NASA-CR-142108
(NASA-CR-142108) ANNOYANCE AND ACCEPTABILITY JUDGEMENTS OF NOISE PRODUCED BY THREE TYPES OF AIRCRAFT BY RESIDENTS LIVING NEAR JFK AIRPORT (Columbia Univ.) CSCL 05E
N75-17092
Unclas
G3/53 09638

ANNOYANCE AND ACCEPTABILITY JUDGEMENTS OF NOISE PRODUCED BY THREE TYPES OF AIRCRAFT BY RESIDENTS LIVING NEAR JFK AIRPORT

By

Paul N. Borsky

Prepared by
Columbia University
Noise Research Unit
Franklin Square, N. Y. 11010
for Langley Research Center
NASA Grant NGL 33-008-118

December 1, 1974

ABSTRACT

Over 1200 residents, representing a random sample of selected communities near JFK Airport, were personally interviewed in 1972 and 1973. Sub-samples, with differing feelings of fear of aircraft crashes and different locations of residence were invited to participate in a laboratory experiment. While watching color TV programs in a laboratory furnished as a living room, 319 subjects were exposed to tape recordings of simulated flyovers of 707, 727 and DC-10 aircraft in approach and departure operations at three nominal distances from the airport. For each of the 18 types of flyovers, presented in randomized order, subjects judged the extent of annoyance and acceptability of the aircraft noises. Results indicate that level of noise is most significant in affecting annoyance judgements; plane types and operations are not judged significantly different if level of noise is equated. Subjects with feelings of high fear report significantly more annoyance and less acceptability of aircraft noise than subjects with feelings of low fear, but the differences are less than expected from the field interviews. The selected acoustic measures of dBA, PNL, dBD_1 and SPL are all about equally highly correlated with subject judgements of annoyance.

PREFACE

This report which presents the results of the first completed field-laboratory experiment utilizing a full cross section of residents living near JFK Airport, is an interdisciplinary team effort. Thelma Weiner was responsible for the sociological field interviewing, coding and subject contacts. Babette Stack and Helen L. Dillinger had the difficult task of actually convincing residents to become subjects and participate in the laboratory experiment. David Fidelman, an Acoustics Engineer, had overall responsibility for developing the aircraft flyover tapes, while Michael Harges, Jr. had the day-to-day tasks of preparing the test tapes and operating and maintaining the audio-video system. Dr. Philip Cheifetz, as a Statistical and Computer Consultant, assisted in the design of the experiment and the analysis of the data. Paula Tito instructed subjects in the laboratory and together with Jean Blansett did most of the statistical calculations in the analyses. Lastly, as office manager, Frances Gach supervised and coordinated the details of daily operations of the entire research team.

SUMMARY

Four of our seven hypotheses were supported by field-laboratory test results, one partially upheld, and two disproven.

Findings upheld

1. The intensity level of an airplane flyover is the most important acoustic parameter affecting annoyance judgements. Annoyance varies directly with intensity of noise.

2. Reflecting primarily differences in intensity of noise level, the 707 is judged significantly more annoying than the 727 and DC-10. There is also a strong tendency for the 727 to be judged more annoying than the DC-10, but the level of statistical significance for this comparison is less than for the 707 comparisons.

3. Summary acoustic measures of dBA, PNL, dBD_1 and SPL are all almost equally highly correlated with subject annoyance judgements. Using the dBA scale, an increase of 10 dBA increases the average annoyance value by 0.9, on a scale with a range of 0-4.

4. Almost all subjects say they can accept a noise with an annoyance score of "0" or "1"; over 80% say an annoyance level of "2" is still acceptable, but scores of "3" are accepted by only 17% and scores of "4" by only 1% of all subjects.

Findings partially upheld

5. Subjects with feelings of high fear report statistically significantly greater annoyance than low fear subjects. No significant differences, however, were reported between high and medium fear subjects. The annoyance differences recorded in the laboratory are also substantially less than expected from survey responses by the same subjects. Experience suggests that some biasing influences may have been introduced to modify the subjects' behavior in the laboratory.

Findings not upheld

6. Arrivals are not judged differently than departures by any subject groups.

7. Location of subject's residence does not appear to be consistently related to annoyance judgements in this experiment.

ANNOYANCE AND ACCEPTABILITY JUDGEMENTS BY RESIDENTS LIVING NEAR JFK AIRPORT OF NOISE PRODUCED BY THREE TYPES OF AIRCRAFT

I. Introduction

A new research program is under way at Columbia University that attempts to study realistic community noise environments under controlled laboratory conditions. 1/ Most previous laboratory studies have been conducted without great concern for the representativeness or the characteristics of the subjects, the realism of the noise stimuli or the laboratory chamber, or the primary activities of the subjects during the noise exposures. In an effort to correct for the artificiality of such laboratory techniques, social surveys have studied actual populations exposed to real noise environments. These direct personal interviews have recorded retrospective perceptions, intervening attitudes and experiences and summated annoyance and behavioral responses of samples of residents. These overall annoyance responses combine very complex and varied physical noise exposures over long periods of time. It is extremely difficult, if not impossible, however, from such survey data to reconstruct the process by which residents differentially weight widely varying physical stimuli and integrate their own personal feelings into a single annoyance response. Such detailed data are needed by noise control engineers and administrators and it is our belief that a combination of field and laboratory techniques may be best suited for this task of decoding the possibly varying effects of different aircraft operations on different populations. 1/

The new research program at Columbia University attempts to utilize the experiences gained in past field and laboratory studies. Small random samples of residents in the vicinity of JFK Airport in New York City, who are exposed to different real life noise environments are interviewed in their homes as part of a regular community study. Details are collected on such personal variables as attitudinal and experience differences as well as reported annoyance and complaint behavior. Sub-samples of those found predisposed to accept or reject given noise environments are then invited to participate in realistic types of acoustic laboratory studies. The laboratory is located at Franklin Square, Nassau County, near the actual residences of the sub-samples of subjects and the experimental environment in the laboratory has been made as realistic as possible. The laboratory, which is an environmental chamber with variable control over the temperature, humidity and noise conditions, is at present furnished as a typical living room in a middle class house. The use of the latest, most sophisticated quadrophonic sound system has succeeded in producing a realistic aircraft noise experience in which the plane appears to fly overhead across the room. Subjects are instructed to participate in a real activity such as watching a color TV program. A variety of controlled noise exposures from aircraft flyovers are simulated in the laboratory and subjects rate each experimental noise in terms of the degree of annoyance and general acceptability. An analysis of the controlled noise levels, the subjective personal factors, and the laboratory responses are expected to provide more precise measures of average acceptability and any differences for those with hostile or favorable predispositions to the noise.

In a pilot study of this new methodology, 2/ only residents with feelings of medium fear of aircraft crashes living at three distances directly under an approach flight path were asked to come to the laboratory and judge the approach noises from untreated 727s and two differently acoustically treated 727s. This initial study demonstrated the general feasibility of the methodology and also provided some valuable data on the perception and reaction to a particular retrofit package of the 727 airplane.

This study is the first attempt to test a complete cross section of real residential populations, with a full range of predispositional psychological feelings, attitudes and experiences with aircraft noise. It also includes a wider range of 18 different realistic noise stimuli, composed of three types of aircraft in both approach and departure operations at three different altitudes related to distance from the airport.

II. Study Design

A. Acoustic Characteristics to be Tested

1. Types of Aircraft flyovers

A total of 18 different types of airplane flyovers were reproduced in the laboratory living room during each test session of 1½ hours. These types of flyovers represent some of the most frequently heard aircraft near John F. Kennedy (JFK) Airport, N.Y., with a wide range of noise spectra, and noise levels. The test stimuli consist of three different aircraft in both arrival and departure operations at three different distances from the airport. The nominal altitudes of aircraft for the three distances are shown in Table 1.

TABLE 1

Nominal Altitudes of Planes at Different Distances from JFK Airport

	Distance from Airport					
	Close		Middle		Distant	
	Arrival	Departure	Arrival	Departure	Arrival	Departure
Nominal Altitude (feet)	370	800	750	1600	1500	3000

Table 2 presents a description of the 18 different flyovers used in this experiment.

TABLE 2

Description of 18 Types of Aircraft Flyovers

	Operation		Plane Type			Distance from Airport		
	Arrival Code A	Departure Code D	707 Code 1	727 Code 2	DC-10 Code 3	Close Code X	Middle Code Y	Distant Code Z
Stimulus								
1	A		1			X		
2	A			2		X		
3	A				3	X		
4		D	1			X		
5		D		2		X		
6		D			3	X		
7	A		1				Y	
8	A			2			Y	
9	A				3		Y	
10		D	1				Y	
11		D		2			Y	
12		D			3		Y	
13	A		1					Z
14	A			2				Z
15	A				3			Z
16		D	1					Z
17		D		2				Z
18		D			3			Z

2. Location of Simulated Dwelling

All flyovers were reproduced as being directly overhead and as heard indoors with windows open.

3. Rate of operations

The frequency of flyovers was 18 for each 30-minute session or an average of one for each 1-minute and 40-seconds (1.7 minutes). Each of six different stimuli were presented three times in sequence, during each 30-minute session. In all, 54 flyovers were presented during a 1½ hour test period.

4. Ambient noise level in room

The average ambient noise level was provided principally by color TV programs which the subjects watched. The first half hour session always watched "All in the Family", which was adjusted to an average level of 60 dBA, with occasional peaks of as much as 65 dBA. The second and third half hour sessions watched "Ironsides", which also had an average level of about 60 dBA, but somewhat more frequent peaks of 65 dBA.

B. Experimental Environment

1. Acoustic environment

All tests were conducted in a triple-wall sound-proof I.A.C. chamber (Model 400-A), 18' X 14', with an 8' ceiling, furnished as a typical living room in a middle class house. The drawing in Figure 1a shows a schematic of the interior of the room and its furnishings, with the location of a couch comfortably seating three persons, a low cocktail table and two chairs facing a 23" color Setchell-Carlson (Model 5 EC 904) television set, and simulated windows in two of the walls. Four Klipschorn loudspeakers are located in the corners of the room, and a one-way mirror in the wall alongside the television set permits observation of the subjects from the control room located adjacent to the acoustic chamber. The floor is covered by a rug, and all interior surfaces have pictures and drapes of the types used in an average home, so that the interior appearances and sound conditions are as realistic as possible.

The aircraft sounds in the chamber were produced by the four Klipschorn corner-horn speakers to provide an accurate replication of a fly-over as heard under actual conditions in an average home. The airplane was heard flying directly over the room from left to right, at the sound pressure levels which are heard in a typical northeastern United States house with the windows open. Our previous studies have shown that the use of the four-speaker system gives a true sensation of overhead flight in the direction of the phasing of the speakers. They have also shown that listeners inside a room judge a direction of motion of the outside aircraft and, therefore, the sense of directionality must be provided to fulfill the subject's expectations. 1/

2. Sound reproduction system

The aircraft flyovers were reproduced by the sound system shown in Figure 1b. The recording of the flight was played back by a Crown model 800 tape recorder. The left and right channels were connected to two calibrated variable attenuators (Daven T-730G) which were used to obtain accurate repeatable settings of the reproduced sound pressure level in the chamber. The electrical signals through the attenuators were amplified by two Crown model DC-300 power amplifiers having an output power rating of 150 watts per channel, which powered the four loudspeakers.

The system is capable of producing a sound pressure level of over 120 dB in the chamber. The lowest ambient noise level in the chamber is 14 dBA, and therefore, the available dynamic range is 105 dB. When the subjects were in the room, with the heating or airconditioning system in operation, the ambient noise level averaged about 30 dBA. The sound of the television set was adjusted to an average level of 60 dBA during the tests.

Sound pressure levels of the flyovers in the chamber were calibrated prior to each session with a B & K model 2204 Sound Level Meter.

3. TV programs watched

A comparison of national Nielsen ratings indicated that "All in the Family" was one of the most popular half hour TV programs and that "Ironsides" was one of the most frequently watched hour long programs. A small telephone survey of Long Island residents confirmed these national ratings, so it was decided to video tape these two programs for use in this experiment.

4. Order of flyovers presented

Since there are 18 different experimental stimuli with each presented three times in sequence, it was not feasible to counterbalance completely the order of presentation in the ninety minutes available for the test sessions. A random order of presentation was used as shown in Table 3. Six groups of three tapes with

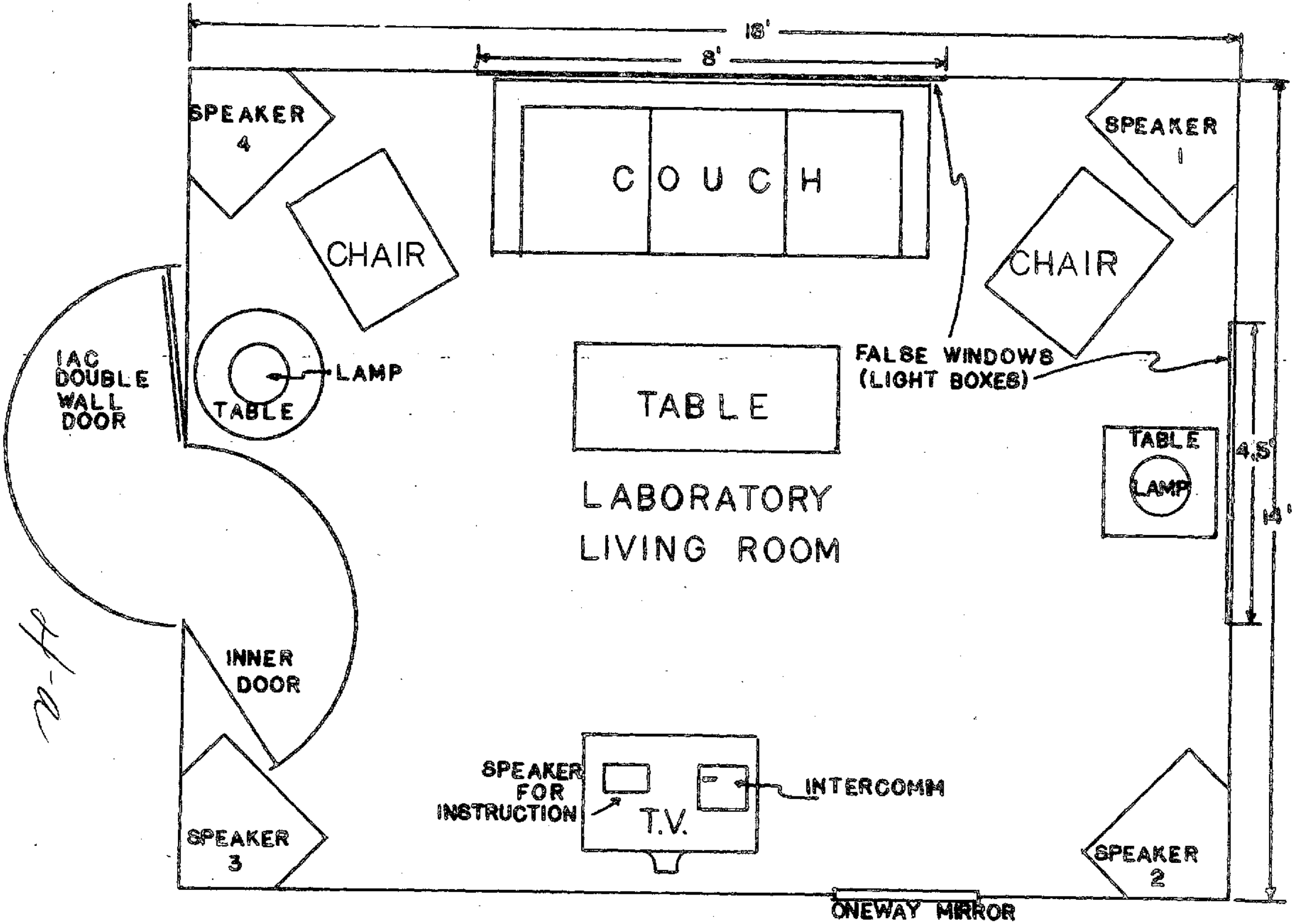

18'
8'
SPEAKER 4
COUCH
SPEAKER 1
CHAIR
CHAIR
IAC DOUBLE WALL DOOR
LAMP
TABLE
TABLE
FALSE WINDOWS (LIGHT BOXES)
TABLE
LAMP
4.5'
14'
LABORATORY LIVING ROOM
INNER DOOR
SPEAKER FOR INSTRUCTION
T.V.
INTERCOMM
SPEAKER 3
SPEAKER 2
ONEWAY MIRROR

fig. 1a

SCHEMATIC OF SOUND SYSTEM

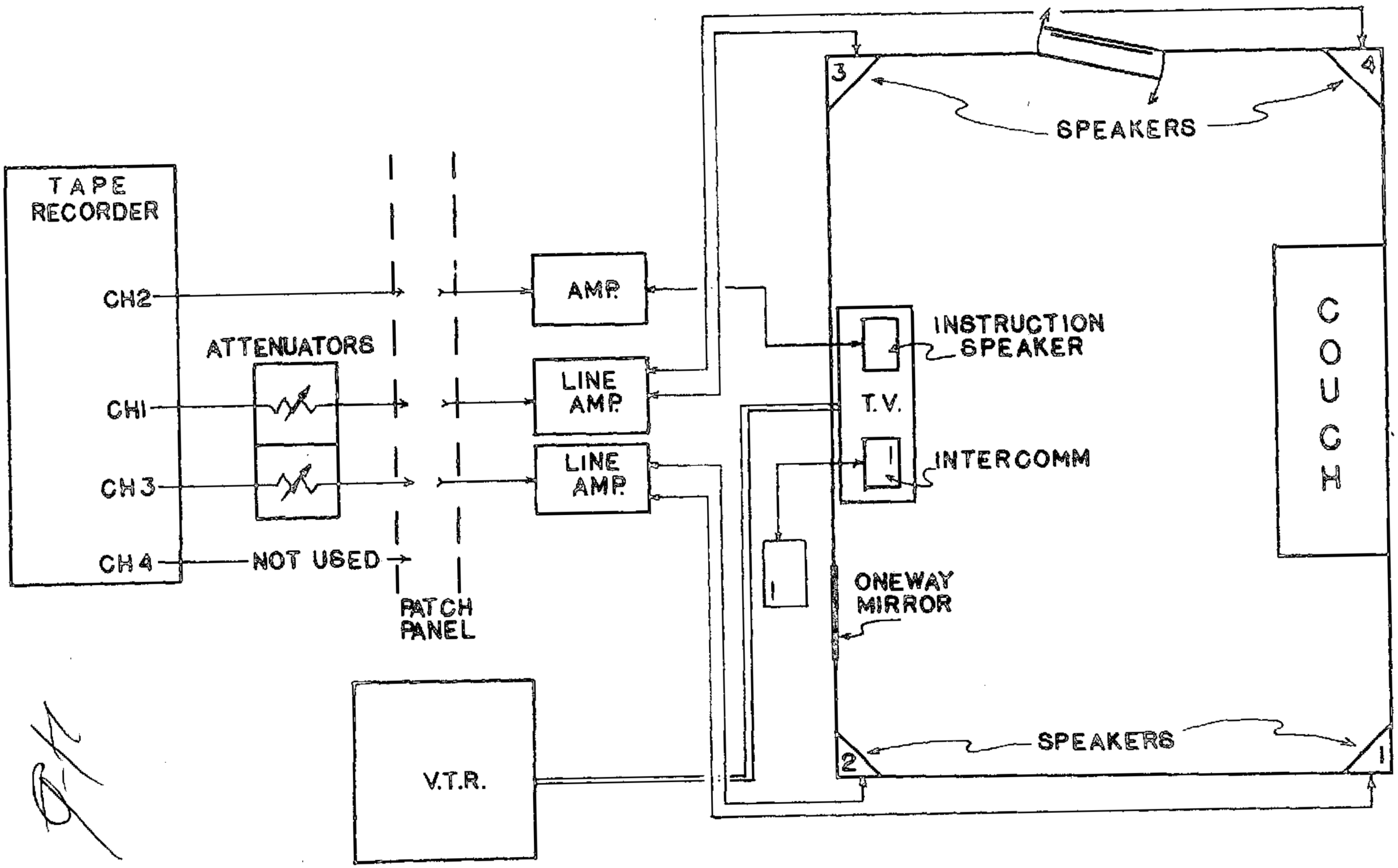


fig. 1b

different orders of stimulus presentation were used, so that one of the tapes presented each of the 18 stimuli first. Each group of three tapes was presented in six different combinations, so that there are 36 different random orders of stimuli presented. For example, for the A_1, B_1, C_1 series of tapes, the six orders were:

1 - A_1 B_1 C_1	4 - B_1 C_1 A_1
2 - A_1 C_1 B_1	5 - C_1 A_1 B_1
3 - B_1 A_1 C_1	6 - C_1 B_1 A_1

TABLE 3

Order of Flyover Presentations Included in Six Sets of Tapes

Tape	1	2	3	4	5	6
A_1	D2X	D1X	D3X	D2Z	D1Z	D3Y
B_1	A1Z	A3Y	A3Z	A2X	A3X	A2Y
C_1	D1Y	D3Z	D2Y	A2Z	A1Y	A1X
A_2	A1Y	A2X	A3X	A1X	A3Y	A2Z
B_2	D2Y	D2X	D2Z	D1X	D3Y	D1Z
C_2	D3Z	D3X	D1Y	A2Y	A1Z	A3Z
A_3	A3Z	A1Y	A2X	A2Y	A1X	A2Z
B_3	D1X	D3Y	D2Y	D1Y	D2X	D1Z
C_3	A3X	A1Z	A3Y	D3Z	D2Z	D3X
A_4	A2Z	A2X	A3X	A3Z	A2Y	A1Z
B_4	D1Z	D2X	D3Y	D1Y	D2Y	D1X
C_4	A1X	A3Y	A1Y	D3X	D2Z	D3Z
A_5	A3Y	A1Z	A2Z	A3X	A1X	A1Y
B_5	D3Y	D1Y	D2Z	D1X	D2Y	D3X
C_5	A2X	A2Y	A3Z	D3Z	D1Z	D2X
A_6	D3X	D1X	D1Z	D3Z	D3Y	D2Y
B_6	A2Y	A1Z	A3X	A3Z	A1Y	A3Y
C_6	D2Z	D1Y	D2X	A2X	A1X	A2Z

C. Subjects to be Tested

Over 1200 residents living in 19 communities under different flight paths and distances from JFK Airport were personally interviewed by the Columbia University Noise Research Unit. These sample areas were selected so that aircraft on approach and departure would be approximately at the nominal altitudes overhead as listed in Table 1. A highly concentrated random sampling procedure was employed which maximized the uniformity of aircraft noise exposure within sampling areas and between sampling areas of comparable distance from JFK runways. Respondents for the surveys were required to be permanent residents of an assigned block and at least 18 years old. In addition, only one respondent from each household was interviewed. No domestics or hired household employees were interviewed, nor were persons with a poor command of the English language.

The interviews averaged about an hour in length and proceeded from general questions about likes and dislikes about neighborhood environments to more specific perceptions and reactions to general noise and finally to aircraft noise exposures. 2/ Since previous survey research 3/4/5/6/7/ had clearly demonstrated that annoyance was related to psychological and attitudinal variables as well as to the noise stimulus, it was decided to select sub-samples of respondents with different subjective attitudes for the laboratory experiment.

First, all respondents were separated with respect to the location of their residences, i.e. comparable close, middle and distant areas, as described in Section A. Then all sub-groups were further classified according to their reported fear of aircraft. This attitudinal variable has been found the most important single factor in explaining variations in annoyance responses on all community noise surveys. In a recent analysis of 1500 interviews 7/ in the vicinity of JFK Airport, it was found that the correlation coefficient between fear and annoyance was .72 i.e., almost half the variance in individual annoyance responses was directly related to fear.

All respondents were classified into low, medium and high fear groups based on a scale of fear computed from four questions included in the survey questionnaire. Appendix A describes the derivation of the fear scale and its classifications.

Each fear group of respondents was tested separately in the laboratory to minimize any possible verbal or non-verbal biases that might result from the interactions of a mixed group of subjects. Since there are 36 different orders of stimuli presentations, the experimental design required 36 subjects from each of the three distance groups for each fear group, or 108 subjects for each fear group and 324 subjects in all. Each of the 36 sessions scheduled three subjects selected from each of the three distance groups, so that order effects of the 18 acoustic stimuli would be minimized in comparisons of laboratory responses of fear and distance subject groups.

D. Procedures Used

Respondents were telephoned by a member of the Noise Research Unit staff and invited to the research facility in the following manner:

"Hello: I am ___________, a supervisor from Columbia University Research Center. May I speak to (Are you) (the person who was interviewed earlier). I want to thank you for helping us in our study of community problems by answering all of our questions on the interview. As you probably know, we found that aircraft noise is one of the major concerns in your area. For this reason city planners, airplane manufacturers and interested community and environmental groups have asked us to conduct an intensive study into aircraft noise specifically.

While we know that almost everyone wants less noise, we don't know how much aircraft noise must be reduced in order to be acceptable to the public. Columbia University has constructed a special research center, nearby, in Franklin Square to which we are inviting citizens, like yourself, to help in this vital, and we hope interesting, research. Our participants will relax in a living room, watching popular TV shows while different types of aircraft fly over. The participants are simply asked to judge the annoying qualities of the various aircraft.

You will receive $6 as a small token of thanks for your cooperation and the study takes about two hours. We will also provide door-to-door transportation in a car and refreshments. We have a number of alternative times and dates for our study and would appreciate knowing when it would be best for you to come. First, could you come.....?"

In the event that a subject failed to keep an appointment or it was not possible to schedule three eligible subjects at the same time, additional sessions of the same stimulus order were held at different times for the missing subject category. If only one eligible subject was available or scheduled for a session, a staff member who was not known to the subject acted as a subject, so that at least two persons were always in the chamber at the same time.

Upon arrival at the research center, the subjects were escorted into the living room and asked to sit on the couch. The following instructions were used:

"Please go into the living room and be seated on the couch. As you know, Columbia University has an extensive environmental research program, of which our group is a part. We are interested in learning more about how people respond to different noises, especially those from airplane flyovers.

<u>We are going to have a TV show for you to watch</u> and we hope you enjoy it. From time to time you will hear airplanes flying over; some may appear louder than you usually hear them; others quieter. <u>Occasionally</u> you will hear a voice from this speaker (point to front over TV), asking you to <u>record your responses</u> to the airplanes which you have just heard.

Here is your reaction sheet. Please fill in your name and address. In the first column labelled annoyance, I would like you to indicate the extent to which the aircraft flyovers annoyed or bothered your watching and listening to the TV program.

There is no right or wrong answer. (If you are not annoyed, we don't want you to say you were.) We just want to know how you feel. You will notice on the <u>right hand side of the sheet</u>, a thermometer with numbers from 0 to 4. 0 means that the airplanes did not bother or annoy you at all. 4 means that you were annoyed <u>very much</u>. Any number in-between would indicate that your feelings were something greater than 0 but less than the top category of 4.

After recording your annoyance response, I want you <u>also</u> to place a check in the "Yes" or "No" box in the right hand column labelled "acceptable" (Point) to indicate whether or not you believe the airplane flyovers you have just rated would be acceptable to you; by this I mean whether or not you feel that you could learn to live with them if you heard them regularly in your own home while watching TV.

Please also notice that there are 18 lines. There will be 18 different times when a voice will ask you to record your responses. You will <u>not</u> be required to do this after each aircraft flyover, but only when you hear a voice from this speaker, (point to speaker).

After each time you hear the voice asking you for your response, you will enter two answers on each line, one number to indicate how you feel about the amount of annoyance, and one check to express your acceptability with the aircraft flyovers, which you heard since the previous time you recorded your responses.

I would like you to remain seated until the end of the first session, which will be about 30 minutes. Then we will have a brief coffee-break. In all, there will be three 30-minute sessions. If at any time during the session you want to talk to one of us for example; if the TV picture or sound is not clear, you can do so by pressing the button on top of the TV speaker and then you will be able to talk.

Please try to record your own personal feelings about the airplanes flying here. Try not to influence eachother by avoiding any discussion or indication of how you, yourself, feel about them. From our past experience we know that there may be a strong temptation to compare your ratings with others in the room. No two people are alike in their feelings about noise and if you do discuss your ratings, it will make our findings less valid; so please, wait until the very end of the third session to discuss your ratings if you feel you must, but not during the three sessions when you are making the eighteen judgements.

Of course, if you want to talk about the TV program, as you might at home, feel free to do so. Naturally, constant conversation, however, would interfere with watching the TV program, so it too should be avoided. O.K.?"

At this point the TV monitor was activated and the interior and exterior chamber doors were closed by the departing experimenter.

The first segment of the session consisted of a 27-minute video-taped "All in the Family" program which had previously been rated as one of the most interesting and most watched TV program. Coincident with activation of the TV monitor, a Crown 800 quadraphonic tape deck was engaged which produced simulated aircraft fly-overs with a mean inter-flight interval of just under two minutes. Eighteen such simulated flyovers occurred in the living room during this segment of the session. After each three flyovers the subjects were requested, via a separate voice channel, to make judgements as to the annoying quality and acceptability of the flyovers since the previous request for judgements. In a previous methodological study 2/, it was found that annoyance judgements seem to stabilize after presentation of three stimuli. Table 4 presents the time sequence of stimulus presentations and Figure 2 presents the form used to record subjective judgements.

At the end of the "All in the Family" program, the experimenter re-entered the living room and asked if the subjects wished to stretch, use the bathroom or would like some tea or coffee.

The second segment of the session consisted of the first half hour of an "Ironsides" series episode, which also had been highly rated by a pre-test sample of TV viewers. 18 aircraft flyovers were again produced in the living room with the same interflight intervals and with the same request for judgements after every third flyover.

After a second intermission, the last half hour of the "Ironsides" episode was viewed by the subjects, while more flyovers were simulated and six more judgement requests were made.

FOR OFFICE USE............
Condition................
No.......................
Distance.................

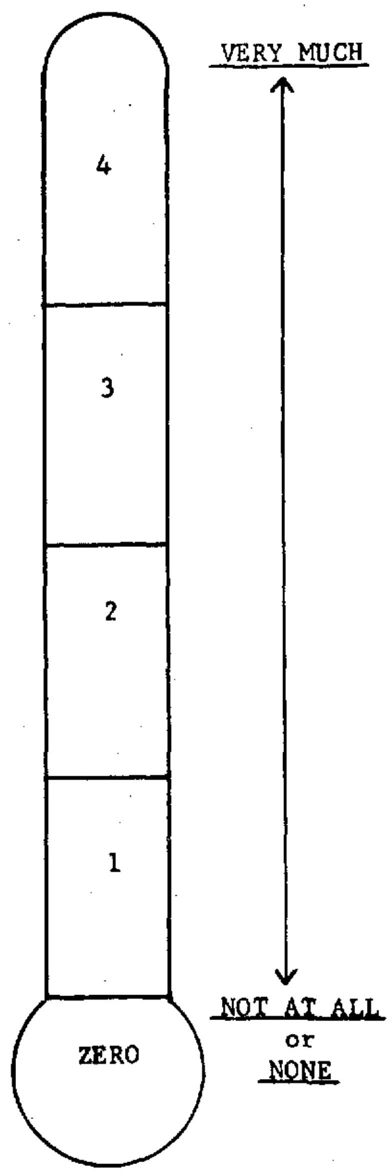
DATE: ______________________________

NAME: ______________________________

ADDRESS: ______________________________
(Street)

____
(Town)

ANNOYANCE	**ACCEPTABLE** Yes	No
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		



8-a

Figure 2

Columbia University
January 1974

TABLE 4

Time Sequence of Flyovers for Each 30 Minute Segment of Laboratory Session

Flight No.		ONSET Time	Minutes & Seconds Interval
1		0:30	0:30
2		1:54	1:24
3		3:36	1:42
	Judgement 1		
4		5:36	2:00
5		7:18	1:42
6		9:00	1:42
	Judgement 2		
7		10:42	1:42
8		12:12	1:30
9		13:42	1:30
	Judgement 3		
10		15:06	1:24
11		16:48	1:42
12		18:12	2:24
	Judgement 4		
13		19:36	1:24
14		21:18	1:42
15		22:42	1:24
	Judgement 5		
16		24:06	1:24
17		25:48	1:42
18		27:30	1:42
	Judgement 6		

E. Summary of Analytical Design

Table 5 presents a schematic of the analytical design of the study.

