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DESCRIPTIONS OF FLYOVER NOISE SIGNALS PRODUCED BY VARIOUS JET TRANSPORT AIRCRAFT

TECHNICAL REPORT

August 1967

by

Dwight E. Bishop

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15808 Wyandotte Street
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Under Contract FA65-WA-1260

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Aircraft Development Service
Washington, D.C. 20590

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ABSTRACT

Descriptions of aircraft flyover noise signals in terms of "effective perceived noise levels" or "integrated perceived noise levels" call for a more detailed analysis of the recorded aircraft flyover signals than has previously been required. To provide a basis for comparing these relatively new measures with other flyover noise measures, this report provides descriptions of maximum levels and time durations for 45 flyover noise signals produced by a variety of turbojet and turbofan transport aircraft in current airline service. The descriptions are based upon one-third octave band noise spectra determined at one-half second intervals throughout the flyover time histories.

Comparisons are provided between integrated perceived noise levels, effective perceived noise levels, perceived noise levels calculated from the maximum third-octave band noise levels occurring during the flyover and N-weighted noise levels. Comparison of various duration measurements and corrections are also presented for durations measured at levels of 10 dB and 20 dB down from the maximum flyover levels. Comparisons indicate high correlation among many of the different measures describing maximum noise levels and duration.

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I. INTRODUCTION

In developing proposed noise criteria for the certification of new jet aircraft (Ref. 1), several relatively new measures of takeoff, approach, and sideline noise levels have been suggested. These measures generally require a much more detailed analysis of the aircraft noise signal than has been undertaken previously. Among the flyover noise measures suggested are the "effective perceived noise level" and the "integrated perceived noise level". Both measures may be calculated from one-third octave band noise spectra determined at half-second intervals during a flyover and both measures include, directly or indirectly, adjustments for the presence of discrete frequency components and for the signal duration. In contrast, the most common measure of aircraft noise in current use is the perceived noise level calculated from the maximum octave or one-third octave band noise levels occurring during the flyover. This measure is calculated from a single determination of octave or one-third octave noise levels for a flyover time history. (Ref. 2, 3)

Descriptions of the flyover noise signals for current aircraft in terms of the effective perceived noise level or integrated perceived noise level are not generally available. In order to provide a basis for comparing these measures of flyover noise with other measures in more common use, Bolt Beranek and Newman Inc. (BBN) undertook a detailed data analysis of a number of flyover signals, as authorized under FAA Contract FA65WA-1260, Modif. 8. This report presents results of the analysis of 45 flyover noise signals produced by a variety of current turbojet and turbofan transport aircraft. Both takeoff and approach flyovers are included, with samples of most types of commercial transport aircraft in current widespread use in this country. The recordings, for the most part, were made at civil airports during takeoffs and approaches of aircraft in regularly scheduled operations.

The data analysis requirements imposed by the definitions of the effective perceived noise level or integrated perceived noise level introduces the needs for flyover noise signal recordings covering a relatively large dynamic range. Therefore, a large number of flyover noise recordings were obtained and screened in order to obtain relatively 'clean' recordings which were finally analyzed.

Section II of this report briefly describes the various measures of flyover noise signals considered, and presents the results of the data analysis in tabular and graphical form.

Data acquisition and reduction techniques, and instrumentation are summarized in Appendix A. The scope of the study did not allow for detailed comparisons of the various measures of the flyover noise signals. However, some of the differences and similarities are briefly summarized in Section III.

II. DATA PRESENTATION

A. Outline of Measured Quantities

The one-third octave band sound pressure levels at center frequencies from 63 Hz to 10,000 Hz were determined at each half-second interval during the recorded flyover time histories. In addition, the N-weighted sound levels were measured at each half-second interval.* The N-weighted levels were included since previous studies had indicated that the maximum N-weighted sound levels are well correlated with perceived noise levels calculated from the maximum octave-or one-third octave band levels occurring during the flyover. Previous study had also indicated that the time durations determined from N-level time histories should be similar to those obtained from perceived noise level time histories. (Ref. 3) The data acquisition and analysis procedures employed are summarized in Appendix A.

1. Maximum Flyover Level Measures

From the one-third octave band noise spectrum determined at each half-second interval, a tone-corrected perceived noise level can be calculated. This quantity will be identified in this report as PNL (0.5 sec). This quantity is determined as follows:

$$PNL\ (0.5\ sec) = PNL\ (1/3\ OB) + F \qquad (1)$$

where

PNL (1/3 OB) = perceived noise level calculated from the noise spectra according to the tables and procedures given in Ref. 2. (This is the usual procedure in calculating the perceived noise level, without corrections for discrete frequencies or duration.)

F = correction for discrete frequency components determined by the procedures and tables of Appendix B.

* The N-weighted sound level is the noise level obtained after passing the flyover noise signal through a frequency weighting network having the inverse of the 40 noy noisiness contour.

From inspection of the PNL (0.5 sec) values occurring during a flyover, the maximum value may be determined. This maximum value is identified as PNL(max). Similarly, from inspection of the PNL(1/3 OB) values, the maximum value of the PNL(1/3 OB) can be identified; this value is designated as $PNL(1/3\ OB)_{max}$.

A third "maximum" value of interest is the perceived noise level (without discrete tone corrections) calculated from the maximum one-third octave band noise levels occurring at any time during the flyover. This quantity corresponds to the perceived noise level quantity value most usually reported for previous flyover data. A fourth "maximum" value was also determined -- the maximum N-weighted sound level.

2. Time Duration

The time duration of a flyover noise signal may be defined as the time, t_K, in which the signal is within KdB of the maximum signal level. Time durations were determined from time histories of the PNL (0.5 sec), PNL(1/3 OB), and the N-weighted sound level. Durations were obtained for values of K equal to 10 dB and 20 dB (i.e., 10 dB and 20 dB down from the maximum levels).

3. Effective Perceived Noise Level

The effective perceived noise level is defined as:

$$PNL_{eff} = PNL(max) + D \tag{2}$$

Where D = a time duration correction determined either from

$$D_{10} = 10 \log \frac{t_{10}}{15} \quad \text{or} \quad D_{20} = 10 \log \frac{t_{20}}{30} \tag{3}$$

4. Integrated Perceived Noise Level

The integrated perceived noise level has also been determined for the flyover time histories. The integrated perceived noise level, PNL_{int} is defined as the addition, on an energy basis, of the PNL (0.5 sec) values over a specified dynamic range:

$$PNL_{int} = 10 \log \sum_{PNL(max)-K}^{PNL(max)} \text{Antilog} \frac{PNL(0.5\ sec)}{10} \qquad (4)$$

The summation indicated by Eq. (4), was performed for values of K equal to 10 and 20 PNdB (i.e., over the uppermost 10 and 20 PNdB of the flyover time history).

D. Data Tabulation

The measures described above are tabulated in Tables I and II for each flyover. In each table, aircraft are identified as to engine type (turbojet or turbofan) and operation (takeoff or landing). The slant distances (i.e., the minimum distance between aircraft and recording microphone during the flyover) are also listed in each table.

Table I lists the various measures of the maximum flyover level. Two values of the effective perceived noise level and integrated perceived noise level are listed. One value was determined considering the upper 10 PNdB of the flyover noise signal (K = 10), the second, with the upper 20 PNdB of the signal considered (K = 20). Also listed are the values of PNL (max), PNL $(1/3\ OB)_{max}$, maximum N-weighted sound level and, in the last column, the perceived noise level calculated from the maximum one-third octave band sound pressure levels occurring at any time during the flyover. (As noted earlier, this last quantity corresponds to the perceived noise level as most commonly calculated from flyover data.) The table also lists the time, with respect to an arbitrary reference, at which the PNL (max), PNL $(1/3\ OB)_{max}$, and the maximum N-weighted sound levels occurred during the flyover.

