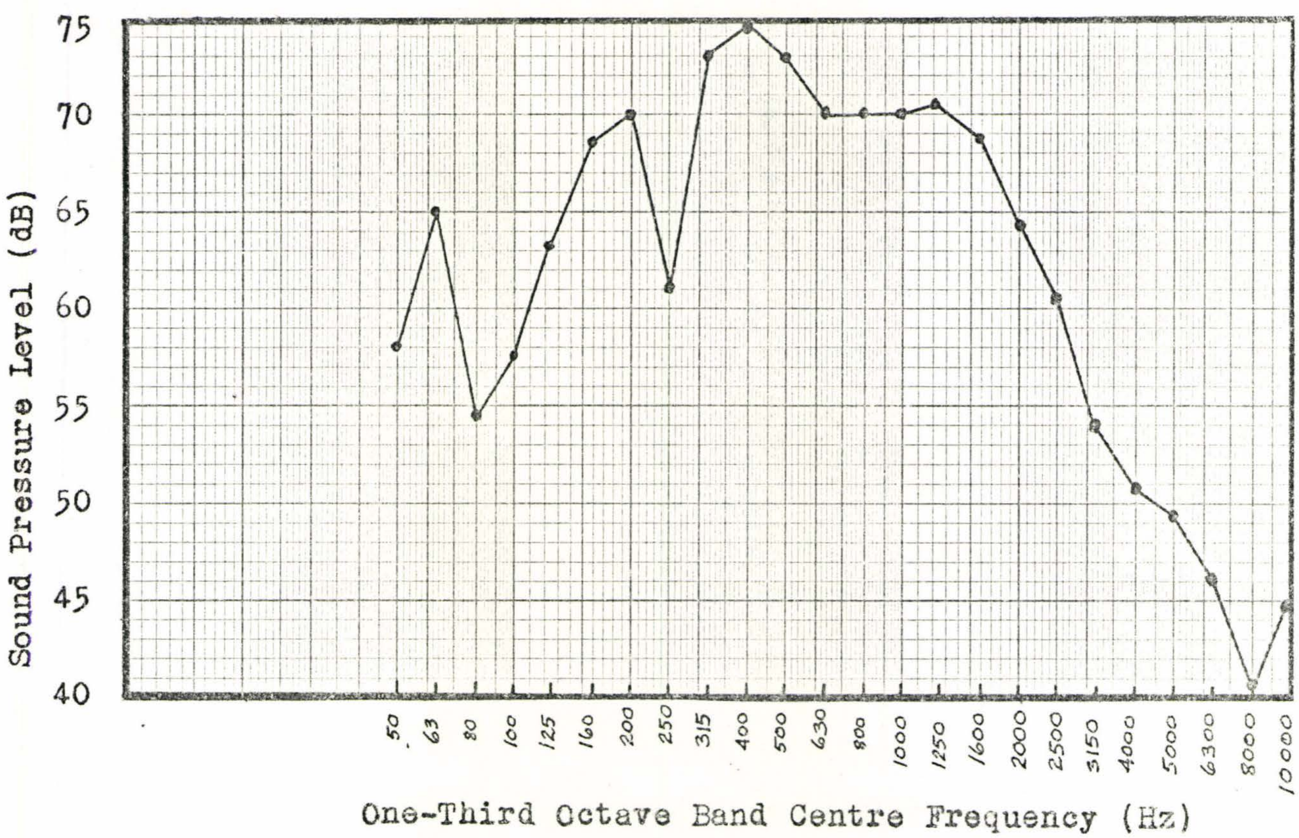
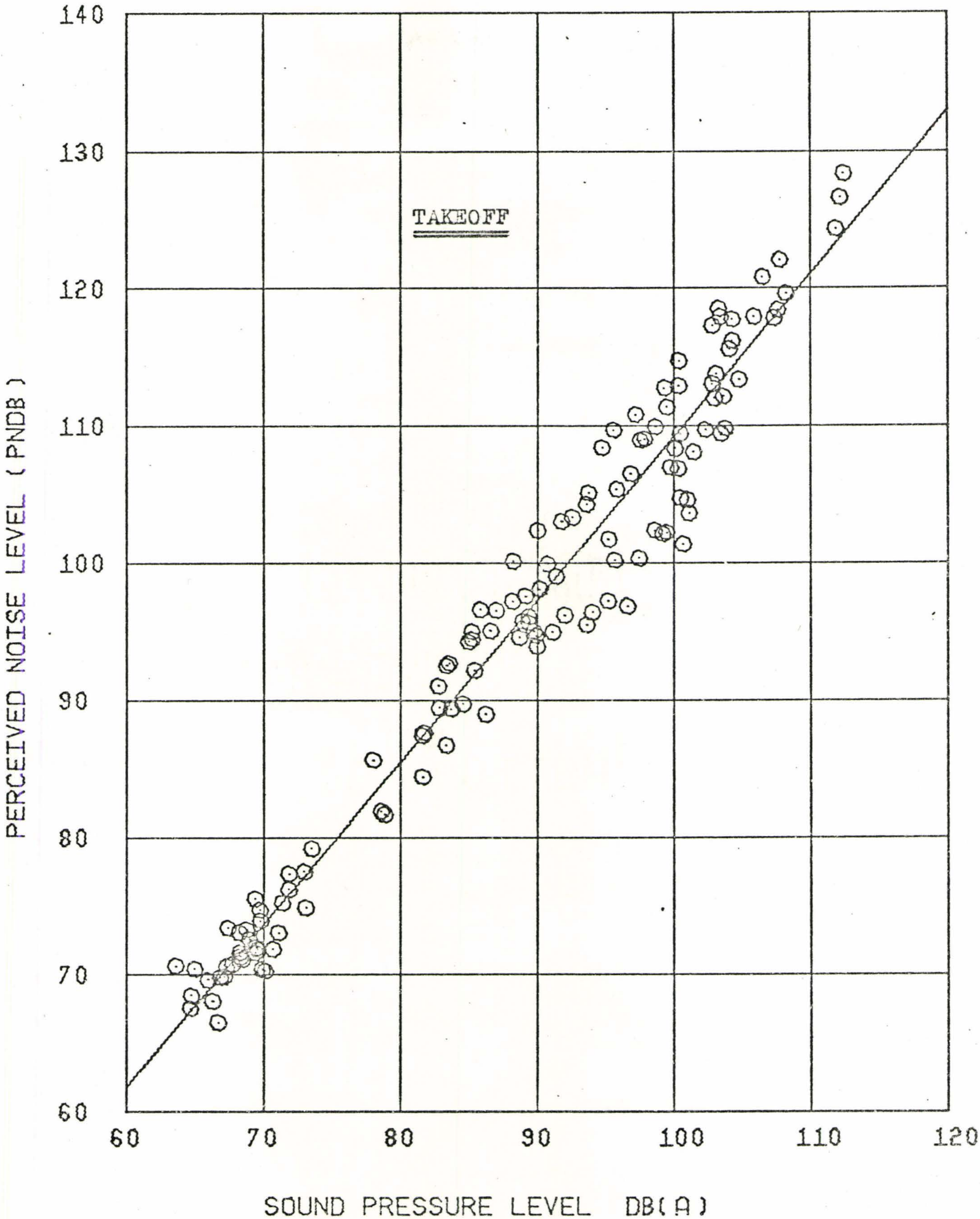


Fig.(4.9) Typical takeoff noise spectrum measured at a distance of approx. 8100 ft. from the aircraft.

(ii) Distance between the observation point and the aircraft

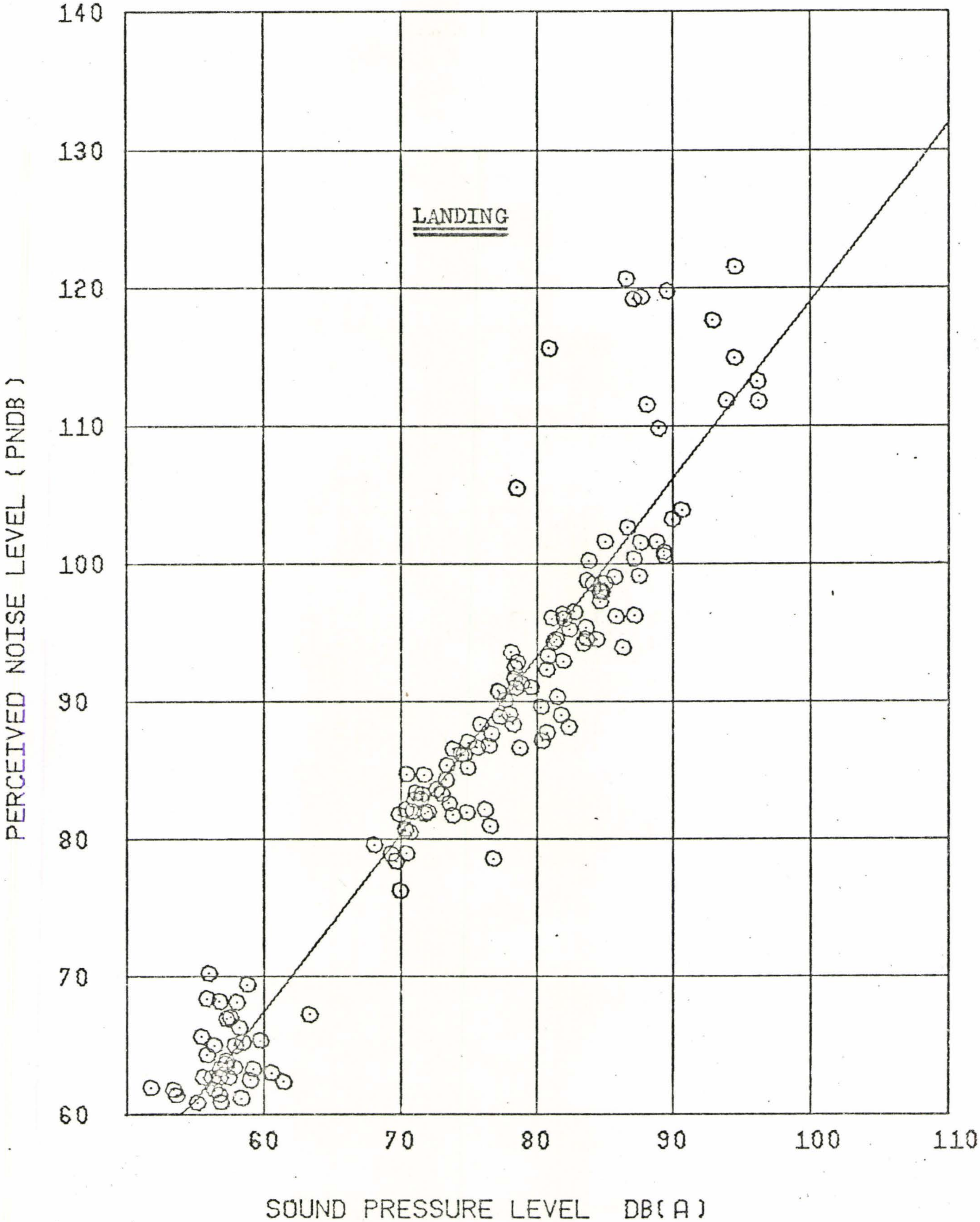
As sound is propagated through the atmosphere, its level progressively decreases. The first factor producing this level reduction is due to the inverse-square law, which results from spherical divergence of sound waves and spreading the energy over an increasingly large surface area. This results in a 6 dB loss in sound level for each doubling of the distance from the source and is uniformly effective at all frequencies. In addition to this spreading of sound energy, there is an absorption of sound energy by the atmosphere. For the distance of interest to aircraft noise this absorption effect is insignificant for noise at low frequency but it is highly significant at higher frequencies. Because of this effect, a particular sound whose PNL is dominated by high-frequency noise near the source may have its PNL controlled by low frequency noise at greater distances, where the high frequencies have been attenuated to a greater degree than low frequencies. Figure 4.8 and Figure 4.9 illustrate the frequency spectrums at the maximum PNL during take-off and measured at a distance approximately 300 ft. and 8,100 ft. respectively.

The experimental results obtained from the analysis showing the PNL and the corresponding dB(A) value were plotted for both cases, take-off and landing as shown on Figure 4.10 and Figure 4.11 respectively. The experimental data were approximated by straight lines using the method of the least-square



EXPERIMENTAL PNDB VS DB(A)

Fig.(4.10)



EXPERIMENTAL PNDB VS DB(A)

Fig.(4.11)

polynomial approximation, and the linear relationship were then plotted on the diagrams.

The empirically derived relationships between the PNdB and dB(A) were then applied to the remainder of the noise measurements in order to convert the maximum dB(A) levels to maximum perceived noise levels in PNdB. The computer programs developed in this study to plot the experimental data and compute the least-square fit of the data are included in Appendix D.

It should be noted that the maximum PNL obtained by the approximate method was corrected for a typical time duration as determined from experiment. The correction factors used are in the range from − 8dB to + 4dB and the value being used is dependent on the distance between the aircraft and the observation point.

Finally, the EPNL calculated for the various measurement locations were then plotted versus the slant perpendicular distance in feet from the measurement point to the aircraft flight path taking into consideration the elevation angle between the aircraft and the measurement point.

4.4 Theoretical Prediction of Aircraft Noise

It is possible to predict theoretically the sound levels due to the operation of an aircraft given some fundamental data. In the following a method of estimation is described whereby the noise level can be calculated as a function of distance to the aircraft.

4.4.1 Assumptions:

(i) The directional characteristics of the noise field produced by the aircraft are rotationally symmetrical.

It should be noted that the radiation pattern from a moving jet is less directional than that of a stationary jet [11] & [12]. The estimated error from this assumption may result in noise levels of ± 3 dB depending on the location.

(ii) Altitude Variations

Altitude variations due to different aircraft loads at the reference point were small. The reference point was selected at a suitable location so that any variation in the aircraft altitude would produce insignificant variation in the slant distance to the aircraft flight path.

(iii) Atmospheric Conditions

Calculated noise levels at the various locations are based on certain atmospheric conditions (59^{o} F, 70 % R.H. and 29.94" Hg).

Attenuation of sound due to wind, temperature gradients, atmospheric turbulence and ground effect is not considered.

(iv) Free field conditions exist for the propagation of sound waves.

4.4.2 Procedure

1. The noise produced by the aircraft was recorded on a magnetic tape and the signal was analyzed in 1/3-octave bands, adjusted for the presence of pure tones and other instrumentation correction factors as explained earlier. The corrected frequency spectrum, which corresponds to the maximum PNL, was used as a "reference spectrum" for further manipulations.

The reference point selected for estimating the reference data was located at about 917 ft. off to the side of the runway and about 1,500 ft. from the runway threshold.

2. In order to estimate the noise level at the various distances, an increment of 200 ft. was used and at each increment the 1/3-octave band levels were corrected for the spherical divergence of sound waves (inverse-square low) and the atmospheric absorption of sound energy according to the following formula:

$$SPL_1 = SPL_o - 20 \log \frac{r_1}{r_o} - A\ (r_1 - r_o) \quad (4.5)$$

where:

SPL_1 = sound-pressure level in dB at a distance r_1 ft. from the source.

SPL_o = sound-pressure level in dB at a distance r_o ft. from the source (Note that r_o is the reference distance). The point r_o must be in the far field of the aircraft noise.

A = Attenuation due to absorption in the air, dB/ft.

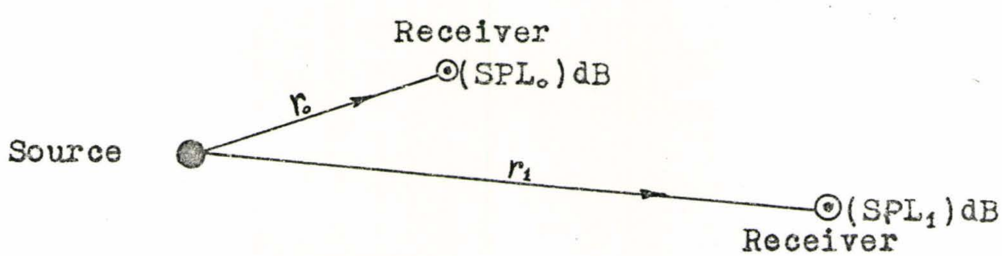


Figure 4.12 illustrates the attenuation dB/100 ft. versus 1/3-octave bands centre frequency as determined from experiment [13].

3. The band levels were adjusted for the presence of pure tones or pronounced irregularities, converted to noy values and summed according to the procedure discussed earlier. The total noy values were converted to "tone-corrected PNL" in PNdB.
4. The PNdB values were then plotted versus distance for both cases, take-off and landing as shown on Figure 4.13 and Figure 4.14 respectively. In order to use the theoretically predicted PNdB values in digital computations, the predicted levels were approximated by a 10th degree polynomial using the method of least-square polynomial approximation.
5. The PNdB values at the various distances were adjusted for typical time durations (obtained from experiment) in order to obtain the EPNdB values. Figure 4.15 and Figure 4.16 illustrate the predicted EPNL versus distance for take-off and landing respectively.

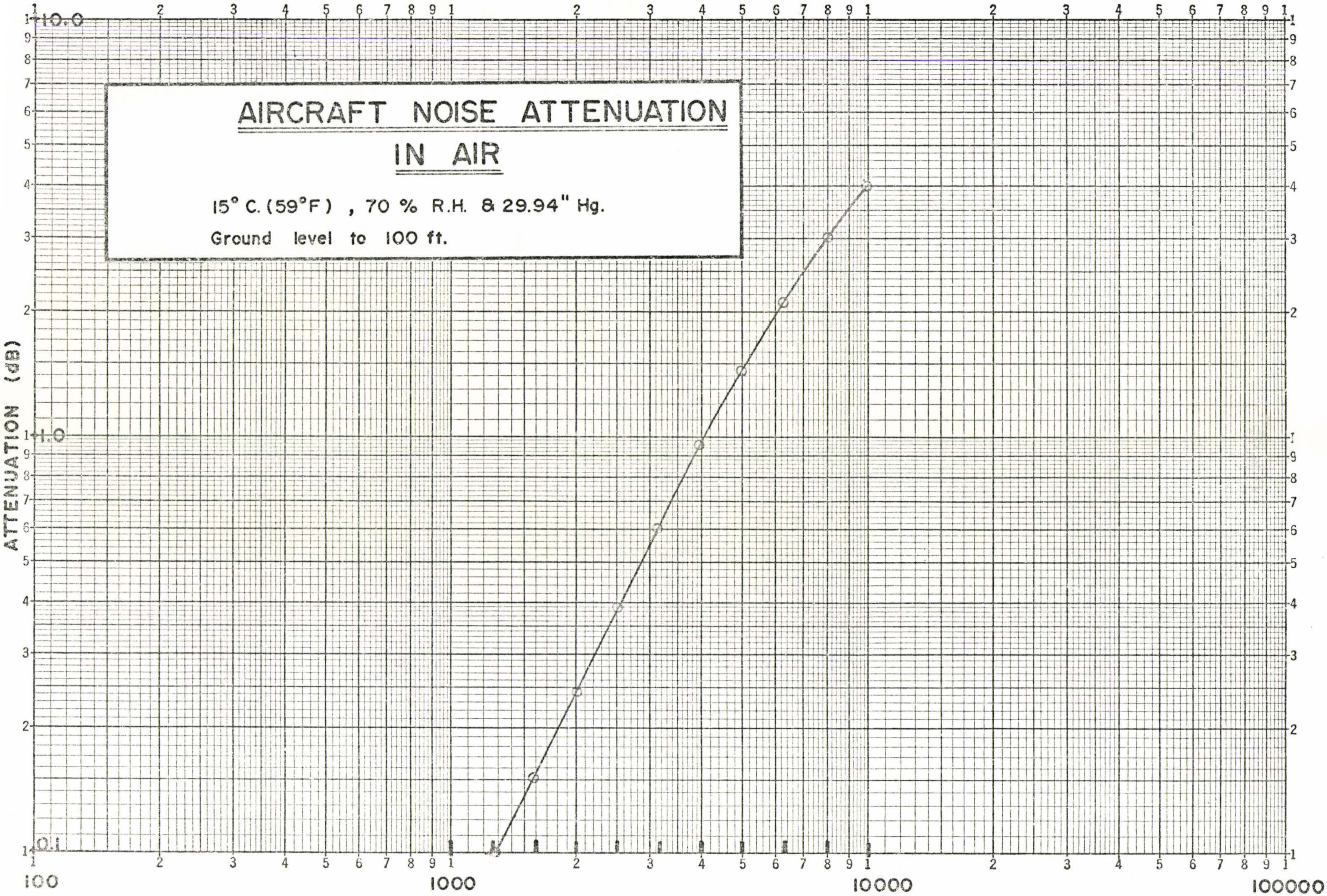


Fig.(4.12)

From Reference(13)

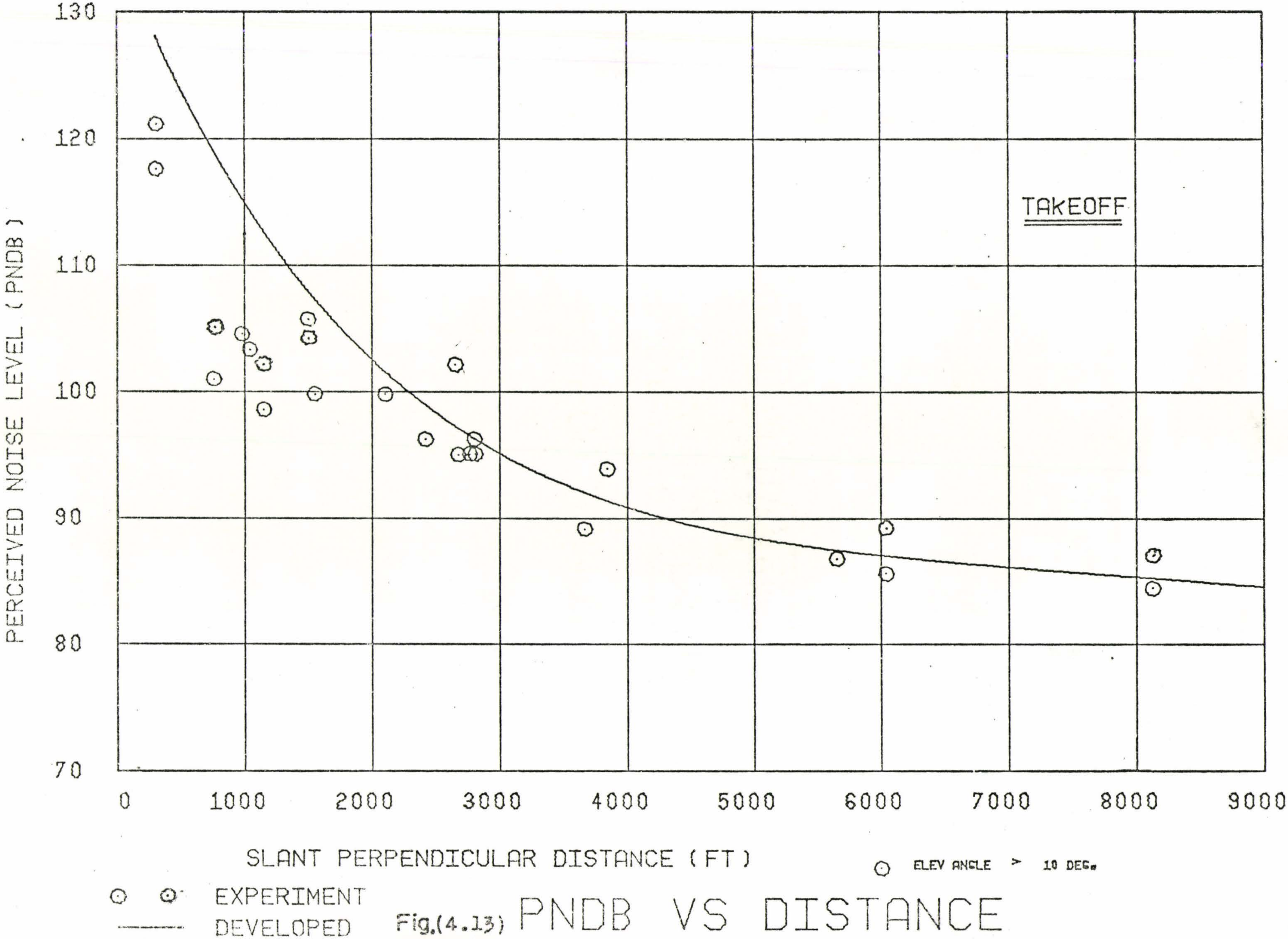


Fig.(4.13) PNDB VS DISTANCE

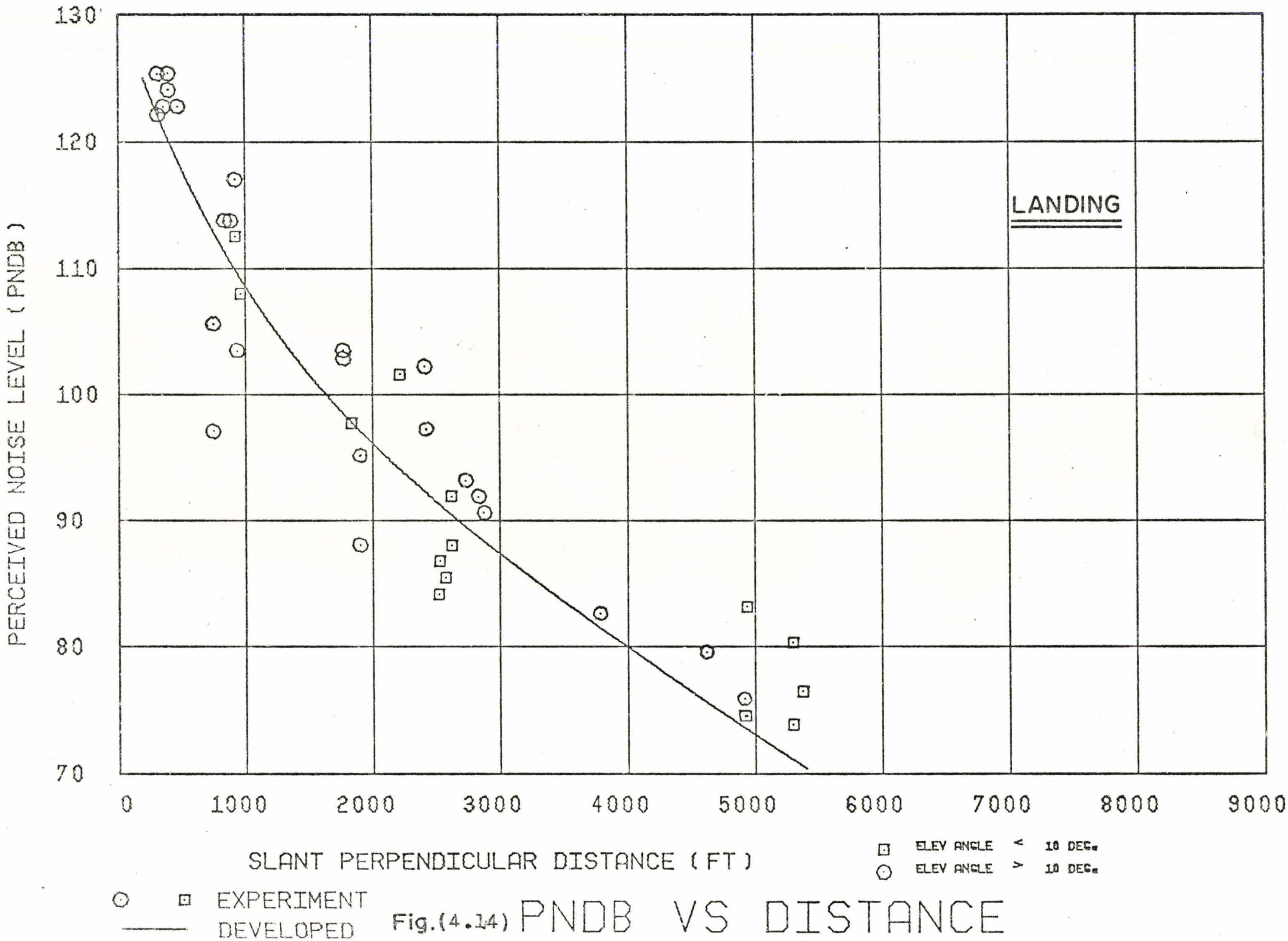


Fig.(4.14) PNDB VS DISTANCE

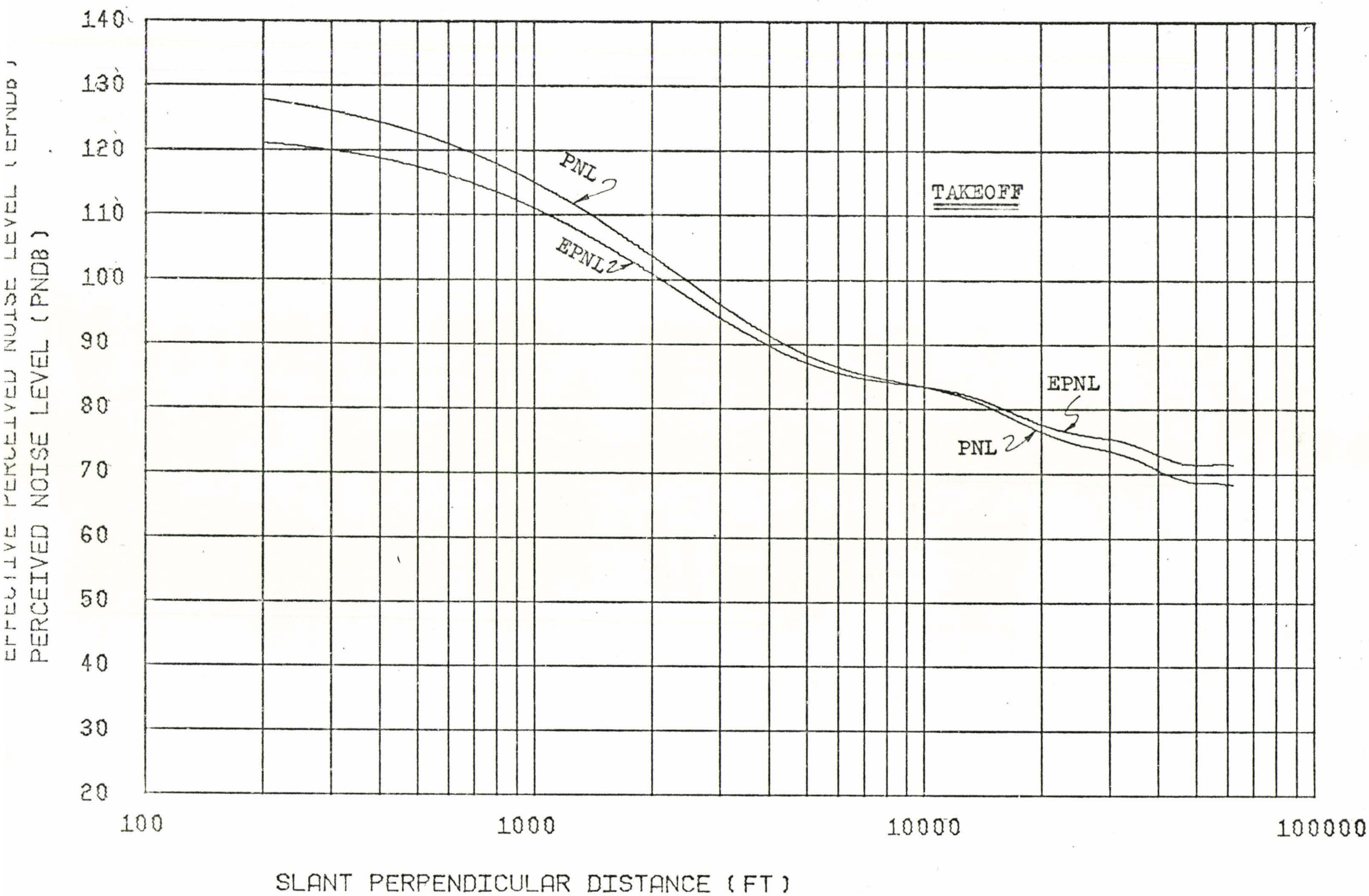


Fig.(4.15) EPNDB AND PNDB VS DISTANCE

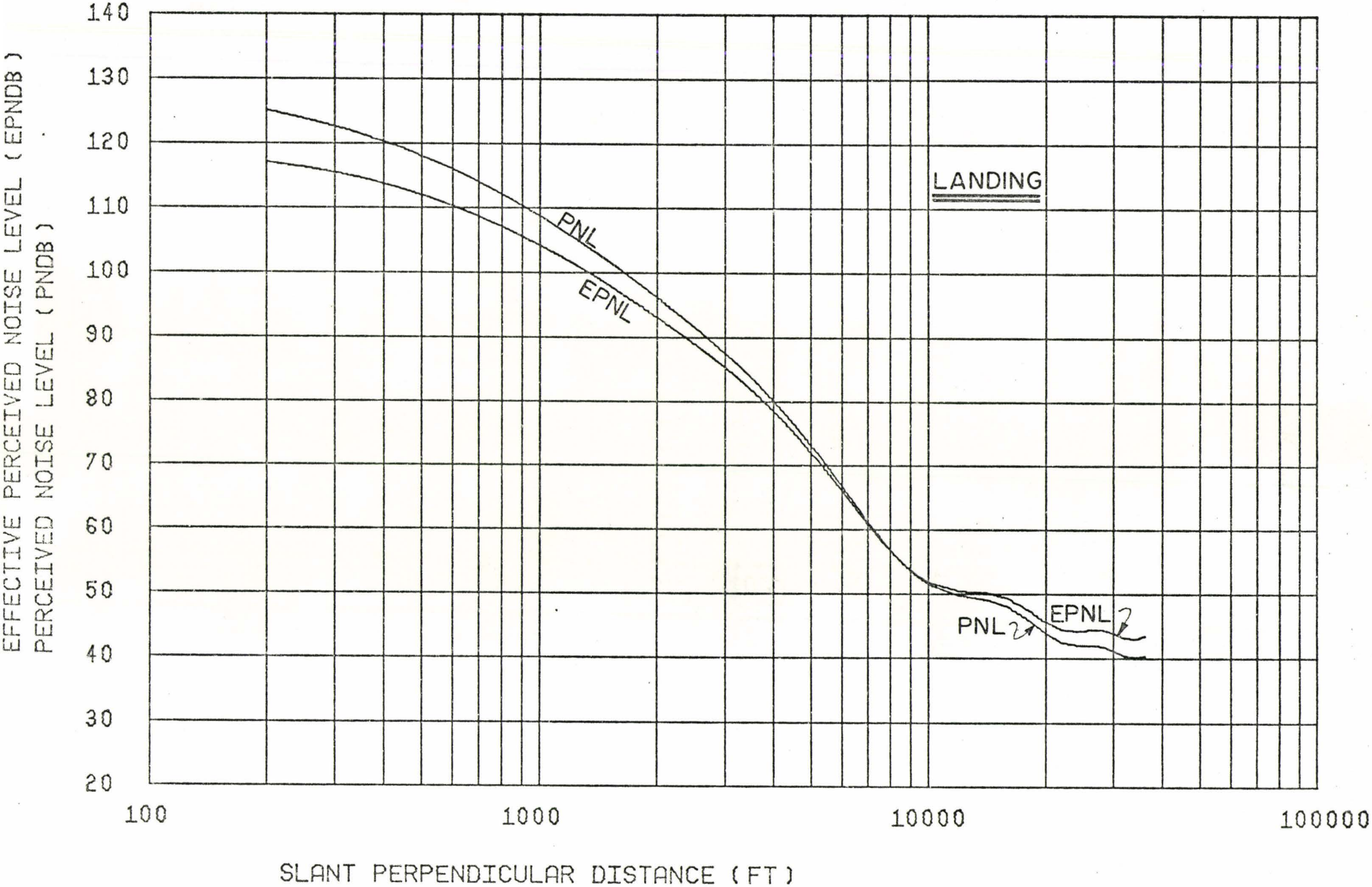


Fig.(4.16) EPNDB AND PNDB VS DISTANCE

CHAPTER 5

METHOD OF DESCRIBING THE NOISE EXPOSURE ON THE GROUND IN THE VICINITY OF THE AIRPORT

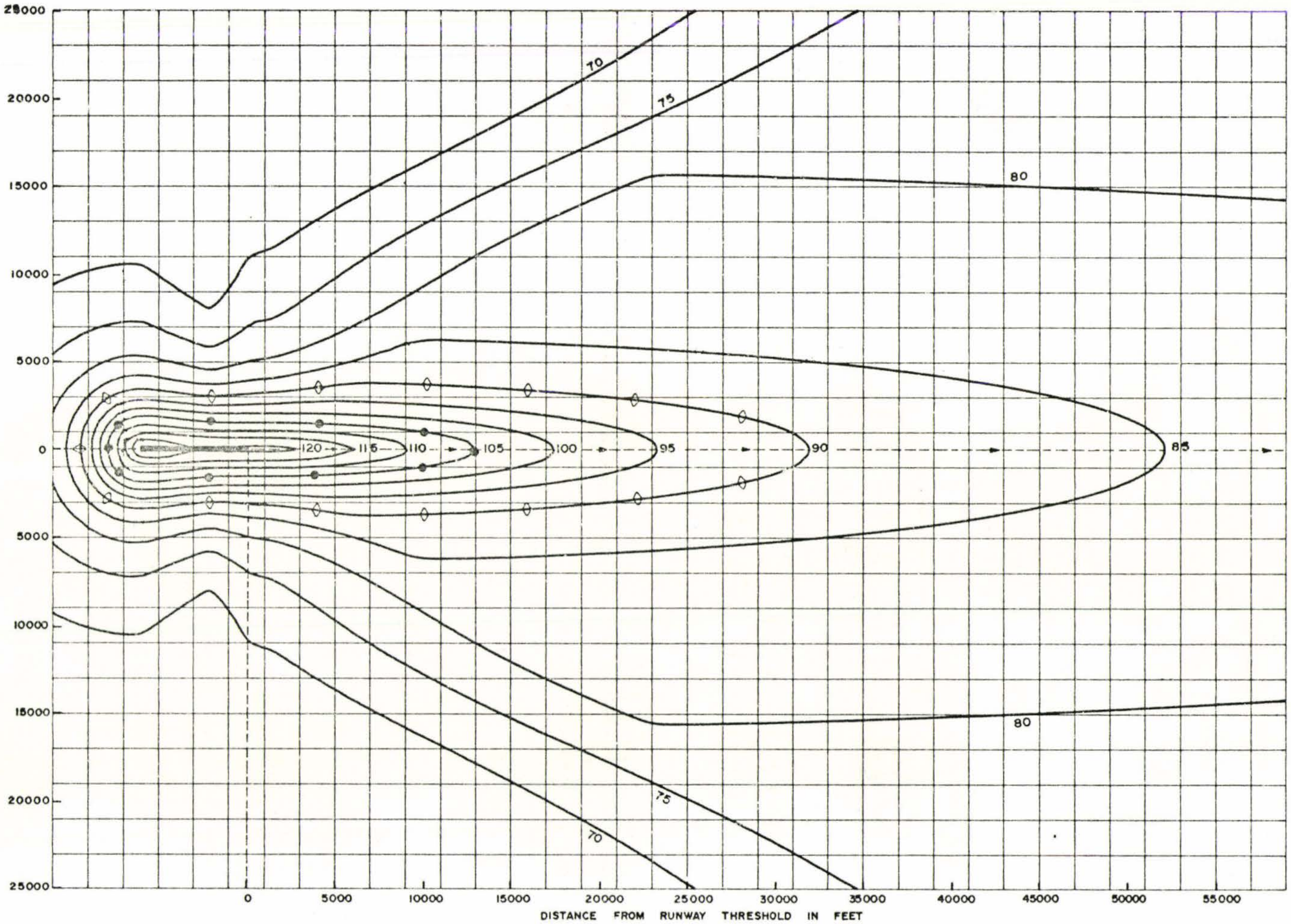
5.1 Construction of Effective Perceived Noise Level Contours for a Single Aircraft Operation

5.1.1 Take-off

Figure 5.1 illustrates equal effective perceived noise level contours for a typical 2-engine turbofan aircraft describing the noise field on the ground produced during take-off, normalized to the aircraft maximum certificated take-off weight and using maximum take-off power. In practice the following data should be available before constructing the contour lines.

(i) The aircraft engines power setting used during take-off and climb-out: the power setting may be varied during the operation in accordance with the instructions given by the aircraft manufacturer or due to noise abatement procedures.

(ii) The take-off profile: The take-off profile depends on the power setting, aircraft configuration, ambient temperature, ambient wind conditions, climb speed and especially on the aircraft take-off gross weight. Information about typical take-off profiles for aircraft at various conditions are available [14], [15] and sometimes prescribed in order to construct a particular set of sound contours. During take-off the



EFFECTIVE PERCEIVED NOISE LEVEL CONTOURS

2-ENGINE TURBOFAN AIRCRAFT , TAKEOFF

TAKEOFF POWER (NO POWER CUTBACK), 100 % OF MAX. G.WT. AND FLIGHT LEVEL = 20000 FT.

—●——●— UNACCEPTABLE (OUTDOOR MEASUREMENTS AND JUDGMENT).

—◊——◊— ACCEPTABLE (" " " ").

Fig.(5.1)

engines produce the same noise levels at all gross weights, but the rate of climb increases with decreasing the gross weight. Accordingly the noise perceived on the ground due to the flyover of a loaded aircraft would be higher than that due to an unloaded aircraft. It should be noted that the difference in the noise level perceived due to the loading conditions of the aircraft gradually increases with the increase of the aircraft forward distance from the runway. Figure 5.2 illustrates the adopted take-off profile* in constructing the EPNL contours shown in Figure 5.1.

(iii) The physical data describing the noise produced by the aircraft: The data could be determined by a similar procedure to that described in Chapter 4, the appropriate curve should be selected according to the location and elevation angle between the aircraft and the particular location on ground. At this point it should be noted that values of ground attenuations obtained throughout actual measurements may not represent <u>all</u> the locations around the airport or the proposed runway because ground attenuation depended on the topography, terrain, obstructions such as buildings, etc., of the particular location. However, the presented data represents a typical locality at the Mount Hope

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* Data as shown in Figure 5.2, obtainted from Nordair.

