FAA-ADS-78

THE EFFECTS OF DURATION AND BACKGROU NOISE LEVEL ON PERCEIVED NOISINESS

TECHNICAL REPORT

April 1966

by

Karl S. Pearsons

Bolt Beranek and Newman Inc.
15808 Wyandotte Street
Van Nuys, California 91406

Under Contract No. FA65WA-1180

for

FEDERAL AVIATION AGENCY

AIRCRAFT DEVELOPMENT SERVICE

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ABSTRACT

Judgment tests were conducted to investigate the effect of duration and background noise on the perceived noisiness of sounds. The tests were conducted in an anechoic chamber with 18 subjects. Aircraft noise recordings were employed in the background level test, and the results indicate that the presence of background noise reduces the judged noisiness of an aircraft flyover. The duration tests utilized stimuli with two different time patterns and various spectrum shapes over a range of durations from 4 to 64 seconds. Combining the results of these tests with those of a previous study provided duration information over the range from 1-1/2 to 64 seconds. These data suggest that the dependence of perceived noisiness on duration might well be a function with a continuously decreasing slope, varying from -6 to -2 PNdB per doubling of duration over the range of durations tested. For practical purposes, we have approximated the data by straight-line segments for various ranges of duration.

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I. INTRODUCTION

Subjective response to aircraft noise depends on a number of factors, including the spectral shape of the aircraft noise, the temporal pattern of the noise, and the shape of the background noise in which the aircraft noise is immersed. Under Contract No. FA65WA-1180 with the Federal Aviation Agency, Bolt Beranek and Newman Inc. (BBN) is investigating several of these factors. The present report describes work investigating the effects of duration and background noise on perceived noisiness. Although some work was conducted over the period from 4 March 1965 to 4 March 1966, work is still proceeding concerning the development of a scale of perceived noise level for aircraft noise, and that work will be reported at a later data in the contract.

Section II of this report describes the test apparatus and procedures used in these studies. Section III summarizes the results of the test investigating the effect of duration on perceived noisiness. Section IV describes the results of the investigations on the effect of background noise level on perceived noisiness. Section V presents the conclusions derived from the test results.

II. TEST DESCRIPTION

A. Subjects

The 18 subjects for these tests consisted mainly of undergraduate students from Santa Monica City College. Others included two representatives of a mortgage company, a musician, and a graduate student. All subjects were screened audiometrically to insure that the group was within 20 dB of the new ISO standard threshold (ref. 1). The subjects ranged in age from 18 to 32 years, with a median age of 19 years.

B. Stimuli

Duration Tests. The stimuli used in these tests were chosen to encompass the range of durations from 4 to 64 seconds. Duration is defined as "the amount of time the sound is within 10 dB of the maximum level." The range of durations was chosen to include typical durations as heard in communities around present-day commercial airports. This range is described in more detail in Appendix A. Table I provides a complete list of the stimuli employed during the tests. Two time patterns, designated A and B, were employed throughout the tests and are shown in Fig. 1. Time pattern A represents a simulated aircraft flyover, while time pattern B represents a simulated ground runup. Figure 2 shows an actual test time pattern, using a one-third octave band of noise. Three sound spectra were employed during the tests, as shown in Fig. 3. The simulated jet spectrum was employed in the preliminary tests and later supplemented in the more detailed tests with one-third octave band noise and pure tones at 1000 Hz. The background noise shown in Fig. 3 was present throughout the tests.

The spectra in Fig. 3 were measured at a typical seat location. The location was chosen by selecting the location whose octave band spectrum most nearly represented the spectra averaged over the entire seating arrangement. A one-third octave band analysis was then performed at this location. The spread of the data shown in Fig. 3 was determined from octave band measurements.

Background Noise Tests. The background noise tests utilized the same background noise described under the duration tests. Sound stimuli included three jet aircraft flyovers, one helicopter, two trucks, and one simulated flyover with time pattern A of Fig. 1. These stimuli were presented in random order at levels shown in Table II. Although the stimuli were recorded out of doors, they were filtered

TABLE I
STIMULI FOR DURATION TESTS

STIMULUS	STIMULUS PRESENTED FIRST	TIME PATTERN		DURATION IN SECONDS		PERCEIVED NOISE LEVEL (PNdB)	
	S=STANDARD C=COMPARISON	STD	COMP	STD	COMP	STD	COMP
1000 Hz TONE	S,C	A	A	16	4	86	99, 95, 91, 87
	S,C	A	A	16	8	86	95, 91, 87, 83
	S	A	A	16	16	86	92, 88, 84, 80
	S	A	A	16	32	86	90, 86, 82, 78
	S	A	A	16	64	86	89, 85, 81, 77
1000 Hz TONE	S,C	B	B	16	4	86	99, 95, 91, 87
	S,C	B	B	16	8	86	95, 91, 87, 83
	S	B	B	16	16	86	92, 88, 84, 80
	S	B	B	16	32	86	90, 86, 82, 78
	S	B	B	16	64	86	89, 85, 81, 77
1/3 OCTAVE	S,C	A	A	16	4	88	101, 97, 93, 89
BAND OF	S,C	A	A	16	8	88	97, 93, 89, 85
NOISE	S	A	A	16	16	88	94, 90, 86, 82
AT 1000 Hz	S,C	A	A	16	32	88	92, 88, 84, 80
	S	A	A	16	64	88	91, 87, 83, 79

(Cont'd)

TABLE I (CONT'D)
STIMULI FOR DURATION TESTS

STIMULUS	STIMULUS PRESENTED FIRST	TIME PATTERN		DURATION IN SECONDS		PERCEIVED NOISE LEVEL (PNdB)	
	S=STANDARD C=COMPARISON	STD	COMP	STD	COMP	STD	COMP
1/3 OCTAVE	S,C	B	B	16	4	88	101, 97, 93, 89
BAND OF	S,C	B	B	16	8	88	97, 93, 89, 85
NOISE	S	B	B	16	16	88	94, 90, 86, 82
AT 1000 Hz	S,C	B	B	16	32	88	92, 88, 84, 80
	S	B	B	16	64	88	91, 87, 83, 79
JET*	S,C	A	A	16	4	91	104, 100, 96, 92
	S,C	A	A	16	8	91	100, 96, 92, 88
	S	A	A	16	16	91	97, 93, 89, 85
	S	A	A	16	32	91	95, 91, 87, 83
	S,C	A	A	16	64	91	94, 90, 86, 82
JET*	S,C	B	B	16	4	91	104, 100, 96, 92
	S,C	B	B	16	8	91	100, 96, 92, 88
	S	B	B	16	16	91	97, 93, 89, 85
	S	B	B	16	32	91	95, 91, 87, 83
	S,C	B	B	16	64	91	94, 90, 86, 82

(Cont'd)

TABLE I (CONT'D)
STIMULI FOR DURATION TESTS

STIMULUS	STIMULUS PRESENTED FIRST	TIME PATTERN		DURATION IN SECONDS		PERCEIVED NOISE LEVEL (PNdB)	
	S=STANDARD C=COMPARISON	STD	COMP	STD	COMP	STD	COMP
JET*	S	A	B	16	4	91	104, 100, 96, 92
	S	A	B	16	8	91	100, 96, 92, 88
	S	A	B	16	16	91	97, 93, 89, 85
	S	A	B	16	32	91	95, 91, 87, 83
JET*	S	B	A	16	4	91	104, 100, 96, 92
	S	B	A	16	8	91	100, 96, 92, 88
	S	B	A	16	16	91	97, 93, 89, 85
	S	B	A	16	32	91	95, 91, 87, 83

*Shaped Noise, See Figure 3

TABLE II

STIMULI FOR BACKGROUND LEVEL TEST

Stimulus*	Perceived Noise Level (PNdB)
Jet Flyover #1	106, 96, 86, 76
Jet Flyover #2	107, 97, 87, 77
Jet Flyover #3	106, 96, 86, 76
Simulated Jet Flyover	106, 96, 86, 76, 66
Helicopter Flyover	90, 80, 70
Truck #1	100, 90, 80, 70
Truck #2	88, 78, 68

* Spectra for these stimuli shown in Fig. 4.

during playback to simulate the effect of residential dwelling noise reduction. In other words, the subjects heard sounds as they would have heard them had they been inside a house. The spectrum of each of the stimuli averaged over all of the seat locations is given in Fig. 4.

C. Equipment

A Zenith 110T audiometer was used for the audiometric screening of the subjects. The equipment used in the presentation of the test stimuli to the subjects consisted of an Ampex AG-350 tape machine, a MacIntosh 60-watt amplifier, and an Altec 605 loudspeaker mounted in a utility enclosure and suspended about 15 ft over the group of subjects, as shown in Fig. 5. (Some preliminary tests were conducted at BBN using an Altec Lansing 165-watt power amplifier and a KLH Model 6 loudspeaker.) The background noise was produced with a noise generator and filter and amplified through a MacIntosh 60-watt amplifier to drive four Altec 515 loudspeakers mounted in the four corners of the anechoic chamber. Measurements of the sound stimuli presented to the subjects were made at the subject's ear position (without the subject present) for each seat location. These measurements were made with a Bruel and Kjaer 4131 one-inch microphone, a Bruel and Kjaer 2203 sound level meter and a Kudelski Nagra IIIB tape recorder. Octave band and one-third octave band analyses were made with a Bruel and Kjaer 2112 and Bruel and Kjaer 1613 filter sets.

Duration Tests. The generation of the sound stimuli for the duration tests is indicated by the block diagram shown in Fig. 6. The various durations were obtained by changing the speed of the motor indicated in Fig. 6. Time pattern A was obtained using a specially constructed continuously rotating logarithmic potentiometer. The signal was stopped and started with the electronic switch which was triggered by a two-second time delay relay operating once per motor revolution. This provided a two-second off-time before the signal repeated itself.

Background Noise Tests. Recordings of stimuli used during this test were made with a Bruel and Kjaer 4131 one-inch microphone, a Bruel and Kjaer 2203 sound level meter, and a Kudelski Nagra IIIB tape recorder. The simulated flyover was obtained using the equipment shown in Fig. 4.

D. Procedure

Duration Tests. Two test methods were employed during the series of duration tests: the method of adjustment and the method of paired comparison. A preliminary test using the method of adjustment was conducted at BBN in a semireverberant room to obtain some idea of the levels which would be used in the more detailed paired-comparison tests. The subjects were asked to adjust the level of a comparison sound until to them it was just as noisy as a standard sound. The standard sound was always 16 seconds in duration. The actual instructions for this test are given in Appendix B. The final series of tests conducted in an anechoic chamber, 15.5 x 22 x 27 ft high, at Douglas Aircraft Company, Santa Monica, California, used the method of paired comparison. With this method, a tape is prepared for presentation to the subjects. To obtain the most accurate and efficient test, the levels used on the paired-comparison tape must be carefully chosen. These levels were chosen using the results of the preliminary method of adjustment tests and the results of earlier tests (ref. 2). The test pairs are then randomized using a random number table and recorded on magnetic tape. During presentation of the paired-comparison tape, the subjects were asked to choose which of two sound stimuli is the noisier and respond by punching the appropriate positions on an IBM port-a-punch card. The actual instructions are given in Appendix B. To avoid the possible effect of fatigue, the tests were given over a period of seven days with a maximum test session length of 45 minutes.

Background Noise Tests. To determine the effect of background noise on the perceived noisiness of a sound stimulus, it might appear logical to have the subject compare the sound stimulus with and without the background noise present. With this method the subject would attempt to judge only the sound stimulus and to ignore, insofar as possible, the background noise. However, the disadvantage of this method is that the subject might tend to include the background noise together with the sound stimulus to be judged. In other words, his judgment might be based upon the total effect of the background noise and sound stimulus added together. To avoid this problem, the background noise remained constant throughout a test session, and the subject was asked to rate the various sound stimuli along some category scales of noisiness. Only one test session of this type was conducted on any one day. During the next test session, the background noise was changed and the entire test was repeated with the sound stimuli presented in a different order. The tests were repeated until three background noise levels were used, as shown in Table III below. The actual test instructions used are given in Appendix B.

TABLE III

SCHEDULE OF BACKGROUND LEVEL TESTS

Day	Background Level OASPL (dB)	PNL (PNdB)
1	60	64
2	45	47
3	75	80

III. RESULTS OF DURATION TESTS

A. Treatment of Data

The subject's responses, recorded on IBM cards, were entered into a digital computer. A computer-generated display of typical results is shown in Fig. 7. Both stimuli were bands of noise with spectra similar to jet aircraft flyover noise as shown in Fig. 3. Figure 7 shows the percentage of subjects who stated that the comparison stimulus was noisier than the standard stimulus. The solid line represents results obtained when the standard stimulus was presented first, and the dashed line represents results obtained when the comparison stimulus was presented first.

We considered that two sounds are equally noisy when 50% of the subjects state that one sound is noisier than the other. Since we would like this level of equal noisiness to be independent of the order of presentation of the stimuli, we obtain it by averaging the two values at the 50% point obtained from the two different orders of presentation. For the data shown in the first graph of Fig. 7 this average 50% level is 4.5 PNdB (i.e., an average of 6 PNdB and 3 PNdB). In other words, the four-second comparison sound must be 4.5 PNdB higher in level than the 16-second standard sound in order that the two sounds are judged equally noisy. Likewise, in the second part of Fig. 7, the 64-second comparison sound must be 4.5 PNdB lower in level than the 16-second standard sound in order that the two sounds are judged equally noisy.

Since not all pairs of sounds were presented in both orders, an average correction was derived to correct the 50% levels of those pairs in which only the stndard stimuli was presented first. This correction was obtained by taking one-half of the average differences between the 50% levels for all data in which two different orders of presentation were employed. The correction thus obtained was 2.8 PNdB.

B. Review of Previous Duration Study

The previous tests of Ref. 2 were conducted very similarly to the present tests, but covered a range of durations from 1-1/2 to 12 seconds. The time patterns and noise spectra employed are shown in Figs. 8 and 9, respectively. The results from these previous tests are shown in Fig. 10. Notice that the slopes of the plotted data for Tests 1 and 2 in Fig. 10 are both 4.5 dB per doubling of duration for the range of stimuli tested.

Incidentally, it might be noted that the results of these tests are tabulated in terms of overall sound pressure level. This was done since the comparison samples had in all cases the same spectrum shape as their respective standards. In other words, the only parameter that was changed was the duration of the signal. Certainly, if any intercomparing of standards had also been tested, then it would have been necessary to plot the results in perceived noise level in PNdB. However, because the comparisons involved identical spectra, the results can be interpreted in terms of PNdB directly.