Table II lists time duration data for each flyover. Shown in the table are the time durations at 10 dB and 20 dB down points as determined from the PNL (0.5 sec), PNL (1/3 OB), and N-weighted time histories. The time duration corrections of Eq. (3) are also tabulated for the PNL (0.5 sec), PNL (1/3 OB) and N-weighted time histories. Also shown are the ratios of the 20 dB- to 10 dB time durations.

In several instances, duration information at 20 dB down points is bracketed in Table II. The brackets indicate possible error, due to insufficient dynamic range in some of the third-octave band time histories.

Figures 1 through 45 depict noise spectra and time history information for each flyover. The upper chart in each figure shows two third-octave band spectra. One is that occurring at the time PNL (max) occurs, the second, the maximum third-octave sound pressure levels occurring at any time during the flyover. The lower chart in each figure shows the time histories for the PNL (0.5 sec), PNL (1/3 OB), and the N-weighted sound level. The chart also shows the calculated perceived noise level of the background noise level for each flyover. This background noise level is governed by the ambient acoustic noise level existing in the field plus the electrical floor of the recording-playback instrumentation.

The difference between the PNL (0.5 sec) and PNL (1/3 OB) value shown in the time history charts represents the discrete frequency corrections determined by the calculation procedure of Appendix B. The variability of third-octave band noise levels determined from 0.5-second samples is high at very low frequencies with variability decreasing as frequency (and bandwidth) is increased. (Ref. 3,4) This variability at low frequencies gives rise to apparent frequency irregularities in the spectra resulting in small discrete frequency corrections even for some spectra which would be judged in listening tests as broadband. The large discrete frequency corrections are, of course, governed by the existence of strong discrete frequency components in the frequency range generally above 1000 Hz.

The N-weighted sound level values listed in Table I are based upon the electrical output from the data reduction system, plus a normalization value based upon previous correlations of N-weighted sound levels and calculated perceived noise levels (based on the maximum levels occurring during the flyover). In preparing the time history plots of Figs. 1 through 45, the N-weighted sound level values have been reduced by 10 dB to increase the ease of reading the curves by eliminating overlap among the various time histories.

III. FLYOVER DATA COMPARISONS

The scope of our program did not provide for detailed examination of the relationships and correlations between the various measures of maximum noise level and time duration. However, we did take a first order step in examining the relationship between measures, by computing the differences between various level and duration measures. Table III presents a tabulation of mean differences and standard deviations of the differences for a number of comparisons. Separate mean and standard deviation values are shown for turbojet and turbofan takeoffs, and for turbojet and turbofan landings. The upper portion of the table lists comparisons for various measures of maximum levels; the lower portion, various measures of time duration.

The first row of Table III compares the differences in the integrated perceived noise level and the effective perceived noise level, both determined over the top 20 dB of the flyover signal. The integrated perceived noise level averages 7 to 9 dB greater than the effective perceived noise level, with standard deviations of the order of 1 dB. The second row compares the differences between integrated perceived noise level determined over the upper 10 and upper 20 dB of the recorded time histories. The mean differences are of the order of 0.3 dB. . In fact, the maximum difference for any of the flyovers is 0.5 dB.

The next four rows in the table compare differences between other measures of maximum noise level. In Row 3, the differences between PNL (max) and PNL $(1/3\ OB)_{max}$, represents differences essentially due to the discrete tone correction. As expected, the differences are largest for landings, particularly of turbofan aircraft.

The fourth row compares the PNL (max) values with the maximum N-weighted sound levels. The mean difference varies from 1.5 to 4.4 PNdB. Row 5 compares PNL $(1/3\ OB)_{max}$ with the N-weighted sound levels. The mean differences are small, ranging from 0.6 to -0.8 dB, with standard deviations of the order of 1.5 dB, indicating quite good correlation between the N-weighted level and the perceived noise level calculated from noise spectra determined at 0.5 second intervals.

The next row (Row 6) compares PNL (max) with the perceived noise level calculated from the maximum third-octave band noise levels occurring at any time during the flyover. The greatest difference is found for the turbofan landings, resulting, of course, from the relatively large discrete tone corrections applied in computing PNL (max) for the turbofan landing data.

The seventh row compares the differences in perceived noise level calculated from the third-octave band spectra at any 0.5-second interval with the maximum third-octave bands occurring at any time during the flyover. The mean differences range from 1 to 2 dB, in accord with previous experience. (Ref. 3)

The remaining columns in Table III present comparisons of different time duration measurements. Rows 8, 9, and 10 compare durations measured at 10 dB and 20 dB down from the maximum levels. The mean differences range from +0.7 to -0.8 dB. The mean duration correction calculated from 10 dB down data is greater than the 20 dB down correction for turbojet takeoffs, and turbofan takeoffs and landings, but not for turbofan takeoffs.

The remaining four rows in Table III compare the various measures of time duration. Rows 11 and 12 compare duration determined from PNL (0.5 sec) data with that determined from the PNL (1/3 OB) time histories (i.e., time histories with and without corrections for discrete frequencies). The last two rows compare the durations determined from the PNL (0.5 sec) time histories and those determined from the N-weighted sound histories. With the possible exception of the turbofan take-off data, the differences in duration corrections are relatively small, averaging less than 0.5 dB. Standard deviations are also of the order of 0.5 dB indicating quite consistent agreement among the various duration measurements. Mean differences and standard deviations are somewhat greater for the turbofan takeoff data.

In general, therefore, the duration data indicate that: a) for most current aircraft (with the possible exception of some turbofan aircraft takeoffs) differences in determining duration corrections at either 10 dB or 20 dB points are not large; and, b) the determination of time durations from N-weighted sound level time histories yields good estimates of the duration determined from time histories of perceived noise levels calculated from third-octave band spectrum at 0.5-second intervals.

REFERENCES

1. "Revised Draft of FAA Noise Certification Procedure", FAA, January 31, 1967.
2. SAE ARP 865, "Definitions and Procedures for Computing the Perceived Noise Level of Aircraft Noise", 1964.
3. D. E. Bishop, "Frequency Spectrum and Time Duration Descriptions of Aircraft Flyover Noise Signals", FAA Technical Report DS-67-6, 1967.
4. W. J. Galloway, "Frequency Analyses of Short-Duration Random Noise", Sound, 1, 31-34, Nov - Dec 1962.