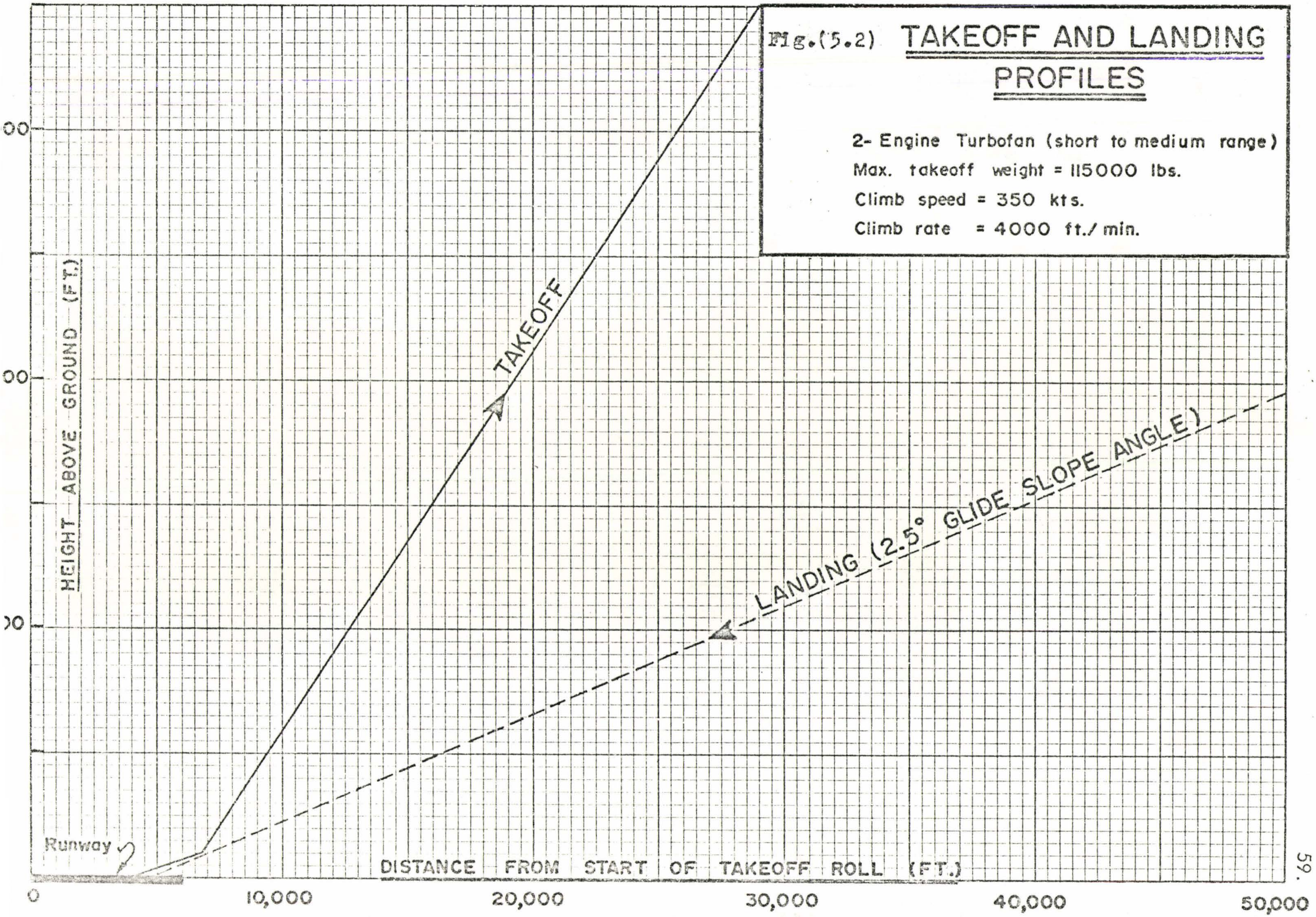


Fig.(5.2) TAKEOFF AND LANDING PROFILES
2- Engine Turbofan (short to medium range)
Max. takeoff weight = 115000 lbs.
Climb speed = 350 kts.
Climb rate = 4000 ft./min.
TAKEOFF
LANDING (2.5° GLIDE SLOPE ANGLE)
HEIGHT ABOVE GROUND (FT.)
Runway
DISTANCE FROM START OF TAKEOFF ROLL (FT.)
0
10,000
20,000
30,000
40,000
50,000

area where no tall buildings exist and the surroundings are mostly open fields with the exception of few low density residential areas.

Distance Computation

(a) For locations directly underneath the flight path

One first determines the aircraft altitude from the appropriate profile curve. The effective perceived noise level corresponding to the altitude is determined from the EPNL vs. distance curve, designated PA in Figure 5.3, in this case the elevation angle between the location and the aircraft is 90 degrees.

(b) For locations off to the side of the flight path

The procedure is slightly different from that given in (a). One first determines the lateral distance from the flight path to the location. The next step is to determine the altitude of the aircraft at the given distance from the start of take-off roll. These two distances form the sides of a right triangle; the desired slant perpendicular distance is the hypotenuse of that triangle. The elevation angle is also determined from the geometry of the triangle. For the resultant distance one determines the corresponding effective perceived noise level from the appropriate EPNL vs. distance curve as follows. For locations behind the brake-release point, i.e. opposite to the direction of take-off, curve PD is used. For locations between the brake-release point and lift-off point interpolate

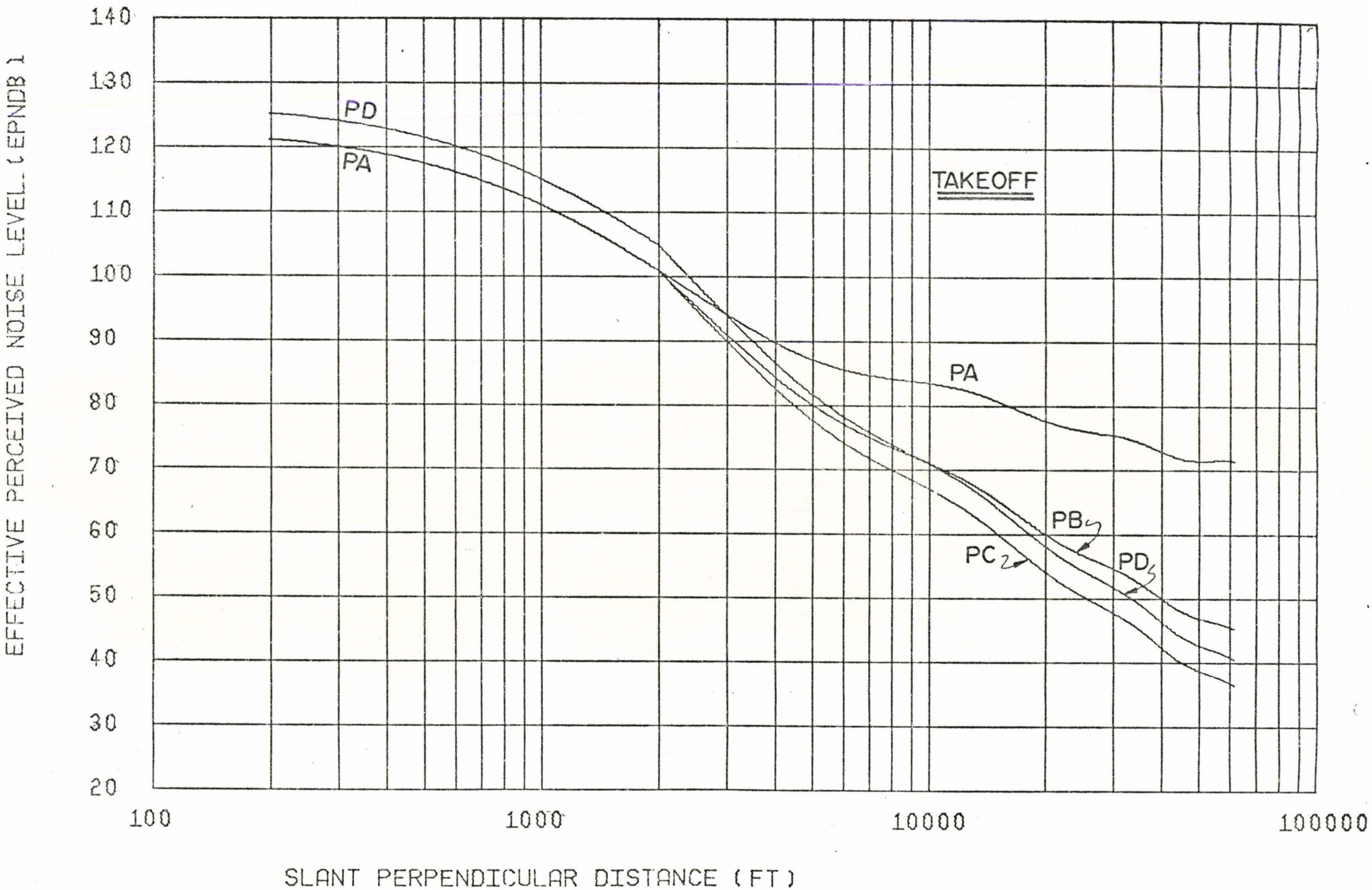


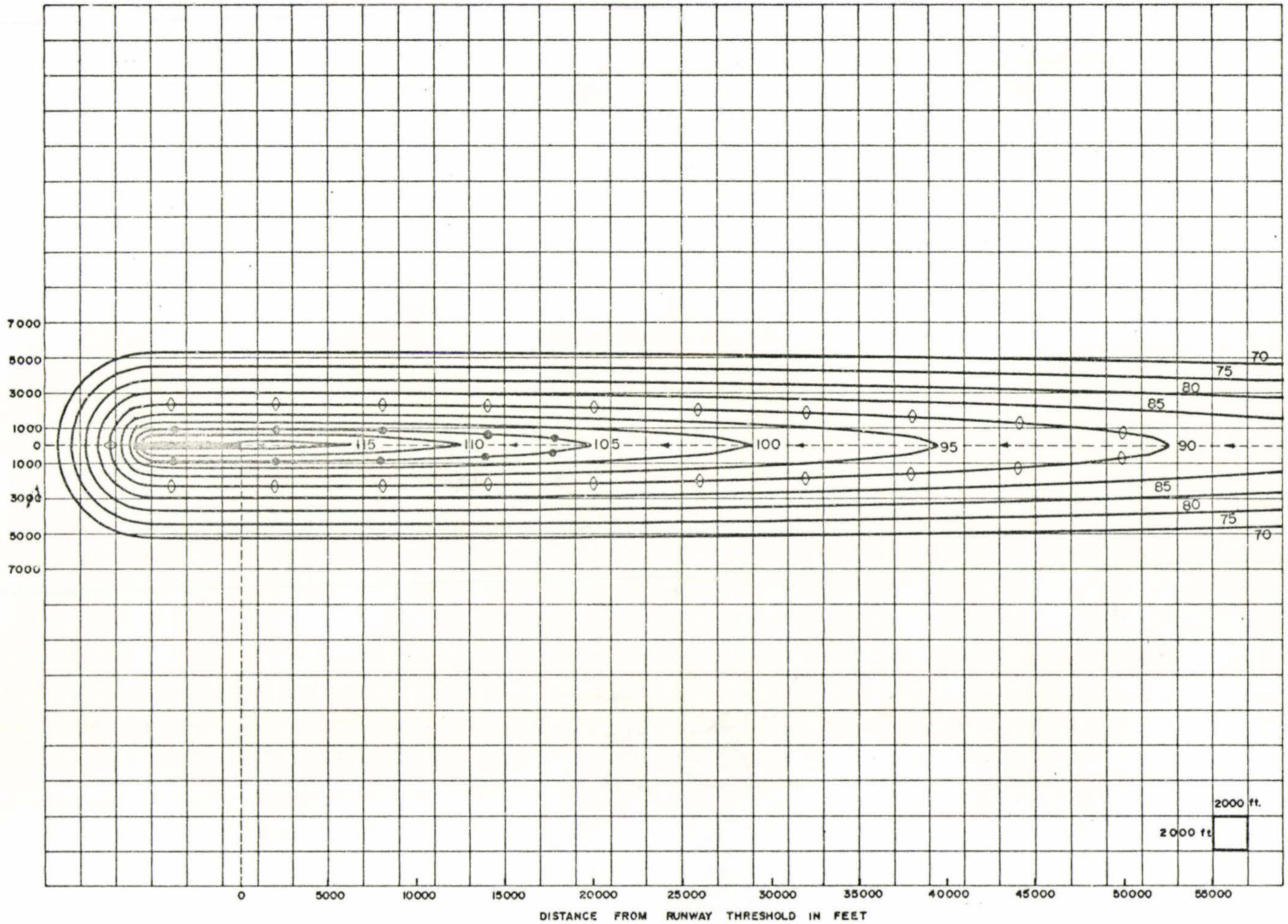
Fig.(5.3) EPNDB VS DISTANCE

between curves PD and PC. For locations forward of the lift-off point, the elevation angle determined must be considered, if the elevation angle is greater than 10 degrees curve PA is used and if the angle is less than 10 degrees the appropriate value may be obtained by interpolating between curves PA and PB. Figure 5.3 illustrates curves PA, PB, PC and PD. The construction of the curves shown on Figure 5.3 was carried out with the aid of Figure 4.13 and is detailed in Appendix E.

5.1.2 Landing

Figure 5.4 illustrates equal effective perceived noise level contours for a typical 2-engine turbofan aircraft describing the noise field on the ground produced during landing normalized for the aircraft maximum weight and using the instrument landing system according to the 2.5° glide slope angle prescribed by the Ministry of Transport at Mount Hope Airport as shown on Figure 5.2. In order to compare regulatory procedures, Figure 5.5 shows a similar set of contours for an assumed 3.5° GSA. In practice the following data should be available before constructing the contour lines:

(i) The engine power setting used during landing: For a certain aircraft, while there is some variations in landing noise levels due to changes in engine thrust as gross weight is changed, the effect is usually small [16].



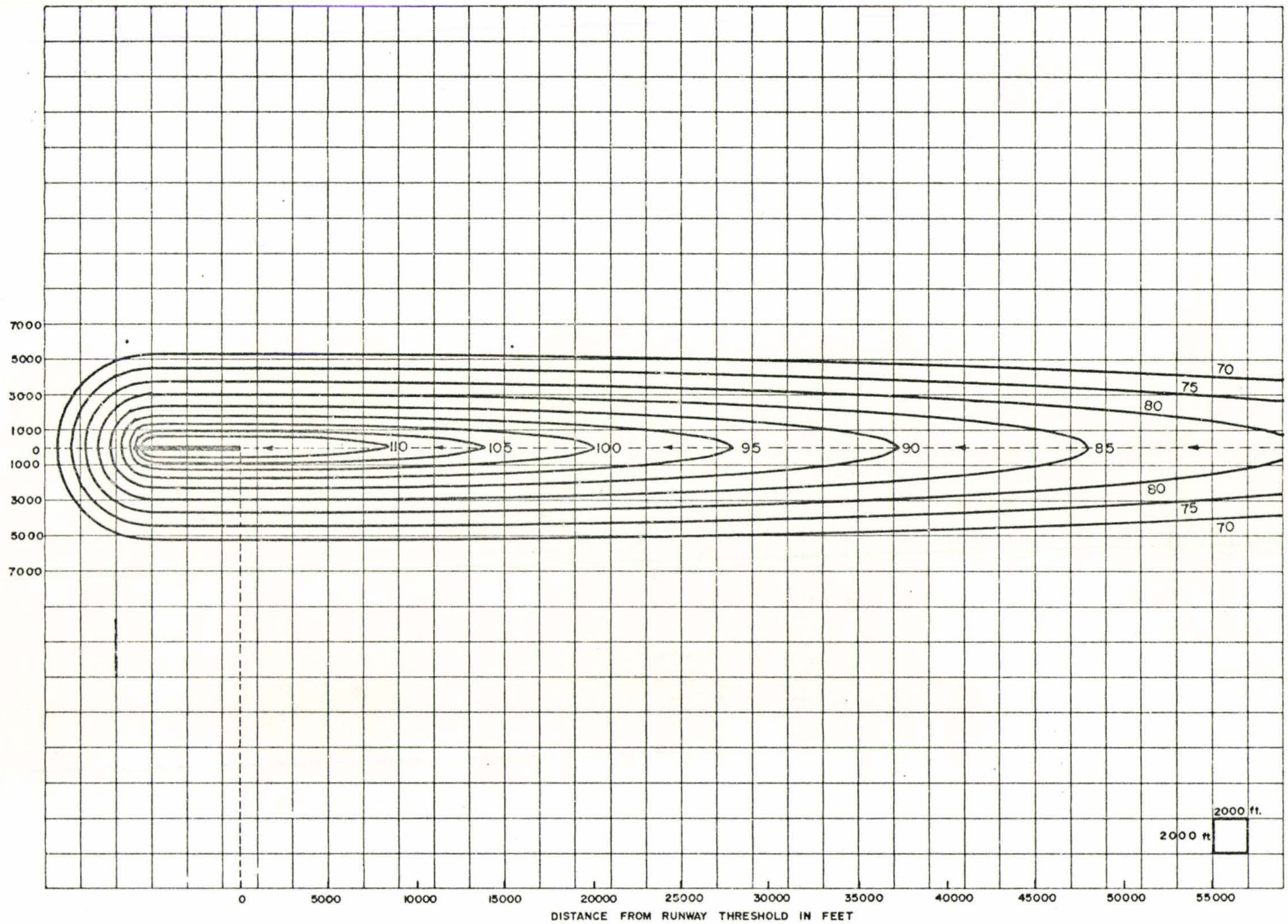
EFFECTIVE PERCEIVED NOISE LEVEL CONTOURS

2-ENGINE TURBOFAN AIRCRAFT, LANDING

GLIDE SLOPE ANGLE = 2.5°, INTERCEPT ALTITUDE = 4000 FT.

—●—●— UNACCEPTABLE (OUTDOOR MEASUREMENTS AND JUDGMENT)
—◊—◊— ACCEPTABLE (" " " ")

Fig.(5.4)



EFFECTIVE PERCEIVED NOISE LEVEL CONTOURS

2-ENGINE TURBOFAN AIRCRAFT, LANDING

GLIDE SLOPE ANGLE = 3.5°, INTERCEPT ALTITUDE = 4000 FT.

Fig.(5.5)

(ii) Aircraft landing profile: Landing profile depends on the glide slope angle prescribed for ILS landing or the angle used in VFR landing.

(iii) The physical data describing the noise produced by the aircraft: The data could be determined by a similar procedure to that described in Chapter 4.

Distance Computation

The slant perpendicular distance between the ground location and the aircraft flight path is calculated in a similar fashion as in the take-off operation. Once the distance has been determined, the corresponding effective perceived noise level from the EPNL vs. distance curve can be selected. Note that one curve is presented for all locations as illustrated earlier in Figure 4.6. The elevation angle has not been considered in this case since noise due to landing has been found to be less than take-off noise.

5.2 Construction of Noise Exposure Forecast (NEF) Contour Sets for Multi-Aircraft Operations

In calculating the NEF contours, i.e. locations that have equal exposure to noise from all operations, the contribution in EPNdB's from each type of aircraft operating from each runway was calculated at the given ground location. The slant perpendicular distance from the given location to the aircraft was calculated and then the effective perceived noise level values were obtained from the appropriate EPNdB vs. distance curve as explained in the previous sections.

The noise contributions from all aircraft type groupings operating on all runways were summed on an energy basis to obtain the total noise exposure at any one location [14].

Basic Equations

For an operation of aircraft type i, runway j, the NEF (ij), is expressed as:

$$NEF(ij) = EPNL(ij) + 10 \, Log\left[\frac{N(day)\ (ij)}{K(day)} + \frac{N(night)\ (ij)}{K(night)}\right] - C \qquad (5.1)$$

where

NEF(ij) = Noise Exposure Forecast value produced by aircraft class i operating on runway j.

EPNL(ij) = Effective perceived noise level produced at the given point by aircraft class i operating on runway j.

N(day) = Number of aircraft movements (0700 AM - 2200 PM).

N(night) = Number of aircraft movements (2200 PM - 0700 AM).

K = Constant normalizing the adjustment in NEF values due to volume of operations. Different values of K were used for daytime and nightime operations.

C = an arbitrary constant.

The value of the constant K(day) was chosen so that for 20 movements of a given aircraft, per daytime period, the adjustment for the number of operations was zero. Hence, K(day) = 20.

The value of the constant K(night) was chosen such that, for the same average number of operations per hour during daytime or night-time periods, the NEF value for nightime operations would be 10 units higher than for daytime operations. Hence, K(night) was calculated to be 1.2.

The choise of C=75 was based on two considerations. Firstly, it was desirable that the numerical values of NEF be distinctly different in magnitude from the effective perceived noise level so that there was no likelihood of confusing the two values. Secondly, it was considered desirable to select a normalization factor which roughly indicated the amount by which the NEF exceeded some threshold value below which aircraft noise would most likely be imperceptible.

Using the values indicated above, the equation can be written:

$$NEF(ij) = EPNL(ij) + 10 \, Log \left[N(day)\,(ij) + 16.67 \, N(night)\,(ij) \right] - 88 \qquad (5.2)$$

The total NEFT at a given ground location was then determined by an energy summation:

$$NEF = 10 \text{ Log} \sum_i \sum_j \text{antilog} \frac{NEF\ (ij)}{10} \qquad (5.3)$$

The computer programs developed in this study to perform the calculations and plot the contour lines are included in Appendix D.

5.3 Noise Generated by 3 and 4-Engine Turbofan Aircraft

In calculating the NEF produced by the various aircraft types the following were assumed:

(a) 3 and 4-engine turbofan aircraft produce noise characteristics and a directivity pattern similar that produced by a 2-engine turbofan aircraft.

(b) The SPL produced by a 3-engine turbofan aircraft at a specific location was approximately 1.76 dB greater than that produced by a 2-engine aircraft at the same location based on the following equation:

$$SPL_x = SPL_y + 10 \log \frac{n_x}{n_y} \qquad (5.4)$$

where

SPL_x = sound pressure level produced by aircraft x

SPL_y = sound pressure level produced by aircraft y

n_x = number of engines in aircraft x

n_y = number of engines in aircraft y (type of engine is similar to that of aircraft x)

Hence,

$$SPL_{(3\ engines)} = SPL_{(2\ engines)} + 10 \log \frac{3}{2}$$

or

$$SPL_{(3\ engines)} = SPL_{(2\ engines)} + 1.76 \qquad (5.5)$$

(c) The SPL produced by a 4-engine turbofan aircraft at a specific location was approximately 3 dB greater than that produced by a 2-engine aircraft at the same location:

i.e.

$$SPL_{(4\ engines)} = SPL_{(2\ engines)} + 10 \log \frac{4}{2}$$

or

$$SPL_{(4\ engines)} = SPL_{(2\ engines)} + 3.0 \qquad (5.6)$$

CHAPTER 6

SUBJECTIVE EVALUATION OF AIRCRAFT NOISE

6.1 Introduction

In this chapter the problem of subjective evaluation of aircraft noise will be discussed briefly and some of the test results available to describe the subjective reactions of a community to subsonic aircraft noise are summarized.

The nature of complaints against aircraft noise

Examination of public surveys reveal that the greatest single complaint concerns the interference of the aircraft noise with talking and listening (masking and speech communication), the second complaint in number is concerned with the disturbance of sleep and rest while the third is with the fear of aircraft crashes.

Tolerable limits of exposure to aircraft noise

The final results of this analysis is presented in terms of physical units of noise measurements and at this stage it seems appropriate to transform these results into sociological units of human response.

Noise environment and opinions obtained through judgement tests

Since "human behaviour - environment" is a fairly complex relationship, the more or less empirically derived relations between complaint activity or annoyance scale and noise exposure have proven to be useful in predicting, in broad terms, human behaviour.

The relations are not precise in a mathematical sense and do not lead to an understanding of the exact nature or basis for the human behaviour recorded in the complaints and annoyance score scales.

As might be expected, various psychological and sociological factors present in individuals and a community influence the annoyance felt and the behaviour expressed by people in response to the annoyance caused by noise. Background noise in real life as present in different communities proved to be a contributing factor to judgement tests and community response to the intruding noise. The sound from an aircraft flying is not as noticeable in a high background noise as it is in a quiet environment. Another major factor that affects the reliability of judgement tests and people's response is the accuracy of the physical units, whether dB(A), phon, EPNdB, etc. in predicting the judged perceived noisiness. Several statistical techniques have been used by researchers for evaluating the accuracy with which the physical units of measurements predict judged perceived noisiness.

6.2 Masking and Speech Communication

A major function of the auditory system is the analysis of acoustical signals so that wanted information components in a sound wave can be discriminated or separated from the unwanted or noisy components.

Studies have been conducted by various researchers to estimate the understandability of speech in the presence of noise. These tests are called intelligibility or articulation tests; the distinction being usually made on the basis of how they are scored.

Kryter [17] in 1965 and Williams [18] in 1967 determined the understandability of speech in "mean percent words correct" and the peak level of an aircraft flyover noise present for a specific conversational level and rate of speech. Figure (C.1), Appendix C illustrates a typical test result obtained by Williams as a typical example of the research done in this area.

6.3 Perceived Noisiness (Annoyance)

6.3.1 Noise Exposure Forecast (NEF)

The overall effective value of a noise environment to which a person is exposed on an average basis has been well established and expressed in various ways. Extensive research and studies have led to the introduction of the Composite Noise Rating (CNR), Noise Pollution Level (NPL), Noise Exposure Forecast (NEF) and others.

In summary, it has been concluded that the NEF system offers the capability of an additional measure of precision than was previously available in the CNR system. As a result, it has been recommended by the Canadian Air Transportation Administration [14] that the NEF system should be used in the determination of the anticipated response to aircraft noise and the development of compatible land use planning criteria in the vicinity of airports. In Reference [14], four different "response areas" were identified and a compatible land use table was presented and typical cases were illustrated. The Compatible Land Use Table from Reference [14] is presented in Appendix C for completeness.

6.3.2 Perceived Noise Level (PNL)

In this section the data available from 5 judgement tests are summarized and plotted in Figure (6.1). The following paragraphs are brief descriptions of the 5 tests surveyed.

(i) The first is a study that took place on three days late in 1961 at Farnborough [19] and 60 subjects made judgements of the sounds of aircraft flying overhead. The subjects were asked to record their impressions on the scales -1A, 1-B and 1-C as shown on Figure 6.1. Two rating scales were used for outdoor judgements using the criteria of "noisiness" (scale 1-A) and "intrusiveness" (scale 1-B). The "intrusiveness" criterion was also used for indoor tests (scale 1-C). Noise levels were expressed in dB(A) and PNdB.

Figure C.2, Appendix C illustrates one of the results obtained. The principal results of the tests were plotted so that the vertical co-ordinate corresponded to the desired criteria and interpreted in numbers running from 0 to 10. The values plotted are the average judgements of the whole group of listeners, each point representing a group judgement on one aircraft and curves have been fitted to the data.

(ii) The second is a study conducted in 1967 by William and others [19] in which the subjects were asked to rate the

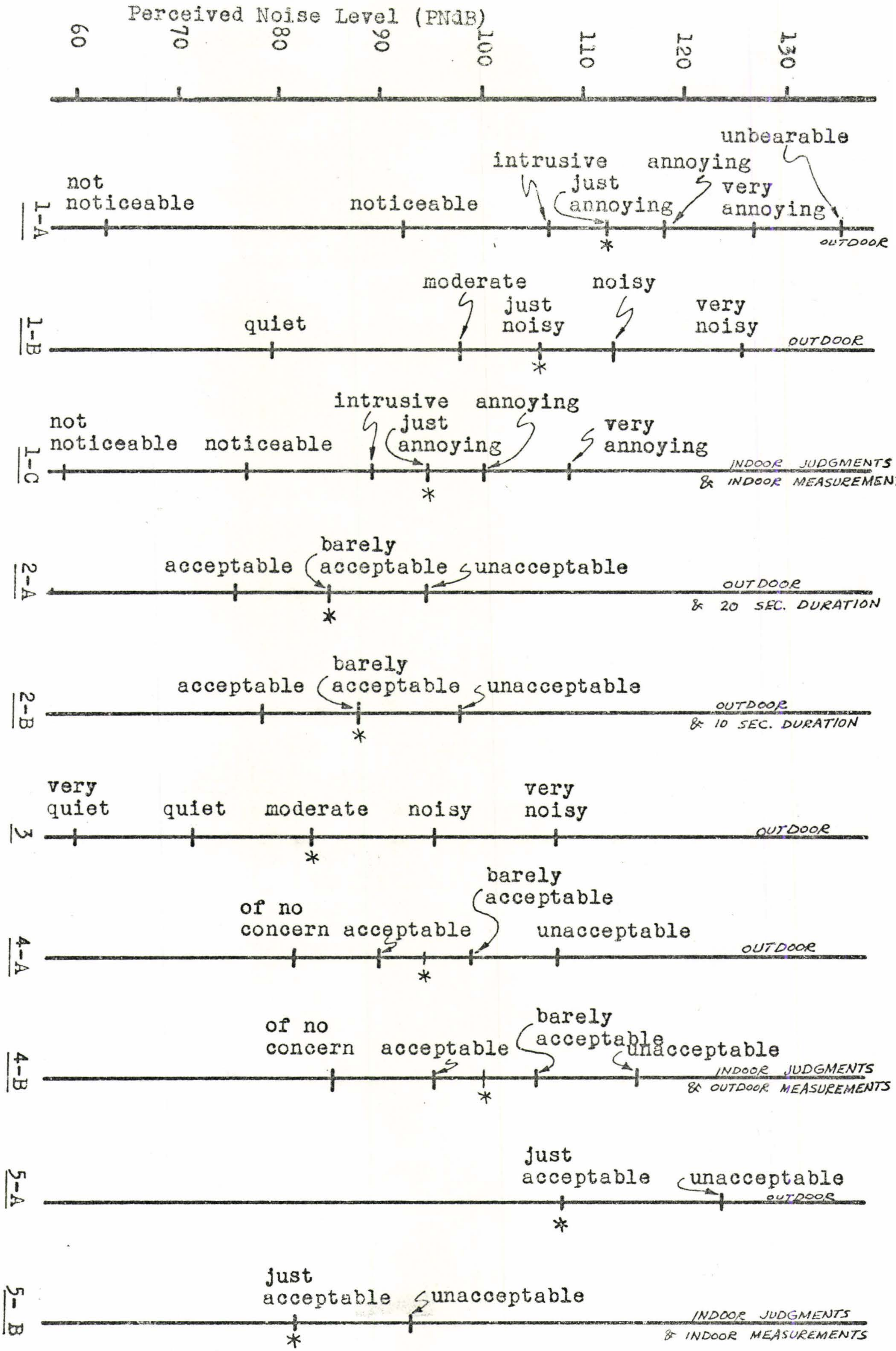


Fig.(6.1) Comparison of subjective scales for aircraft noise.

* Mid-point of the category scale

"acceptability" of the aircraft noise. The study concludes that a level of about 85 peak PNdB was barely acceptable. Figure 6.1 illustrates some of the results obtained from the study; scale 2-A is for a 20 seconds noise duration and scale 2-B for a 10 seconds noise duration (time was measured between the 2 points 10 dB below the maximum level as illustrated in Figure 4.6.

(iii) Pearsons and Horonjeff [20] conducted field tests where a wide variety of test subjects were selected from the general adult community and from a population of college students. These groups were asked to judge the noise of several classes of motor vehicles and aircraft. The results obtained have been fitted to straight lines as shown on Figure C.3 and Figure C.4, Appendix C. Figure 6.1, scale 3 also illustrates the PNL in PNdB (estimated from weighting network) and the corresponding mean noisiness rating for all stimuli during all field test sessions.

(iv) Bishop [2] reported a study performed at Los Angeles in which 55 subjects selected from Los Angeles International Airport neighbourhood judged the acceptability of noise produced by aircraft flyovers and by recorded flyover signals. Judgements were compared with the maximum PNL occurring during the flyovers. Judgements on actual flyovers on a category scale were made both inside and outside of the test buildings which were located close to the approach and take-off paths.

Most of the flyovers judged were of commercial turbojet and turbofan transport aircraft. In one of the tests, subjects were asked to rate aircraft noise on an acceptability scale in which four categories -- of no concern, acceptable, barely acceptable, and unacceptable -- were placed at equal intervals.

The maximum noise levels produced by the aircraft extended from 83 to 120 PNdB for outdoor judgements, and for indoor tests noise levels ranged from 61 to 96 PNdB. Mean noise-reduction values for the test rooms were in the range 21 - 24 PNdB.

In this test it was observed that for a given PNL, little difference existed between rating of take-off and approach noise or live and recorded noise signals.

The 2 composite curves relating PNL with acceptability ratings are shown on Figure C.5, Appendix C and also Figure 6.1, scales 4-A and 4-B. The dashed line on Figure C.5, Appendix C represents the mean of the four regression lines for indoor judgement tests and the solid line is the mean of the two regression lines calculated from the outdoor judgements. In Figure 6.1 both lines have been plotted for the PNL measured outdoors and they represent approximately the mean judgements of the people tested. For typical indoor levels, the given outdoor levels should be shifted 20 PNdB downward.

(v) Kryter, Johnson and Young [22] performed a study on residents of a military air-force base and had the subjects judge aircraft noise on a scale of equal intervals from 1 to 13. Scale index 13 being very acceptable, 7 just acceptable and 1 unacceptable. Two different units of measurements were reported, Peak PNdB and EPNdB, also indoor and outdoor judgements were performed. Figure 6.1 illustrates outdoor judgements (scale 5-A) and indoor judgements (scale 5-B). In the latter the sound measurements were recorded indoors.

Comparison of Judgement Tests

Differences in category scales, test stimuli, dynamic range of stimuli, and instructions given to the subjects in each test, tend to limit the validity of comparison between various test results employing different rating scales in order to reach a universally accepted rating scale.

In analyzing the results of the various tests, different curve fitting equations to the data have been employed, hence there is unequal spacing between the different categories.

Moreover, if a greater dynamic range would have been used in some of the tests, acceptability rating scales would have spread out or visa versa.

6.3.3 Proposed EPNL Tolerable Limits

As discussed earlier, the results of judgement tests are valid for a particular test condition and any of these results could be used in predicting, in broad terms, human response to aircraft noise. However, one of the test results, that from the Los Angeles study [21], was adopted in the present study since it appeared to represent the average of all the tests surveyed. The values that correspond to mid-point of the category scales shown in Figure 6.1 have been taken from the original curves. For example, from Figure C.2 a mid point value (the ordinate equal to 5.0) is 106 PNdB and shown on scale 1-B, Figure 6.1.

The values reported in PNdB in the test were adjusted for typical flyover time durations and the following limits are suggested for outdoor judgement and outdoor measurements in residential areas.

82	EPNdB	of no concern
89	EPNdB	acceptable
97	EPNdB	barely acceptable
104	EPNdB	unacceptable

For indoor judgement and indoor measurements the following limits are suggested:

65	EPNdB	of no concern
73	EPNdB	acceptable
82	EPNdB	barely acceptable
91	EPNdB	unacceptable

It should be noted that the indoor levels are based on a typical house attenuation value of 20 PNdB where windows and doors are closed.

CHAPTER 7

RESULTS AND DISCUSSIONS

7.1 Results and Discussion

7.1.1 Ground and Terrain Attenuation of Noise

Ground and terrain attenuation of noise contributed a great deal to community noise reduction in some localities, specifically those located on a distance greater than 2,000 ft. along the sides of the runway*. The elevation angle between the observer and the aircraft, at which ground attenuation becomes noticeable, was found to be approximately 10°. Inspection of the EPNL contours shows that the effectiveness of foliage for noise abatement is limited to a value of 4 to 8 dB reduction in noise level [24] only for those locations opposite to the sides of the runway and provided that the foliage comprises a belt of tall, dense trees.

Locations close to or directly under the flight path where a substantial reduction in noise level is desirable will not be alleviated by the introduction of foliage or noise barriers since the aircraft will be mostly exposed during flyover and accordingly most of the sound energy perceived by the ear will be direct sound waves.

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* See Appendix E for typical sound pressure levels measured in this region.

7.1.2 Flight Path

The effective perceived noise level and noise exposure forecast contours are computed and displayed in this study for straight flight paths during approach and take-off. Graphical techniques are available to reconstruct the EPNL contours for any curvey flight path, provided the rate of climb or descending angle is known [15]. The developed computer programs, given the equations of the curved flight path, could be modified to suit the requirements of a prescribed or an optimum flight path with regards to local noise abatement standards and air traffic control procedures (ATC). Hence, a new set of NEF and EPNL contour lines could be constructed for the new input data.

7.1.3 The Experimental Relationship Between PNdB and dB(A)

Figure 4.10 and Figure 4.11 illustrates the PNL in PNdB (calculated in accordance with the procedures given in Chapter 4) versus SPL in dB(A) for both cases take-off and landing respectively. The experimental data are approximated by straight line relationships of the following form:

Take-off

$$PNL = -9.35 + 1.19 \ dB(A) \qquad PNdB \qquad (7.1)$$

For example if on take-off the measured sound level is 100 dB(A), then the PNL would be approximately 109 PNdB.

The mean value of the difference between PNL and dB(A) for all the test points (take-off) was found to be approximately equal to 7.7 dB.

<u>Landing</u>

PNL = -9.78 + 1.29 dB(A) PNdB (7.2)

Again on landing if we consider a measured sound level of 100 dB(A), then the PNL would be approximately 118.

The mean value of the difference between PNL and dB(A) for all the test points (landing) was found to be approximately equal to 11dB.

It should be noted that the equations and values presented above apply only to a specific class of aircraft, accordingly different values would have to be established for other classes. On the basis of this information it is quite possible to use the sound level meter for direct measurements or monitoring of aircraft noise in simple dB(A) levels and then transform the data to approximate the PNL and PNdB.

7.1.4 Comparison of 2 and 4 engine turbofan aircraft Noise Levels

Figure 7.1 illustrates the "PNdB versus distance" results by McPike [16] and Bolt, Beranek & Newman Inc. [15] for a typical 4-engine turbofan aircraft as compared to the results obtained in this study for the 2-engine turbofan aircraft. Considering the difference, in the acoustic power and the noise pattern, between 2 and 4-engine turbofan aircraft, the results of this study show a good agreement with the other studies in view of the PNdB trend versus distance.

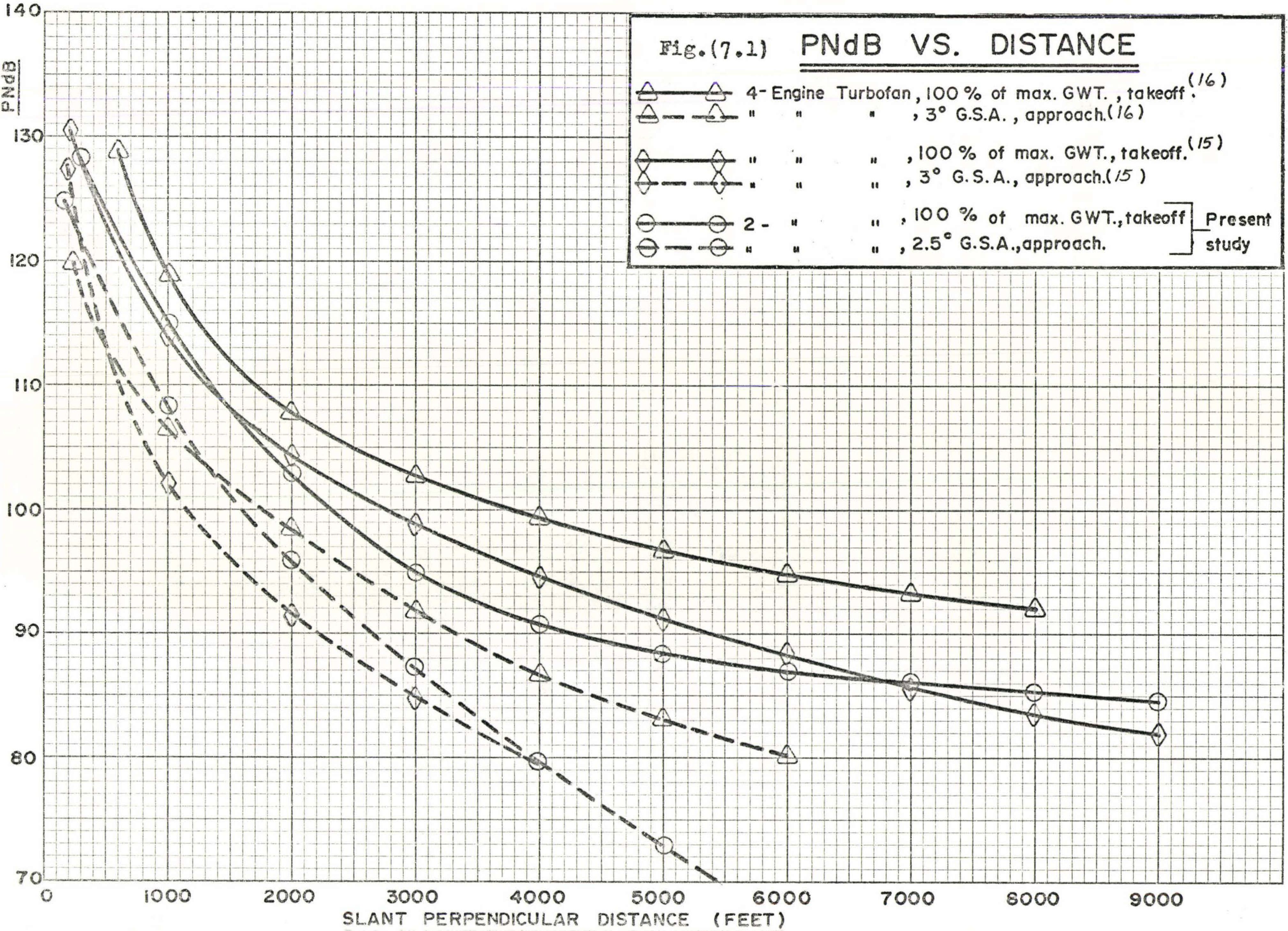
Fig.(7.1) PNdB VS. DISTANCE
4- Engine Turbofan, 100 % of max. GWT. , takeoff.(16)
" " " , 3° G.S.A. , approach.(16)
" " " , 100 % of max. GWT., takeoff.(15)
" " " , 3° G. S. A., approach.(15)
2- " " , 100 % of max. GWT., takeoff
" " " , 2.5° G.S.A., approach.
Present study
PNdB
140
130
120
110
100
90
80
70
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
SLANT PERPENDICULAR DISTANCE (FEET)

7.1.5 Measurements

Field measurements in general show good agreement with the developed PNdB vs. distance equations for landing take-off.

The accuracy of instruments, measurements and data reduction techniques was carefully controlled within ± 2 dB; nevertheless repeated measurements in some locations exhibited greater differences. These differences resulted from the contribution of several factors such as weather condition, aircraft flight path, take-off and landing profiles, aircraft weight, etc. However, the relative effectiveness of these factors on the readings depend on the measurement locations. In this analysis no corrections were applied to the measurements due to variations in weather and wind conditions, however, it should be noted that measurements made with wind speeds over 10 mph, extreme weather conditions and off-course aircraft flights were rejected in the final analysis.

7.1.6 NEF Contours For The Existing Operations

Figure 7.2 illustrates the Noise Exposure Forecast Contours for the existing operations on runway 24* at Mount Hope Airport.

The type and number of aircraft were taken from the timetable, over the period the measurements were made, of the major commercial aircarrier ** using Mount Hope Airport for a typical weekday. Business jets and light weight private aircraft were not considered

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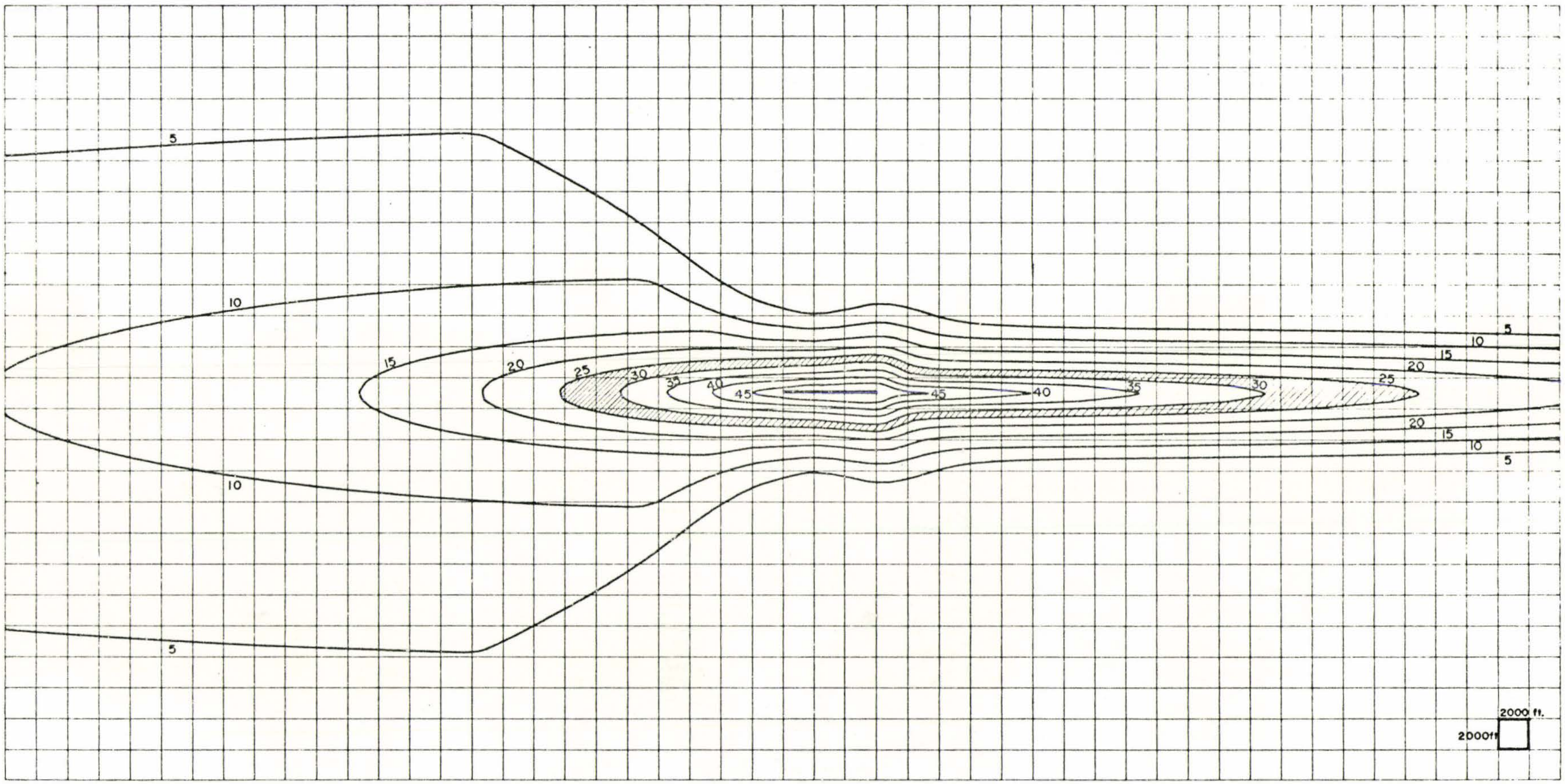
* Contours could be rotated 180° to show a similar case using runway 06.