C. Results of Current Duration Study

The results of the current study were plotted in terms of perceived noise level difference from the standard level. A sample of the results is shown in Fig. 11 for the simulated jet noise spectrum. A line indicating the slope of 4.5 PNdB per doubling of duration found in the previous tests (and extrapolated beyond 12 seconds) is shown in this figure for comparison. Notice that these results appear to lie on a slope that is less than 4.5 PNdB per doubling of duration.

The sample results described above were for a test where the standard and comparison spectra had the same shaped time pattern. Most of the tests in this current study were conducted under these conditions. However, some judgments were made where time pattern A was compared with time pattern B for the simulated jet spectrum. It is of interest to examine the results of this type of test before we look at the rest of the data.

Comparing time pattern A and B at the same duration of 16 seconds, we find as with the other tests that the results differ, depending on the order in which the stimuli are presented. This difference is 5 PNdB in this case (at the 50% level), which means that the result obtained from each order is 2.5 PNdB from the average. This agrees fairly well with the average of 2.8 PNdB which had been determined previously for the samples where the time pattern was the same for both the standard and the comparison stimuli.

Once the 2.8 PNdB correction was made to the data, we found that time pattern B had to be 2 PNdB lower than time pattern A to be judged equally noisy when the duration of each is 16 seconds. Time pattern A was also compared with other durations of time pattern B. Likewise, time pattern B was compared with other durations of time pattern A. A plot of the results using time pattern A as a standard and time pattern B as a comparison, and vice versa, is shown in Fig. 12. The trend (slope) of these results appears to be the same as those in Fig. 11.

All of the data from the present tests have been summarized in Fig. 13. Where data were obtained for both orders of presentation, average results are plotted. Where data were taken for only one order of presentation, a correction of 2.8 PNdB has been made, as noted above. Finally, for the data where the two different time patterns were compared, adjustment of 2 PNdB has been made to permit the data to be compared.

Using the method of least squares, the regression line of PNdB difference on $\log_{10}$ (duration) was fitted to the data shown in Fig. 13. The slope of this line, as indicated on the figure, is 2.5 PNdB per doubling of duration, while the standard deviation of the data about this line at the mean, was calculated to be 1.5 PNdB. This slope is significantly lower than the 4.5 PNdB-per-doubling slope reported previously (ref. 2). It should be remembered, however, that the range of durations used in the previous study was from 1-1/2 seconds to 12 seconds, while the range of durations used in the present test extended from 4 seconds to 64 seconds. The difference in slopes between the data for the two studies indicates that as duration is increased, the effect of a doubling in duration decreases.

D. Combined Results of Both Studies

To gain the maximum information from the two studies, we have combined the results to provide data over the range from 1-1/2 to 64 seconds. In combining the data we had to take into account the fact that the two studies employed different durations for the standard stimuli (4 seconds in the earlier study, and 16 seconds in the present study). We fitted a least squares line for the previous data over the duration range of 4 to

12 seconds and another least squares line for the present data over the range of durations from 4 to 16 seconds. These two lines were then equated at 8 seconds duration permitting all of the data to be combined as shown in Fig. 14.

Visual examination of the data in Fig. 14 suggests that the effect of duration on perceived noisiness might well be a monotonic function of duration, with a continuously decreasing slope.

Since it appears that one straight line would not adequately describe the results, the curvature of the data was approximated by three lines which were fitted for duration ranges of 1-1/2 to 4 seconds, 4 to 16 seconds, and 16 to 64 seconds.* The slopes of these lines are indicated in Fig. 14.

It might be noted that a least squares line was fitted to the combined data from 4 seconds to 64 seconds with a calculated slope of 2.7 PNdB per doubling of duration, and also to the range from 1-1/2 to 16 seconds with calculated slope of 4.2 PNdB per doubling of duration. These slopes compare quite well with 2.5 and 4.6 PNdB slopes determined for approximately the same ranges of data before the results of the two studies were combined. It seems safe to say, therefore, that combining the data did not significantly alter the results observed before the data were consolidated. A summary of all the slopes and standard deviations for various combinations of data in the earlier and the current study is presented in Table IV.

It should be clearly pointed out that in all tests during both the earlier and the present study, the spectrum of the two signals compared was the same. Additionally, in the present test, the time patterns were the same for the two signals except for the eight samples reported in Fig. 12. The few samples of aircraft flyovers tested are not reported since they provided inconclusive results, probably because of the combined effect of duration, spectrum shape, and presence of pure tones. Therefore, it would

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* These duration ranges were somewhat arbitrarily chosen based on a visual examination of the data; each covers a range of about a factor of four in duration.

seem that before we employ complex stimuli (such as recordings of aircrrft flyover noise) in tests such as those described herein, further work is required to determine the additive effect of duration, spectrum shape, and pure tones on perceived noisiness. Some evidence already exists which supports the theory that the effects of duration and the presence of pure tones may tend to cancel one another in present-day flight operations. Reference 3 reports on judgment tests comparing aircraft noise during approach and takeoff operations. For the same perceived noise level (calculated without corrections for either pure-tone or duration effects), the two kinds of noises were judged equally acceptable even though the approach noise signals contained more pronounced pure tones and were generally of shorter duration than the takeoff noise signals.

TABLE IV

SUMMARY OF LEAST SQUARES CALCULATIONS
FOR VARIOUS DURATION RANGES OF DATA
FROM CURRENT AND PREVIOUS TESTS

Duration Range (Seconds)	Data Set P = Previous C = Combined N = New	Slope for Doubling of Duration ($PNdB/\log_{10}\Delta T$)	Std.Dev. at Sample Mean (PNdB)
1-1/2 - 4	P	-5.4	2.1
1-1/2 - 4	C	-6	2.0
1-1/2 - 12	P	-4.6*	1.7
1-1/2 - 16	C	-4.2	1.8
4 - 12	P	-4.0	1.3
4 - 16	N	-3.1	1.6
4 - 16	C	-3.5	1.5
16 - 64	N	-2.0	1.2
4 - 64	N	-2.5	1.5
4 - 64	C	-2.7	1.8

* Reported as 4.5 dB in the previous study.

IV. RESULTS OF BACKGROUND NOISE TESTS

Before the results of this test were summarized, the individual subject responses were replotted in order of decreasing stimulus level for each type of stimulus presented. A typical subject response plotted in this manner is shown in Fig. 15. Although the results of this subject appear to be somewhat inconsistent, an increase in background noise level tends to decrease the assessed noisiness. The next step was to combine the results of all the subjects. In combining these results, category boundaries were selected midway between adjacent categories. Any responses within this given range were included in the labeled categories. The unlabeled portions of the scale at each extreme were considered as separate categories for this analysis. Using the calculated perceived noise level for each stimulus, an average perceived noise level was determined for each category at each background level. These averages are plotted in Fig. 16. Notice that the data are fairly well ordered. As background level increases, the perceived noise level for the stimuli decreases in most of the categories. As a measure of the spread of the data, the standard deviations for three of the categories are shown in Table V.

To obtain a quantitative measure of this background noise effect, the category judgments for the sound stimuli were replotted as a function of stimulus noise-to-background noise ratio (S/B). The replotted results shown in Fig. 17 have been normalized relative to those obtained with the lowest background noise. That is, for each category rating, the differences between either the 64 PNdB or 80 PNdB curve and the 47 PNdB curve are replotted in Fig. 17. It was assumed that the results with the 47 PNdB (which was used to normalize the category judgments) would not be greatly different from those which might have been obtained with no background noise. However, for those levels of stimuli that approach the background noise of 47 PNdB, we have extrapolated the data to what we feel would have been the results without any noise present. This is indicated by the dotted line extension of the 47 PNdB background level curve shown in Fig. 16. It should be mentioned that, because the standard deviations of this data are approximately 5 dB, they might tend to mask the results shown in Fig. 17. However, we still feel that, even though the spread of the data is large compared with the net effect, the results shown in

TABLE V

STANDARD DEVIATIONS OF PNL's WITHIN CATEGORIES

Background Level (PNdB)	Category: Very Noisy		Category: Somewhat Noisy		Category: Quiet	
	Std.Dev.	n	Std.Dev.	n	Std.Dev.	n
47	5.8	80	5.7	94	4.4	49
64	5.9	60	5.2	84	6.0	62
60	3.4	41	6.2	94	5.6	78

Fig. 17 still represents the trend which we observed. Perhaps some other method of testing might reduce the spread of data which would give the net effect more significance.

The main purpose of this portion of the task was to show whether or not an effect due to background noise did indeed exist. Although we feel that these tests do show that such an effect does exist, certainly a more complete study is necessary in order to reduce the experimental uncertainty before quantitative measure can be used to develop a procedure to modify the perceived noise level calculation for background noise effects.

V. CONCLUSIONS

This study has examined separately the effect of duration and background noise on the judgment of perceived noisiness. The test results have led to the following conclusions:

1) Previous tests have shown that an increase in the duration of an aircraft noise signal produces an increase in its judged noisiness.

   A combination of all previous and current data indicates that the slope showing the effect of duration on perceived noisiness is continuously varying over the range of durations from 1-1/2 to 64 seconds. For practical purposes, the curvature can be approximated by three line segments: 6 PNdB per doubling of duration over the range of 1-1/2 to 4 seconds; 3.5 PNdB per doubling over the range of 4 to 16 seconds; and 2.0 PNdB over the range of 16 to 64 seconds.

   Over the range of durations examined in the present study, 4 seconds to 64 seconds, the perceived noise level increases by an average of 2.5 PNdB for a doubling of duration, compared to the increase of 4.5 PNdB for a doubling of duration found in the previous tests over a range of durations of 1-1/2 seconds to 12 seconds.

   It should be noted that the conclusions of this study are restricted to the comparison of signals having the same spectra and time pattern shapes.

2) The examination of background noise made during this study suggests that the presence of background noise reduces the judged noisiness of an aircraft flyover. However, because the standard deviation is of the same magnitude as the observed effect, we believe that further work is necessary before one can conclude that background noise should be considered in the calculation of perceived noise level.

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2. Kryter, K. D., K. S. Pearsons, "Some Effects of Spectral Content and Duration on Perceived Noise Level," J. Acoust. Soc. Am., 35, 866-883 (1963).