TABLE I

TABULATION OF VARIOUS MEASURES OF THE MAXIMUM FLYOVER NOISE LEVELS

Fig.	Aircraft	Engine	Operation	Slant Distance ft	PNL_{eff} PNdB (1)	PNL_{eff} PNdB (2)	PNL_{integ} PNdB - sec (1)	PNL_{integ} PNdB - sec (2)	PNL(max) PNdB	PNL(max) Time	PNL(1/3 OB) PNdB	PNL(1/3 OB) Time	N(max) dB(3)	N(max) Time	PNL (max 1/3 OB) PNdB
1	Boeing 720	Jet	T/O	370	127.0	126.5	136.0	136.5	131.5	22.0	130.5	21.5	128.0	21.0	130.5
2	Boeing 720	Jet	T/O	550	125.0	124.5	133.5	134.0	127.0	15.5	126.0	15.5	126.0	15.5	127.5
3	Douglas DC-8	Jet	T/O	700	124.0	123.5	133.0	132.5	127.0	17.0	126.0	17.0	126.0	17.0	127.0
4	Convair 880	Jet	T/O	506	124.0	123.5	133.0	133.0	128.5	14.5	127.0	15.0	127.0	15.0	128.0
5	Convair 880	Jet	T/O	820	120.0	120.0	128.5	129.0	123.0	14.0	120.5	16.0	121.0	15.5	121.5
6	Caravelle 6R	Jet	T/O	1264	118.0	118.0	126.0	126.5	118.5	30.5	116.5	30.5	119.0	30.5	117.5
7	Caravelle 6R	Jet	T/O	2394	100.5	102.0	109.0	109.5	103.0	28.5	100.0	28.5	101.0	28.5	101.5
8	Boeing 707	Fan	T/O	870	118.5	121.0	125.5	126.5	124.0	23.5	114.5	23.5	117.0	23.5	120.5
9	Boeing 720B	Fan	T/O	1280	112.0	113.5	120.0	120.5	116.5	22.0	110.5	22.0	110.0	22.0	112.0
10	Boeing 720B	Fan	T/O	880	117.5	117.5	125.5	126.0	121.5	20.5	117.0	20.5	116.0	19.5	118.5
11	Douglas DC-8-50	Fan	T/O	1160	115.0	116.0	112.0	122.5	117.5	17.0	113.5	17.0	113.0	17.0	114.5
12	Douglas DC-8-50	Fan	T/O	1325	116.5	117.0	124.5	125.0	118.0	26.0	114.5	26.0	113.0	24.5	115.5
13	Douglas DC-8-50	Fan	T/O	1343	106.0	108.5	114.0	114.5	108.0	26.0	104.0	28.5	102.0	28.0	105.5
14	Boeing 727	Fan	T/O	1590	109.5	110.0	117.5	117.5	109.5	24.0	107.5	24.0	108.0	24.0	109.0
15	Boeing 727	Fan	T/C	530	115.0	115.5	124.0	124.5	120.0	11.0	119.5	10.5	119.0	10.5	120.5
16	Boeing 727	Fan	T/O	1000	112.0	111.5	121.0	121.0	115.0	13.0	112.5	14.0	112.0	13.5	114.0
17	Douglas DC-9	Fan	T/O	770	111.5	112.5	120.0	120.5	115.0	13.0	113.0	13.0	112.0	12.5	114.0
18	Douglas DC-9	Fan	T/O	1323	102.0	101.5	108.5	109.0	103.5	30.5	99.5	30.5	101.0	30.5	102.0
19	Convair 990	Fan	T/O	992	115.0	116.0	123.0	123.5	118.5	[illegible]	113.5	19.5	112.0	19.0	121.5
20	Convair 990	Fan	T/O	1861	96.5	97.0	104.0	104.5	98.5	17.5	92.5	17.5	91.0	14.0	94.0
21	BAC 111	Fan	T/O	1326	108.5	109.0	114.0	115.0	109.5	24.0	105.0	24.0	107.0	28.0	108.0
22	BAC 111	Fan	T/O	1122	108.5	109.0	115.0	115.5	108.5	45.5	107.0	45.5	107.0	45.5	108.0
23	Boeing 720	Jet	L	1020	112.0	110.5	120.0	120.5	111.5	17.0	108.5	24.5	110.0	25.0	110.0
24	Boeing 720	Jet	L	890	114.5	113.5	122.0	112.5	115.5	13.5	111.[illegible]	17.5	112.0	17.0	113.5
25	Douglas DC-8	Jet	L	1100	109.0	106.5	117.5	117.5	110.0	20.5	106.5	25.0	109.0	25.0	108.5
26	Douglas DC-8	Jet	L	1020	112.5	111.[illegible]	119.5	119.5	114.0	22.0	[illegible]	22.0	110.0	27.0	112.5
27	Convair 880	Jet	L	990	106.5	[illegible]	115.0	115.5	107.5	[illegible]	104.5	20.0	106.0	19.5	105.5
28	Convair 880	Jet	L	960	108.5	[illegible]	115.5	116.[illegible]	104.5	14.0	103.5	21.[illegible]	105.0	14.[illegible]	107.0
29	Caravelle 6R	Jet	L	374	112.5	112.0	120.0	120.5	116.5	36.5	113.[illegible]	36.5	114.0	36.5	115.0
30	Caravelle 6R	Jet	L	428	102.5	101.5	110.5	110.5	106.5	32.[illegible]	104.[illegible]	32.5	102.0	32.5	105.0
31	Boeing 707	Fan	L	1020	117.0	116.0	124.5	124.5	118.5	17.0	112.5	17.0	115.0	14.0	114.5
32	Boeing 707	Fan	L	1010	120.0	118.5	126.5	127.0	112.0	13.5	113.5	20.0	115.0	20.5	115.0
33	Boeing 720B	Fan	L	775	117.0	11[illegible].0	125.5	126.[illegible]	121.5	11.[illegible]	116.[illegible]	11.	118.0	20.5	117.0
34	Boeing 720B	Fan	L	865	118.0	12[illegible].5	124.0	124.0	120.5	13.5	114.5	13.5	115.0	13.0	115.5
35	Douglas DC-8-50	Fan	L	930	117.5	115.5	124.0	124.0	118.5	14.[illegible]	113.5	14.0	115.0	14.0	114.5
36	Douglas DC-8-50	Fan	L	1120	113.0	111.5	120.5	121.0	112.5	19.5	108.5	16.5	111.0	19.0	110.0
37	Douglas DC-8-61	Fan	L	480	114.0	112.5	123.[illegible]	123.0	117.0	[illegible]	113.5	[illegible]	114.0	35.0	115.0
38	Douglas DC-8-61	Fan	L		119.0	118.[illegible]	126.0	126.5	124.5	15.5	11[illegible].5	1[illegible].5	117.0	15.5	119.5
39	Convair 990A	Fan	L	575	109.5	111.[illegible]	117.0	117.5	115.5	27.5	10[illegible].0	27.0	105.0	27.0	107.0
40	Boeing 727	Fan	L	850	112.5	112.5	120.0	120.5	115.5	13.0	109.0	15.0	110.0	14.5	111.5
41	Boeing 727	Fan	L	950	106.0	10[illegible].5	123.0	113.5	103.0	20.5	105.0	20.5	106.0	20.5	105.5
42	Douglas DC-9	Fan	L	1020	107.0	107.5	114.5	114.5	109.5	20.5	10[illegible].0	20.5	108.0	20.5	10[illegible].5
43	Douglas DC-9	Fan	L	539	99.0	99.5	107.0	107.5	103.5	26.0	101.5	26.0	100.0	26.0	102.0
44	BAC 111	Fan	L	447	98.0	100.0	107.0	107.5	101.5	37.0	99.5	37.5	98.0	37.5	102.0
45	BAC 111	Fan	L		107.5	107.5	114.5	115.0	110.0	39.5	106.5	39.5	106.0	40.5	108.0

NOTE: (1) Based upon the upper 10 dB of the flyover signal

(2) Based upon the upper 20 dB of the flyover signal

(3) Includes a normalization value based upon previous correlations of N-weighted sound levels and calculated perceived noise levels (see text).