TABLE 5

ANALYTICAL DESIGN OF STUDY

Type of Subject			Repeated Measures of Level, Type Plane and Operation		
Residence	Fear		Level X	Level Y	Level Z
			Plane: 707 727 DC-10	Plane: 707 727 DC-10	Plane: 707 727 DC-10
			Operation: A D A D A D	Operation: A D A D A D	Operation: A D A D A D
Close	High	1 : 36			
	Medium	1 : 36			
	Low	1 : 36			
	Total	108			
Middle	High	1 : 36			
	Medium	1 : 36			
	Low	1 : 36			
	Total	108			
Distant	High	1 : 36			
	Medium	1 : 36			
	Low	1 : 36			
	Total	108			
Grand Total		324			

Seven major hypotheses were investigated in this study:

1. Each type of airplane would be judged differently due to spectral and noise level variations. In general, it was expected that plane 1 (707) would be judged more annoying than plane 2 (727) which would be more annoying than plane 3 (DC-10).

2. Arrivals would be judged more annoying than departures. Arrivals have more high frequency energy, which is generally believed to be more annoying.

3. Annoyance is generally positively correlated with the intensity of a noise stimulus.

4. Subjects from distant areas, whose normal exposures are from the lowest levels of aircraft noise should be most annoyed with laboratory noises typical of middle and close distance areas. Likewise, middle distance residents should be more annoyed with noise levels typical of close areas, which is more intense than their own usual exposures.

5. Fear of airplanes would be directly related to annoyance responses. The subjects with high fear would report the highest annoyance, followed by the medium and low fear groups.

6. The various Acoustic measures such as dBA, PNL, dBD_1 and SPL of the 18 stimuli would not vary greatly in their ability to predict annoyance.

7. Most subjects would realistically be willing to accept some level of annoyance with which they felt they could live.

III. Findings

A. Selected Characteristics of Laboratory Subjects

1. Representativeness of respondents in field survey

All interviewers were given predesignated addresses in primary sample areas, consisting of small clusters of adjacent blocks. In some assignments, where the number of dwellings in a sample area was limited, every household was contacted. In other areas, every n'th dwelling was randomly selected.

In the fall of 1973, eight primary sample areas were selected, and 1239 households were assigned to interviewers. As Table 6 indicates, completed interviews were achieved in 86% of all assignments, and only 6% refused an interview. Higher completion rates could have been obtained in some of the sample areas, but call backs were discontinued when the survey objective of completing over 1000 interviews was reached. These completion rates were slightly higher than those achieved in previous 1972 and earlier surveys near JFK Airport, and this sample of interviews can be considered fully representative of the selected communities.

TABLE 6

Completion Rates of Assignments in 1973 Field Survey

Close Areas	Assigned	Completed Number	Completed %	Refusals Number	Refusals %
Far Rockaway	139	102	73%	19	14%
Inwood	85	56	66	1	1
N. Woodmere	85	72	85	7	8
N. Valley Stream	160	136	85	11	7
Sub-Total	469	366	77%	38	8%
Middle Areas					
E. Rockaway	190	171	90	10	5
Canarsie	200	182	91	16	8
Sub-Total	390	353	91%	26	7%
Distant Areas					
E. Atlantic Beach	219	201	92	9	4
Lido Beach	161	139	86	8	5
Sub-Total	380	340	89%	17	4%
All Areas	1239	1059	86%	81	6%

2. Representativeness of Subjects Participating in Laboratory Study

In addition to the 1059 interviews completed in 1973, 179 residents interviewed in 11 sample areas during the previous year were contacted for use in this experiment. A simple screening procedure was used to be certain that their basic feelings of fear had not changed since the interview. This augmentation of subjects was necessary since reported fear and distance of residence are correlated ($r = .41$). In the 1973 survey only 70 of the 343 close residents reported feelings of low fear and 51 of the 334 distant residents indicated feelings of high fear. In addition, some residents had no telephones or could not be contacted within the time period of the experiment or for other reasons. Thus, the deadlines for completing the experiment made it necessary to expand the list of eligible residents.

As Table 7 indicates, of the 1238 eligible residents with completed interviews, just over 70% were actually contacted. Most of those not called were not required to complete the experimental design of 36 subjects for each distance and fear group.

TABLE 7

Comparison of Eligible and Contacted Residents for the Laboratory Study

Fear Group	DISTANCE OF RESIDENCE							
	Close		Middle		Distant		Total	
A. High	No.	%	No.	%	No.	%	No.	%
Total Eligible	170	100	113	100	144	100	427	100
Never Contacted	47	28	21	19	50	35	118	28
Contacted	123	72	92	81	94	65	309	72
B. Medium								
Total Eligible	126	100	129	100	127	100	382	100
Never Contacted	31	25	34	26	41	32	106	28
Contacted	95	75	95	74	86	68	276	72
C. Low								
Total Eligible	110	100	157	100	162	100	429	100
Never Contacted	23	21	50	32	52	32	125	29
Contacted	87	79	107	68	110	68	304	71

As Table 8 indicates between 31-43% of all residents contacted came to the laboratory to participate in the experiment. About an equal number were not able to come because of understandable reasons, such as illness, infants, multiple jobs, etc. From 12-19%, however, were firm refusals to cooperate.

The small differences in numbers of subjects reported in Tables 8 and 21 are due to the omissions of 10 respondents who came to the laboratory but whose responses were excluded from the analyses. Most of the disqualifications were due to equipment malfunctions, so the subjects could not complete the test sessions. In a few cases, subjects could not comprehend or follow the instructions and were excused.

TABLE 8

Outcome of Invitations to Participate in Laboratory Study

Fear Group	Close		Middle		Distant		Total	
	Distance of Residence							
	No.	%	No.	%	No.	%	No.	%
A. High								
Total contacted	123	100	92	100	94	100	309	100
Laboratory Subjects	38	31	38	41	36	38	112	36
Not able to come	35	28	25	27	38	40	98	32
Temporary not avail.	28	23	20	22	9	10	57	18
Refusals	22	18	9	10	11	12	42	14
B. Medium								
Total contacted	95	100	95	100	86	100	276	100
Laboratory Subjects	37	39	35	37	37	43	109	40
Not able to come	36	38	34	36	35	41	105	38
Temporary not avail.	9	9	8	8	11	13	28	10
Refusals	13	14	18	19	3	3	34	12
C. Low								
Total contacted	87	100	107	100	110	100	304	100
Laboratory Subjects	34	39	37	35	37	34	108	35
Not able to come	37	42	28	26	31	28	96	32
Temporary not avail.	4	5	14	13	24	22	42	14
Refusals	12	14	28	26	18	16	58	19

Table 9 presents some selected personal characteristics of the participants and non-participants in the laboratory study. In general, high and medium fear subjects and non-subjects are about the same. Low fear subjects, however, have an upward bias in their reported TV and general aircraft annoyance in comparison to survey responses reported by non-subjects. Reported TV annoyance was based on a single question with a range in scores of 0-4; general aircraft annoyance is based on 11 questions with a range in scale scores of 0-44. (see Appendix A) Due to their greater availability, laboratory subjects were somewhat more often women. With respect to income levels, all groups of subjects and non-participants are about equal. When TV annoyance and general aircraft annoyance are compared, no significant differences are found between the high and medium fear subjects and non-subjects. The low fear distant subjects, however, rated TV ($p = .05$) and general aircraft annoyance ($p = .01$) higher than the comparable distant non-participants. The same upward bias is shown in Table 9 for all low fear subjects in general aircraft annoyance ($p = .01$).

TABLE 9

Comparative Characteristics of Subjects and Non-Participants

Characteristics	SUBJECTS				NON PARTICIPANTS			
	Distance of Residence				Distance of Residence			
A. High Fear	Close N=38	Middle N=38	Distant N=36	Total N=112	Close N=132	Middle N=75	Distant N=108	Total N=315
Sex								
Male	13%	16%	28%	19%	26%	26%	29%	24%
Female	87	84	72	81	74	74	71	76
Median Income	$ 14,375	$ 15,000+	$ 13,507	$ 15,000+	$ 15,000+	$ 15,000+	$ 15,000+	$ 15,000+
Mean TV Annoyance	3.7	3.6	3.6	3.6	3.7	3.3	3.6	3.5
Mean genl. aircraft annoyance	29.3	24.2	25.3	26.3	26.7	23.4	24.7	25.3
B. Medium	N=37	N=35	N=37	N=109	N=89	N=94	N=90	N=273
Sex								
Male	30	74	11	22	29	32	26	29
Female	70	26	89	78	71	68	74	71
Median Income	$ 15,000+	$ 15,000+	$ 15,000+	$ 15,000+	$ 15,000+	$ 15,000+	$ 15,000+	$ 15,000+
Mean TV Annoyance	2.6	2.6	2.4	2.5	3.0	2.5	2.4	2.6
Mean genl. aircraft annoyance	13.1	12.6	10.6	12.1	16.1	10.5	9.5	12.0
C. Low	N=34	N=37	N=37	N=108	N=76	N=120	N=125	N=321
Sex								
Male	35	30	22	29	36	27	34	31
Female	65	70	78	71	64	73	66	69
Median Income	$ 15,000+	$ 15,000+	$ 15,000+	$ 15,000+	$ 15,000+	$ 15,000+	$ 15,000+	$ 15,000+
Mean TV Annoyance	1.5	1.6	2.2	1.8	1.4	1.9	1.5	1.6
Mean genl. aircraft annoyance	7	7	6.7	6.9	5.4	6.0	4.1	5.1

3. Factors Producing Possible Biases in Laboratory Responses

The goal of the Columbia University field-laboratory methodology is to bring different residents who actually experience varying aircraft flyovers in their daily environments into our realistic living room laboratory. It is our hope that they will bring their subjective attitudes, that in the real environment interact with the physical noise exposure, into the laboratory and differentially respond to the controlled noise experiences. Thus, the dynamics of the annoyance response can be systematically studied. In this first full use of the new methodology, a number of factors have been identified that may have modified the behavior of residents, so that their laboratory responses did not reflect the way they normally behave at home. In additional experiments, efforts will be made to minimize these possibly biasing factors.

a. Not enough time may have been allowed for subjects to schedule their personal activities as well as participate in the laboratory study. The residents who were interviewed represent random cross sections of different community populations, with many interests, activities and responsibilities, quite apart from environmental concerns. Given enough lead time, it should be possible to avoid undue pressuring of residents into cancelling some of their normal activities in order to come to the laboratory. When they are pressured, there is reason to believe it may increase their feelings about the importance of the aircraft noise problem. The urgent need for test results compelled efforts to schedule at least 10 sessions a week. Experience, however, indicates that residents in general, are available for laboratory research, during only limited time periods. Late mornings seem to be best; afternoons sometimes are appropriate, but must permit time to return to their homes before 3-3:30 PM, when children and family chores are important. Week-ends and periods preceding and including holidays, when the entire family is together, are not generally appropriate. Likewise, bad weather and summer months are poor for scheduling laboratory work.

Table 10 illustrates our actual experience with laboratory scheduling. Ideally, a total of 108 sessions, 36 per fear group, was required to complete the study design. Actually, 173 sessions were required, 60% more than ideal, and still 5 subjects were missing from the number needed to complete the study design. Only about a fourth of all sessions were complete, consisting of three subjects from different residential distances. Although a postcard reminder was routinely sent at least a week before the scheduled appointment and a phone call was made the day before, confirming the date, three-fourths of the sessions were incomplete due to last minute cancellations or inability to fill a scheduled date. In most cases, subjects appeared to have legitimate reasons for last minute changes and agreed to make new appointments. But enough time must be allowed for such contingencies. Note that over 80% of all sessions with residents reporting feelings of low fear were incomplete. Such residents were usually less motivated to cooperate and after agreeing to come, more often failed to do so.

TABLE 10

Number of Laboratory Sessions by Fear Group

Fear Group	Total No.	%	TYPE Complete No.	%	Incomplete No.	%	TIME Morning No.	%	Afternoon No.	%	Evening No.	%
A. High	55	100	16	29	39	71	24	44	20	36	11	20
B. Medium	56	100	17	30	39	70	27	48	21	38	8	14
C. Low	62	100	12	19	50	81	25	40	23	37	14	23
Total	173	100	45	26	128	74	76	44	64	37	33	19

Table 11 illustrates the futility of efforts to schedule residents during the month of July. Residents with high fear were tested from February 6 to April 9. The low fear group was tested from April 23 to June 10. Due to extreme pressure to complete the study, an all out effort was made to test the moderate fear subjects during the summer. As Table 11 indicates, 50% could not be contacted, although several calls were made during day and early evening hours. While only 8% made appointments during this summer period, normally over a third agreed to come as subjects. It is possible that some of the 44% who had active phones could have been reached eventually and been persuaded to become subjects, but comments by the "temporary not available" clearly indicated a deep reluctance to cancel summer outdoor activities in favor of accepting our invitation. It was decided to test those who had made appointments, if they came, and postpone the remaining appointments for September. In fact, in July, 14 sessions were held with 26 subjects. In September and early October, 42 sessions were held for the remaining subjects in 19 available working days, or 2.2 sessions per working day.

While a concerted effort was made by Columbia University staff not to press too hard during the July contacts, so that future call backs would be possible, it is likely, as will be discussed below, that the medium fear residents who eventually agreed to come after a second contact in September may have been biased by the initial contact.

TABLE 11

Outcome of Efforts to Schedule Subjects during July

		No.	%
Number residents Available	357		
Number not called	21		
Number called	336		
No answer after several calls		176	44
No phone active		25	6
Temporarily not available in July		126	32
Refused		40	10
Made appointments		30	8

b. "Hard Sell" may change residents' feelings about seriousness of aircraft noise as an environmental problem. In inviting residents to become subjects, as indicated in Section D-Procedures Used, residents were told, "As you probably know, we found that aircraft noise is one of the major concerns in your area. For this reason city planners, airplane manufacturers and interested community and environmental groups have asked us to conduct an intensive study into aircraft noise specifically." This phrase was used to indicate the importance of the study in order to encourage the resident to give of his limited time and participate as a subject. For those already substantially annoyed with their aircraft noise environment, there undoubtedly was agreement that "aircraft noise is one of the major concerns." This was probably generally true of the "high fear" residents, and their eagerness to cooperate was noted by Columbia staff members who talked to them.

The "low fear" residents, however, reflected a different response. As we know from their survey responses, shown in Table 9, their annoyance with aircraft was low. This was especially true in distant areas, where most people had "low fear" and "low annoyance". Often, such subjects would challenge the invitation and say, "I don't feel airplanes are a serious problem and I won't be a good person for your study," or "I feel other things are much more important for me to spend my time." Staff members were then told to reassure the residents that people differ in their feelings about aircraft noise and it was essential for a fair study to include all sorts of people and not only those who felt it was a serious problem. They were told we only wanted to find out how they, themselves, felt, etc. After much discussion and urging, appointments were sometimes eventually made, but the "hard sell" probably convinced the resident that aircraft noise actually must be more important than they originally believed. This may explain in part why the laboratory annoyance responses for low and medium fear groups were greater than expected from original survey judgements. Maybe subjects began to believe that they were out of step and should be more annoyed.

Table 9 indicated that the low fear subjects had higher annoyance responses on the initial interview than the non-participants. Table 10 showed that they more often failed to keep appointments, and had to be persuaded to reschedule their visits to the laboratory. Hindsight suggests that there should be more neutral wording in the invitation process and in all discussions involving subject contacts.

c. Influence of other contacts with other subjects. Debriefings of Columbia University staff who transported subjects to the laboratory indicate that despite our precautions, many subjects were typically tense as if they were apprehensive of being in a test situation. Questions were asked about what they would be asked to do; what the research was all about; whether it was a test; what we expected and who is paying for it, etc. Such feelings of insecurity are not unexpected and staff members tried to reassure subjects in as neutral a fashion as possible. Considering the previous discussion of possible "hard sell" effects, these questions may be further indications that our efforts were not fully successful in having subjects behave in the laboratory as they would at home. Some of this "test" insecurity is probably unavoidable but should be minimized by close supervision of all communication with subjects.

The instructions to subjects in the laboratory also could have contributed to modifying the subjects normal behavior patterns. From observations of possible biases in feelings of low fear subjects about the seriousness of the noise problem, an effort was made to reinforce the concept that non-annoyance was equally acceptable as a scale annoyance response. The principle of uniform instructions was fully understood, but since this was the first full test of a new methodology, it was decided that a minor modification in the wording of instructions might produce enough valuable knowledge to justify a modification of the "uniformity" rule. The original instructions to subjects said, "There is no right or wrong answer." Following this instruction, the following sentence was added to reinforce the contents of this sentence. "If you are not annoyed, we don't want you to say you were." Then followed the original sentence, "We just want to know how you feel." This additional sentence was used for the last 22 of the 105 low fear subjects. Comparison of the mean annoyance responses of these 22 subjects with those given by the 83 others who had not been given the extra sentence indicated that those with the extra sentence had a lower mean annoyance of 2.2 compared to 2.4 for those without the reinforcement. At first, this appeared to be the result of the new sentence, but when the possible order effects of the flyovers were considered, the conclusion is that the difference is probably not due to the modification in instructions. When the mean annoyance responses of the high fear subjects were compared for the identical sequences of stimuli presentations, that the two groups of low fear subjects judged, an identical difference of 0.2 between the means was obtained. Consequently, this minor deviation in survey procedure had no significant effect on overall annoyance means.

Instructions about remaining seated through-out a session and refraining from excessive conversation probably gave more than normal focus and attention to the TV program and the aircraft flyovers. Debriefings of subjects after each session indicate that many subjects felt that in their own homes they hardly ever sit through an entire one-half hour TV program. They usually also do other chores while watching TV. A number of subjects expressed guilt that they were just watching TV and listening to the airplanes. There is reason to believe that residents with low fear usually pay less attention to continuous overflights in their own homes, and this instruction that they sit and listen to TV and airplanes was a test artificiality that may have made them unduly attentive and biased their laboratory responses.

B. <u>Description of Airplane Flyovers</u>

The 18 test tapes were prepared from actual Columbia University field recordings of commercial plane flights at distances and altitudes as closely approximating the actual experimental design requirements as was practical. The acoustics characteristics of each aircraft recording were then modified, as described in Appendix B, to the average specific distance and altitude values as specified by FAA documents, taking into account atmospheric attenuation and other operational changes. The tapes of flyovers heard in the laboratory living room chamber also included corrections for outdoor-indoor attenuation as given by SAE recommendations for average cold climate houses with open windows.

Table 12 presents some of the peak acoustic measures of the 18 indoor aircraft flyovers used in this experiment.

TABLE 12

Some Peak Acoustic Measures of the Indoor Aircraft Flyovers used in Experiment

Airplane	DISTANCE FROM AIRPORT											
	CLOSE				MIDDLE				DISTANT			
	Op Code	dBA	PNL	SPL	Op Code	dBA	PNL	SPL	Op Code	dBA	PNL	SPL
A. Arrivals												
707	A1X	86	99	99	A1Y	80	95	87	A1Z	68	80	84
727	A2X	78	91	90	A2Y	72	85	86	A2Z	60	70	74
DC-10	A3X	76	88	95	A3Y	66	79	88	A3Z	58	74	74
B. Departures												
707	D1X	87	100	100	D1Y	79	91	94	D1Z	71	81	82
727	D2X	83	96	97	D2Y	76	86	90	D2Z	66	77	80
DC-10	D3X	75	89	92	D3Y	67	77	83	D3Z	58	73	75

Table 13 rearranges the same 18 aircraft flyovers in rank order of dBA levels. From this table the range and differences in the experimental stimuli are more apparent. For example, the range is 29 dBA and the following flyovers, while differing in plane type or operation are nearly equal in dBA levels; as shown in Table 14.

TABLE 13

Aircraft Flyovers Rank Ordered by Peak dBA Noise Level

Rank Order	Aircraft Operation Code	dBA Level	PNL Level	dBD_1 Level	SPL Level
1	D1X	87	100	95	100
2	A1X	86	99	93	99
3	D2X	83	96	89	97
4	A1Y	80	95	87	87
5	D1Y	79	91	87	94
6	A2X	78	91	85	90
7	A3X	76	88	85	95
8	D2Y	76	86	82	90
9	D3X	75	89	84	92
10	A2Y	72	85	81	86
11	D1Z	71	81	76	82
12	A1Z	68	80	76	84
13	D3Y	67	77	75	83
14	D2Z	66	77	73	80
15	A3Y	66	79	76	88
16	A2Z	60	70	66	74
17	A3Z	58	74	64	74
18	D3Z	58	73	66	75

TABLE 14

Comparison of Flyovers with Nearly Equal dBA Levels

Flyover Op.Code	Peak dBA	vs.	Flyover Op.Code	Peak dBA
D1X	87	vs.	A1X	86
D1Y	79	vs.	A1Y	80
A2X	78	vs.	D1Y	79
A2X	78	vs.	A1Y	80
A3X	76	vs.	D2Y	76
A3X	76	vs.	D3X	75
D3X	76	vs.	D2Y	76
A2Y	72	vs.	D1Z	71
A3Y	66	vs.	A1Z	68
A3Y	66	vs.	D2Z	66
A3Y	66	vs.	D3Y	67
A2Z	60	vs.	A3Z	58
A2Z	60	vs.	D3Z	58
A3Z	58	vs.	D3Z	58

Typical peak dBA indoor noise spectra for aircraft approaching the close areas at 1.1 miles from touchdown under the flight path are shown in Figure 3. As can be seen, the 707 has the most intense low frequencies above 80 Hz and also the most intense high frequencies in the 1000-3000 Hz range. The DC-10 has the highest SPL levels in the low frequencies below 80 Hz, and proportionately less high frequencies than the other two airplanes.

Figure 4 presents the peak dBA noise spectra for aircraft departing at the close areas about 4 miles from start of roll. The three aircraft spectra differ substantially, with the 707 having the most intense SPL above 630 Hz, while the 727 has the highest SPL below 630 Hz. The DC-10 has by far the lowest SPL at practically all frequencies. Other noise spectra for the middle and distant areas are shown in Appendix B.

Typical dBA time histories of ambient TV program material and intrusive 707 airplanes arriving and departing over the close areas are shown in Figures 5 and 6. Other time histories for other aircraft are shown in Appendix B.

C. Judgements of Annoyance

1. Summary of major effects

The intensity or level of noise was the most significant physical characteristic directly related to annoyance judgements. The type of aircraft operation, whether approach or departure, was not at all significant in any distance or fear group comparison. The 707 was judged more annoying than the DC-10 ($p = .01$) in all 9 fear and distance subject categories. The 707 was also judged significantly more annoying than the 727 in 8 of the 9 subject groups. The 727 was judged more annoying than the DC-10 mostly by the distant residents. The judgements of the close and middle distance residents tended also to judge the 727 more annoying than the DC-10, but the statistical significance tests indicated that in only one of the 6 subject groups was the difference at the p.05 level; in three groups it was close to the p.05 level and in two groups not significant

INDOOR NOISE SPECTRA OF 707, 727, DC-10 AT MAXIMUM dBA LEVEL ON APPROACH - 1 MILE FROM TOUCHDOWN

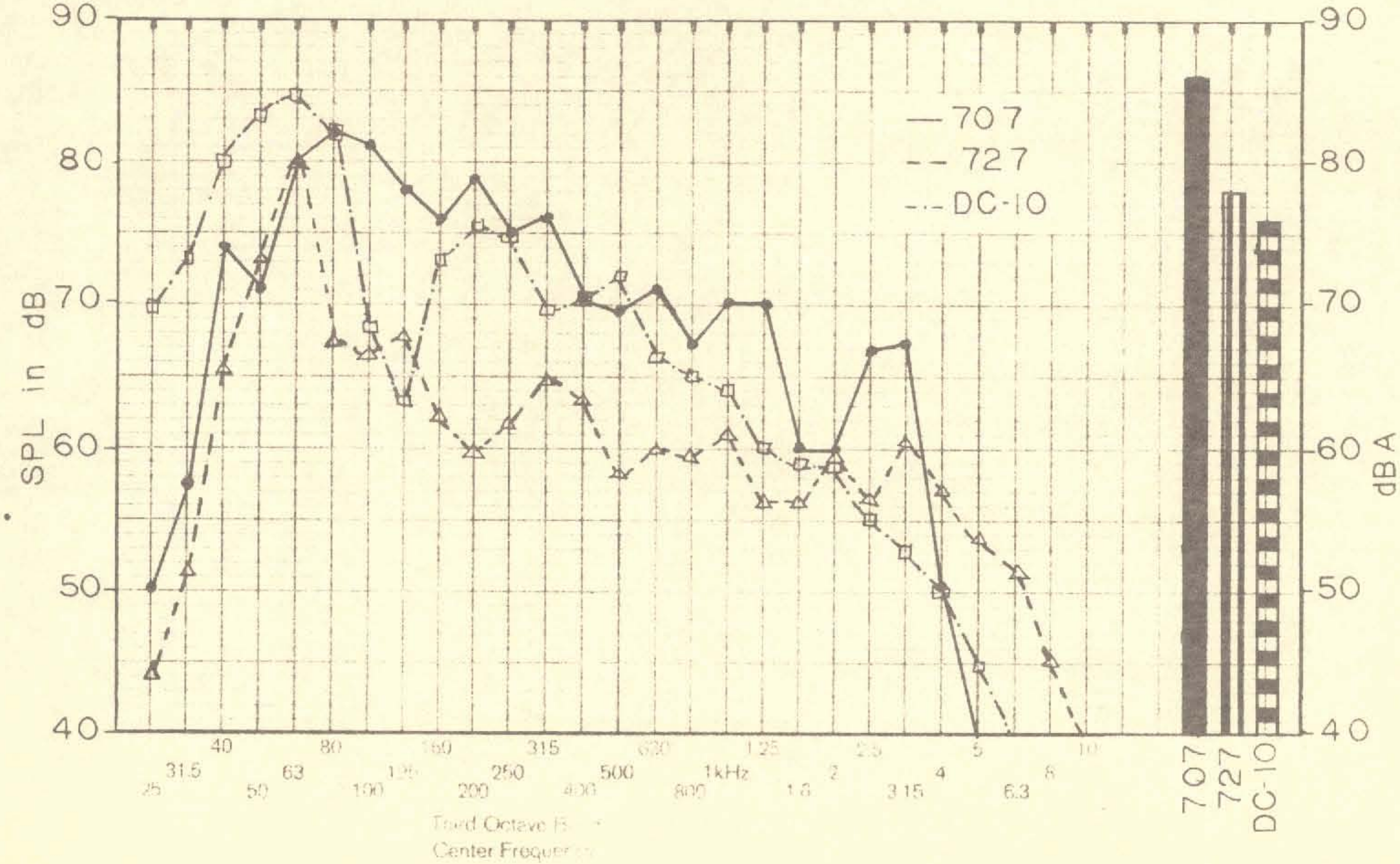
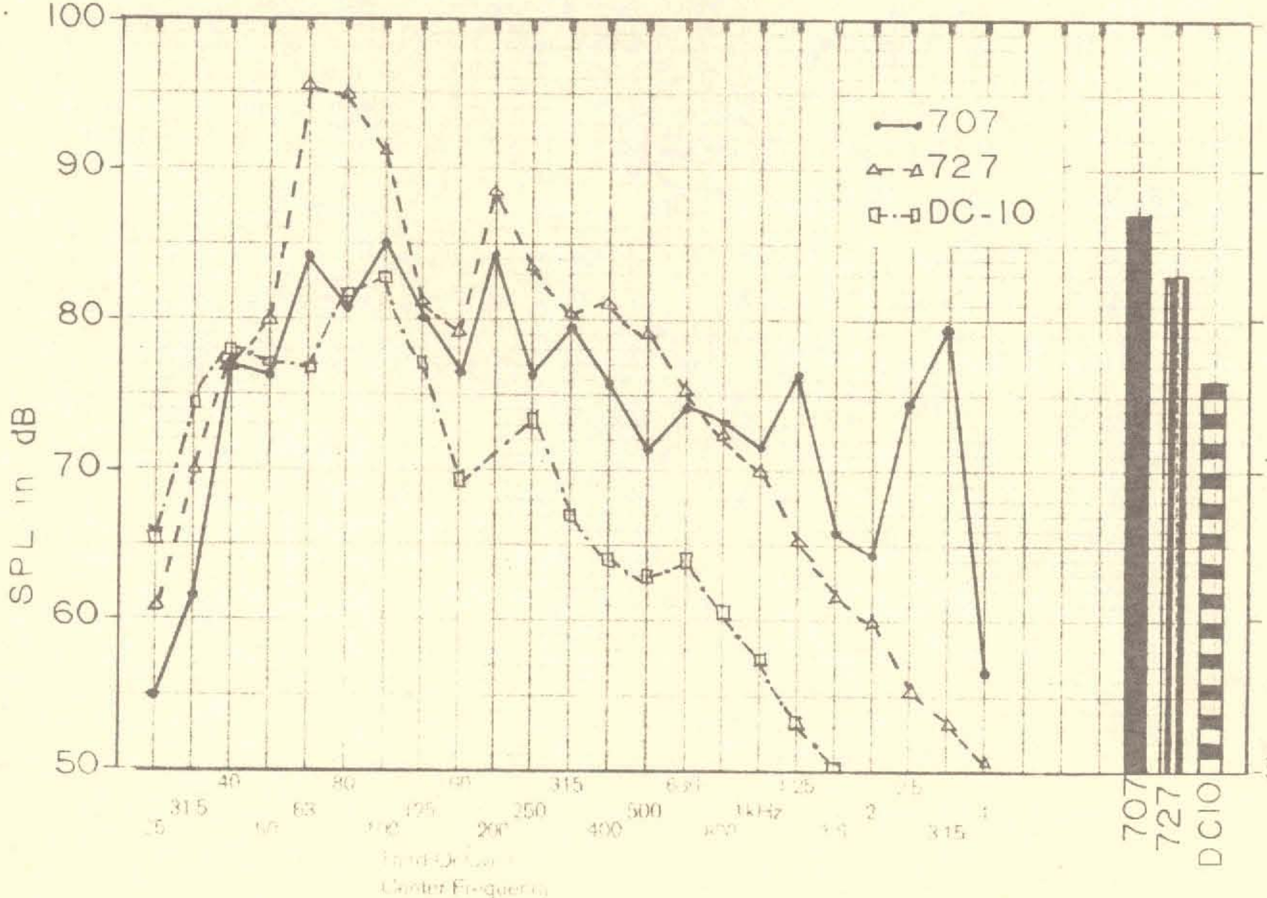