3. Bishop, D. E., Federal Aviation Agency SRDS Report No. RD-65-130 (Dec. 1965).

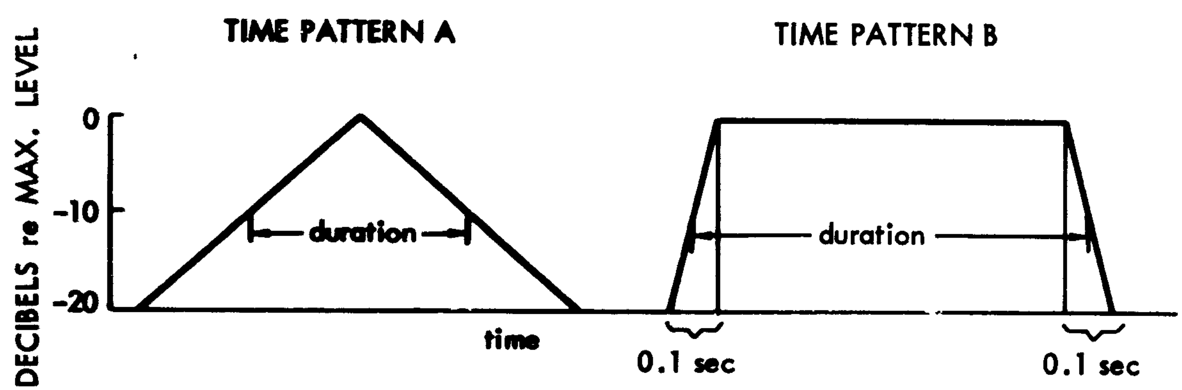


FIGURE 1. IDEALIZED TIME PATTERNS OF SIGNAL EMPLOYED IN THE JUDGMENT TESTS ON DURATION

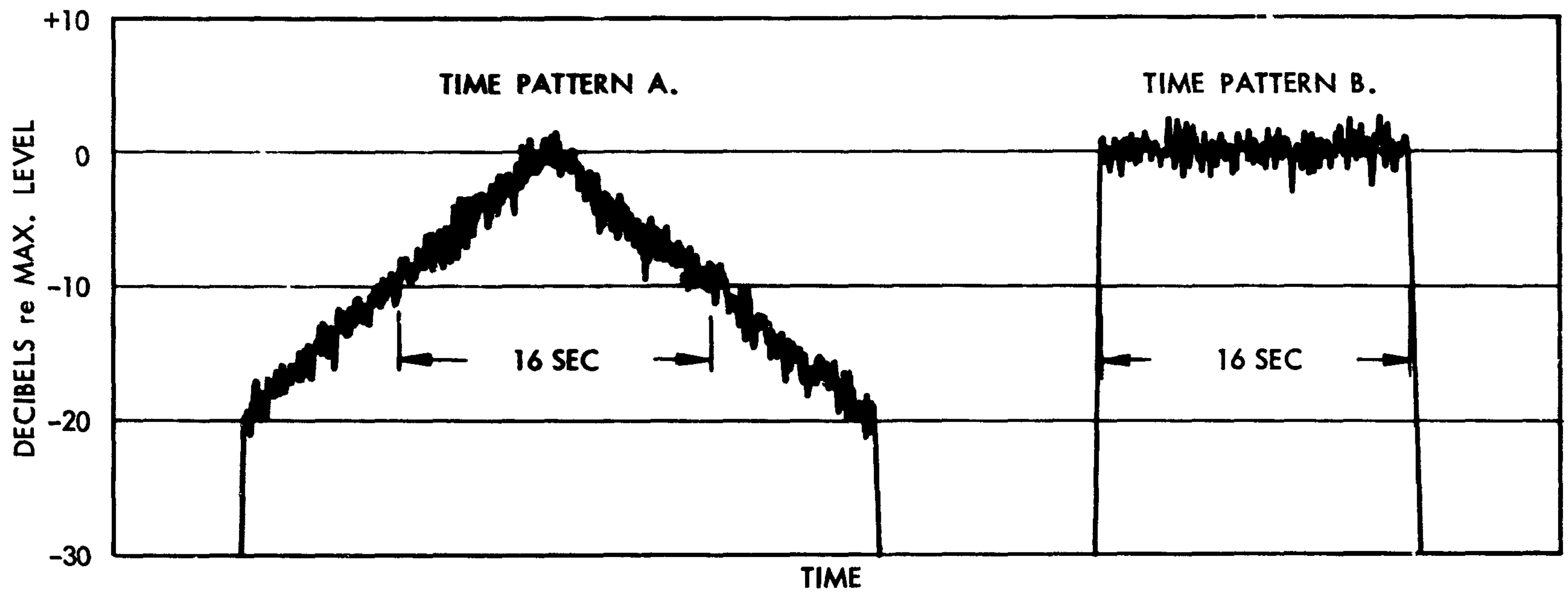


FIGURE 2. MEASURED TIME PATTERNS OF 1/3 OCTAVE BAND NOISE EMPLOYED IN JUDGMENT TESTS ON DURATION

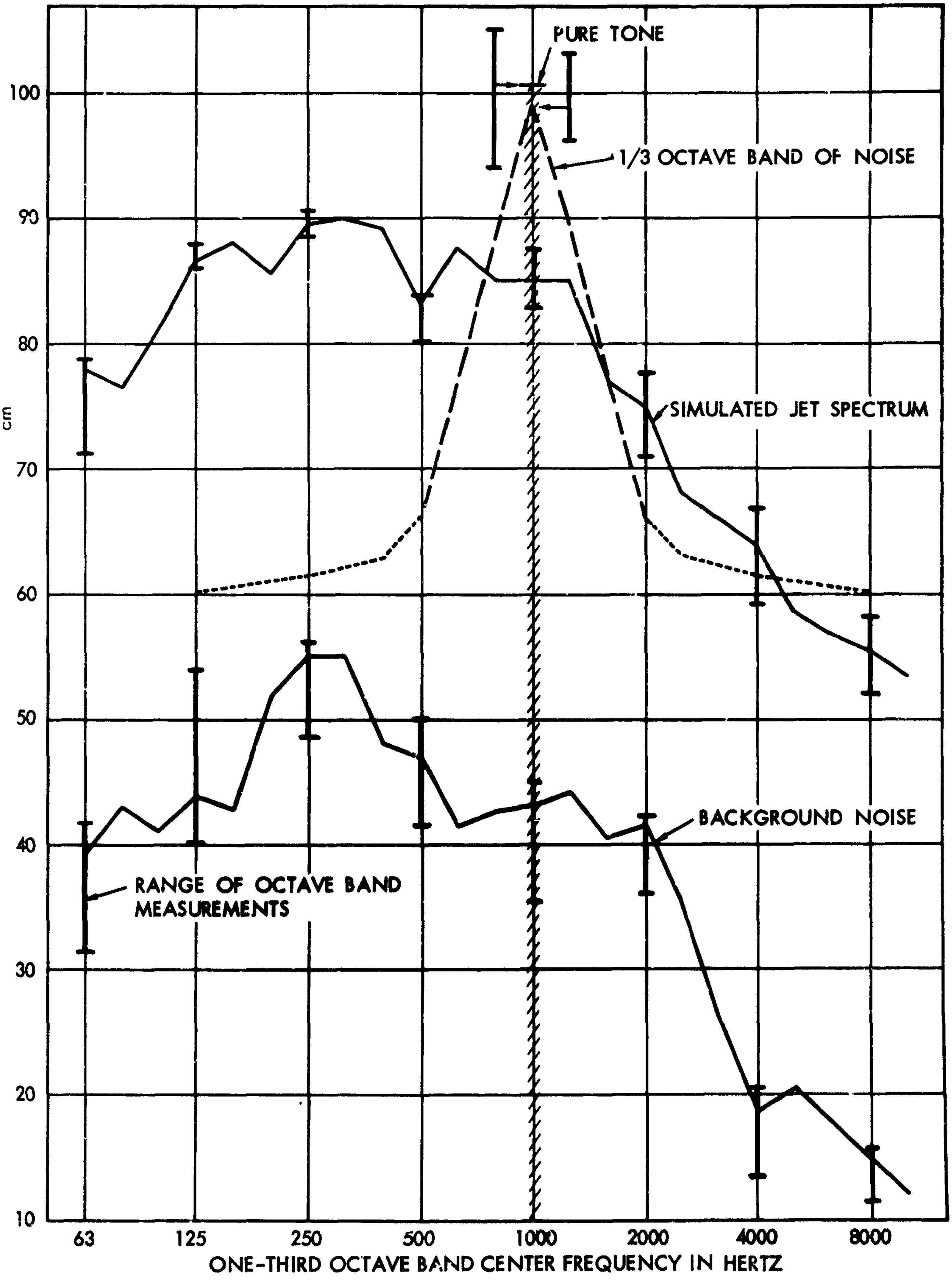


FIGURE 3. SPECTRA OF STIMULI FOR DURATION TESTS AT TYPICAL SEAT LOCATION

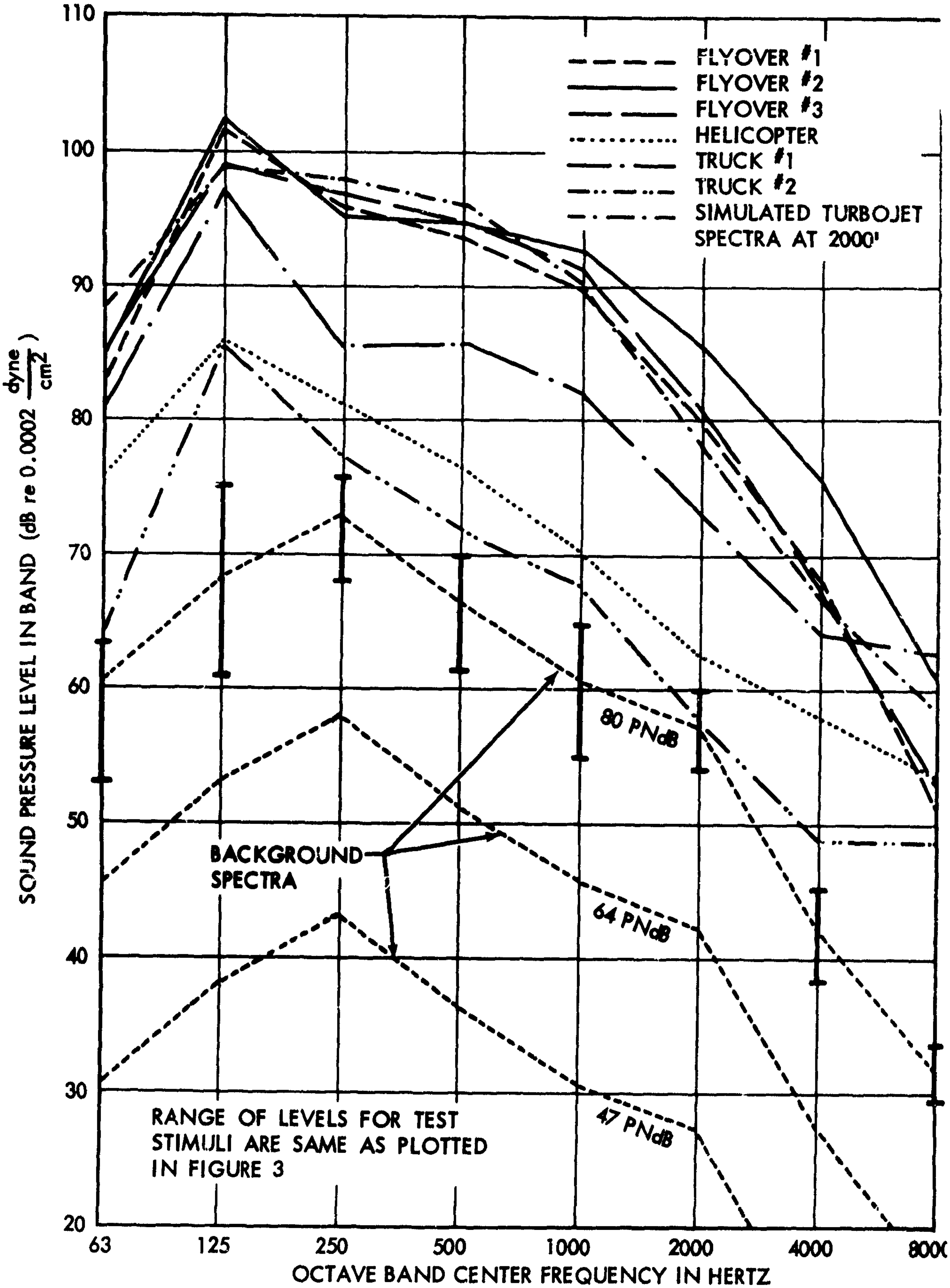


FIGURE 4. AVERAGE SPECTRA FOR BACKGROUND LEVEL TESTS

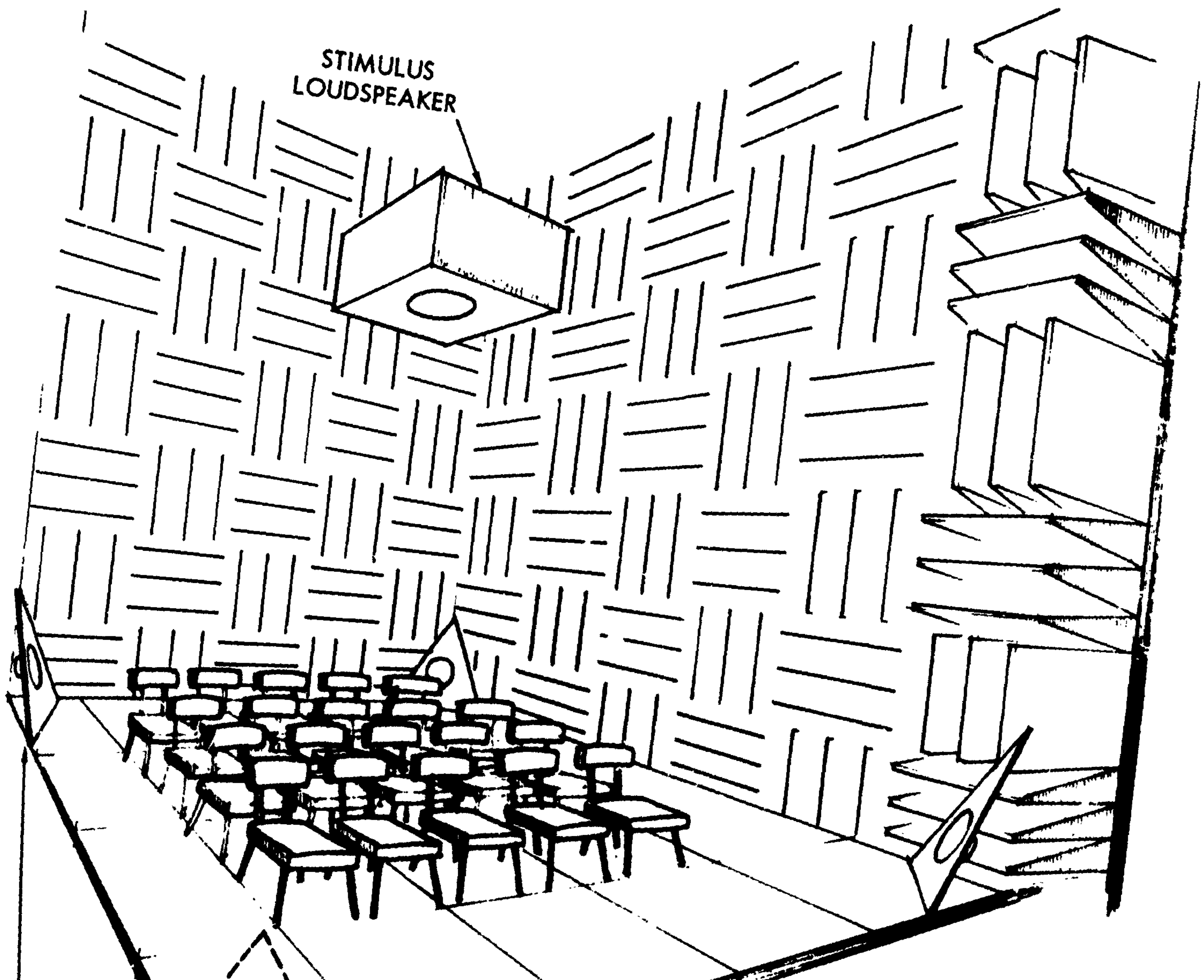