TABLE II

TABULATION OF VARIOUS MEASURES OF THE TIME DURATION OF FLYOVER NOISE SIGNALS

					PNL(1/3 OB) + F					PNL(1/3 OB)					N-Weighted Sound Level				
Fig.	Aircraft	Engine	Opera-tion	Slant Dist. ft.	T_{10} sec	T_{20} sec	T_{20}/T_{10}	D_{10}	D_{20}	T_{10} sec	T_{20} sec	T_{20}/T_{10}	D_{10}	D_{20}	T_{10} sec	T_{20} sec	T_{20}/T_{10}	D_{10}	D_{20}
1	Boeing 720	Jet	T/O	370	6.0	10.0	1.6[illegible]	-4.0	-4.8	5.5	9.0	1.63	-4.4	-5.2	6.0	11.5	1.91	-4.0	-4.2
2	Boeing 720	Jet	T/O	550	9.5	16.5	1.73	[illegible]	-2.6	8.0	16.0	2.00	-2.7	-2.7	9.0	16.5	1.83	-2.2	-2.6
3	Douglas DC-8	Jet	T/O	700	7.5	14.0	1.86	-3.0	-3.3	7.0	12.5	1.78	-3.3	-3.8	7.5	12.5	1.66	-3.0	-3.8
4	Convair 880	Jet	T/O	506	5.0	9.5	[illegible]	-4.8	-5.0	5.0	9.0	1.80	-4.8	-5.2	6.0	10.0	1.66	-4.0	-4.8
5	Convair 880	Jet	T/O	820	8.0	16.0	2.00	-2.7	-2.7	8.0	16.0	2.00	-2.7	-2.7	10.0	16.0	1.60	-1.8	-2.7
6	Caravelle 6R	Jet	T/O	1264	13.5	26.5	1.96	-0.5	-0.5	13.5	26.5	1.96	-0.5	-0.5	13.0	26.5	2.03	-0.6	-0.5
7	Caravelle 6R	Jet	T/O	[illegible]	26.5	35.0	1.32	2.5	0.8	27.0	36.5	1.35	2.6	0.9	27.5	37.0	1.34	2.6	0.9
8	Boeing 707	Fan	T/O	870	4.0	11.0	2.7[illegible]	[illegible]	-2.3	6.0	13.0	2.16	-4.0	-2.9	7.5	17.5	2.33	-3.0	-2.3
9	Boeing 720B	Fan	T/O	1280	7.5	16.[illegible]	[illegible]	-4.8	-2.0	8.5	19.0	2.23	-2.5	-1.4	10.0	29.5	2.95	-1.8	-0.8
10	Boeing 720B	Fan	T/O	880	6.0	13.[illegible]	2.1[illegible]	-4.5	-3.6	6.0	14.5	2.41	-4.[illegible]	-3.2	7.0	16.0	2.28	-3.3	-2.7
11	Douglas DC-8-50	Fan	T/O	1160	8.5	21.0	2.47	-2.7	-1.6	10.0	23.0	2.30	-1.8	-1.2	12.0	24.5	2.04	-1.0	-0.9
12	Douglas DC-8-50	Fan	T/O	1325	10.5	23.5	2.2[illegible]	-1.[illegible]	-2.1	13.0	29.5	2.26	-0.6	-0.1	15.0	(29.5)	(1.96)	0.0	(-0.1)
13	Douglas DC-8-50	Fan	T/O	1343	10.0	23.0	2.[illegible]	-1.8	[illegible].4	11.5	24.0	2.08	-1.2	0.4	11.5	26.0	2.26	-1.2	0.5
14	Boeing 727	Fan	T/O	1500	15.0	22.0	2.13	[illegible]	0.3	16.0	32.0	2.00	0.3	0.3	18.0	28.5	1.58	0.8	-0.2
15	Boeing 727	Fan	T/O	530	5.0	11.0	2.[illegible]	-4.[illegible]	-4.4	5.0	10.0	2.00	-4.8	-4.8	5.0	11.0	2.20	-4.8	-4.4
16	Boeing 727	Fan	T/O	1000	7.5	14.0	1.8[illegible]	-3.[illegible]	-3.3	7.5	16.5	2.20	-3.[illegible]	-2.6	8.0	18.5	2.31	-2.7	-2.1
17	Douglas DC-9	Fan	T/O	[illegible]	6.5	17.0	2.[illegible]1	-3.[illegible]	-3.[illegible]	7.0	(23.5)	(3.35)	-3.3	(-1.1)	7.5	(15.5)	(2.06)	-3.0	(-2.9)
18	Douglas DC-9	Fan	T/O	13[illegible]	10.5	23.0	1.[illegible]	-1.[illegible]	-1.[illegible]	13.[illegible]	23.5	1.8[illegible]	-0.[illegible]	-1.1	12.0	21.5	1.79	-1.0	-1.5
19	Convair 990	Fan	T/O	[illegible]	7.5	17.[illegible]	2.2[illegible]	-2.[illegible]	-2.1	[illegible]	21.[illegible]	2.21	-2.[illegible]	-1.[illegible]	11.5	28.5	2.47	-1.2	0.0
20	Convair 990	Fan	T/O	1851	9.5	22.[illegible]	2.[illegible]	-2.0	-1.[illegible]	1[illegible].5	38.0	2.[illegible]	0.4	1.0	20.0	42.0	2.10	1.3	1.5
21	BAC 111	Fan	T/O	1326	11.0	26.[illegible]	2.4	-1.4	[illegible]	18.5	34.5	1.8[illegible]	0.[illegible]	0.6	22.0	41.0	1.86	1.7	1.4
22	BAC 111	Fan	T/O	1122	15.0	31.[illegible]	2.1[illegible]	[illegible]	0.5	12.[illegible]	29.5	2.1[illegible]	-1.[illegible]	0.5	1[illegible]	31.5	2.03	0.1	0.5
23	Boeing 720	Jet	L	1[illegible]	1[illegible]	24.[illegible]	1.[illegible]	[illegible]	[illegible]	15.[illegible]	25.[illegible]	1.64	0.1	-0.[illegible]	13.5	22.0	1.62	-0.5	-1.4
24	Boeing 720	Jet	L	8[illegible]	12.5	21.[illegible]	1.[illegible]	[illegible]	-1.[illegible]	1[illegible]	20.5	1.73	-0.[illegible]	-1.3	11.5	22.5	1.95	-1.2	-1.3
25	Douglas DC-8	Jet	L	11[illegible]	12.0	2[illegible]	1.[illegible]	[illegible]	-1.7	1[illegible]	20.5	1.[illegible]	-0.8	-1.[illegible]	12.[illegible]	2[illegible]	1.[illegible]	-0.8	-1.8
26	Douglas DC-8	Jet	L	[illegible]	11.[illegible]	[illegible]	1.5[illegible]	-1.4	[illegible]	12.[illegible]	19.5	1.5[illegible]	-0.8	-1.[illegible]	12.[illegible]	19.5	1.5[illegible]	-0.8	-1.9
27	Convair 880	Jet	L	[illegible]	12.5	2[illegible]	1.[illegible]	[illegible]	-1.[illegible]	1[illegible]	23.5	1.[illegible]	-1.[illegible]	-1.1	11.[illegible]	2[illegible]	1.78	-1.2	-1.7
28	Convair 880	Jet	L	[illegible]	1[illegible]	[illegible]	2.1	-2.[illegible]	[illegible]	14.[illegible]	27.[illegible]	1.8[illegible]	-0.[illegible]	[illegible]	14.5	2[illegible]	1.79	-0.2	-0.5
29	Caravelle 6R	Jet	L	374	[illegible]	11.[illegible]	1.[illegible]	-4.[illegible]	-4.[illegible]	[illegible]	11.[illegible]	1.[illegible]	-3.[illegible]	-4.[illegible]	[illegible]	11.5	1.91	-4.0	-4.2
30	Caravelle 6R	Jet	L	408	[illegible].5	1[illegible]	1.[illegible]1	[illegible]	-4.[illegible]	[illegible]	12.5	1.78	-3.[illegible]	-3.9	[illegible]	12.0	2.00	-4.0	-4.0
31	Boeing 707	Fan	L	1[illegible]	11.[illegible]	1[illegible]	1.[illegible]	-1.4	[illegible]	11.[illegible]	18.0	1.[illegible]	-1.4	-2.2	11.0	18.[illegible]	1.[illegible]	-1.4	-2.7
32	Boeing 707	Fan	L	1010	10.[illegible]	14.[illegible]	1.4	-1.[illegible]	[illegible]	11.[illegible]	1[illegible].0	1.40	-1.4	-2.[illegible]	10.5	15.[illegible]	1.4[illegible]	-1.[illegible]	-2.9
33	Boeing 720B	Fan	L	775	5.5	8.5	1.[illegible]	[illegible]	[illegible]	[illegible]	9.0	1.[illegible]	-4.4	-5.2	[illegible]	[illegible]	1.[illegible]	-4.4	-5.2
34	Boeing 720B	Fan	L	8[illegible]	8.0	11.0	1.[illegible]	-2.[illegible]	[illegible]	[illegible]	12.0	1.[illegible]	[illegible]	-4.[illegible]	[illegible]	12.[illegible]	1.5	-2.7	-3.8
35	Douglas DC-8-50	Fan	L	[illegible]	11.5	15.0	1.[illegible]	[illegible]	[illegible]	[illegible]	15.5	1.[illegible]	[illegible]	[illegible]	[illegible]	14.[illegible]	1.40	-1.8	-3.3
36	Douglas DC-8-50	Fan	L	1120	14.5	18.5	1.[illegible]	[illegible]	[illegible]	1[illegible]	1[illegible]	1.[illegible]	-0.8	-1.[illegible]	11.[illegible]	1[illegible]	1.52	-1.[illegible]	-[illegible].3
37	Douglas DC-8-61	Fan	L	480	7.5	10.5	1.4[illegible]	-1.[illegible]	-4.[illegible]	[illegible]	11.5	1.[illegible]	-3.[illegible]	-4.2	[illegible]	11.[illegible]	1.53	-3.[illegible]	-4.[illegible]
38	Douglas DC-8-61	Fan	L		4.5	[illegible]	1.59	[illegible]	[illegible]	[illegible]	[illegible]	1.[illegible]	-4.[illegible]	-5.2	[illegible]	[illegible]	1.[illegible]	-4.4	-5.2
39	Convair 990A	Fan	L	[illegible]5	4.[illegible]	10.5	2.[illegible]	[illegible]	[illegible]	[illegible]	11.5	2.5[illegible]	-4.8	[illegible]	[illegible]	1[illegible]	[illegible]	-5.[illegible]	-4.[illegible]
40	Boeing 727	Fan	L	850	7.0	14.5	2.[illegible]	[illegible]	-3.[illegible]	[illegible]	18.5	1.54	-2.0	-2.1	[illegible]	18.5	[illegible]	-3.0	-2.1
41	Boeing 727	Fan	L	350	[illegible].5	1[illegible]	2.[illegible]	[illegible]	[illegible]	8.[illegible]	14.[illegible]	1.[illegible]	-2.[illegible]	-1.[illegible]	[illegible]	1[illegible]	2.13	-3.0	-2.[illegible]
42	Douglas DC-9	Fan	L	1020	6.5	13.0	2.[illegible]	[illegible]	[illegible]	1[illegible].5	15.5	1.8[illegible]	-1.[illegible]	-1.[illegible]	8.5	1[illegible]	[illegible]	-2.5	-2.0
43	Douglas DC-9	Fan	L	[illegible]	5.0	11.0	[illegible]	-4.[illegible]	-4.[illegible]	[illegible]	11.5	2.3[illegible]	-4.8	-4.2	4.[illegible]	11.0	[illegible].44	-4.2	-4.4
44	BAC 111	Fan	L	447	[illegible].5	1[illegible].5	2.[illegible]	[illegible]	[illegible]	[illegible]	14.[illegible]	2.1[illegible]	-3.[illegible]	[illegible]	[illegible]	15.0	[illegible]	-4.0	-1.8
45	BAC 111	Fan	L		8.[illegible]	17.5	2.2[illegible]	[illegible]	[illegible]	[illegible]	18.0	1.8[illegible]	-2.[illegible]	[illegible]	[illegible]	1[illegible]	[illegible]	-2.[illegible]	-2.0