** Nordair Timetable - effective October 1, 1972.



NOISE EXPOSURE FORECAST CONTOURS

EXISTING AIRPORT OPERATIONS - RUNWAY 06/24

SCALE 1 : 50,000

ASSUMING ALL LANDINGS & TAKEOFFS ON RUNWAY 24.

TYPICAL — MARGINAL ZONE FOR RESIDENTIAL DEVELOPMENT.

DATA

		DAY	NIGHT
TAKEOFF	2 ENGINES TURBOFAN	7	1
	2 ENGINES TURBOPROP	1	0
LANDING	2 ENGINES TURBOFAN	7	2
	2 ENGINES TURBOPROP	1	0

Fig.(7.2)

since the contribution of these aircraft to the final NEF is negligible compared with a twin-engine commercial jet aircraft with an average take-off weight of about 90,000 lbs.

In computing and constructing these contours it was assumed that all landings and take-offs were on one runway only, i.e. 100% utilization of one runway 06/24 in order to show the highest possible value of the noise exposure index in the various locations. The contour lines show that the NEF contours due to landing encompass long narrow strips of land as compared to the take-off pattern, where the noise affects a shorter but broader land area.

The area of land encompassed by the 30 NEF contour is approximately 4.4 square miles and by the 40 NEF contour approximately 1.1 square miles. It should be noted that if a different runway utilization factor was used in the analysis, the land area encompassed by each contour line would have remained almost the same, but the shape of the contours would contract or expand in certain locations, in a manner depending on the utilization factor.

The NEF contours of the existing airport operations are presented in this study in order to serve as a basis for comparison with the planned operation after the proposed expansion.

7.1.7 <u>NEF Contours For The Proposed Plans</u>

(a) Assuming all landings and take-offs on one runway (11/29):

Figure 7.3 illustrates the NEF contours for the proposed expansion assuming all landings and take-offs on runway 29 *.

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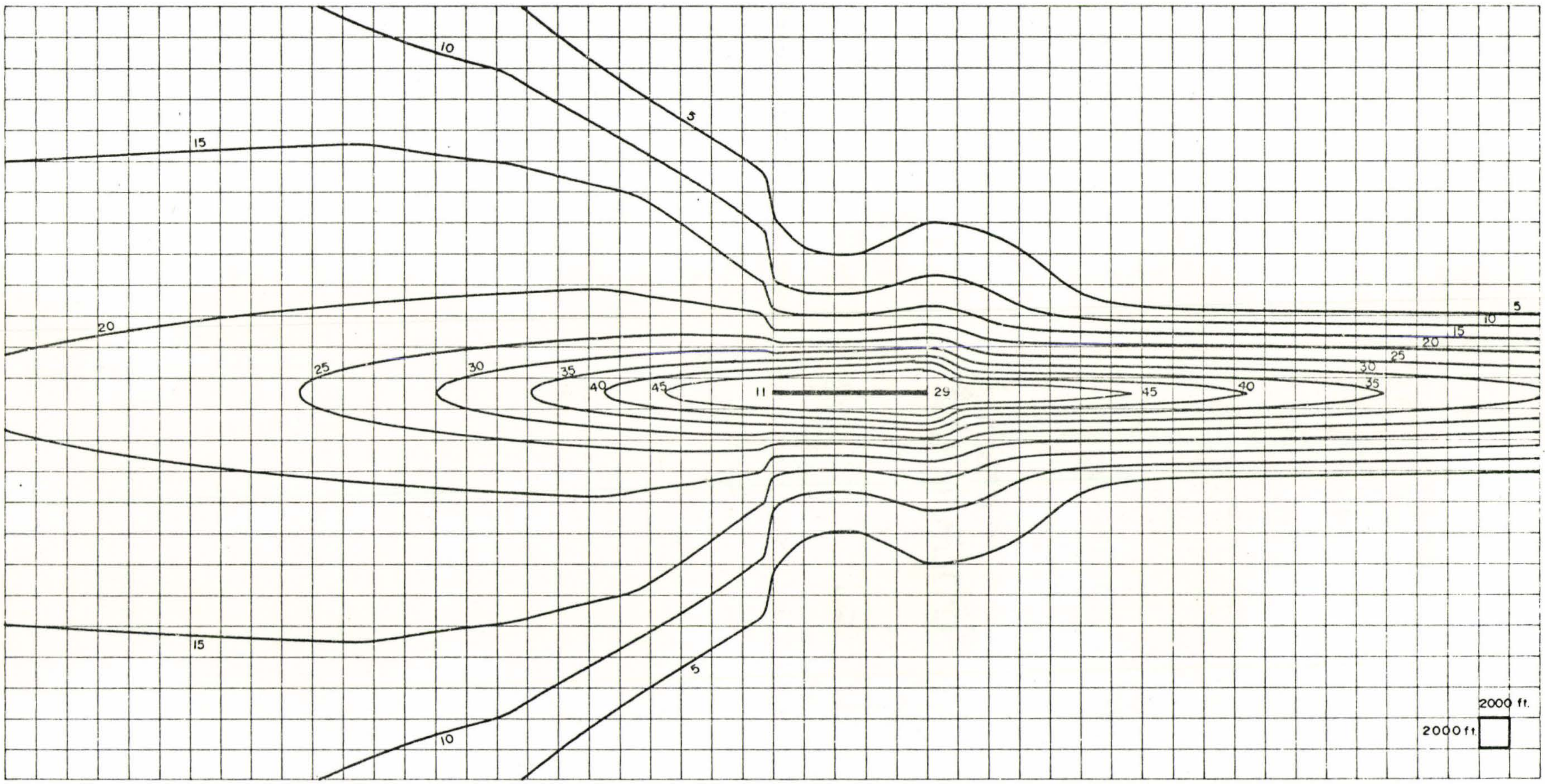
* contours could be rotated 180° to show a similar case using runway 11.



NOISE EXPOSURE FORECAST CONTOURS

PROPOSED AIRPORT EXPANSION - PLAN NO. 2B

SCALE : 1 : 50,000

ASSUMING ALL LANDINGS & TAKEOFFS ON RUNWAY 29

Note: Aircraft movements as on Fig.(7.4)

Fig.(7.3)

The mix and aircraft types [3] are shown on the diagram, and the runway is located as per plan 2B[3].

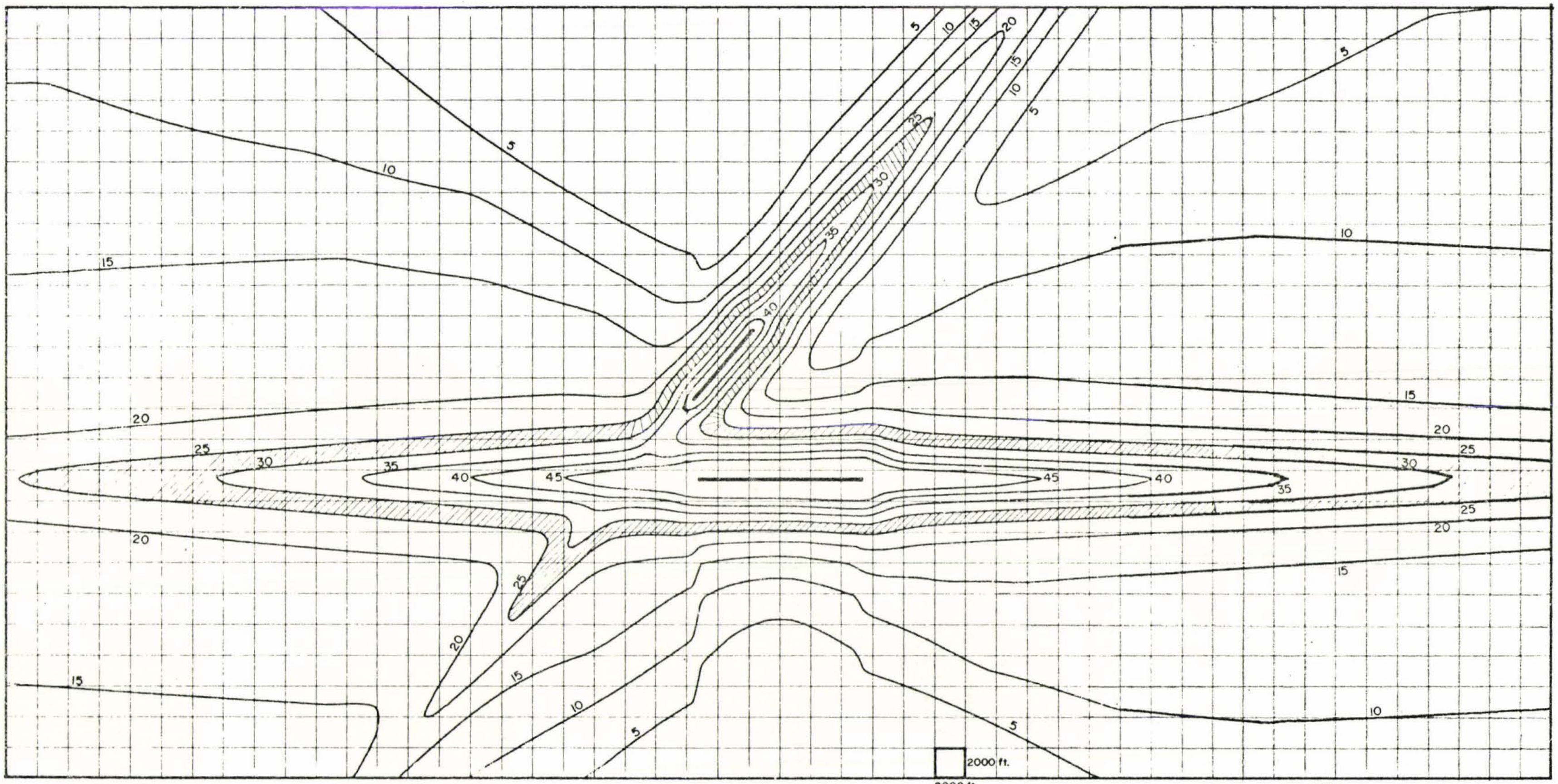
In this particular case where only one runway is being utilized, the same contour lines could be used as well for plans 1 and 2A by just shifting the overlay. Comments regarding the contours are similar to the case of existing operations with a recognized increase in area under exposure.

The land area of land encompassed by the 30 NEF contour is found to be approximately 11.9 square miles and by the 40 NEF contour approximately 4.2 square miles.

(b) <u>Assuming landings and take-offs on runways 06/24 and 11/29</u>

One of the important results of this study is illustrated in Figure 7.4 which shows contour levels encompassing both the 06/24 and 11/29 runways. It will be noted that the minimum contour level is rated at 5 NEF while the maximum is shown to be 45 NEF. These contours apply only to plan 2B for a specific aircraft mix and runway utilization. It has been further assumed that the 5% utilization allocated to the existing runway (06/24) will be divided equally i.e. 2.5% for each direction. It has also been assumed that the total number of 2 and 3 engine aircraft is divided with an equal number of each type of aircraft.

Since no plan for the extension of the existing runway



NOISE EXPOSURE FORECAST CONTOURS

PROPOSED AIRPORT EXPANSION - PLAN NO. 2 B

SCALE 1 : 50,000

RUNWAY UTILIZATION :
- 11 - 20 %, 29 - 75 % — ALL AIRCRAFTS.
- 06 - 2.5 %, 24 - 2.5 % — 2 & 3 ENGINES AIRCRAFTS ONLY.

(hatched) TYPICAL - MARGINAL ZONE FOR RESIDENTIAL DEVELOPMENT.

DATA

			DAY	NIGHT
TAKEOFF	4-ENGINES	TURBOFAN (2500 - 3500 MILES)	8	1
	4- "	" (500 MILES)	7	1
	2- "	"	18	2
	3- "	"	18	2
		TOTAL	51	6
LANDING	SAME AS TAKEOFF			
		TOTAL	51	6

TOTAL AIRCRAFT MOVEMENTS = 114

Fig.(7.4)

was submitted, the utilization of runway 06/24 was restricted in this analysis to 2 and 3 engine aircraft only. The area of land encompassed by each contour line was measured and found to be as follows:

45	NEF	2.4 square miles
40	NEF	4.8 square miles
35	NEF	8.7 square miles
30	NEF	14.9 square miles

These contour lines represent an average daily exposure to aircraft noise and it would seem appropriate and a fair practice to use these values in general cases of compatible land use and planning.

7.1.8 NEF Maximum Envelopes

The concept of "NEF Contour Envelopes", as the term and concept are introduced in this study, forecasts the highest noise exposure that might occur at certain locations in the airport vicinity.

Since noise could be a critical factor in site selection and constructional design of a proposed establishment, it would seem appropriate to investigate the maximum value of noise exposure rather than a value based on an average daily basis. The latter is computed from accumulated statistical data of the yearly prevailing winds at the airport location, proposed runways orientation and anticipated aircraft movements.

To construct the "NEF Maximum Envelopes", the NEF was computed assuming 100% utilization of each runway i.e. all landings and take-offs on one runway, the NEF contour lines of all runways were then superimposed on the airport map and the envelopes containing the various levels were constructed and identified. Figure 7.5 illustrates a typical 30 "NEF Maximum Envelope" computed for the proposed expansion at the Mount Hope Airport using runways 06/24 and 11/29, assuming 114 aircraft movements (57 landings & 57 take-offs) with an aircraft mix as shown on the diagram and assuming the various possibilities of wind direction including severe south or north winds. It should be noted that the existing runway 06/24 would be required only in severe crosswind conditions over runway 11/29, i.e. S or N wind directions, and the new runway 11/29 would be used for all other wind directions [3].

The 30 "NEF Maximum Envelope" depicted in Figure 7.5 was selected to demonstrate the concept since at this level a marginal zone exists for further residential development.

The area of land encompassed by the 30 "NEF Maximum Envelope" is approximately 29.7 square miles as compared to 14.9 square miles for the case and data shown on Figure 7.4. Furthermore, the contour lines extend to a

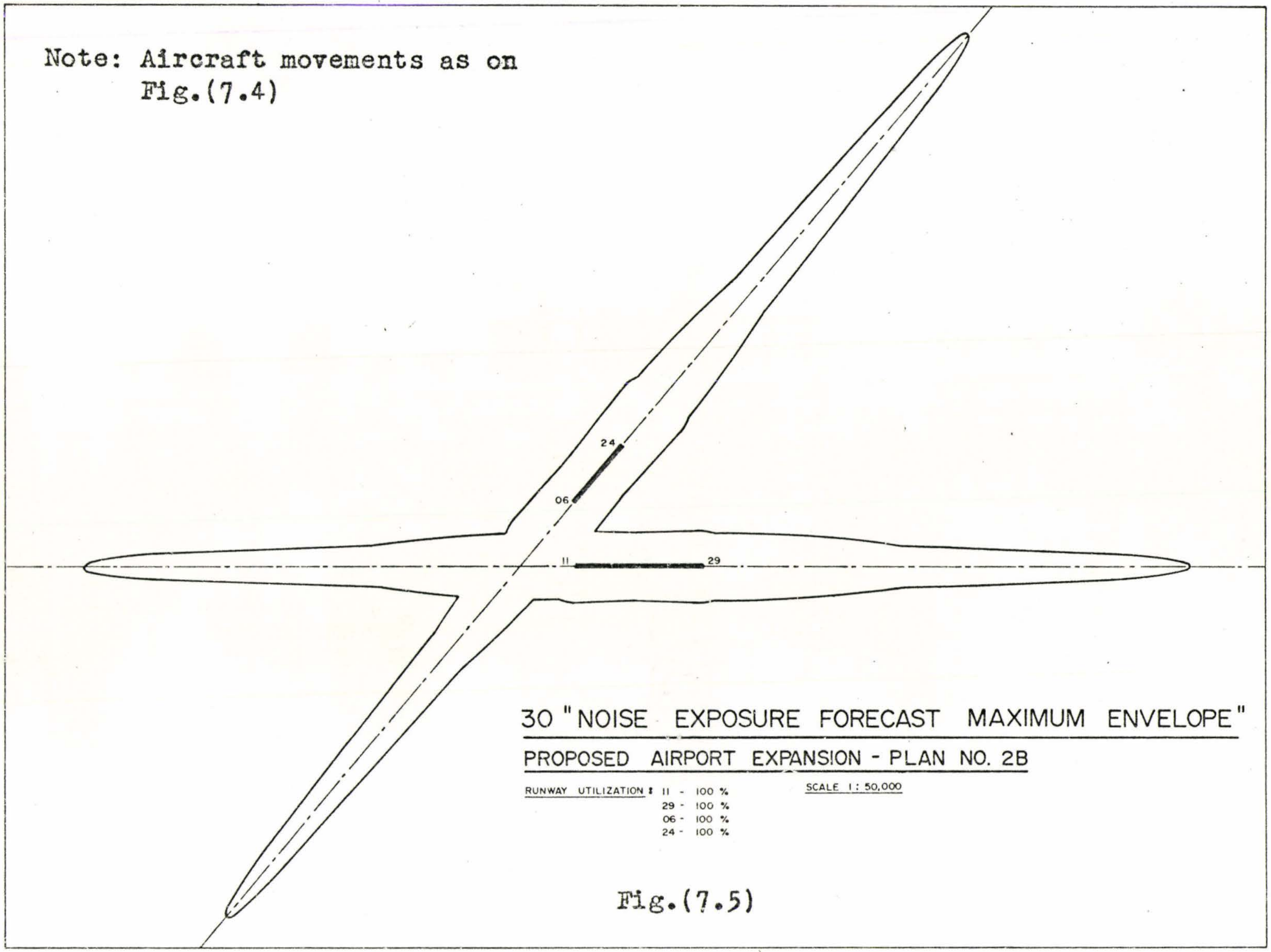

Note: Aircraft movements as on Fig.(7.4)
24
06
11
29
30 "NOISE EXPOSURE FORECAST MAXIMUM ENVELOPE"
PROPOSED AIRPORT EXPANSION - PLAN NO. 2B
RUNWAY UTILIZATION : 11 - 100 %
29 - 100 %
06 - 100 %
24 - 100 %
SCALE 1 : 50,000

Fig.(7.5)

distance of about 7.5 miles beyond the threshold of all runways in the former case as compared to 2.4, 2.3, 5.9 and 7.2 miles for runways 06, 24, 11 and 29 respectively in the latter case.

It is expected that this concept would represent a realistic approach of exposure to aircraft noise and a typical case which might happen on certain days, however, these maximum levels of exposure may not happen for several days, or even weeks, but the possibility is always present. The use of this approach is restricted to specific critical cases of land-use such as hospitals, schools, etc. The NEF based on an average percentage of runway utilization seems to be adequate and appropriate generally in land-use planning and rezoning.

7.1.9 Changes in operational procedures

The choice between take-off power along the entire flight path versus power cutback at some acceptable altitude has been recognized as a means of reducing noise in the close-in community. Several take-off procedures and profiles monitored in actual day-to-day operations at a major international airport in the U.S.A., demonstrated noise reductions over the community on the order of 4 to 7.5 PNdB. Such reductions are to be encouraged since noise-abatement take-off procedures can be performed effectively with virtually all present day jet transport aircraft without modification of the aircraft, with no effect on safety and with little effect on pilot-workload.

Aircraft flap settings after take-off has proven to be an effective method of further reducing aircraft noise, within certain limits, and the further introduction of automated flap systems, permitting speed-controlled programming of flaps during climbout, promise to add an improvement in the noise picture [25].

Inspection of the NEF contours reveal that any reduction in take-off noise mainly because of engine power cutback will be more effective than altitude changes especially from those locations further away from the centre line of the flight path and off to the side; since at these locations the relative change in aircraft altitude is very small compared to the slant perpendicular distance to the flight path. It should be recognized that locations close to the airport and approximately 3 miles alongside the take-off flight path will not experience any particular noise reductions with power cutback since this procedure is not applied in the early stages of take-off as noise abatement procedure.

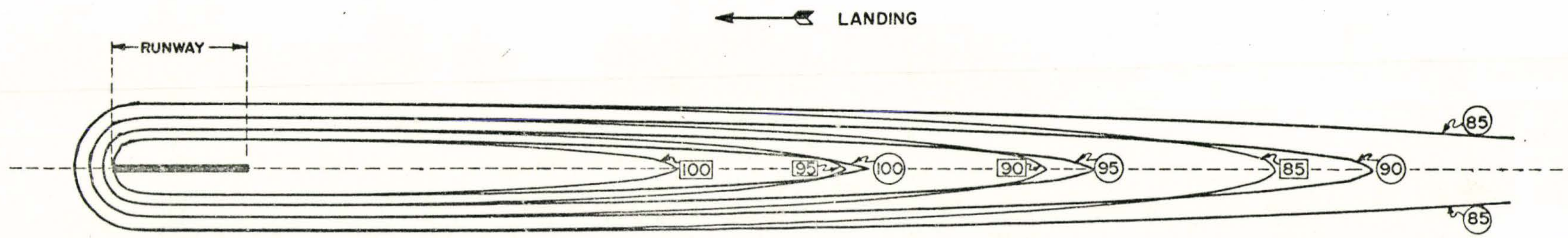
The computer programs developed in this analysis could be used satisfactorily to compare various take-off profiles and procedures with regards to reduction in community noise and the relative effectiveness of such a procedure upon noise contours.

7.1.10 Regulatory Procedure

The present regulations at Mount Hope Airport specify a 2.5° glide slope angle for approach when using an instrument landing system (ILS), accordingly measurements of landing noise were based on this angle. The experimental data has been further analyzed to examine the noise reductions which may be obtained assuming a 3.5° glide slope angle for approach and these results are shown earlier (see for example Fig. 5.5). The trades between glide slope angle and noise for a 2-engine turbofan aircraft are illustrated in Figure 7.6. In this analysis the 85, 90, 95 and 100 EPNL contours; assuming 2.5° and 3.5° glide slope angles, are superimposed and from the results it is concluded that these contours exhibited a shrinkage in length of about 4.0, 2.9, 2.2 and 1.7 miles respectively when the glide angle was increased by 1°.

Another way of looking at the noise benefits of higher glide slopes is the change in community area in square miles subjected to a given noise level. As an example the percentage reduction in the 90 EPNL contour is found to be approximately 25%. Note that the percentage reduction and shrinkage in length as explained above were slightly underestimated because at higher glide slope angles the aircraft power setting is usually decreased, accordingly further noise reductions in the order of 2 dB might be achieved.

Increasing the GSA within limitations offers a potential for a significant relief of the community noise problem. However, the



INFLUENCE OF AIRCRAFT GLIDE SLOPE ANGLE ON LANDING NOISE PATTERNS

SCALE 1 : 50,000

2-ENGINE TURBOFAN AIRCRAFT

○ EFFECTIVE PERCEIVED NOISE LEVEL USING 2.5° GLIDE SLOPE ANGLE (INTERCEPT ALTITUDE = 4000 FT.)

□ " " " " ASSUMING 3.5° " " " (" " " ")

Fig.(7.6)

effective reduction varies from one location to the other.

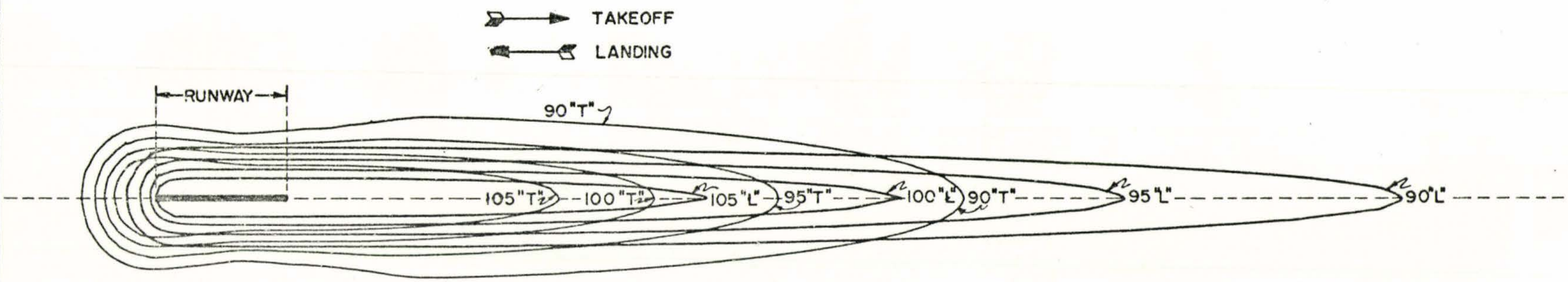
Results of a series of tests [25] conducted on 727-200 aircraft shows noise reductions in the order of 5 to 7 EPNdB for a 1° increase in glide slope directly under the flight path at a distance range of 1 to 5 nautical miles from the runway threshold.

7.2 CONCLUSIONS

(i) Measurement results for a twin engine jet aircraft show that EPNL contours due to landing (2.5° GSA) encompass long narrow strips of land as compared to take-off (100 GWT), where the noise affects shorter but broader strips. The superposition of landing and take-off EPNL contours, as shown in Figure 7.7, revealed the locations at which the landing noise will exceed the take-off noise and also represent the envelopes which contain the maximum levels of noise at the various locations due to the operation of a single aircraft.

(ii) Expanding Mount Hope Airport to accommodate 57 different aircraft per day, runway utilization, aircraft mix and runway location as shown on Figure 7.4, would result in approximately 2.4, 4.8, 8.7 and 14.9 square miles of land encompassed by the 45, 40, 35 and 30 NEF contours respectively.

(iii) A comparison between the proposed expansion and the existing operations at Mount Hope Airport; based on all aircraft take-offs and landings on one runway, showed that the area of



COMPARISON OF LANDING AND TAKEOFF NOISE PATTERNS ON THE COMMUNITY

2-ENGINE TURBOFAN AIRCRAFT

SCALE 1 : 50,000

"T" EFFECTIVE PERCEIVED NOISE LEVEL DUE TO TAKEOFF (100 % OF MAX. G.WT. AND FLIGHT LEVEL = 20000 FT.)

"L" " " " " " LANDING (GLIDE SLOPE ANGLE = 2.5° AND INTERCEPT ALTITUDE = 4000 FT.)

Fig.(7.7)

land encompassed by the existing 40 NEF contour would be enlarged 3.8 times and the area of land encompassed by the existing 30 NEF contours would be enlarged 2.7 times, due to the proposed expansion plan.

(iv) Versatile computer programs have been developed in this study to compute and construct the EPNL and NEF for any combination of requirements such as runway orientation, flight procedures, type of aircraft etc. The programs have the capability of computing the EPNL or NEF at any given location in the airport vicinity, within the accuracy of the techniques used. The impact of changing operational or regulatory procedures on the community could also be investigated.

(v) For land use, only where the noise constitutes a critical factor in selecting the site, the planner or designer should use the proposed concept of "NEF Maximum Envelope" to forecast the maximum level of noise exposure that might prevail at the proposed site. Based on 57 aircraft per day, the area encountered by the 30 "NEF Maximum Envelopes" was estimated to be approximately 30 square miles.

(vi) When an effective control of the noise produced by aircraft is desired, it is not enough to estimate the noise from various aircraft and determine a noise exposure index. The actually produced noise must also be measured and monitored at various key positions around the airport. Such monitoring systems and local noise regulations supervised by the local and federal authorities are necessary to control the environmental quality.

(vii) A preliminary analysis concerning the possibility of further reductions in noise shows that increasing the glide slope angle offers a potential for approximately 25% reduction in the area of land encountered by the 90 EPNL contour if the existing 2.5° GSA is increased to 3.5°. However, the increase is governed by aircraft performance capabilities, pilot acceptance and most of all the safety of passengers and the community.

(viii) Tolerable limits of exposure to aircraft noise are presented in Chapter 6 and displayed on the noise contours. However, the interpretation and application of these data for the setting of environmental noise limits that are economical and, at the same time, acceptable to the public in a specific locality is a task that may require special information and judgement about that locality.

(ix) It should be mentioned that all the aircraft used in the analysis are what might be termed "last generation aircraft" in that many of the engines and airframes were designed over 10 years ago. At that time only limited attention was given to research in the area of aircraft noise.

Next generation aircraft including the Boeing 747, the Douglas DC-10 and the Lockheed 1011 (Tristar) have much lower noise levels and when these aircraft are in general use there will be a significant reduction in the area of critical noise exposure which is shown in this study. Aircraft presently in the design stage such as the deHavilland DHC-7 will generate still lower noise levels and it is to be expected that this type of aircraft will be a primary carrier for intercity transport.

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APPENDIX A

Perceived noisiness in noys as a function of sound pressure level

Band centre frequency in Hz

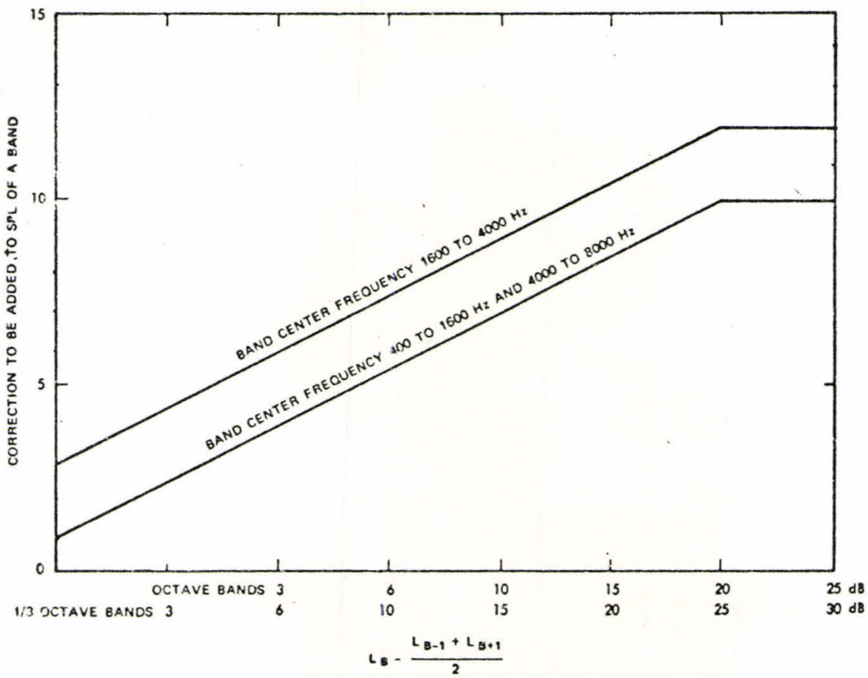
	50	63	80	100	125	160	200	250	315	400	500	630	800	1000
29														
30														
31														
32														
33														
34														
35														
36														
37														
38														
39														
40										1.00	1.00	1.00	1.00	1.00
41										1.07	1.07	1.07	1.07	1.07
42									1.00	1.15	1.15	1.15	1.15	1.15
43									1.07	1.23	1.23	1.23	1.23	1.23
44								1.00	1.15	1.32	1.32	1.32	1.32	1.32
45								1.08	1.24	1.41	1.41	1.41	1.41	1.41
46							1.00	1.16	1.33	1.52	1.52	1.52	1.52	1.52
47							1.08	1.25	1.42	1.62	1.62	1.62	1.62	1.62
48						1.00	1.17	1.34	1.53	1.74	1.74	1.74	1.74	1.74
49						1.08	1.26	1.45	1.64	1.87	1.87	1.87	1.87	1.87
50						1.17	1.36	1.56	1.76	2.00	2.00	2.00	2.00	2.00
51					1.00	1.26	1.47	1.68	1.89	2.14	2.14	2.14	2.14	2.14
52					1.08	1.36	1.58	1.80	2.03	2.30	2.30	2.30	2.30	2.30
53				1.00	1.18	1.47	1.71	1.94	2.17	2.46	2.46	2.46	2.46	2.46
54				1.09	1.28	1.58	1.85	2.09	2.33	2.64	2.64	2.64	2.64	2.64
55				1.18	1.38	1.71	2.00	2.25	2.50	2.83	2.83	2.83	2.83	2.83
56			1.00	1.29	1.50	1.85	2.15	2.42	2.69	3.03	3.03	3.03	3.03	3.03
57			1.09	1.40	1.63	2.00	2.33	2.61	2.88	3.25	3.25	3.25	3.25	3.25
58			1.18	1.53	1.77	2.15	2.51	2.81	3.10	3.48	3.48	3.48	3.48	3.48
59			1.29	1.66	1.92	2.33	2.71	3.03	3.32	3.73	3.73	3.73	3.73	3.73
60		1.00	1.40	1.81	2.08	2.51	2.93	3.26	3.57	4.00	4.00	4.00	4.00	4.00
61		1.10	1.53	1.97	2.26	2.71	3.16	3.51	3.83	4.29	4.29	4.29	4.29	4.29
62		1.21	1.66	2.15	2.45	2.93	3.41	3.78	4.11	4.59	4.59	4.59	4.59	4.59
63		1.32	1.81	2.34	2.65	3.16	3.69	4.06	4.41	4.92	4.92	4.92	4.92	4.92
64	1.00	1.45	1.97	2.54	2.88	3.41	3.98	4.38	4.73	5.28	5.28	5.28	5.28	5.28
65	1.11	1.60	2.15	2.77	3.12	3.69	4.30	4.71	5.08	5.66	5.66	5.66	5.66	5.66
66	1.22	1.75	2.34	3.01	3.39	3.98	4.64	5.07	5.45	6.06	6.06	6.06	6.06	6.06
67	1.35	1.92	2.54	3.28	3.68	4.30	5.01	5.46	5.85	6.50	6.50	6.50	6.50	6.50
68	1.49	2.11	2.77	3.57	3.99	4.64	5.41	5.88	6.27	6.96	6.96	6.96	6.96	6.96
69	1.65	2.32	3.01	3.88	4.33	5.01	5.84	6.33	6.73	7.46	7.46	7.46	7.46	7.46
70	1.82	2.55	3.28	4.23	4.69	5.41	6.31	6.81	7.23	8.00	8.00	8.00	8.00	8.00
71	2.02	2.79	3.57	4.60	5.09	5.84	6.81	7.33	7.75	8.57	8.57	8.57	8.57	8.57
72	2.23	3.07	3.88	5.01	5.52	6.31	7.36	7.90	8.32	9.19	9.19	9.19	9.19	9.19
73	2.46	3.37	4.23	5.45	5.99	6.81	7.94	8.50	8.93	9.85	9.85	9.85	9.85	9.85
74	2.72	3.70	4.60	5.94	6.50	7.36	8.57	9.15	9.59	10.6	10.6	10.6	10.6	10.6
75	3.01	4.06	5.01	6.46	7.05	7.94	9.19	9.85	10.3	11.3	11.3	11.3	11.3	11.3
76	3.32	4.46	5.45	7.03	7.65	8.57	9.85	10.6	11.0	12.1	12.1	12.1	12.1	12.1
77	3.67	4.89	5.94	7.66	8.29	9.19	10.6	11.3	11.8	13.0	13.0	13.0	13.0	13.0
78	4.06	5.37	6.46	8.33	9.00	9.85	11.3	12.1	12.7	13.9	13.9	13.9	13.9	13.9
79	4.49	5.90	7.03	9.07	9.76	10.6	12.1	13.0	13.6	14.9	14.9	14.9	14.9	14.9
80	4.96	6.48	7.66	9.85	10.6	11.3	13.0	13.9	14.6	16.0	16.0	16.0	16.0	16.0
81	5.48	7.11	8.33	10.6	11.3	12.1	13.9	14.9	15.7	17.1	17.1	17.1	17.1	17.1
82	6.06	7.81	9.07	11.3	12.1	13.0	14.9	16.0	16.9	18.4	18.4	18.4	18.4	18.4
83	6.70	8.57	9.87	12.1	13.0	13.9	16.0	17.1	18.1	19.7	19.7	19.7	19.7	19.7
84	7.41	9.41	10.7	13.0	13.9	14.9	17.1	18.4	19.4	21.1	21.1	21.1	21.1	21.1
85	8.19	10.3	11.7	13.9	14.9	16.0	18.4	19.7	20.8	22.6	22.6	22.6	22.6	22.6
86	9.05	11.3	12.7	14.9	16.0	17.1	19.7	21.1	22.4	24.3	24.3	24.3	24.3	24.3
87	10.0	12.1	13.9	16.0	17.1	18.4	21.1	22.6	24.0	26.0	26.0	26.0	26.0	26.0
88	11.1	13.0	14.9	17.1	18.4	19.7	22.6	24.3	25.8	27.9	27.9	27.9	27.9	27.9
89	12.2	13.9	16.0	18.4	19.7	21.1	24.3	26.0	27.7	29.9	29.9	29.9	29.9	29.9
90	13.5	14.9	17.1	19.7	21.1	22.6	26.0	27.9	29.7	32.0	32.0	32.0	32.0	32.0
91	14.9	16.0	18.4	21.1	22.6	24.3	27.9	29.9	31.8	34.3	34.3	34.3	34.3	34.3
92	16.0	17.1	19.7	22.6	24.3	26.0	29.9	32.0	34.2	36.8	36.8	36.8	36.8	36.8
93	17.1	18.4	21.1	24.3	26.0	27.9	32.0	34.3	36.7	39.4	39.4	39.4	39.4	39.4
94	18.4	19.7	22.6	26.0	27.9	29.9	34.3	36.8	39.4	42.2	42.2	42.2	42.2	42.2
95	19.7	21.1	24.3	27.9	29.9	32.0	36.8	39.4	42.2	45.3	45.3	45.3	45.3	45.3
96	21.1	22.6	26.0	29.9	32.0	34.3	39.4	42.2	45.3	48.5	48.5	48.5	48.5	48.5
97	22.6	24.3	27.9	32.0	34.3	36.8	42.2	45.3	48.5	52.0	52.0	52.0	52.0	52.0
98	24.3	26.0	29.9	34.3	36.8	39.4	45.3	48.5	52.0	55.7	55.7	55.7	55.7	55.7
99	26.0	27.9	32.0	36.8	39.4	42.2	48.5	52.0	55.7	59.7	59.7	59.7	59.7	59.7
100	27.9	29.9	34.3	39.4	42.2	45.3	52.0	55.7	59.7	64.0	64.0	64.0	64.0	64.0
101	29.9	32.0	36.8	42.2	45.3	48.5	55.7	59.7	64.0	68.6	68.6	68.6	68.6	68.6
102	32.0	34.3	39.4	45.3	48.5	52.0	59.7	64.0	68.6	73.5	73.5	73.5	73.5	73.5
103	34.3	36.8	42.2	48.5	52.0	55.7	64.0	68.6	73.5	78.8	78.8	78.8	78.8	78.8
104	36.8	39.4	45.3	52.0	55.7	59.7	68.6	73.5	78.8	84.4	84.4	84.4	84.4	84.4
105	39.4	42.2	48.5	55.7	59.7	64.0	73.5	78.8	84.4	90.5	90.5	90.5	90.5	90.5
106	42.2	45.3	52.0	59.7	64.0	68.6	78.8	84.4	90.5	97.0	97.0	97.0	97.0	97.0
107	45.3	48.5	55.7	64.0	68.6	73.5	84.4	90.5	97.0	104	104	104	104	104
108	48.5	52.0	59.7	68.6	73.5	78.8	90.5	97.0	104	111	111	111	111	111
109	52.0	55.7	64.0	73.5	78.8	84.4	97.0	104	111	119	119	119	119	119
110	55.7	59.7	68.6	78.8	84.4	90.5	104	111	119	128	128	128	128	128
111	59.7	64.0	73.5	84.4	90.5	97.0	111	119	128	137	137	137	137	137
112	64.0	68.6	78.8	90.5	97.0	104	119	128	137	147	147	147	147	147
113	68.6	73.5	84.4	97.0	104	111	128	137	147	158	158	158	158	158
114	73.5	78.8	90.5	104	111	119	137	147	158	169	169	169	169	169
115	78.8	84.4	97.0	111	119	128	147	158	169	181	181	181	181	181
116	84.4	90.5	104	119	128	137	158	169	181	194	194	194	194	194
117	90.5	97.0	111	128	137	147	169	181	194	208	208	208	208	208
118	97.0	104	119	137	147	158	181	194	208	223	223	223	223	223
119	104	111	128	147	158	169	194	208	223	239	239	239	239	239
120	111	119	137	158	169	181	208	223	239	256	256	256	256	256
121	119	128	147	169	181	194	223	239	256	274	274	274	274	274
122	128	137	158	181	194	208	239	256	274	294	294	294	294	294
123	137	147	169	194	208	223	256	274	294	315	315	315	315	315
124	147	158	181	208	223	239	274	294	315	338	338	338	338	338
125	158	169	194	223	239	256	294	315	338	362	362	362	362	362
126	169	181	208	239	256	274	315	338	362	388	388	388	388	388
127	181	194	223	256	274	294	338	362	388	416	416	416	416	416
128	194	208	239	274	294	315	362	388	416	446	446	446	446	446
129	208	223	256	294	315	338	388	416	446	478	478	478	478	478
130	223	239	274	315	338	362	416	446	478	512	512	512	512	512
131	239	256	294	338	362	388	446	478	512	549	549	549	549	549
132	256	274	315	362	388	416	478	512	549	588	588	588	588	588
133	274	294	338	388	416	446	512	549	588	630	630	630	630	630
134	294	315	362	416	446	478	549	588	630	676	676	676	676	676
135	315	338	388	446	478	512	588	630	676	724	724	724	724	724
136	338	362	416	478	512	549	630	676	724	776	776	776	776	776
137	362	388	446	512	549	588	676	724	776	832	832	832	832	832
138	388	416	478	549	588	630	724	776	832	891	891	891	891	891
139	416	446	512	588	630	676	776	832	891	955	955	955	955	955
140	446	478	549	630	676	724	832	891	955	1024	1024	1024	1024	1024
141	478	512	588	676	724	776	891	955	1024	1098	1098	1098	1098	1098
142	512	549	630	724	776	832	955	1024	1098	1176	1176	1176	1176	1176
143	549	588	676	776	832	891	1024	1098	1176	1261	1261	1261	1261	1261
144	588	630	724	832	891	955	1098	1176	1261	1351	1351	1351	1351	1351
145	630	676	776	891	955	1024	1176	1261	1351	1448	1448	1448	1448	1448
146	676	724	832	955	1024	1098	1261	1351	1448	1552	1552	1552	1552	1552
147	724	776	891	1024	1098	1176	1351	1448	1552	1664	1664	1664	1664	1664
148	776	832	955	1098	1176	1261	1448	1552	1664	1783	1783	1783	1783	1783
149	832	891	1024	1176	1261	1351	1552	1664	1783	1911	1911	1911	1911	1911
150	891	955	1098	1261	1351	1448	1664	1783	1911	2048	2048	2048	2048	2048