FIGURE 5. ANECHOIC CHAMBER FACILITY FOR DURATION AND BACKGROUND LEVEL TESTS

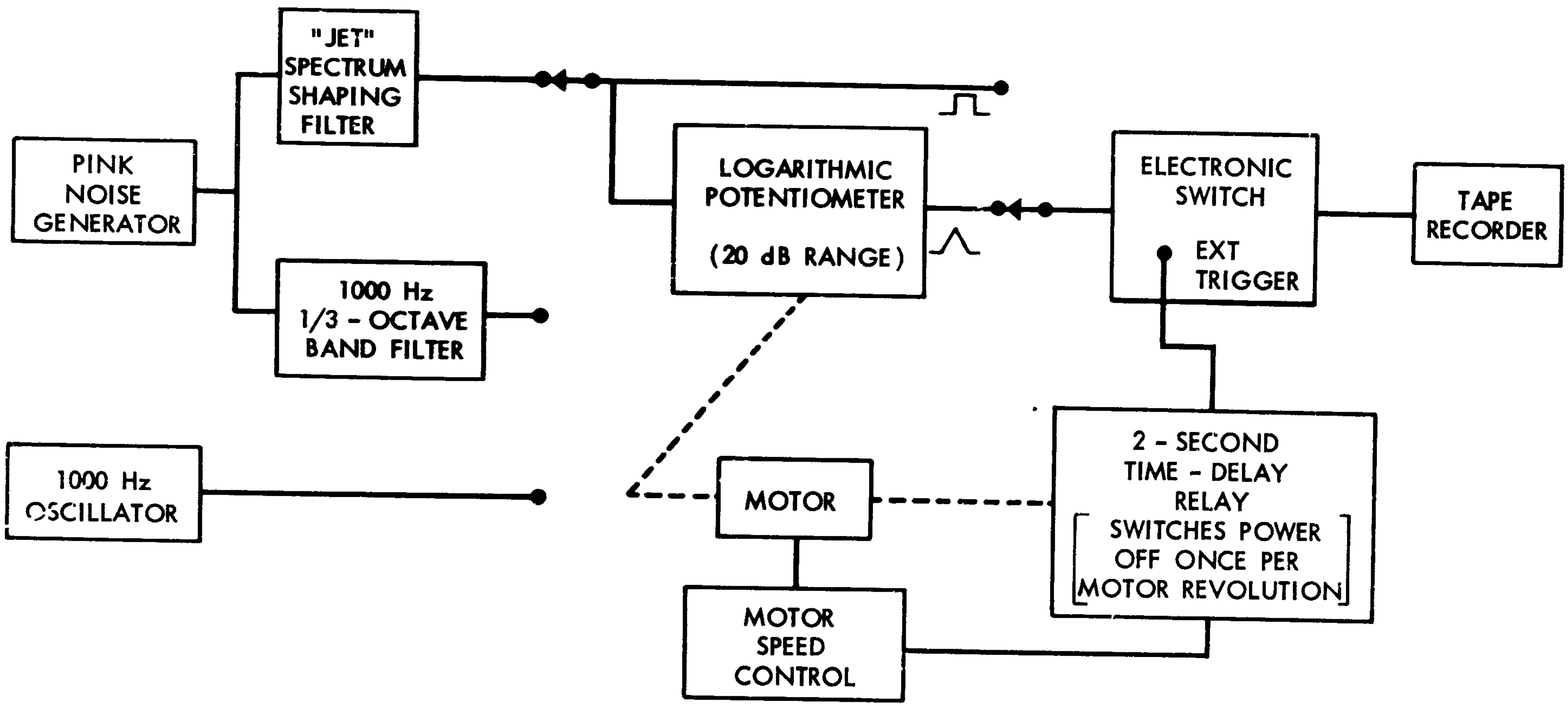
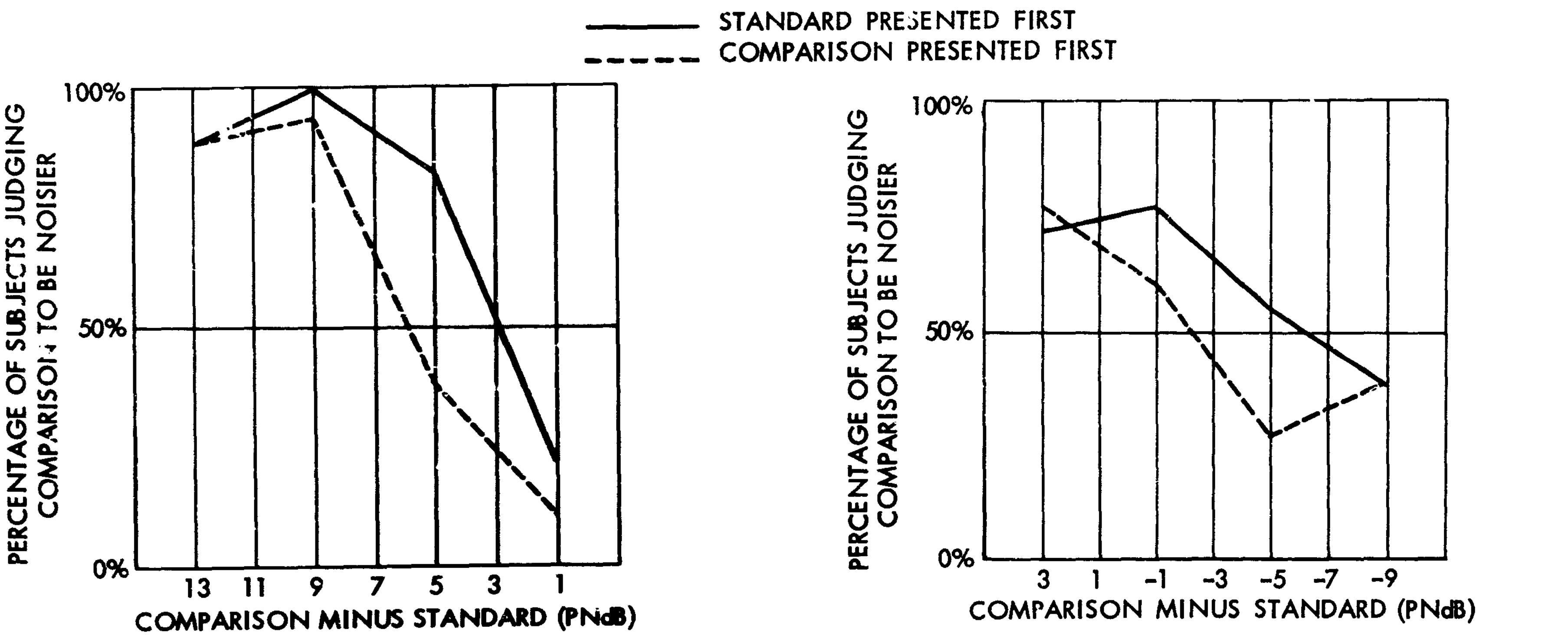


FIGURE 6. BLOCK DIAGRAM OF STIMULUS-GENERATING EQUIPMENT



STANDARD SIGNAL DURATION: 16 SEC
COMPARISON SIGNAL DURATION: 4 SEC
TIME PATTERN A.

STANDARD SIGNAL DURATION: 16 SEC
COMPARISON SIGNAL DURATION: 64 SEC
TIME PATTERN B.

FIGURE 7. SAMPLES OF TEST RESULTS SHOWING EFFECTS OF DURATION ON JUDGED NOISINESS

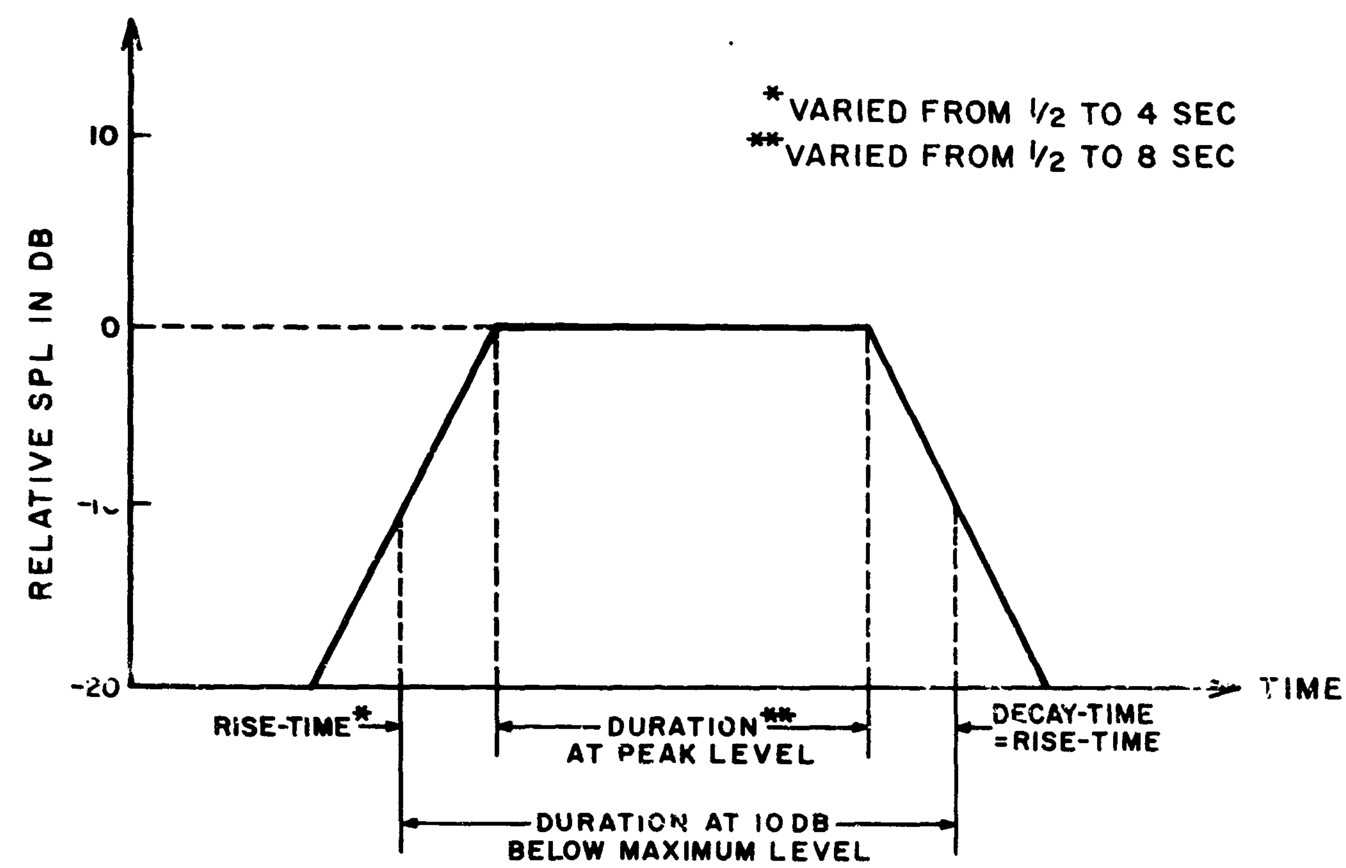


FIGURE 8. TIME PATTERN OF SIGNALS EMPLOYED IN PREVIOUS

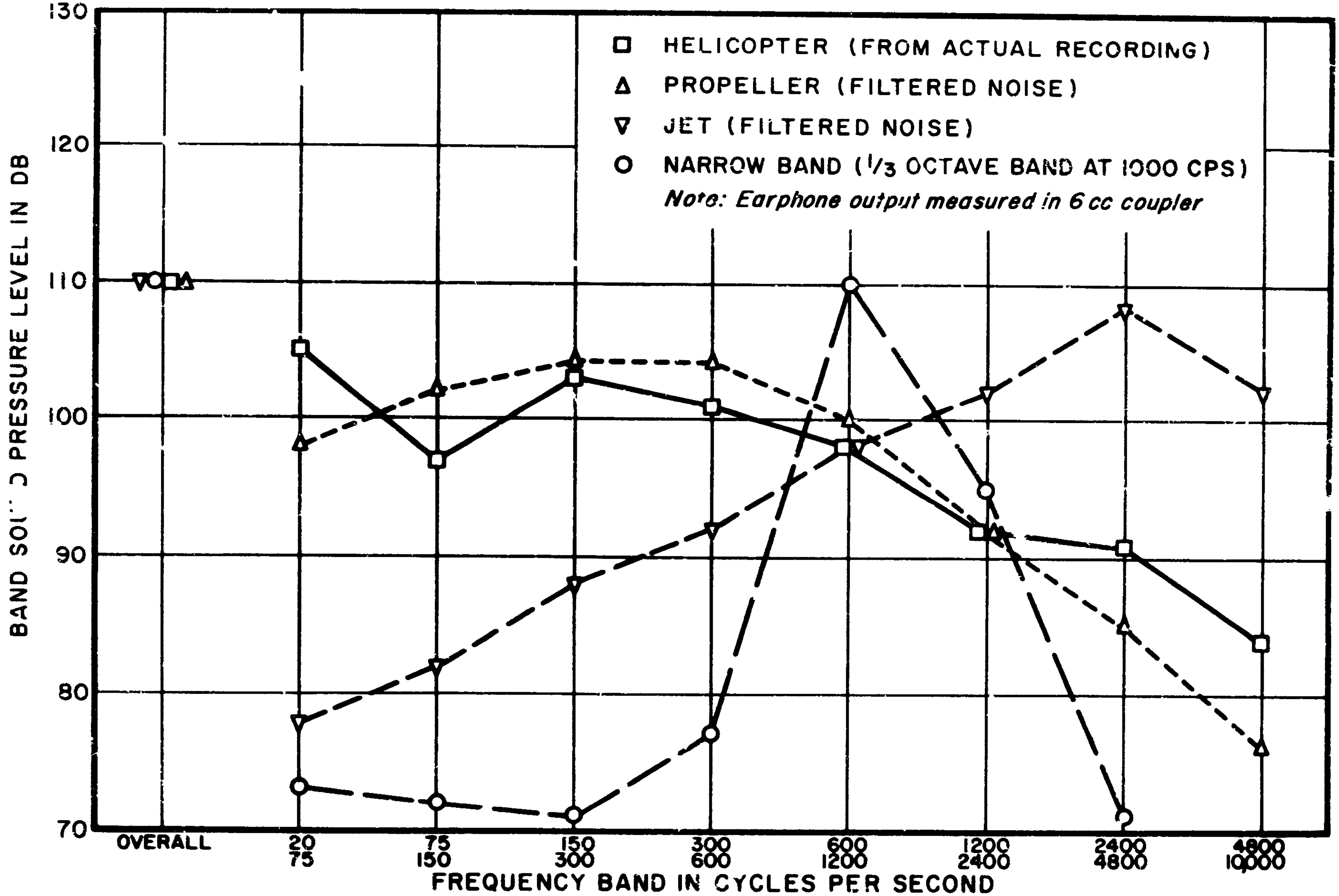


FIGURE 9. SPECTRA OF NOISES FOR PREVIOUS DURATION TESTS (REF 2)