TABLE III

A STATISTICAL COMPARISON OF DIFFERENT FLYOVER NOISE MEASURES

ROW	MEASURED QUANTITIES	TAKEOFFS				LANDINGS			
		Turbojet		Turbofan		Turbojet		Turbofan	
		Mean Dif.	Std. Dev.	Mean Dif.	Std. Dev.	Mean Dif.	Std. Dev.	Mean Dif.	Std. Dev.
1	$PNL_{int}(2) - PNL_{eff}(2)$	9.0	0.8	7.4	1.2	9.0	1.2	8.3	1.3
2	$PNL_{int}(1) - PNL_{int}(2)$	-0.3	0.4	-0.5	0.3	-0.3	0.2	-0.3	0.2
3	$PNL(max) - PNL(1/3\ OB)_{max}$	1.7	0.8	3.6	1.6	3.8	1.2	5.2	2.2
4	PNL(max) - N(max)	1.5	1.2	4.2	2.2	3.0	1.3	4.4	2.2
5	$PNL(1/3\ OB)_{max} - N(max)$	-0.2	1.6	0.6	1.2	-0.8	1.2	-0.7	1.2
6	PNL(max) - PNL(max 1/3 OB)	0.7	0.8	1.7	2.0	1.6	0.2	3.8	2.2
7	$PNL(max\ 1/3\ OB) - PNL(1/3\ OB)_{max}$	1.0	0.5	1.9	1.8	2.1	1.0	1.3	0.8
8	$D_{10} - D_{20}$, PNL(0.5 sec)	0.5	0.6	-0.8	0.7	0.7	0.5	0.6	1.2
9	$D_{10} - D_{20}$, PNL(1/3 OB)	0.5	0.6	-0.7	0.7	0.6	0.3	0.3	0.7
10	$D_{10} - D_{20}$, N-level	0.7	0.6	-0.3	0.7	0.5	0.4	0.2	1.1
11	D_{10}(PNL 0.5 sec) - D_{10}(PNL(1/3 OB))	0.2	0.3	-0.9	1.0	-0.3	0.3	-0.4	0.5
12	D_{20}(PNL 0.5 sec) - D_{20}(PNL(1/3 OB))	0.2	0.2	-0.7	0.7	-0.3	0.3	-0.3	0.6
13	D_{10}(PNL(0.5 sec)) - D_{10}(N-level)	-0.2	0.4	-1.4	1.2	0.1	0.5	0.0	0.5
14	D_{20}(PNL(0.5 sec)) - D_{20}(N-level)	0.0	0.3	-0.9	1.0	-0.1	0.4	-0.3	0.4

NOTE: (1) Based upon the upper 10 dB of the flyover signal
(2) Based upon the upper 20 dB of the flyover signal