	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000
29					1.00	1.00				
30				1.00	1.07	1.07	1.00			
31				1.07	1.15	1.15	1.07	1.00		
32			1.00	1.15	1.23	1.23	1.15	1.07		
33			1.07	1.23	1.32	1.32	1.23	1.15		
34		1.00	1.15	1.32	1.41	1.41	1.32	1.23		
35		1.07	1.23	1.41	1.51	1.51	1.41	1.32		
36		1.15	1.32	1.51	1.62	1.62	1.51	1.41		
37		1.23	1.41	1.62	1.74	1.74	1.62	1.51	1.00	
38	1.00	1.32	1.51	1.74	1.86	1.86	1.74	1.62	1.10	
39	1.07	1.41	1.62	1.86	1.99	1.99	1.86	1.74	1.21	
40	1.15	1.51	1.74	1.99	2.14	2.14	1.99	1.86	1.34	
41	1.23	1.62	1.86	2.14	2.29	2.29	2.14	1.99	1.48	1.00
42	1.32	1.74	1.99	2.29	2.45	2.45	2.29	2.14	1.63	1.10
43	1.41	1.86	2.14	2.45	2.63	2.63	2.45	2.29	1.79	1.21
44	1.52	1.99	2.29	2.63	2.81	2.81	2.63	2.45	1.99	1.34
45	1.62	2.14	2.45	2.81	3.02	3.02	2.81	2.63	2.14	1.48
46	1.74	2.29	2.63	3.02	3.23	3.23	3.02	2.81	2.29	1.63
47	1.87	2.45	2.81	3.23	3.46	3.46	3.23	3.02	2.45	1.79
48	2.00	2.63	3.02	3.46	3.71	3.71	3.46	3.23	2.63	1.98
49	2.14	2.81	3.23	3.71	3.97	3.97	3.71	3.46	2.81	2.18
50	2.30	3.02	3.46	3.97	4.26	4.26	3.97	3.71	3.02	2.40
51	2.46	3.23	3.71	4.26	4.56	4.56	4.26	3.97	3.23	2.63
52	2.64	3.46	3.97	4.56	4.89	4.89	4.56	4.26	3.46	2.81
53	2.83	3.71	4.26	4.89	5.24	5.24	4.89	4.56	3.71	3.02
54	3.03	3.97	4.56	5.24	5.61	5.61	5.24	4.89	3.97	3.23
55	3.25	4.26	4.89	5.61	6.01	6.01	5.61	5.24	4.26	3.46
56	3.48	4.56	5.24	6.01	6.44	6.44	6.01	5.61	4.56	3.71
57	3.73	4.89	5.61	6.44	6.90	6.90	6.44	6.01	4.89	3.97
58	4.00	5.24	6.01	6.90	7.39	7.39	6.90	6.44	5.24	4.26
59	4.29	5.61	6.44	7.39	7.92	7.92	7.39	6.90	5.61	4.56
60	4.59	6.01	6.90	7.92	8.49	8.49	7.92	7.39	6.01	4.89
61	4.92	6.44	7.39	8.49	9.09	9.09	8.49	7.92	6.44	5.24
62	5.28	6.90	7.92	9.09	9.74	9.74	9.09	8.49	6.90	5.61
63	5.66	7.39	8.49	9.74	10.4	10.4	9.74	9.09	7.39	6.01
64	6.06	7.92	9.09	10.4	11.2	11.2	10.4	9.74	7.92	6.44
65	6.50	8.49	9.74	11.2	12.0	12.0	11.2	10.4	8.49	6.90
66	6.96	9.09	10.4	12.0	12.8	12.8	12.0	11.2	9.09	7.39
67	7.46	9.74	11.2	12.8	13.8	13.8	12.8	12.0	9.74	7.92
68	8.00	10.4	12.0	13.8	14.7	14.7	13.8	12.8	10.4	8.49
69	8.57	11.2	12.8	14.7	15.8	15.8	14.7	13.8	11.2	9.09
70	9.19	12.0	13.8	15.8	16.9	16.9	15.8	14.7	12.0	9.74
71	9.85	12.8	14.7	16.9	18.1	18.1	16.9	15.8	12.8	10.4
72	10.6	13.8	15.8	18.1	19.4	19.4	18.1	16.9	13.8	11.2
73	11.3	14.7	16.9	19.4	20.8	20.8	19.4	18.1	14.7	12.0
74	12.1	15.8	18.1	20.8	22.3	22.3	20.8	19.4	15.8	12.8
75	13.0	16.9	19.4	22.3	23.9	23.9	22.3	20.8	16.9	13.8
76	13.9	18.1	20.8	23.9	25.6	25.6	23.9	22.3	18.1	14.7
77	14.9	19.4	22.3	25.6	27.4	27.4	25.6	23.9	19.4	15.8
78	16.0	20.8	23.9	27.4	29.4	29.4	27.4	25.6	20.8	16.9
79	17.1	22.3	25.6	29.4	31.5	31.5	29.4	27.4	22.3	18.1
80	18.4	23.9	27.4	31.5	33.7	33.7	31.5	29.4	23.9	19.4
81	19.7	25.6	29.4	33.7	36.1	36.1	33.7	31.5	25.6	20.8
82	21.1	27.4	31.5	36.1	38.7	38.7	36.1	33.7	27.4	22.3
83	22.6	29.4	33.7	38.7	41.5	41.5	38.7	36.1	29.4	23.9
84	24.3	31.5	36.1	41.5	44.4	44.4	41.5	38.7	31.5	25.6
85	26.0	33.7	38.7	44.4	47.6	47.6	44.4	41.5	33.7	27.4
86	27.9	36.1	41.5	47.6	51.0	51.0	47.6	44.4	36.1	29.4
87	29.9	38.7	44.4	51.0	54.7	54.7	51.0	47.6	38.7	31.5
88	32.0	41.5	47.6	54.7	58.6	58.6	54.7	51.0	41.5	33.7
89	34.3	44.4	51.0	58.6	62.7	62.7	58.6	54.7	44.4	36.1
90	36.8	47.6	54.7	62.7	67.2	67.2	62.7	58.6	47.6	38.7
91	39.4	51.0	58.6	67.2	72.0	72.0	67.2	62.7	51.0	41.5
92	42.2	54.7	62.7	72.0	77.2	77.2	72.0	67.2	54.7	44.4
93	45.3	58.6	67.2	77.2	82.7	82.7	77.2	72.0	58.6	47.6
94	48.5	62.7	72.0	82.7	88.6	88.6	82.7	77.2	62.7	51.0
95	52.0	67.2	77.2	88.6	94.9	94.9	88.6	82.7	67.2	54.7
96	55.7	72.0	82.7	94.9	102	102	94.9	88.6	72.0	58.6
97	59.7	77.2	88.6	102	109	109	102	94.9	77.2	62.7
98	64.0	82.7	94.9	109	117	117	109	102	82.7	67.2
99	68.6	88.6	102	117	125	125	117	109	88.6	72.0
100	73.5	94.9	109	125	134	134	125	117	94.9	77.2
101	78.8	102	117	134	144	144	134	125	102	82.7
102	84.4	109	125	144	154	154	144	134	109	88.6
103	90.5	117	134	154	165	165	154	144	117	94.9
104	97.0	125	144	165	177	177	165	154	125	102
105	104	134	154	177	189	189	177	165	134	109
106	111	144	165	189	203	203	189	177	144	117
107	119	154	177	203	217	217	203	189	154	125
108	128	165	189	217	233	233	217	203	165	134
109	137	177	203	233	249	249	233	217	177	144
110	147	189	217	249	267	267	249	233	189	154
111	158	203	233	267	286	286	267	249	203	165
112	169	217	249	286	307	307	286	267	217	177
113	181	233	267	307	329	329	307	286	233	189
114	194	249	286	329	352	352	329	307	249	203
115	208	267	307	352	377	377	352	329	267	217
116	223	286	329	377	404	404	377	352	286	233
117	239	307	352	404	433	433	404	377	307	249
118	256	329	377	433	464	464	433	404	329	267
119	274	352	404	464	497	497	464	433	352	286
120	294	377	433	497	533	533	497	464	377	307
121	315	404	464	533	571	571	533	497	404	329
122	338	433	497	571	611	611	571	533	433	352
123	362	464	533	611	655	655	611	571	464	377
124	388	497	571	655	702	702	655	611	497	404
125	416	533	611	702	752	752	702	655	533	433
126	446	571	655	752	806	806	752	702	571	464
127	478	611	702	806	863	863	806	752	611	497
128	512	655	752	863	925	925	863	806	655	533
129	549	702	806	925	991	991	925	863	702	571
130	588	752	863	991	1062	1062	991	925	752	611
131	630	806	925	1062	1137	1137	1062	991	806	655
132	676	863	991	1137	1219	1219	1137	1062	863	702
133	724	925	1062	1219	1306	1306	1219	1137	925	752
134	776	991	1137	1306	1399	1399	1306	1219	991	806
135	832	1062	1219	1399	1499	1499	1399	1306	1062	863
136	891	1137	1306	1499	1606	1606	1499	1399	1137	925
137	955	1219	1399	1606	1721	1721	1606	1499	1219	991
138	1024	1306	1499	1721	1844	1844	1721	1606	1306	1062
139	1098	1399	1606	1844	1975	1975	1844	1721	1399	1137
140	1176	1499	1721	1975			1975	1844	1499	1219
141	1261	1606	1844					1975	1606	1306
142	1351	1721	1975						1721	1399
143	1448	1844							1844	1499
144	1552	1975							1975	1606
145	1664									1721
146	1783									1844
147	1911									1975
148	2048									
149										
150										

The number of significant figures in the above Table does not necessarily indicate the precision of the measurements of noisiness.

Fig.(A.1)

From Reference (8)



dB correction to be added to SPL of band that exceeds adjacent bands by amount on abscissa. The parameter is band-center frequency.

Fig.(A.2)

From Reference (10)

In order to facilitate programming the calculation of perceived noisiness with a digital computer, the following information is provided.

The value of n in noy in Table 2 is related to the band pressure level L by the equation :

$$n = 10^{m\,(L - L_0)}$$

where m and L_0 depend on the band centre frequency and on the range of L. For the bands with centre frequency from 400 to 6300 Hz inclusive, single values of m and L_0 suffice to define the noy value in each band. For each other band it is necessary to define two values of m and L_0 depending on whether L is greater or less than a critical value.

The coefficients m and L_0 are given in Table 3 below.

Coefficients m and L_0

Band centre frequency (Hz)	Lower range of L			Upper range of L		
	L	m	L_0	L	m	L_0
50	64 to 91	0.043 48	64	92 to 150	0.030 10	52
63	60 to 85	0.040 57	60	86 to 150	0.030 10	51
80	56 to 85	0.036 83	56	86 to 150	0.030 10	49
100	53 to 79	0.036 83	53	80 to 150	0.030 10	47
125	51 to 79	0.035 34	51	80 to 150	0.030 10	46
160	48 to 75	0.033 33	48	76 to 150	0.030 10	45
200	46 to 73	0.033 33	46	74 to 150	0.030 10	43
250	44 to 74	0.032 05	44	75 to 150	0.030 10	42
315	42 to 94	0.030 68	42	95 to 150	0.030 10	41
	Full range of L					
400				40 to 150	0.030 10	40
500				40 to 150	0.030 10	40
630				40 to 150	0.030 10	40
800				40 to 150	0.030 10	40
1 000				40 to 150	0.030 10	40
1 250				38 to 148	0.030 10	38
1 600				34 to 144	0.029 96	34
2 000				32 to 142	0.029 96	32
2 500				30 to 140	0.029 96	30
3 150				29 to 139	0.029 96	29
4 000				29 to 139	0.029 96	29
5 000				30 to 140	0.029 96	30
6 300				31 to 141	0.029 96	31
	Lower range of L			Upper range of L		
8 000	38 to 47	0.042 29	37	48 to 144	0.029 96	34
10 000	41 to 50	0.042 29	41	51 to 147	0.029 96	37

Fig.(A.3)

From Reference(8)

APPENDIX B

Typical computer output

INTERVAL (.5 SEC)	PERC.NOISE LEVEL (TONE CORRECTED)	DB(A)	DIFFA	DB(D)	DIFFB
1	105.07	93.68	11.4	100.71	4.4
2	104.26	93.55	10.7	100.85	3.4
3	103.01	91.75	11.3	98.58	4.4
4	106.47	96.81	9.7	105.08	1.4
5	109.02	97.82	11.2	105.82	3.2
6	111.34	99.46	11.9	107.65	3.7
7	112.00	102.96	9.0	110.73	1.3
8	118.49	103.26	15.2	111.95	6.5
9	117.25	102.79	14.5	110.49	6.8
10	116.15	104.25	11.9	111.60	4.5
11	120.80	106.47	14.3	114.54	6.3
12	122.03	107.75	14.3	115.67	6.4
13	118.39	107.60	10.8	114.56	3.8
14	117.80	107.33	10.5	113.57	4.2
15	113.35	104.73	8.6	110.45	2.9
16	112.13	103.61	8.5	109.45	2.7
17	109.38	103.43	6.0	108.96	.4
18	103.59	101.10	2.5	106.50	-2.9
19	101.35	100.66	.7	105.83	-4.5
20	102.22	99.45	2.8	104.69	-2.5
21	102.36	98.57	3.8	103.83	-1.5
22	97.22	95.16	2.1	100.54	-3.3
23	96.39	93.99	2.4	99.56	-3.2
24	95.50	93.58	1.9	99.00	-3.5
25	96.20	91.98	4.2	97.43	-1.2

MAX PERC. NOISE LEVEL = 122.03 PNDB

EFFECTIVE PERC. NOISE LEVEL = 115.51 PNDB

MEAN VALUE OF(PNDBT-DB(A)) = 8.40 STANDARD DEVIATION = 4.51

MEAN VALUE OF(PNDBT-DB(D)) = 1.75 STANDARD DEVIATION = 3.52

Fig.(B.1) Typical results of a flyover noise(takeoff) measured at a distance of approx. 300 ft. from the aircraft.

<u>Note:</u>

DIFFA = PERC. NOISE LEVEL- DB(A)

DIFFD = PERC. NOISE LEVEL- DB(D)

CO-EFFICIENTS OF THE POLONOMIAL (SDIST,PNDBT)

.131614604240089E+03	-.199071270745 28E-01
.356980109081 13E-05	-.351211133877 52E-09
.204331563201 50E-13	-.743202140542 15E-18
.173577347422 31E-22	-.260203330937 83E-27
.242026564627 40E-32	-.127167428040 92E-37
.288522005412 28E-43	

Results

The theoretical prediction of aircraft noise

(Takeoff)

(FT)	THEORY.	POLYNOMIAL APPROXN.	ABS.DIFF.
200.00	134.26	127.77	6.48
400.00	126.90	124.20	2.70
600.00	122.06	120.88	1.18
800.00	117.67	117.80	-.13
1000.00	114.45	114.95	-.50
1200.00	111.61	112.30	-.69
1400.00	106.78	109.85	-3.07
1600.00	103.44	107.59	-4.15
1800.00	102.08	105.50	-3.42
2000.00	100.84	103.57	-2.74
2200.00	99.68	101.80	-2.12
2400.00	98.60	100.17	-1.57
2600.00	97.58	98.67	-1.08
2800.00	96.62	97.29	-.67
3000.00	95.71	96.03	-.32
3200.00	94.83	94.87	-.04
3400.00	93.99	93.81	.18
3600.00	91.95	92.85	-.90
3800.00	91.47	91.96	-.49
4000.00	91.02	91.16	-.14
4200.00	90.60	90.43	.17
4400.00	90.34	89.77	.57
4600.00	89.94	89.17	.78
4800.00	89.57	88.62	.95
5000.00	89.21	88.12	1.08
5200.00	88.86	87.67	1.19
5400.00	88.53	87.27	1.26
5600.00	88.21	86.90	1.31
5800.00	87.90	86.57	1.33
6000.00	87.60	86.27	1.33
6200.00	87.31	85.99	1.31
6400.00	87.03	85.75	1.28
6600.00	86.75	85.52	1.23
6800.00	86.49	85.32	1.17
7000.00	86.23	85.13	1.10
7200.00	85.99	84.96	1.03
7400.00	85.74	84.80	.94
7600.00	85.51	84.65	.85
7800.00	85.28	84.52	.76
8000.00	85.06	84.39	.67
8200.00	84.84	84.27	.57
8400.00	84.62	84.15	.47
8600.00	84.42	84.04	.38
8800.00	84.21	83.93	.28
9000.00	84.01	83.83	.19
9200.00	83.82	83.72	.10
9400.00	83.63	83.62	.01
9600.00	83.44	83.52	-.08
9800.00	83.26	83.41	-.16
10000.00	83.08	83.31	-.23
10200.00	82.90	83.20	-.30
10400.00	82.73	83.10	-.36
10600.00	82.56	82.99	-.42
10800.00	82.40	82.87	-.48
11000.00	82.23	82.76	-.53
11200.00	82.07	82.64	-.57

[illegible]	[illegible]	[illegible]	-.60
11600.00	81.76	82.40	-.64
11800.00	81.61	82.27	-.66
12000.00	81.46	82.14	-.68
12200.00	81.31	82.01	-.70
12400.00	81.16	81.87	-.71
12600.00	81.02	81.74	-.72
12800.00	80.88	81.59	-.72
13000.00	80.74	81.45	-.71
13200.00	80.60	81.31	-.70
13400.00	80.34	81.16	-.82
13600.00	80.21	81.01	-.80
13800.00	80.08	80.86	-.78
14000.00	79.95	80.70	-.76
14200.00	79.82	80.55	-.73
14400.00	79.69	80.39	-.70
14600.00	79.57	80.24	-.67
14800.00	79.45	80.08	-.63
15000.00	79.33	79.92	-.60
15200.00	79.21	79.76	-.56
15400.00	79.09	79.61	-.52
15600.00	78.98	79.45	-.47
15800.00	78.86	79.29	-.43
16000.00	78.75	79.13	-.38
16200.00	78.64	78.97	-.34
16400.00	78.53	78.82	-.29
16600.00	78.42	78.66	-.25
16800.00	78.31	78.51	-.20
17000.00	78.20	78.36	-.15
17200.00	78.10	78.21	-.11
17400.00	78.00	78.06	-.06
17600.00	77.89	77.91	-.02
17800.00	77.79	77.77	.02
18000.00	77.69	77.62	.07
18200.00	77.59	77.48	.11
18400.00	77.49	77.35	.15
18600.00	77.40	77.21	.19
18800.00	77.30	77.08	.22
19000.00	77.21	76.95	.26
19200.00	77.11	76.82	.29
19400.00	77.02	76.70	.32
19600.00	76.93	76.57	.35
19800.00	76.84	76.46	.38
20000.00	76.75	76.34	.41
20200.00	76.66	76.23	.43
20400.00	76.57	76.12	.45
20600.00	76.48	76.01	.47
20800.00	76.39	75.91	.49
21000.00	76.31	75.81	.50
21200.00	76.22	75.71	.51
21400.00	76.14	75.62	.52
21600.00	76.06	75.52	.53
21800.00	75.97	75.44	.54
22000.00	75.89	75.35	.54
22200.00	75.81	75.27	.54
22400.00	75.73	75.19	.54
22600.00	75.65	75.11	.54
22800.00	75.57	75.04	.53
23000.00	75.49	74.97	.53
23200.00	75.41	74.90	.52

		[illegible]	.51
	75.26	74.77	.50
23800.00	75.19	74.70	.48
24000.00	75.11	74.64	.47
24200.00	75.04	74.59	.45
24400.00	74.96	74.53	.43
24600.00	74.89	74.48	.41
24800.00	74.82	74.42	.39
25000.00	74.74	74.37	.37
25200.00	74.67	74.33	.35
25400.00	74.60	74.28	.32
25600.00	74.53	74.23	.30
25800.00	74.46	74.19	.27
26000.00	74.39	74.14	.25
26200.00	74.32	74.10	.22
26400.00	74.26	74.06	.20
26600.00	74.19	74.02	.17
26800.00	74.12	73.98	.14
27000.00	74.05	73.94	.11
27200.00	73.99	73.90	.08
27400.00	73.92	73.87	.06
27600.00	73.86	73.83	.03
27800.00	73.79	73.79	.00
28000.00	73.73	73.75	-.03
28200.00	73.67	73.72	-.05
28400.00	73.60	73.68	-.08
28600.00	73.54	73.64	-.11
28800.00	73.48	73.61	-.13
29000.00	73.41	73.57	-.16
29200.00	73.35	73.53	-.18
29400.00	73.29	73.49	-.20
29600.00	73.23	73.46	-.22
29800.00	73.17	73.42	-.25
30000.00	73.11	73.38	-.27
30200.00	73.05	73.34	-.29
30400.00	72.99	73.30	-.30
30600.00	72.93	73.25	-.32
30800.00	72.87	73.21	-.34
31000.00	72.82	73.17	-.35
31200.00	72.76	73.12	-.37
31400.00	72.70	73.08	-.38
31600.00	72.64	73.03	-.39
31800.00	72.59	72.99	-.40
32000.00	72.53	72.94	-.41
32200.00	72.48	72.89	-.41
32400.00	72.42	72.84	-.42
32600.00	72.37	72.79	-.42
32800.00	72.31	72.74	-.43
33000.00	72.26	72.69	-.43
33200.00	72.20	72.63	-.43
33400.00	72.15	72.58	-.43
33600.00	72.09	72.52	-.43
33800.00	72.04	72.47	-.42
34000.00	71.99	72.41	-.42
34200.00	71.94	72.35	-.41
34400.00	71.88	72.29	-.41
34600.00	71.83	72.23	-.40
34800.00	71.78	72.17	-.39
35000.00	71.73	72.11	-.38
35200.00	71.68	72.04	-.36

		[illegible]	[illegible]
[illegible]	71.58	71.91	-.34
35800.00	71.53	71.85	-.32
36000.00	71.48	71.78	-.31
36200.00	71.43	71.72	-.29
36400.00	71.38	71.65	-.27
36600.00	71.33	71.58	-.25
36800.00	71.28	71.52	-.24
37000.00	71.23	71.45	-.22
37200.00	71.18	71.38	-.20
37400.00	71.14	71.31	-.18
37600.00	71.09	71.24	-.15
37800.00	71.04	71.17	-.13
38000.00	70.99	71.10	-.11
38200.00	70.95	71.03	-.09
38400.00	70.90	70.97	-.07
38600.00	70.85	70.90	-.04
38800.00	70.81	70.83	-.02
39000.00	70.76	70.76	.00
39200.00	70.71	70.69	.02
39400.00	70.67	70.62	.05
39600.00	70.62	70.55	.07
39800.00	70.58	70.49	.09
40000.00	70.53	70.42	.11
40200.00	70.49	70.35	.13
40400.00	70.44	70.29	.16
40600.00	70.40	70.22	.18
40800.00	70.36	70.16	.20
41000.00	70.31	70.10	.22
41200.00	70.27	70.03	.24
41400.00	70.22	69.97	.25
41600.00	70.18	69.91	.27
41800.00	70.14	69.85	.29
42000.00	70.10	69.79	.30
42200.00	70.05	69.73	.32
42400.00	70.01	69.68	.33
42600.00	69.97	69.62	.35
42800.00	69.93	69.57	.36
43000.00	69.89	69.51	.37
43200.00	69.84	69.46	.38
43400.00	69.80	69.41	.39
43600.00	69.76	69.36	.40
43800.00	69.72	69.32	.40
44000.00	69.68	69.27	.41
44200.00	69.64	69.22	.41
44400.00	69.60	69.18	.42
44600.00	69.56	69.14	.42
44800.00	69.52	69.10	.42
45000.00	69.48	69.06	.42
45200.00	69.44	69.02	.42
45400.00	69.40	68.98	.42
45600.00	69.36	68.95	.41
45800.00	69.32	68.92	.41
46000.00	69.28	68.88	.40
46200.00	69.24	68.85	.39
46400.00	69.20	68.82	.38
46600.00	69.17	68.80	.37
46800.00	69.13	68.77	.36
47000.00	69.09	68.74	.35
47200.00	69.05	68.72	.33

		68.70	.32
	68.98	68.68	.30
47800.00	68.94	68.66	.28
48000.00	68.90	68.64	.26
48200.00	68.86	68.62	.24
48400.00	68.83	68.61	.22
48600.00	68.79	68.59	.20
48800.00	68.75	68.58	.18
49000.00	68.72	68.56	.15
49200.00	68.68	68.55	.13
49400.00	68.64	68.54	.10
49600.00	68.61	68.53	.07
49800.00	68.57	68.52	.05
50000.00	68.53	68.52	.02
50200.00	68.50	68.51	-.01
50400.00	68.46	68.50	-.04
50600.00	68.43	68.50	-.07
50800.00	68.39	68.49	-.10
51000.00	68.36	68.49	-.13
51200.00	68.32	68.49	-.16
51400.00	68.29	68.48	-.20
51600.00	68.25	68.48	-.23
51800.00	68.22	68.48	-.26
52000.00	68.18	68.48	-.30
52200.00	68.15	68.48	-.33
52400.00	68.11	68.48	-.36
52600.00	68.08	68.48	-.40
52800.00	68.05	68.48	-.43
53000.00	68.01	68.48	-.46
53200.00	67.98	68.48	-.50
53400.00	67.95	68.48	-.53
53600.00	67.91	68.48	-.57
53800.00	67.88	68.48	-.60
54000.00	67.85	68.48	-.63
54200.00	67.81	68.48	-.67
54400.00	67.78	68.48	-.70
54600.00	67.75	68.48	-.73
54800.00	67.71	68.48	-.76
55000.00	67.68	68.48	-.80
55200.00	67.65	68.48	-.83
55400.00	67.62	68.47	-.86
55600.00	67.58	68.47	-.89
55800.00	67.55	68.47	-.92
56000.00	67.52	68.47	-.95
56200.00	67.49	68.46	-.98
56400.00	67.46	68.46	-1.01
56600.00	67.42	68.46	-1.03
56800.00	68.90	68.45	.45
57000.00	68.88	68.45	.43
57200.00	68.86	68.44	.42
57400.00	68.84	68.44	.41
57600.00	68.82	68.43	.39
57800.00	68.80	68.42	.38
58000.00	68.79	68.42	.37
58200.00	68.77	68.41	.36
58400.00	68.75	68.40	.35
58600.00	68.73	68.39	.34
58800.00	68.71	68.38	.33
59000.00	68.69	68.37	.32
59200.00	68.67	68.36	.32

		[illegible]	.31
	[illegible].64	68.33	.31
[illegible]	68.62	68.32	.30
60000.00	68.60	68.31	.29
60200.00	68.58	68.29	.29
60400.00	68.57	68.28	.29
60600.00	68.55	68.27	.28
60800.00	68.53	68.25	.28
61000.00	68.51	68.24	.28
61200.00	68.50	68.22	.28
61400.00	68.48	68.21	.28
61600.00	68.46	68.19	.27
61800.00	68.45	68.17	.27
62000.00	68.43	68.16	.27
62200.00	68.41	68.14	.27
62400.00	68.40	68.12	.27
62600.00	68.38	68.11	.27
62800.00	68.36	68.09	.27
63000.00	68.35	68.07	.27
63200.00	68.33	68.06	.27
63400.00	68.31	68.04	.27
63600.00	68.30	68.02	.28
63800.00	68.28	68.01	.28
64000.00	68.27	67.99	.28
64200.00	68.25	67.97	.28
64400.00	68.24	67.96	.28
64600.00	68.22	67.94	.28
64800.00	67.89	67.93	-.03
65000.00	67.88	67.91	-.03
65200.00	67.86	67.90	-.03
65400.00	67.85	67.88	-.03
65600.00	67.84	67.87	-.03
65800.00	67.82	67.86	-.04
66000.00	67.81	67.84	-.04
66200.00	67.79	67.83	-.04
66400.00	67.78	67.82	-.04
66600.00	67.76	67.81	-.04
66800.00	67.75	67.79	-.05
67000.00	67.73	67.78	-.05
67200.00	67.72	67.77	-.05
67400.00	67.71	67.76	-.06
67600.00	67.69	67.75	-.06
67800.00	67.68	67.74	-.06
68000.00	67.66	67.73	-.07
68200.00	67.65	67.72	-.07
68400.00	67.64	67.71	-.08
68600.00	67.62	67.71	-.08
68800.00	67.61	67.70	-.09
69000.00	67.60	67.69	-.09
69200.00	67.58	67.68	-.10
69400.00	67.57	67.67	-.10
69600.00	67.56	67.67	-.11
69800.00	67.54	67.66	-.11
70000.00	67.53	67.65	-.12
70200.00	67.52	67.64	-.12
70400.00	67.51	67.63	-.13
70600.00	67.49	67.63	-.13
70800.00	67.48	67.62	-.13
71000.00	67.47	67.61	-.14
71200.00	67.46	67.60	-.14

		[illegible]	-.14
	67.43	67.57	-.14
[illegible]	67.42	67.56	-.14
72000.00	67.41	67.55	-.14
72200.00	67.39	67.54	-.14
72400.00	67.38	67.52	-.14
72600.00	67.37	67.50	-.13
72800.00	67.36	67.49	-.13
73000.00	67.35	67.47	-.12
73200.00	67.34	67.45	-.12
73400.00	67.32	67.43	-.11
73600.00	67.31	67.41	-.10
73800.00	67.30	67.39	-.09
74000.00	67.29	67.36	-.08
74200.00	67.28	67.34	-.06
74400.00	67.27	67.31	-.05
74600.00	67.26	67.29	-.03
74800.00	67.24	67.26	-.02
75000.00	67.23	67.23	.00
75200.00	67.22	67.20	.02
75400.00	67.21	67.17	.04
75600.00	67.20	67.14	.06
75800.00	67.19	67.11	.08
76000.00	67.18	67.08	.10
76200.00	67.17	67.05	.12
76400.00	67.16	67.02	.13
76600.00	67.15	67.00	.15
76800.00	67.14	66.97	.17
77000.00	67.13	66.95	.18
77200.00	67.12	66.93	.19
77400.00	67.11	66.91	.20
77600.00	67.09	66.89	.20
77800.00	67.08	66.89	.20
78000.00	67.07	66.88	.19
78200.00	67.06	66.89	.18
78400.00	67.05	66.90	.16
78600.00	67.04	66.92	.13
78800.00	67.03	66.95	.09
79000.00	67.03	66.99	.04
79200.00	67.02	67.04	-.02
79400.00	67.01	67.11	-.10
79600.00	67.00	67.19	-.19
79800.00	66.99	67.29	-.30
80000.00	66.98	67.41	-.43

Results

The developed polynomial

(Landing)

1	200.0	124.96	116.96
2	220.0	124.45	116.65
3	240.0	123.93	116.32
4	260.0	123.43	115.99
5	280.0	122.93	115.65
6	300.0	122.44	115.30
7	320.0	121.95	114.95
8	340.0	121.47	114.60
9	360.0	121.00	114.25
10	380.0	120.53	113.90
11	400.0	120.07	113.55
12	420.0	119.61	113.19
13	440.0	119.16	112.84
14	460.0	118.72	112.49
15	480.0	118.28	112.14
16	500.0	117.85	111.80
17	520.0	117.42	111.45
18	540.0	117.00	111.11
19	560.0	116.58	110.77
20	580.0	116.17	110.43
21	600.0	115.76	110.10
22	620.0	115.36	109.77
23	640.0	114.96	109.44
24	660.0	114.57	109.11
25	680.0	114.18	108.79
26	700.0	113.80	108.46
27	720.0	113.42	108.15
28	740.0	113.04	107.83
29	760.0	112.67	107.52
30	780.0	112.31	107.21
31	800.0	111.95	106.90
32	820.0	111.59	106.60
33	840.0	111.24	106.30
34	860.0	110.89	106.00
35	880.0	110.55	105.70
36	900.0	110.21	105.41
37	920.0	109.87	105.12
38	940.0	109.54	104.84
39	960.0	109.21	104.55
40	980.0	108.89	104.27
41	1000.0	108.57	103.99
42	1200.0	105.54	101.36
43	1400.0	102.83	98.97
44	1600.0	100.36	96.79
45	1800.0	98.11	94.79
46	2000.0	96.03	92.94
47	2200.0	94.10	91.21
48	2400.0	92.28	89.57
49	2600.0	90.55	88.02
50	2800.0	88.90	86.52
51	3000.0	87.31	85.08
52	3200.0	85.77	83.67
53	3400.0	84.26	82.29
54	3600.0	82.78	80.94
55	3800.0	81.32	79.60
56	4000.0	79.89	78.27
57	4200.0	78.48	76.96

		[illegible]	74.37
	4800.0	74.33	73.10
61	5000.0	72.99	71.84
62	5200.0	71.66	70.60
63	5400.0	70.36	69.38
64	5600.0	69.09	68.19
65	5800.0	67.84	67.02
66	6000.0	66.63	65.87
67	6200.0	65.45	64.76
68	6400.0	64.31	63.69
69	6600.0	63.20	62.65
70	6800.0	62.14	61.65
71	7000.0	61.12	60.69
72	7200.0	60.14	59.77
73	7400.0	59.21	58.90
74	7600.0	58.33	58.08
75	7800.0	57.49	57.30
76	8000.0	56.71	56.56
77	8200.0	55.97	55.88
78	8400.0	55.28	55.24
79	8600.0	54.64	54.65
80	8800.0	54.05	54.11
81	9000.0	53.50	53.61
82	9200.0	53.00	53.15
83	9400.0	52.54	52.74
84	9600.0	52.12	52.37
85	9800.0	51.75	52.04
86	10000.0	51.41	51.74
87	10200.0	51.11	51.48
88	12000.0	49.61	50.33
89	14000.0	49.00	50.05
90	16000.0	47.87	49.20
91	18000.0	45.87	47.45
92	20000.0	43.72	45.53
93	22000.0	42.29	44.30
94	24000.0	41.86	44.05
95	26000.0	41.93	44.30
96	28000.0	41.75	44.27
97	30000.0	40.99	43.67
98	32000.0	40.15	42.96
99	34000.0	39.98	42.92
100	36000.0	40.33	43.39

Results

The Developed polynomials

(Takeoff)

			PA	PB	PC	PD
1	200.0	127.77	120.98	120.98	120.98	124.98
2	220.0	127.40	120.77	120.77	120.77	124.77
3	240.0	127.04	120.56	120.56	120.56	124.56
4	260.0	126.67	120.33	120.33	120.33	124.33
5	280.0	126.31	120.10	120.10	120.10	124.10
6	300.0	125.95	119.86	119.86	119.86	123.86
7	320.0	125.60	119.62	119.62	119.62	123.62
8	340.0	125.25	119.37	119.37	119.37	123.37
9	360.0	124.89	119.12	119.12	119.12	123.12
10	380.0	124.55	118.87	118.87	118.87	122.87
11	400.0	124.20	118.61	118.61	118.61	122.61
12	420.0	123.86	118.35	118.35	118.35	122.35
13	440.0	123.52	118.09	118.09	118.09	122.09
14	460.0	123.18	117.83	117.83	117.83	121.83
15	480.0	122.84	117.57	117.57	117.57	121.57
16	500.0	122.51	117.31	117.31	117.31	121.31
17	520.0	122.18	117.04	117.04	117.04	121.04
18	540.0	121.85	116.78	116.78	116.78	120.78
19	560.0	121.53	116.52	116.52	116.52	120.52
20	580.0	121.20	116.26	116.26	116.26	120.26
21	600.0	120.88	115.99	115.99	115.99	119.99
22	620.0	120.56	115.73	115.73	115.73	119.73
23	640.0	120.25	115.47	115.47	115.47	119.47
24	660.0	119.93	115.21	115.21	115.21	119.21
25	680.0	119.62	114.95	114.95	114.95	118.95
26	700.0	119.31	114.69	114.69	114.69	118.69
27	720.0	119.01	114.44	114.44	114.44	118.44
28	740.0	118.70	114.18	114.18	114.18	118.18
29	760.0	118.40	113.92	113.92	113.92	117.92
30	780.0	118.10	113.67	113.67	113.67	117.67
31	800.0	117.80	113.41	113.41	113.41	117.41
32	820.0	117.51	113.16	113.16	113.16	117.16
33	840.0	117.21	112.91	112.91	112.91	116.91
34	860.0	116.92	112.66	112.66	112.66	116.66
35	880.0	116.63	112.41	112.41	112.41	116.41
36	900.0	116.35	112.16	112.16	112.16	116.16
37	920.0	116.06	111.92	111.92	111.92	115.92
38	940.0	115.78	111.67	111.67	111.67	115.67
39	960.0	115.50	111.43	111.43	111.43	115.43
40	980.0	115.22	111.19	111.19	111.19	115.19
41	1000.0	114.95	110.95	110.95	110.95	114.95
42	1200.0	112.30	108.62	108.62	108.62	112.62
43	1400.0	109.85	106.44	106.44	106.44	110.44
44	1600.0	107.59	104.41	104.41	104.41	108.41
45	1800.0	105.50	102.52	102.52	102.52	106.52
46	2000.0	103.57	100.78	100.78	100.78	104.78
47	2200.0	101.80	99.17	98.44	98.19	102.19
48	2400.0	100.17	97.69	96.29	95.82	99.82
49	2600.0	98.67	96.33	94.31	93.64	97.64
50	2800.0	97.29	95.08	92.50	91.64	95.64
51	3000.0	96.03	93.93	90.82	89.79	93.79
52	3200.0	94.87	92.89	89.29	88.08	92.08
53	3400.0	93.81	91.94	87.87	86.51	90.51
54	3600.0	92.85	91.07	86.56	85.06	89.06
55	3800.0	91.96	90.28	85.36	83.72	87.72
56	4000.0	91.16	89.57	84.25	82.48	86.48
57	4200.0	90.43	88.92	83.24	81.34	85.34

	[illegible]	[illegible]	[illegible]	82.30	80.28	84.28
		89.17	87.82	81.43	79.30	83.30
60	4800.0	88.62	87.34	80.63	78.39	82.39
61	5000.0	88.12	86.92	79.89	77.55	81.55
62	5200.0	87.67	86.54	79.21	76.77	80.77
63	5400.0	87.27	86.20	78.58	76.04	80.04
64	5600.0	86.90	85.89	78.00	75.36	79.36
65	5800.0	86.57	85.62	77.46	74.73	78.73
66	6000.0	86.27	85.38	76.95	74.15	78.15
67	6200.0	85.99	85.16	76.49	73.59	77.59
68	6400.0	85.75	84.97	76.05	73.08	77.08
69	6600.0	85.52	84.80	75.64	72.59	76.59
70	6800.0	85.32	84.65	75.26	72.13	76.13
71	7000.0	85.13	84.51	74.90	71.70	75.70
72	7200.0	84.96	84.39	74.56	71.29	75.29
73	7400.0	84.80	84.28	74.24	70.90	74.90
74	7600.0	84.65	84.18	73.94	70.53	74.53
75	7800.0	84.52	84.09	73.65	70.17	74.17
76	8000.0	84.39	64.00	73.37	69.83	73.83
77	8200.0	84.27	83.92	73.10	69.50	73.50
78	8400.0	84.15	83.85	72.84	69.18	73.18
79	8600.0	84.04	83.78	72.59	68.86	72.86
80	8800.0	83.93	83.71	72.35	68.56	72.56
81	9000.0	83.83	83.64	72.11	68.27	72.27
82	9200.0	83.72	83.58	71.88	67.97	71.97
83	9400.0	83.62	83.51	71.65	67.69	71.69
84	9600.0	83.52	83.45	71.42	67.41	71.41
85	9800.0	83.41	83.38	71.19	67.13	71.13
86	10000.0	83.31	83.31	70.97	66.85	70.85
87	10200.0	83.20	83.24	70.74	66.58	70.58
88	12000.0	82.14	82.46	68.72	64.14	68.14
89	14000.0	80.70	81.29	66.37	61.39	65.39
90	16000.0	79.13	79.95	64.00	58.69	62.69
91	18000.0	77.62	78.64	61.80	56.18	60.18
92	20000.0	76.34	77.54	59.89	54.00	58.00
93	22000.0	75.35	76.72	58.33	52.20	56.20
94	24000.0	74.64	76.16	57.11	50.76	54.76
95	26000.0	74.14	75.80	56.13	49.58	53.58
96	28000.0	73.75	75.54	55.31	48.56	52.56
97	30000.0	73.38	75.29	54.52	47.60	51.60
98	32000.0	72.94	74.96	53.70	46.61	50.61
99	34000.0	72.41	74.53	52.81	45.56	49.56
100	36000.0	71.78	74.01	51.84	44.46	48.46
101	38000.0	71.10	73.42	50.84	43.32	47.32
102	40000.0	70.42	72.83	49.85	42.20	46.20
103	42000.0	69.79	72.28	48.94	41.15	45.15
104	44000.0	69.27	71.84	48.14	40.24	44.24
105	46000.0	68.88	71.53	47.49	39.47	43.47
106	48000.0	68.64	71.36	46.99	38.87	42.87
107	50000.0	68.52	71.31	46.63	38.40	42.40
108	52000.0	68.48	71.34	46.36	38.03	42.03
109	54000.0	68.48	71.41	46.13	37.71	41.71
110	56000.0	68.47	71.46	45.91	37.39	41.39
111	58000.0	68.42	71.47	45.65	37.04	41.04
112	60000.0	68.31	71.42	45.34	36.64	40.64
113	62000.0	68.16	71.33	44.99	36.21	40.21

APPENDIX C

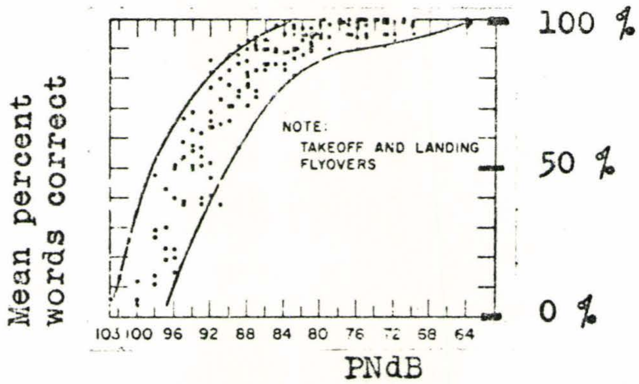


Fig.(C.1) The mean percent words correct plotted against peak levels of aircraft flyover noise. Reference (18)

5 = Mid-point of the category scale.