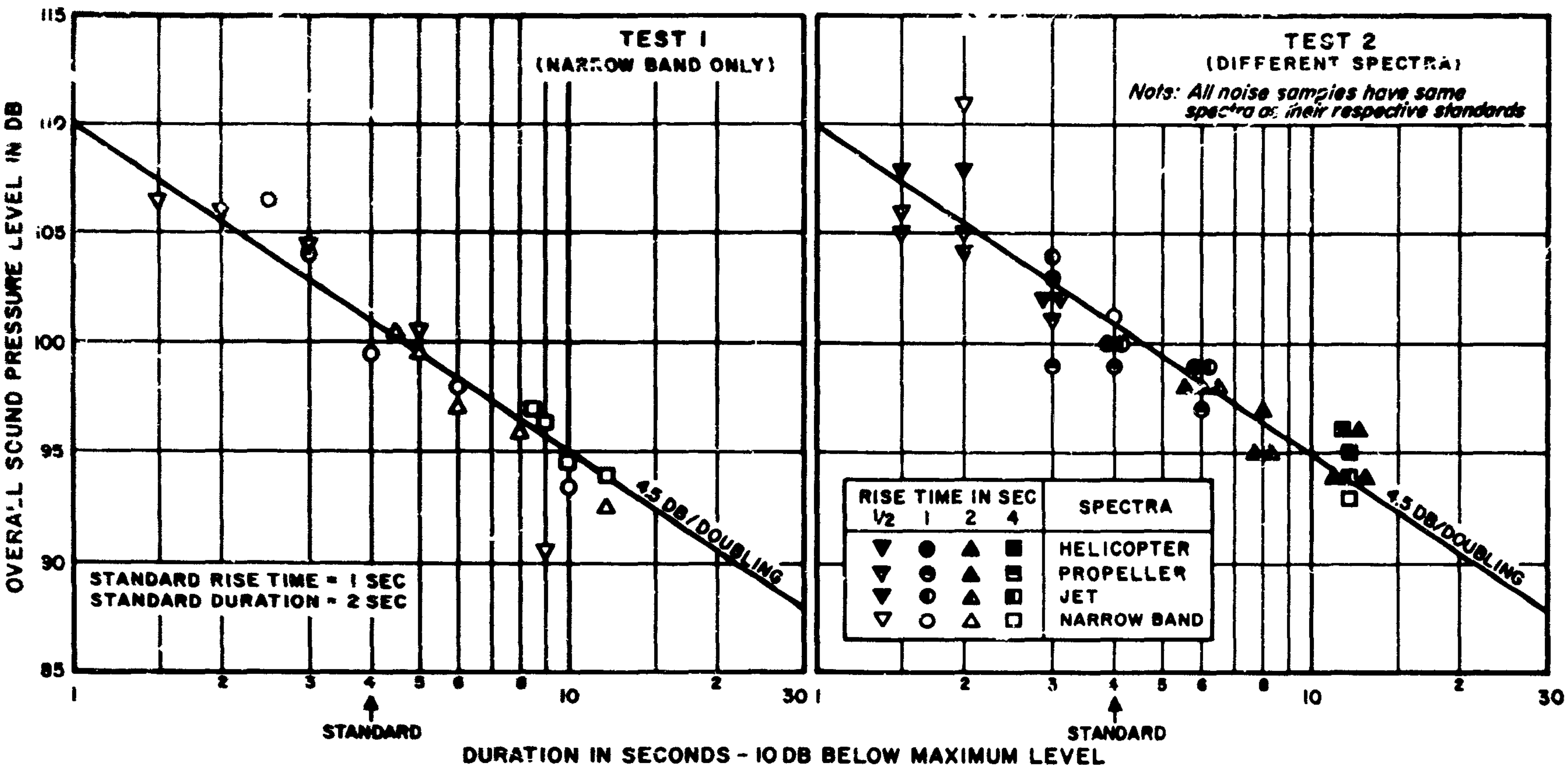


FIGURE 10. EQUALLY ACCEPTABLE NOISES FROM PREVIOUS DURATION TEST (REF 2)

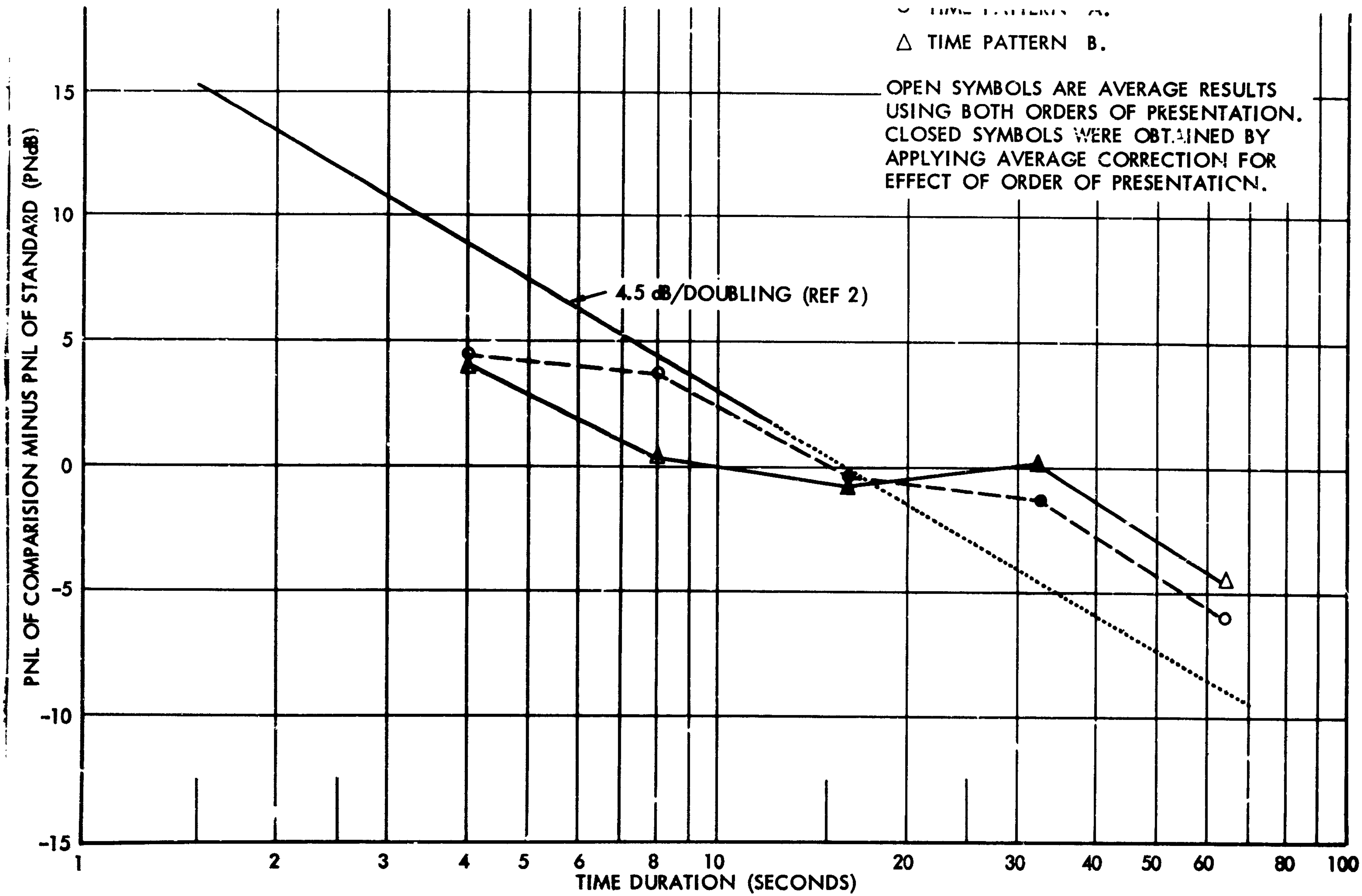
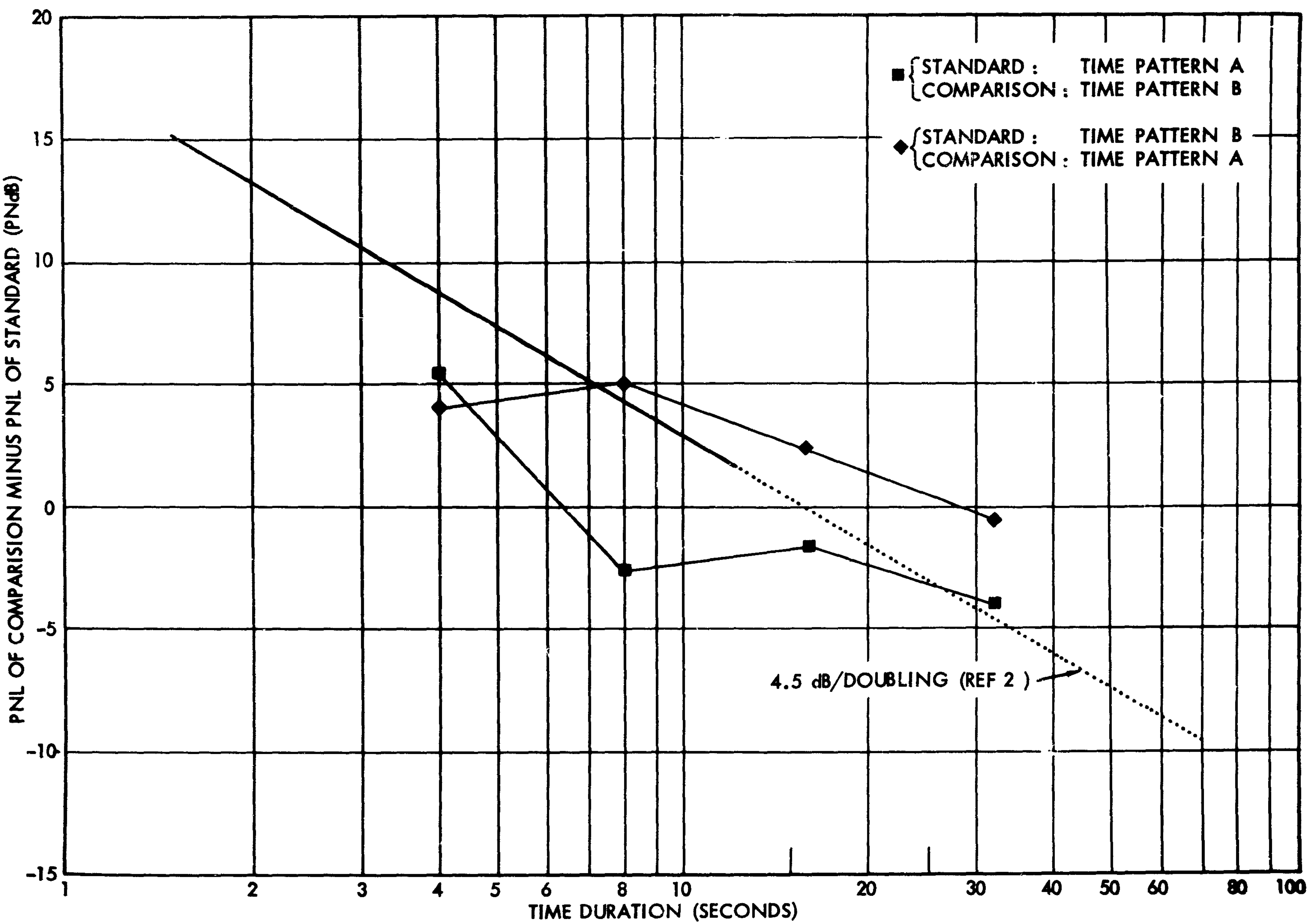


FIGURE 11. EQUALLY ACCEPTABLE NOISES OF VARIOUS DURATIONS WITH SIMULATED JET SPECTRA


STANDARD : TIME PATTERN A
COMPARISON : TIME PATTERN B
STANDARD : TIME PATTERN B
COMPARISON : TIME PATTERN A
4.5 dB/DOUBLING (REF 2)
PNL OF COMPARISION MINUS PNL OF STANDARD (PNdB)
TIME DURATION (SECONDS)
20
15
10
5
0
-5
-10
-15
1
2
3
4
5
6
8
10
20
30
40
50
60
80
100