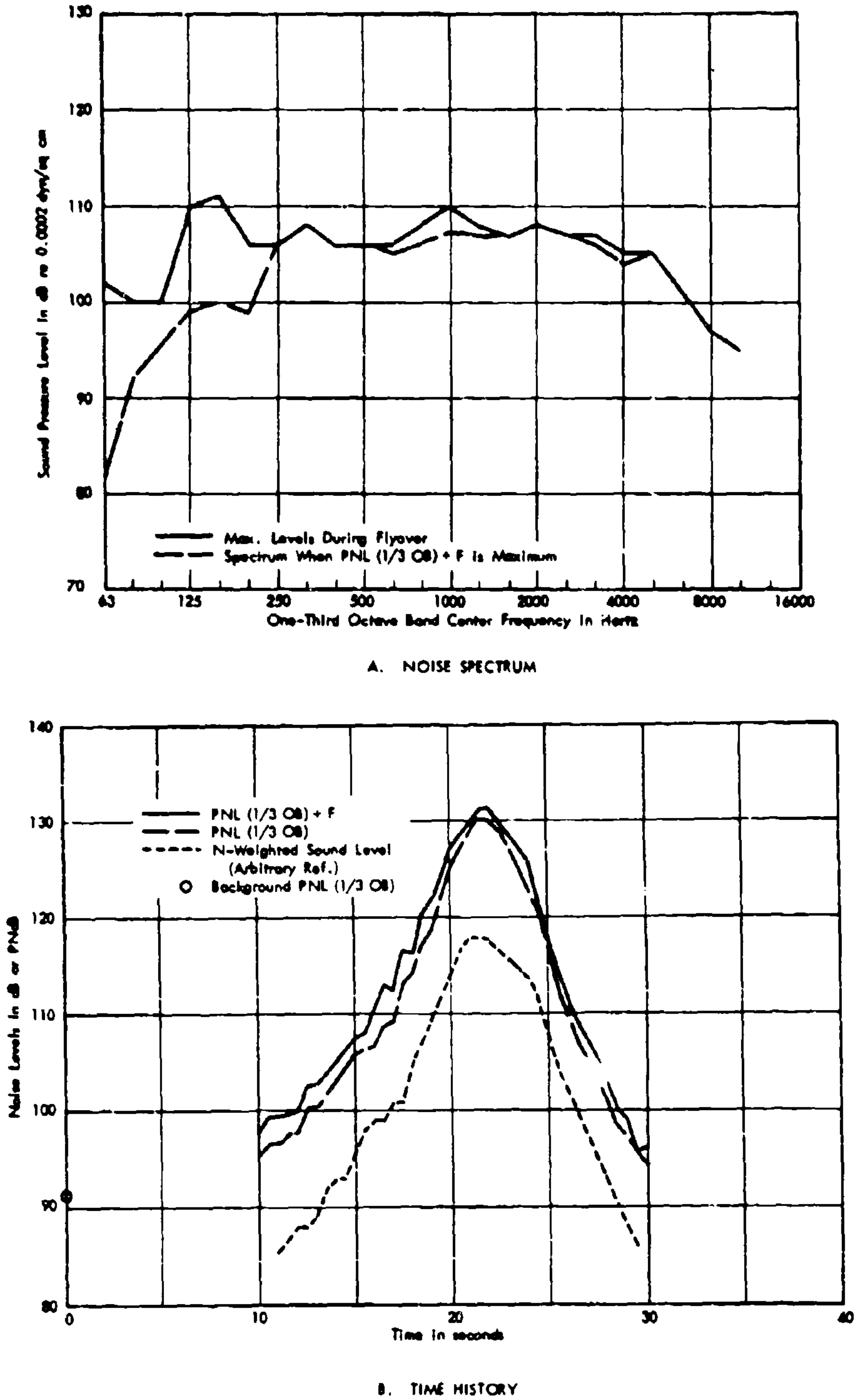
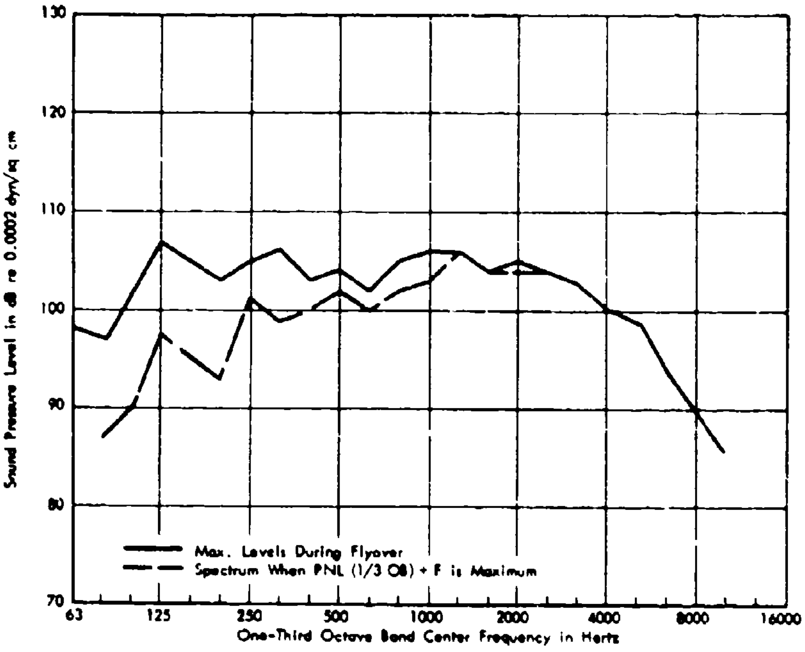
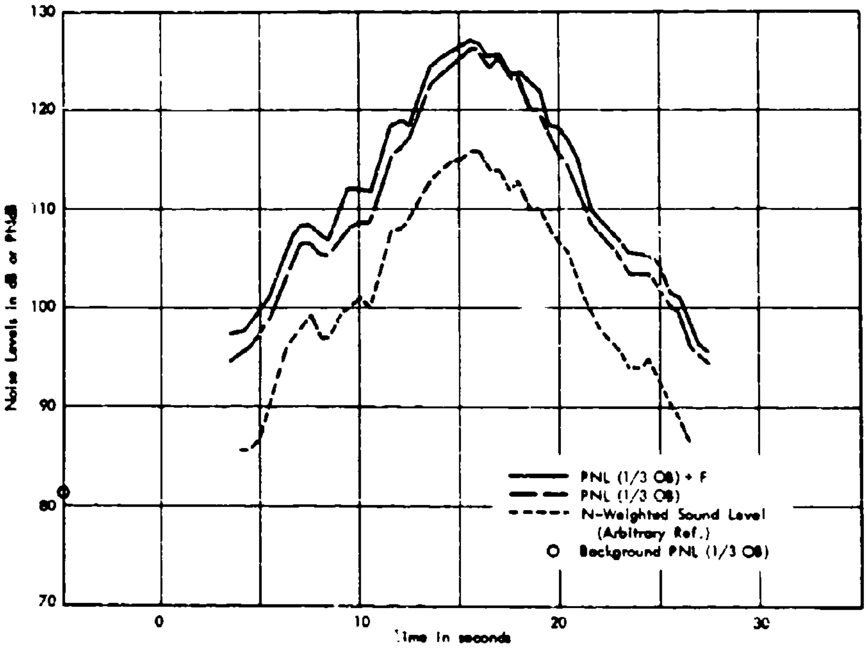