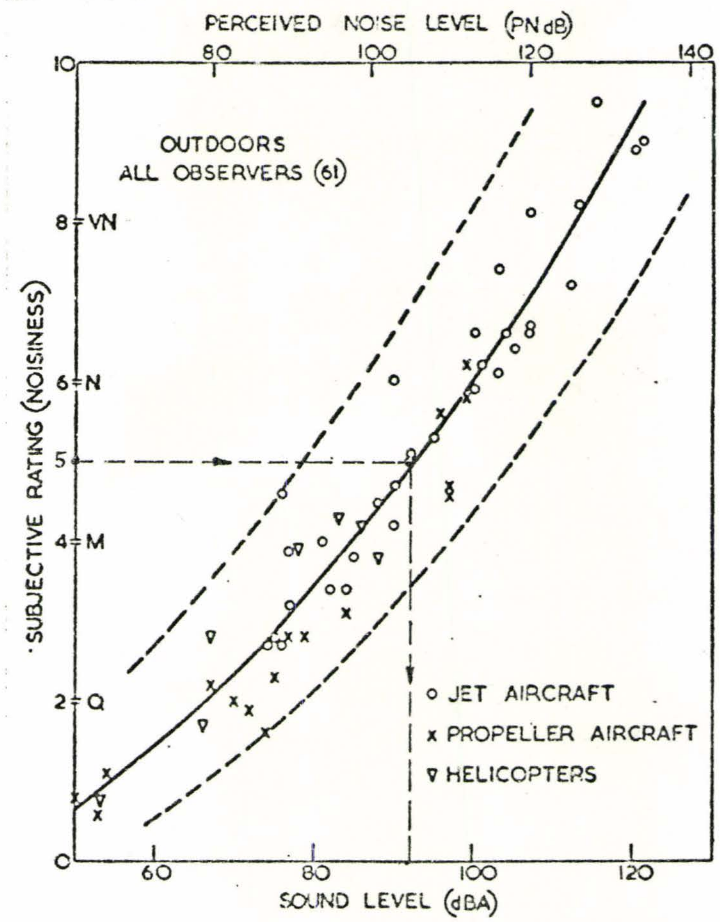


Fig.(C.2) Outdoor judgments on the category scale of noisiness plotted against sound level A and perceived noise level. Reference(19) (Q=quiet , M=moderate , N=noisy and VN= very noisy)

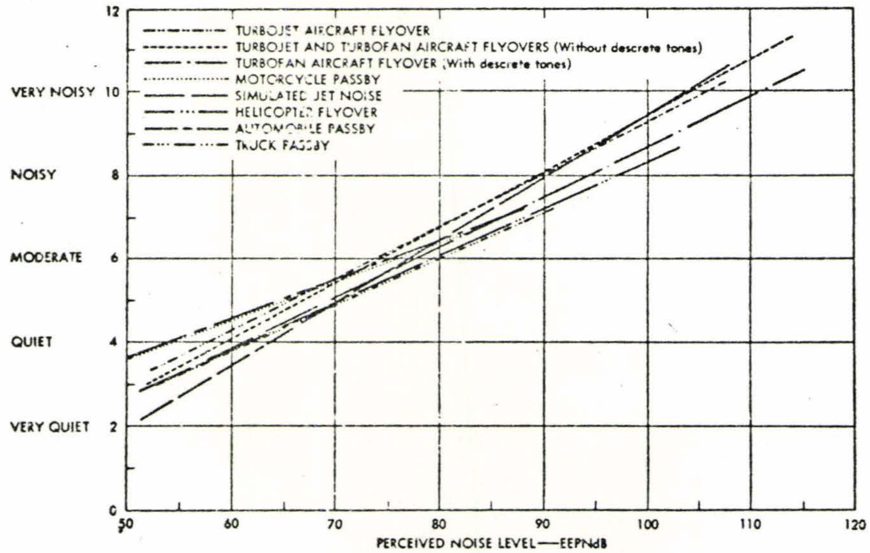


Fig.(C.3) Mean noisiness rating vs. perceived noise level of noise-stimulus groups for all laboratory test sessions. Reference (20)

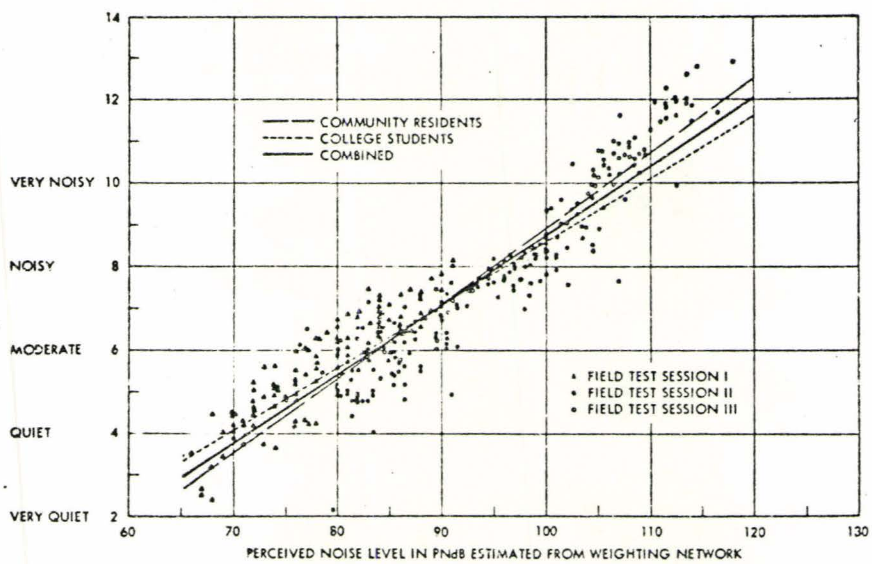


Fig.(C.4) Mean noisiness rating for all stimuli during all field test sessions. Reference(20)

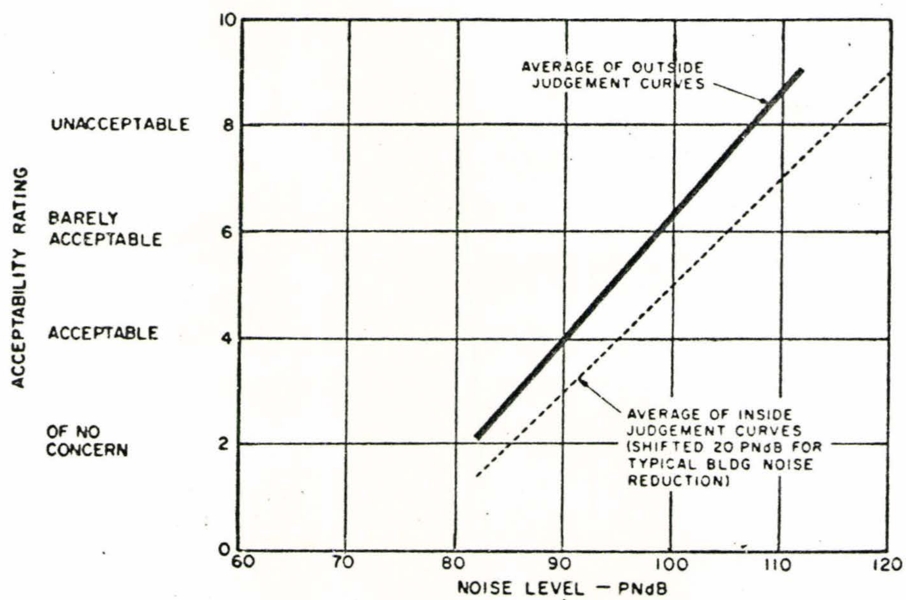


Fig.(C.5) Comparison of average outdoor and indoor acceptability-judgment curves. Combined takeoff- and approach- noise judgments. Reference (21)

COMPATIBLE LAND USE TABLE

From Reference(14)

Aircraft Noise Considerations Only

No	- Indicates that new construction or development of this nature should not be undertaken.
A	- This particular land use may be acceptable in accordance with the appropriate note and subject to the limitations indicated therein.
Yes	- The indicated land use is not considered to be adversely affected by aircraft noise and no special noise insulation should be required for new construction or development of this nature.

Noise Exposure Forecast Value	Over 40	40-35	35-30	Below 30
Response Area	1	2	3	4
Land Use				
1. RESIDENTIAL				
Detached and Semi Detached	No	No	B	A
Town Houses, Garden Homes	No	No	B	A
Apartments	No	No	B	A
2. PUBLIC				
Schools	No	No	D	C
Churches	No	No	D	C
Hospitals	No	No	D	C
Community Centres	No	No	D	C
Auditoriums	No	No	D	C
Libraries	No	No	D	C
Cemeteries	Yes	Yes	Yes	Yes

Noise Exposure Forecast Value	Over 40	40-35	35-30	Below 30
Response Area	1	2	3	4
<u>Land Use</u>				
3. COMMERCIAL				
Offices	F	E	D	Yes
Retail Sales	F	D	Yes	Yes
Restaurants	F	D	D	Yes
Indoor Theatres	No	G	D	Yes
Hotels & Motels	No	F	G	Yes
Parking Lots	Yes	Yes	Yes	Yes
Gasoline Stations	Yes	Yes	Yes	Yes
Warehouses	Yes	Yes	Yes	Yes
Outdoor Sales	E	K	Yes	Yes
4. INDUSTRIAL				
Factories	I	I	Yes	Yes
Machine Shops	I	I	Yes	Yes
Rail Yards	Yes	Yes	Yes	Yes
Ship Yards	Yes	Yes	Yes	Yes
Cement Plants	I	I	Yes	Yes
Quarries	Yes	Yes	Yes	Yes
Refineries	I	I	Yes	Yes
Laboratories	No	D	Yes	Yes
Lumber Yards	Yes	Yes	Yes	Yes
Saw Mills	I	I	Yes	Yes

Noise Exposure Forecast Value	Over 40	40-35	35-30	Below 30
Response Area	1	2	3	4
<u>Land Use</u>				
5. MUNICIPAL UTILITIES				
Electric Generating Plants	Yes	Yes	Yes	Yes
Gas and Oil Storage	Yes	Yes	Yes	Yes
Garbage Disposal	Yes	Yes	Yes	Yes
Sewage Treatment	Yes	Yes	Yes	Yes
Water Treatment	Yes	Yes	Yes	Yes
Water Storage	Yes	Yes	Yes	Yes
6. RECREATIONAL - OUTDOOR				
Athletic Fields	No	J	K	Yes
Stadiums	No	No	K	Yes
Theatres - Outdoor	No	No	No	H
Racetracks - horses	No	K	K	Yes
Racetracks - auto	Yes	Yes	Yes	Yes
Parks and Picnic Areas	No	K	Yes	Yes
Fairgrounds	K	K	Yes	Yes
Golf Courses	Yes	Yes	Yes	Yes
Beaches and Pools	Yes	Yes	Yes	Yes
Tennis Courts	No	K	Yes	Yes
Playgrounds	K	K	Yes	Yes
Marinas	Yes	Yes	Yes	Yes
Camping Grounds	No	No	No	H

Noise Exposure Forecast Value	Over 40	40-35	35-30	Below 30
Response Area	1	2	3	4
Land Use				
7. TRANSPORTATION				
Highways	Yes	Yes	Yes	Yes
Railroads	Yes	Yes	Yes	Yes
Shipping Terminals	Yes	Yes	Yes	Yes
Passenger Terminals	D	Yes	Yes	Yes
8. AGRICULTURAL				
Crop Farms	Yes	Yes	Yes	Yes
Market Gardens	Yes	Yes	Yes	Yes
Plant Nurseries	Yes	Yes	Yes	Yes
Tree Farms	Yes	Yes	Yes	Yes
Livestock Pastures	M	Yes	Yes	Yes
Poultry Farms	L	L	Yes	Yes
Stockyards	M	Yes	Yes	Yes
Dairy Farms	M	Yes	Yes	Yes
Feed Lots	M	Yes	Yes	Yes

RESPONSE AREA		*COMMUNITY RESPONSE PREDICTION
1	(over 40 NEF)	Repeated and vigorous individual complaints are likely. Concerted group and legal action might be expected.
2	(35-40 NEF)	Individual complaints may be vigorous. Possible group action and appeals to authorities.
3	(30-35 NEF)	Sporadic to repeated individual complaints. Group action is possible.
4	(below 30 NEF)	Sporadic complaints may occur. Noise may interfere occasionally with certain activities of the resident.

*It should be noted that the above community response predictions are generalizations based upon experience resulting from the evolutionary development of various noise exposure units used by other countries. For specific locations, the above response areas may vary somewhat in accordance with existing ambient or background noise levels and prevailing social, economic, and political conditions.

EXPLANATORY NOTES:

It is important to understand that the locations of the lines between noise zones cannot be fixed exactly. It will be necessary in some specific cases, therefore, for the responsible public authority to make an appropriate interpretation of what regulations are to be made applicable.

A. A marginal zone exists near the 30 NEF where aircraft noise may begin to annoy some residents. It is recommended that developers be made aware of this fact and that they undertake to so inform prospective tenants or purchasers of residential units. In addition, it is suggested that development should not proceed until the noise environment is assessed and it is established what noise control features, if any, should be included in the building design.

B. The developer should be made aware of the noise problem and he should be required to relay this information to all prospective tenants or purchasers of residential units. Moreover, construction should not take place unless a detailed analysis of noise requirements is made and the required noise control features are included in the building design.

C. It is advisable that these facilities not be located close to the 30 NEF. However, should a decision be made to proceed with this type of development, it is strongly recommended that the restrictions outlined in Note D be applied.

D. These uses should not be approved unless a detailed analysis is conducted to determine the noise reduction requirement for the development being considered, and the needed noise control features are included in the building design.

E. When associated with a permitted land use, an office may be located in this zone provided that all relevant factors are considered, and a detailed analysis is conducted to establish the noise reduction features required to provide an environment suited to the specific office function.

F. This specific use may be permitted only if related directly to aviation oriented activities or services. Conventional construction will generally be inadequate and special noise insulation features should be included in the building design.

G. Generally these facilities should not be permitted in this zone. However, where it can be demonstrated that such a land use is the most appropriate in a specific instance, construction may proceed provided that a detailed analysis is made for the development in question, and needed noise control features are included in the bukldings design.

H. It is advisable that this use not be located close to the 30 NEF contour. Prior to construction a detailed noise analysis is recommended.

I. Many of these uses would be acceptable in all NEF zones. However, an analysis should be conducted to establish the levels of internally generated noise, acceptable noise levels in the working area, and the degree of sound-proofing required.

J. Undesirable if there is spectator involvement.

K. It is recommended that serious consideration be given to an analysis of peak noise levels and the effects of these levels on the specific land use under consideration.

L. The construction of covered enclosures should be undertaken if this use is to be permitted.

M. Research has shown that animals condition to high noise levels. However, it is recommended that peak noise levels be assessed before this use is allowed.

APPENDIX D

```
C         THIS PROGRAM COMPUTES THE PNDB VS. TIME AND THE EPNDB FOR AN AIRCRAFT
C         ---------------------------------------------------------------------
C         FLY-BY (OR FLY-OVER) BASED ON ACTUAL MEASUREMENTS TAKEN AT ANY
C         ------------------------------------------------------------
C         PARTICULAR LOCATION ON THE GROUND IN THE AIRPORT VICINITY.
C         ----------------------------------------------------------
C         THIS PROGRAM COMPUTES ALSO THE DB(A) VS. TIME,THE AVERAGE VALUE OF
C         ------------------------------------------------------------------
C         (PNDBT-DB(A)),(PNDBT-DB(D)) AND THE STANDARD DEVIATIONS.
C         --------------------------------------------------------
C
C
C
C
C
C
C
C
      DIMENSION DBIN(24,31),DBLC(24,31),DBLT(24,31),BNOY(24,31)
      DIMENSION XT(24,31),PNDBT(31),FUNC(31)
      DIMENSION ATTEN(24),CMIC(24),CWIND(24),CTAPE(24)
      DIMENSION DBA(50),DBD(50),DIFFA(50),DIFFD(50)
      DIMENSION CDBA(24),CDBD(24)
C     NT= NO. OF POINTS CONSIDERED ( AT TIME INTERVALS OF 0.508 SECONDS )
      NT=31
C     NF= NO. OF ONE THIRD OCTAVE BANDS
      NF=24
      READ (5,200)(CDBA(JF),JF=1,NF)
 200  FORMAT(16F5.0)
      READ (5,201)(CDBD(JF),JF=1,NF)
 201  FORMAT(16F5.0)
      READ(5,680) (CMIC(JF),JF=1,NF)
 680  FORMAT(24F2.0)
      READ (5,681)(CWIND(JF) ,JF=1,NF)
 681  FORMAT(20F4.0)
      READ (5,682) (CTAPE(JF) ,JF=1,NF)
 682  FORMAT(16F5.0)
      READ (5,679) (ATTEN(JF),JF=1,NF)
 679  FORMAT(24F3.0)
      DO 111 JF=1,NF
      READ(5,678) (DBIN(JF,IT),IT=1,NT)
 678  FORMAT(13F6.0)
 111  CONTINUE
      WRITE(6,683)
 683  FORMAT (1H1,4X,*ATTEN*,4X,*CMIC*,4X,*CWIND*,4X,*CTAPE*/5X,*DB*
     1,7X,*DB*,6X,*DB*,7X,*DB*//)
      DO 684 JF=1,NF
      WRITE (6,685) ATTEN(JF),CMIC(JF),CWIND(JF),CTAPE(JF)
 685  FORMAT(3X,F6.2,3X,F6.2,3X,F6.2,2X,F6.2)
 684  CONTINUE
      PNDBMAX=0.0
      WRITE(6,1700)
 1700 FORMAT(1H1,4X,*INTERVAL*,3X,*PERC.NOISE LEVEL*,3X,*DB(A)*,3X,
     1*DIFF*,4X,*DB(D)*,3X,*DIFF*/4X,*(.5 SEC)*,3X,*(TONE CORRECTED)*
     2 //)
      SUMA=0.0
      SUMD=0.0
      SUMSQA=0.0
      SUMSQD=0.0
```

```
      DO 20 IT=1,NT
      TOTALA=0.0
      TOTALD=0.0
      DO 30 JF=1,NF
      CONST1=12.7
      DBLC(JF,IT)=DBIN(JF,IT)*CONST1+ATTEN(JF)+CMIC(JF)+CWIND(JF)
     1+CTAPE(JF)
      DBLA=DBLC(JF,IT)+CDBA(JF)
      DBLD=DBLC(JF,IT)+CDBD(JF)
      ANTLOGA=10.0**(DBLA/10.0)
      ANTLOGD=10.0**(DBLD/10.0)
      TOTALA=TOTALA+ANTLOGA
      TOTALD=TOTALD+ANTLOGD
 30   CONTINUE
      DBA(IT)=10.0*ALOG10(TOTALA)
      DBD(IT)=10.0*ALOG10(TOTALD)
      DBLT(1,IT)=DBLC(1,IT)
      BNOY(1,IT)=ANOY(DBLT(1,IT),1)
      BNOYMAX=BNOY(1,IT)
      TOTAL=0.0
      DO 40 JF=1,NF
      IF(JF .LE. 9 .OR. JF .EQ. 24) GO TO 301
      XT(JF,IT)=DBLC(JF,IT)-((DBLC((JF-1),IT)+DBLC((JF+1),IT))/2.0)
      IF(JF .GE. 16 .AND. JF .LE. 20) GO TO 302
      IF(JF .GE. 10 .AND. JF .LE. 15) GO TO 303
      IF(JF .GE. 21 .AND. JF .LE. 23) GO TO 303
C
C     THE FOLLOWING STEPS WILL ADD TONE CORRECTION TO BANDS  NOISE LEVEL.
C
 302  DBLT(JF,IT)=DBLC(JF,IT)+((0.36*XT(JF,IT))+3.0)
      GO TO 304
 303  DBLT(JF,IT)=DBLC(JF,IT)+((0.36*XT(JF,IT))+1.0)
      GO TO 304
 301  DBLT(JF,IT)=DBLC(JF,IT)
C
C     TO CONVERT THE DB VALUES TO NOYS USING  TABLE FROM K.KRYTER.
C
 304  BNOY(JF,IT)=ANOY(DBLT(JF,IT),JF)
      IF(BNOY(JF,IT) .GT. BNOYMAX) GO TO 1600
      GO TO 40
 1600 BNOYMAX=BNOY(JF,IT)
      TOTAL=TOTAL+BNOY(JF,IT)
 40   CONTINUE

      ADDING THE NOY VALUES ACCORDING TO STEVEN'S FORMULA.

      SIGMNOY=BNOYMAX+(.15*(TOTAL-BNOYMAX))
      PNDBT(IT)=40.0+(ALOG10(SIGMNOY)/.030103)
      FUNC(IT)=10.0**(PNDBT(IT)/10.0)
      DIFFA(IT)=PNDBT(IT)-DBA(IT)
      DIFFD(IT)=PNDBT(IT)-DBD(IT)
      SUMA=SUMA+DIFFA(IT)
      SUMD=SUMD+DIFFD(IT)
      SUMSQA=SUMSQA+(DIFFA(IT))**2
      SUMSQD=SUMSQD+(DIFFD(IT))**2
      WRITE(6,170)IT,PNDBT(IT),DBA(IT),DIFFA(IT),DBD(IT),DIFFD(IT)
    0 FORMAT(6X,I3,8X,F8.2,7X,F7.2,2X,F5.1,2X,F7.2,2X,F5.1)
```

```
      WRITE(7,50)PNDBT(IT)
      WRITE(7,50)DBA(IT)
      WRITE(7,50)DBD(IT)
 50   FORMAT(F10.4)
      IF(PNDBT(IT) .GT. PNDBMAX) GO TO 1800
      GO TO 20
 1800 PNDBMAX=PNDBT(IT)
      ITMAX=IT
 20   CONTINUE
C     AMEAN= MEAN VALUE OF THE RECORDED DIFFERENCE BETWEEN PNDBT AND DB(A)
      AMEAN=SUMA/FLOAT(NT)
C     DMEAN= MEAN VALUE OF THE RECORDED DIFFERENCE BETWEEN PNDBT AND DB(D)
      DMEAN=SUMD/FLOAT(NT)
C     SIGMAA= STANDARD DEVIATION OF THE VALUES(PNDBT-DB(A)).
      SIGMAA=SQRT((SUMSQA/FLOAT(NT))-AMEAN**2)
C     SIGMAD= STANDARD DEVIATION OF THE VALUES(PNDBT-DB(D)).
      SIGMAD=SQRT((SUMSQD/FLOAT(NT))-DMEAN**2)
      WRITE(6,1900) PNDBMAX
 1900 FORMAT(//,4X,*MAX PERC NOISE LEVEL = *,F9.2,2X,*PNDB*//)
      RANGE=FLOAT(NT-1)*.508
      M=NT
C
C     USING SIMPSONS RULE TO INTEGRATE THE PNDBT VALUES OVER THE SET TIME TO
C     OBTAIN A SINGLE VALUE (EFFECTIVE PERCEIVED NOISE) EPNDB.
C
      EPNDB=10.0*ALOG10(0.1*FSIMP(FUNC,RANGE,M))
      WRITE(6,1901) EPNDB
 1901 FORMAT(4X,*EFFECTIVE PERC NOISE LEVEL = *,F9.2,2X,*PNDB*//)
      WRITE(6,400)AMEAN,SIGMAA
 400  FORMAT(//,4X,*MEAN VALUE OF(PNDBT-DB(A)) =*,F5.2,6X,*STANDARD DEVI
     1ATION =*,F5.2)
      WRITE(6,401)DMEAN,SIGMAD
 401  FORMAT(//,4X,*MEAN VALUE OF(PNDBT-DB(D)) =*,F5.2,6X,*STANDARD DEVI
     1ATION =*,F5.2)
C
C        PROGRAM TO PLOT THE FREQUENCY SPECTRUM BEFORE,AFTER AND AT THE MAXIMU
C        LEVEL OF NOISE OCCURED.
C
      Y1=20.0
      Y2=120.0
      XMIN=1.0
      XMAX=24.0
      DELTA=1.0
      LL=ITMAX-2
      MM=ITMAX+2
      DO 25 KK=LL,MM,1
      DO 21 JF=1,NF
      X=XMIN+FLOAT(JF-1)*DELTA
      Y=DBLC(JF,KK)
      CALL PLOTPT(X,Y1,2)
      CALL PLOTPT(X,Y2,2)
      CALL PLOTPT(X,Y,4)
  1   CONTINUE
      CALL OUTPLT
  5   CONTINUE

         PROGRAM TO PLOT THE PNDBT VS. TIME OF THE FLY-BY.
```

```
C
      DO 24 IT=1,NT
      XX=0.508*FLOAT(IT-1)
      YY=PNDBT(IT)
      CALL PLOTPT(XX,YY,4)
   24 CONTINUE
      CALL OUTPLT
      WRITE(6,555)
  555 FORMAT(1H1,4X,*BAND NO.*,3X,*S.P.L.(DB)*/)
      DO 22 JF=1,NF
      WRITE(6,23)JF,DBLC(JF,ITMAX)
   23 FORMAT(6X,I3,8X,F8.2)
   22 CONTINUE
      WRITE(7,556) (DBLC(JF,ITMAX),JF=1,NF)
  556 FORMAT(8F10.5)
      STOP
      END
      FUNCTION FSIMP ( FUNC,RANGE,M)
C
C     -----------------------------------------------
C     SUBPROGRAM FOR INTEGRATION USING SIMPSON'S RULE.
C     -----------------------------------------------
C
C     M MUST BE ODD
      DIMENSION FUNC(1)
      XX=RANGE/(3.*FLOAT(M-1))
      AREA=FUNC(1)+FUNC(M)
      MM=M-1
      DO 1 I=2,MM,2
    1 AREA=AREA+4.*FUNC(I)
      MM=MM-1
      DO 2 I=3,MM,2
    2 AREA=AREA+2.*FUNC(I)
      FSIMP=XX*AREA
      RETURN
      END
      FUNCTION ANOY(D,JF)

      SUBPROGRAM TO CONVERT BANDS SOUND PRESSURE LEVELS TO NOY VALUES USING
      ---------------------------------------------------------------------
      DATA FROM K.KRYTER.
      -------------------

      GO TO(601,602,603,604,605,606,607,608,609,610,611,612,613,614,
     1615,616,617,618,619,620,621,622,623,624),JF
  ,01 IF(D .LT. 64.0) GO TO 666
      IF(D .GE. 64.0 .AND. D .LT. 92.0) GO TO 11
      IF(D .GE. 92.0) GO TO 12
    1 C=.04348
      E=64.
      GO TO 777
    2 C=0.03010
      E=52.
      GO TO 777
   '2 IF(D .LT. 60.0) GO TO 666
      IF(D .GE. 60.0 .AND. D .LT. 86.0) GO TO 21
      IF(D .GE. 86.0) GO TO 22
```

```
21    C=.04057
      E= 60.
      GO TO 777
22    C=0.03010
      E=51.
      GO TO 777
603   IF(D .LT. 56.0) GO TO 666
      IF(D .GE. 56.0 .AND. D .LT. 86.0) GO TO 31
      IF(D .GE. 86.0) GO TO 32
31    C=.03683
      E=56.
      GO TO 777
32    C=0.03010
      E=49.
      GO TO 777
604   IF(D .LT. 53.0) GO TO 666
      IF(D .GE. 53.0 .AND. D .LT. 80.0) GO TO 41
      IF(D .GE. 80.0) GO TO 42
41    C=.03683
      E=53.
      GO TO 777
42    C=0.03010
      E=47.
      GO TO 777
605   IF(D .LT. 51.0) GO TO 666
      IF(D .GE. 51.0 .AND. D .LT. 80.0) GO TO 51
      IF(D .GE. 80.0) GO TO 52
51    C=.03534
      E=51.
      GO TO 777
52    C=0.03010
      E=46.
      GO TO 777
606   IF(D .LT. 48.0) GO TO 666
      IF(D .GE. 48.0 .AND. D .LT. 76.0) GO TO 61
      IF(D .GE. 76.0) GO TO 62
61    C=.03333
      E=48.
      GO TO 777
62    C=0.03010
      E=45.
      GO TO 777
607   IF(D .LT. 46.0) GO TO 666
      IF(D .GE. 46.0 .AND. D .LT. 74.0) GO TO 71
      IF(D .GE. 74.0) GO TO 72
71    C=.03333
      E=46.
      GO TO 777
72    C=0.03010
      E=43.
      GO TO 777
,08   IF(D .LT. 44.0) GO TO 666
      IF(D .GE. 44.0 .AND. D .LT. 75.0) GO TO 81
      IF(D .GE. 75.0) GO TO 82
 1    C=.03205
      E=44.
      GO TO 777
```

```
82    C=0.03010
      E=42.
      GO TO 777
609   IF(D .LT. 42.0) GO TO 666
      IF(D .GE. 42.0 .AND. D .LT. 95.0) GO TO 91
      IF(D .GE. 95.0) GO TO 92
91    C=.03068
      E=42.
      GO TO 777
92    C=0.03010
      E=41.
      GO TO 777
610   IF(D .LT. 40.0) GO TO 666
      C=0.03010
      E=40.0
      GO TO 777
611   IF(D .LT. 40.0) GO TO 666
      C=0.03010
      E=40.0
      GO TO 777
612   IF(D .LT. 40.0) GO TO 666
      C=0.03010
      E=40.0
      GO TO 777
613   IF(D .LT. 40.0) GO TO 666
      C=0.03010
      E=40.0
      GO TO 777
614   IF(D .LT. 40.0) GO TO 666
      C=0.03010
      E=40.0
      GO TO 777
615   IF(D .LT. 38.0) GO TO 666
      C=0.03010
      E=38.
      GO TO 777
616   IF(D .LT. 34.0) GO TO 666
      C=0.02996
      E=34.
      GO TO 777
617   IF(D .LT. 32.0) GO TO 666
      C=0.02996
      E=32.
      GO TO 777
618   IF(D .LT. 30.0) GO TO 666
      C=0.02996
      E=30.
      GO TO 777
619   IF(D .LT. 29.0) GO TO 666
      C=0.02996
      E=29.
      GO TO 777
620   IF(D .LT. 29.0) GO TO 666
      C=0.02996
      E=29.
      GO TO 777
621   IF(D .LT. 30.0) GO TO 666
```

```
      C=0.02996
      E=30.
      GO TO 777
 622  IF(D .LT. 31.0) GO TO 666
      C=0.02996
      E=31.
      GO TO 777
 623  IF(D .LT. 38.0) GO TO 666
      IF(D .GE. 38.0 .AND. D .LT. 48.0) GO TO 231
      IF(D .GE. 48.0) GO TO 232
 231  C=.04229
      E=37.
      GO TO 777
 232  C=0.02996
      E=34.
      GO TO 777
 624  IF(D .LT. 41.0) GO TO 666
      IF(D .GE. 41.0 .AND. D .LT. 51.0) GO TO 241
      IF(D .GE. 51.0) GO TO 242
 241  C=.04229
      E=41.
      GO TO 777
 242  C=0.02996
      E=37.
      GO TO 777
 666  ANOY=0.0
      GO TO 999
 777  ANOY=10.0**(C*(D-E))
 999  RETURN
      END
'        6400 END OF RECORD
-30.2-26.1-22.3-19.1-16.2-13.2-10.8-08.0-06.5-04.8-03.3-01.9-00.8+00.0+00.5+01
+01.2+01.2+01.2+01.0+00.5-00.2-01.1-02.5
-19.0-17.0-14.0-11.0-09.0-07.0-05.0-03.0-02.0+00.0+00.0+00.0+00.0+00.0+02.0+06
+08.0+10.0+11.0+11.0+10.0+09.0+06.0+03.0
0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
+0.4+0.4+0.4+0.4+0.4+0.4+0.4+0.4+0.4+0.4+0.4+0.4+0.4+0.4+0.4+0.5+1.7+2.7+2.7+3
+0.5-1.7-3.0+0.3
.5    .5    .5    .5    .5    .5    .5    .5    .5    .5    .5    .5    .5    .5    .5    .53
.67   .75   .92   1.13 1.4   1.82 2.5   3.27
40.40.40.40.40.40.40.40.40.40.40.40.40.40.40.40.40.40.40.40.30.30.30.30.
  2.04  2.07  1.53  1.89   .88  1.30  1.91  1.38  1.29  1.49  1.66  1.08  1.29
  1.46  1.75  2.02  2.03  2.00  2.25  2.73  2.40  2.83  2.84  2.53  2.64  3.03
  2.84  2.95  3.29  3.16  3.21
  1.80  1.52  1.72  1.36  1.28  1.17  1.84  1.50  1.80  2.13  1.98  2.22  2.19
  1.65  1.99  1.93  1.94  1.77  1.89  2.03  2.40  2.14  3.06  2.52  3.21  3.18
  3.24  2.88  3.34  3.32  3.22
  1.22  1.24  1.44  2.38  1.07  1.73  1.58  1.92  1.85  2.41  2.63  2.60  2.21
  2.64  2.60  2.33  2.71  2.41  2.30  2.25  2.26  2.37  2.37  2.78  2.76  3.06
  3.06  2.86  2.77  2.66  2.93
  1.76  1.25  1.20  1.33  1.91  2.05  2.33  2.67  2.56  2.87  3.14  3.07  2.95
  3.27  2.94  3.24  3.35  2.97  3.23  2.98  2.48  3.14  2.42  2.54  2.75  2.69
  2.72  2.17  2.65  2.95  2.65
  1.83  1.99  1.83  1.92  2.16  2.22  2.70  2.56  2.67  2.77  2.99  3.10  2.81
  3.03  2.87  3.10  3.30  3.19  3.08  3.18  3.15  3.38  3.15  2.58  3.29  2.80
  3.12  2.13  2.71  3.11  2.65
  1.78  2.02  2.32  2.08  2.74  2.35  2.84  2.48  2.53  2.06  2.46  2.43  2.17
```

2.71	2.20	2.73	2.83	3.14	3.37	3.20	3.28	3.22	3.66	3.08	3.22	3.30
3.35	2.66	2.23	2.91	2.11								
1.71	1.83	2.09	2.18	1.94	2.11	1.83	2.03	2.41	2.83	2.95	2.61	3.00
2.88	3.25	3.40	2.97	3.27	2.91	2.89	2.95	3.29	3.20	2.96	3.27	3.31
3.21	3.37	2.41	3.34	2.83								
1.87	1.96	1.49	1.96	1.92	2.14	1.93	1.98	2.69	2.66	2.70	2.69	2.69
2.97	2.87	3.09	3.44	3.52	3.71	3.50	2.96	2.74	2.76	2.96	2.64	3.08
3.25	2.78	2.80	3.06	2.67								
1.98	2.11	2.12	2.39	2.02	2.06	2.34	2.14	2.37	2.72	2.67	2.65	2.78
2.98	3.29	3.12	2.71	3.06	2.99	2.80	3.36	2.73	3.15	2.45	2.29	2.52
2.26	2.60	2.71	3.10	2.65								
1.85	1.99	2.01	2.05	1.77	2.11	2.40	2.31	2.67	2.20	2.23	2.59	3.03
2.97	3.06	3.13	3.00	3.33	3.39	3.02	2.76	2.72	2.80	2.91	3.05	2.81
2.57	2.47	2.18	2.62	2.61								
1.93	1.89	2.40	2.42	2.29	2.60	2.70	2.40	2.54	2.36	2.63	2.71	2.87
2.70	2.76	3.07	3.02	3.30	2.99	2.63	2.93	2.62	2.42	2.38	2.46	2.66
2.77	2.56	2.27	2.80	2.34								
2.08	2.14	2.06	2.46	2.20	2.25	2.40	2.61	2.31	2.55	2.53	2.50	2.70
2.73	2.75	2.70	3.00	2.84	2.58	2.82	2.79	2.55	2.29	2.23	2.51	2.37
2.30	2.09	2.11	2.48	2.26								
2.31	1.87	2.23	2.62	2.43	2.42	2.70	2.41	2.28	2.85	2.50	2.70	2.67
2.77	2.66	2.79	3.08	2.76	2.72	2.62	2.36	2.57	2.52	2.48	2.23	2.16
2.06	2.01	2.00	2.34	1.92								
1.79	2.10	2.06	2.31	2.19	2.14	2.47	2.45	2.26	2.40	2.48	2.53	2.59
2.78	2.52	2.60	2.90	2.41	2.38	2.39	2.59	2.42	2.34	2.04	2.48	2.11
2.08	1.87	2.00	2.25	1.89								
1.94	2.12	2.08	2.05	2.49	2.36	2.33	2.47	2.44	2.57	2.50	2.51	2.64
2.76	2.66	2.42	2.70	2.83	2.55	2.55	1.97	2.51	2.11	1.94	2.25	2.10
1.79	1.91	1.79	2.16	1.50								
2.22	2.10	2.03	2.31	2.28	2.51	2.68	2.47	2.27	2.51	2.48	2.46	2.74
2.78	2.55	2.27	2.59	2.21	2.33	2.49	2.08	2.11	1.98	1.92	2.03	1.81
1.56	1.68	1.45	1.93	1.43								
1.98	1.90	1.95	2.37	2.06	2.32	2.50	2.39	2.38	2.40	2.51	2.61	2.61
2.82	2.70	2.44	2.73	2.41	2.44	2.58	2.25	2.33	2.11	1.94	1.83	1.64
1.54	1.39	1.31	1.74	1.20								
1.86	1.69	1.91	2.21	2.30	2.21	2.49	2.42	2.34	2.47	2.73	2.91	3.06
3.34	3.32	2.97	3.12	2.64	2.48	2.71	2.58	2.59	2.15	2.06	2.31	1.91
1.76	1.89	1.57	2.10	1.30								
2.18	2.00	2.16	2.84	2.24	2.45	2.72	2.92	2.52	2.64	2.79	3.00	3.02
3.00	2.92	2.56	2.73	2.27	1.98	2.18	1.88	1.97	1.64	1.63	1.58	1.27
1.21	1.19	1.04	1.14	.90								
1.02	1.20	1.06	1.77	1.40	1.69	1.91	1.88	1.92	2.06	2.26	2.51	2.57
2.74	2.58	2.50	2.55	1.94	1.67	2.07	1.65	1.68	1.31	1.16	1.31	1.01
.95	.95	.79	.93	.80								
1.32	1.26	1.44	1.87	1.55	1.74	1.84	2.05	2.10	2.34	2.57	2.73	2.81
3.19	2.87	2.69	2.76	2.32	2.14	2.30	2.13	2.12	2.01	2.02	2.02	2.12
2.12	2.03	2.05	1.95	2.01								
.96	1.03	.97	1.07	.98	1.09	1.39	1.10	1.38	1.41	1.76	1.91	2.00
2.27	2.08	1.97	1.97	1.85	1.80	1.82	1.78	1.78	1.74	1.74	1.78	1.80
1.76	1.79	1.81	1.75	1.77								
.77	.77	.79	.85	.79	.80	.87	.80	.81	.82	1.15	1.22	1.55
1.57	1.59	1.58	1.55	1.55	1.57	1.55	1.53	1.53	1.53	1.54	1.55	1.54
1.55	1.54	1.52	1.53	1.53								
.89	.89	.89	.91	.87	.90	.96	.96	.89	.94	1.17	1.06	1.33
1.69	1.71	1.71	1.67	1.68	1.73	1.70	1.70	1.69	1.70	1.68	1.67	1.69
1.70	1.68	1.67	1.69	1.68								

END OF FILE

```
C
C
C      ----------------------------------------------------------------
C      PROGRAM TO PREDICT THEORETICALLY THE PERCEIVED NOISE LEVEL AT VARIOU
C      ----------------------------------------------------------------
C      DISTANCES FOR A CERTAIN AIRCRAFT(NOT CONSIDERING GROUND ATTENUATION)
C      ----------------------------------------------------------------
C      BASED ON ACTUAL MEASUREMENTS RECORDED AT A REFERENCE LOCATION.
C      ----------------------------------------------------------------
C
C
C
C
C
C
C
C
      DIMENSION DBL(24),AIRATT(24),SDIST(400),DBLC(24),XT(24)
      DIMENSION PNDBT(400),DBLT(24),BNOY(24)
      DIMENSION B(11),A(200)
C
C        ALT=AIRCRAFT ALTITUDE AT MEASUREMENT LOCATION (FT)
      ALT=6417.0 * TAN(2.5*0.0174532925199)
C        ND= NO. OF DISTANCE INCREMENTS
      ND=400
C        Y= SIDE DISTANCE TO MEASUREMENT LOCATION (FT)
      Y=146.0
C        NF= NO. OF 1/3 OCTAVE BANDS USED IN THE ANALYSIS
      NF=24
C        DELTA= INCREMENTS OF DISTANCE (FT)
      DELTA=100.
C        DIST= REFRENCE DISTANCE (FT), AT WHICH THE AIRCRAFT FLYBY MEASUREMEN
C        WERE RECORDED
      DIST=SQRT((Y**2)+(ALT**2))
C        DBL(JF)= 1/3 OCTAVE BANDS S.P.L. IN DECIBELS AS MEASURED AND AFTER
C        ADDING VARIOUS INSTRUMENTATION CORRECTIONS
      READ(5,10) (DBL(JF) , JF=1,NF)
 10   FORMAT(8F10.0)
C        AIRATT(JF)= 1/3 OCTAVE BANDS AIR ATTENUATION CONSTANT IN DECIBELS PE
C        FEET (FROM G.M.COLES,ROLLS-ROYCE LTD,U.K.) ASSUMING 59 DEG. F,0.70 R
C        AND 29.94 IN. HG.
      READ(5,20) (AIRATT(JF) ,JF=1,NF)
 20   FORMAT(13F6.0)
      WRITE(6,22)
 22   FORMAT(1H1,4X,*BAND NO.*,4X,*ATMOS.ABSORP.(DB/FT)*/)
      DO 23 JF=1,NF
      WRITE(6,24)JF,AIRATT(JF)
 24   FORMAT(6X,I3,11X,F10.6)
 23   CONTINUE
      DO 30 ID=1,ND
C        SDIST= SLANT DISTANCE PERPENDICULAR TO AIRCRAFT FLIGHT PATH
      SDIST(ID)=DELTA*FLOAT(ID)
C
C        THE FOLLOWING STEPS WILL ADJUST THE BANDS LEVEL FOR 'INVERSE-SQUARE
C        ASSUMING FREE FIELD CONDITIONS) AND ATMOS. ABSORPTION OF NOISE
      DO 40 JF=1,NF
      DBLC(JF)=DBL(JF)-(20.*ALOG10(SDIST(ID)/DIST))-(AIRATT(JF)*(SDIST
     1(ID)-DIST))
 40   CONTINUE
```

```
C
C         THE FOLLOWING STEPS WILL ADD CORRECTION FOR THE PRESENCE OF TONES IN
C         THE SPECTRUM.
      DBLT(1)=DBLC(1)
      BNOY(1)=ANOY(DBLT(1),1)
      BNOYMAX=BNOY(1)
      TOTAL=0.0
      DO 50 JF=1,NF
      IF(JF .LE. 9 .OR. JF .EQ. 24) GO TO 301
      XT(JF)=DBLC(JF)-((DBLC(JF-1)+DBLC(JF+1))/2.0)
      IF(JF .GE. 16 .AND. JF .LE. 20) GO TO 302
      IF(JF .GE. 10 .AND. JF .LE. 15) GO TO 303
      IF(JF .GE. 21 .AND. JF .LE. 23) GO TO 303
 302  DBLT(JF)=DBLC(JF)+((0.36*XT(JF))+3.0)
      GO TO 304
 303  DBLT(JF)=DBLC(JF)+((0.36*XT(JF))+1.0)
      GO TO 304
 301  DBLT(JF)=DBLC(JF)
 304  BNOY(JF)=ANOY(DBLT(JF),JF)
      IF(BNOY(JF) .GT. BNOYMAX) GO TO 1600
      GO TO 50
 1600 BNOYMAX=BNOY(JF)
      TOTAL=TOTAL+BNOY(JF)
  50  CONTINUE
C
C         USING STEVEN'S FORMULA TO ADD THE NOY VALUES OF BANDS
      SIGMNOY=BNOYMAX+(.15*(TOTAL-BNOYMAX))
      IF(SIGMNOY .LE. 0.0) SIGMNOY=1.0
      PNDBT(ID)=40.0+(ALOG10(SIGMNOY)/0.030103)
  30  CONTINUE
C
C         PROGRAM TO PLOT THE PNDB(TONE CORRECRED) VS. SLANT DISTANCE
      Y1=50.0
      XMIN=0.0
      XMAX=60000.0
      DO 21 ID=1,ND,2
      XPL=XMIN+(DELTA*FLOAT(ID))
      Y=PNDBT(ID)
      CALL PLOTPT(XPL,Y1,2)
      CALL PLOTPT(XPL,Y,4)
  21  CONTINUE
      CALL OUTPLT
C
C
C         USING LIBRARY SUBROUTINE (LESQ) TO FIND THE LEAST SQUARE FIT OF POIN
C        (SDIST,PNDBT) TO A CURVE Y= A POLONOMIAL OF THE 10TH.DEGREE.
C
C
      M=10
      CALL LESQ (A,B,SDIST,PNDBT,M,ND)
      WRITE(6,14)
 14   FORMAT(1H1,*CO-EFFICIENTS OF THE POLONOMIAL (SDIST,PNDBT)*/)
      WRITE(6,11) B
  11  FORMAT(2E24.14)
      WRITE(7,12) B
  12  FORMAT(2E24.14)
      WRITE(7,669)B
```

```
669  FORMAT(7X,E24.14)
     WRITE(6,668)
668  FORMAT(1H1,4X,*SLANT DISTANCE*,11X,*PNDBT*,13X,*POLYNOMIAL*,5X,
    1*ABS.DIFF.*,/,8X,*(FT)*,17X,*THEORY*,12X,*APPROXN.*,//)
     DO 666 ID=1,ND
     X=FLOAT(ID)*DELTA
     PPNDBT=B(1)+B(2)*(X)+B(3)*(X**2)+B(4)*(X**3)+B(5)*(X**4)+B(6)*(X*
    1*5)+B(7)* (X**6)+B(8)*(X**7)+B(9)*(X**8)+B(10)*(X**9)+B(11)*(X**
    210)
     DIFF=PNDBT(ID)-PPNDBT
     WRITE(6,667)X,PNDBT(ID),PPNDBT,DIFF
667  FORMAT    (7X,F9.2,13X,F6.2,13X ,F6.2,10X,F6.2)
666  CONTINUE
     STOP
     END
     FUNCTION ANOY(D,JF)
     GO TO(601,602,603,604,605,606,607,608,609,610,611,612,613,614,
    1615,616,617,618,619,620,621,622,623,624),JF
601  IF(D .LT. 64.0) GO TO 666
     IF(D .GE. 64.0 .AND. D .LT. 92.0) GO TO 11
     IF(D .GE. 92.0) GO TO 12
11   C=.04348
     E=64.
     GO TO 777
12   C=0.03010
     E=52.
     GO TO 777
602  IF(D .LT. 60.0) GO TO 666
     IF(D .GE. 60.0 .AND. D .LT. 86.0) GO TO 21
     IF(D .GE. 86.0) GO TO 22
21   C=.04057
     E= 60.
     GO TO 777
22   C=0.03010
     E=51.
     GO TO 777
603  IF(D .LT. 56.0) GO TO 666
     IF(D .GE. 56.0 .AND. D .LT. 86.0) GO TO 31
     IF(D .GE. 86.0) GO TO 32
31   C=.03683
     E=56.
     GO TO 777
32   C=0.03010
     E=49.
     GO TO 777
604  IF(D .LT. 53.0) GO TO 666
     IF(D .GE. 53.0 .AND. D .LT. 80.0) GO TO 41
     IF(D .GE. 80.0) GO TO 42
41   C=.03683
     E=53.
     GO TO 777
42   C=0.03010
     E=47.
     GO TO 777
605  IF(D .LT. 51.0) GO TO 666
     IF(D .GE. 51.0 .AND. D .LT. 80.0) GO TO 51
     IF(D .GE. 80.0) GO TO 52
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51    C=.03534
      E=51.
      GO TO 777
52    C=0.03010
      E=46.
      GO TO 777
606   IF(D .LT. 48.0) GO TO 666
      IF(D .GE. 48.0 .AND. D .LT. 76.0) GO TO 61
      IF(D .GE. 76.0) GO TO 62
61    C=.03333
      E=48.
      GO TO 777
62    C=0.03010
      E=45.
      GO TO 777
607   IF(D .LT. 46.0) GO TO 666
      IF(D .GE. 46.0 .AND. D .LT. 74.0) GO TO 71
      IF(D .GE. 74.0) GO TO 72
71    C=.03333
      E=46.
      GO TO 777
72    C=0.03010
      E=43.
      GO TO 777
608   IF(D .LT. 44.0) GO TO 666
      IF(D .GE. 44.0 .AND. D .LT. 75.0) GO TO 81
      IF(D .GE. 75.0) GO TO 82
81    C=.03205
      E=44.
      GO TO 777
82    C=0.03010
      E=42.
      GO TO 777
609   IF(D .LT. 42.0) GO TO 666
      IF(D .GE. 42.0 .AND. D .LT. 95.0) GO TO 91
      IF(D .GE. 95.0) GO TO 92
91    C=.03068
      E=42.
      GO TO 777
92    C=0.03010
      E=41.
      GO TO 777
610   IF(D .LT. 40.0) GO TO 666
      C=0.03010
      E=40.0
      GO TO 777
611   IF(D .LT. 40.0) GO TO 666
      C=0.03010
      E=40.0
      GO TO 777
612   IF(D .LT. 40.0) GO TO 666
      C=0.03010
      E=40.0
      GO TO 777
613   IF(D .LT. 40.0) GO TO 666
      C=0.03010
      E=40.0
```

```
      GO TO 777
614   IF(D .LT. 40.0) GO TO 666
      C=0.03010
      E=40.0
      GO TO 777
615   IF(D .LT. 38.0) GO TO 666
      C=0.03010
      E=38.
      GO TO 777
616   IF(D .LT. 34.0) GO TO 666
      C=0.02996
      E=34.
      GO TO 777
617   IF(D .LT. 32.0) GO TO 666
      C=0.02996
      E=32.
      GO TO 777
618   IF(D .LT. 30.0) GO TO 666
      C=0.02996
      E=30.
      GO TO 777
619   IF(D .LT. 29.0) GO TO 666
      C=0.02996
      E=29.
      GO TO 777
620   IF(D .LT. 29.0) GO TO 666
      C=0.02996
      E=29.
      GO TO 777
621   IF(D .LT. 30.0) GO TO 666
      C=0.02996
      E=30.
      GO TO 777
622   IF(D .LT. 31.0) GO TO 666
      C=0.02996
      E=31.
      GO TO 777
623   IF(D .LT. 38.0) GO TO 666
      IF(D .GE. 38.0 .AND. D .LT. 48.0) GO TO 231
      IF(D .GE. 48.0) GO TO 232
231   C=.04229
      E=37.
      GO TO 777
232   C=0.02996
      E=34.
      GO TO 777
624   IF(D .LT. 41.0) GO TO 666
      IF(D .GE. 41.0 .AND. D .LT. 51.0) GO TO 241
      IF(D .GE. 51.0) GO TO 242
241   C=.04229
      E=41.
      GO TO 777
242   C=0.02996
      E=37.
      GO TO 777
666   ANOY=0.0
      GO TO 999
```

```
777   ANOY=10.0**(C*(D-E))
999   RETURN
      END
'          END OF RECORD
  66.26700  67.53700  67.79100  73.37900  78.33200  77.31600  68.80700  73.25
  76.80800  73.63300  71.85500  74.01400  75.91900  73.12500  76.55400  79.85
  84.12000  85.45400 102.99000  99.94400  85.68200  79.83800  74.64600  67.54
0.00000.00000.00000.00000.00000.00000.00000.00000.00000.00000.00000.00000.000
0.00050.00100.00150.00250.00390.00610.00960.01450.02150.03000.0400
'          END OF FILE
```