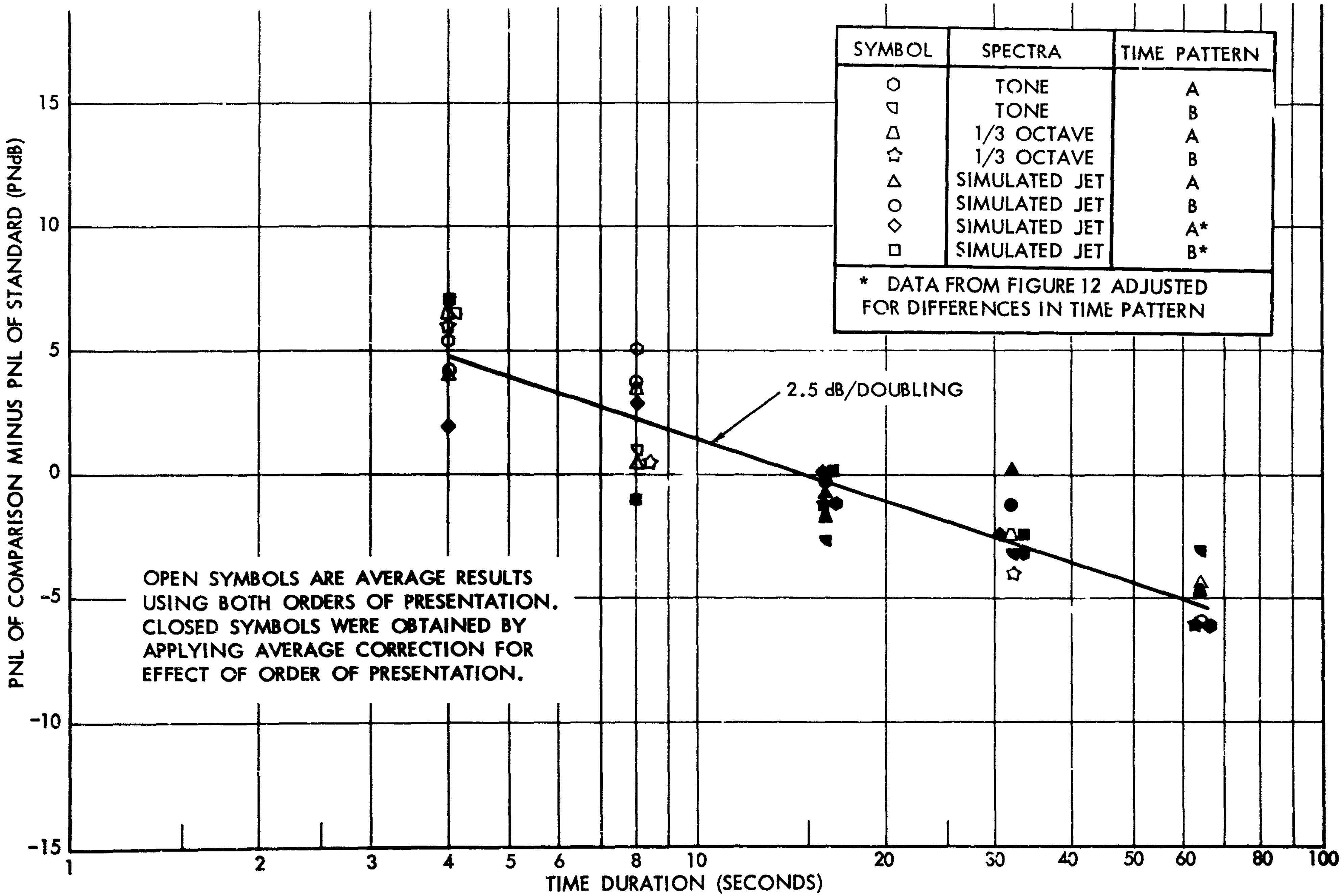
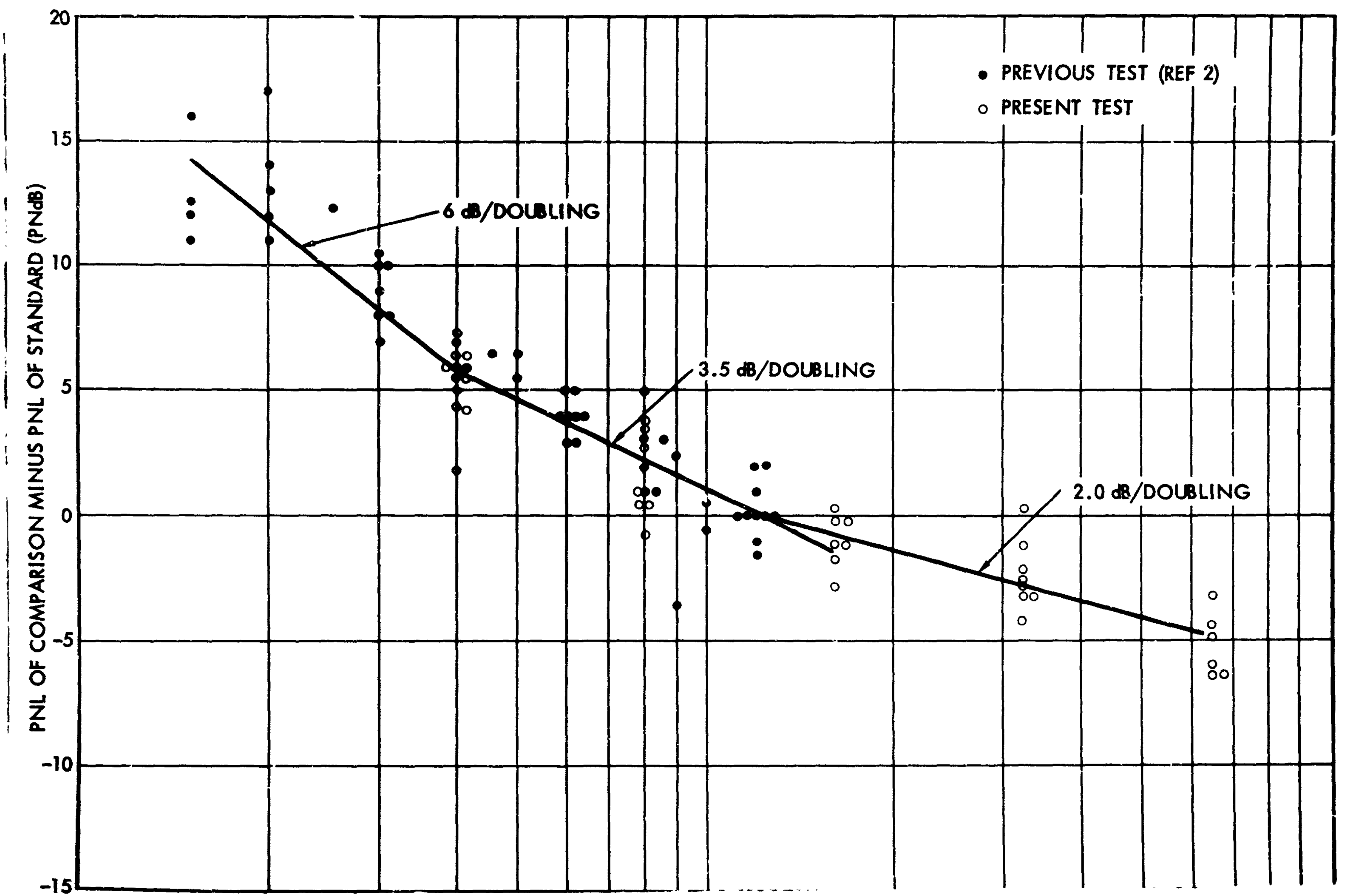


FIGURE 13. EQUALLY ACCEPTABLE NOISES OF VARIOUS DURATIONS (CURRENT TESTS 4 - 64 SECONDS)



PREVIOUS TEST (REF 2)
PRESENT TEST
6 dB/DOUBLING
3.5 dB/DOUBLING
2.0 dB/DOUBLING
PNL OF COMPARISON MINUS PNL OF STANDARD (PNdB)
20
15
10
5
0
-5
-10
-15

DURATIONS (COMBINED TESTS 1.5 - 64 SECONDS)

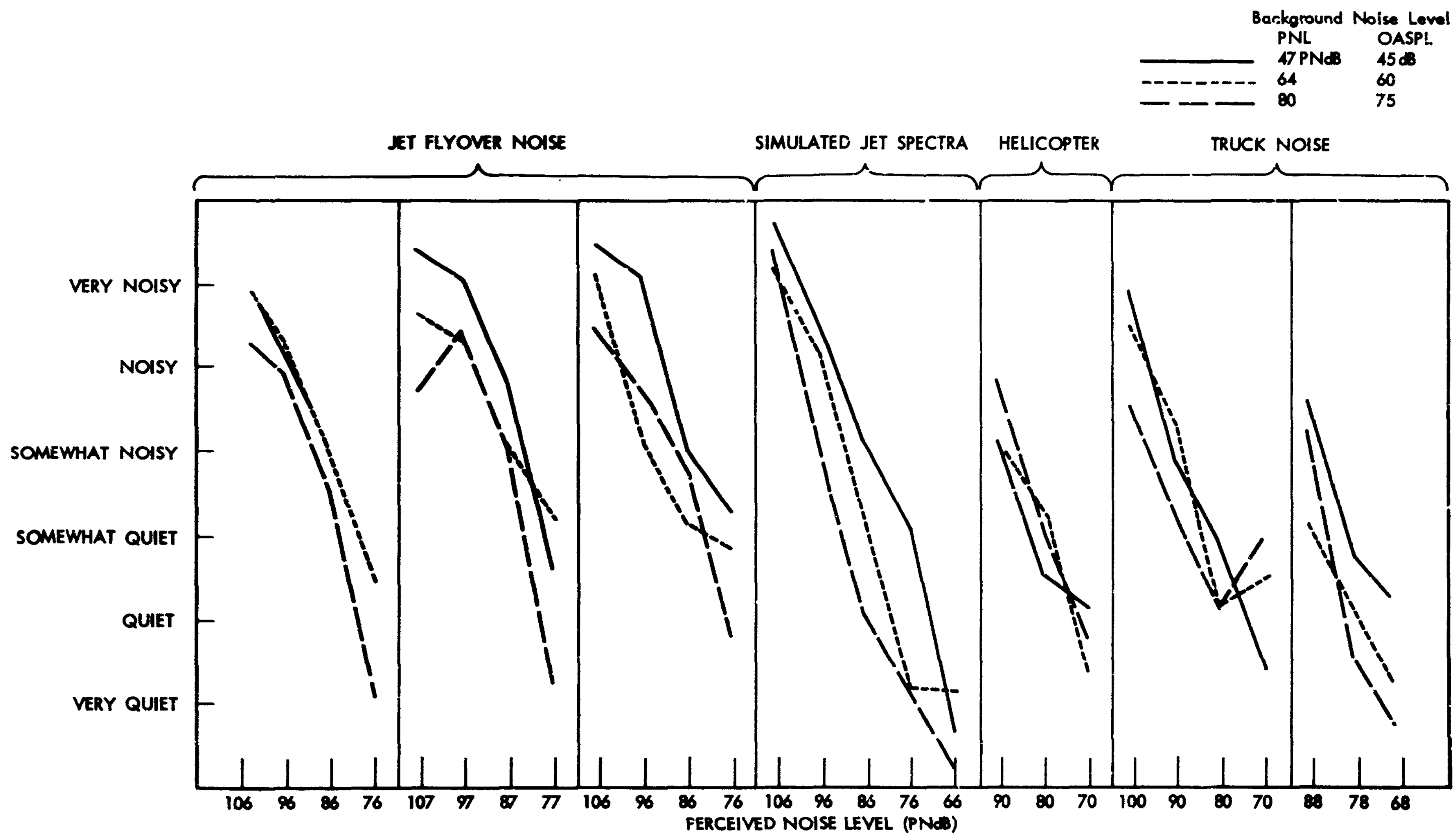


FIGURE 15. TYPICAL SUBJECT RESPONSE FOR BACKGROUND LEVEL TESTS

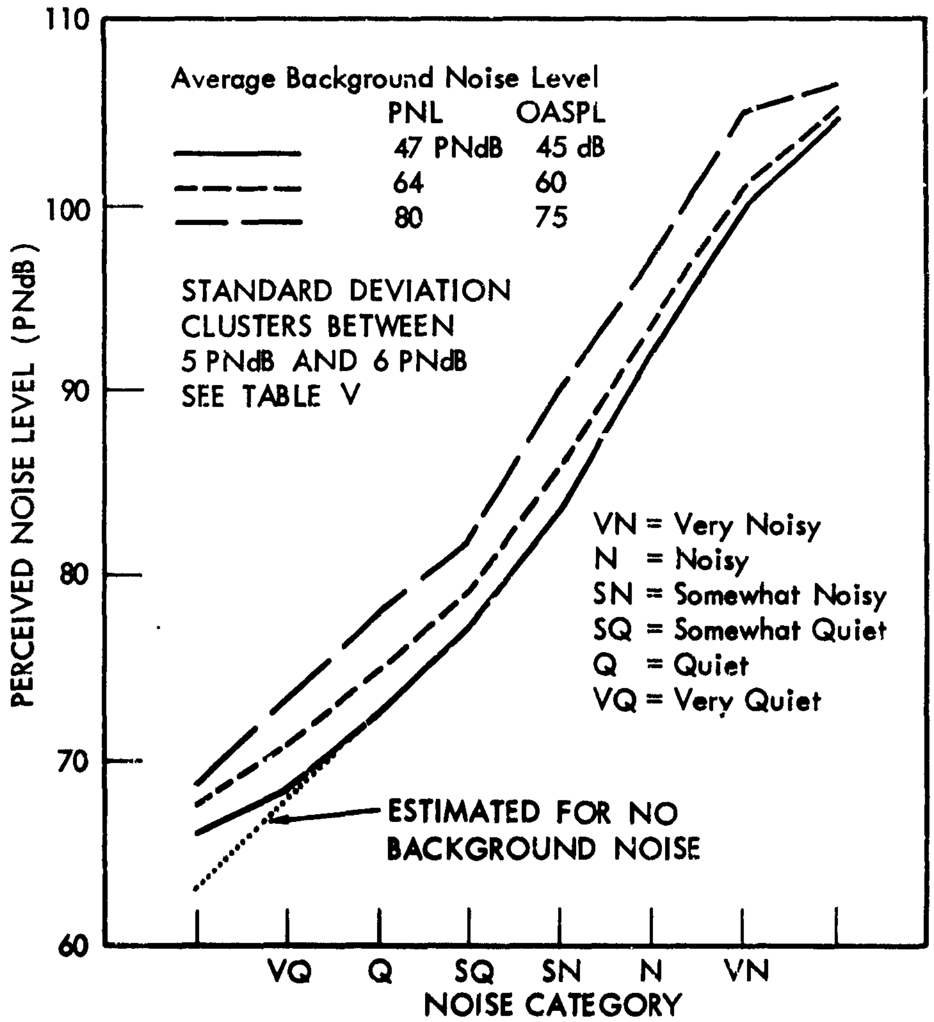
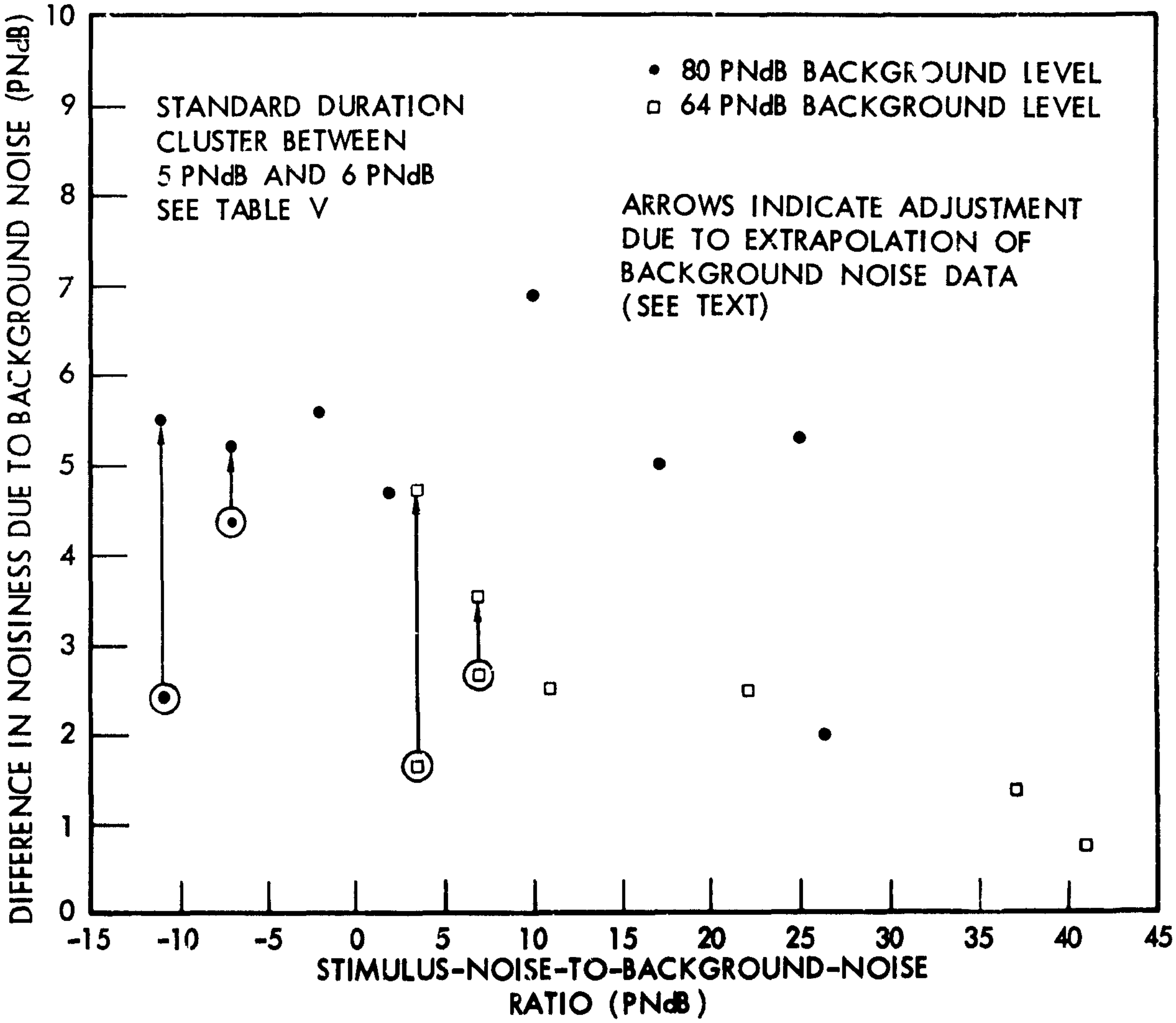