fig.3

INDOOR NOISE SPECTRA OF 707, 727, DC-10 AT MAXIMUM dBA LEVEL ON DEPARTURE - 4 MILES FROM START OF ROLL

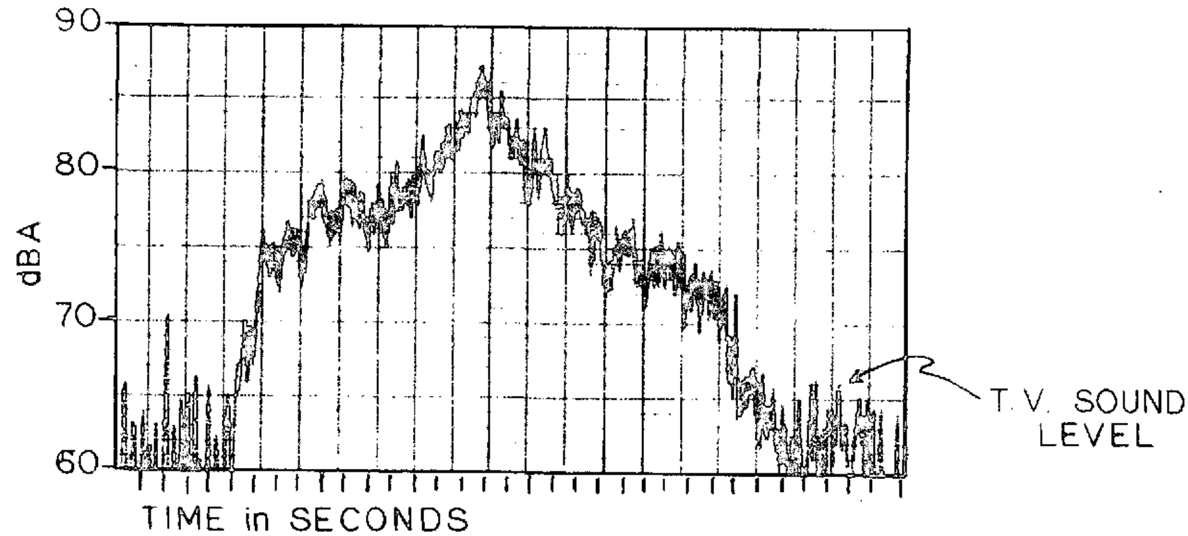


9-18

fig.4

INDOOR dBA LEVELS OF 707
1.-MILE FROM TOUCHDOWN

TIME HISTORY



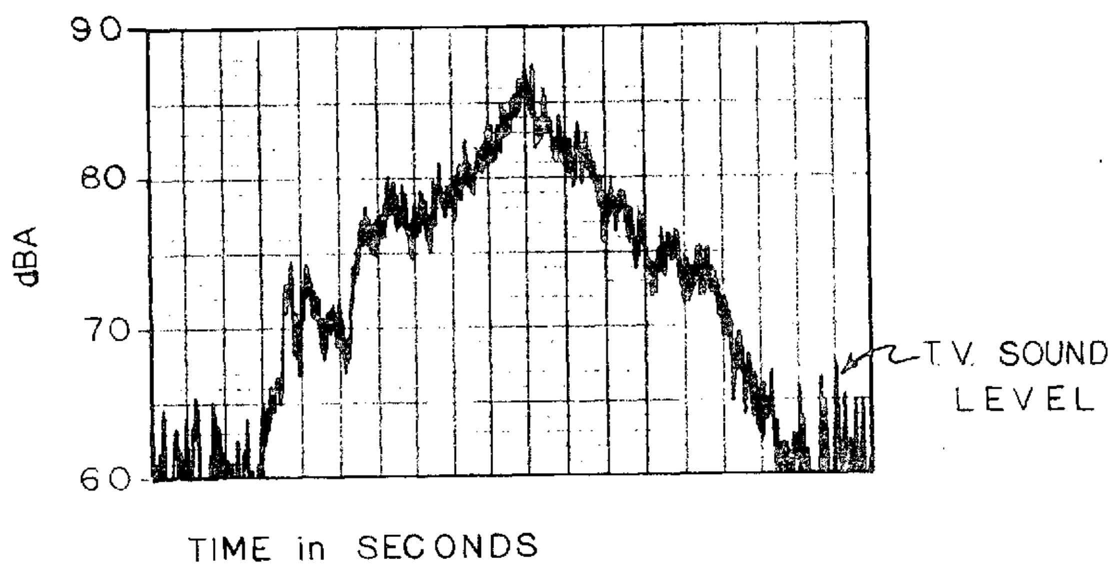
21-C

fig.5

INDOOR dBA LEVELS OF 707

4-MILES FROM START OF ROLL

TIME HISTORY



21-d

fig.6

at all. When comparisons were made among plane types, with dBA approximately equal, annoyance differences were not at all significant, suggesting again that level of noise was the important parameter. All of the acoustic measures of dBA, PNL and SPL appear to be about equally highly correlated to the annoyance judgements in this experiment.

Subject differences in annoyance judgements were not as great as anticipated from survey responses. High fear subjects reported statistically significant more annoyance than low fear subjects ($p = .01$) for all distance groups, but the amount of difference in annoyance was much less than the responses in the real life survey. High and Medium fear subjects reported about the same annoyance levels in the laboratory study. The importance of distance of residence from the airport was also ambiguous. Middle distance residents generally reported more annoyance than close or distant residents, if they had feelings of low or medium fear, but high fear subjects reported no differences in annoyance regardless of residence. In comparing subjects' judgements of their own residential levels of noise with those of subjects living in other areas, in only 14 of 162 comparisons did a group of subjects whose normal residential noise was usually less intense, judge a more noisy flyover more annoying than other subjects who usually experienced that level or even a more noisy level. In 5 comparisons, the reported annoyance was less than expected, and in the remaining 142 tests, no differences were observed.

2. Analytical Scheme

According to the research design presented in Table 5, subjects are divided into 9 primary groups - 3 fear by 3 residential distance groups. Each group made repeated judgements of annoyance of 18 different flyovers, composed of 3 plane types in two modes of operation (approach and departure), at 3 different levels, X, Y and Z. The analytical scheme is to calculate a two-way analysis of variance for each of the 9 subject groups and use a conservative Scheffe test of significance between means if the major variables are significant. Comparisons can be made for annoyance means for different plane types, operations and levels of noise. "T" tests will be used to compare annoyance means for different combined subject groups. Correlation analyses will be used to relate different physical measures of the 18 flyovers with annoyance responses.

3. Analyses of Variance by Fear Group

a. Subjects with feelings of high fear

As expected, the variations in annoyance judgements among subjects and among the 18 different flyovers are significantly different at the $p = .01$ level, for all 3 distance groups of residents. These findings are presented in the main analysis of Table 15. Scheffe tests of differences between means by plane type, operation and level of noise are also included.

TABLE 15

Analyses of Variance in Annoyance by Subjects with Feelings of High Fear

A. Residence close distance

1. Main Analyses

	Variables	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
(rows)	Subjects	135.26	35	3.86	8.21 (sig at .01)
(columns)	Flyovers	347.95	17	20.47	43.55 (sig at .01)
	Interaction	281.27	595	.47	
	Total	764.48			

2. Scheffé Tests of Comparison of Means

F score of 26.86 is sig. at p = .05
F score of 32.13 is sig. at p = .01

Plane Type	Mean Annoyance	F Ratio	
P1 vs P2	3.04 vs 2.74	22.5	(not significant)
P1 vs P3	3.04 vs 2.45	87.03	(significant at .01)
P2 vs P3	2.74 vs 2.45	21.03	(not significant)
Operation			
Arrival vs Departure	2.66 vs 2.82	8.83	(not significant)
Level			
X vs Y	3.56 vs 2.85	126.03	(significant at .01)
Y vs Z	2.85 vs 1.82	265.23	(significant at .01)
X vs Z	3.56 vs 1.82	756.9	(significant at .01)

TABLE 15

B. Residence middle distance

1. Main Analyses

	Variables	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
(rows)	Subjects	122.04	35	3.49	7.12 (sig at .01)
(columns)	Flyovers	408.12	17	24.01	49.00 (sig at .01)
	Interaction	294.49	595	.49	
	Total	824.65			

2. Scheffé Tests of Comparison of Means

F score of 26.86 is sig. at p = .05
F score of 32.13 is sig. at p = .01

Plane Type	Mean Annoyance	F Ratio	
P1 vs P2	3.03 vs 2.71	22.76	(not significant)
P1 vs P3	3.03 vs 2.44	77.36	(significant at .01)
P2 vs P3	2.71 vs 2.44	16.20	(not significant)
Operation			
Arrival vs Departure	2.65 vs 2.81	9.63	(not significant)
Level			
X vs Y	3.56 vs 2.84	115.2	(significant at .01)
Y vs Z	2.84 vs 1.78	249.69	(significant at .01)
X vs Z	3.56 vs 1.78	704.09	(significant at .01)

TABLE 15

C. Residence Distant from Airport

1. Main Analyses

	Variables	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
(rows)	Subjects	123.75	34	3.64	8.88(sig at .01)
(columns)	Flyovers	385.67	17	22.69	55.34 (sig at .01)
	Interaction	239.39	578	.41	
	Total	748.81			

2. Scheffe Tests of Comparison of Means

F score of 26.86 is sig at p =.05
F score of 32.13 is sig at p =.01

Plane Type	Mean Annoyance	F Ratio	
P1 vs P2	3.14 vs 2.84	23.68	(not significant)
P1 vs P3	3.14 vs 2.53	97.92	(significant at .01)
P2 vs P3	2.84 vs 2.53	25.29	(not significant)
Operation			
Arr. vs Dep.	2.72 vs 2.96	23.04	(not significant)
Level			
X vs Y	3.67 vs 2.92	148.03	(significant at .01)
Y vs Z	2.92 vs 1.93	257.92	(significant at .01)
X vs Z	3.67 vs 1.93	796.74	(significant at .01)

As can be seen in Table 16, the reported mean annoyance for arrivals is almost the same as that for departures for all distance groups. Overall, the mean annoyance for arrivals is 2.68 compared to 2.86 for departures. Scheffe test results shown in Table 15, indicate that there are no statistically significant differences among the means for arrivals and departures in all residence distance groups. Subjects with high fear judged annoyance about the same for both arrivals and departures, disproving one of our hypotheses that arrivals would be judged more annoying.

The 707 was judged significantly more annoying than the DC-10 by all residential distance groups (p.01). Overall, high fear subjects reported the 707 caused a 3.07 mean annoyance compared to 2.48 for the DC-10.

While all of the distance groups reported higher annoyance averages for the 707 compared to the 727 flyovers, the differences between annoyance means as measured by the Scheffe test were just below the 5% level of statistical significance. Overall the mean annoyance for the 727 was 2.77 compared to 3.07 for the 707. As Table 15 shows, an F score of 26.86 is required for a difference between means to be significant at the 5% level. The actual F scores for the 707-727 comparison ranged from 22.5 to 23.7, almost at the 5% level. In view of the conservative characteristics of the Scheffe test, it may be stated that there was a consistently strong tendency (above the 10% level of significance) for 707s to be judged more annoying than 727s.

In the case of the 727 - DC-10 comparison, the close and distant residents also reported the 727s more annoying, just below the 5% level of significance. The middle distance residents, however, reported no substantial differences in judgement.

b. Subjects with feelings of medium fear

The main analyses of variance shown in Table 17, shows identical results to those reported for High Fear subjects. The variations among subjects and flyovers were significant beyond the 1% level of significance. Table 18 presents the mean annoyance scores for medium fear subjects.

As in the case of high fear subjects, no significant differences are reported for judgements of annoyance due to arrivals or departures. Overall, the mean annoyance for arrivals was 2.73 and for departures 2.85.

Similar to the high fear group, as seen in Table 18, all three medium fear distance groups judged the 707 more annoying than the DC-10. For the close and middle distance groups, the statistical probability level was at the 1% level; for the distant residents it was at the 5% level. Overall, the mean annoyance for the 707 was 3.14 compared to 2.46 for the DC-10.

In the 707 vs. 727 comparison, all three distance groups also judged the 707 more annoying than the 727, but the level of statistical significance among the residents varied. The Scheffe tests show that differences between annoyance means was at the 5% level of significance for the close distance, 1% for the middle distance and just below the 5% level for the distant residents. Overall the mean annoyance for the 727 was 2.78 compared to 3.14 for the 707.

As in the high fear comparisons, the 727 vs. DC-10 annoyance differences were marginal. Only the distant residents reported a statistically significant varia-

TABLE 16

Mean Annoyance Responses by Subjects with High Fear

A. Residence Close Distance

Plane Type	Operation:	Level X A	Level X D	Level Y A	Level Y D	Level Z A	Level Z D	Total
707		3.69	3.78	3.22	3.28	1.97	2.28	3.04
727		3.14	3.78	2.61	3.03	1.94	1.94	2.74
DC-10		3.50	3.47	2.39	2.58	1.50	1.28	2.45
Total		3.56		2.85		1.82		2.74

Total Arrivals 2.66
Total Departures 2.82

B. Residence Middle Distance

Plane Type	Operation:	Level X A	Level X D	Level Y A	Level Y D	Level Z A	Level Z D	Total
707		3.67	3.86	3.17	3.25	2.00	2.22	3.03
727		3.08	3.72	2.83	3.08	1.64	1.92	2.71
DC-10		3.50	3.53	2.47	2.25	1.44	1.44	2.44
Total		3.56		2.84		1.78		2.73

Total Arrivals 2.65
Total Departures 2.81

C. Residence Distant

Plane Type	Operation:	Level X A	Level X D	Level Y A	Level Y D	Level Z A	Level Z D	Total
707		3.77	3.94	3.29	3.46	2.06	2.34	3.14
727		3.37	3.86	2.51	3.34	1.83	2.14	2.84
DC-10		3.60	3.46	2.51	2.43	1.57	1.63	2.53
Total		3.67		2.92		1.93		2.84

Total Arrivals 2.72
Total Departures 2.96

D. All High Fear Subjects

Plane Type	Operation:	Level X A	Level X D	Level Y A	Level Y D	Level Z A	Level Z D	Total
707		3.71	3.86	3.23	3.33	2.01	2.28	3.07
727		3.20	3.79	2.65	3.15	1.80	2.00	2.77
DC-10		3.53	3.49	2.46	2.42	1.50	1.45	2.48
Total		3.60		2.87		1.84		2.77

Total Arrivals 2.68
Total Departures 2.86

TABLE 17

Analyses of Variance in Annoyance by Subjects with Feelings of Medium Fear

A. Residence close distance

1. Main Analyses

	Variables	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
(rows)	Subjects	248.33	35	7.10	16.14 (sig at .01)
(columns)	Flyovers	403.05	17	23.71	53.89 (sig at .01)
	Interaction	259.95	595	.44	
	Total	911.33			

2. Scheffé Tests of Comparison of Means

F score of 26.86 is sig. at p = .05
F score of 32.13 is sig. at p = .01

Plane Type	Mean Annoyance	F Ratio	
P1 vs P2	3.16 vs 2.82	28.20	(significant at .05)
P1 vs P3	3.16 vs 2.52	99.90	(significant at .01)
P2 vs P3	2.82 vs 2.52	21.95	(not significant)
Operation			
Arrival vs Departure	2.74 vs 2.92	10.80	(not significant)
Level			
X vs Y	3.64 vs 2.95	116.12	(significant at .01)
Y vs Z	2.95 vs 1.91	263.80	(significant at .01)
X vs Z	3.64 vs 1.91	729.98	(significant at .01)

TABLE 17

B. Residence middle distance

1. Main Analyses

	Variables	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
(rows)	Subjects	148.14	34	4.36	8.90 (sig at .01)
(columns)	Flyovers	467.73	17	27.51	56.14 (sig at .01)
	Interaction	284.49	578	.49	
	Total	900.36			

2. Scheffe Tests of Comparison of Means

F score of 26.86 is sig. at p =.05
F score of 32.13 is sig. at p =.01

Plane Type	Mean Annoyance	F Ratio	
P1 vs P2	3.04 vs 2.62	37.53	(significant at .01)
P1 vs P3	3.04 vs 2.28	122.89	(significant at .01)
P2 vs P3	2.62 vs 2.28	24.60	(not significant)
Operation			
Arrival vs Departure	2.63 vs 2.66	.21	(not significant)
Level			
X vs Y	3.53 vs 2.77	122.89	(significant at .01)
Y vs Z	2.77 vs 1.64	271.68	(significant at .01)
X vs Z	3.53 vs 1.64	760.02	(significant at .01)

TABLE 17

C. Residence distant from airport

1. Main Analyses

	Variables	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
(rows)	Subjects	157.63	35	4.50	10.47 (sig at .01)
(columns)	Flyovers	389.01	17	22.88	53.21 (sig at .01)
	Interaction	255.43	595	.43	
	Total	802.07			

2. Scheffe Tests of Comparison of Means

F score of 26.86 is sig. at p =.05
F score of 32.13 is sig. at p =.01

Plane Type	Mean Annoyance	F Ratio	
P1 vs P2	3.21 vs 2.92	21.03	(not significant)
P1 vs P3	3.21 vs 2.58	99.23	(significant at .05)
P2 vs P3	2.92 vs 2.58	28.90	(significant at .01)
Operation			
Arrivals vs Departure	2.82 vs 2.99	10.70	(not significant)
Level			
X vs Y	3.68 vs 3.07	93.03	(significant at .01)
Y vs Z	3.07 vs 1.97	302.50	(significant at .01)
X vs Z	3.68 vs 1.97	731.03	(significant at .01)

TABLE 18

Mean Annoyance Responses by Subjects with Medium Fear

A. Residence Close Distance

Plane Type	Operation:	Level X A	Level X D	Level Y A	Level Y D	Level Z A	Level Z D	Total
707		3.72	3.89	3.36	3.39	2.17	2.44	3.16
727		3.19	3.83	2.67	3.17	1.86	2.17	2.82
DC-10		3.67	3.53	2.56	2.53	1.47	1.33	2.52
Total		3.64		2.95		1.91		2.83

Total Arrivals 2.74
Total Departures 2.92

B. Residence Middle Distance

Plane Type	Operation:	Level X A	Level X D	Level Y A	Level Y D	Level Z A	Level Z D	Total
707		3.80	3.89	3.34	3.26	1.97	2.00	3.04
727		3.11	3.57	2.49	3.03	1.80	1.69	2.62
DC-10		3.57	3.23	2.46	2.03	1.17	1.20	2.28
Total		3.53		2.77		1.64		2.65

Total Arrivals 2.63
Total Departures 2.66

C. Residence Distant

Plane Type	Operation:	Level X A	Level X D	Level Y A	Level Y D	Level Z A	Level Z D	Total
707		3.89	3.94	3.53	3.47	2.03	2.42	3.21
727		3.28	3.86	2.89	3.31	1.97	2.22	2.92
DC-10		3.61	3.47	2.58	2.64	1.61	1.56	2.58
Total		3.68		3.07		1.97		2.91

Total Arrivals 2.82
Total Departures 2.99

D. All Medium Fear Subjects

Plane Type	Operation:	Level X A	Level X D	Level Y A	Level Y D	Level Z A	Level Z D	Total
707		3.80	3.91	3.41	3.37	2.06	2.29	3.14
727		3.19	3.75	2.68	3.17	1.88	2.03	2.78
DC-10		3.62	3.41	2.53	2.40	1.42	1.36	2.46
Total		3.61		2.93		1.84		2.79

Total Arrivals 2.73
Total Departures 2.85

TABLE 19

Analyses of Variance in Annoyance by Subjects with Feelings of Low Fear

A. Residence Close Distance

1. Main Analyses

	Variables	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
(rows)	Subjects	275.23	32	8.60	18.30 (sig at .01)
(columns)	Flyovers	461.46	17	27.14	57.74 (sig at .01)
	Interaction	257.98	544	.47	
	Total	994.67			

2. Sheffe Tests of Comparison of Means

F score of 26.86 is sig at p =.05
F score of 32.13 is sig at p =.01

Plane Type	Mean Annoyance	F Ratio	
P1 vs P2	2.58 vs 2.17	35.77	(significant at .01)
P1 vs P3	2.58 vs 1.92	92.68	(significant at .01)
P2 vs P3	2.17 vs 1.92	13.30	(not significant)
Operation			
Arrivals vs Departures	2.20 vs 2.24	.53	(not significant)
Level			
X vs Y	3.17 vs 2.32	153.72	(significant at .01)
Y VS Z	2.32 vs 1.19	271.68	(significant at .01)
X VS Z	3.17 vs 1.19	834.13	(significant at .01)

TABLE 19

B. Residence Middle Distance

1. Main Analyses

	Variables	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
(rows)	Subjects	261.22	35	7.46	15.54 (sig at .01)
(columns)	Flyovers	495.05	17	29.12	60.67 (sig at .01)
	Interaction	286.17	595	.48	
	Total	1042.44			

2. Sheffe Tests of Comparison of Means

F scores of 26.86 is sig at p =.05
F score of 32.13 is sig at p =.01

Plane Type	Mean Annoyance	F Ratio	
P1 vs P2	2.95 vs 2.56	38.03	(significant at .01)
P1 vs P3	2.95 vs 2.22	133.23	(significant at .01)
P2 vs P3	2.56 vs 2.22	28.90	(significant at .05)
Operation			
Arrivals vs Departures	2.46 vs 2.69	17.63	(not significant)
Level			
X vs Y	3.48 vs 2.70	152.10	(significant at .01)
Y vs Z	2.70 vs 1.55	330.63	(significant at .01)
X vs Z	3.48 vs 1.55	931.23	(significant at .01)

TABLE 19

C. Residence Distant from Airport

1. Main Analyses

	Variables	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
(rows)	Subjects	296.61	35	8.47	16.61 (sig at .01)
(columns)	Flyovers	550.14	17	32.36	63.45 (sig at .01)
	Interaction	305.58	595	.51	
	Total	1152.33			

2. Sheffe Tests of Comparison of Means

F score of 26.86 is sig at p =.05
F score of 32.13 is sig at p =.01

Plane Type	Mean Annoyance	F Ratio	
P1 vs P2	2.66 vs 2.38	15.68	(not significant)
P1 vs P3	2.66 vs 1.95	100.82	(significant at .01)
P2 vs P3	2.38 vs 1.95	36.98	(significant at .01)
Operation			
Arrivals vs Departure	2.23 vs 2.43	13.33	(not significant)
Level			
X vs Y	3.32 vs 2.42	163.20	(significant at .01)
Y vs Z	2.42 vs 1.26	269.12	(significant at .01)
X vs Z	3.32 vs 1.26	852.85	(significant at .01)

tion at the p.01 level of significance with the mean annoyance for the 727 at 2.92 compared to 2.58 for the DC-10. The close and middle distance residents gave judgements just below the 5% level of significance. Consequently, our conclusion is still that there is a strong tendency for the 727 to be judged more annoying than the DC-10. Overall, the mean annoyance for the 727 was 2.78 compared to 2.46 for the DC-10.

Level of noise was again the most pronounced difference. For all distance groups of residents, annoyance with Level X exceeded Level Y, which exceeded Level Z. The statistical level of significance was well beyond the p.01 level. Overall, the mean annoyance for Level X was 3.61 compared to 2.93 for Level Y and 1.84 for Level Z.

c. Subjects with feelings of low fear

The main effects for subjects with low fear of aircraft and the Scheffé tests of comparisons of means are presented in Table 19, and the actual reported annoyance means are shown in Table 20. The main analysis of variance, as in the other two fear groups, clearly establish the differences in annoyance judgements (p.01 level) among subjects and flyovers.

Consistent with the other fear groups, no significant differences in annoyance are found between arrivals and departures. For all low fear subjects, the mean annoyance for arrivals was 2.30 compared to 2.45 for departures.

In comparisons of plane types, the 707 vs. the DC-10 is consistently the most clear cut. All distance groups judged the 707 more annoying than the DC-10 at the 1% level of statistical significance. The average mean annoyance for all low fear subjects reported for the 707 was 2.73 compared to 2.03 for the DC-10.

The 707 was also judged more annoying than the 727 by the close and middle distance subjects (p.01), but not significantly different by the distant low fear residents. Overall, the mean annoyance for the 707 was 2.73 compared to 2.37 for the 727.

Likewise, mixed results are reported for the 727 vs. DC-10 comparisons. The close residents judged them about the same, but the middle distance (p.05) and the distant residents (p.01) judged the 727 more annoying than the DC-10. For all low fear subjects, the mean annoyance reported for the 727 was 2.37 compared to 2.03 for the DC-10.

With respect to judging levels of noise, as expected, Level X was overwhelmingly judged more annoying than Level Y and Level Y was much more annoying than Level Z. These differences in annoyance were reported by all distance groups at well beyond the p.01 level of statistical significance. Overall, Level X had a mean annoyance of 3.32 compared to 2.48 for Level Y and 1.33 for Level Z.

4. Variations in Annoyance by Subject Characteristics

a. Feelings of fear

Table 21 summarizes the mean annoyance responses by subject's feelings of fear and location of residence. "T" tests of differences between means indicate that subjects with high fear reported statistically significant more annoyance than low fear residents at the 1% level of significance. Overall, the mean

TABLE 20

Mean Annoyance Responses by Subjects with Low Fear

A. Residence Close Distance

Plane Type	Operation:	Level X A	Level X D	Level Y A	Level Y D	Level Z A	Level Z D	Total
707		3.42	3.55	2.79	2.94	1.33	1.45	2.58
727		2.73	3.15	2.21	2.52	1.15	1.27	2.17
DC-10		3.24	2.91	1.85	1.58	1.09	0.82	1.92
Total		3.17		2.32		1.19		2.23

Total Arrivals 2.20
Total Departures 2.24

B. Residence Middle Distance

Plane Type	Operation:	Level X A	Level X D	Level Y A	Level Y D	Level Z A	Level Z D	Total
707		3.64	3.78	3.14	3.31	1.69	2.14	2.95
727		3.03	3.72	2.39	3.00	1.53	1.67	2.56
DC-10		3.47	3.22	2.08	2.25	1.17	1.11	2.22
Total		3.48		2.70		1.55		2.58

Total Arrivals 2.46
Total Departures 2.69

C. Residence Distant

Plane Type	Operation:	Level X A	Level X D	Level Y A	Level Y D	Level Z A	Level Z D	Total
707		3.44	3.75	2.83	3.00	1.38	1.55	2.66
727		2.86	3.55	2.38	2.75	1.16	1.58	2.38
DC-10		3.27	3.05	1.77	1.77	1.00	0.86	1.95
Total		3.32		2.42		1.26		2.33

Total Arrivals 2.23
Total Departures 2.43

D. All Low Fear Subjects

Plane Type	Operation:	Level X A	Level X D	Level Y A	Level Y D	Level Z A	Level Z D	Total
707		3.50	3.69	2.92	3.08	1.47	1.71	2.73
727		2.87	3.47	2.33	2.76	1.28	1.51	2.37
DC-10		3.33	3.06	1.90	1.87	1.09	.93	2.03
Total		3.32		2.48		1.33		2.38

Total Arrivals 2.30
Total Departures 2.45

annoyance for high fear residents was 2.77 compared to 2.38 for low fear residents. This 0.39 difference in mean annoyance compares to a 1.8 difference reported in Table 9 by these same subjects for annoyance with TV listening and watching reported previously in the survey interviews conducted in their homes. Of course, the judgements in the laboratory were of only one flyover level which was comparable to each subject's home environment and two levels which were different. Likewise, in the home, a single annoyance judgement was a composite of characteristic proportions of different aircraft at different rates of occurrence over time. In the laboratory equal numbers of each type of flyover, equally spaced over time, were judged. It is obvious that the laboratory and field judgements were not comparable, but the magnitude of the differences in means between high and low fear subjects was lower than expected. The importance of the difference that was found in the laboratory, however, clearly establishes that subjects with differences in feelings of high and low fear report statistically different annoyance responses. These significant differences are consistently true for all three distance groups at the 1% level of significance.

TABLE 21

Reported Mean Annoyance by Selected Subject Characteristics

Distance of Residence	FEELINGS OF FEAR: HIGH		MEDIUM		LOW	
	No.	Mean	No.	Mean	No.	Mean
Close	36	2.74	36	2.83	33	2.22
Middle	36	2.76	35	2.64	36	2.57
Distant	35	2.84	36	2.90	36	2.33
Total	107	2.77	107	2.79	105	2.38

The annoyance responses between subjects with high and medium fear were not significantly different. Only in the middle distance area was the high fear annoyance of 2.76 significantly different from the medium fear mean of 2.64 (p.05). This is due to less variability in responses of the 35 medium fear subjects which is a factor in the "t" test. In the survey interviews, the high fear subjects reported a mean TV annoyance of 3.6 compared to 2.6 for the medium fear subjects.

Figures 7 and 8 present the relationships between subject's feelings of fear and annoyance judgements of different levels of noise and types of airplane flyovers heard. The consistently higher annoyance responses by high fear subjects is clearly indicated.

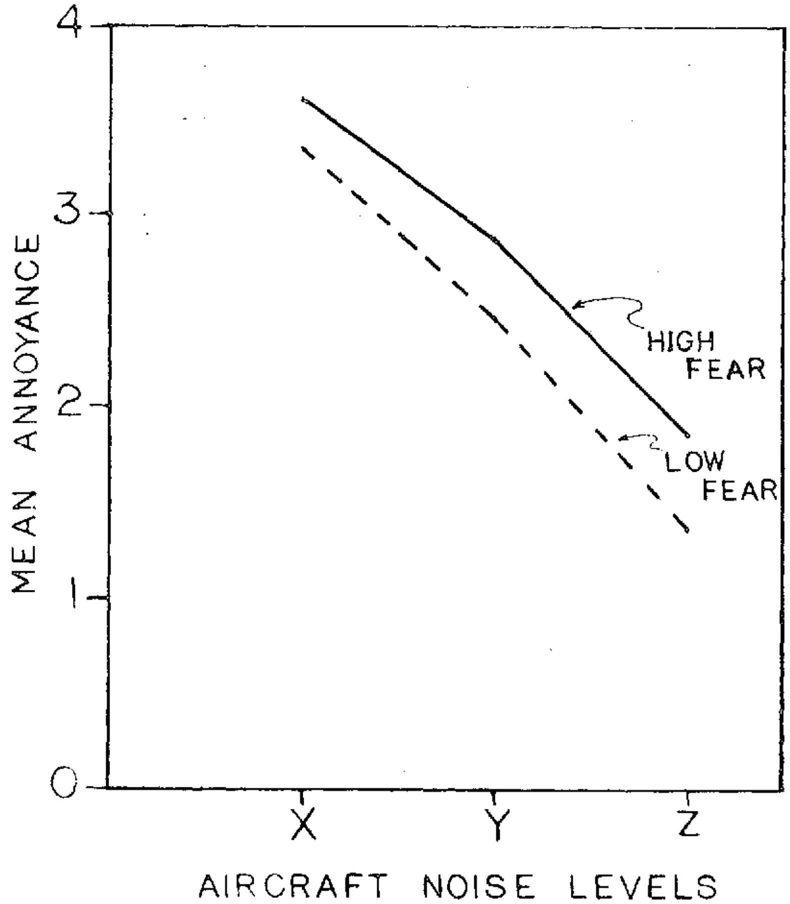
b. Location of Subject's residence

When the mean annoyance reports for each fear group are compared by residential distance groups, the following mixed results are found:

(1) No statistically significant differences are found for the high fear subjects.