FIGURE 1. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - BOEING 720 TAKEOFF, 370 FEET SLANT DISTANCE

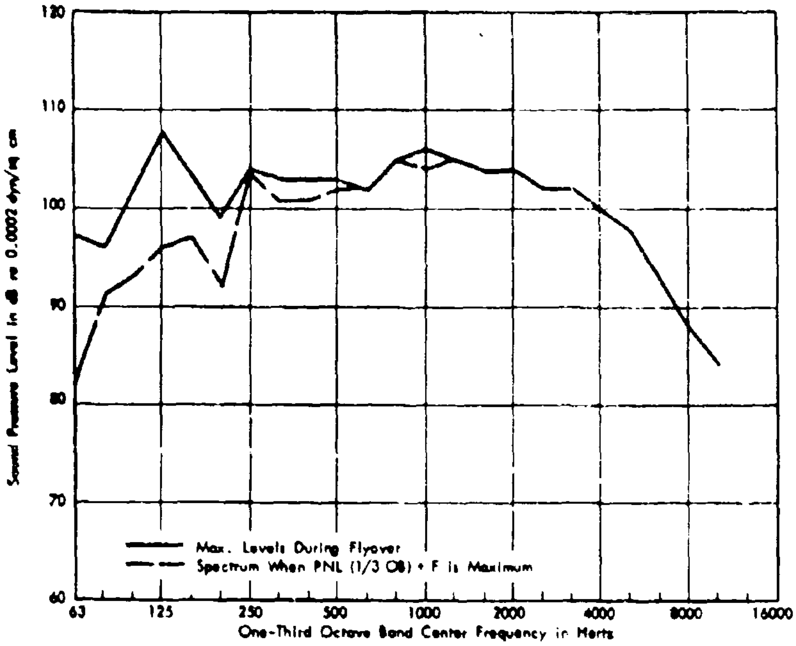


A. NOISE SPECTRUM

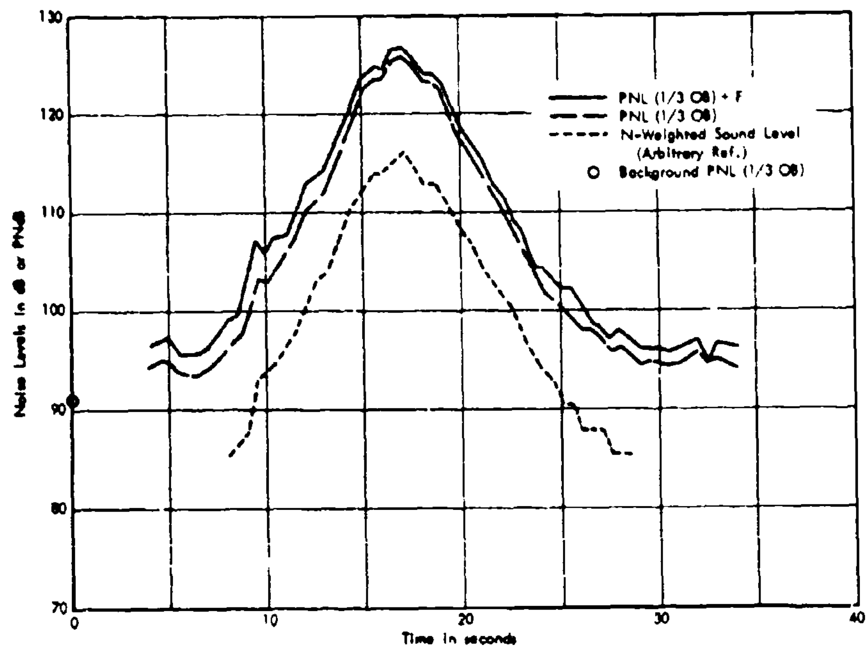


B. TIME HISTORY

FIGURE 2. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - BOEING 720 TAKEOFF, 550 FEET SLANT DISTANCE

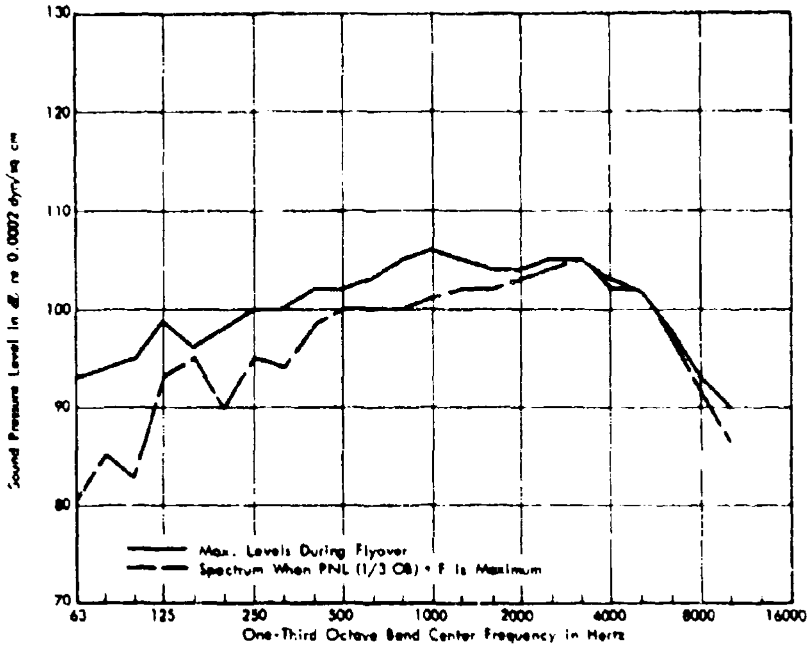


A. NOISE SPECTRUM

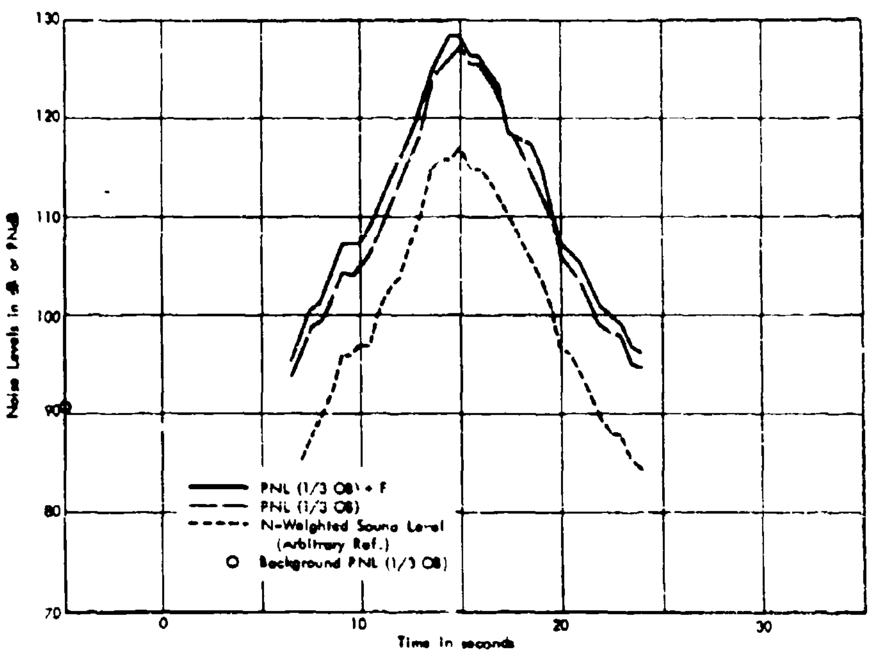


B. TIME HISTORY

FIGURE 3. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - DOUGLAS DC-8 TAKEOFF, 700 FEET SLANT DISTANCE