FIGURE 16. CATEGORY SCALE JUDGMENTS SHOWING THE EFFECTS OF BACKGROUND NOISE LEVEL ON THE PERCEIVED NOISE LEVEL OF ALL STIMULI PRESENTED



IGURE 17. EFFECT OF BACKGROUND NOISE ON NOISINESS

APPENDIX A

Measured Durations of Aircraft Flyovers

Previous judgment tests conducted over a range of 1-1/2 to 12 seconds indicate that the duration of a sound influences the judged noisiness of that sound. Since it is desirable to apply this effect in the determination of the noisiness of aircraft flyovers, it becomes important to acquire some knowledge of the duration of aircraft noise experienced in communities adjacent to an airport. To obtain this information, durations of recorded aircraft flyovers were obtained from recordings of aircraft flyovers collected in a previous study for FAA.*

The recordings of the aircraft flyovers were made following takeoff in the vicinity of New York's Kennedy International Airport. It should be noted that the data from flyover recordings reported are mainly associated with aircraft which followed a path along the straight-line extension along the runway. Since some additional recordings were made of aircraft following other paths, they were included in this summary of durations in order to obtain a more general sample of aircraft flyover operations. However, the total sample still is somewhat biased because it contains more of the "straight-out" flyovers than would be observed under normal flight operations.

The locations of the measuring sites relative to the airport runway are shown in Fig. A-1. The equipment employed in the measurement of the aircraft flyovers consisted basically of a Bruel and Kjaer 1/2 in. microphone, Model 4133, a Bruel and Kjaer sound level meter, Model 2203, and a Kudelski tape recorder, Model Nagra III.

The data were analyzed using a Bruel and Kjaer sound level meter, Model 2203, and a Bruel and Kjaer graphic level recorder, Model 2305. An N-network was employed to provide a time history of perceived noise level (PNL) of the flyover. A typical time history is shown in Fig. A-2. The durations reported below were obtained from this time history and taken to include the amount of time the level was within 10 dB of the maximum level. Further details of the measurement and analysis techniques are given in Appendix B of the report.*

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* Galloway, W. J., A. C. Pietrasanta, K. S. Pearsons, "Study of the Effect of Departure Procedures on the Noise Produced by Jet Transport Aircraft" FAA-ADS-41 (March 1965).

Distributions of the duration data obtained at the four measurement locations are shown in Figs. A-3 through A-6. The total number of aircraft observed at each measurement site differs mainly because all planes passing over one measurement site did not necessarily pass over the others. In addition, Position C shows significantly fewer aircraft flyovers than the other positions because recordings were not made at Position C throughout the entire operation.

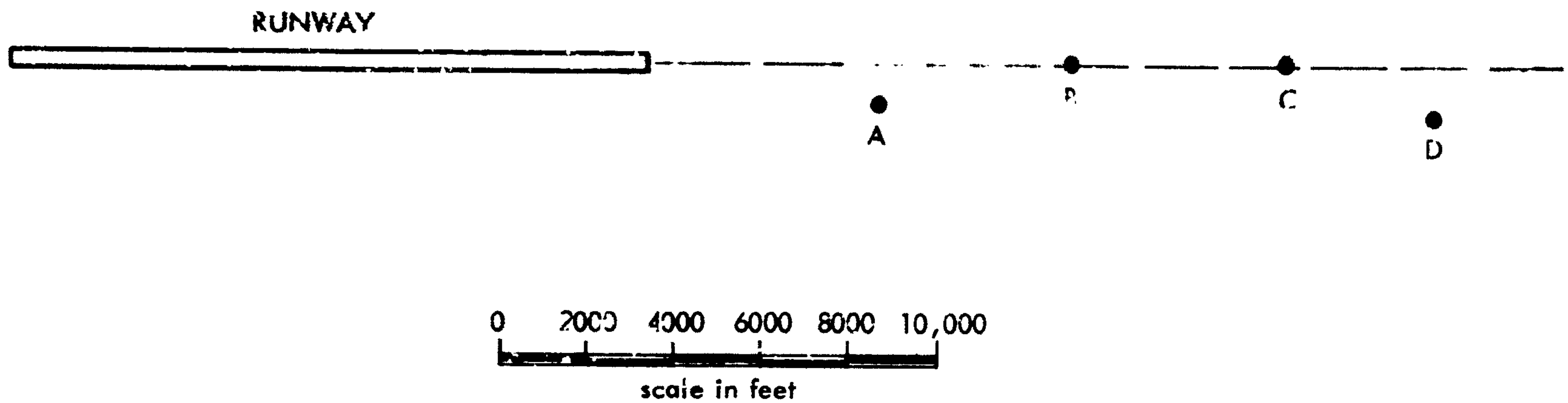
The means of the data are indicated by an arrow on each of the graphs and are tabulated in Table I along with the calculated standard deviations of the data. The range of observed durations indicated by the graphs extends from 6 to 50 seconds. Closer examination of the histograms indicates that 90% of the durations lie within the range of 6 to 32 seconds. Under normal flight operations, this range might extend to longer durations since, as noted above, the sample of aircraft flyover recordings obtained under this study contain more of the aircraft following a "straight-out" path than would normally be experienced.

From the information shown in these histograms and the assumption that the range of durations shown may be slightly biased toward shorter durations, it was decided that a range from 4 to 64 seconds should include most of the aircraft flyover durations encountered in communities near an airport.

TABLE I

SUMMARY OF CALCULATED MEANS AND STANDARD DEVIATIONS OF DURATION INFORMATION

Measurement Location	Number of Aircraft	Mean Duration (Seconds)	Standard Deviation (Seconds)
A	121	17.9	6.6
B	142	18.3	8.2
C	35	18.7	6.4
D	74	23.3	8.0
All Locations	372	19.2	8.2