(2) No significant differences are found between close and distant residents.

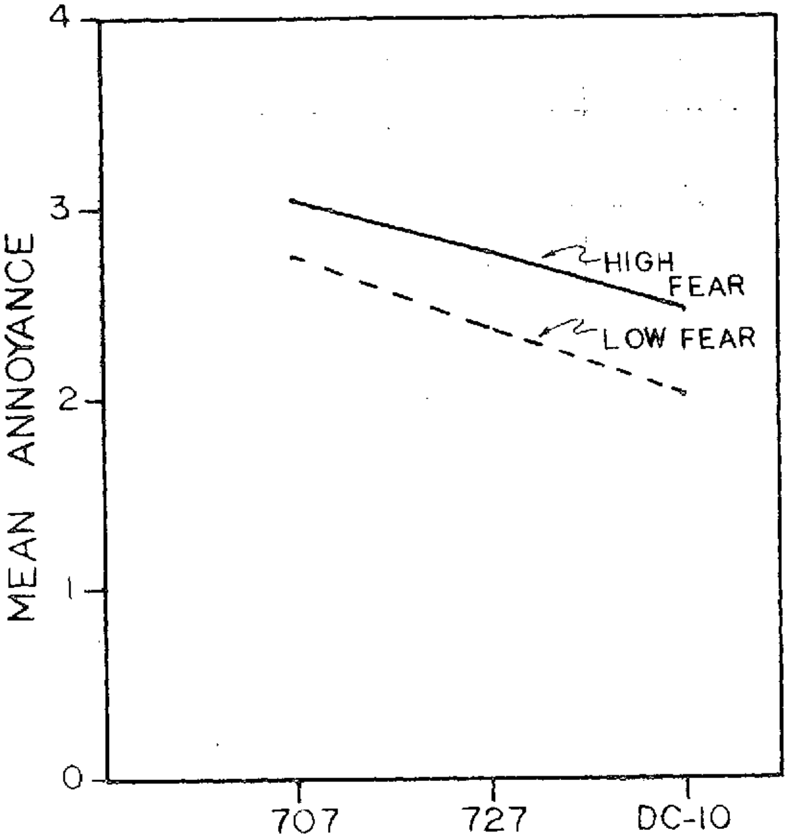
REPORTED ANNOYANCE BY FEELINGS OF FEAR FOR SELECTED AIRCRAFT NOISE LEVELS



37-a

fig. 7

REPORTED ANNOYANCE BY FEELINGS OF FEAR FOR SELECTED AIRCRAFT



37-b

fig. 8

(3) For both the low and medium fear groups, however, the mean annoyances are different for the close and middle distance groups and for the middle and distant residents. The meaning of this finding is obscured by the fact that for the medium fear group the close and distant residents reported more annoyance, while the opposite was true for the low fear group which reported more annoyance for the middle distance group.

Further comparisons of judgements of flyovers, by whether or not the level was comparable to each subject's own residential level, casts further doubt on the importance of the subject's residential environment in the annoyance judgements obtained in this experiment. For each of the 18 flyovers, three "t" tests were calculated for each fear group, or 54 tests in all. For example, for the A1X (arrival, 707, Level X), the close residents were compared to the middle and distant residents and the middle distance with the distant residents. According to our hypothesis, the close residents should judge Level X less annoying than the middle or distant residents, who normally experience lower levels of noise in their homes. Likewise, for a Level Y noise comparison, distant residents should report greater annoyance than close or middle distance subjects.

In all 54 comparisons, the high fear subjects report in only <u>one</u> test, D3Z (Departure, DC-10, Level Z), that the distant residents gave a mean annoyance of 1.63 which was significantly greater (p.05) than the close residents' annoyance of 1.28. In all other 53 comparisons by high fear subjects, no significant differences were found by residence location.

In the medium fear group, in 9 of the 54 comparisons, statistically significant differences in mean annoyance were found, of which 5 supported our hypothesis and 4 did not. The following are the 9 tests:

1. <u>Tests which support hypothesis</u>

Noise Level	Flight	Comparison of Means	
X	D2X	Distant (3.86)	middle (3.57) p.05
Y	D3Y	Distant (2.64)	middle (2.03) p.01
Z	A3Z	Distant (1.61)	middle (1.17) p.05
	D1Z	Distant (2.42)	middle (2.00) p.05
	D2Z	Distant (2.22)	middle (1.69) p.01

2. <u>Tests which did not support hypothesis</u>

Noise Level	Flight	Comparison of Means	
X	D3X	Close (3.53)	middle (3.23) p.05
Y	D3Y	Close (2.53)	middle (2.03) p.05
Z	D1Z	Close (2.44)	middle (2.00) p.05
	D2Z	Close (2.17)	middle (1.69) p.05

In the low fear group, 9 of the 54 tests proved significantly different, of which 8 supported the hypothesis and one did not. These 9 significant comparisons are:

1. Tests which support hypothesis

Noise Level	Flight	Comparison of Means	
X	D2X	Middle (3.72	close (3.15) p.01
		Distant (3.55)	close (3.15) p.05
Y	D1Y	Middle (3.31)	close (2.94) p.05
	D2Y	Middle (3.00)	close (2.52) p.05
	D3Y	Middle (2.25)	close (1.58) p.01
Z	A2Z	Middle (1.53)	close (1.15) p.05
	D1Z	Middle (2.14)	close (1.45) p.01
		Middle (2.14)	distant (1.55) p.05

2. Tests not supporting hypothesis

Y	D3Y	Middle (2.25)	distant (1.77) p.05

c. Selected other subject characteristics

Table 12 presents Spearman rank correlation coefficients (non parametric) for selected responses of the test subjects. For the size samples included in each of the 9 columns, a correlation coefficient of .31 = p.05 and .43 = p.01 level of significance.

The actual sum of TV annoyance responses for all 18 judgements made by each subject was correlated with actual survey scale scores.

1. Laboratory TV and Total Survey Annoyance vs. Fear

Only the close distance residents in each fear group have significant correlations between laboratory annoyance scores and actual fear scale scores. The distant low fear group is also close to significant; the other 5 groups are not significant. In contrast, total survey annoyance was significantly correlated to fear in most of the fear-distance groups. This underlines the major laboratory findings of less than expected differences in laboratory annoyance responses by fear groups.

2. Laboratory TV Annoyance vs. Survey TV Annoyance

The high and low fear groups generally had significant correlations between laboratory TV annoyance and survey TV annoyance. The medium fear group had very low correlations, underscoring the lack of laboratory TV differences between medium and high fear respondents.

3. Laboratory TV and Survey TV Annoyance vs. Total Survey Annoyance

In only the close low fear group are the laboratory responses significantly correlated to general aircraft annoyance scores reported on the survey. This is surprising since survey TV annoyance responses are generally highly correlated to total survey annoyance in all distance and fear groups.

TABLE 22

Spearman Rank Correlation Coefficients for Selected Responses of Test Subjects

Variable	High Fear			Medium Fear			Low Fear		
	Distance of Residence			Distance of Residence			Distance of Residence		
	Close	Middle	Distant	Close	Middle	Distant	Close	Middle	Distant
Lab annoyance vs fear	.33	-.03	.03	.39	-.13	.05	.54	.18	.29
Lab annoyance vs TV survey annoyance	.47	.44	.32	.02	-.16	.19	.61	.45	.19
Lab annoyance vs total survey annoyance	.22	.14	-.14	.24	-.27	.12	.55	.22	.20
Lab annoyance vs misfeasance	.09	-.09	.31	.19	-.13	.18	.39	-.03	.23
Total survey annoyance vs fear	.31	.59	.56	.25	.37	.20	.56	.34	.44
Total survey annoyance vs TV survey annoyance	.63	.58	.67	.78	.71	.77	.89	.77	.80
Total survey annoyance vs misfeasance	.16	.35	.36	.08	.29	.29	.41	.26	.43
Misfeasance vs fear	-.01	.15	.12	.08	.11	.33	.42	.02	.33
Misfeasance vs TV survey annoyance	.25	.20	.44	.24	.32	.08	.40	.06	.49
Fear vs survey TV	.37	.33	.59	.10	.37	.13	.58	.28	.17

4. Laboratory TV and Survey TV Annoyance vs. Misfeasance

Only the extreme psychological predispositional minorities - the high fear subjects in distant areas and the low fear close residents have positive correlations between their laboratory TV annoyance scores and feelings of misfeasance. Survey TV annoyance appears to be somewhat better correlated to misfeasance, again suggesting that laboratory subjects' annoyance judgements did not fully incorporate basic attitudes present in the real residential environments.

5. Correlation Analyses between Selected Physical Measures of Flyovers and Annoyance

Some of the criteria for the use of a parametric correlation coefficient may not have been met by our annoyance scale, since it is not precisely defined as a ratio scale. A comparison of Spearman (non parametric) and Pearson (parametric) correlation coefficients that were computed for judgements of all flyovers by each fear group shows almost identical ratios. The Pearson and Spearman correlation coefficients for dBA vs. annoyance were r = .64 vs .65 for the low fear group; r = .66 vs .68 for the medium fear and r = .67 vs .67 for the high fear group.

It appears as if subjects may be using the annoyance scale 0-4 as an approximate ratio scale, even though only the limits of the scale were defined. The similarity in test results obtained from the two correlation methods has also been found by other researchers and mathematicians and because the Pearson method is most frequently used, it was decided to rely on this method in the analyses reported in this section.

Table 23 presents the Pearson correlation coefficients for dBA, PNL, dBD_1 and SPL, by fear group. As can be seen, all four acoustic measures are about equally highly correlated with the annoyance responses. These ratios are based on the 18 separate annoyance judgements made by the 319 subjects tested, or a total of 5742 judgements. It should be noted that only jet aircraft with relatively similar sound spectra and a limited range of intensities are included in these analyses. It is possible that a wider range of noise types and levels would result in significant differences in the correlation coefficients.

TABLE 23

Correlations between Acoustic Measures of Flyovers and Annoyance Reported by Subjects

Planes	High Fear	Medium Fear	Low Fear	All Subjects
		dBA		
707	.68	.66	.63	.64
727	.64	.59	.61	.60
DC-10	.71	.71	.68	.69
All Planes	.67	.66	.64	.65
		PNL		
707	.67	.66	.65	.65
727	.63	.58	.61	.59
DC-10	.70	.69	.67	.68
All Planes	.66	.65	.64	.64
		dBD_1		
707	.68	.66	.66	.65
727	.63	.57	.60	.59
DC-10	.71	.71	.67	.69
All Planes	.68	.66	.66	.66
		SPL		
707	.60	.60	.61	.60
727	.64	.59	.61	.60
DC-10	.70	.70	.66	.68
All Planes	.67	.66	.65	.65

Table 24 presents the regression equations for each of the correlation coefficients.

TABLE 24

Regression Equations by Plane and Fear Group

A. High Fear

Plane	dBA
707	$Y' = -4.566 + .0973\,X$ - $S_y.x = .74$
727	$Y' = -3.727 + .0895\,X$ - $S_y.x = .82$
DC-10	$Y' = -5.203 + .1149\,X$ - $S_y.x = .84$
All Planes	$Y' = -3.455 + .0857\,X$ - $S_y.x = .88$

Plane	PNL
707	$Y' = -4.652 + .0848\,X$ - $S_y.x = .75$
727	$Y' = -3.836 + .0784\,X$ - $S_y.x = .83$
DC-10	$Y' = -8.048 + .1315\,X$ - $S_y.x = .85$
All Planes	$Y' = -4.245 + .0825\,X$ - $S_y.x = .84$

Plane	dBD_1
707	$Y' = -4.818 + .0921\,X$ - $S_y.x = .75$
727	$Y' = -4.152 + .0872\,X$ - $S_y.x = .83$
DC-10	$Y' = -5.409 + .1051\,X$ - $S_y.x = .84$
All Planes	$Y' = -4.059 + .0854\,X$ - $S_y.x = .82$

Plane	SPL
707	$Y' = -5.096 + .0897\,X$ - $S_y.x = .79$
727	$Y' = -5.160 + .0920\,X$ - $S_y.x = .82$
DC-10	$Y' = -6.282 + .1036\,X$ - $S_y.x = .85$
All Planes	$Y' = -5.465 + .0944\,X$ - $S_y.x = .83$

B. Medium Fear

Plane	dBA	
707	$Y' = -4.717 + .1001\ X$	$S_{y}.x = .80$
727	$Y' = -3.426 + .0857\ X$	$S_{y}.x = .90$
DC-10	$Y' = -5.383 + .1173\ X$	$S_{y}.x = .86$
All Planes	$Y' = -3.608 + .0882\ X$	$S_{y}.x = .88$
	PNL	
707	$Y' = -4.892 + .0883\ X$	$S_{y}.x = .80$
727	$Y' = -3.524 + .0750\ X$	$S_{y}.x = .91$
DC-10	$Y' = -8.150 + .1326\ X$	$S_{y}.x = .88$
All Planes	$Y' = -4.397 + .0846\ X$	$S_{y}.x = .89$
	dBD_1	
707	$Y' = -4.976 + .0947\ X$	$S_{y}.x = .80$
727	$Y' = -3.829 + .0834\ X$	$S_{y}.x = .92$
DC-10	$Y' = -5.647 + .1081\ X$	$S_{y}.x = .86$
All Planes	$Y' = -4.234 + .0879\ X$	$S_{y}.x = .87$
	SPL	
707	$Y' = -4.070 + .0902\ X$	$S_{y}.x = .85$
727	$Y' = -4.798 + .0880\ X$	$S_{y}.x = .91$
DC-10	$Y' = -6.611 + .1073\ X$	$S_{y}.x = .87$
All Planes	$Y' = -5.593 + .0962\ X$	$S_{y}.x = .88$

C. Low Fear

Plane	dBA
707	$Y' = -6.097 + .1125\ X$ - $S_{y}.x = .98$
727	$Y' = -4.845 + .0996\ X$ - $S_{y}.x = .98$
DC-10	$Y' = -6.120 + .1218\ X$ - $S_{y}.x = .97$
All Planes	$Y' = -4.584 + .0959\ X$ - $S_{y}.x = 1.00$

	PNL
707	$Y' = -6.678 + .1034\ X$ - $S_{y}.x = .97$
727	$Y' = -5.006 + .0877\ X$ - $S_{y}.x = .98$
DC-10	$Y' = -9.195 + .1404\ X$ - $S_{y}.x = .97$
All Planes	$Y' = -5.635 + .0942\ X$ - $S_{y}.x = 1.00$

	dBD_1
707	$Y' = -6.901 + .1125\ X$ - $S_{y}.x = .95$
727	$Y' = -5.373 + .0977\ X$ - $S_{y}.x = .99$
DC-10	$Y' = -6.267 + .1107\ X$ - $S_{y}.x = .98$
All Planes	$Y' = -5.356 + .0967\ X$ - $S_{y}.x = .99$

	SPL
707	$Y' = -7.278 + .1100\ X$ - $S_{y}.x = 1.00$
727	$Y' = -6.427 + .1022\ X$ - $S_{y}.x = .98$
DC-10	$Y' = -7.178 + .1090\ X$ - $S_{y}.x = .99$
All Planes	$Y' = -6.888 + .1063\ X$ - $S_{y}.x = .99$

D. All Subjects Combined

Plane	dBA
707	$Y' = -5.121 + .1032\ X \quad - \quad S_{y}.x = .87$
727	$Y' = -3.993 + .0915\ X \quad - \quad S_{y}.x = .93$
DC-10	$Y' = -5.560 + .1180\ X \quad - \quad S_{y}.x = .91$
All Planes	$Y' = -3.878 + .0899\ X \quad - \quad S_{y}.x = .92$
	PNL
707	$Y' = -5.400 + .0921\ X \quad - \quad S_{y}.x = .86$
727	$Y' = -4.117 + .0803\ X \quad - \quad S_{y}.x = .94$
DC-10	$Y' = -8.460 + .1348\ X \quad - \quad S_{y}.x = .93$
All Planes	$Y' = -4.753 + .0870\ X \quad - \quad S_{y}.x = .93$
	dBD_1
707	$Y' = -5.557 + .0997\ X \quad - \quad S_{y}.x = .86$
727	$Y' = -4.446 + .0894\ X \quad - \quad S_{y}.x = .94$
DC-10	$Y' = -5.771 + .1079\ X \quad - \quad S_{y}.x = .92$
All Planes	$Y' = -4.545 + .0899\ X \quad - \quad S_{y}.x = .92$
	SPL
707	$Y' = -5.805 + .0966\ X \quad - \quad S_{y}.x = .90$
727	$Y' = -5.455 + .0940\ X \quad - \quad S_{y}.x = .93$
DC-10	$Y' = -6.687 + .1066\ X \quad - \quad S_{y}.x = .93$
All Planes	$Y' = -5.976 + .0989\ X \quad - \quad S_{y}.x = .92$

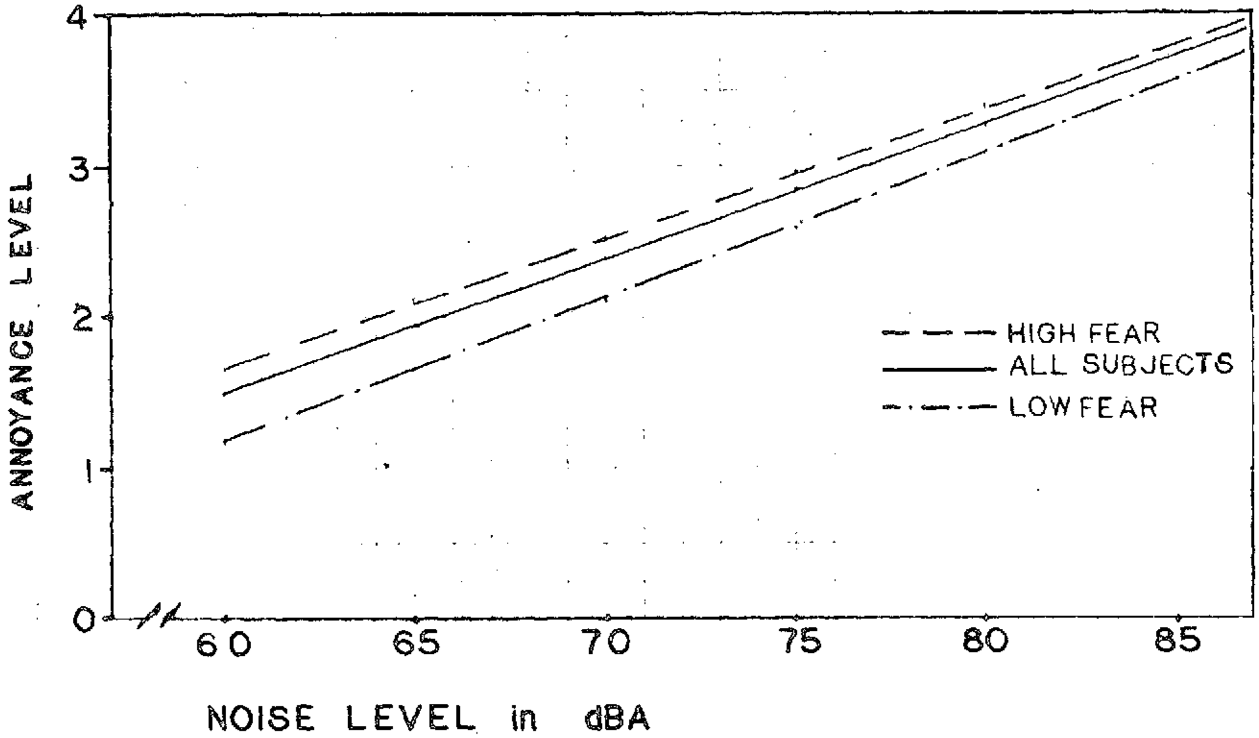
In addition, when all fear groups are combined, the correlation coefficient between dBA for all planes and annoyance is r = .65. The regression equation for this relationship is: $Y' = -3.878+.0899X$. Figure 9 presents this overall relationship between dBA and reported annoyance, and Table 25 presents some of the computed values for different selected dBA levels. As can be seen, an increase of 10 dBA produces an average increase of 0.9 on the annoyance scale.

TABLE 25

Computed Average Values of Annoyance from Regression Equations of dBA and Annoyances

	Computed Average Annoyance			
	Feelings of Fear			All
dBA	High	Medium	Low	Subjects
80	3.40	3.45	3.09	3.31
75	2.97	3.01	2.61	2.86
70	2.54	2.57	2.13	2.42
65	2.12	2.13	1.65	1.97
60	1.69	1.68	1.17	1.52

INDOOR NOISE LEVEL IN RELATION TO MEAN ANNOYANCE RATINGS



47-a

fig.9

D. Judgements of Acceptability

1. Introduction

Especially in an urban society, most people are usually exposed to all sorts of stresses and irritations. It becomes a way of life and a certain amount of stress and unwanted discomforts are expected and accepted as tolerable. The key question is how much is tolerable and acceptable, especially in the case of aircraft noise exposure.

The annoyance scale that is used in this study was previously used by other researchers and had the advantages of comparability with the findings of their studies. The 5 point annoyance scale, 0-4, has certain limitations, however, in that while the lower limit is clearly stated, viz. "0" means no annoyance at all, the rest of the scale is not clearly defined. What is the meaning of an annoyance of "1"; "2" is greater than "1", but how much greater? Are 4 positive numbers on an annoyance scale enough to measure accurately the range in intensities of annoyance with the variations in noise stimuli to which people are exposed? While no effort was made in this experiment to change the annoyance scale itself, an attempt was made to learn more about the meaning of the scale in terms of "acceptability". It was our hypothesis that most people do not expect a noise-free environment, and that they would accept some level of annoyance as acceptable. To test this hypothesis, as the instructions to the subjects stated, after each annoyance judgement, the subject also was asked to indicate the meaning of the annoyance number. He was asked, "After recording your annoyance response, I want you also to place a check in the "Yes" or "No" box in the right-hand column labelled "acceptable" to indicate whether or not you believe the airplane flyovers you have just rated would be acceptable to you; by this I mean whether or not you feel you could learn to live with them if you heard them regularly in your own home while watching TV." A simple dichotomous response was requested rather than a numerical scale, because, as a first effort, there was concern about overloading the subjects and confusing them with too many required detailed judgements.

2. Overall Relationships between judgements of acceptability and residence of subjects

As Table 26 indicates, subjects appear to have consistent and clear cut ideas about what levels of annoyance are acceptable. Only a few variations are noted among residents of different areas. Clearly only about 1% feel that a "4" rating of annoyance is acceptable, and only about 2% feel that a "1" rating is not acceptable. In fact, reflecting the general pragmatism of our hypothesis, about 20% feel that an annoyance score of "2" is still acceptable. But, perhaps as an artifact of our 4 point scale, a score of "3" is acceptable to only 17% of the subjects. Clearly, the dividing line in our 5 point scale is at "3". A score of "3" or "4" is generally not acceptable. This definition gives new meaning to the mean annoyance scores discussed in previous sections.

TABLE 26

TOTAL

Reports of Acceptability by Annoyance and Distance Residence

A. All Subjects

DISTANCE FROM AIRPORT

	TOTAL N=319			CLOSE N=105			MIDDLE N=107			DISTANT N=107		
Annoyance Score	Total Judgements	Acceptable No.	Acceptable %	Total Judgements	Acceptable No.	Acceptable %	Total Judgements	Acceptable No.	Acceptable %	Total Judgements	Acceptable No.	Acceptable %
4	1825	19	1.0	590	7	1.2	592	4	0.7	643	8	1.2
3	1497	252	16.8	473	80	16.9	525	56	10.7	499	116	23.2
2	1354	1112	82.1	445	359	80.7	465	372	80.0	444	381	85.8
1	718	700	97.5	263	257	97.7	228	221	96.9	227	222	97.8
0	348	348	100.0	119	119	100.0	116	116	100.0	113	113	100.0
Total	5742	2431	42.3	1890	822	43.5	1926	769	39.9	1926	840	43.6

3. Relationships between judgements of acceptability, annoyance and feelings of fear

Table 27 provides some additional insights into the differential responses of subjects with feelings of high and low fear. Subjects with feelings of low fear reported somewhat less high annoyance, but more often said the high annoyance was acceptable. While high fear subjects gave 646 code "4" annoyance scores (34% of total), and 272 code "1" or "0" scores (14% of total), low fear subjects gave 486 code "4" scores (26% of total) and 512 code "1" or "0" scores (27% of total). With respect to acceptability, however, only 0.3% of the high fear subjects said code "4" was acceptable, 14% said code "3" was acceptable and 97% said codes "1" or "0" were acceptable. In contrast, 3% of the low fear subjects said code "4" was acceptable, 24% said code "3" was acceptable and 99.4% said code "1" or "0" was acceptable. Similarly, 90% of the low fear subjects said an annoyance score of "2" was acceptable compared to only 76% of the high fear subjects. Perhaps, the instruction referring them back to their home environments, as a frame of reference for the acceptability judgement, accounts for this greater differentation in response between the fear groups.

4. Relationships between judgements of acceptability, dBA level and annoyance

Table 28 presents the mean annoyance and percent acceptable judgements by fear and distance groups of subjects, rank ordered by dBA level of flyover; the table further shows that the differences in annoyance scores are smaller than the acceptability judgements when high and low fear groups are compared. For example, 24% of the atypical low fear close residents accept an 87 dBA noise, compared to only 3% of the high fear close residents. Similarly, 42% of the low fear close residents say they accept an 80 dBA noise compared to only 17% of the high fear close residents. From an examination of judgements recorded on this table, it appears as if a dBA level of about 70 would be acceptable to a majority of all subjects. Further studies, however, should be made with more precise acceptability scales and more realistic combinations of aircraft and rates of flyovers per hour to determine what proportions of different kinds of populations will accept what levels of aircraft noise exposure.

TABLE 27

Reports of Acceptability by Annoyance and Fear Groups

A. SUMMARY

	ALL SUBJECTS N=319			High Fear N=107			Medium Fear N=107			Low Fear N=105		
Annoyance Score	Total Judgements	Acceptable No.	%	Total Judgements	Acceptable No.	%	Total Judgements	Acceptable No.	%	Total Judgements	Acceptable No.	%
4	1825	19	1.0	646	2	0.3	693	2	0.3	486	15	3.1
3	1497	252	16.8	520	74	14.2	579	70	13.5	458	108	23.6
2	1354	1112	82.1	488	371	76.0	432	351	81.3	434	390	89.9
1	718	700	97.5	214	206	96.3	189	180	95.2	315	314	99.7
0	348	348	100.0	58	58	100.0	93	93	100.0	197	197	100.0
Total	5742	2431	42.3	1926	711	36.9	1926	696	36.1	1890	1024	54.2

B. HIGH FEAR

	TOTAL N=107			CLOSE N=36			MIDDLE N=36			DISTANT N=35		
Annoyance Score	Total Judgements	Acceptable No.	%	Total Judgements	Acceptable No.	%	Total Judgements	Acceptable No.	%	Total Judgements	Acceptable No.	%
4	646	2	0.3	216	0	0	208	1	0.5	222	1	0.5
3	520	74	14.2	167	15	9.0	171	15	8.8	182	44	24.2
2	488	371	76.0	169	126	74.6	177	138	78.0	142	107	75.4
1	214	206	96.3	75	70	93.3	68	67	98.5	71	69	97.2
0	58	58	100.0	21	21	100.0	24	24	100.0	13	13	100.0
Total	1926	711	36.9	648	232	35.8	648	245	37.8	630	234	37.1

C. MEDIUM FEAR

Annoyance Score	TOTAL N=107 Total Judgements	Acceptable No.	%	CLOSE N=36 Total Judgements	Acceptable No.	%	MIDDLE N=35 Total Judgements	Acceptable No.	%	DISTANT N=36 Total Judgements	Acceptable No.	%
4	693	2	0.3	251	0	0	190	2	1.1	252	0	0
3	519	70	13.5	165	29	17.6	174	13	7.5	180	28	15.6
2	432	351	81.3	133	103	77.4	158	122	77.2	141	126	89.4
1	189	180	95.2	69	68	98.6	68	62	91.2	52	50	96.2
0	93	93	100.0	30	30	100.0	40	40	100.0	23	23	100.0
Total	1926	696	36.1	648	230	35.5	630	239	37.9	648	227	35.0

D. LOW FEAR

Annoyance Score	TOTAL N=105 Total Judgements	Acceptable No.	%	CLOSE N=33 Total Judgements	Acceptable No.	%	MIDDLE N=36 Total Judgements	Acceptable No.	%	DISTANT N=36 Total Judgements	Acceptable No.	%
4	486	15	3.1	123	7	5.7	194	1	0.5	169	7	4.1
3	458	108	23.6	141	36	25.5	180	28	15.6	137	44	32.1
2	434	390	89.9	143	130	90.9	130	112	86.2	161	148	91.9
1	315	314	99.7	119	119	100.0	92	92	100.0	104	103	99.0
0	197	197	100.0	68	68	100.0	52	52	100.0	77	77	100.0
Total	1890	1024	54.2	594	360	60.6	648	285	44.0	648	379	58.5

TABLE 28

Mean Annoyance and Per Cent Acceptability by dBA and Fear Group

Fly-over Code	dBA	HIGH FEAR Close X̄	HIGH FEAR Close % Acc.	HIGH FEAR Middle X̄	HIGH FEAR Middle % Acc.	HIGH FEAR Distant X̄	HIGH FEAR Distant % Acc.	MEDIUM FEAR Close X̄	MEDIUM FEAR Close % Acc.	MEDIUM FEAR Middle X̄	MEDIUM FEAR Middle % Acc.	MEDIUM FEAR Distant X̄	MEDIUM FEAR Distant % Acc.	LOW FEAR Close X̄	LOW FEAR Close % Acc.	LOW FEAR Middle X̄	LOW FEAR Middle % Acc.	LOW FEAR Distant X̄	LOW FEAR Distant % Acc.
D1X	87	3.78	2.8	3.86	2.8	3.94	0	3.89	2.8	3.89	0	3.94	0	3.55	24.2	3.78	5.6	3.75	8.3
A1X	86	3.69	2.8	3.67	5.6	3.77	8.6	3.72	5.6	3.80	5.7	3.89	0	3.42	24.2	3.64	2.8	3.44	22.2
D2X	83	3.78	0	3.72	2.8	3.86	2.9	3.83	8.3	3.57	8.5	3.86	0	3.15	27.3	3.72	11.1	3.55	13.9
A1Y	80	3.22	16.7	3.17	22.2	3.29	14.3	3.36	16.7	3.34	8.5	3.53	8.3	2.79	42.4	3.14	22.2	2.83	36.1
D1Y	79	3.28	13.9	3.25	13.9	3.46	2.9	3.39	16.7	3.26	8.5	3.47	11.1	2.94	39.4	3.31	13.9	3.00	36.1
A2X	78	3.14	19.4	3.08	27.8	3.37	14.3	3.19	19.4	3.11	20.0	3.28	19.4	2.73	45.5	3.03	38.9	2.86	47.2
A3X	76	3.50	8.3	3.50	8.3	3.60	2.9	3.67	11.1	3.57	8.5	3.61	5.6	3.24	30.3	3.47	13.9	3.27	16.7
D2Y	76	3.03	27.8	3.08	13.9	3.34	17.1	3.17	16.7	3.03	14.3	3.31	13.9	2.52	45.5	3.00	30.6	2.75	50.0
D3X	76	3.47	5.6	3.53	8.3	3.46	14.3	3.53	11.1	3.23	8.5	3.47	11.1	2.91	39.4	3.22	25.0	3.05	33.3
A2Y	72	2.61	36.1	2.83	36.1	2.51	48.6	2.67	44.4	2.49	42.9	2.89	36.1	2.21	54.5	2.39	47.2	2.38	58.3
D1Z	71	2.28	50.0	2.22	61.1	2.34	62.8	2.44	55.6	2.00	62.9	2.42	55.6	1.45	84.8	2.14	66.7	1.55	94.4
A1Z	68	1.97	55.6	2.00	55.6	2.06	57.1	2.17	55.6	1.97	65.7	2.03	69.4	1.33	90.9	1.69	66.7	1.38	91.7
D3Y	67	2.58	36.1	2.25	55.6	2.43	51.4	2.53	44.4	2.03	54.3	2.64	52.3	1.58	84.8	2.25	55.6	1.77	88.9
D2Z	66	1.94	75.0	1.92	72.2	2.14	65.7	2.17	58.3	1.69	80.0	2.22	50.0	1.27	93.9	1.67	77.8	1.58	91.7
A3Y	66	2.39	55.6	2.47	44.4	2.51	57.1	2.56	41.7	2.46	37.1	2.58	58.3	1.85	72.7	2.08	63.9	1.77	75.0
A2Z	60	1.94	66.7	1.64	77.8	1.83	77.1	1.86	69.4	1.80	74.3	1.97	61.1	1.15	93.9	1.53	75.0	1.16	94.4
A3Z	58	1.50	80.1	1.44	88.9	1.57	88.6	1.47	83.3	1.17	91.4	1.61	86.1	1.09	100.0	1.17	88.9	1.00	97.2
D3Z	58	1.28	91.7	1.44	83.3	1.63	82.9	1.33	77.8	1.20	91.4	1.56	91.7	.82	97.0	1.11	86.1	.86	97.2

BIBLIOGRAPHY

1/ A New Field-Laboratory Methodology for Assessing Human Response to Noise - NASA Report CR-2221, Washington, D.C. - March 1973

2/ Annoyance Judgements of Aircraft with and without Acoustically Treated Nacelles - NASA Report CR-2261, Washington, D.C. - August 1973

3/ TRACOR, Community Reaction to Aircraft Noise, Vol. 1 & 2, TRACOR Document T-70-AU-7454-U, Austin, Texas, September 4, 1970

4/ McKennell, A.C., Aircraft Noise Annoyance Around London Airport, Central Office of Information, London 1963

5/ Borsky, Paul N., Community Aspects of Aircraft Noise - National Advisory Committee for Aeronautics, 1952

6/ Borsky, Paul N., Community Reactions to Air Force Noise, W.A.D.D., Technical Report 60-689, March 1961

7/ Borsky, Paul N. - Leonard, Skipton, A Causal Model for Relating Noise Exposure, Psycho-social Variables and Aircraft Noise Annoyance, International Congress on Noise as a Public Health Problem, Dubrovnik, Yugoslavia, May 13-18, 1973

8/ Nunnally, J., Psychometric Theory, New York, N.Y. McGraw-Hill 1967

APPENDIX A

Definitions of Scales Used in Study

1. Fear - This is defined as a belief that aircraft flying overhead poses a threat to one's safety. The noise connotes an approaching plane and fear is the belief that it may crash into the place where the person is located. The Likert summated ratings technique 8/ is used to measure the intensity of a human response. In this process, the separate scores for response categories of a set of questions, all representing a particular dimension or attribute, are summed to form a composite rating. By using a set of questions rather than a single question, greater reliability in the measurement of the dimension or attribute is usually obtained.