CD TOT   0297

```
C              ------- ---------------------------------------------
C              PROGRAM TO PLOT THE EXPERIMENTAL PNDB VS. DB(A) AND TO FIND THE
C              ----------------------------------------------------------
C              LEAST SQUARE FIT OF THE DATA
C              ----------------------------
C
C
      DIMENSION HORIZ(3),VERT(3),TITLE(3),PNDB(129),DBA(129),DBD(129)
      DIMENSION B(2),A(8)
      DATA VERT/10HPERCEIVED ,10HNOISE LEVE,10HL (PNDB)  /
      DATA HORIZ/10HSOUND PRES,10HSURE LEVEL,10H  DB(A)    /
      DATA TITLE/10HEXPERIMENT,10HAL PNDB VS,10H DB(A)     /
C     NP=NO. OF TEST POINTS
      NP=129
      DO 10 I=1,NP
      READ(5,11)PNDB(I)
 11   FORMAT(F10.0)
      READ(5,12)DBA(I)
 12   FORMAT(F10.0)
      READ(5,13)DBD(I)
 13   FORMAT(F10.0)
 10   CONTINUE
C
C     USING LIBRARY SUBROUTINE LESQ TO FIND THE LEAST SQARE FIT OF THE DATA TO
C     STRAIGHT LINE PNDB=B(1)+B(2)*(DBA)
C
      M=1
      CALL LESQ(A,B,DBA,PNDB,M,NP)
      WRITE(6,14)
 14   FORMAT(1H1,6X,*CO-EFFICIENTS OF THE POLONOMIAL(DB(A),PNDB*//)
      WRITE(6,15)B
 15   FORMAT(4X,2E15.6,///)
C
C     USING THE BENSON-LEHNER PLOTTER ROUTINES
C
      CALL DATE(THEDATE)
      CALL LETTER(6,.25,90.,6.0,3.0,6HGIDAMY)
      CALL LETTER(10,.25,90.,7.0,3.0,THEDATE)
C
C     A NEW ORIGIN
C
      CALL PLOT(10.0,2.0,-3)
      YMAX=140.
      YMIN=60.
      XMAX=120.
      XMIN=60.
      XSCALE=(120.0-60.0)/6.0
      YSCALE=(140.0-60.0)/8.0
      V=60.
      W=60.
      CALL PLTIN(XSCALE,YSCALE,V,W,XMIN,XMAX,YMIN,YMAX)
C
C     TO PLOT THE BOUNDERIES OF THE GRAPH
C
      CALL PLOT(6.0,0.0,2)
      CALL PLOT(6.0,8.0,2)
      CALL PLOT(0.0,8.0,2)
      CALL PLOT(0.0,0.0,2)
C
```

```
C       TO LABEL AXES
C
        CALL LETTER(30,.12,0.0,1.0,-0.75,HORIZ)
        CALL LETTER(30,.12,90.,-0.75,2.0,VERT)
        CALL LETTER(30,.25,0.0,0.0,-1.5,TITLE)
C
C       TO CONSTRUCT A GRID PATTERN
C
        XG=0.0
        YG=0.0
        DELTAX=1.0
        DELTAY=1.0
        IDELX=0
        IDELY=0
        NV=5
        NH=7
        CALL GRIDGS(XG,YG,DELTAX,DELTAY,IDELX,IDELY,NV,NH)
C
C       TO PLOT NUMBERS ON AXIS
C
        CALL LETTER(3,0.12,0.0,-.12,-0.25,3H60 )
        CALL LETTER(3,0.12,0.0,0.88,-0.25,3H70 )
        CALL LETTER(3,0.12,0.0,1.88,-0.25,3H80 )
        CALL LETTER(3,0.12,0.0,2.88,-0.25,3H90 )
        CALL LETTER(3,0.12,0.0,3.88,-0.25,3H100)
        CALL LETTER(3,0.12,0.0,4.88,-0.25,3H110)
        CALL LETTER(3,0.12,0.0,5.88,-0.25,3H120)
C
        CALL LETTER(3,0.12,0.0,-0.5,-.06,3H60 )
        CALL LETTER(3,0.12,0.0,-0.5,0.94,3H70 )
        CALL LETTER(3,0.12,0.0,-0.5,1.94,3H80 )
        CALL LETTER(3,0.12,0.0,-0.5,2.94,3H90 )
        CALL LETTER(3,0.12,0.0,-0.5,3.94 ,3H100)
        CALL LETTER(3,0.12,0.0,-0.5,4.94 ,3H110)
        CALL LETTER(3,0.12,0.0,-0.5,5.94 ,3H120)
        CALL LETTER(3,0.12,0.0,-0.5,6.94 ,3H130)
        CALL LETTER(3,0.12,0.0,-0.5,7.94 ,3H140)
C
C       TO PLOT THE EXP. DATA POINTS
C
        DO 20 I=1,NP
        XD=DBA(I)
        YD=PNDB(I)
        CALL UNITTO(XD,YD,XP,YP)
        CALL GRAF(XP,YP,0.12,3HCIR)
 20     CONTINUE
        CALL PLOT(0.0,0.0,3)
C
C       TO PLOT THE LEAST SQARE FIT LINE
C
        WRITE(6,31)
 31     FORMAT(1H1,6X,*DB(A)*,6X,*PNDB*,//)
        DO 30 J=60,120,1
        DB=FLOAT(J)
        PN=B(1)+B(2)*DB
        WRITE(6,32)DB,PN
 32     FORMAT(6X,F6.2,5X,F6.2)
```

```
      CALL UNITTO(DB,PN,XX,YY)
      CALL PLOT(XX,YY,2)
 30   CONTINUE
      CALL PLOT(X,Y,999)
      STOP
      END
            END OF RECORD
            END OF FILE

                                   CD TOT   0124
```

```
C        ------------- ------------------------------------------------
C        PROGRAM TO PLOT THE EXPEREMINTAL DATA(PNDB VS. SLANT DISTANCE)
C        --------------------------------------------------------------
C        AND PLOT THE DEVELOPED POLYNOMIAL
C        ------------------------------------
C        TAKEOFF
      DIMENSION HORIZ(4),VERT(3),TITLE(3)
      DIMENSION X(26),Y(26),PNDB(26),SD(26),THETA(26),RATIO(26)
      DIMENSION B(11)
      DATA HORIZ/10HSLANT PERP,10HENDICULAR ,10HDISTANCE (,8HFT)      /
      DATA VERT/10HPERCEIVED ,10HNOISE LEVE,10HL (PNDB)  /
      DATA TITLE/10H          ,10H  PNDB VS,10H DISTANCE /
      WRITE(6,9)
 9    FORMAT(1H1,2X,*TEST NO*,2X,*X(FT)*,2X,*Y(FT)*,2X,*H(FT)*,2X,*SD(F
     1T)*,2X,*RATIO(H/Y)*,2X,*THETA*,2X,*PNDB*,//)
      NP=26
      DO 10 I=1,NP
      READ(5,11)X(I)
      READ(5,11)Y(I)
      READ(5,11)PNDB(I)
 11   FORMAT(F10.0)
      IF(X(I) .LT. 6750.0) GO TO 12
C     H IS THE HEIGHT OF THE AIRCRAFT ABOVE GROUND BASED ON THE ADOPTED TAKEOF
C     PROFILE (100 PERCENT GWT.) FOR 2 ENGINES JET AIRCRAFT.
      H=-929.2079210+0.1524752475 *X(I)
      GO TO 13
 12   H=(X(I)-4000.0)/2.75
 13   SD(I)=SQRT(Y(I)**2+H**2)
      RATIO(I)=H/Y(I)
      THETA(I)=ATAN(RATIO(I))*57.29578
      WRITE(6,14)I,X(I),Y(I),H    ,SD(I),RATIO(I),THETA(I),PNDB(I)
 14   FORMAT(4X,I3,4X,F6.0,1X,F5.0,2X,F5.0,2X,F6.0,2X,F9.4,2X,F7.3,1X,
     1F6.2,/)
 10   CONTINUE
C
      CALL DATE(THEDATE)
      CALL LETTER(6,.25,90.,6.0,3.0,6HGIDAMY)
      CALL LETTER(10,.25,90.,7.0,3.0,THEDATE)
      CALL PLOT(10.0,2.0,-3)
C
      YMAX=130.0
      YMIN=70.0
      XMAX=9000.0
      XMIN=0.0
      XSCALE=(XMAX-XMIN)/9.0
      YSCALE=(YMAX-YMIN)/6.0
      V=0.0
      W=70.0
      CALL PLTIN(XSCALE,YSCALE,V,W,XMIN,XMAX,YMIN,YMAX)
C
      CALL PLOT(9.0,0.0,2)
      CALL PLOT(9.0,6.0,2)
      CALL PLOT(0.0,6.0,2)
      CALL PLOT(0.0,0.0,2)
C
      CALL LETTER(40,.12,0.0,1.0,-.75,HORIZ)
      CALL LETTER(30,.12,90.,-.75,1.0,VERT)
      CALL LETTER(30,.25,0.0,0.0,-1.25,TITLE)
```

```
C
C   TO CONSTRUCT A GRID PATTERN
C
      XG=0.0
      YG=0.0
      DELTAX=1.0
      DELTAY=1.0
      IDELX=0
      IDELY=0
      NV=8
      NH=5
      CALL GRIDGS(XG,YG,DELTAX,DELTAY,IDELX,IDELY,NV,NH)
C
      CALL LETTER(1,.12,0.0,0.0,-.3,1H0)
      CALL LETTER(4,.12,0.0,0.7,-.3,4H1000)
      CALL LETTER(4,.12,0.0,1.7,-.3,4H2000)
      CALL LETTER(4,.12,0.0,2.7,-.3,4H3000)
      CALL LETTER(4,.12,0.0,3.7,-.3,4H4000)
      CALL LETTER(4,.12,0.0,4.7,-.3,4H5000)
      CALL LETTER(4,.12,0.0,5.7,-.3,4H6000)
      CALL LETTER(4,.12,0.0,6.7,-.3,4H7000)
      CALL LETTER(4,.12,0.0,7.7,-.3,4H8000)
      CALL LETTER(4,.12,0.0,8.7,-.3,4H9000)
C
      CALL LETTER(3,0.12,0.0,-0.5,-.06 ,3H70 )
      CALL LETTER(3,0.12,0.0,-0.5,0.94,3H80 )
      CALL LETTER(3,0.12,0.0,-0.5,1.94,3H90 )
      CALL LETTER(3,0.12,0.0,-0.5,2.94,3H100)
      CALL LETTER(3,0.12,0.0,-0.5,3.94 ,3H110)
      CALL LETTER(3,0.12,0.0,-0.5,4.94 ,3H120)
      CALL LETTER(3,0.12,0.0,-0.5,5.94 ,3H130)
C
      DO 20 I=1,NP
      XD=SD(I)
      YD=PNDB(I)
      CALL UNITTO(XD,YD,XP,YP)
      IF(RATIO(I) .LT. 0.1763) GO TO 21
      CALL GRAF(XP,YP,0.12,3HCIR)
      GO TO 22
 21   CALL GRAF(XP,YP,0.12,3HSQR)
 22   CONTINUE
 20   CONTINUE
      CALL PLOT(0.0,0.0,3)
      CALL GRAF(6.0,-0.78,0.12,3HCIR)
      CALL GRAF(6.0,-0.60,0.12,3HSQR)
      CALL LETTER(10,0.06,0.0,6.25,-0.78,10HELEV ANGLE)
      CALL LETTER(10,0.06,0.0,6.25,-0.60,10HELEV ANGLE)
      CALL MATH(7.0,-0.78,0.12,0.0,5HGTHAN)
      CALL MATH(7.0,-0.60,0.12,0.0,5HLTHAN)
      CALL LETTER(10,0.06,0.0,7.20,-0.78,10H 10 DEG.   )
      CALL LETTER(10,0.06,0.0,7.20,-0.60,10H 10 DEG.   )
C   TO PLOT THE POLYNOMIAL PNDB=A+BX+C(X**2)+.................
      READ(5,80) (B(JC),JC=1,11)
  80  FORMAT(5E15.6)
      ND=90
      X=300.
      PPNDBT=B(1)+B(2)*(X)+B(3)*(X**2)+B(4)*(X**3)+B(5)*(X**4)+B(6)*(X*
```

```
     1*5)+B(7)*  (X**6)+B(8)*(X**7)+B(9)*(X**8)+B(10)*(X**9)+B(11)*(X**
     210)
      CALL UNITTO(X,PPNDBT,XPP,YPP)
      CALL PLOT(XPP,YPP,3)
      DO 666 ID=3,ND
      X=FLOAT(ID)*100.0
      PPNDBT=B(1)+B(2)*(X)+B(3)*(X**2)+B(4)*(X**3)+B(5)*(X**4)+B(6)*(X*
     1*5)+B(7)*  (X**6)+B(8)*(X**7)+B(9)*(X**8)+B(10)*(X**9)+B(11)*(X**
     210)
      CALL UNITTO(X,PPNDBT,XP,YP)
      CALL PLOT(XP,YP,2)
  666 CONTINUE
C
      CALL PLOT(0.0,-1.25,3)
      CALL PLOT(0.5,-1.25,2)
      CALL PLOT(0.0,0.0,3)
      CALL GRAF(0.0,-1.0,.12,3HCIR)
      CALL GRAF(0.5,-1.0,.12,3HSQR)
      CALL LETTER(10,.12,0.0,.75,-1.31,10HDEVELOPED )
      CALL LETTER(10,.12,0.0,.75,-1.06,10HEXPERIMENT)
      CALL LETTER(10,.12,0.0,7.1,4.4,10HTAKEOFF    )
C
      CALL PLOT(X,Y,999)
      STOP
      END
'       6400 END OF RECORD
'            END OF FILE
```

CD TOT   0143

```
C
C
C     ------------------------------------------------------------------
C     PROGRAM TO PLOT THE EQUATIONS DEVELOPED FOR THE EPNDB VS. DISTANCE
C     ------------------------------------------------------------------
C     POLYNOMIALS PA,PB,PC AND PD.
C     ----------------------------
C
C     -------
C     TAKEOFF
C     -------
C
      DIMENSION XP(200),PAP(200),PBP(200),PCP(200),PDP(200),PPP(200)
      DIMENSION HORIZ(4),VERT(3),TITLE(3),VERT2(4)
      DIMENSION DELTA(3),B(11)
      READ(5,80)(B(JC),JC=1,11)
   80 FORMAT(2E24.14)
      DATA HORIZ/10HSLANT PERP,10HENDICULAR ,10HDISTANCE (,8HFT)      /
      DATA VERT/10HPERCEIVED ,10HNOISE LEVE,10HL (PNDB)  /
      DATA TITLE/10H          ,10H  EPNDB VS,10H DISTANCE /
      CALL DATE(THEDATE)
      CALL LETTER(6,.25,90.,6.0,3.0,6HGIDAMY)
      CALL LETTER(10,.25,90.,7.0,3.0,THEDATE)
      CALL PLOT(10.0,2.0,-3)
      CALL LETTER(40,.12,0.0,1.0,-.75,HORIZ)
      CALL LETTER(30,.25,0.0,0.0,-1.25,TITLE)
C     TO DRAW HORIZONTAL GRID LINES
      CALL PLOT(0.0,0.0,3)
      DO 704 IG=1,13
      YG=FLOAT(IG-1)*0.5
      CALL PLOT(9.0,YG,2)
      YGG=FLOAT(IG)*0.5
      CALL PLOT(0.0,YGG,3)
  704 CONTINUE
C
C     TO CONSTRUCT LOGARITHMIC VERTICAL GRID LINES
      XCYCLE=3.0
      NC=3
      YCYCLE=6.0
      XSTART=100.
      DELTA(1)=100.
      DELTA(2)=1000.
      DELTA(3)=10000.
      DO 777 IC=1,NC,1
      DO 888 ICOUNT=1,10,1
      XDD=DELTA(IC)*FLOAT(ICOUNT)
      XPP=XCYCLE*ALOG10(XDD/XSTART)
      CALL PLOT(XPP,0.0,3)
      CALL PLOT(XPP,YCYCLE,2)
  888 CONTINUE
  777 CONTINUE

      CALL PLOT(-0.2,-0.3,3)
      CALL LETTER(6,0.12,0.0,-.2,-.3,6H100   )
      CALL LETTER(6,0.12,0.0,2.7,-.3,6H1000  )
      CALL LETTER(6,0.12,0.0,5.7,-.3,6H10000 )
      CALL LETTER(6,0.12,0.0,8.7,-.3,6H100000)

      CALL LETTER(3,0.12,0.0,-0.5,-.06,3H20 )
```

```
      CALL LETTER(3,0.12,0.0,-0.5,0.44,3H30 )
      CALL LETTER(3,0.12,0.0,-0.5,0.94,3H40 )
      CALL LETTER(3,0.12,0.0,-0.5,1.44,3H50 )
      CALL LETTER(3,0.12,0.0,-0.5,1.94,3H60 )
      CALL LETTER(3,0.12,0.0,-0.5,2.44,3H70 )
      CALL LETTER(3,0.12,0.0,-0.5,2.94,3H80 )
      CALL LETTER(3,0.12,0.0,-0.5,3.44,3H90 )
      CALL LETTER(3,0.12,0.0,-0.5,3.94,3H100)
      CALL LETTER(3,0.12,0.0,-0.5,4.44,3H110)
      CALL LETTER(3,0.12,0.0,-0.5,4.94,3H120)
      CALL LETTER(3,0.12,0.0,-0.5,5.44,3H130)
      CALL LETTER(3,0.12,0.0,-0.5,5.94,3H140)
C
      WRITE(6,21)
   21 FORMAT(1H1,3X,*COUNT*,4X,*DISTANCE*,4X,*PNDB*,6X,*POLY(A)*,3X,
     1*POLY(B)*,3X,*POLY(C)*,3X,*POLY(D)*,//)
      CPB=30.0/ALOG10(50.0)
      CPC=40.0/ALOG10(50.0)
      X=180.
      DO 300 L=1,41,1
      X=X+20.
      PAPNDB=B(1)+B(2)*(X)+B(3)*(X**2)+B(4)*(X**3)+B(5)*(X**4)+B(6)*(X*
     1*5)+B(7)* (X**6)+B(8)*(X**7)+B(9)*(X**8)+B(10)*(X**9)+B(11)*(X**
     210)
      PAEPNL=PAPNDB+(4.0*ALOG10(X))-16.0
      PBEPNL=PAEPNL
      PCEPNL=PAEPNL
      PDEPNL=PAEPNL+4.0
      XP(L)=XCYCLE*ALOG10(X/XSTART)
      PAP(L)=(PAEPNL-20.0)/20.0
      PBP(L)=(PBEPNL-20.0)/20.0
      PCP(L)=(PCEPNL-20.0)/20.0
      PDP(L)=(PDEPNL-20.0)/20.0
      PPP(L)=(PAPNDB-20.0)/20.0
      WRITE(6,500)L,X,PAPNDB,PAEPNL,PBEPNL,PCEPNL,PDEPNL
  500 FORMAT(4X,I4,4X,F8.1,4X,F6.2,4X,F6.2,4X,F6.2,4X,F6.2,4X,F6.2)
  300 CONTINUE
      X=1000.
      DO 301 L=42,87,1
      X=X+200.
      PAPNDB=B(1)+B(2)*(X)+B(3)*(X**2)+B(4)*(X**3)+B(5)*(X**4)+B(6)*(X*
     1*5)+B(7)* (X**6)+B(8)*(X**7)+B(9)*(X**8)+B(10)*(X**9)+B(11)*(X**
     210)
      PAEPNL=PAPNDB+(4.0*ALOG10(X))-16.0
      IF(X .GT. 2000.) GO TO 302
      PBEPNL=PAEPNL
      PCEPNL=PAEPNL
      PDEPNL=PAEPNL+4.0
      XP(L)=XCYCLE*ALOG10(X/XSTART)
      PAP(L)=(PAEPNL-20.0)/20.0
      PBP(L)=(PBEPNL-20.0)/20.0
      PCP(L)=(PCEPNL-20.0)/20.0
      PDP(L)=(PDEPNL-20.0)/20.0
      PPP(L)=(PAPNDB-20.0)/20.0
      GO TO 306
  302 PBEPNL=PAEPNL-(CPB*ALOG10(X/2000.))
      PCEPNL=PAEPNL-(CPC*ALOG10(X/2000.))
```

```
      PDEPNL=PCEPNL+4.
      XP(L)=XCYCLE*ALOG10(X/XSTART)
      PAP(L)=(PAEPNL-20.0)/20.0
      PBP(L)=(PBEPNL-20.)/20.
      PCP(L)=(PCEPNL-20.)/20.
      PDP(L)=(PDEPNL-20.)/20.
      PPP(L)=(PAPNDB-20.0)/20.0
  306 CONTINUE
      WRITE(6,500)L,X,PAPNDB,PAEPNL,PBEPNL,PCEPNL,PDEPNL
  301 CONTINUE
      X=10000.
      DO 303 L=88,113,1
      X=X+2000.
      PAPNDB=B(1)+B(2)*(X)+B(3)*(X**2)+B(4)*(X**3)+B(5)*(X**4)+B(6)*(X*
     1*5)+B(7)* (X**6)+B(8)*(X**7)+B(9)*(X**8)+B(10)*(X**9)+B(11)*(X**
     210)
      PAEPNL=PAPNDB+(4.0*ALOG10(X))-16.0
      PBEPNL=PAEPNL-(CPB*ALOG10(X/2000.))
      PCEPNL=PAEPNL-(CPC*ALOG10(X/2000.))
      PDEPNL=PCEPNL+4.0
      XP(L)=XCYCLE*ALOG10(X/XSTART)
      PAP(L)=(PAEPNL-20.)/20.
      PBP(L)=(PBEPNL-20.)/20.
      PCP(L)=(PCEPNL-20.)/20.
      PDP(L)=(PDEPNL-20.)/20.
      PPP(L)=(PAPNDB-20.)/20.
      WRITE(6,500)L,X,PAPNDB,PAEPNL,PBEPNL,PCEPNL,PDEPNL
  303 CONTINUE
C
C     TO PLOT THE GENERATED POLYNOMIALS PA,PB,PC,PD.
C
      CALL PLOT(XP(1),PAP(1),3)
      DO 400 L=1,113
      CALL PLOT(XP(L),PAP(L),2)
  400 CONTINUE
      CALL PLOT(XP(1),PBP(1),3)
      DO 402 L=1,113
      CALL PLOT(XP(L),PBP(L),2)
  402 CONTINUE
C
      CALL PLOT(XP(1),PCP(1),3)
      DO 403 L=1,113
      CALL PLOT(XP(L),PCP(L),2)
  403 CONTINUE
C
      CALL PLOT(XP(1),PDP(1),3)
      DO 404 L=1,113
      CALL PLOT(XP(L),PDP(L),2)
  404 CONTINUE
C
      CALL PLOT(-1.0,1.0,3)
      DATA VERT2/10HEFFECTIVE ,10HPERCEIVED ,10HNOISE LEVE,10HL (EPNDB)
     1 /
      CALL LETTER(40,0.12,90.0,-1.0,1.0,VERT2)
C
      CALL PLOT(X,Y,999)
      STOP
```

```
 END
   6400 END OF RECORD
 .13161460424089E+03     -.19907127074528E-01
 .35698010908113E-05     -.35121113387752E-09
 .20433156320150E-13     -.74320214054215E-18
 .17357734742231E-22     -.26020333093783E-27
 .24202656462740E-32     -.12716742804092E-37
 .28852200541228E-43

                              CD TOT   0181
```

```
C
C
C        ------------------------------------------------------------------------
C        PROGRAM TO PLOT THE EQUATIONS DEVELOPED FOR PNDB AND EPNDB VS. DISTAN
C        ------------------------------------------------------------------------
C        -------
C        LANDING
C        -------
C
C
      DIMENSION XP(200),PNDBP(200),EPNLP(200)
      DIMENSION HORIZ(4),VERT(3),TITLE(3),VERT2(4)
      DIMENSION DELTA(3),B(11)
      READ(5,80)(B(JC),JC=1,11)
   80 FORMAT(2E24.14)
      DATA HORIZ/10HSLANT PERP,10HENDICULAR ,10HDISTANCE (,8HFT)      /
      DATA VERT/10HPERCEIVED ,10HNOISE LEVE,10HL (PNDB)  /
      DATA TITLE/10H          ,10H   PNDB VS,10H DISTANCE /
      CALL DATE(THEDATE)
      CALL LETTER(6,.25,90.,6.0,3.0,6HGIDAMY)
      CALL LETTER(10,.25,90.,7.0,3.0,THEDATE)
      CALL PLOT(10.0,2.0,-3)
      CALL LETTER(40,.12,0.0,1.0,-.75,HORIZ)
      CALL LETTER(30,.12,90.,-.75,1.0,VERT)
      CALL LETTER(30,.25,0.0,0.0,-1.25,TITLE)
C     TO DRAW HORIZONTAL GRID LINES
      CALL PLOT(0.0,0.0,3)
      DO 704 IG=1,13
      YG=FLOAT(IG-1)*0.5
      CALL PLOT(9.0,YG,2)
      YGG=FLOAT(IG)*0.5
      CALL PLOT(0.0,YGG,3)
  704 CONTINUE
C
C     TO CONSTRUCT LOGARITHMIC VERTICAL GRID LINES
      XCYCLE=3.0
      NC=3
      YCYCLE=6.0
      XSTART=100.
      DELTA(1)=100.
      DELTA(2)=1000.
      DELTA(3)=10000.
      DO 777 IC=1,NC,1
      DO 888 ICOUNT=1,10,1
      XDD=DELTA(IC)*FLOAT(ICOUNT)
      XPP=XCYCLE*ALOG10(XDD/XSTART)
      CALL PLOT(XPP,0.0,3)
      CALL PLOT(XPP,YCYCLE,2)
  888 CONTINUE
  777 CONTINUE
C
      CALL PLOT(-0.2,-0.3,3)
      CALL LETTER(6,0.12,0.0,-.2,-.3,6H100   )
      CALL LETTER(6,0.12,0.0,2.7,-.3,6H1000  )
      CALL LETTER(6,0.12,0.0,5.7,-.3,6H10000 )
      CALL LETTER(6,0.12,0.0,8.7,-.3,6H100000)
C
      CALL LETTER(3,0.12,0.0,-0.5,-.06,3H20 )
      CALL LETTER(3,0.12,0.0,-0.5,0.44,3H30 )
```

```
      CALL LETTER(3,0.12,0.0,-0.5,0.94,3H40 )
      CALL LETTER(3,0.12,0.0,-0.5,1.44,3H50 )
      CALL LETTER(3,0.12,0.0,-0.5,1.94,3H60 )
      CALL LETTER(3,0.12,0.0,-0.5,2.44,3H70 )
      CALL LETTER(3,0.12,0.0,-0.5,2.94,3H80 )
      CALL LETTER(3,0.12,0.0,-0.5,3.44,3H90 )
      CALL LETTER(3,0.12,0.0,-0.5,3.94,3H100)
      CALL LETTER(3,0.12,0.0,-0.5,4.44,3H110)
      CALL LETTER(3,0.12,0.0,-0.5,4.94,3H120)
      CALL LETTER(3,0.12,0.0,-0.5,5.44,3H130)
      CALL LETTER(3,0.12,0.0,-0.5,5.94,3H140)
C
      WRITE(6,21)
   21 FORMAT(1H1,3X,*COUNT*,4X,*DISTANCE*,4X,*PNDB*,6X,*EPNL*,///)
      VALUE1=11.0/ALOG10(175.0)
      X=180.
      DO 300 L=1,41,1
      X=X+20.
        PNDB=B(1)+B(2)*(X)+B(3)*(X**2)+B(4)*(X**3)+B(5)*(X**4)+B(6)*(X*
     1*5)+B(7)* (X**6)+B(8)*(X**7)+B(9)*(X**8)+B(10)*(X**9)+B(11)*(X**
     210)
      EPNL=PNDB+(VALUE1*ALOG10(X/200.))-8.
      XP(L)=XCYCLE*ALOG10(X/XSTART)
      PNDBP(L)=(PNDB-20.0)/20.0
      EPNLP(L)=(EPNL-20.0)/20.0
      WRITE(6,500)L,X,PNDB,EPNL
  500 FORMAT(4X,I4,4X,F8.1,4X,F6.2,4X,F6.2)
  300 CONTINUE
      X=1000.
      DO 301 L=42,87,1
      X=X+200.
        PNDB=B(1)+B(2)*(X)+B(3)*(X**2)+B(4)*(X**3)+B(5)*(X**4)+B(6)*(X*
     1*5)+B(7)* (X**6)+B(8)*(X**7)+B(9)*(X**8)+B(10)*(X**9)+B(11)*(X**
     210)
      EPNL=PNDB+(VALUE1*ALOG10(X/200.))-8.
      XP(L)=XCYCLE*ALOG10(X/XSTART)
      PNDBP(L)=(PNDB-20.0)/20.0
      EPNLP(L)=(EPNL-20.0)/20.0
      WRITE(6,500)L,X,PNDB,EPNL
  301 CONTINUE
      X=10000.
      DO 303 L=88,100
      X=X+2000.
        PNDB=B(1)+B(2)*(X)+B(3)*(X**2)+B(4)*(X**3)+B(5)*(X**4)+B(6)*(X*
     1*5)+B(7)* (X**6)+B(8)*(X**7)+B(9)*(X**8)+B(10)*(X**9)+B(11)*(X**
     210)
      EPNL=PNDB+(VALUE1*ALOG10(X/200.))-8.
      XP(L)=XCYCLE*ALOG10(X/XSTART)
      PNDBP(L)=(PNDB-20.0)/20.0
      EPNLP(L)=(EPNL-20.0)/20.0
      WRITE(6,500)L,X,PNDB,EPNL
  303 CONTINUE
C
C     TO PLOT THE GENERATED POLYNOMIALS PNDB AND EPNL
C
      CALL PLOT(XP(1),PNDBP(1),3)
      DO 400 L=1,100
```

```
      CALL PLOT(XP(L),PNDBP(L),2)
 400  CONTINUE
      CALL PLOT(XP(1),EPNLP(1),3)
      DO 402 L=1,100
      CALL PLOT(XP(L),EPNLP(L),2)
 402  CONTINUE
C
C
      CALL PLOT(-1.0,1.0,3)
      DATA VERT2/10HEFFECTIVE ,10HPERCEIVED ,10HNOISE LEVE,10HL (EPNDB)
     1 /
      CALL LETTER(40,0.12,90.0,-1.0,1.0,VERT2)
      CALL LETTER(9,0.25,0.0,0.7,-1.25,9HEPNDB AND)
C
      CALL PLOT(X,Y,999)
      STOP
      END
'       6400 END OF RECORD
     .130535634662267E+03     -.297249521158 25E-01
     .977961981885 46E-05     -.232498353874 04E-08
     .326427302015 12E-12     -.275024215460 42E-16
     .143792972228 31E-20     -.470853748255 63E-25
     .940053378971 54E-30     -.104663489591 87E-34
     .498303756466 54E-40
'            END OF FILE
```

CD TOT 0141

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C     ----------------------------------------------------------------------
C     PROGRAM TO COMPUTE AND DRAW THE NOISE EXPOSURE FORECAST (NEF) CONTOURS
C     ----------------------------------------------------------------------
C     FOR THE EXISTING FACILITY AND OPERATION AT THE MOUNT HOPE AIRPORT.
C     ---------------- -----------------------------------------------------
C     ASSUMING THAT ALL LANDINGS AND TAKEOFFS WILL BE ON ONE RUNWAY(06 OR 24)
C     ----------------------------------------------------------------------
C
C         TAKEOFF
C         -------
C     2-ENGINES JET (DAY)           =7  AIRCRAFT(S)
C     2-ENGINES JET (NIGHT)         =1  AIRCRAFT(S)
C     2-ENGINES TURBOPROP(DAY)      =1 AIRCRAFT(S)
C     2-ENGINES TURBOPROP(NIGHT)    =0 AIRCRAFT(S)
C
C         LANDING
C         -------
C     2-ENGINES JET (DAY)           =7  AIRCRAFT(S)
C     2-ENGINES JET (NIGHT)         =2  AIRCRAFT(S)
C     2-ENGINES TURBOPROP(DAY)      =1 AIRCRAFT(S)
C     2-ENGINES TURBOPROP(NIGHT)    =0 AIRCRAFT(S)
C
C
      INTEGER TEXT(4)
      DIMENSION K(10,6),DNA(10,6),ENA(10,6)
      DIMENSION ARRAY(101,201),IARRAY(101)
      DIMENSION X(10),Y(10),XPAR(10),YPAR(10)
C     NI IS THE NUMBER OF DISTANCE INCREMENTS  IN THE X-DIRECTION
      NI=201
C     NJ IS THE NUMBER OF DISTANCE INCREMENTS  IN THE Y-DIRECTION
      NJ=101
C     NR IS THE NUMBER OF RUNWAYS FILED IN THE PROGRAM
      NR=10
C     NA IS THE NUMBER OF AIRCRAFTS FILED IN THE PROGRAM TIMES TWO (SINCE EACH
C     AIRCRAFT HAS TWO OPERATIONS WHICH ARE TAKE-OFF AND LANDING)
      NA=6
      DO 20 IR=1,NR
C     DNA IS THE NUMBER OF AIRCRAFTS LANDING OR TAKEOFF DURING DAY TIME F-R A
C     CERTAIN AIRCRAFT ON A CERTAIN RUNWAY.
C     ENA IS THE NUMBER OF AIRCRAFTS LANDING OR TAKEOFF DURING NIGHT TIME FOR A
C     CERTAIN AIRCRAFT ON A CERTAIN RUNWAY.
C     K IS A CODE WHICH  CAUSES THE PROGRAM TO BE EXCUTED OR NOT TO BE EXCUTED
C     FOR A PARTICULAR AIRCRAFT ON A PARTICULAR RUNWAY
      READ(5,21)(DNA(IR,JA),JA=1,NA),(ENA(IR,JA),JA=1,NA),(K(IR,JA),
     1JA=1,NA)
 21   FORMAT(6F5.0,6F5.0,6I1)
 20   CONTINUE
      DO 1 I=1,NI
      DO 2 J=1,NJ
      X=(FLOAT(I-1)*500.0)-50000.
      Y=(FLOAT(J-1)*500.0)-25000.
      TOTAL=0.0
      DO 3 IR=1,NR
      DO 4 JA=1,NA
      IF(K(IR,JA) .EQ. 0) GO TO 5
      SUBROUTINES RUN CONTAINS THE INFORMATION ON THE FILED RUNWAYS SUCH AS
      THE LENGTH , ORIENTATION AND CO-ORDINATES W.R.T. TO A CHOOSEN  ORIGIN
      GO TO(101,102,103,104,105,106,107,108,109,110),IR
 101  CALL RUN1(X,Y,X1,Y1,R)
```

```
      GO TO 6
 102  CALL RUN2(X,Y,X1,Y1,R)
      GO TO 6
 103  CALL RUN3(X,Y,X1,Y1,R)
      GO TO 6
 104  CALL RUN4(X,Y,X1,Y1,R)
      GO TO 6
 105  CALL RUN5(X,Y,X1,Y1,R)
      GO TO 6
 106  CALL RUN6(X,Y,X1,Y1,R)
      GO TO 6
 107  CALL RUN7(X,Y,X1,Y1,R)
      GO TO 6
 108  CALL RUN8(X,Y,X1,Y1,R)
      GO TO 6
 109  CALL RUN9(X,Y,X1,Y1,R)
      GO TO 6
 110  CALL RUN10(X,Y,X1,Y1,R)
      GO TO 6
 6    CONTINUE
C     SUBROUTINES TAKEOF CONTAINS THE ADOPTED TAKEOFF PROFILES OF THE VARIOUS
C     AIRCRAFTS FILED IN THE PROGRAM.
      GO TO(201,202,203,204,205,206),JA
 201  CALL TAKEOF1(X1,Y1,SDIST,RATIO,A)
      GO TO 7
 202  CALL TAKEOF2(X1,Y1,SDIST,RATIO,A)
      GO TO 7
 203  CALL TAKEOF3(X1,Y1,SDIST,RATIO,A)
      GO TO 7
C     SUBROUTINES ALAND CONTAINS THE ADOPTED LANDING PROFILES OF THE VARI-US
C     AIRCRAFTS FILED IN THE PROGRAM.
 204  CALL ALAND1(X1,Y1,R,SDIST,RATIO)
      GO TO 7
 205  CALL ALAND2(X1,Y1,R,SDIST,RATIO)
      GO TO 7
 206  CALL ALAND3(X1,Y1,R,SDIST,RATIO)
      GO TO 7
 7    CONTINUE
C     SUBROUTINES POLYT CONTAINS THE NOISE LEVEL VS. DISTANCE FOR THE VARIOUS
C     AIRCRAFTS FILED IN THE PROGRAM DURING TAKEOFF.
      GO TO(301,302,303,304,305,306),JA
 301  CALL POLYT1(A,R,SDIST,RATIO,X1,Y1,EPNL)
      GO TO 9
 302  CALL POLYT2(A,R,SDIST,RATIO,X1,Y1,EPNL)
      GO TO 9
 303  CALL POLYT3(A,R,SDIST,RATIO,X1,Y1,EPNL)
      GO TO 9
C     SUBROUTINES POLYL CONTAINS THE NOISE LEVEL VS. DISTANCE FOR THE VARIOUS
C     AIRCRAFTS FILED IN THE PROGRAM DURING LANDING.
 304  CALL POLYL1(X1,Y1,SDIST,RATIO,R,EPNL)
      GO TO 9
 305  CALL POLYL2(X1,Y1,SDIST,RATIO,R,EPNL)
      GO TO 9
 306  CALL POLYL3(X1,Y1,SDIST,RATIO,R,EPNL)
      GO TO 9
 9    CONTINUE
      ANEF IS THE NOISE EXPOSURE FORECAST INDEX RESULTING FROM A PARTICULAR
```

```
C      AIRCRAFT DURING OPERATION ON A CERTAIN RUNWAY GIVEN THE NUMBER OF AIRCRAF
C      MOVEMENTS  PER DAY AND NIGHT(COMPUTED AT DISTANCE X AND Y)
       ANEF=EPNL+(10.0*ALOG10(DNA(IR,JA)+16.67*ENA(IR,JA)))-88.0
C      ANTNEF IS THE ANTILOG OF ANEF WHICH WILL BE USED TO COMPUTE THE TOTAL NEF
       ANTNEF=10.0**(ANEF/10.0)
       GO TO 44
 5     ANTNEF=0.0
C      TOTAL IS THE SUM OF ALL THE ANTILOGS OF NEF RESULTING FROM ALL THE
C      AIRCRAFTS OPERATIONS AT THIS PARTICULAR LOCATION (X AND Y)
 44    TOTAL=TOTAL+ANTNEF
 4     CONTINUE
 3     CONTINUE
       IF(TOTAL .LE. 0.0) TOTAL=0.00001
C      ARRAY IS THE NOISE EXPOSURE FORECAST  AT A PARTICULAR LOCATION IN THE
C      AIRPORT VICINITY (THIS VALUE WILL BE USED TO CONSTRUCT THE NEF CONT-URS)
       ARRAY(J,I)=10.0*ALOG10(TOTAL)
 2     CONTINUE
 1     CONTINUE
       DO 10 I=1,NI
       DO 11 J=11,51
       IARRAY(J)=IFIX(ARRAY(J,I))
 11    CONTINUE
       WRITE(6,12)(IARRAY(J),J=11,51),I
 12    FORMAT(1X,41I3,3X,I3,/)
 10    CONTINUE
C
C
C          ------------ -----------------------------------------------
C          PROGRAM TO PLOT THE NOISE EXPOSURE FORECAST CONTOURS USING (EAI)
C          ------------------------------------------------------------
C          FLAT BED PLOTTER
C          ----------------
C
C
       TEXT(1)=10HGIDAMY-NEF
       TEXT(2)=10H EXISTING
       TEXT(3)=10HAIRPORT OP
       TEXT(4)=10HERATIONS
       ICOUNT=38
       CALL NAME(TEXT,ICOUNT)
C
C      MAP SCALE IS 1 TO 50000
       SCX=50000./12.
       SCY=50000./12.
       DELX=500.
       DELY=500.
C
C      TO CLEAR PLOTTING ARRAYS
       DO 30 IIC=1,10
       XPAR(IIC)=0.0
       YPAR(IIC)=0.0
       X(IIC)=0.0
       Y(IIC)=0.0
 30    CONTINUE