RUNWAY
A
B
C
D
0
2000
4000
6000
8000
10,000
scale in feet

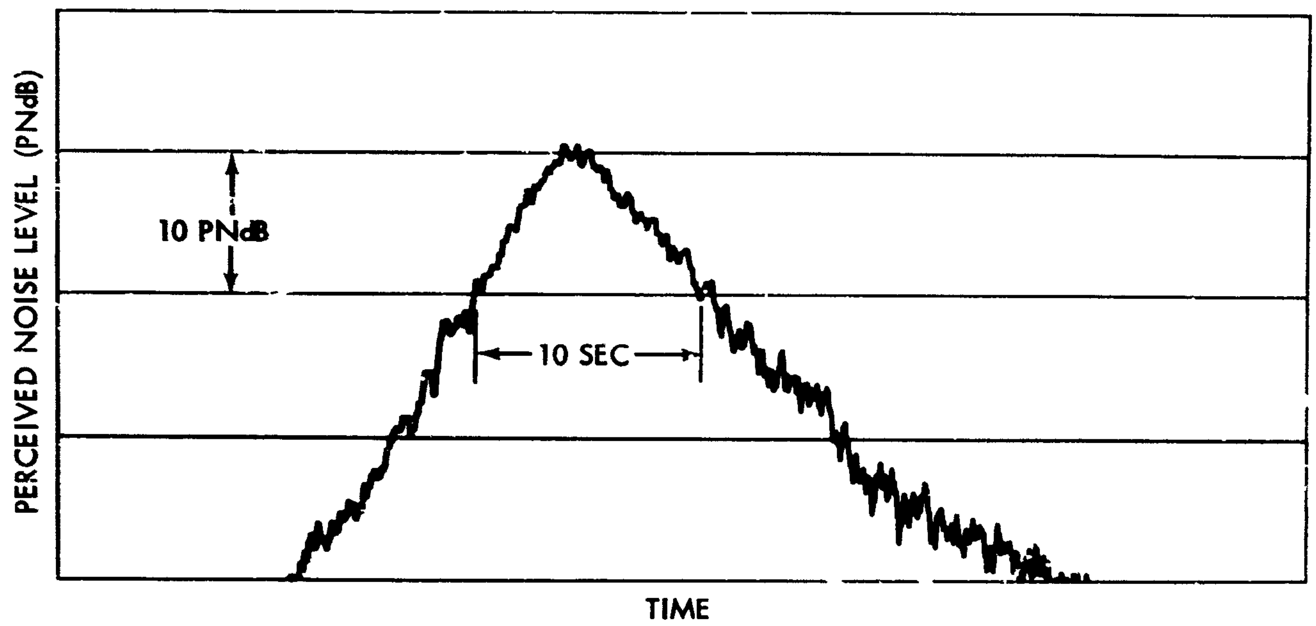


FIGURE A-2. TYPICAL TIME HISTORY OF AN AIRCRAFT FLYOVER

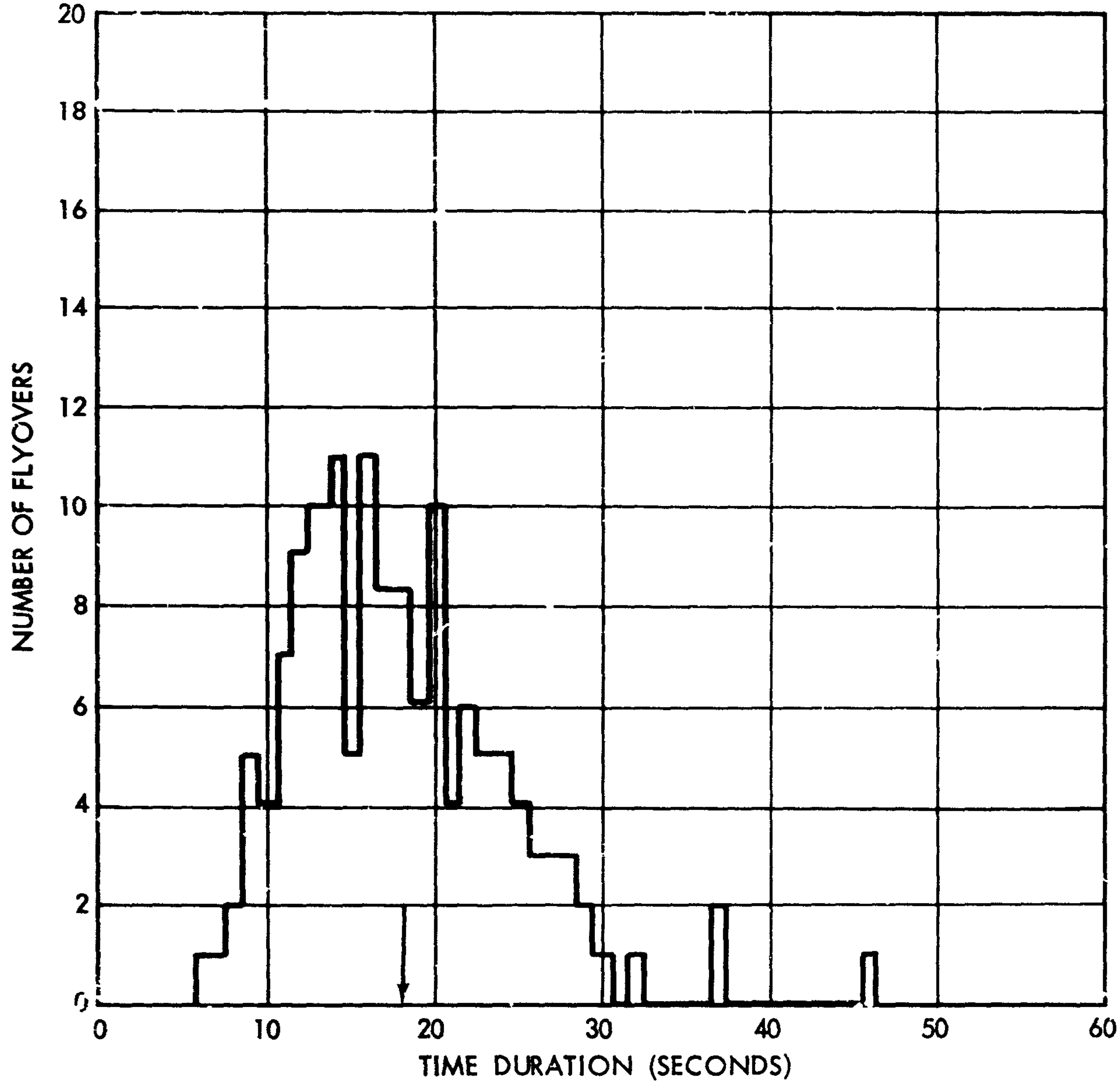


FIGURE A-3. TIME DURATIONS OF AIRCRAFT FLYOVERS AT POSITION A

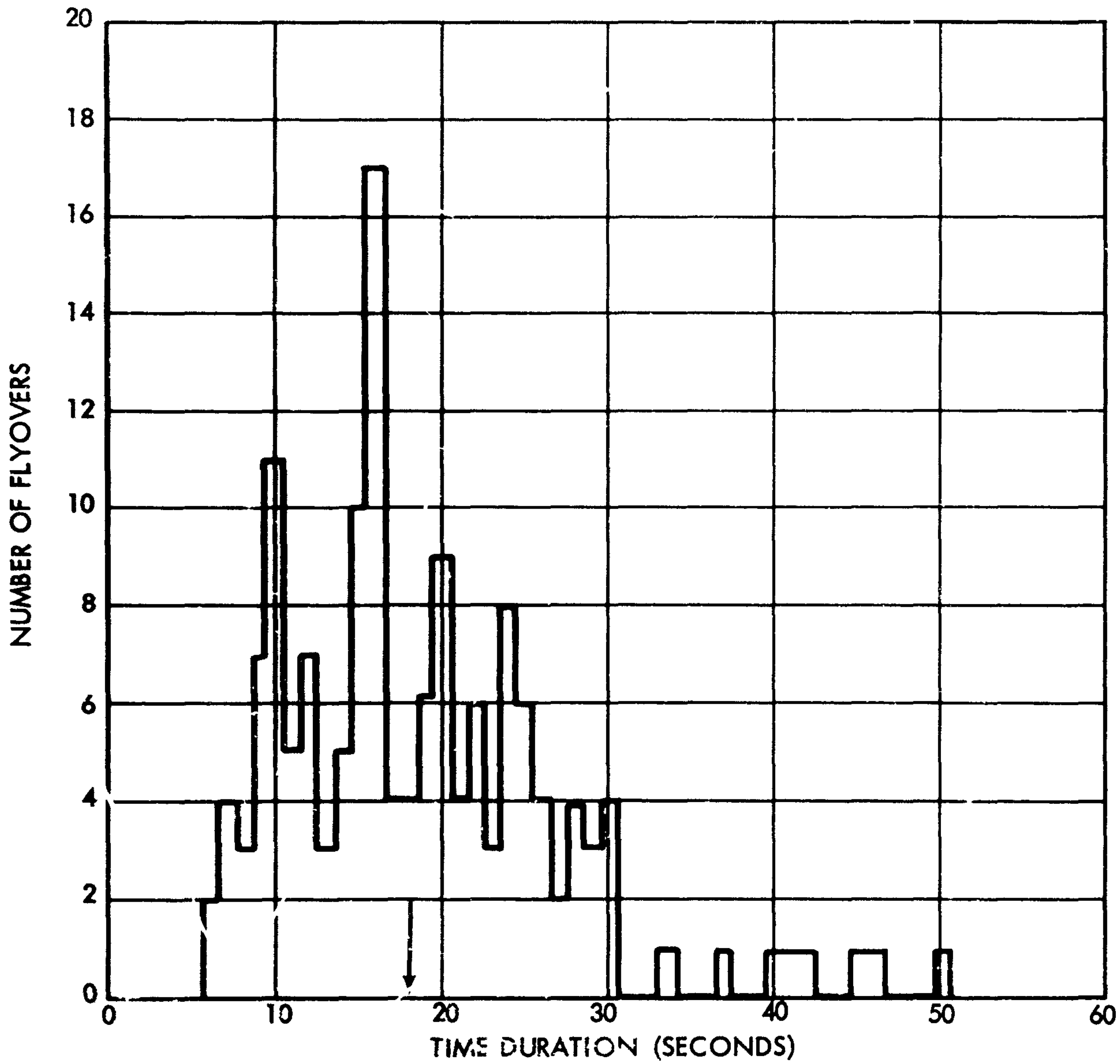


FIGURE A-4. TIME DURATIONS OF AIRCRAFT FLYOVERS AT POSITION B

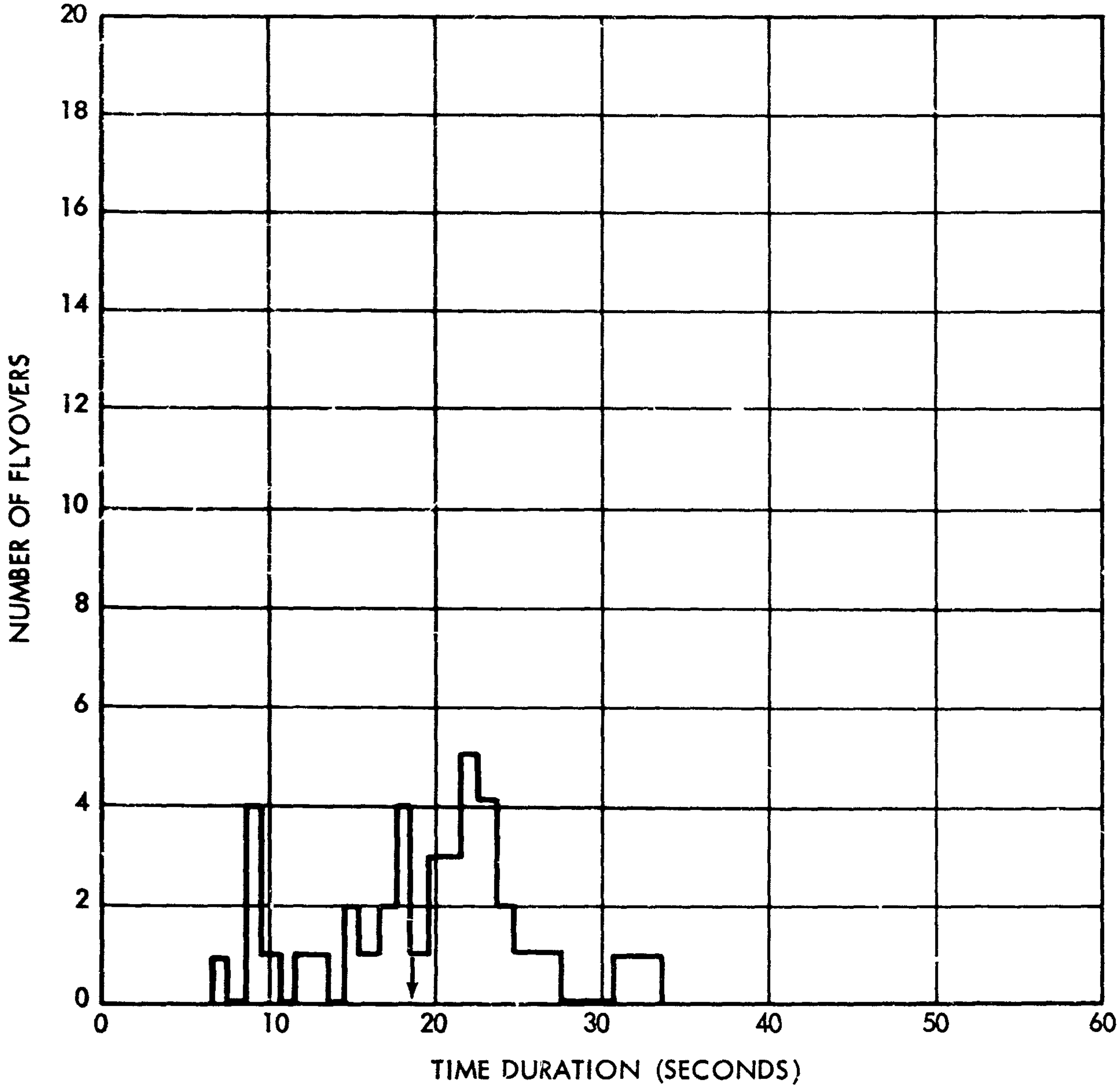


FIGURE A-5. TIME DURATIONS OF AIRCRAFT FLYOVERS AT POSITION C

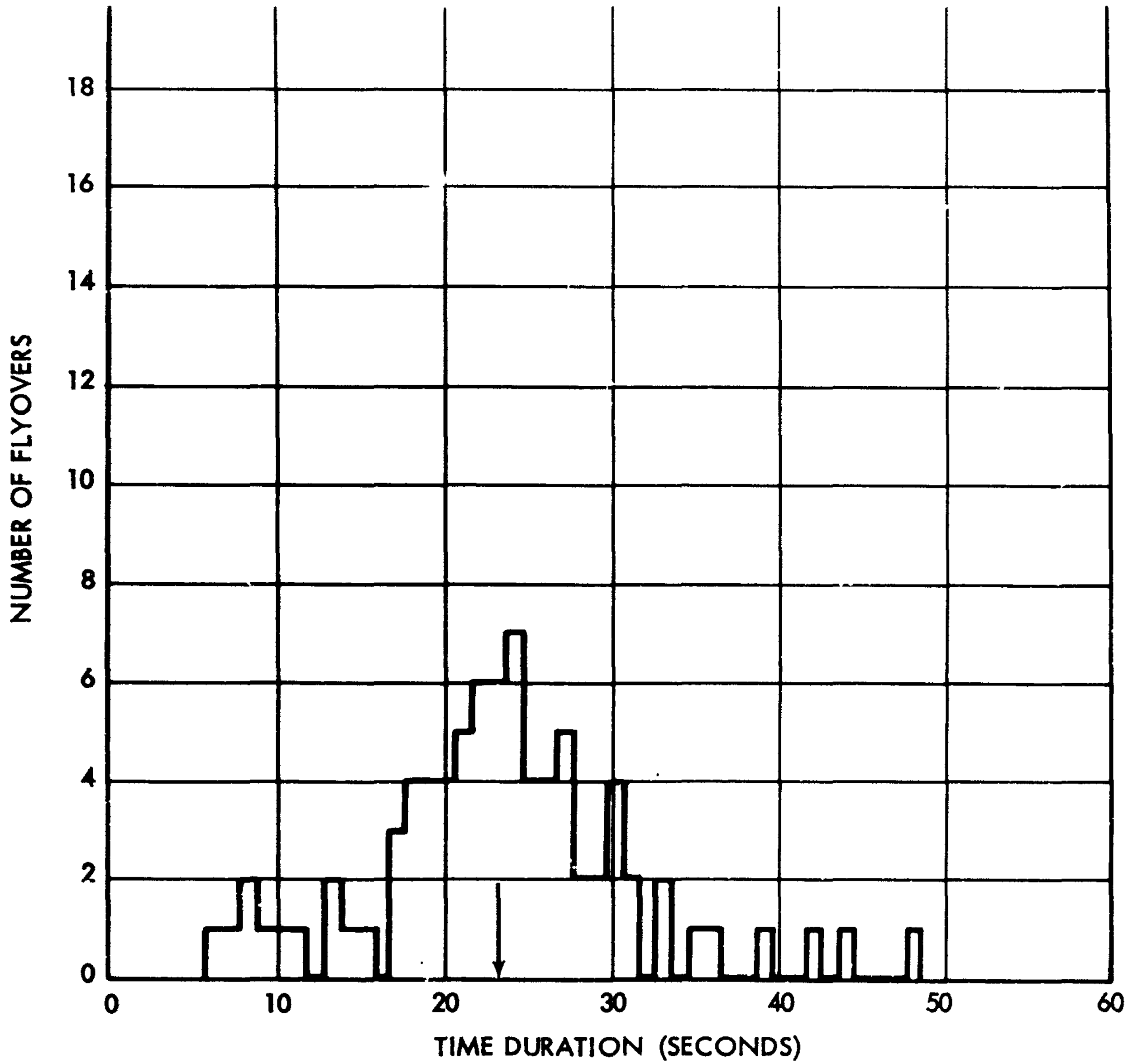


FIGURE A-6. TIME DURATIONS OF AIRCRAFT FLYOVERS AT POSITION D

APPENDIX B

Test Instructions

INSTRUCTIONS [Duration Test] - Paired Comparison

Judgments of Noisiness

The purpose of these tests is to determine the relative noisiness of different sounds. The tests are part of a program of research designed to obtain information that will be of aid in the planning of military and civilian airports and for noise control purposes in general.

When the tests start, you will hear a number followed by two noises presented in quick succession. The number represents a pair of sounds. Your job is to punch a hole in Column 1 or 2 corresponding to the noise (the first or second) which you feel is noisier or more objectionable. Please make a judgment for each pair of noises, even though you feel you may be guessing.

In making this judgment, assume that the noise would occur at your home 20 to 30 times during the day and night. Please remember to include in your judgment the total effect of the sound which may include intensity level, duration, and type of sound, rather than maximum intensity level alone.

Please write on the back of your answer card your name, age, occupation, sex, seat number, and the date. Please remember to use the same seat location each time you take the test.

INSTRUCTIONS [Background Level Test]

Scale of Noisiness

The purpose of these tests is to determine the noisiness of different sounds. The tests are part of a program designed to obtain information that will be of aid in planning land use around airports. During the following test, you will hear recordings of various sounds. Your job is to rate the sound you hear on the following scale of noisiness. According to your rating, place a mark along the scale provided on the answer sheet for each sound. Feel free to mark anywhere along the scale rather than just at the labeled points. The end points of the scale may be used for extreme cases. In making your judgment, consider that the sounds would occur at your home 20 to 30 times during the day and night. For this portion of the test, the number of each sound will appear in the display on the wall in front of you. Please remember to use the same seat location each time you take the test.

NAME DATE SEAT NUMBER

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
Very Noisy																	Very Noisy
Noisy																	Noisy
Moderate																	Moderate
Quiet																	Quiet
Very Quiet																	Ve y Quiet
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	

INSTRUCTIONS [Duration Test] - Method of Adjustment

The purpose of these tests is to determine the relative noisiness of various sounds.

When you move the control switch to "standard" the light will glow and you will hear a noise; this noise will repeat itself over and over until you move the switch. When you move the switch to "comparison," you will then hear a different noise. The overall intensity of the comparison noise may be controlled by turning the knob on the "level control."

Your job is to listen first to the standard noise, then to listen to the comparison noise, and then to adjust the intensity of the comparison noise until it sounds as noisy to you as the standard. By equally noisy, we mean that you would just as soon have one as the other in or outside your home periodically 20 to 30 times during the day and night. Stated another way, we mean by equally noisy that the comparison noise would be no more nor no less disturbing to you in or outside your home than the standard noise.

You may turn back and forth between the two noises as often as you wish and listen to each as long as you wish. It is suggested that before you proceed to equate the comparison noise to the standard noise you make the comparison noise much more intense than the standard; then make the comparison noise much less intense than the standard. With those limits established, adjust the intensity of the comparison noise until it would be just as noisy as the standard noise in or outside your home.

You will notice that you can switch from the standard to comparison and vice versa only during the brief pause that exists between the end and the beginning of each noise. When you feel the two noises are equally noisy, press the "finished" button and turn the switch to comparison. Leave the switch in the comparison position until the light goes out. Then switch to the neutral position. Proceed with the next judgment when the standard light goes on.