Question 5B, Item 8 - Respondents were asked how much they disliked twelve aspects that apply to living conditions in their community. Each respondent referred to an "opinion thermometer" on which "0" corresponded to "none" and "4" corresponded to "Very Much". In Question 5B, Item 8, respondents rated the dislike of ....

Unsafe low-flying airplanes.....

Question 22D. How much does the noise from (item) startle or frighten you? The question was asked for various (5) noise sources. The response to airplane noise was used in the fear scale. Again the response choices ranged from "0" (not at all) to "4" (very much).

Question 27. When you see or hear airplanes fly by, how often do you feel they are flying too low for the safety of the residents around here? Response choices were "0" (not at all) to "4" (very often).

Question 28. And how often do you feel there is some danger that they might crash nearby? Response choices were "0" (not at all) to "4" (very often).

Each respondent's fear score was obtained by summing the responses to each of the four fear items. Since possible responses for each item were 0, 1, 2, 3, 4, the range of fear scores was 0-16.

Table 1 shows the distribution of respondents by fear score and residential area. The cutting points of the scale, into three groups were determined by two factors: a) a sufficient number of eligible subjects (36) were required for each fear and distance group, allowing for refusals and other reasons for not being available. b) The low fear group should represent as little fear as possible.

Table 2 shows the relation between fear and annoyance for each fear scale score and group.

2. Misfeasance - This is defined as the respondent's belief that various agents connected with the propogation of aircraft noise are capable of reducing the noise, but for some insignificant reasons are not doing so.

A six item scale was used with a coefficient of reliability (alpha) of .76. Each item had a response range of 0-4, so the total scores ranged from 0-24. On Question 36, respondents were asked, "Would you say any of these people are in a position to do anything about the aircraft noise around here?

a. The people who run the airlines.....
b. The airport officials.....
c. The other government officials.....
d. The pilots.....
e. The designers and makers of airplanes.....
f. The community leaders.....

For each "yes" response, a sub-question was asked, "How much do you feel they are actually doing to reduce the noise?, with 0 meaning nothing at all and 4 meaning very much, In calculating the misfeasance score, the order of response is reversed, i.e. 0=4, very misfeasant; 4=0, not misfeasant at all.

3. Annoyance - An 11 item scale was used with a coefficient alpha of .91.

Columbia University Q.24 was as follows:

"Can you tell me if the noise from airplanes ever (ask each item below)(Do they ever?.....)

1. Interfere with your listening to radio or TV?.....
2. Make the TV picture flicker?.....
3. Startle or frighten anyone in your family?.....
4. Disturb your family's sleep?
5. Make your house rattle or shake?.....
6. Interfere with family's rest or relaxation?.....
7. Interfere with conversation?.....
8. Make you keep your windows shut during the day?.....
9. Make you keep your windows shut at night?...
10. Make you feel tense and edgy?.....
11. Give you a headache?.....

For each "yes", a subquestion was asked, "And how disturbed or annoyed does this make you feel? (0 = none, 4 = very much).

TABLE A-1

Reported Number Respondents by Fear and Distance of Resident

	Fear Score	Total	Close	Middle	Distant
			DISTANCE		
A. Low Fear (0-1)					
	0	234	47	68	119
	1	109	23	43	43
	Total	343	70	111	162
	$\bar{X}$ fear	.32	.33	.39	.27
	S	.47	.47	.49	.44
B. Medium Fear (2-7)	2	101	26	34	41
	3	93	31	31	31
	4	60	15	25	20
	5	46	18	17	11
	6	49	19	17	13
	7	33	17	5	11
	Total	382	126	129	127
	$\bar{X}$ fear	3.86	4.19	3.74	3.66
	S	1.64	1.74	1.50	1.65
C. High Fear (8-16)	8	45	16	17	12
	9	49	21	19	9
	10	37	19	12	6
	11	36	19	11	6
	12	46	27	14	5
	13	28	14	11	3
	14	40	20	14	6
	15	20	14	6	0
	16	33	20	9	4
	Total	334	170	113	51
	$\bar{X}$	11.59	11.95	11.41	10.78
	S	2.56	2.53	2.55	2.52

TABLE A-2

Annoyance Scale Scores by Fear and Distance of Residence

			Total		Close		Middle		Distant	
		Fear Score	$\bar{X}$	S_T	$\bar{X}$	S_C	$\bar{X}$	S_M	$\bar{X}$	S_D
A.	Low	0	4.5	5.8	5.9	8.0	4.6	5.6	4.0	4.8
	Fear	1	7.3	6.2	8.6	7.2	7.2	6.1	6.7	5.8
		Total	5.41	6.1	6.7	7.8	5.9	5.9	4.7	5.2
B.	Medium	2	9.7	9.1	13.9	9.8	7.3	6.1	9.1	9.8
	Fear	3	9.9	7.7	11.6	9.3	10.2	8.1	7.8	4.9
		4	13.3	8.2	17.2	7.9	11.6	8.4	12.4	7.4
		5	12.0	7.4	12.1	6.9	13.5	8.8	9.4	5.6
		6	15.7	10.3	19.3	9.9	15.1	11.9	11.3	6.6
		7	17.6	10.7	20.8	11.4	18.4	6.7	12.3	9.6
		Total	12.03	9.1	15.2	9.8	11.1	8.7	9.8	7.8
C.	High	8	19.0	9.4	21.9	8.6	16.3	8.9	18.9	10.8
	Fear	9	20.5	11.2	22.7	10.3	21.5	12.4	13.2	8.1
		10	20.5	9.2	21.8	7.7	23.3	9.5	11.0	8.2
		11	24.1	9.6	24.2	9.5	22.1	11.1	27.3	7.7
		12	24.3	10.8	25.2	10.5	26.1	11.2	14.4	7.2
		13	30.7	9.0	35.2	6.4	26.4	9.9	25.3	6.1
		14	26.5	10.5	29.7	11.0	25.0	9.7	19.3	7.2
		15	32.7	7.5	33.4	8.7	31.0	3.6	--	--
		16	32.6	8.3	35.4	8.5	30.8	5.1	22.8	4.6
		Total	24.7	10.8	27.3	10.5	23.7	10.5	18.3	9.4
Grand Total			13.9	11.8	19.2	12.7	13.4	11.4	8.7	8.4

APPENDIX B

A. INTRODUCTION

This section will describe the procedures and equipment used in the development of the airplane sound tapes used in the tests.

Satisfactory recordings cannot be made in the vicinity of Kennedy Airport because it is generally impossible to find locations with low enough ambient noise levels that they will not be intrusive when the tapes are played back in the test chamber. In most of the suitable locations, vehicular noise levels are high. Others are in densely populated residential neighborhoods with background noises of children, lawn mowers, automobiles, etc. In one sparsely populated location, urban transit trains come by regularly to interfere with recordings. It was, therefore, necessary to find an alternate airport location with the proper type of airplane traffic and low background noise levels.

Fortunately, suitable recording sites and airplane traffic mix exist at Dulles Airport which serves the Washington, DC area. During July and August of 1973, trips were made with a recording van to Dulles Airport, and recordings were made of the airplane flyovers which were needed for the laboratory experiment.

B. SET-UP OF RECORDING VAN AND RECORDING PROCEDURE

The recording van was a Ford Econoline. The interior was modified to permit installation of the tape recorders and the auxiliary equipment necessary for sound level measurement, noise elimination, communication with the control tower, and the 110 volt 60 cycle power source.

The circuit set-up for recording in the van is shown in the black diagram of Figure B1. Duplicate single-channel recordings were made of each flight - a recording on one track with the microphone connected directly into the tape recorder, and a recording on a second track using the Burwen noise eliminator. When these recordings were processed in the laboratory, the better of the two recordings was used, the choice generally depending on the required dynamic range as determined by the maximum recorded sound level when the airplane was approximately directly overhead. The third channel of the four-track tape was used for voice commentary containing flight identification, maximum level indicated on the sound level meter, etc. The output of the radio receiver pickup from the flight control tower was recorded on the fourth track as an additional check on identification of each recorded flight, and this information was cross-checked against the flight log provided by the flight controllers.

A map showing the runways at Dulles Airport and the recording sites is shown in Figure B2. These sites were selected on the basis of accessibility, background noise level, and flight operations schedule.

C. PROCESSING OF RECORDINGS

It should be noted that it was not possible to find all recording sites at the exact locations required by the study design. Because of practical considerations such as ambient noise level, accessibility, etc., it was necessary to make some slight compromises in the distances. Furthermore, the pilots rarely fly exactly over the specified flight path; therefore, even if the recording site were at the ideal location, it would be necessary in most cases to make corrections for altitude, etc.

The recordings which were made at these locations were later processed to reproduce the flights as they would be at the exact distances, the true flight paths, and nominal levels. To modify a recording of an airplane taken at one of the distances in this experiment to another one, the following acoustic parameters must be modified:

1. Maximum sould level during flyover
2. Attenuation of sound by the atmosphere
3. Duration of the sound from its initial emergence above the ambient noise level until its eventual disappearance

The necessary corrections were made manually during rerecording of the existing flight by use of variable attenuators and variable frequency response equalizers. The degree of each of the various corrections was determined according to the criteria given in the following sources:

1. Maximum sound level. Information provided by FAA which gave the maximum sound levels of the different types of airplanes when operated under various flight conditions.

2. Attenuation characteristics of the atmosphere. The SAE Atmosphere Absorption coefficients (Document #ARP-866) were used. A curve showing the atmosphere attenuation is given in Figure B3.

3. Duration of the flyover. The correction of sound levels during the flyover, and the amount of any necessary duration correction, can be computed from the information given in FAA Report No. FAA-EQ-73-3.

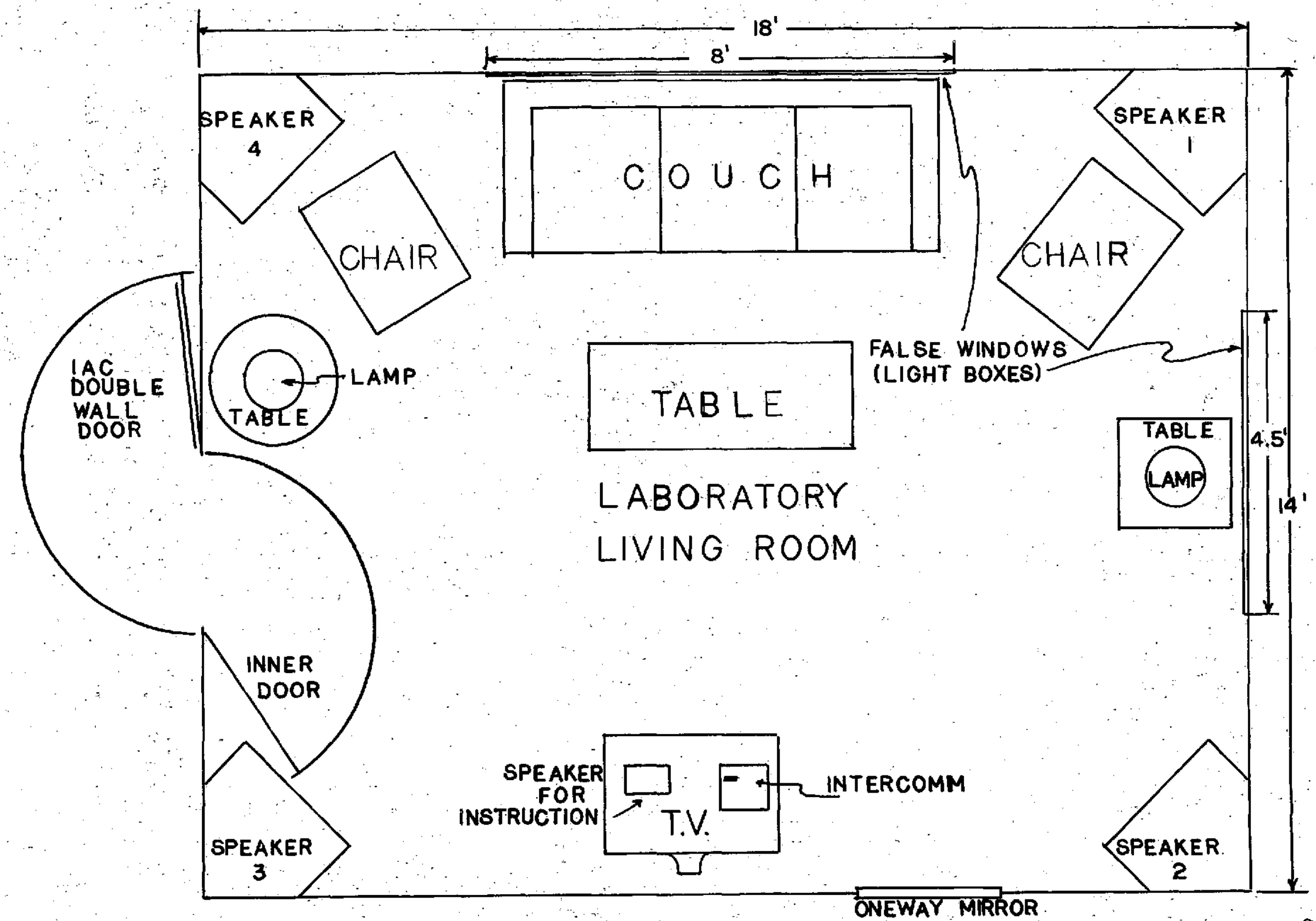
By use of the information provided in (1) above, which gives the relationships between sound level and altitude, the measured sound level of a flight was used to estimate the actual altitude of the airplane. The difference between the actual altitude and the required altitude then gives the degree of correction required to produce the flight tapes which are to be used.

This initial processing provided monaural tapes of all the flights to be used in the experiment. The additional required processing of the recordings was:

1. Addition of motion quadraphonically to the monophonic tapes.
2. Sound level and frequency spectrum correction to produce the proper indoor sound from outdoor recordings. SAE proposal AIR 1087 gave the data necessary for this correction. The attenuation characteristic for a cold climate house, with windows open is shown in Figure B4.

The acoustic and temporal characteristics of the flights which were heard by the subjects are given in Figures B5 to B14. Figure B5 shows the one-third octave spectra at maximum sound level of the approach at the three distances, and Figure B6 shows the spectra of the 707 departures at the same distances. Figures B7 and B8 are the spectra of the 727, and Figures B9 and B10, the spectra of the DC-10. The time histories for the 727 and DC-10 at the close distances are shown in Figures B11 through B14.

From the master tapes, the flights were rerecorded in the appropriate sequences to produce the final subject tapes. During the course of the tests, the playback levels were tested before each series of tests to assure proper operation of the entire system.


18'
8'
SPEAKER 4
COUCH
SPEAKER 1
CHAIR
CHAIR
IAC DOUBLE WALL DOOR
LAMP
TABLE
FALSE WINDOWS (LIGHT BOXES)
TABLE
TABLE
LAMP
4.5'
14'
LABORATORY LIVING ROOM
INNER DOOR
SPEAKER FOR INSTRUCTION
T.V.
INTERCOMM
SPEAKER 3
SPEAKER 2
ONEWAY MIRROR
fig.1a

19

SCHEMATIC OF SOUND SYSTEM

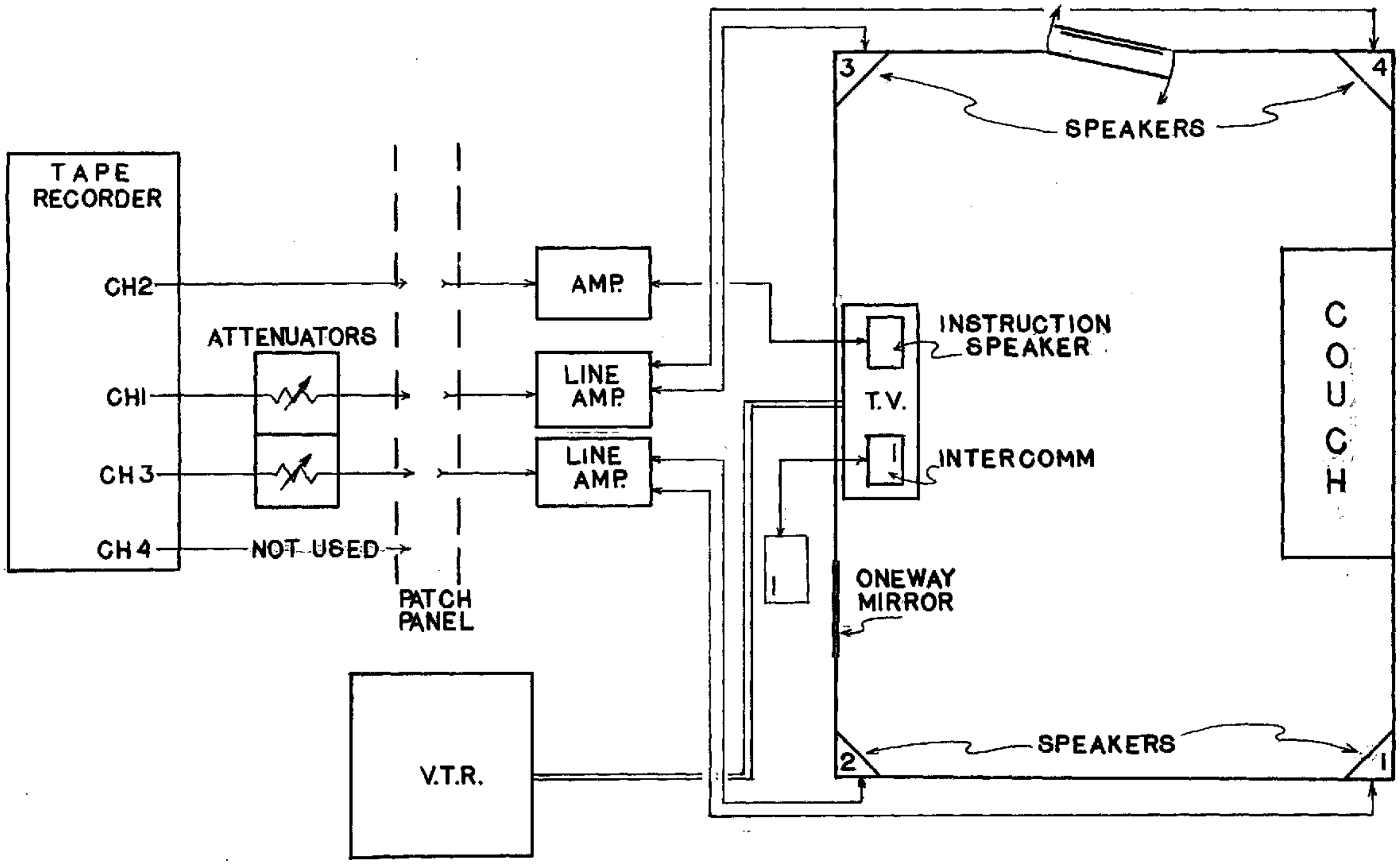


fig. 1b

INDOOR NOISE SPECTRA OF 707, 727, DC-10 AT MAXIMUM dBA LEVEL ON APPROACH -1 MILE FROM TOUCHDOWN

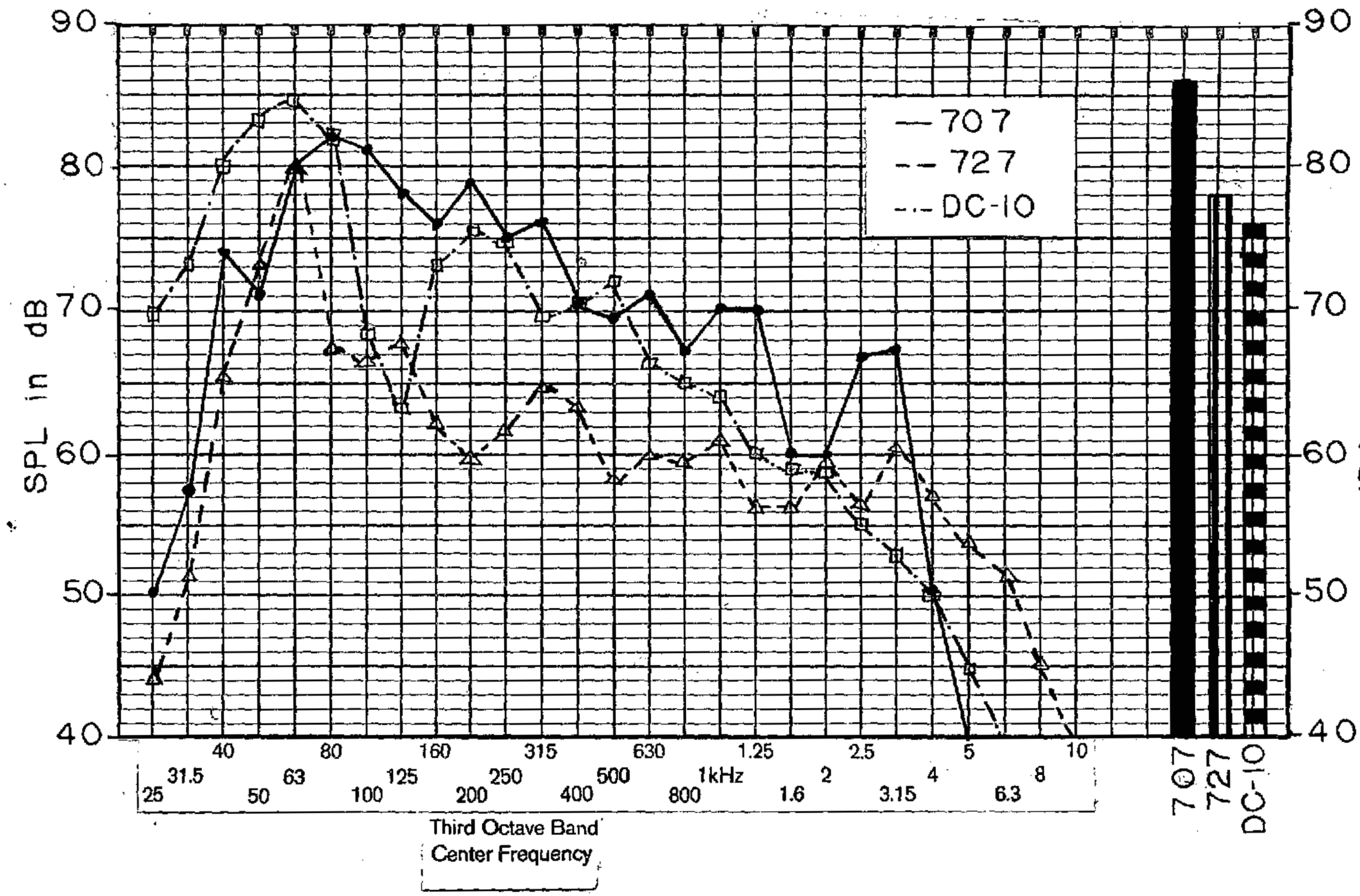
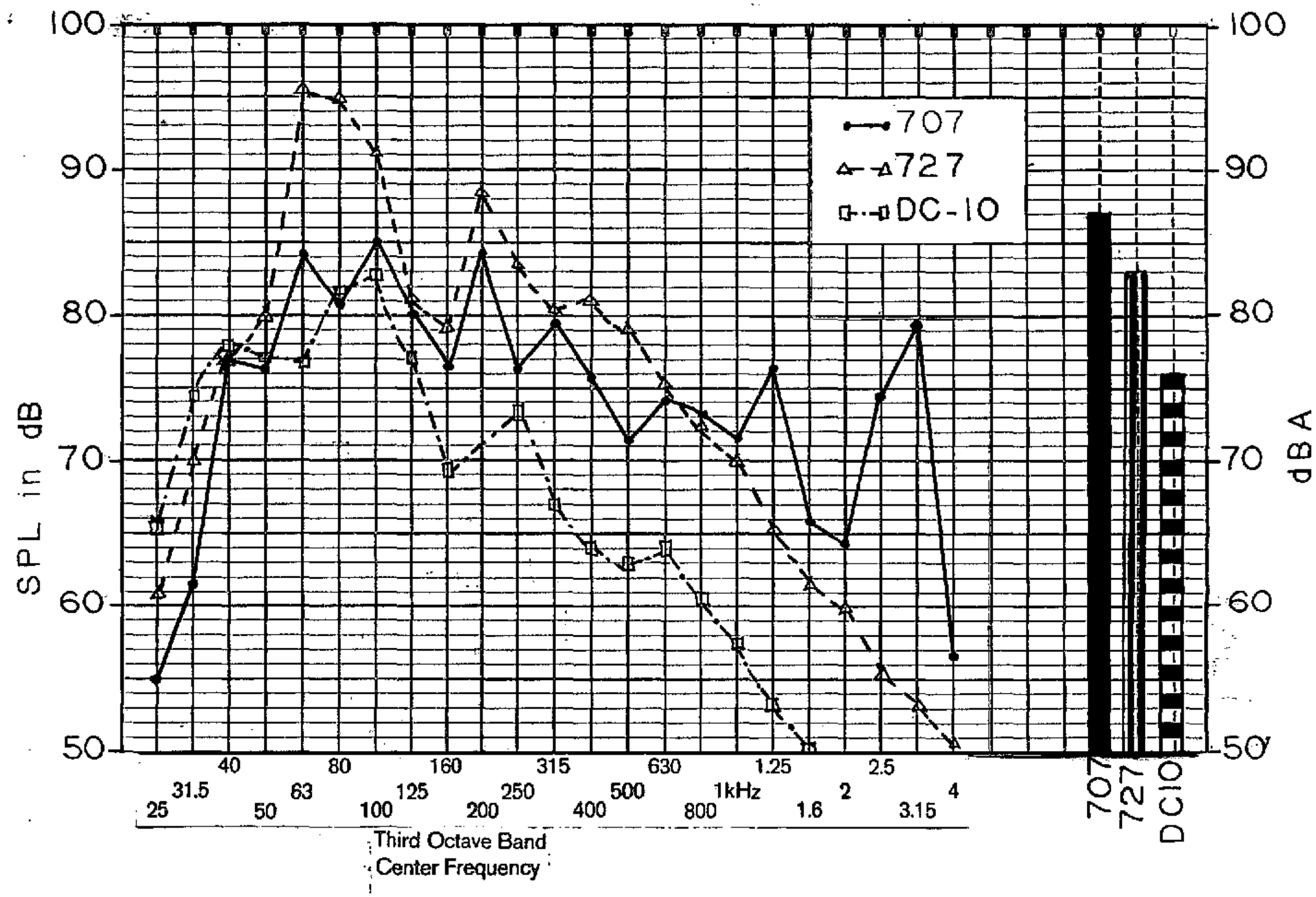