       M=NJ
       N=NI
```

```
      M1=1
      M2=101
      N1=1
      N2=201
      XPAR(1)=1.0
      YPAR(1)=2.0
      XPAR(2)=(DELX*FLOAT(N2-N1))/SCX
      YPAR(2)=(DELY*FLOAT(M2-M1))/SCY
      XPAR(5)=-1.0
      YPAR(5)=6.0
      XPAR(7)=1.0
      YPAR(7)=0.0
      XPAR(8)=5.0
      YPAR(8)=5.0
      VMIN=5.0
      VMAX=45.0
      VINC=5.0
      CALL CONTOUR(ARRAY,M,N,M1,M2,N1,N2,VMIN,VMAX,VINC,XPAR,YPAR)
C
C     TO CONSTRUCT GRID LINES
      YPAR(5)=6.0
      XINC=2000./SCX
      YINC=2000./SCY
      IND=1
      CALL GRID(XINC,YINC,XPAR,YPAR,IND)
C
C     TO DRAW THE RUNWAY
      M3=51
      N3=101
      XPAR(4)=SCX
      YPAR(4)=SCY
      XPAR(5)=0.0
      YPAR(5)=6.0
      XPAR(3)=0.0
      YPAR(3)=0.0
      ICOUNT=2
      KODE=0
      X(1)=FLOAT(N3-N1)*DELX
      Y(1)=FLOAT(M3-M1)*DELY
      X(2)=X(1)+6000.
      Y(2)=Y(1)
      CALL FLIN(X,Y,ICOUNT,XPAR,YPAR,KODE)
C
C
      CALL PAPAD
      STOP
      END
      SUBROUTINE RUN1(X,Y,X1,Y1,R)
C
C     RUNWAY NO. 1  CONFIGURATION RELATED TO CHOOSEN X AND Y CO-ORDINATES
      R=9000.
      XO=-3812.
      YO=500.
      ANGD=0.0
      ANGR=ANGD*0.0174532925199
      SINANG=SIN(ANGR)
      COSANG=COS(ANGR)
```

```
      DELTAX=X-XO
      DELTAY=Y-YO
      X1=(DELTAX*COSANG)+(DELTAY*SINANG)
      Y1=(DELTAY*COSANG)-(DELTAX*SINANG)
      RETURN
      END
      SUBROUTINE RUN2(X,Y,X1,Y1,R)
C
C     RUNWAY NO. 2  CONFIGURATION RELATED TO CHOOSEN X AND Y CO-ORDINATES
      R=9000.
      XO=5188.
      YO=500.
      ANGD=180.
      ANGR=ANGD*0.0174532925199
      SINANG=SIN(ANGR)
      COSANG=COS(ANGR)
      DELTAX=X-XO
      DELTAY=Y-YO
      X1=(DELTAX*COSANG)+(DELTAY*SINANG)
      Y1=(DELTAY*COSANG)-(DELTAX*SINANG)
      RETURN
      END
      SUBROUTINE RUN3(X,Y,X1,Y1,R)
C
C     RUNWAY NO. 3  CONFIGURATION RELATED TO CHOOSEN X AND Y CO-ORDINATES
      R=6000.
      XO=540.
      YO=-450.
      ANGD=50.
      ANGR=ANGD*0.0174532925199
      SINANG=SIN(ANGR)
      COSANG=COS(ANGR)
      DELTAX=X-XO
      DELTAY=Y-YO
      X1=(DELTAX*COSANG)+(DELTAY*SINANG)
      Y1=(DELTAY*COSANG)-(DELTAX*SINANG)
      RETURN
      END
      SUBROUTINE RUN4(X,Y,X1,Y1,R)
C
C     RUNWAY NO. 4  CONFIGURATION RELATED TO CHOOSEN X AND Y CO-ORDINATES
      R=6000.
      XO=3630.
      YO=4650.
      ANGD=230.
      ANGR=ANGD*0.0174532925199
      SINANG=SIN(ANGR)
      COSANG=COS(ANGR)
      DELTAX=X-XO
      DELTAY=Y-YO
      X1=(DELTAX*COSANG)+(DELTAY*SINANG)
      Y1=(DELTAY*COSANG)-(DELTAX*SINANG)
      RETURN
      END
      SUBROUTINE RUN5(X,Y,X1,Y1,R)
C
C     RUNWAY NO. 5  CONFIGURATION RELATED TO CHOOSEN X AND Y CO-ORDINATES
```

```
      R=6000.
      XO=0.
      YO=0.
      ANGD=0.0
      ANGR=ANGD*0.0174532925199
      SINANG=SIN(ANGR)
      COSANG=COS(ANGR)
      DELTAX=X-XO
      DELTAY=Y-YO
      X1=(DELTAX*COSANG)+(DELTAY*SINANG)
      Y1=(DELTAY*COSANG)-(DELTAX*SINANG)
      RETURN
      END
      SUBROUTINE RUN6(X,Y,X1,Y1,R)
C
C     RUNWAY NO. 6  CONFIGURATION RELATED TO CHOOSEN X AND Y CO-ORDINATES
      R=6000.
      XO=6000.
      YO=0.
C     ANGD=180.
C     ANGR=ANGD*0.0174532925199
C     SINANG=SIN(ANGR)
C     COSANG=COS(ANGR)
      SINANG=0.0
      COSANG=-1.0
      DELTAX=X-XO
      DELTAY=Y-YO
      X1=(DELTAX*COSANG)+(DELTAY*SINANG)
      Y1=(DELTAY*COSANG)-(DELTAX*SINANG)
      RETURN
      END
      SUBROUTINE RUN7(X,Y,X1,Y1,R)
C
C     RUNWAY NO. 7  CONFIGURATION RELATED TO CHOOSEN X AND Y CO-ORDINATES
      R=10000.
      XO=-4812.
      YO=-5000.
      ANGD=0.
      ANGR=ANGD*0.0174532925199
      SINANG=SIN(ANGR)
      COSANG=COS(ANGR)
      DELTAX=X-XO
      DELTAY=Y-YO
      X1=(DELTAX*COSANG)+(DELTAY*SINANG)
      Y1=(DELTAY*COSANG)-(DELTAX*SINANG)
      RETURN
      END
      SUBROUTINE RUN8(X,Y,X1,Y1,R)
C
C     RUNWAY NO. 8  CONFIGURATION RELATED TO CHOOSEN X AND Y CO-ORDINATES
      R=10000.
      XO=5188.
      YO=-5000.
      ANGD=180.
      ANGR=ANGD*0.0174532925199
      SINANG=SIN(ANGR)
      COSANG=COS(ANGR)
```

```
      DELTAX=X-XO
      DELTAY=Y-YO
      X1=(DELTAX*COSANG)+(DELTAY*SINANG)
      Y1=(DELTAY*COSANG)-(DELTAX*SINANG)
      RETURN
      END
      SUBROUTINE RUN9(X,Y,X1,Y1,R)
C
C     RUNWAY NO. 9  CONFIGURATION RELATED TO CHOOSEN X AND Y CO-ORDINATES
      R=10500.
      XO=750.
      YO=-5600.
      ANGD=0.
      ANGR=ANGD*0.0174532925199
      SINANG=SIN(ANGR)
      COSANG=COS(ANGR)
      DELTAX=X-XO
      DELTAY=Y-YO
      X1=(DELTAX*COSANG)+(DELTAY*SINANG)
      Y1=(DELTAY*COSANG)-(DELTAX*SINANG)
      RETURN
      END
      SUBROUTINE RUN10(X,Y,X1,Y1,R)
C
C     RUNWAY NO. 10 CONFIGURATION RELATED TO CHOOSEN X AND Y CO-ORDINATES
      R=10500.
      XO=11250.
      YO=-5600.
      ANGD=180.
      ANGR=ANGD*0.0174532925199
      SINANG=SIN(ANGR)
      COSANG=COS(ANGR)
      DELTAX=X-XO
      DELTAY=Y-YO
      X1=(DELTAX*COSANG)+(DELTAY*SINANG)
      Y1=(DELTAY*COSANG)-(DELTAX*SINANG)
      RETURN
      END
      SUBROUTINE TAKEOF1(X1,Y1,SDIST,RATIO,A)
C
C     TAKEOFF PROFILE OF AIRCRAFT CLASS 1
C     2-ENGINES JET AIRCRAFT
C
      A=4000.
      B=6750.
      C=29000.
      E=100.
      F=3500.
      G=20000.
      D=B+(((G-E)*(C-B))/(F-E))
      SLOPE1=E/(B-A)
      SLOPE2=(G-E)/(D-B)
      IF(X1 .LT. 0.0) GO TO 61
      IF(X1 .GE. 0.0 .AND. X1 .LE. A)ALT=0.0
      IF(X1 .GT. A .AND. X1.LE. B)ALT=SLOPE1*(X1-A)
      IF(X1 .GT. B .AND. X1 .LE. D)ALT=E+(SLOPE2*(X1-B))
      IF(X1 .GT. D)ALT=G
```

```
      SDIST=SQRT((ALT**2)+(ABS(Y1)**2))
      IF(Y1 .EQ. 0.0) GO TO 81
      RATIO=ALT/ABS(Y1)
      GO TO 82
 61   SDIST=SQRT((ABS(X1)**2)+(ABS(Y1)**2))
      RATIO=0.0
      GO TO 82
 81   RATIO=1000000000.
 82   RETURN
      END
      SUBROUTINE TAKEOF2(X1,Y1,SDIST,RATIO,A)
C
C     TAKEOFF PROFILE OF AIRCRAFT CLASS 2
C     4-ENGINES JET AIRCRAFT
C
      A=8000.
      B=10500.
      C=43000.
      E=100.
      F=3500.
      G=20000.
      D=B+(((G-E)*(C-B))/(F-E))
      SLOPE1=E/(B-A)
      SLOPE2=(G-E)/(D-B)
      IF(X1 .LT. 0.0) GO TO 61
      IF(X1 .GE. 0.0 .AND. X1 .LE. A)ALT=0.0
      IF(X1 .GT. A .AND. X1.LE. B)ALT=SLOPE1*(X1-A)
      IF(X1 .GT. B .AND. X1 .LE. D)ALT=E+(SLOPE2*(X1-B))
      IF(X1 .GT. D)ALT=G
      SDIST=SQRT((ALT**2)+(ABS(Y1)**2))
      IF(Y1 .EQ. 0.0) GO TO 81
      RATIO=ALT/ABS(Y1)
      GO TO 82
 61   SDIST=SQRT((ABS(X1)**2)+(ABS(Y1)**2))
      RATIO=0.0
      GO TO 82
 81   RATIO=1000000000.
 82   RETURN
      END
      SUBROUTINE TAKEOF3(X1,Y1,SDIST,RATIO,A)
C
C     TAKEOFF PROFILE OF AIRCRAFT CLASS 3
C     4-ENGINES TURBOPROP
C
      A=4500.
      B=7500.
      C=47500.
      E=150.
      F=3500.
      G=20000.
      D=B+(((G-E)*(C-B))/(F-E))
      SLOPE1=E/(B-A)
      SLOPE2=(G-E)/(D-B)
      IF(X1 .LT. 0.0) GO TO 61
      IF(X1 .GE. 0.0 .AND. X1 .LE. A)ALT=0.0
      IF(X1 .GT. A .AND. X1.LE. B)ALT=SLOPE1*(X1-A)
      IF(X1 .GT. B .AND. X1 .LE. D)ALT=E+(SLOPE2*(X1-B))
```

```
      IF(X1 .GT. D)ALT=G
      SDIST=SQRT((ALT**2)+(ABS(Y1)**2))
      IF(Y1 .EQ. 0.0) GO TO 81
      RATIO=ALT/ABS(Y1)
      GO TO 82
 61   SDIST=SQRT((ABS(X1)**2)+(ABS(Y1)**2))
      RATIO=0.0
      GO TO 82
 81   RATIO=1000000000.
 82   RETURN
      END
      SUBROUTINE ALAND1(X1,Y1,R,SDIST,RATIO)
C
C     LANDING PROFILE OF AIRCRAFT CLASS 1
C     2-ENGINES JET AIRCRAFT
      FL=4000.
      TDP=1000.
C     GSAD=2.5
C     GSAR=GSAD*0.0174532925199
C     TANGS=TAN(GSAR)
C     DP=-((FL/TANGS)-TDP)
      TR=0.6666666666*R
      TANGS=0.04366094290840
      DP=-90615.062193951695
      Z=TDP+TR
      IF(X1 .GT. Z) GO TO 30
      IF(X1 .GE. TDP .AND. X1 .LE. Z) ALT=0.0
      IF(X1 .LE. DP)ALT=FL
      IF(X1 .GT. DP .AND. X1 .LE. 0.0)ALT=(ABS(X1)+TDP)*TANGS
      IF(X1 .GE. 0.0 .AND. X1 .LE. TDP)ALT=(TDP-X1)*TANGS
      SDIST=SQRT((ALT**2)+(ABS(Y1)**2))
      IF(Y1 .EQ. 0.0) GO TO 10
      RATIO=ALT/ABS(Y1)
      GO TO 20
 30   SDIST=SQRT((ABS(X1-Z)**2)+(ABS(Y1)**2))
      RATIO=0.0
      GO TO 20
 10   RATIO=1000000000.
 20   RETURN
      END
      SUBROUTINE ALAND2(X1,Y1,R,SDIST,RATIO)
C
C     LANDING PROFILE OF AIRCRAFT CLASS 2
C     4-ENGINES JET AIRCRAFT
      FL=4000.
      TDP=1000.
C     GSAD=2.5
C     GSAR=GSAD*0.0174532925199
C     TANGS=TAN(GSAR)
C     DP=-((FL/TANGS)-TDP)
      TR=0.6666666666*R
      TANGS=0.04366094290840
      DP=-90615.062193951695
      Z=TDP+TR
      IF(X1 .GT. Z) GO TO 30
      IF(X1 .GE. TDP .AND. X1 .LE. Z) ALT=0.0
      IF(X1 .LE. DP)ALT=FL
```

```
      IF(X1 .GT. DP .AND. X1 .LE. 0.0)ALT=(ABS(X1)+TDP)*TANGS
      IF(X1 .GE. 0.0 .AND. X1 .LE. TDP)ALT=(TDP-X1)*TANGS
      SDIST=SQRT((ALT**2)+(ABS(Y1)**2))
      IF(Y1 .EQ. 0.0) GO TO 10
      RATIO=ALT/ABS(Y1)
      GO TO 20
 30   SDIST=SQRT((ABS(X1-Z)**2)+(ABS(Y1)**2))
      RATIO=0.0
      GO TO 20
 10   RATIO=1000000000.
 20   RETURN
      END
      SUBROUTINE ALAND3(X1,Y1,R,SDIST,RATIO)
C
C     LANDING PROFILE OF AIRCRAFT CLASS 3
C     4-ENGINES TURBOPROP
      FL=4000.
      TDP=1000.
C     GSAD=2.5
C     GSAR=GSAD*0.0174532925199
C     TANGS=TAN(GSAR)
C     DP=-((FL/TANGS)-TDP)
      TR=0.6666666666*R
      TANGS=0.04366094290840
      DP=-90615.062193951695
      Z=TDP+TR
      IF(X1 .GT. Z) GO TO 30
      IF(X1 .GE. TDP .AND. X1 .LE. Z) ALT=0.0
      IF(X1 .LE. DP)ALT=FL
      IF(X1 .GT. DP .AND. X1 .LE. 0.0)ALT=(ABS(X1)+TDP)*TANGS
      IF(X1 .GE. 0.0 .AND. X1 .LE. TDP)ALT=(TDP-X1)*TANGS
      SDIST=SQRT((ALT**2)+(ABS(Y1)**2))
      IF(Y1 .EQ. 0.0) GO TO 10
      RATIO=ALT/ABS(Y1)
      GO TO 20
 30   SDIST=SQRT((ABS(X1-Z)**2)+(ABS(Y1)**2))
      RATIO=0.0
      GO TO 20
 10   RATIO=1000000000.
 20   RETURN
      END
      SUBROUTINE POLYT1(A,R,SDIST,RATIO,X1,Y1,EPNL)
C
C     THIS SUBPROGRAM CONTAINS THE EPNL VS. SLANT DISTANCE INFORMATION
C     2-ENGINES JET AIRCRAFT
C
      A1=0.13161460424089E+03
      A2=-0.19907127074528E-01
      A3=0.35698010908113E-05
      A4=-0.35121113387752E-09
      A5=0.20433156320150E-13
      A6=-0.74320214054215E-18
      A7=0.17357734742231E-22
      A8=-0.26020333093783E-27
      A9=0.24202656462740E-32
      A10=-0.12716742804092E-37
      A11=0.28852200541228E-43
```

```
      X=SDIST
      IF(X .EQ. 0.0)X=10.0
      CPB=30./ALOG10(50.)
      CPC=40./ALOG10(50.)
C     PERCEIVED NOISE LEVEL
      PNL=A1+A2*(X)+A3*(X**2)+A4*(X**3)+A5*(X**4)+A6*(X**5)+A7*(X**6)+
     1A8*(X**7)+A9*(X**8)+A10*(X**9)+A11*(X**10)
C     EFFECTIVE PERCEIVED NOISE LEVEL
      PA=PNL+(4.0*ALOG10(X))-16.0
      IF(X .GT. 2000.) GO TO 800
      PB=PA
      PC=PA
      PD=PC+4.0
      GO TO 801
 800  PB=PA-(CPB*ALOG10(X/2000.))
      PC=PA-(CPC*ALOG10(X/2000.))
      PD=PC+4.
 801  CONTINUE
      IF(X1 .GE. R .AND. RATIO .GE. 0.1763)EPNL=PA
      IF(X1.GE.R.AND.RATIO.LE.0.1763)EPNL=PB+((PA-PB)*(RATIO/.1763))
      IF(X1.GE.A.AND.X1.LE.R)EPNL=PC+((PB-PC)*((X1-A)/(R-A)))
      IF(X1.GE.0.0.AND.X1.LE.A)EPNL=PD-(4.0*(X1/A))
      IF(X1 .LT. 0.0)EPNL=PD
      RETURN
      END
      SUBROUTINE POLYT2(A,R,SDIST,RATIO,X1,Y1,EPNL)
C
C     THIS SUBPROGRAM CONTAINS THE EPNL VS. SLANT DISTANCE INFORMATION
C     4-ENGINES JET AIRCRAFT
C
      A1=0.13161460424089E+03
      A2=-0.19907127074528E-01
      A3=0.35698010908113E-05
      A4=-0.35121113387752E-09
      A5=0.20433156320150E-13
      A6=-0.74320214054215E-18
      A7=0.17357734742231E-22
      A8=-0.26020333093783E-27
      A9=0.24202656462740E-32
      A10=-0.12716742804092E-37
      A11=0.28852200541228E-43
      X=SDIST
      IF(X .EQ. 0.0)X=10.0
      CPB=30./ALOG10(50.)
      CPC=40./ALOG10(50.)
C     PERCEIVED NOISE LEVEL
      PNL=A1+A2*(X)+A3*(X**2)+A4*(X**3)+A5*(X**4)+A6*(X**5)+A7*(X**6)+
     1A8*(X**7)+A9*(X**8)+A10*(X**9)+A11*(X**10)+3.0
C     EFFECTIVE PERCEIVED NOISE LEVEL
      PA=PNL+(4.0*ALOG10(X))-16.0
      IF(X .GT. 2000.) GO TO 800
      PB=PA
      PC=PA
      PD=PC+4.0
      GO TO 801
 800  PB=PA-(CPB*ALOG10(X/2000.))
      PC=PA-(CPC*ALOG10(X/2000.))
```

```
      PD=PC+4.
 801  CONTINUE
      IF(X1 .GE. R .AND. RATIO .GE. 0.1763)EPNL=PA
      IF(X1.GE.R.AND.RATIO.LE.0.1763)EPNL=PB+((PA-PB)*(RATIO/.1763))
      IF(X1.GE.A.AND.X1.LE.R)EPNL=PC+((PB-PC)*((X1-A)/(R-A)))
      IF(X1.GE.0.0.AND.X1.LE.A)EPNL=PD-(4.0*(X1/A))
      IF(X1 .LT. 0.0)EPNL=PD
      RETURN
      END
      SUBROUTINE POLYT3(A,R,SDIST,RATIO,X1,Y1,EPNL)
C
C     THIS SUBPROGRAM CONTAINS THE EPNL VS. SLANT DISTANCE INFORMATION
C     4-ENGINES TURBOPROP
C
      X=SDIST
      IF(X .EQ. 0.0)X=10.0
      CPB=30./ALOG10(50.)
      CPC=40./ALOG10(50.)
      CONST=(113.3-76.3)/ALOG10(10000./300.)
C     PERCEIVED NOISE LEVEL
      PNL=113.3-(CONST*ALOG10(X/300.))
C     EFFECTIVE PERCEIVED NOISE LEVEL
      PA=PNL+(4.0*ALOG10(X))-16.0
      IF(X .GT. 2000.) GO TO 800
      PB=PA
      PC=PA
      PD=PC+4.0
      GO TO 801
 800  PB=PA-(CPB*ALOG10(X/2000.))
      PC=PA-(CPC*ALOG10(X/2000.))
      PD=PC+4.
 801  CONTINUE
      IF(X1 .GE. R .AND. RATIO .GE. 0.1763)EPNL=PA
      IF(X1.GE.R.AND.RATIO.LE.0.1763)EPNL=PB+((PA-PB)*(RATIO/.1763))
      IF(X1.GE.A.AND.X1.LE.R)EPNL=PC+((PB-PC)*((X1-A)/(R-A)))
      IF(X1.GE.0.0.AND.X1.LE.A)EPNL=PD-(4.0*(X1/A))
      IF(X1 .LT. 0.0)EPNL=PD
      RETURN
      END
      SUBROUTINE POLYL1(X1,Y1,SDIST,RATIO,R,EPNL)
C
C     THIS SUBPROGRAM CONTAINS THE EPNL VS. SLANT DISTANCE INFORMATION
C     2-ENGINES JET AIRCRAFT
C
      A1=   .13053563466267E+03
      A2=  -.29724952115825E-01
      A3=   .97796198188546E-05
      A4=  -.23249835387404E-08
      A5=   .32642730201512E-12
      A6=  -.27502421546042E-16
      A7=   .14379297222831E-20
      A8=  -.47085374825563E-25
      A9=   .94005337897154E-30
      A10= -.10466348959187E-34
      A11=  .49830375646654E-40
      VALUE1=11.0/ALOG10(175.0)
      TDP=1000.
```

```
      X=SDIST
      IF(X .EQ. 0.0)X=10.0
      IF(X .GT. 35000.) GO TO 10
C     PERCEIVED NOISE LEVEL
      PNL=A1+A2*(X)+A3*(X**2)+A4*(X**3)+A5*(X**4)+A6*(X**5)+A7*(X**6)+
     1A8*(X**7)+A9*(X**8)+A10*(X**9)+A11*(X**10)
      GO TO 20
 10   PNL=40.0-(20.0*ALOG10(ABS(X)/35000.0))
 20   CONTINUE
C     EFFECTIVE PERCEIVED NOISE LEVEL
      EPNL=PNL+(VALUE1*ALOG10(ABS(X)/200.))-8.0
      RETURN
      END
      SUBROUTINE POLYL2(X1,Y1,SDIST,RATIO,R,EPNL)
C
C     THIS SUBPROGRAM CONTAINS THE EPNL VS. SLANT DISTANCE INFORMATION
C     4-ENGINES JET AIRCRAFT
C
      A1=   .13053563466267E+03
      A2=  -.29724952115825E-01
      A3=   .97796198188546E-05
      A4=  -.23249835387404E-08
      A5=   .32642730201512E-12
      A6=  -.27502421546042E-16
      A7=   .14379297222831E-20
      A8=  -.47085374825563E-25
      A9=   .94005337897154E-30
      A10= -.10466348959187E-34
      A11=  .49830375646654E-40
      VALUE1=11.0/ALOG10(175.0)
      TDP=1000.
      X=SDIST
      IF(X .EQ. 0.0)X=10.0
      IF(X .GT. 35000.) GO TO 10
C     PERCEIVED NOISE LEVEL
      PNL=A1+A2*(X)+A3*(X**2)+A4*(X**3)+A5*(X**4)+A6*(X**5)+A7*(X**6)+
     1A8*(X**7)+A9*(X**8)+A10*(X**9)+A11*(X**10)+3.0
      GO TO 20
 10   PNL=40.0-(20.0*ALOG10(ABS(X)/35000.0))
 20   CONTINUE
C     EFFECTIVE PERCEIVED NOISE LEVEL
      EPNL=PNL+(VALUE1*ALOG10(ABS(X)/200.))-8.0
      RETURN
      END
      SUBROUTINE POLYL3(X1,Y1,SDIST,RATIO,R,EPNL)

      THIS SUBPROGRAM CONTAINS THE EPNL VS. SLANT DISTANCE INFORMATION
      4-ENGINES TURBOPROP AIRCRAFT

      VALUE1=11.0/ALOG10(175.0)
      CONST=(106.4-72.0)/ALOG10(20.0)
      TDP=1000.
      X=SDIST
      IF(X .EQ. 0.0)X=10.0
      PERCEIVED NOISE LEVEL
      PNL=106.4-(CONST*ALOG10(ABS(X)/300.0))
      EFFECTIVE PERCEIVED NOISE LEVEL
```

```
      EPNL=PNL+(VALUE1*ALOG10(ABS(X)/200.))-8.0
      RETURN
      END
'        6400 END OF RECORD



7.0  0.0  1.0  7.0  0.0  1.0  1.0  0.0  0.0  2.0  0.0  0.0  101101



'             END OF FILE

                                    CD TOT    0758
```

```
C     ------------------------------------------------------------------------
C     PROGRAM TO COMPUTE AND DRAW THE NOISE EXPOSURE FORECAST (NEF) CONTOURS
C     ------------------------------------------------------------------------
C     FOR THE PROPOSED FACILITY AND OPERATION AT THE MOUNT HOPE AIRPORT.
C     ------------------------------------------------------------------------
C     ASSUMING THAT ALL LANDINGS AND TAKEOFF WILL BE ON RUNWAYS 11-29
C     ------------------------------------------------------------------------
C     AND 06-24
C     ---------
C
C     RUNWAY UTILIZATION
C     ------------------
C     RUNWAY 11=20 PERCENT
C     RUNWAY 29=75 PERCENT
C     RUNWAY 06=2.5 PERCENT
C     RUNWAY 24=2.5 PERCENT
C
C     NOTE..... IT HAS BEEN ASSUMED THAT RUNWAY 06-24 WILL NOT HANDLE 4-ENGINE
C     AIRCRAFTS DUE TO THE SHORT LENGTH OF THIS RUNWAY.
C
C        TAKEOFF
C        -------
C     4-ENGINES TURBOFAN (2500-3500 NM.) (DAY)   =8  AIRCRAFT(S)
C     4-ENGINES TURBOFAN (2500-3500 NM.) (NIGHT) =1  AIRCRAFT(S)
C     4-ENGINES TURBOFAN (500 NM.) (DAY)         =7  AIRCRAFT(S)
C     4-ENGINES TURBOFAN (500 NM.) (NIGHT)       =1  AIRCRAFT(S)
C     2-ENGINES TURBOFAN (DAY)                   =18 AIRCRAFT(S)
C     2-ENGINES TURBOFAN (NIGHT)                 =2  AIRCRAFT(S)
C     3-ENGINES TURBOFAN (DAY)                   =18 AIRCRAFT(S)
C     3-ENGINES TURBOFAN (NIGHT)                 =2  AIRCRAFT(S)
C
C        LANDING
C        -------
C     4-ENGINES TURBOFAN (2500-3500 NM.) (DAY)   =8  AIRCRAFT(S)
C     4-ENGINES TURBOFAN (2500-3500 NM.) (NIGHT) =1  AIRCRAFT(S)
C     4-ENGINES TURBOFAN (500 NM.) (DAY)         =7  AIRCRAFT(S)
C     4-ENGINES TURBOFAN (500 NM.) (NIGHT)       =1  AIRCRAFT(S)
C     2-ENGINES TURBOFAN (DAY)                   =18 AIRCRAFT(S)
C     2-ENGINES TURBOFAN (NIGHT)                 =2  AIRCRAFT(S)
C     3-ENGINES TURBOFAN (DAY)                   =18 AIRCRAFT(S)
C     3-ENGINES TURBOFAN (NIGHT)                 =2  AIRCRAFT(S)
C
C
      INTEGER TEXT(4)
      DIMENSION KARRAY(101)
      DIMENSION K(10,10),DNA(10,10),ENA(10,10)
      DIMENSION ARRAY(101,201),IARRAY(101)
      DIMENSION X(10),Y(10),XPAR(10),YPAR(10)
C     NI IS THE NUMBER OF DISTANCE INCREMENTS  IN THE X-DIRECTION
      NI=201
C     NJ IS THE NUMBER OF DISTANCE INCREMENTS  IN THE Y-DIRECTION
      NJ=101
C     NR IS THE NUMBER OF RUNWAYS FILED IN THE PROGRAM
      NR=10
C     NA IS THE NUMBER OF AIRCRAFTS FILED IN THE PROGRAM TIMES TWO (SINCE EACH
C     AIRCRAFT HAS TWO OPERATIONS WHICH ARE TAKE-OFF AND LANDING)
      NA=10
C     K IS A CODE WHICH  CAUSES THE PROGRAM TO BE EXCUTED OR NOT TO BE EXCUTED
C     FOR A PARTICULAR AIRCRAFT ON A PARTICULAR RUNWAY
```

```
      DO 20 IR=1,NR
      READ(5,21)(K(IR,JA),JA=1,NA)
 21   FORMAT(10I5)
 20   CONTINUE
C     DNA IS THE NUMBER OF AIRCRAFTS LANDING OR TAKEOFF DURING DAY TIME F-R A
C     CERTAIN AIRCRAFT ON A CERTAIN RUNWAY.
      DO 40 IR=1,NR
      READ(5,41)(DNA(IR,JA),JA=1,NA)
 41   FORMAT(10F5.0)
 40   CONTINUE
C     ENA IS THE NUMBER OF AIRCRAFTS LANDING OR TAKEOFF DURING NIGHT TIME FOR
C     CERTAIN AIRCRAFT ON A CERTAIN RUNWAY.
      DO 42 IR=1,NR
      READ(5,43)(ENA(IR,JA),JA=1,NA)
 43   FORMAT(10F5.0)
 42   CONTINUE
      DO 1 I=1,NI
      DO 2 J=1,NJ
      X=(FLOAT(I-1)*500.0)-44000.
      Y=25000.-(FLOAT(J-1)*500.)
      TOTAL=0.0
      DO 3 IR=1,NR
      DO 4 JA=1,NA
      IF(K(IR,JA) .EQ. 0) GO TO 5
C     SUBROUTINES RUN CONTAINS THE INFORMATION ON THE FILED RUNWAYS SUCH AS
C     THE LENGTH , ORIENTATION AND CO-ORDINATES W.R.T. TO A CHOOSEN  ORIGIN
      GO TO(101,102,103,104,105,106,107,108,109,110),IR
 101  CALL RUN1(X,Y,X1,Y1,R)
      GO TO 6
 102  CALL RUN2(X,Y,X1,Y1,R)
      GO TO 6
 103  CALL RUN3(X,Y,X1,Y1,R)
      GO TO 6
 104  CALL RUN4(X,Y,X1,Y1,R)
      GO TO 6
 105  CALL RUN5(X,Y,X1,Y1,R)
      GO TO 6
 106  CALL RUN6(X,Y,X1,Y1,R)
      GO TO 6
 107  CALL RUN7(X,Y,X1,Y1,R)
      GO TO 6
 108  CALL RUN8(X,Y,X1,Y1,R)
      GO TO 6
 109  CALL RUN9(X,Y,X1,Y1,R)
      GO TO 6
 110  CALL RUN10(X,Y,X1,Y1,R)
      GO TO 6
 6    CONTINUE
C     SUBROUTINES TAKEOF CONTAINS THE ADOPTED TAKEOFF PROFILES OF THE VARIOUS
C     AIRCRAFTS FILED IN THE PROGRAM.
      GO TO(201,202,203,204,205,206,207,208,209,210),JA
 201  CALL TAKEOF1(X1,Y1,SDIST,RATIO,A)
      GO TO 7
 202  CALL TAKEOF2(X1,Y1,SDIST,RATIO,A)
      GO TO 7
 203  CALL TAKEOF3(X1,Y1,SDIST,RATIO,A)
      GO TO 7
```

```
 204   CALL TAKEOF4(X1,Y1,SDIST,RATIO,A)
       GO TO 7
 205   CALL TAKEOF5(X1,Y1,SDIST,RATIO,A)
       GO TO 7
C      SUBROUTINES ALAND CONTAINS THE ADOPTED LANDING PROFILES OF THE VARI-US
C      AIRCRAFTS FILED IN THE PROGRAM.
 206   CALL ALAND1(X1,Y1,R,SDIST,RATIO)
       GO TO 7
 207   CALL ALAND2(X1,Y1,R,SDIST,RATIO)
       GO TO 7
 208   CALL ALAND3(X1,Y1,R,SDIST,RATIO)
       GO TO 7
 209   CALL ALAND4(X1,Y1,R,SDIST,RATIO)
       GO TO 7
 210   CALL ALAND5(X1,Y1,R,SDIST,RATIO)
       GO TO 7
 7     CONTINUE
C      SUBROUTINES POLYT CONTAINS THE NOISE LEVEL VS. DISTANCE FOR THE VARIOUS
C      AIRCRAFTS FILED IN THE PROGRAM DURING TAKEOFF.
       GO TO(301,302,303,304,305,306,307,308,309,310),JA
 301   CALL POLYT1(A,R,SDIST,RATIO,X1,Y1,EPNL)
       GO TO 9
 302   CALL POLYT2(A,R,SDIST,RATIO,X1,Y1,EPNL)
       GO TO 9
 303   CALL POLYT3(A,R,SDIST,RATIO,X1,Y1,EPNL)
       GO TO 9
 304   CALL POLYT4(A,R,SDIST,RATIO,X1,Y1,EPNL)
       GO TO 9
 305   CALL POLYT5(A,R,SDIST,RATIO,X1,Y1,EPNL)
       GO TO 9
C      SUBROUTINES POLYL CONTAINS THE NOISE LEVEL VS. DISTANCE FOR THE VARIOUS
C      AIRCRAFTS FILED IN THE PROGRAM DURING LANDING.
 306   CALL POLYL1(X1,Y1,SDIST,RATIO,R,EPNL)
       GO TO 9
 307   CALL POLYL2(X1,Y1,SDIST,RATIO,R,EPNL)
       GO TO 9
 308   CALL POLYL3(X1,Y1,SDIST,RATIO,R,EPNL)
       GO TO 9
 309   CALL POLYL4(X1,Y1,SDIST,RATIO,R,EPNL)
       GO TO 9
 310   CALL POLYL5(X1,Y1,SDIST,RATIO,R,EPNL)
       GO TO 9
 9     CONTINUE
C      ANEF IS THE NOISE EXPOSURE FORECAST INDEX RESULTING FROM A PARTICULAR
C      AIRCRAFT DURING OPERATION ON A CERTAIN RUNWAY GIVEN THE NUMBER OF AIRCRA
C      MOVEMENTS  PER DAY AND NIGHT(COMPUTED AT DISTANCE X AND Y)
       ANEF=EPNL+(10.0*ALOG10(DNA(IR,JA)+16.67*ENA(IR,JA)))-88.0
C      ANTNEF IS THE ANTILOG OF ANEF WHICH WILL BE USED TO COMPUTE THE TOTAL NE
       ANTNEF=10.0**(ANEF/10.0)
       GO TO 44
 5     ANTNEF=0.0
C      TOTAL IS THE SUM OF ALL THE ANTILOGS OF NEF RESULTING FROM ALL THE
C      AIRCRAFTS OPERATIONS AT THIS PARTICULAR LOCATION (X AND Y)
 44    TOTAL=TOTAL+ANTNEF
 4     CONTINUE
 3     CONTINUE
       IF(TOTAL .LE. 0.0) TOTAL=0.00001
```

```
C      ARRAY IS THE NOISE EXPOSURE FORECAST  AT A PARTICULAR LOCATION IN THE
C      AIRPORT VICINITY (THIS VALUE WILL BE USED TO CONSTRUCT THE NEF CONT-URS)
       ARRAY(J,I)=10.0*ALOG10(TOTAL)
 2     CONTINUE
 1     CONTINUE
       DO 10 I=1,NI
       KM=71
       DO 11 J=31,71
       IARRAY(J)=IFIX(ARRAY(J,I))
       KARRAY(KM)=IARRAY(J)
       KM=KM-1
 11    CONTINUE
       WRITE(6,12)(KARRAY(KM),KM=31,71),I
 12    FORMAT(1X,41I3,3X,I3,/)
 10    CONTINUE
C
C
C          -----------------------------------------------------------------
C          PROGRAM TO PLOT THE NOISE EXPOSURE FORECAST CONTOURS USING (EAI)
C          -----------------------------------------------------------------
C          FLAT BED PLOTTER
C          ----------------
C
C
       TEXT(1)=10HGIDAMY-NEF
       TEXT(2)=10H PROPOSED
       TEXT(3)=10HAIRPORT OP
       TEXT(4)=10HERATIONS
       ICOUNT=38
       CALL NAME(TEXT,ICOUNT)
C
C      MAP SCALE IS 1 TO 50000
       SCX=50000./12.
       SCY=50000./12.
       DELX=500.
       DELY=500.
C
C      TO CLEAR PLOTTING ARRAYS
       DO 30 IIC=1,10
       XPAR(IIC)=0.0
       YPAR(IIC)=0.0
       X(IIC)=0.0
       Y(IIC)=0.0
 30    CONTINUE
C
       M=NJ
       N=NI
       M1=1
       M2=101
       N1=1
       N2=201
       XPAR(1)=1.0
       YPAR(1)=2.0
       XPAR(2)=(DELX*FLOAT(N2-N1))/SCX
       YPAR(2)=(DELY*FLOAT(M2-M1))/SCY
       XPAR(5)=-1.0
       YPAR(5)=6.0
```

```
      XPAR(7)=1.0
      YPAR(7)=0.0
      XPAR(8)=5.0
      YPAR(8)=5.0
      VMIN=5.0
      VMAX=45.0
      VINC=5.0
      CALL CONTOUR(ARRAY,M,N,M1,M2,N1,N2,VMIN,VMAX,VINC,XPAR,YPAR)
C
C     TO CONSTRUCT GRID LINES
      YPAR(5)=7.0
      XINC=2000./SCX
      YINC=2000./SCY
      IND=1
      CALL GRID(XINC,YINC,XPAR,YPAR,IND)
C
C     TO DRAW RUNWAY 11-29 (CODE 9 AND 10)
      M3=51
      N3=89
      XPAR(4)=SCX
      YPAR(4)=SCY
      XPAR(5)=0.0
      YPAR(5)=8.0
      XPAR(3)=0.0
      YPAR(3)=0.0
      ICOUNT=2
      KODE=0
      X(1)=(FLOAT(N3-N1)*DELX)+750.
      Y(1)=(FLOAT(M3-M1)*DELY)-5600.
      X(2)=X(1)+10500.
      Y(2)=Y(1)
      CALL LINE(X,Y,ICOUNT,XPAR,YPAR,KODE)
C
C     TO DRAW RUNWAY 06-24 (CODE 3 AND 4)
      M3=51
      N3=89
      XPAR(4)=SCX
      YPAR(4)=SCY
      XPAR(5)=0.0
      YPAR(5)=8.0
      XPAR(3)=0.0
      YPAR(3)=0.0
      ICOUNT=2
      KODE=0
      X(1)=(FLOAT(N3-N1)*DELX)+463.0
      Y(1)=(FLOAT(M3-M1)*DELY)-414.0
      X(2)=(FLOAT(N3-N1)*DELX)+4320.0
      Y(2)=(FLOAT(M3-M1)*DELY)+4182.0
      CALL LINE(X,Y,ICOUNT,XPAR,YPAR,KODE)
C
      CALL PAPAD
      STOP
      END
      SUBROUTINE RUN1(X,Y,X1,Y1,R)
C
C     RUNWAY NO. 1  CONFIGURATION RELATED TO CHOOSEN X AND Y CO-ORDINATES
      R=9000.
```

```
      XO=-3812.
      YO=500.
C     ANGD=0.0
C     ANGR=ANGD*0.0174532925199
C     SINANG=SIN(ANGR)
C     COSANG=COS(ANGR)
      SINANG=0.0
      COSANG=1.0
      DELTAX=X-XO
      DELTAY=Y-YO
      X1=(DELTAX*COSANG)+(DELTAY*SINANG)
      Y1=(DELTAY*COSANG)-(DELTAX*SINANG)
      RETURN
      END
      SUBROUTINE RUN2(X,Y,X1,Y1,R)
C
C     RUNWAY NO. 2  CONFIGURATION RELATED TO CHOOSEN X AND Y CO-ORDINATES
      R=9000.
      XO=5188.
      YO=500.
C     ANGD=180.
C     ANGR=ANGD*0.0174532925199
C     SINANG=SIN(ANGR)
C     COSANG=COS(ANGR)
      SINANG=0.0
      COSANG=-1.0
      DELTAX=X-XO
      DELTAY=Y-YO
      X1=(DELTAX*COSANG)+(DELTAY*SINANG)
      Y1=(DELTAY*COSANG)-(DELTAX*SINANG)
      RETURN
      END
      SUBROUTINE RUN3(X,Y,X1,Y1,R)
C
C     RUNWAY NO. 3  CONFIGURATION RELATED TO CHOOSEN X AND Y CO-ORDINATES
      R=6000.
      XO=463.
      YO=-414.
C     ANGD=50.
C     ANGR=ANGD*0.0174532925199
C     SINANG=SIN(ANGR)
C     COSANG=COS(ANGR)
      SINANG=+0.766044443119
      COSANG=+0.642787609687
      DELTAX=X-XO
      DELTAY=Y-YO
      X1=(DELTAX*COSANG)+(DELTAY*SINANG)
      Y1=(DELTAY*COSANG)-(DELTAX*SINANG)
      RETURN
      END
      SUBROUTINE RUN4(X,Y,X1,Y1,R)
C
C     RUNWAY NO. 4  CONFIGURATION RELATED TO CHOOSEN X AND Y CO-ORDINATES
      R=6000.
      XO=4320.
      YO=4182.
C     ANGD=230.
```