fig.3

INDOOR NOISE SPECTRA OF 707, 727, DC-10 AT MAXIMUM dBA LEVEL ON DEPARTURE - 4 MILES FROM START OF ROLL



49

fig.4

INDOOR dBA LEVELS OF 707
1.-MILE FROM TOUCHDOWN

TIME HISTORY

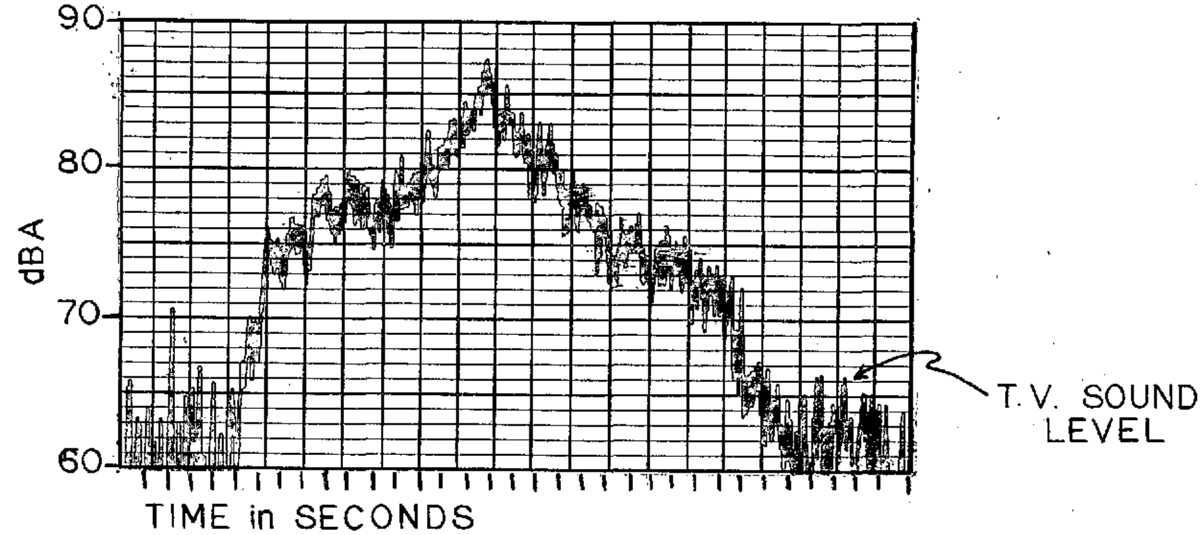


fig. 5

INDOOR dBA LEVELS OF 707
4-MILES FROM START OF ROLL

TIME HISTORY

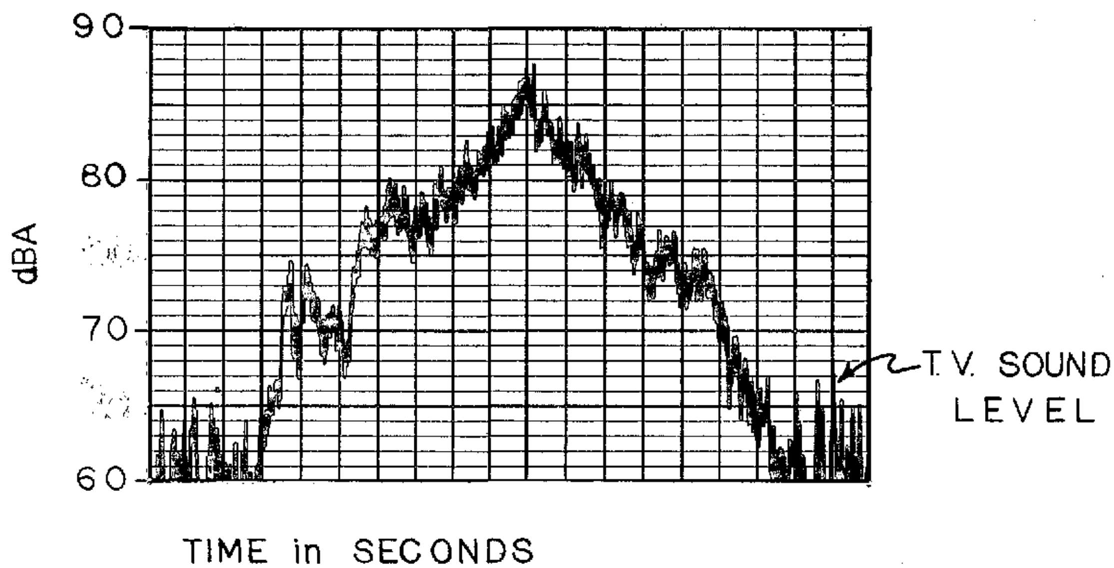


fig.6

REPORTED ANNOYANCE BY FEELINGS OF FEAR FOR SELECTED AIRCRAFT NOISE LEVELS

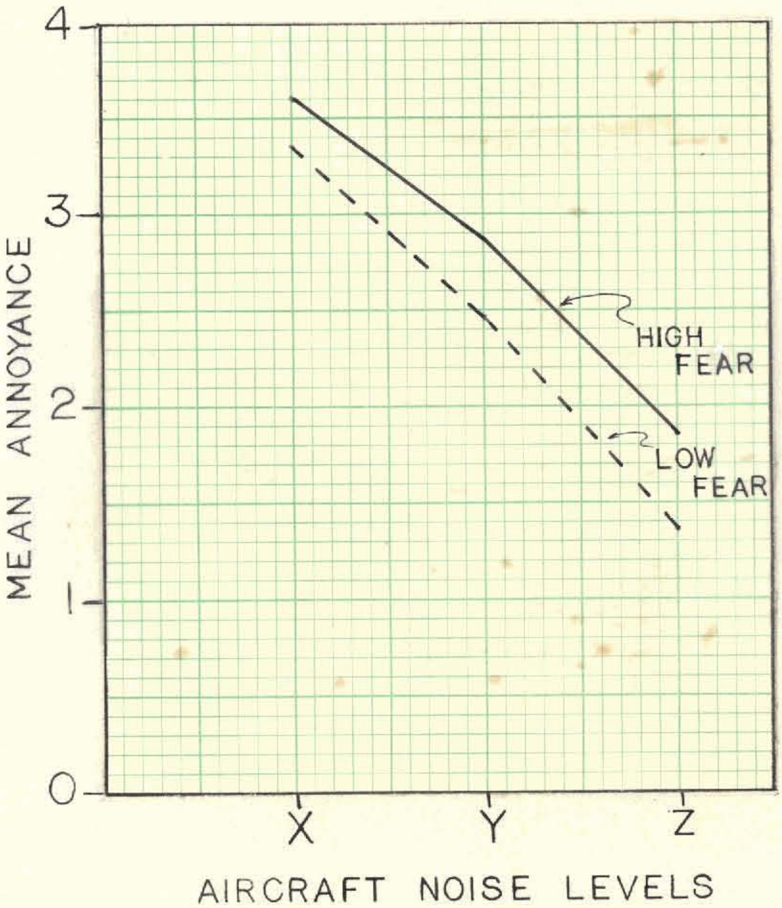


fig. 7

REPORTED ANNOYANCE BY FEELINGS OF FEAR FOR SELECTED AIRCRAFT

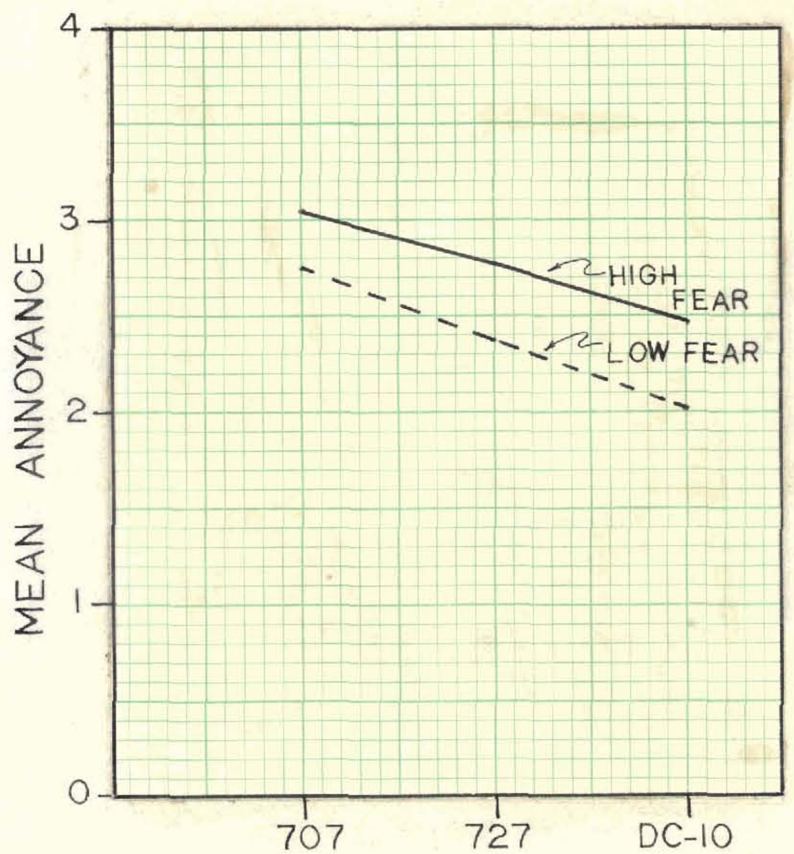


fig. 8

INDOOR NOISE LEVEL IN RELATION TO MEAN ANNOYANCE RATINGS

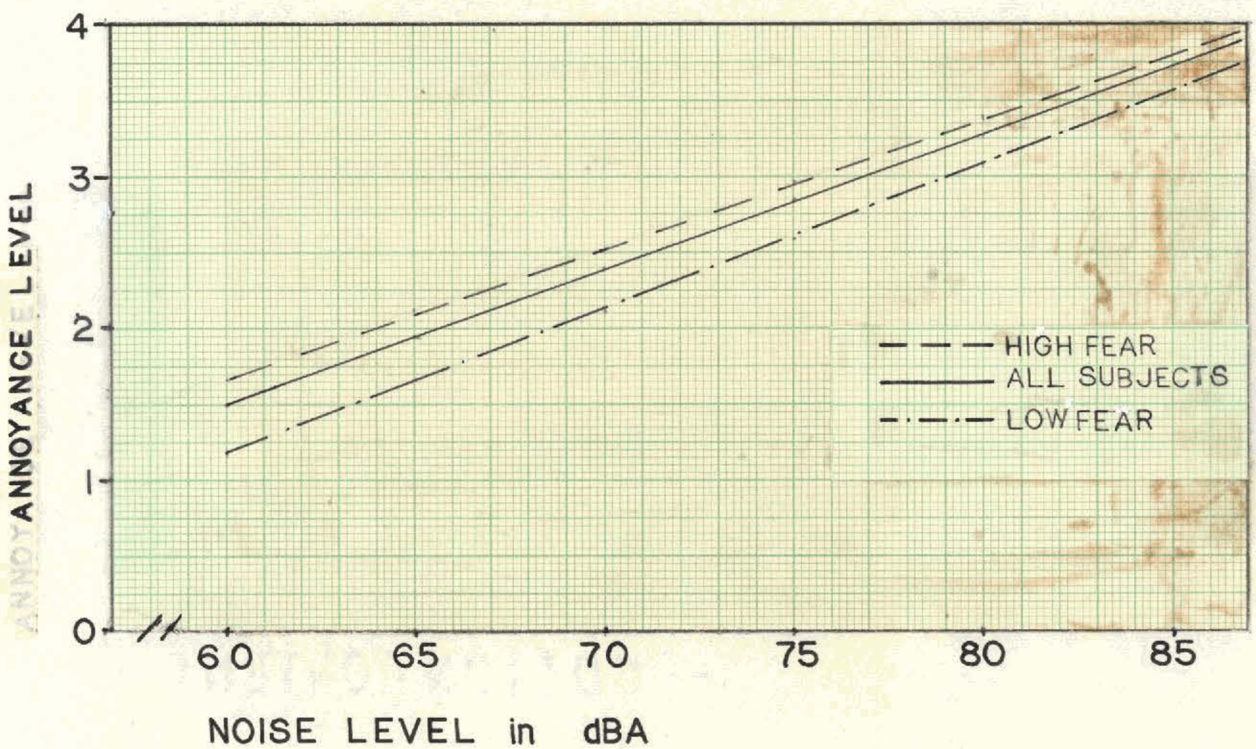


fig.9

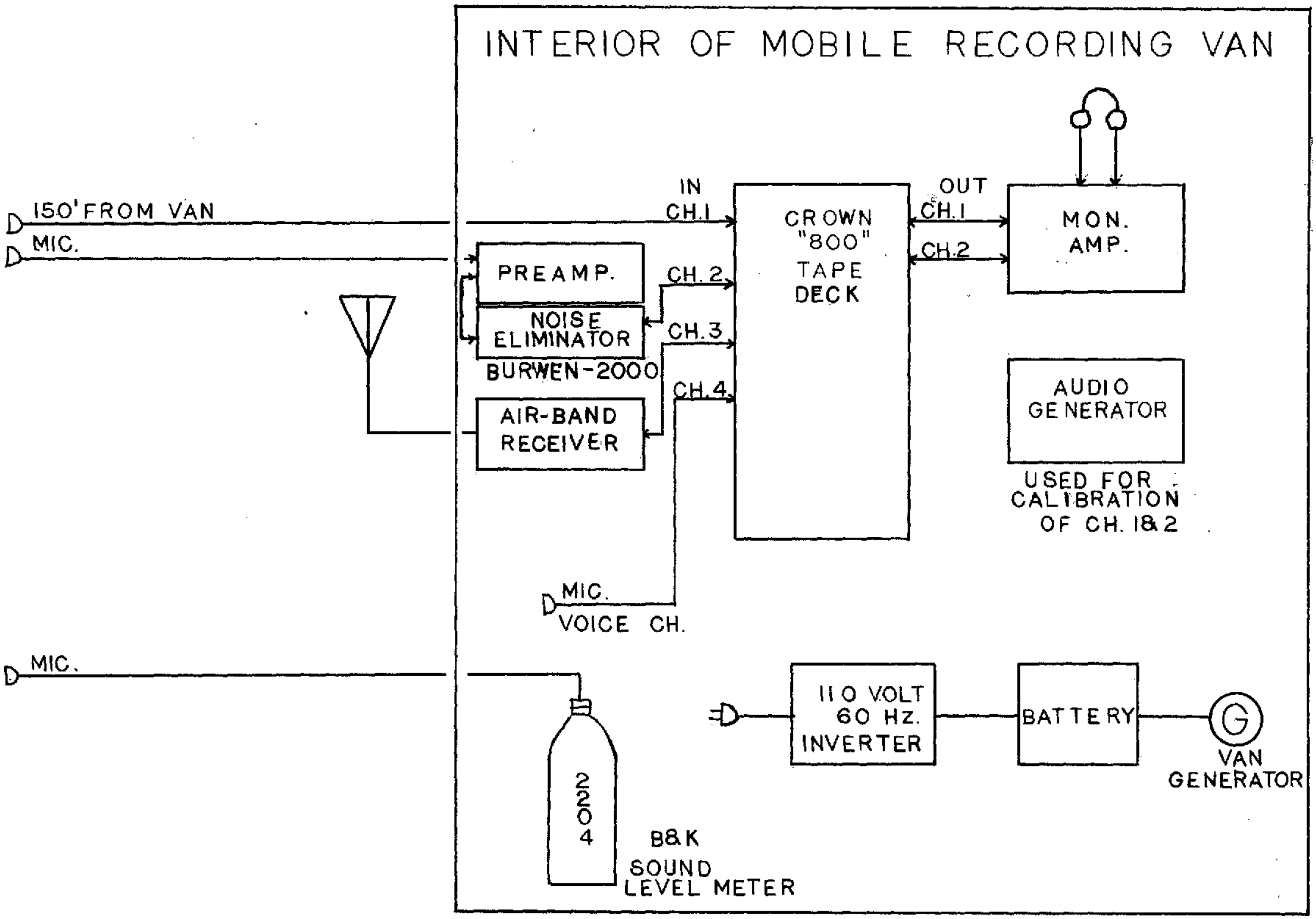
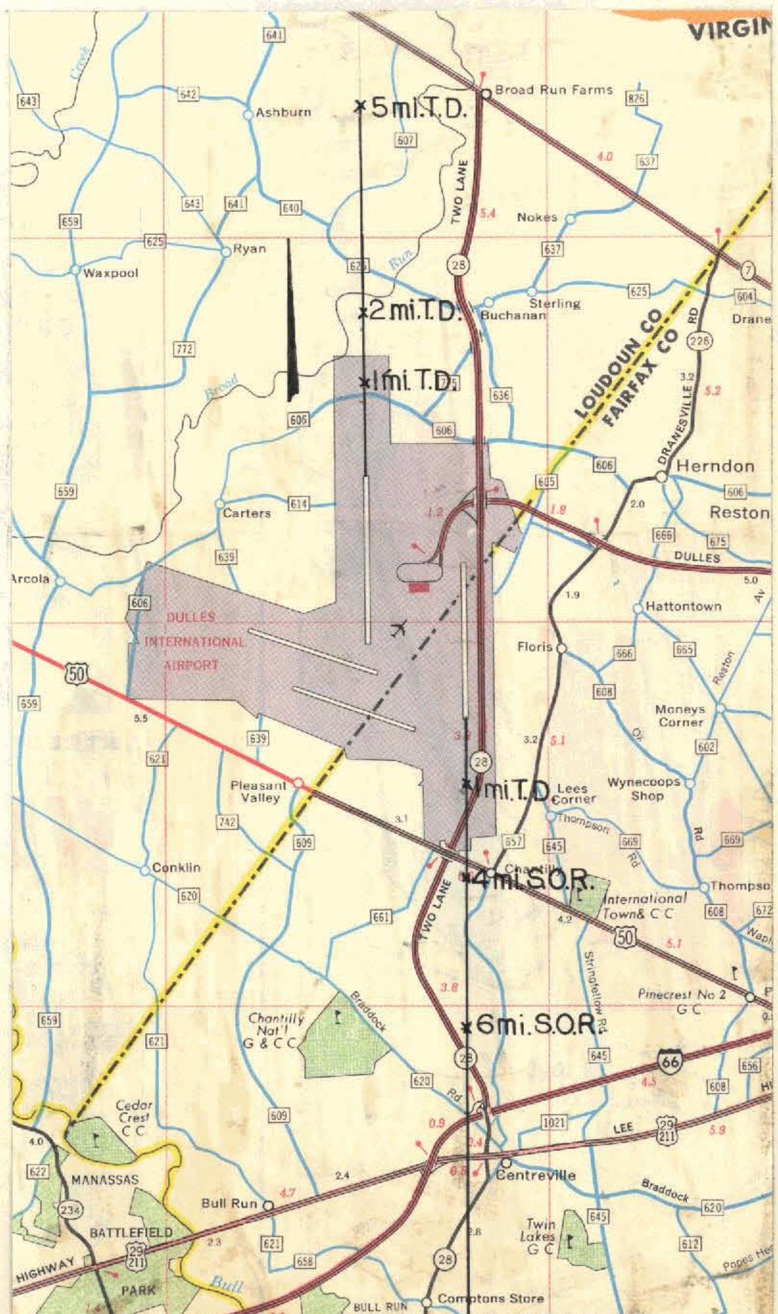

INTERIOR OF MOBILE RECORDING VAN
150' FROM VAN
MIC.
IN
CH.1
CROWN
"800"
TAPE
DECK
OUT
CH.1
CH.2
MON.
AMP.
PREAMP.
NOISE
ELIMINATOR
BURWEN-2000
CH.2
CH.3
CH.4
AIR-BAND
RECEIVER
AUDIO
GENERATOR
USED FOR
CALIBRATION
OF CH. 1& 2
MIC.
VOICE CH.
MIC.
110 VOLT
60 Hz.
INVERTER
BATTERY
VAN
GENERATOR
2204
B&K
SOUND
LEVEL METER

fig. B-1

RECORDING SITES IN VICINITY OF DULLES INTERNATIONAL AIRPORT

71



I inch = approximately 2.6 mi.

fig. B-2

SAE ATMOSPHERIC ABSORPTION COEFFICIENTS (ARP-866)

from ICAO ANNEX 16

RELATIVE HUMIDITY-60%
TEMP. CENTIGRADE 30.0

78

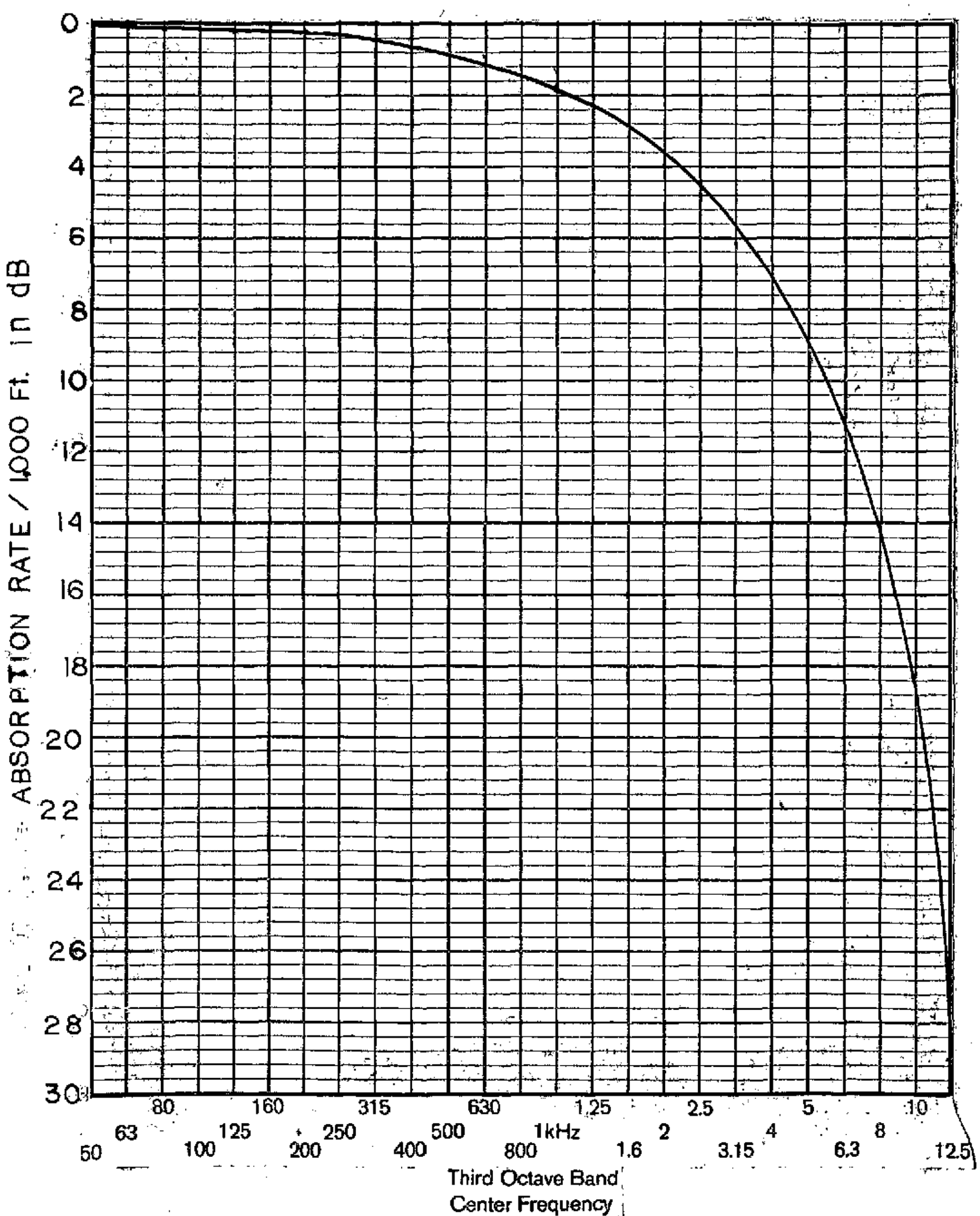


fig. B-3

INDOOR ATTENUATION CURVE
COLD CLIMATE, WINDOWS OPEN
SAE-AIR 1081

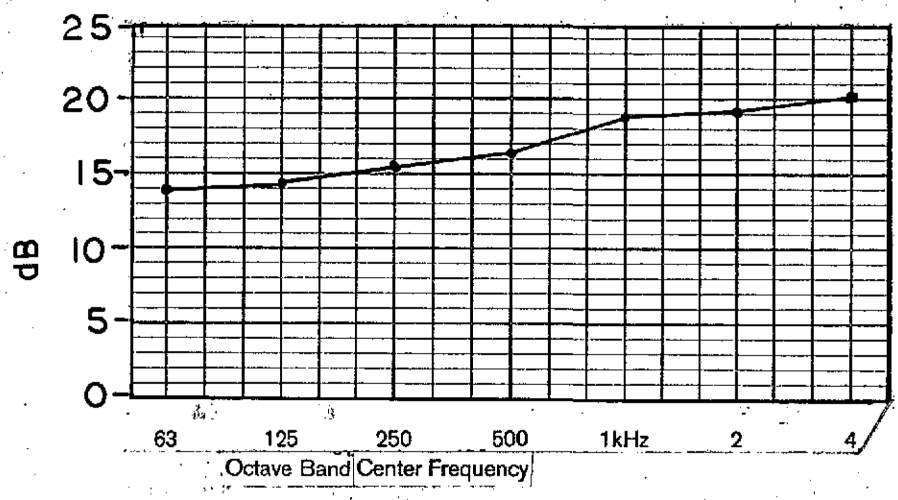


fig. B-4

INDOOR NOISE SPECTRA OF 707 MAXIMUM dBA LEVEL ON APPROACH

74

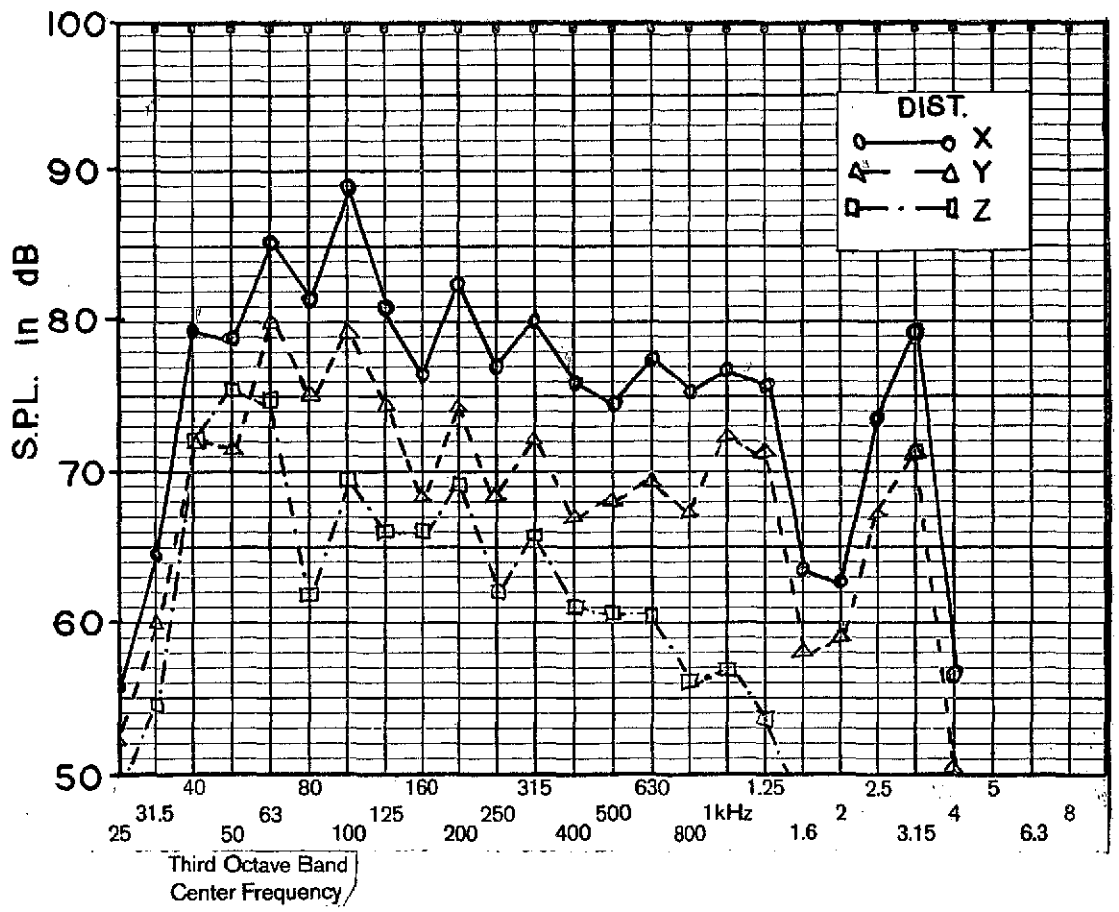


fig. B-5

INDOOR NOISE SPECTRA OF 707

MAXIMUM dBA LEVEL ON DEPARTURE

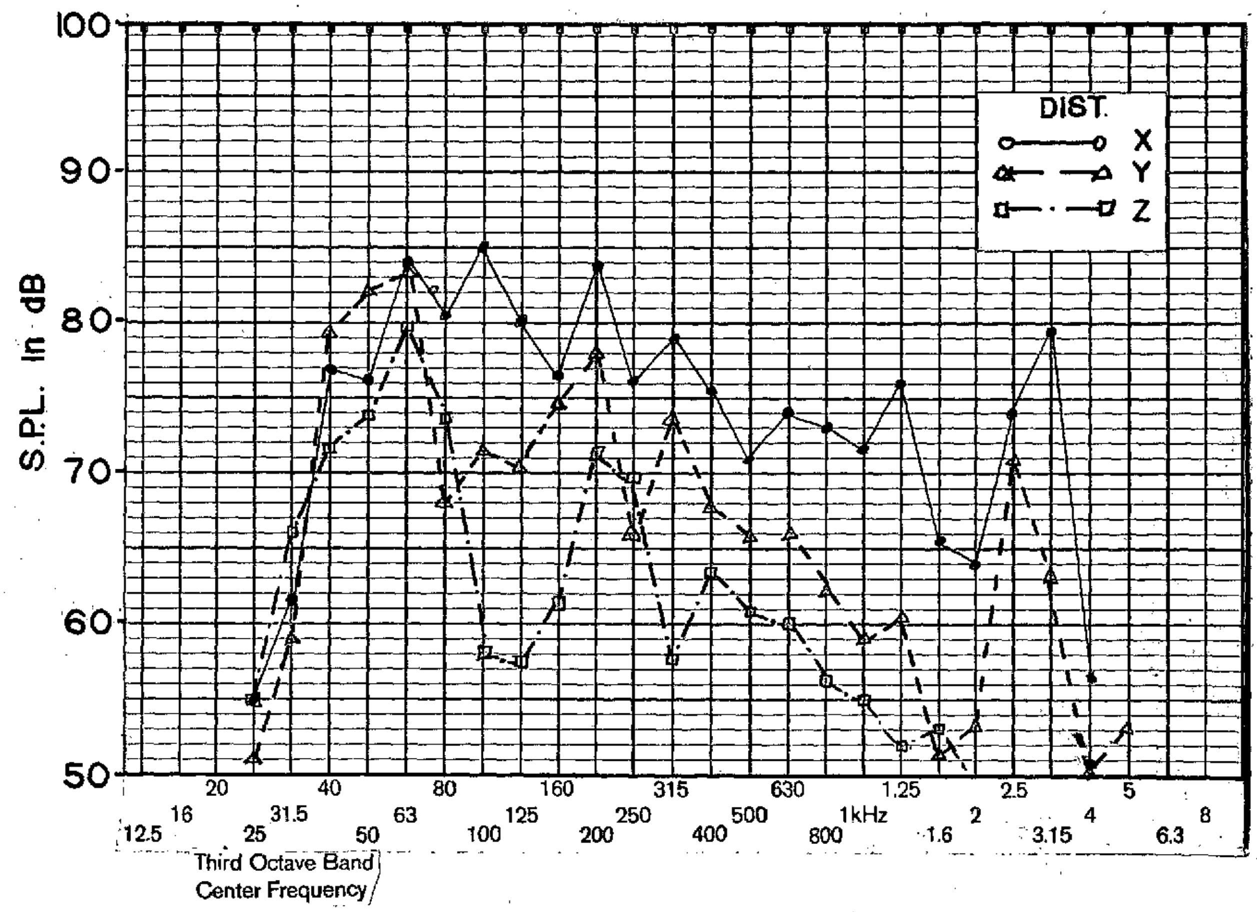


fig. B-6

INDOOR NOISE SPECTRA OF 727
MAXIMUM dBA LEVEL ON APPROACH

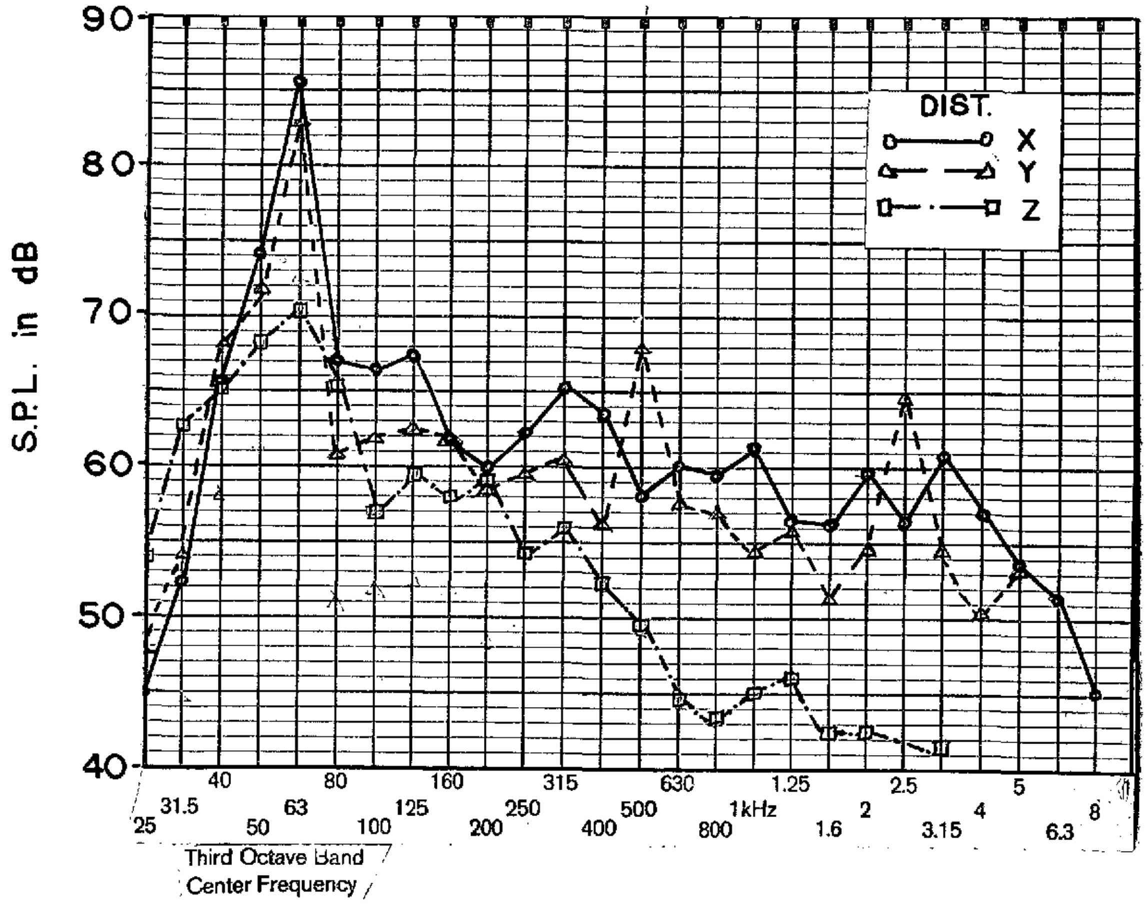


fig.B-7

INDOOR NOISE SPECTRA OF 727

77

MAXIMUM dBA LEVEL ON DEPARTURE

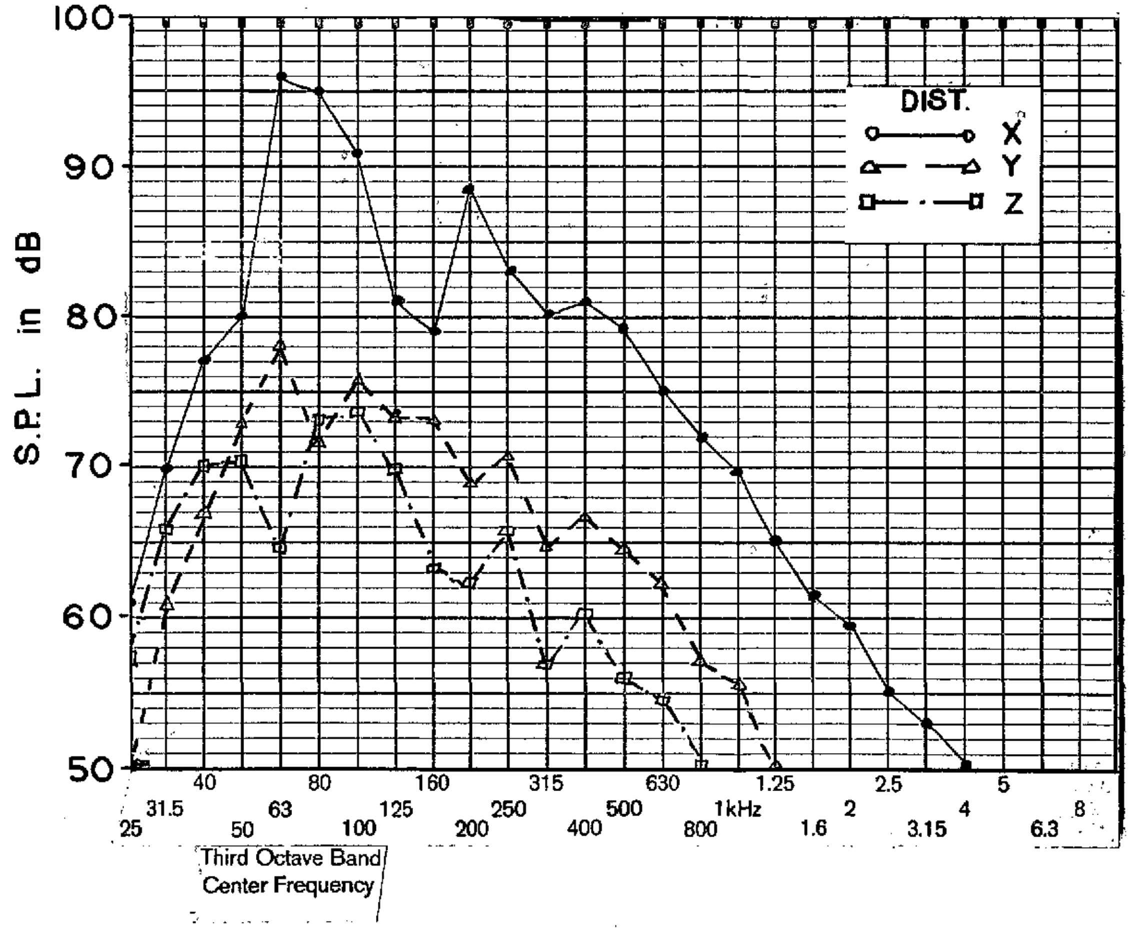


fig. B-8

78

INDOOR NOISE SPECTRA OF DC-10
MAXIMUM dBA LEVEL ON APPROACH

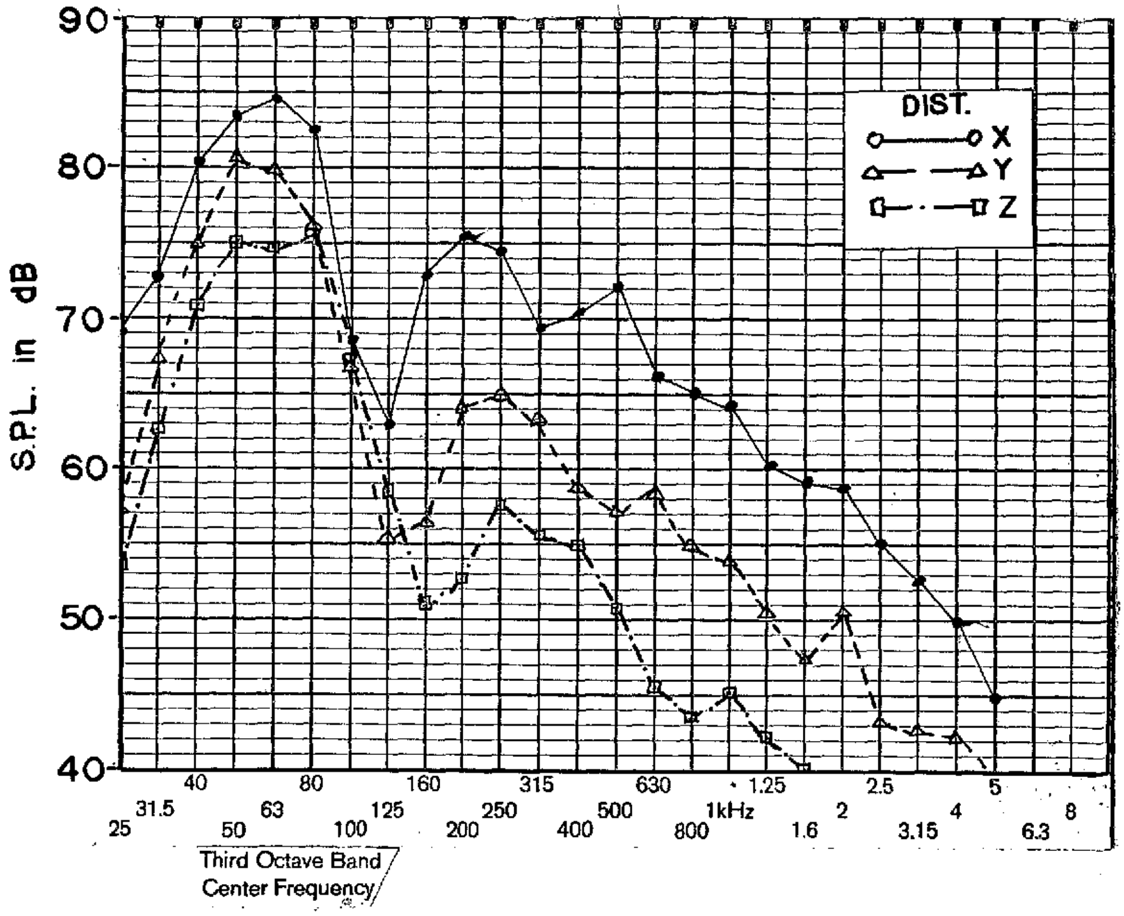


fig. B-9

INDOOR NOISE SPECTRA OF DC-10 MAXIMUM dBA LEVEL ON DEPARTURE

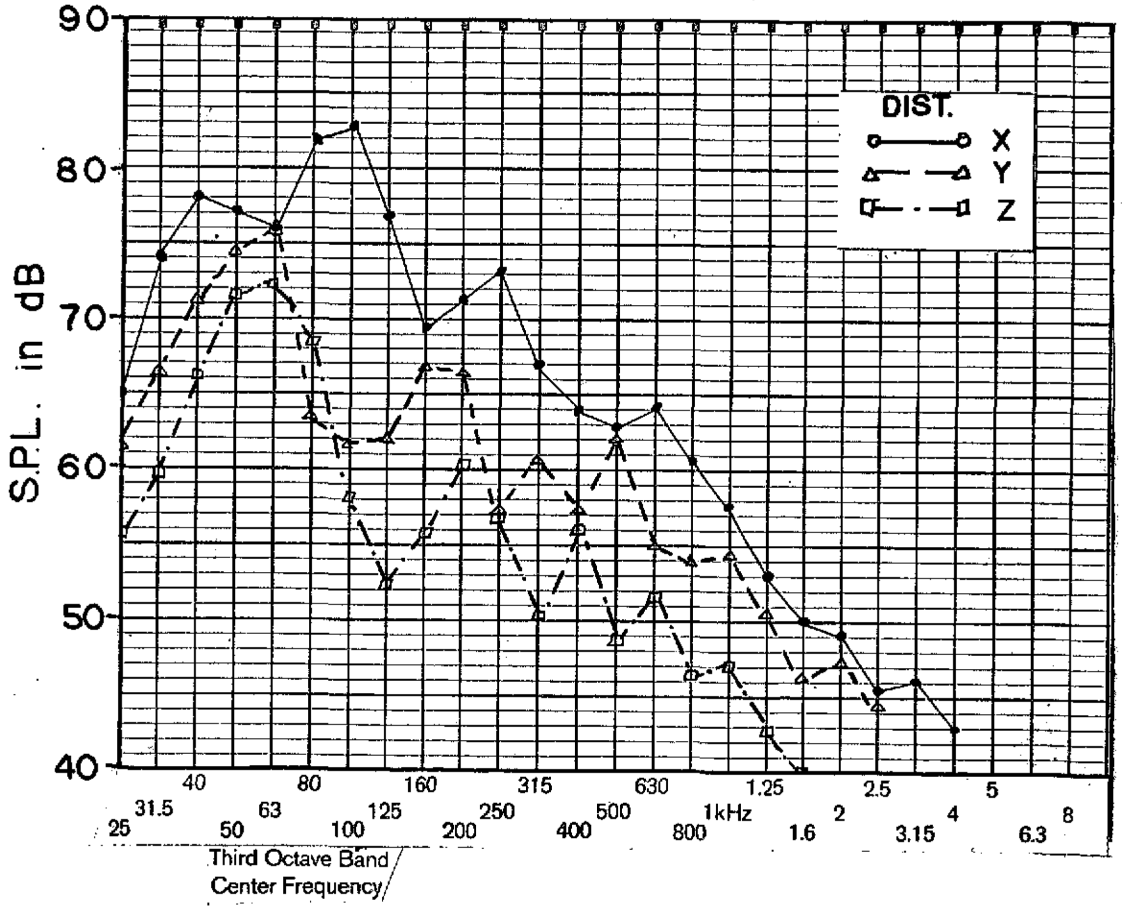


fig. B-10

INDOOR dBA LEVELS OF 727 1-MILE FROM TOUCHDOWN

TIME HISTORY

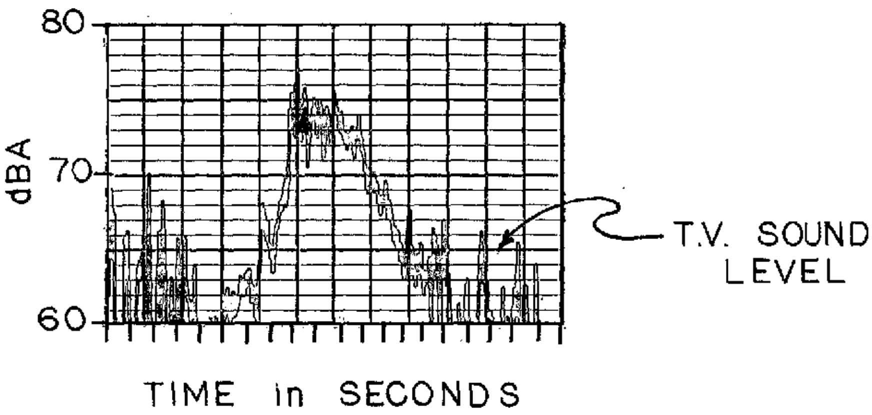


fig. B-11

INDOOR dBA LEVELS OF 727

4-MILES FROM START OF ROLL

TIME HISTORY

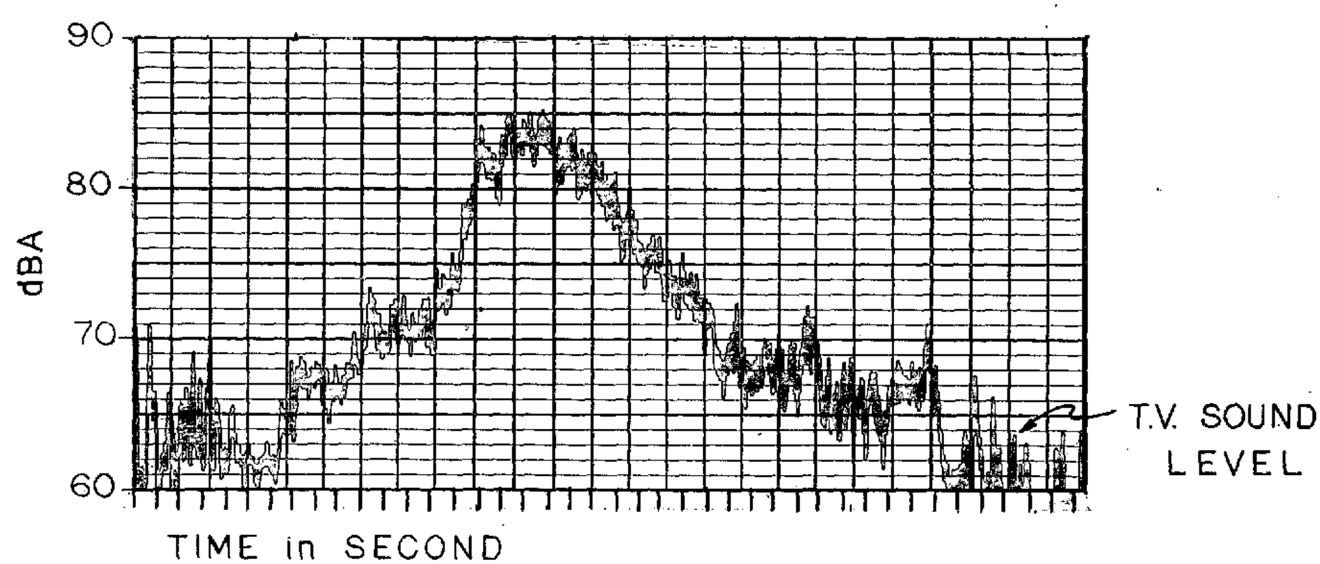


fig.B-12

INDOOR dBA LEVELS OF DC-10 1.-MILE FROM TOUCHDOWN

TIME HISTORY

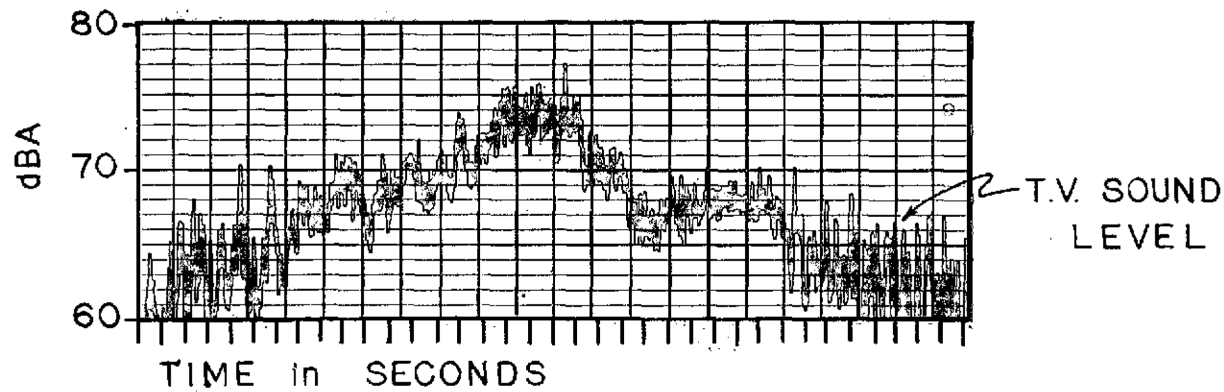


fig. B-13

83

INDOOR dBA LEVELS OF DC-10
4-MILES FROM START OF ROLL
TIME HISTORY

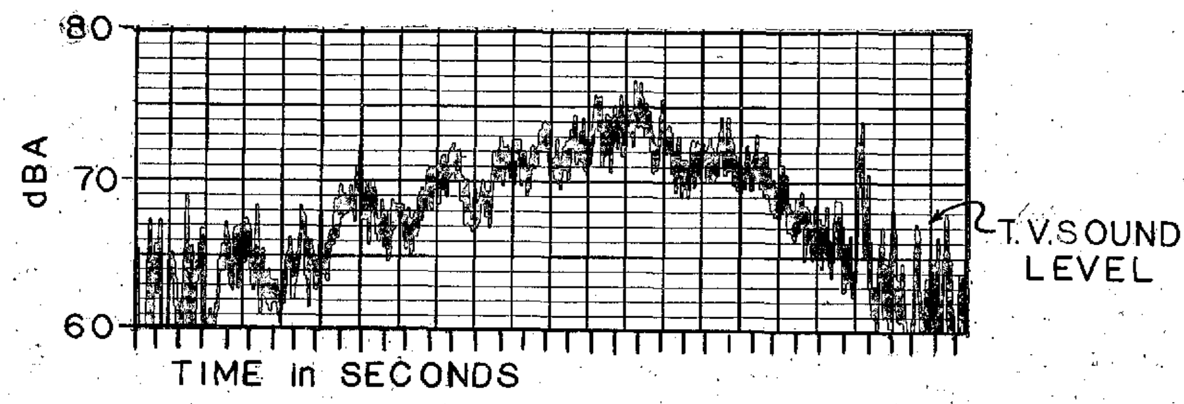


fig. B-14

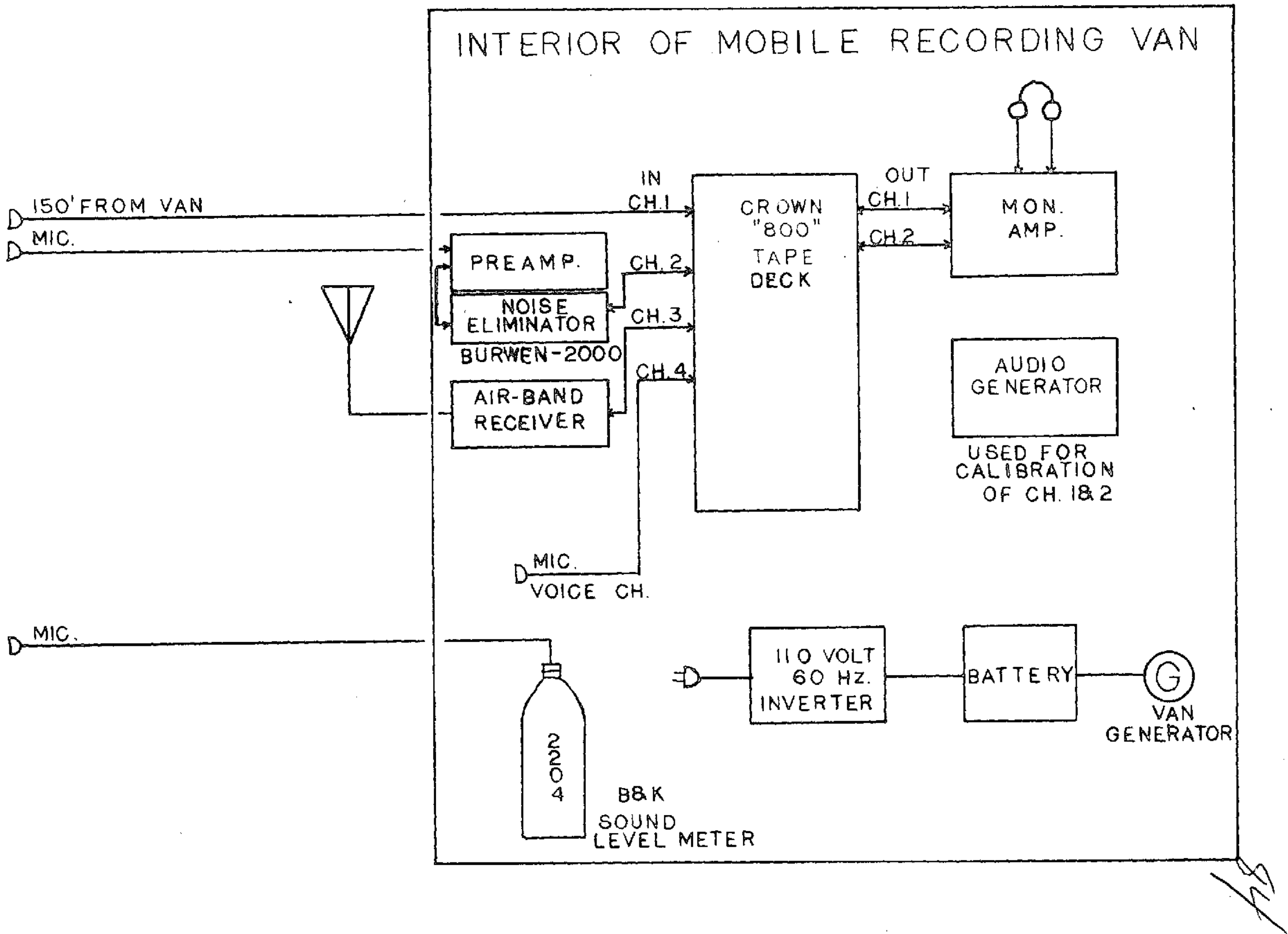
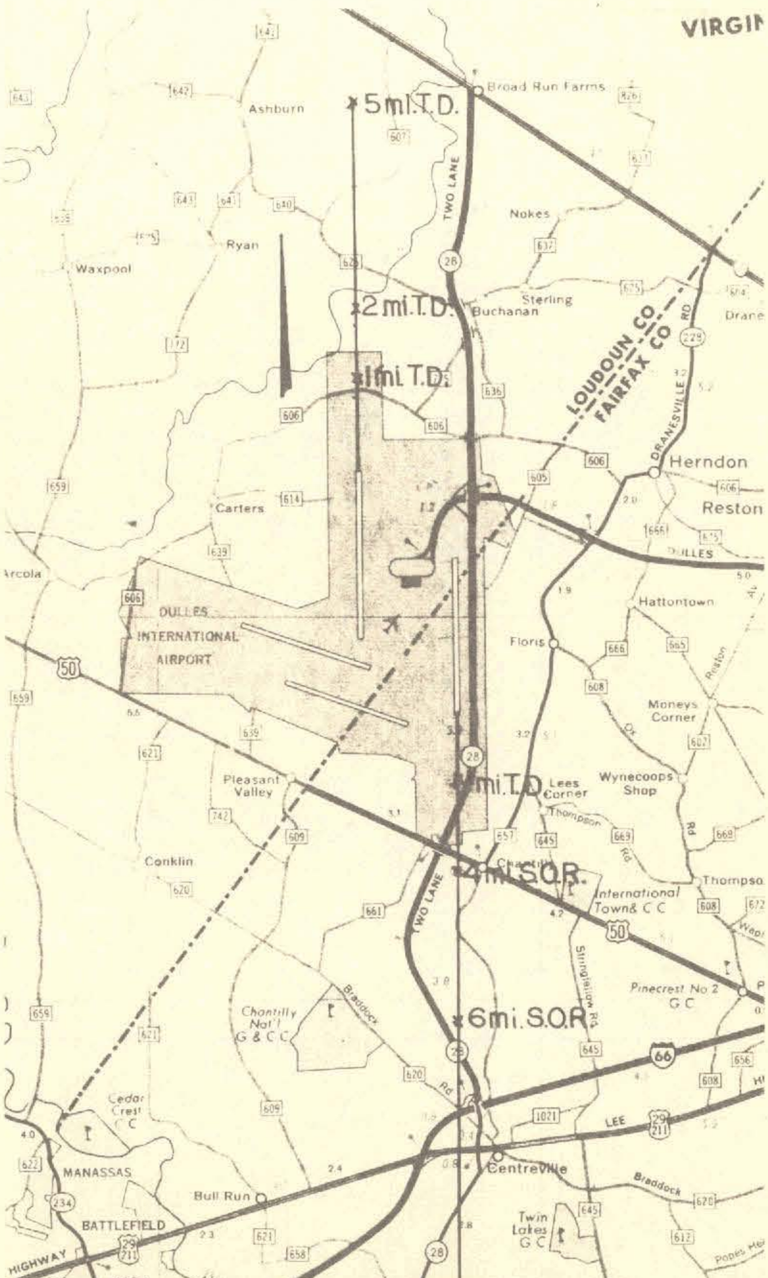


fig. B-1

ORIGINAL PAGE IS OF POOR QUALITY

85

RECORDING SITES IN VICINITY OF DULLES INTERNATIONAL AIRPORT



I inch = approximately 2.6 mi.