```
C       ANGR=ANGD*0.0174532925199
C       SINANG=SIN(ANGR)
C       COSANG=COS(ANGR)
        SINANG=-0.766044443119
        COSANG=-0.642787609687
        DELTAX=X-XO
        DELTAY=Y-YO
        X1=(DELTAX*COSANG)+(DELTAY*SINANG)
        Y1=(DELTAY*COSANG)-(DELTAX*SINANG)
        RETURN
        END
        SUBROUTINE RUN5(X,Y,X1,Y1,R)
C
C       RUNWAY NO. 5  CONFIGURATION RELATED TO CHOOSEN X AND Y CO-ORDINATES
        R=5188.
        XO=0.
        YO=0.
C       ANGD=0.0
C       ANGR=ANGD*0.0174532925199
C       SINANG=SIN(ANGR)
C       COSANG=COS(ANGR)
        SINANG=0.0
        COSANG=1.0
        DELTAX=X-XO
        DELTAY=Y-YO
        X1=(DELTAX*COSANG)+(DELTAY*SINANG)
        Y1=(DELTAY*COSANG)-(DELTAX*SINANG)
        RETURN
        END
        SUBROUTINE RUN6(X,Y,X1,Y1,R)
C
C       RUNWAY NO. 6  CONFIGURATION RELATED TO CHOOSEN X AND Y CO-ORDINATES
        R=5188.
        XO=5188.
        YO=0.
C       ANGD=180.
C       ANGR=ANGD*0.0174532925199
C       SINANG=SIN(ANGR)
C       COSANG=COS(ANGR)
        SINANG=0.0
        COSANG=-1.0
        DELTAX=X-XO
        DELTAY=Y-YO
        X1=(DELTAX*COSANG)+(DELTAY*SINANG)
        Y1=(DELTAY*COSANG)-(DELTAX*SINANG)
        RETURN
        END
        SUBROUTINE RUN7(X,Y,X1,Y1,R)
C
C       RUNWAY NO. 7  CONFIGURATION RELATED TO CHOOSEN X AND Y CO-ORDINATES
        R=10000.
        XO=-4812.
        YO=-5000.
C       ANGD=0.0
C       ANGR=ANGD*0.0174532925199
C       SINANG=SIN(ANGR)
C       COSANG=COS(ANGR)
```

```
      SINANG=0.0
      COSANG=1.0
      DELTAX=X-XO
      DELTAY=Y-YO
      X1=(DELTAX*COSANG)+(DELTAY*SINANG)
      Y1=(DELTAY*COSANG)-(DELTAX*SINANG)
      RETURN
      END
      SUBROUTINE RUN8(X,Y,X1,Y1,R)
C
C     RUNWAY NO. 8  CONFIGURATION RELATED TO CHOOSEN X AND Y CO-ORDINATES
      R=10000.
      XO=5188.
      YO=-5000.
C     ANGD=180.
C     ANGR=ANGD*0.0174532925199
C     SINANG=SIN(ANGR)
C     COSANG=COS(ANGR)
      SINANG=0.0
      COSANG=-1.0
      DELTAX=X-XO
      DELTAY=Y-YO
      X1=(DELTAX*COSANG)+(DELTAY*SINANG)
      Y1=(DELTAY*COSANG)-(DELTAX*SINANG)
      RETURN
      END
      SUBROUTINE RUN9(X,Y,X1,Y1,R)
C
C     RUNWAY NO. 9  CONFIGURATION RELATED TO CHOOSEN X AND Y CO-ORDINATES
      R=10500.
      XO=750.
      YO=-5600.
C     ANGD=0.0
C     ANGR=ANGD*0.0174532925199
C     SINANG=SIN(ANGR)
C     COSANG=COS(ANGR)
      SINANG=0.0
      COSANG=1.0
      DELTAX=X-XO
      DELTAY=Y-YO
      X1=(DELTAX*COSANG)+(DELTAY*SINANG)
      Y1=(DELTAY*COSANG)-(DELTAX*SINANG)
      RETURN
      END
      SUBROUTINE RUN10(X,Y,X1,Y1,R)
C
C     RUNWAY NO. 10 CONFIGURATION RELATED TO CHOOSEN X AND Y CO-ORDINATES
      R=10500.
      XO=11250.
      YO=-5600.
C     ANGD=180.
C     ANGR=ANGD*0.0174532925199
C     SINANG=SIN(ANGR)
C     COSANG=COS(ANGR)
      SINANG=0.0
      COSANG=-1.0
      DELTAX=X-XO
```

```
      DELTAY=Y-YO
      X1=(DELTAX*COSANG)+(DELTAY*SINANG)
      Y1=(DELTAY*COSANG)-(DELTAX*SINANG)
      RETURN
      END
      SUBROUTINE TAKEOF1(X1,Y1,SDIST,RATIO,A)
C
C     TAKEOFF PROFILE OF AIRCRAFT CLASS 1
C     2-ENGINES TURBOFAN AIRCRAFT
C
      A=4500.
      B=6000.
      C=23500.
      E=100.
      F=3000.
      G=20000.
C     D=B+(((G-E)*(C-B))/(F-E))
C     SLOPE1=E/(B-A)
C     SLOPE2=(G-E)/(D-B)
      D=126086.21
      SLOPE1=.06666666666667
      SLOPE2=.16571428571429
      IF(X1 .LT. 0.0) GO TO 61
      IF(X1 .GE. 0.0 .AND. X1 .LE. A)ALT=0.0
      IF(X1 .GT. A .AND. X1.LE. B)ALT=SLOPE1*(X1-A)
      IF(X1 .GT. B .AND. X1 .LE. D)ALT=E+(SLOPE2*(X1-B))
      IF(X1 .GT. D)ALT=G
      SDIST=SQRT((ALT**2)+(ABS(Y1)**2))
      IF(Y1 .EQ. 0.0) GO TO 81
      RATIO=ALT/ABS(Y1)
      GO TO 82
 61   SDIST=SQRT((ABS(X1)**2)+(ABS(Y1)**2))
      RATIO=0.0
      GO TO 82
 81   RATIO=10000000000.
 82   RETURN
      END
      SUBROUTINE TAKEOF2(X1,Y1,SDIST,RATIO,A)
C
C     TAKEOFF PROFILE OF AIRCRAFT CLASS 2
C     3-ENGINES TURBOFAN AIRCRAFT
C
      A=8000.
      B=10500.
      C=38000.
      E=100.
      F=3000.
      G=20000.
C     D=B+(((G-E)*(C-B))/(F-E))
C     SLOPE1=E/(B-A)
C     SLOPE2=(G-E)/(D-B)
      D=199206.90
      SLOPE1=.04000000000000
      SLOPE2=.10545454545455
      IF(X1 .LT. 0.0) GO TO 61
      IF(X1 .GE. 0.0 .AND. X1 .LE. A)ALT=0.0
      IF(X1 .GT. A .AND. X1.LE. B)ALT=SLOPE1*(X1-A)
```

```
      IF(X1 .GT. B .AND. X1 .LE. D)ALT=E+(SLOPE2*(X1-B)D
      IF(X1 .GT. D)ALT=G
      SDIST=SQRT((ALT**2)+(ABS(Y1)**2))
      IF(Y1 .EQ. 0.0) GO TO 81
      RATIO=ALT/ABS(Y1)
      GO TO 82
 61   SDIST=SQRT((ABS(X1)**2)+(ABS(Y1)**2))
      RATIO=0.0
      GO TO 82
 81   RATIO=10000000000.
 82   RETURN
      END
      SUBROUTINE TAKEOF3(X1,Y1,SDIST,RATIO,A)
C
C     TAKEOFF PROFILE OF AIRCRAFT CLASS 3
C     4-ENGINES TURBOFAN AIRCRAFT (500 NM.)
C
      A=4500.
      B=6000.
      C=23500.
      E=100.
      F=3000.
      G=20000.
C     D=B+(((G-E)*(C-B))/(F-E))
C     SLOPE1=E/(B-A)
C     SLOPE2=(G-E)/(D-B)
      D=126086.21
      SLOPE1=.06666666666667
      SLOPE2=.16571428571429
      IF(X1 .LT. 0.0) GO TO 61
      IF(X1 .GE. 0.0 .AND. X1 .LE. A)ALT=0.0
      IF(X1 .GT. A .AND. X1.LE. B)ALT=SLOPE1*(X1-A)
      IF(X1 .GT. B .AND. X1 .LE. D)ALT=E+(SLOPE2*(X1-B))
      IF(X1 .GT. D)ALT=G
      SDIST=SQRT((ALT**2)+(ABS(Y1)**2))
      IF(Y1 .EQ. 0.0) GO TO 81
      RATIO=ALT/ABS(Y1)
      GO TO 82
 61   SDIST=SQRT((ABS(X1)**2)+(ABS(Y1)**2))
      RATIO=0.0
      GO TO 82
 81   RATIO=10000000000.
 82   RETURN
      END
      SUBROUTINE TAKEOF4(X1,Y1,SDIST,RATIO,A)
C
C     TAKEOFF PROFILE OF AIRCRAFT CLASS 4
C     4-ENGINES TURBOFAN AIRCRAFT (2500 TO 3500 NM.)
C
      A=6000.
      B=8000.
      C=30000.
      E=100.
      F=3000.
      G=20000.
C     D=B+(((G-E)*(C-B))/(F-E))
C     SLOPE1=E/(B-A)
```

```
C     SLOPE2=(G-E)/(D-B)
      D=158965.52
      SLOPE1=.0500000000000
      SLOPE2=.13181818181818
      IF(X1 .LT. 0.0) GO TO 61
      IF(X1 .GE. 0.0 .AND. X1 .LE. A)ALT=0.0
      IF(X1 .GT. A .AND. X1.LE. B)ALT=SLOPE1*(X1-A)
      IF(X1 .GT. B .AND. X1 .LE. D)ALT=E+(SLOPE2*(X1-B)D
      IF(X1 .GT. D)ALT=G
      SDIST=SQRT((ALT**2)+(ABS(Y1)**2))
      IF(Y1 .EQ. 0.0) GO TO 81
      RATIO=ALT/ABS(Y1)
      GO TO 82
 61   SDIST=SQRT((ABS(X1)**2)+(ABS(Y1)**2))
      RATIO=0.0
      GO TO 82
 81   RATIO=10000000000.
 82   RETURN
      END
      SUBROUTINE TAKEOF5(X1,Y1,SDIST,RATIO,A)
C
C     TAKEOFF PROFILE OF AIRCRAFT CLASS 5
C     4-ENGINES TURBOPROP
C
      A=4500.
      B=7500.
      C=47500.
      E=150.
      F=3500.
      G=20000.
C     D=B+(((G-E)*(C-B))/(F-E))
C     SLOPE1=E/(B-A)
C     SLOPE2=(G-E)/(D-B)
      D=244514.93
      SLOPE1=.0500000000000
      SLOPE2=.08375000000000
      IF(X1 .LT. 0.0) GO TO 61
      IF(X1 .GE. 0.0 .AND. X1 .LE. A)ALT=0.0
      IF(X1 .GT. A .AND. X1.LE. B)ALT=SLOPE1*(X1-A)
      IF(X1 .GT. B .AND. X1 .LE. D)ALT=E+(SLOPE2*(X1-B)D
      IF(X1 .GT. D)ALT=G
      SDIST=SQRT((ALT**2)+(ABS(Y1)**2))
      IF(Y1 .EQ. 0.0) GO TO 81
      RATIO=ALT/ABS(Y1)
      GO TO 82
 61   SDIST=SQRT((ABS(X1)**2)+(ABS(Y1)**2))
      RATIO=0.0
      GO TO 82
 81   RATIO=10000000000.
 82   RETURN
      END
      SUBROUTINE ALAND1(X1,Y1,R,SDIST,RATIO)
C
C     LANDING PROFILE OF AIRCRAFT CLASS 1
C     2-ENGINES TURBOFAN AIRCRAFT
      FL=4000.
      TDP=1000.
```

```
      TDP=1000.
C     GSAD=2.5
C     GSAR=GSAD*0.0174532925199
C     TANGS=TAN(GSAR)
C     DP=-((FL/TANGS)-TDP)
      TR=0.6666666666*R
      TANGS=0.04366094290840
      DP=-90615.06219395156950
      Z=TDP+TR
      IF(X1 .GT. Z) GO TO 30
      IF(X1 .GE. TDP .AND. X1 .LE. Z) ALT=0.0
      IF(X1 .LE. DP)ALT=FL
      IF(X1 .GT. DP .AND. X1 .LE. 0.0)ALT=(ABS(X1)+TDP)MTANGS
      IF(X1 .GE. 0.0 .AND. X1 .LE. TDP)ALT=(TDP-X1)*TANGS
      SDIST=SQRT((ALT**2)+(ABS(Y1)**2))
      IF(Y1 .EQ. 0.0) GO TO 10
      RATIO=ALT/ABS(Y1)
      GO TO 20
 30   SDIST=SQRT((ABS(X1-Z)**2)+(ABS(Y1)**2))
      RATIO=0.0
      GO TO 20
 10   RATIO=1000000000.
 20   RETURN
      END
      SUBROUTINE ALAND4(X1,Y1,R,SDIST,RATIO)
C
C     LANDING PROFILE OF AIRCRAFT CLASS 4
C     4-ENGINES TURBOFAN AIRCRAFT (2500 TO 3500 NM.)
      FL=4000.
      TDP=1000.
C     GSAD=2.5
C     GSAR=GSAD*0.0174532925199
C     TANGS=TAN(GSAR)
C     DP=-((FL/TANGS)-TDP)
      TR=0.66666666666*R
      TANGS=0.04366094290840
      DP=-90615.06219395156950
      Z=TDP+TR
      IF(X1 .GT. Z) GO TO 30
      IF(X1 .GE. TDP .AND. X1 .LE. Z) ALT=0.0
      IF(X1 .LE. DP)ALT=FL
      IF(X1 .GT. DP .AND. X1 .LE. 0.0)ALT=(ABS(X1)+TDP)MTANGS
      IF(X1 .GE. 0.0 .AND. X1 .LE. TDP)ALT=(TDP-X1)*TANGS
      SDIST=SQRT((ALT**2)+(ABS(Y1)**2))
      IF(Y1 .EQ. 0.0) GO TO 10
      RATIO=ALT/ABS(Y1)
      GO TO 20
 30   SDIST=SQRT((ABS(X1-Z)**2)+(ABS(Y1)**2))
      RATIO=0.0
      GO TO 20
 10   RATIO=1000000000.
 20   RETURN
      END
      SUBROUTINE ALAND5(X1,Y1,R,SDIST,RATIO)
C
C     LANDING PROFILE OF AIRCRAFT CLASS 5
C     4-ENGINES TURBOPROP
```

```
      FL=4000.
      TDP=1000.
C     GSAD=2.5
C     GSAR=GSAD*0.0174532925199
C     TANGS=TAN(GSAR)
C     DP=-((FL/TANGS)-TDP)
      TR=0.66666666666*R
      TANGS=0.04366094290840
      DP=-90615.06219395156950
      Z=TDP+TR
      IF(X1 .GT. Z) GO TO 30
      IF(X1 .GE. TDP .AND. X1 .LE. Z) ALT=0.0
      IF(X1 .LE. DP)ALT=FL
      IF(X1 .GT. DP .AND. X1 .LE. 0.0)ALT=(ABS(X1)+TDP)*TANGS
      IF(X1 .GE. 0.0 .AND. X1 .LE. TDP)ALT=(TDP-X1)*TANGS
      SDIST=SQRT((ALT**2)+(ABS(Y1)**2))
      IF(Y1 .EQ. 0.0) GO TO 10
      RATIO=ALT/ABS(Y1)
      GO TO 20
 30   SDIST=SQRT((ABS(X1-Z)**2)+(ABS(Y1)**2))
      RATIO=0.0
      GO TO 20
 10   RATIO=1000000000.
 20   RETURN
      END
      SUBROUTINE POLYT1(A,R,SDIST,RATIO,X1,Y1,EPNL)
C
C     THIS SUBPROGRAM CONTAINS THE EPNL VS. SLANT DISTANCE INFORMATION
C     2-ENGINES TURBOFAN
C
      A1=0.131614604240 89E+03
      A2=-0.19907127074528E-01
      A3=0.35698010908113E-05
      A4=-0.35121113387752E-09
      A5=0.20433156320150E-13
      A6=-0.74320214054215E-18
      A7=0.17357734742231E-22
      A8=-0.26020333093783E-27
      A9=0.24202656462740E-32
      A10=-0.12716742804092E-37
      A11=0.28852200541228E-43
      X=SDIST
      IF(X .EQ. 0.0)X=10.0
C     CPB=30./ALOG10(50.0)
C     CPC=40./ALOG10(50.0)
      CPB=17.65775731
      CPC=23.54367641
C     PERCEIVED NOISE LEVEL
      PNL=A1+A2*(X)+A3*(X**2)+A4*(X**3)+A5*(X**4)+A6*(XM*5)+A7*(X**6)+
     1A8*(X**7)+A9*(X**8)+A10*(X**9)+A11*(X**10)
C     EFFECTIVE PERCEIVED NOISE LEVEL
      PA=PNL+(4.0*ALOG10(X))-16.0
      IF(X .GT. 2000.) GO TO 800
      PB=PA
      PC=PA
      PD=PC+4.0
      GO TO 801
```

```
 800   PB=PA-(CPB*ALOG10(X/2000.))
       PC=PA-(CPC*ALOG10(X/2000.))
       PD=PC+4.
 801   CONTINUE
       IF(X1 .GE. R .AND. RATIO .GE. 0.1763)EPNL=PA
       IF(X1.GE.R.AND.RATIO.LE.0.1763)EPNL=PB+((PA-PB)*(RATIO/.1763))
       IF(X1.GE.A.AND.X1.LE.R)EPNL=PC+((PB-PC)*((X1-A)/(R-A)))
       IF(X1.GE.0.0.AND.X1.LE.A)EPNL=PD-(4.0*(X1/A))
       IF(X1 .LT. 0.0)EPNL=PD
       RETURN
       END
       SUBROUTINE POLYT2(A,R,SDIST,RATIO,X1,Y1,EPNL)
C
C      THIS SUBPROGRAM CONTAINS THE EPNL VS. SLANT DISTANCE INFORMATION
C      3-ENGINES TURBOFAN
C
       A1=0.13161460424089E+03
       A2=-0.19907127074528E-01
       A3=0.35698010908113E-05
       A4=-0.35121113387752E-09
       A5=0.20433156320150E-13
       A6=-0.74320214054215E-18
       A7=0.17357734742231E-22
       A8=-0.26020333093783E-27
       A9=0.24202656462740E-32
       A10=-0.12716742804092E-37
       A11=0.28852200541228E-43
       X=SDIST
       IF(X .EQ. 0.0)X=10.0
       CPB=17.65775731
       CPC=23.54367641
C      PERCEIVED NOISE LEVEL
       PNL=A1+A2*(X)+A3*(X**2)+A4*(X**3)+A5*(X**4)+A6*(X**5)+A7*(X**6)+
      1A8*(X**7)+A9*(X**8)+A10*(X**9)+A11*(X**10)+1.76
C      EFFECTIVE PERCEIVED NOISE LEVEL
       PA=PNL+(4.0*ALOG10(X))-16.0
       IF(X .GT. 2000.) GO TO 800
       PB=PA
       PC=PA
       PD=PC+4.0
       GO TO 801
 800   PB=PA-(CPB*ALOG10(X/2000.))
       PC=PA-(CPC*ALOG10(X/2000.))
       PD=PC+4.
 801   CONTINUE
       IF(X1 .GE. R .AND. RATIO .GE. 0.1763)EPNL=PA
       IF(X1.GE.R.AND.RATIO.LE.0.1763)EPNL=PB+((PA-PB)*(RATIO/.1763))
       IF(X1.GE.A.AND.X1.LE.R)EPNL=PC+((PB-PC)*((X1-A)/(R-A)))
       IF(X1.GE.0.0.AND.X1.LE.A)EPNL=PD-(4.0*(X1/A))
       IF(X1 .LT. 0.0)EPNL=PD
       RETURN
       END
       SUBROUTINE POLYT3(A,R,SDIST,RATIO,X1,Y1,EPNL)
C
C      THIS SUBPROGRAM CONTAINS THE EPNL VS. SLANT DISTANCE INFORMATION
C      4-ENGINES TURBOFAN (500 NM.)
C
```

```
      A1=0.13161460424089E+03
      A2=-0.19907127074528E-01
      A3=0.35698010908113E-05
      A4=-0.35121113387752E-09
      A5=0.20433156320150E-13
      A6=-0.74320214054215E-18
      A7=0.17357734742231E-22
      A8=-0.26020333093783E-27
      A9=0.24202656462740E-32
      A10=-0.12716742804092E-37
      A11=0.28852200541228E-43
      X=SDIST
      IF(X .EQ. 0.0)X=10.0
      CPB=17.65775731
      CPC=23.54367641
C     PERCEIVED NOISE LEVEL
      PNL=A1+A2*(X)+A3*(X**2)+A4*(X**3)+A5*(X**4)+A6*(X**5)+A7*(X**6)+
     1A8*(X**7)+A9*(X**8)+A10*(X**9)+A11*(X**10)+3.0
C     EFFECTIVE PERCEIVED NOISE LEVEL
      PA=PNL+(4.0*ALOG10(X))-16.0
      IF(X .GT. 2000.) GO TO 800
      PB=PA
      PC=PA
      PD=PC+4.0
      GO TO 801
  800 PB=PA-(CPB*ALOG10(X/2000.))
      PC=PA-(CPC*ALOG10(X/2000.))
      PD=PC+4.
  801 CONTINUE
      IF(X1 .GE. R .AND. RATIO .GE. 0.1763)EPNL=PA
      IF(X1.GE.R.AND.RATIO.LE.0.1763)EPNL=PB+((PA-PB)*(RATIO/.1763))
      IF(X1.GE.A.AND.X1.LE.R)EPNL=PC+((PB-PC)*((X1-A)/(R-A)))
      IF(X1.GE.0.0.AND.X1.LE.A)EPNL=PD-(4.0*(X1/A))
      IF(X1 .LT. 0.0)EPNL=PD
      RETURN
      END
      SUBROUTINE POLYT4(A,R,SDIST,RATIO,X1,Y1,EPNL)
C
C     THIS SUBPROGRAM CONTAINS THE EPNL VS. SLANT DISTANCE INFORMATION
C     4-ENGINES TURBOFAN (2500 TO 3500 NM.)
C
      A1=0.13161460424089E+03
      A2=-0.19907127074528E-01
      A3=0.35698010908113E-05
      A4=-0.35121113387752E-09
      A5=0.20433156320150E-13
      A6=-0.74320214054215E-18
      A7=0.17357734742231E-22
      A8=-0.26020333093783E-27
      A9=0.24202656462740E-32
      A10=-0.12716742804092E-37
      A11=0.28852200541228E-43
      X=SDIST
      IF(X .EQ. 0.0)X=10.0
      CPB=17.65775731
      CPC=23.54367641
C     PERCEIVED NOISE LEVEL
```

```
      PNL=A1+A2*(X)+A3*(X**2)+A4*(X**3)+A5*(X**4)+A6*(X**5)+A7*(X**6)+
     1A8*(X**7)+A9*(X**8)+A10*(X**9)+A11*(X**10)+3.0
C     EFFECTIVE PERCEIVED NOISE LEVEL
      PA=PNL+(4.0*ALOG10(X))-16.0
      IF(X .GT. 2000.) GO TO 800
      PB=PA
      PC=PA
      PD=PC+4.0
      GO TO 801
  800 PB=PA-(CPB*ALOG10(X/2000.))
      PC=PA-(CPC*ALOG10(X/2000.))
      PD=PC+4.
  801 CONTINUE
      IF(X1 .GE. R .AND. RATIO .GE. 0.1763)EPNL=PA
      IF(X1.GE.R.AND.RATIO.LE.0.1763)EPNL=PB+((PA-PB)*(RATIO/.1763))
      IF(X1.GE.A.AND.X1.LE.R)EPNL=PC+((PB-PC)*((X1-A)/(R-A)))
      IF(X1.GE.0.0.AND.X1.LE.A)EPNL=PD-(4.0*(X1/A))
      IF(X1 .LT. 0.0)EPNL=PD
      RETURN
      END
      SUBROUTINE POLYT5(A,R,SDIST,RATIO,X1,Y1,EPNL)
C
C     THIS SUBPROGRAM CONTAINS THE EPNL VS. SLANT DISTANCE INFORMATION
C     4-ENGINES TURBOPROP
C
      X=SDIST
      IF(X .EQ. 0.0)X=10.0
      CPB=17.65775731
      CPC=23.54367641
      CONST=(113.3-76.3)/ALOG10(10000./300.)
C     PERCEIVED NOISE LEVEL
      PNL=113.3-(CONST*ALOG10(X/300.))
C     EFFECTIVE PERCEIVED NOISE LEVEL
      PA=PNL+(4.0*ALOG10(X))-16.0
      IF(X .GT. 2000.) GO TO 800
      PB=PA
      PC=PA
      PD=PC+4.0
      GO TO 801
  800 PB=PA-(CPB*ALOG10(X/2000.))
      PC=PA-(CPC*ALOG10(X/2000.))
      PD=PC+4.
  801 CONTINUE
      IF(X1 .GE. R .AND. RATIO .GE. 0.1763)EPNL=PA
      IF(X1.GE.R.AND.RATIO.LE.0.1763)EPNL=PB+((PA-PB)*(RATIO/.1763))
      IF(X1.GE.A.AND.X1.LE.R)EPNL=PC+((PB-PC)*((X1-A)/(R-A)))
      IF(X1.GE.0.0.AND.X1.LE.A)EPNL=PD-(4.0*(X1/A))
      IF(X1 .LT. 0.0)EPNL=PD
      RETURN
      END
      SUBROUTINE POLYL1(X1,Y1,SDIST,RATIO,R,EPNL)
C
C     THIS SUBPROGRAM CONTAINS THE EPNL VS. SLANT DISTANCE INFORMATION
C     2-ENGINES TURBOFAN
C
      A1=   .13053563466267E+03
      A2=  -.29724952115825E-01
```

```
      A3=    .977961981885 46E-05
      A4=   -.23249835387404E-08
      A5=    .32642730201512E-12
      A6=   -.27502421546042E-16
      A7=    .14379297222831E-20
      A8=   -.47085374825563E-25
      A9=    .94005337897154E-30
      A10=  -.10466348959187E-34
      A11=   .49830375646654E-40
C     VALUE1=11.0/ALOG10(175.0)
      VALUE1=4.904063045
      TDP=1000.
      X=SDIST
      IF(X .EQ. 0.0)X=10.0
      IF(X .GT. 35000.) GO TO 10
C     PERCEIVED NOISE LEVEL
      PNL=A1+A2*(X)+A3*(X**2)+A4*(X**3)+A5*(X**4)+A6*(X**5)+A7*(X**6)+
     1A8*(X**7)+A9*(X**8)+A10*(X**9)+A11*(X**10)
      GO TO 20
 10   PNL=40.0-(20.0*ALOG10(ABS(X)/35000.0))
 20   CONTINUE
C     EFFECTIVE PERCEIVED NOISE LEVEL
      EPNL=PNL+(VALUE1*ALOG10(ABS(X)/200.))-8.0
      RETURN
      END
      SUBROUTINE POLYL2(X1,Y1,SDIST,RATIO,R,EPNL)
C
C     THIS SUBPROGRAM CONTAINS THE EPNL VS. SLANT DISTANCE INFORMATION
C     3-ENGINES TURBOFAN
C
      A1=    .13053563466267E+03
      A2=   -.29724952115825E-01
      A3=    .97796198188546E-05
      A4=   -.23249835387404E-08
      A5=    .32642730201512E-12
      A6=   -.27502421546042E-16
      A7=    .14379297222831E-20
      A8=   -.47085374825563E-25
      A9=    .94005337897154E-30
      A10=  -.10466348959187E-34
      A11=   .49830375646654E-40
      VALUE1=4.904063045
      TDP=1000.
      X=SDIST
      IF(X .EQ. 0.0)X=10.0
      IF(X .GT. 35000.) GO TO 10
C     PERCEIVED NOISE LEVEL
      PNL=A1+A2*(X)+A3*(X**2)+A4*(X**3)+A5*(X**4)+A6*(X**5)+A7*(X**6)+
     1A8*(X**7)+A9*(X**8)+A10*(X**9)+A11*(X**10)+1.76
      GO TO 20
 10   PNL=40.0-(20.0*ALOG10(ABS(X)/35000.0))
 20   CONTINUE
C     EFFECTIVE PERCEIVED NOISE LEVEL
      EPNL=PNL+(VALUE1*ALOG10(ABS(X)/200.))-8.0
      RETURN
      END
      SUBROUTINE POLYL3(X1,Y1,SDIST,RATIO,R,EPNL)
```

```
C
C     THIS SUBPROGRAM CONTAINS THE EPNL VS. SLANT DISTANCE INFORMATION
C     4-ENGINES TURBOFAN (500 NM.)
C
      A1=    .13053563466267E+03
      A2=   -.29724952115825E-01
      A3=    .97796198188546E-05
      A4=   -.23249835387404E-08
      A5=    .32642730201512E-12
      A6=   -.27502421546042E-16
      A7=    .14379297222831E-20
      A8=   -.47085374825563E-25
      A9=    .94005337897154E-30
      A10=  -.10466348959187E-34
      A11=   .49830375646654E-40
      VALUE1=4.904063045
      TDP=1000.
      X=SDIST
      IF(X .EQ. 0.0)X=10.0
      IF(X .GT. 35000.) GO TO 10
C     PERCEIVED NOISE LEVEL
      PNL=A1+A2*(X)+A3*(X**2)+A4*(X**3)+A5*(X**4)+A6*(X**5)+A7*(X**6)+
     1A8*(X**7)+A9*(X**8)+A10*(X**9)+A11*(X**10)+3.0
      GO TO 20
 10   PNL=40.0-(20.0*ALOG10(ABS(X)/35000.0))
 20   CONTINUE
C     EFFECTIVE PERCEIVED NOISE LEVEL
      EPNL=PNL+(VALUE1*ALOG10(ABS(X)/200.))-8.0
      RETURN
      END
      SUBROUTINE POLYL4(X1,Y1,SDIST,RATIO,R,EPNL)
C
C     THIS SUBPROGRAM CONTAINS THE EPNL VS. SLANT DISTANCE INFORMATION
C     4-ENGINES TURBOFAN (2500 TO 3500 NM.)
C
      A1=    .13053563466267E+03
      A2=   -.29724952115825E-01
      A3=    .97796198188546E-05
      A4=   -.23249835387404E-08
      A5=    .32642730201512E-12
      A6=   -.27502421546042E-16
      A7=    .14379297222831E-20
      A8=   -.47085374825563E-25
      A9=    .94005337897154E-30
      A10=  -.10466348959187E-34
      A11=   .49830375646654E-40
      VALUE1=4.904063045
      TDP=1000.
      X=SDIST
      IF(X .EQ. 0.0)X=10.0
      IF(X .GT. 35000.) GO TO 10
C     PERCEIVED NOISE LEVEL
      PNL=A1+A2*(X)+A3*(X**2)+A4*(X**3)+A5*(X**4)+A6*(X**5)+A7*(X**6)+
     1A8*(X**7)+A9*(X**8)+A10*(X**9)+A11*(X**10)+3.0
      GO TO 20
 10   PNL=40.0-(20.0*ALOG10(ABS(X)/35000.0))
 20   CONTINUE
```

```
C      EFFECTIVE PERCEIVED NOISE LEVEL
       EPNL=PNL+(VALUE1*ALOG10(ABS(X)/200.))-8.0
       RETURN
       END
       SUBROUTINE POLYL5(X1,Y1,SDIST,RATIO,R,EPNL)
C
C      THIS SUBPROGRAM CONTAINS THE EPNL VS. SLANT DISTANCE INFORMATION
C      4-ENGINES TURBOPROP AIRCRAFT
C
       VALUE1=4.904063045
       CONST=(106.4-72.0)/ALOG10(20.0)
       TDP=1000.
       X=SDIST
       IF(X .EQ. 0.0)X=10.0
C      PERCEIVED NOISE LEVEL
       PNL=106.4-(CONST*ALOG10(ABS(X)/300.0))
C      EFFECTIVE PERCEIVED NOISE LEVEL
       EPNL=PNL+(VALUE1*ALOG10(ABS(X)/200.))-8.0
       RETURN
       END
'        6400 END OF RECORD

1    1    0    0    0    1    1    0    0    0
1    1    0    0    0    1    1    0    0    0


1    1    1    1    0    1    1    1    1    0
1    1    1    1    0    1    1    1    1    0

.45  .45  0.0  0.0  0.0  .45  .45  0.0  0.0  0.0
.45  .45  0.0  0.0  0.0  .45  .45  0.0  0.0  0.0


3.6  3.6  1.75 2.0  0.0  3.6  3.6  1.75 2.0  0.0
13.5 13.5 5.25 6.0  0.0  13.5 13.5 5.25 6.0  0.0

.05  .05  0.0  0.0  0.0  .05  .05  0.0  0.0  0.0
.05  .05  0.0  0.0  0.0  .05  .05  0.0  0.0  0.0


.4   .4   .25  .75  0.0  .4   .4   .25  .75  0.0
1.5  1.5  .75  .75  0.0  1.5  1.5  .75  .75  0.0
'            END OF FILE

                     CD TOT   1137
```

APPENDIX E

THE CONSTRUCTION OF THE EPNL VERSUS DISTANCE CURVES

Figure 5.3 (see Chapter 5) illustrates typical 2-engine turbofan EPNL vs. distance curves as used in the computation of the NEF contours. The EPNL vs. distance curves were constructed according to the following procedure.

Take-off

1. The perceived noise levels in PNdB due to take-off were calculated theoretically as a function of distance (not considering ground or terrain attentuation effects) as detailed in Section 4.4, Chapter 4. The predicted levels were approximated by a 10th degree polynomial. The computer program used in this analysis and the results obtained are included in Appendix D.

2. Field measurements were analyzed according to the procedure given in Section 4.2, Chapter 4. The measurement results were divided into four groups.

   The first group consists of 5 measurements which have been taken opposite to the break-release point and before the aircraft started the take-off roll. The maximum levels were noted in dB(A). The points numbered 1 to 5 on Figure E.1 and Figure E.2 illustrate the measurement locations and the results obtained respectively.

   The second group consists of 5 noise level recordings which have been noted just before the aircraft started to lift-off the runway. The elevation angles between the aircraft and the observation points are zero degrees in this case. The points numbered 6 to 10 on Figure E.1 and Figure E.2 illustrate the measurement locations and the results obtained respectively.

The third group consists of 38 measurements which have been taken after the aircraft lifted off the runway. The elevation angles in this case are in the range from 1 to 90 degrees (90° means an overhead aircraft).

3. The results were plotted and compared with the theoretically developed PNdB vs. distance relation. Inspection of the results reveal that:

(a) Measurements taken for the aircraft in-flight and provided that the elevation angles were greater than approximately 10° show a good agreement with the theoretically developed equation.

(b) On the other hand measurements taken for the aircraft in-flight and provided that the elevation angles were less than 10° exhibited, in general, less PNL as compared with those measured on greater angles. The difference was noticeable especially on distances greater than 2000 ft.

(c) Measurements taken opposite to the break-release point (stationary aircraft), generally exhibited higher levels than those measurements taken at an equal distance for the aircraft in-flight or at the end of the take-off roll.

4. In order to calculate the NEF values at greater distances than those measured in the field and to facilitate the computations, the theoretically developed equation was adopted to represent the PNdB vs. distance information (designated PA). However, it should be noted that this equation was developed for an aircraft flyover not considering the ground and terrain attenuation effects.

5. To introduce the ground attenuation in the final analysis, equation PA was modified by trial and error in order to achieve a reasonable fit of the experimental data.

   (a) Curve PC was fitted to the data representing aircraft noise levels in the locations opposite to the lift-off point (elevation angles equal to zero degrees).

   (b) Curve PB was fitted to the data representing the aircraft in-flight at very small elevation angles.

   (c) Considering the results obtained from the 5 measurements taken opposite to the break-release point, it was assumed that the difference between the noise level produced by the aircraft prior to take-off (at the break-release point) and the noise level produced at the lift-off point is approximately 4 dB (this reduction is mainly due to the decrease in effective exhaust velocity as the aircraft accelorates along the runway).

   Accordingly, curve PD was constructed by adding 4 dB to the values of curve PC (note that in both cases PC and PD, the elevation angles are equal to zero degrees). Figure E.2 illustrates the experimental data and the developed curves PA, PB, PC and PD.

The Developed Equations

$$PA = A_1 + A_2 X + A_3 X^2 + \ldots\ldots\ldots\ldots + A_{11} X^{10} \quad [PNdB] \quad (1)$$

If $X < 2000$ ft.

$$PB = PA \quad [PNdB] \quad (2)$$

$$PC = PA \quad [PNdB] \quad (3)$$

$$PD = PC + 4.0 \quad [PNdB] \quad (4)$$

If $X > 2000$ ft.

$$PB = PA - 17.7 \log \frac{X}{2000} \quad [PNdB] \quad (5)$$

$$PC = PA - 23.6 \log \frac{X}{2000} \quad [PNdB] \quad (6)$$

$$PD = PC + 4.0$$

where X is the slant perpendicular distance to the aircraft (ft)

6. The PNL values were corrected for typical time durations as discussed in Chapter 4 and the final results were expressed in EPNL values.

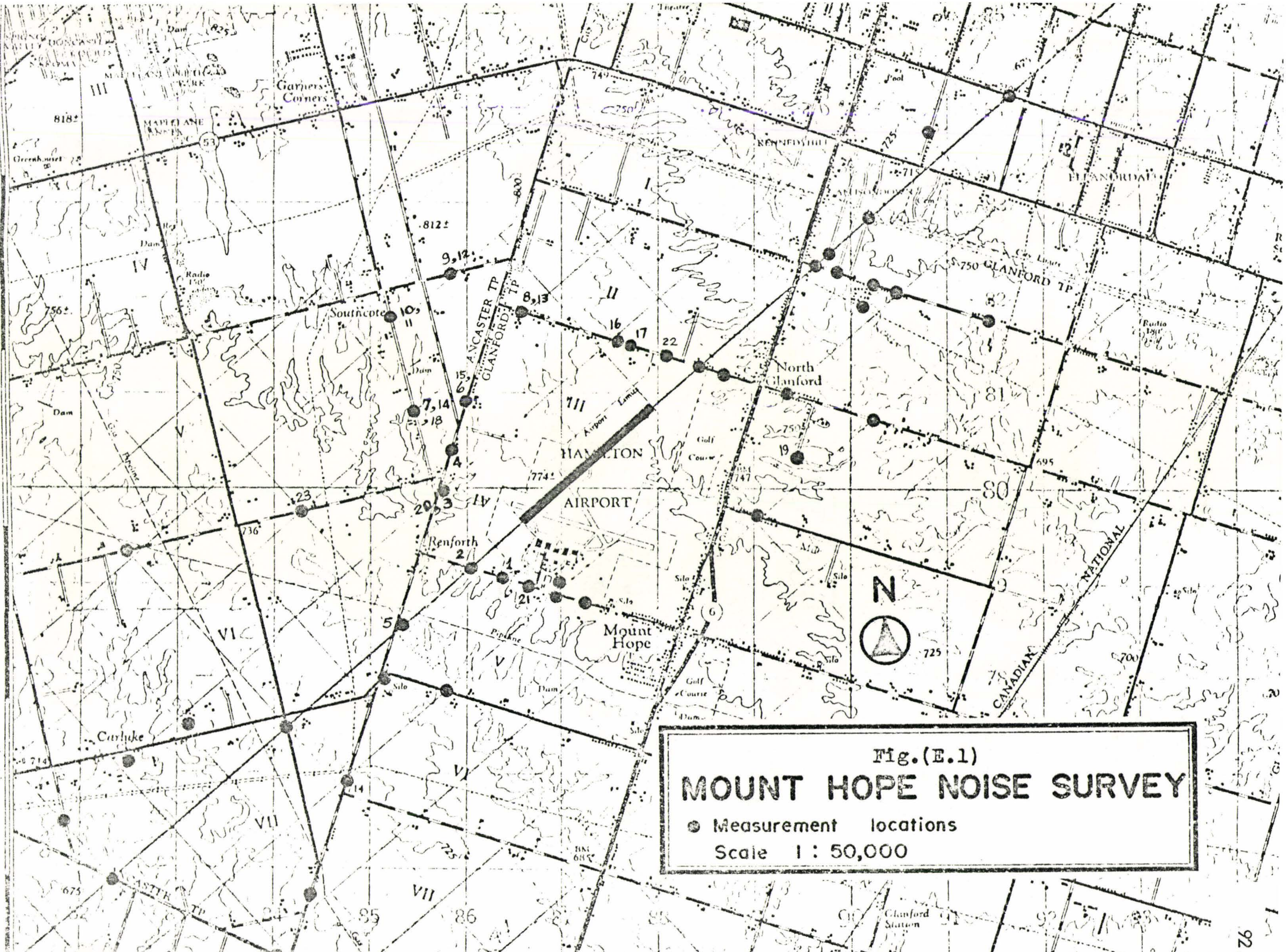

Fig.(E.1)

MOUNT HOPE NOISE SURVEY

● Measurement locations

Scale 1 : 50,000

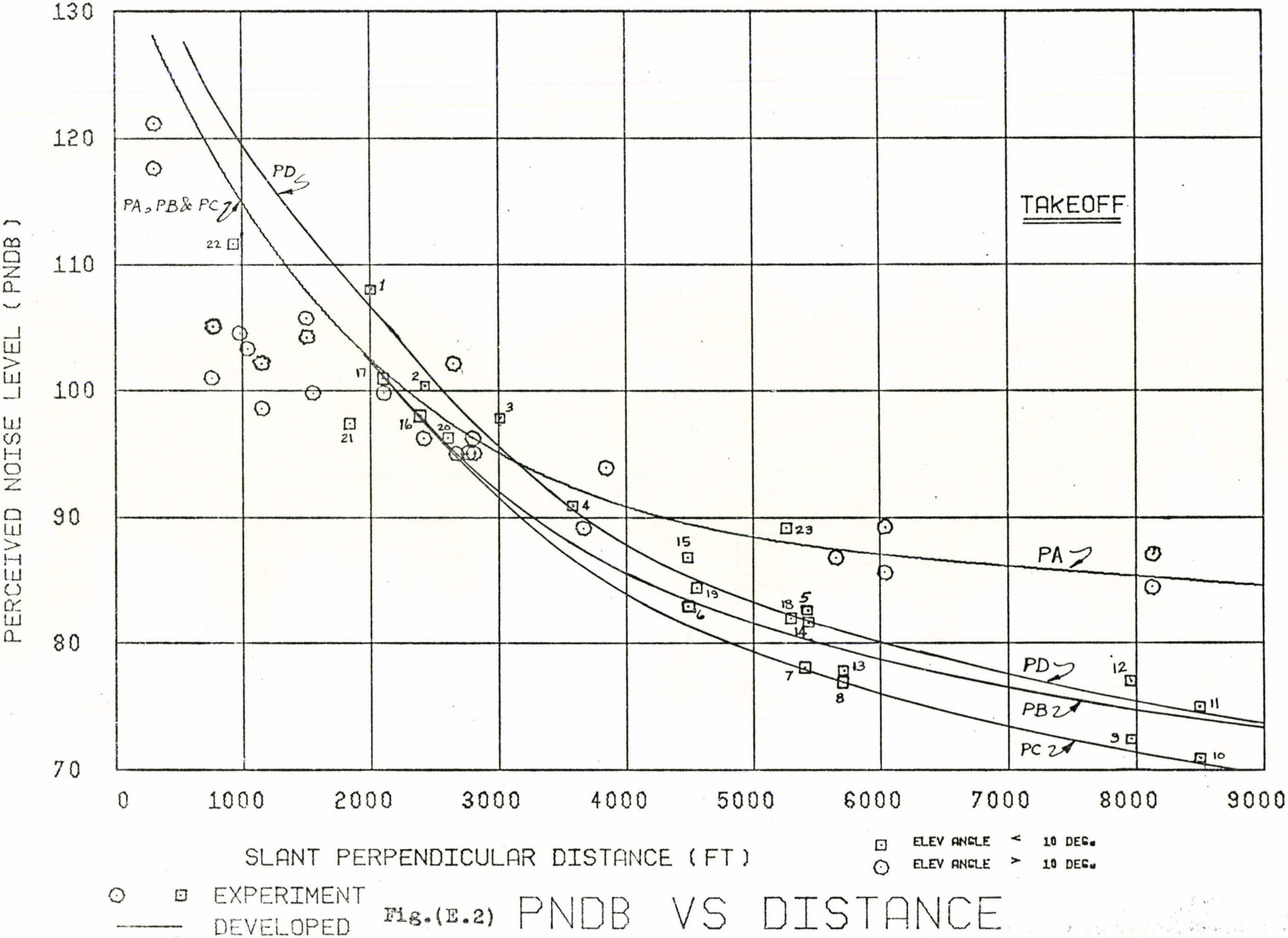

Fig.(E.2) PNDB VS DISTANCE