fig. B-2

SAE ATMOSPHERIC ABSORPTION COEFFICIENTS (ARP-866)

from ICAO ANNEX 16

RELATIVE HUMIDITY-60%
TEMP. CENTIGRADE 30.0

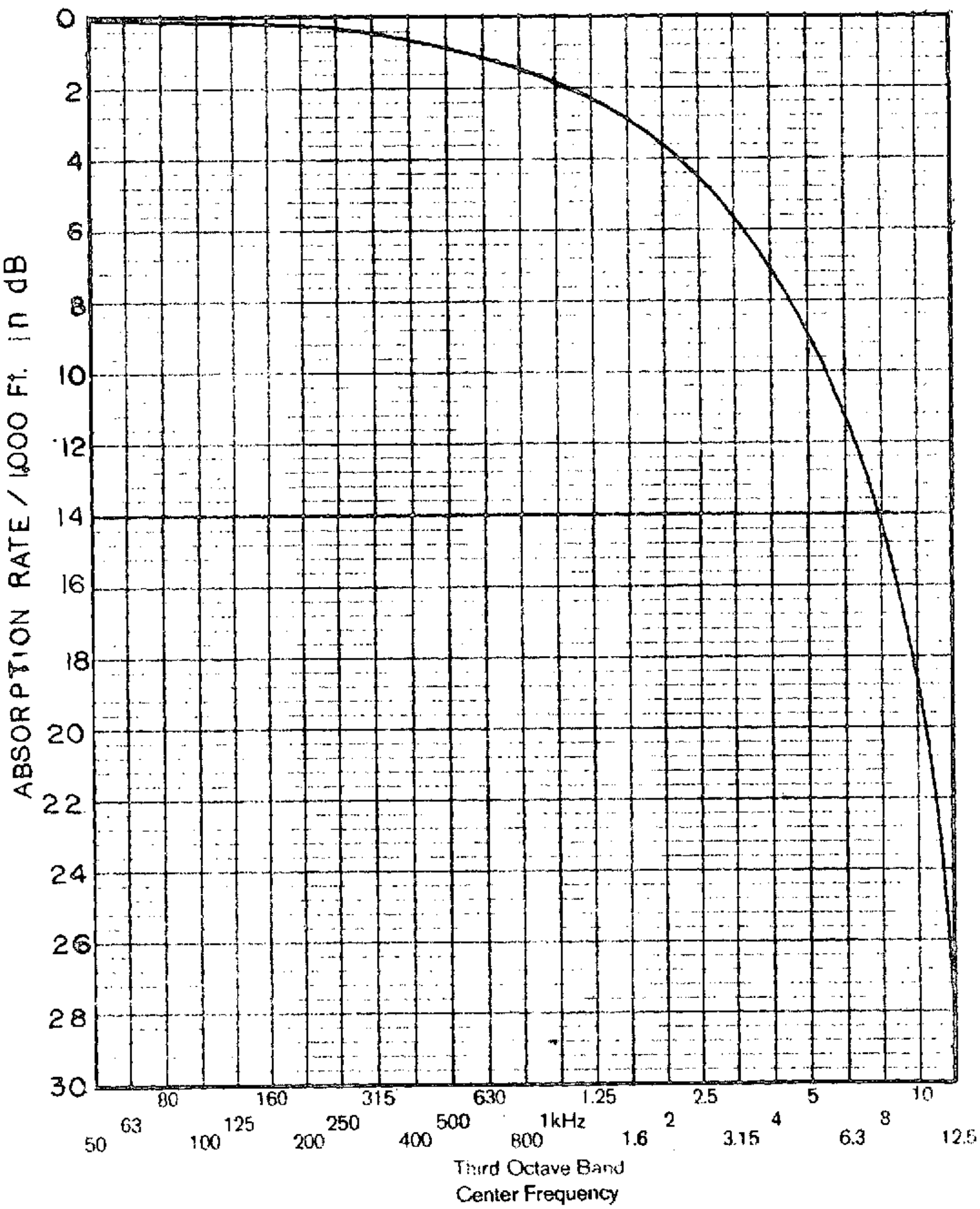


fig. B-3

86

INDOOR ATTENUATION CURVE
COLD CLIMATE, WINDOWS OPEN
SAE-AIR 1081

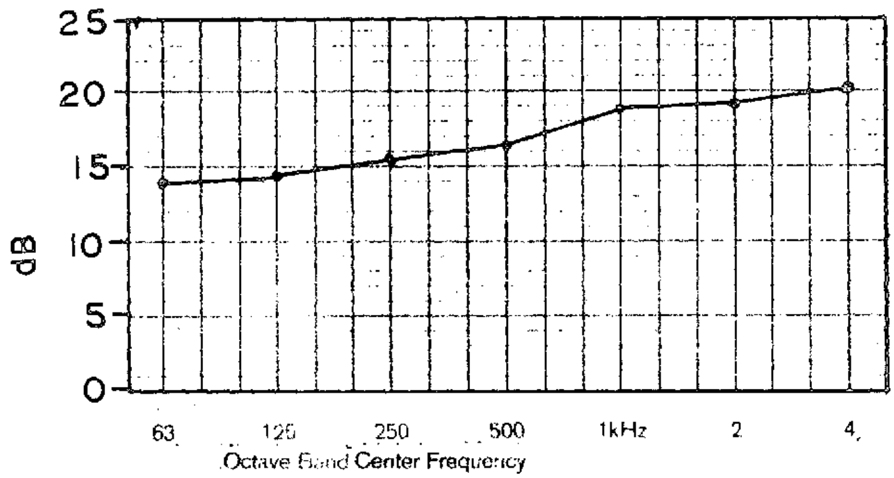


fig. B-4

INDOOR NOISE SPECTRA OF 707 MAXIMUM dBA LEVEL ON APPROACH

88

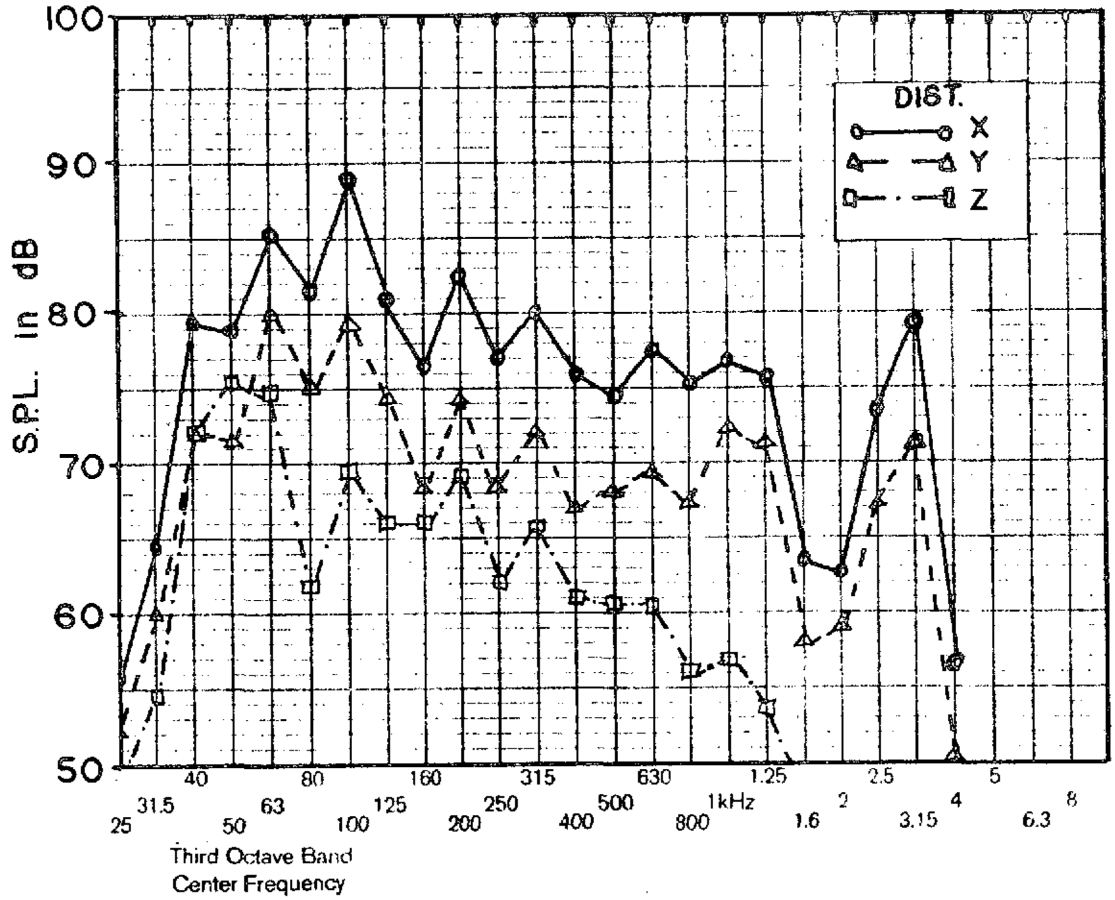


fig. B-5

INDOOR NOISE SPECTRA OF 707
MAXIMUM dBA LEVEL ON DEPARTURE

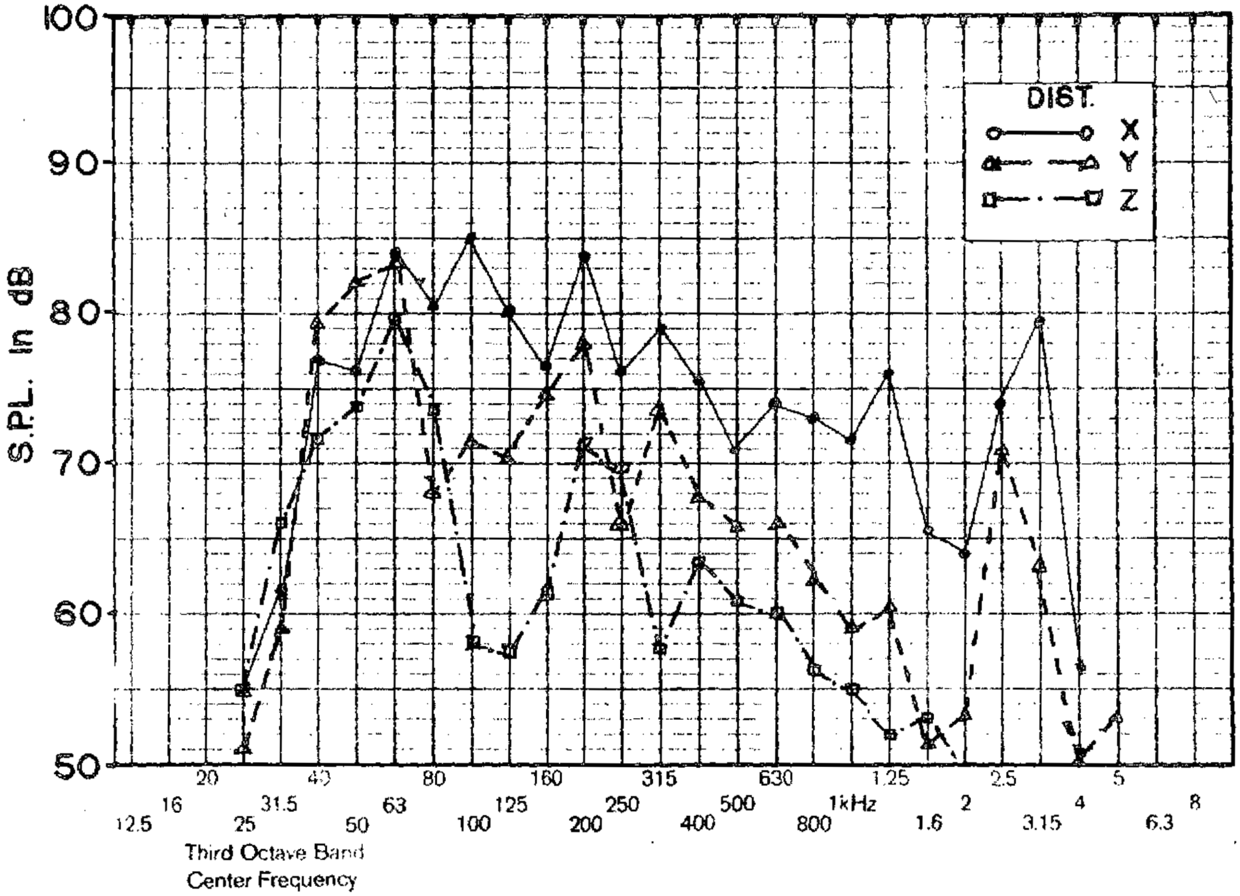


fig. B-6

INDOOR NOISE SPECTRA OF 727

MAXIMUM dBA LEVEL ON APPROACH

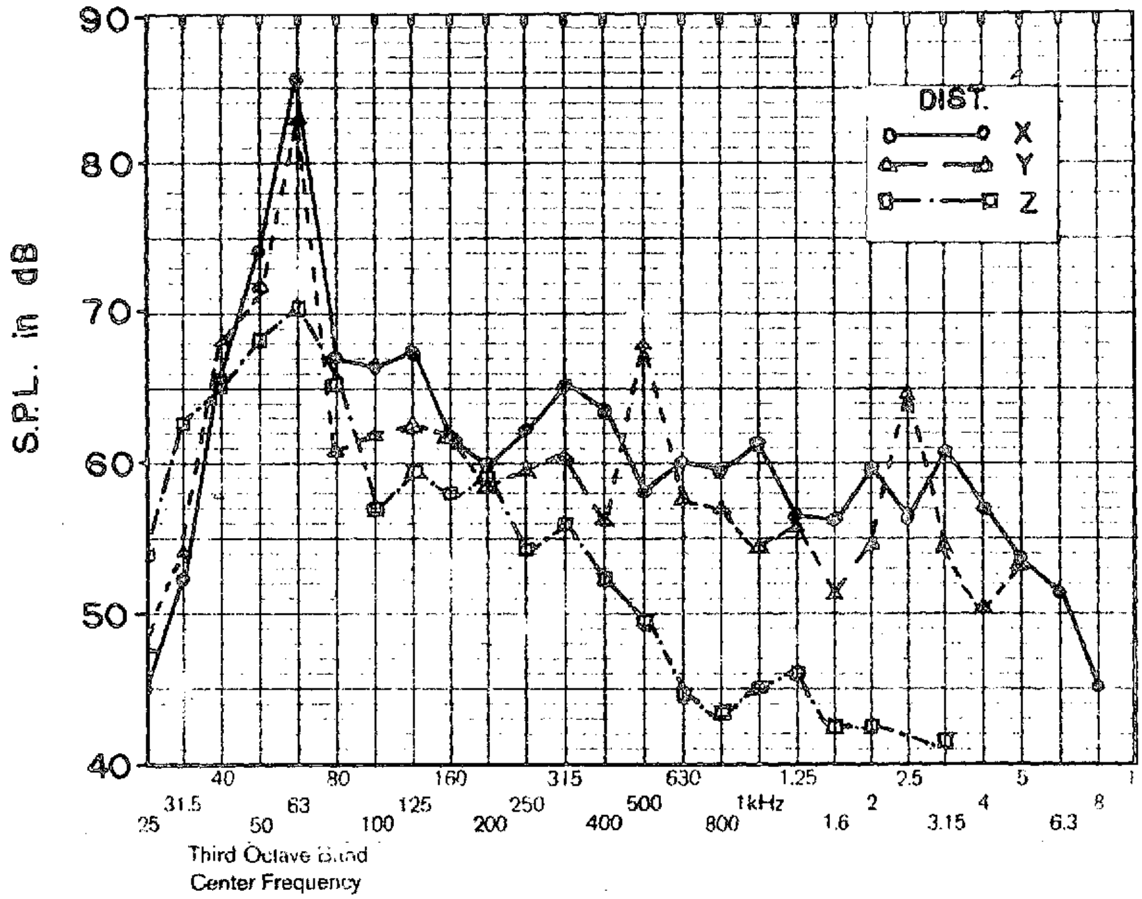


fig.B-7

INDOOR NOISE SPECTRA OF 727

MAXIMUM dBA LEVEL ON DEPARTURE

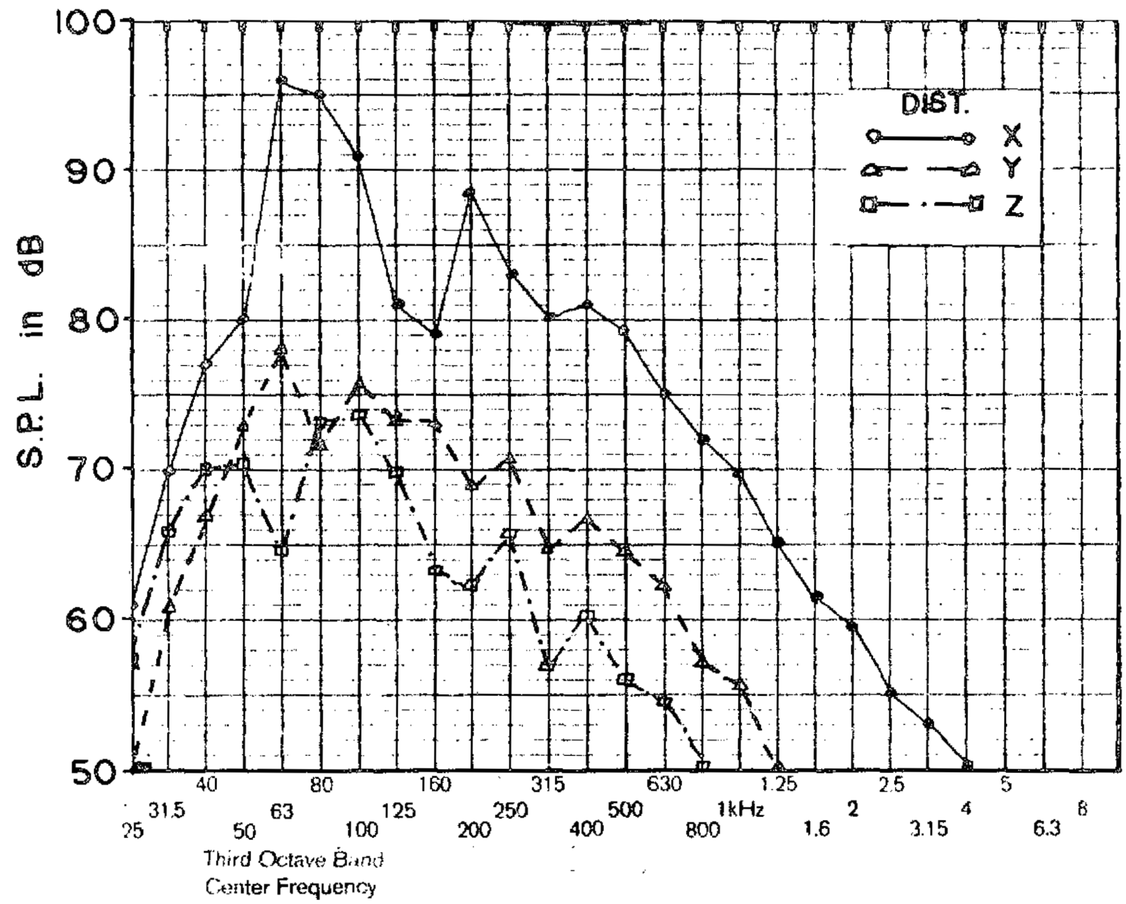


fig. B-8

INDOOR NOISE SPECTRA OF DC-10 MAXIMUM dBA LEVEL ON APPROACH

92

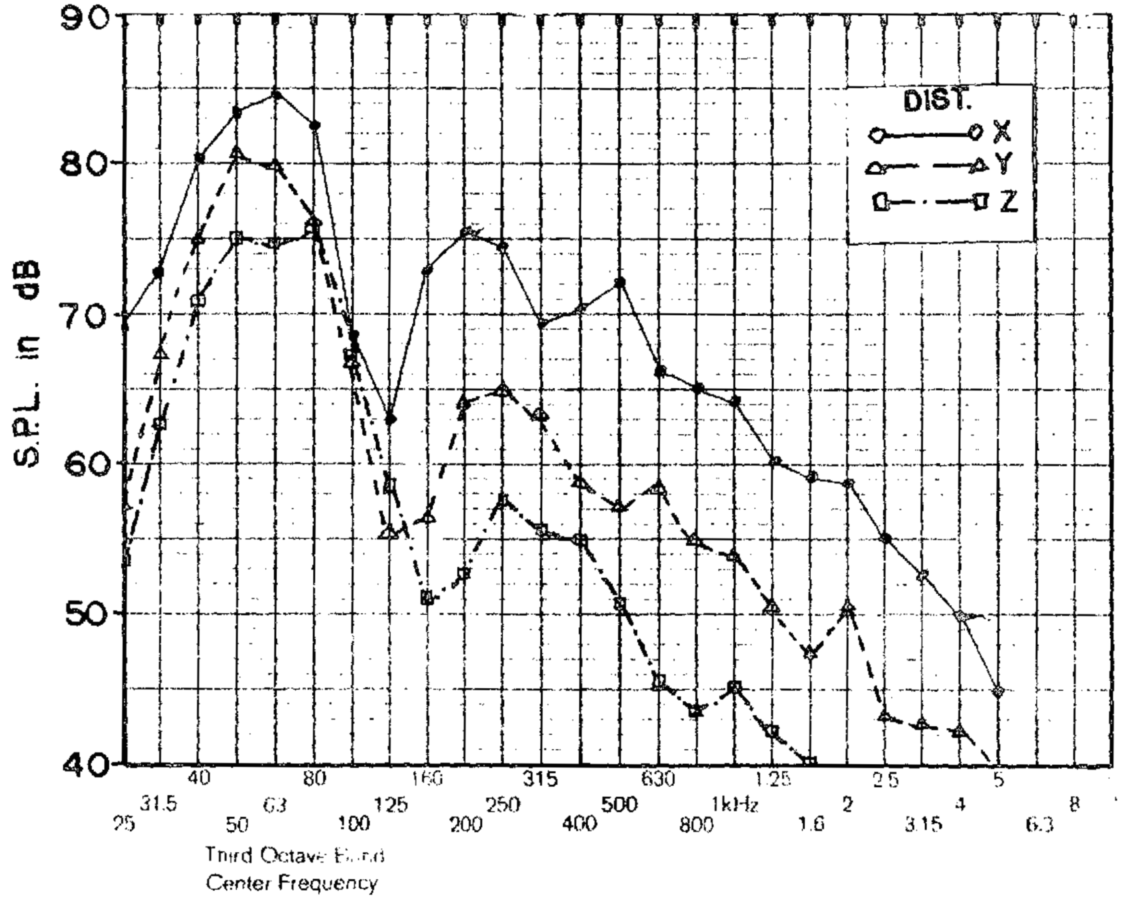


fig. B-9

INDOOR NOISE SPECTRA OF DC-10
MAXIMUM dBA LEVEL ON DEPARTURE

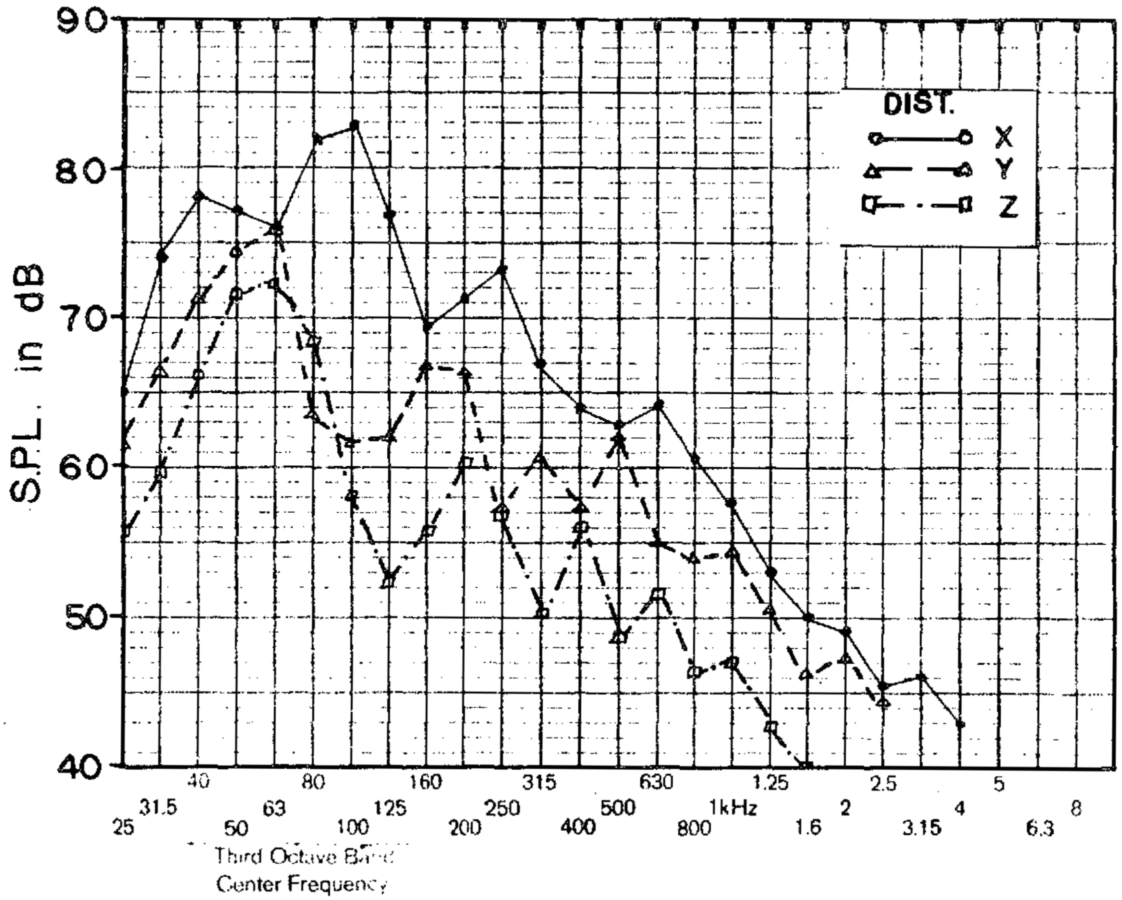


fig. B-10

93

INDOOR dBA LEVELS OF 727
1-MILE FROM TOUCHDOWN

TIME HISTORY

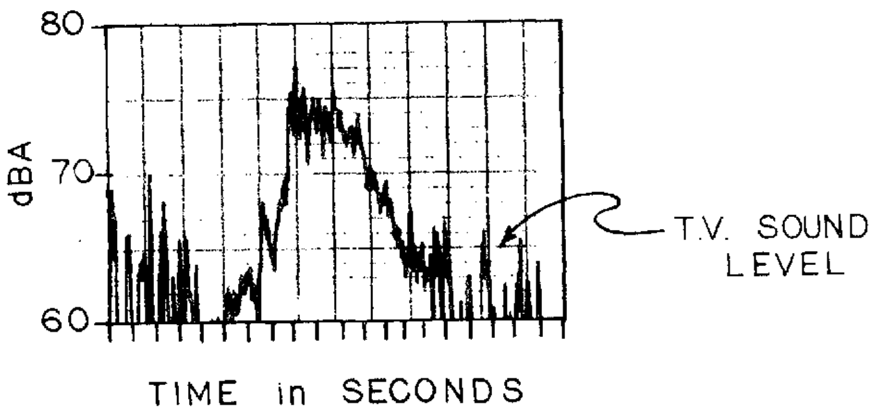


fig. B-11

INDOOR dBA LEVELS OF 727

4-MILES FROM START OF ROLL

TIME HISTORY

95

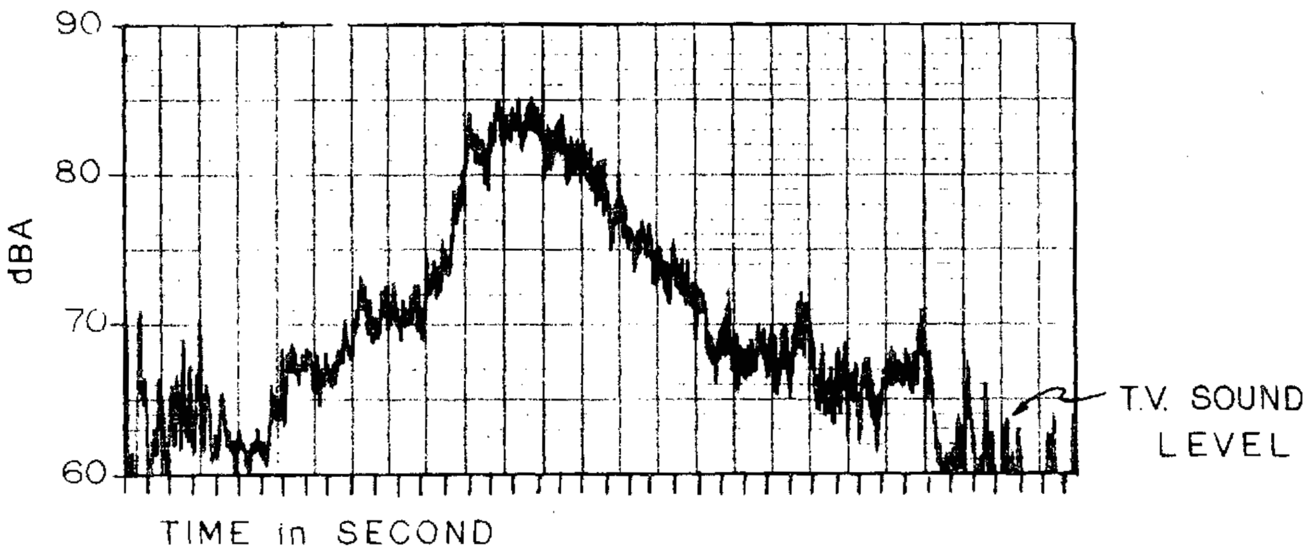


fig.B-12

INDOOR dBA LEVELS OF DC-10 1.-MILE FROM TOUCHDOWN

TIME HISTORY

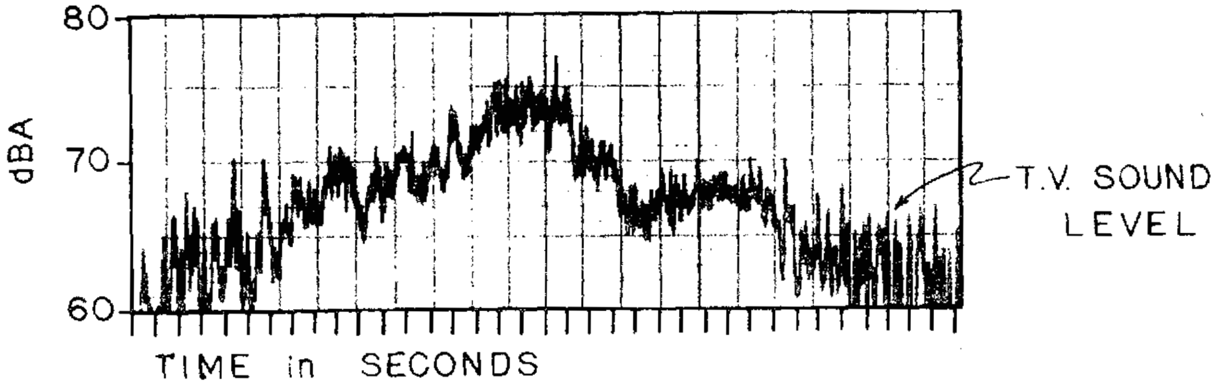


fig. B-13

97

INDOOR dBA LEVELS OF DC-10
4-MILES FROM START OF ROLL
TIME HISTORY

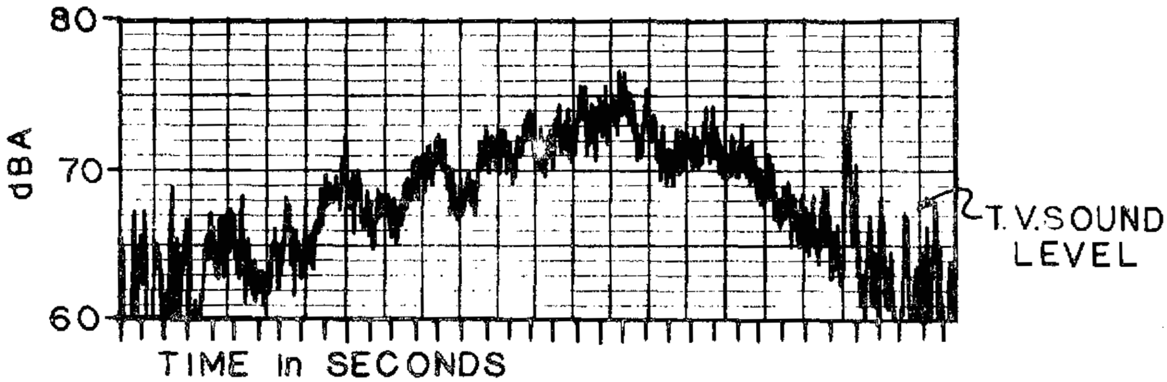


fig. B-14