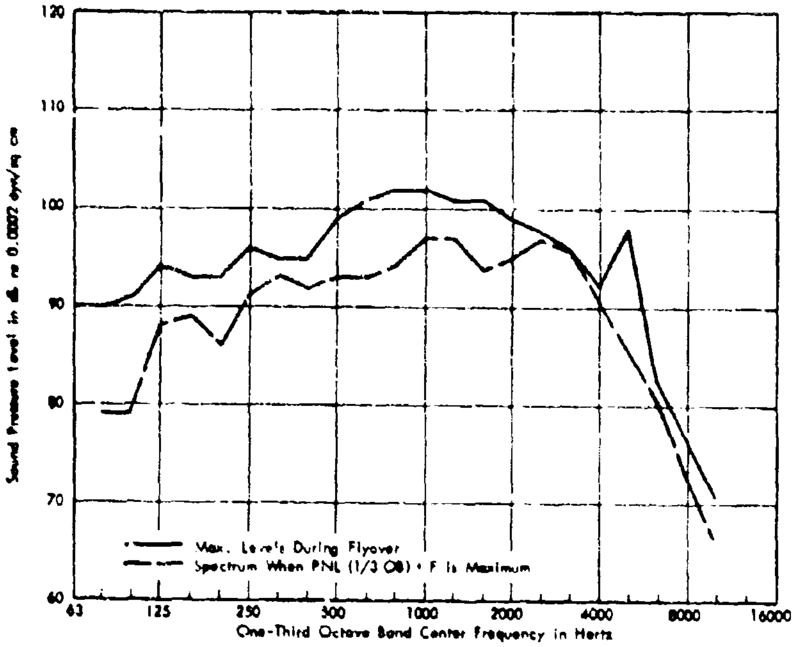


A. NOISE SPECTRUM

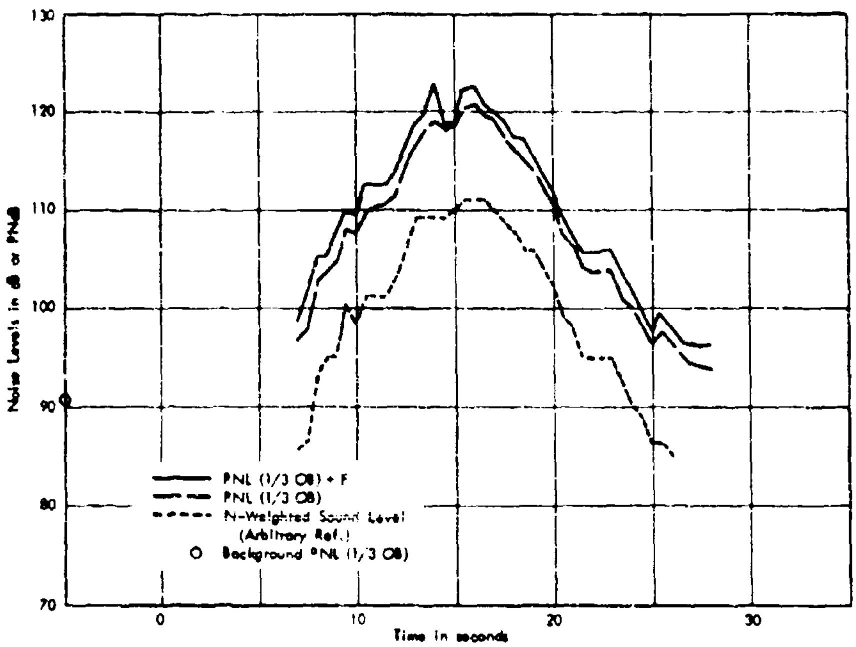


B. TIME HISTORY

FIGURE 4. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - CONVAIR 880 TAKEOFF, 506 FEET SLANT DISTANCE

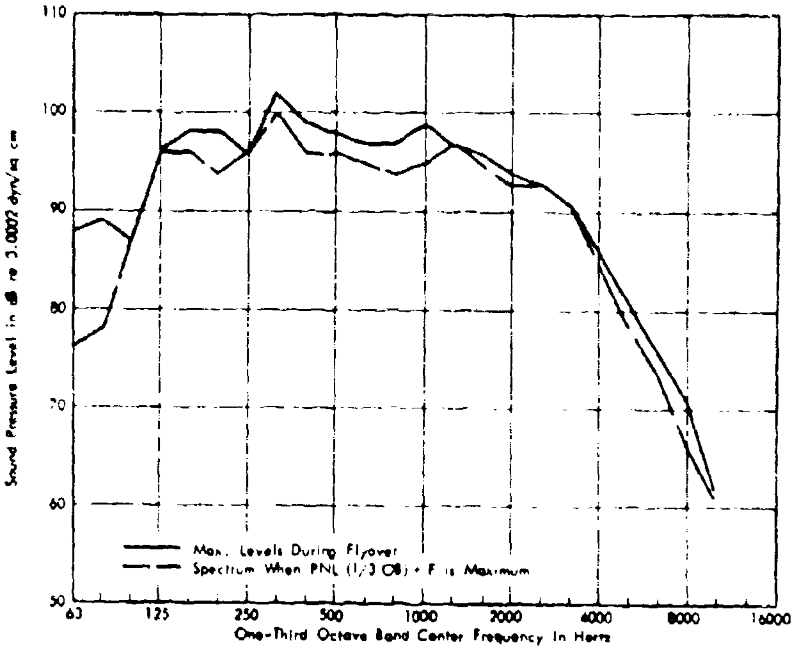


A NOISE SPECTRUM

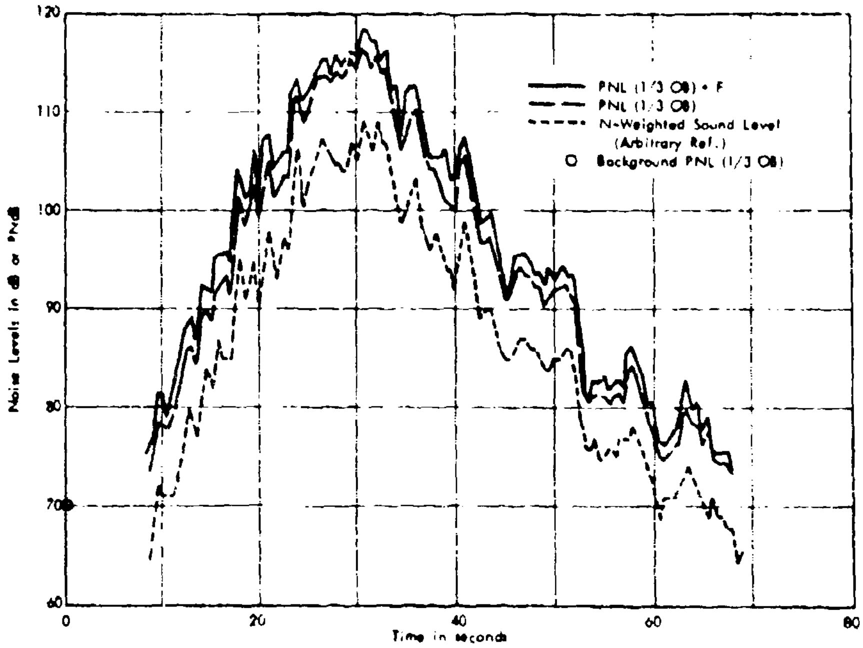


B. TIME HISTORY

FIGURE 5. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - CONVAIR 880 TAKEOFF, 820 FEET SLANT DISTANCE

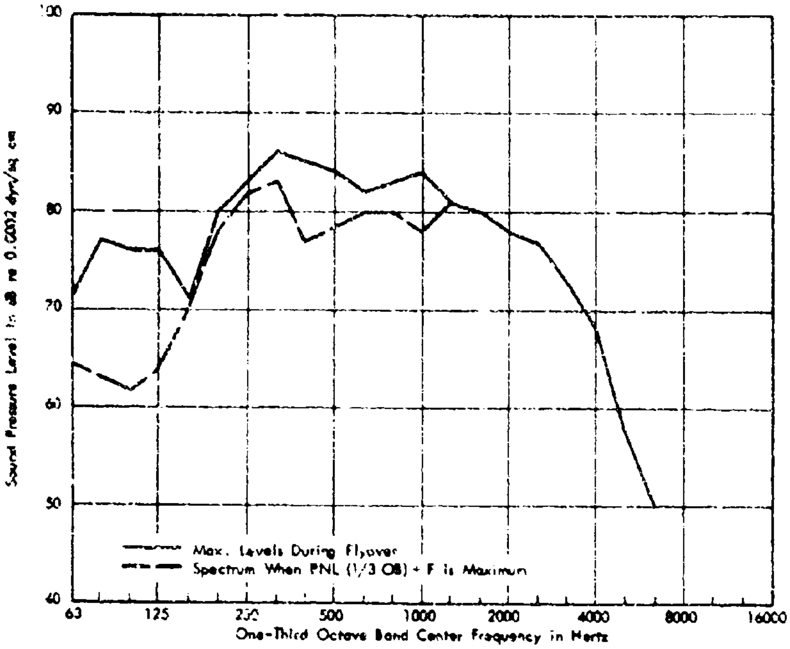


A. NOISE SPECTRUM

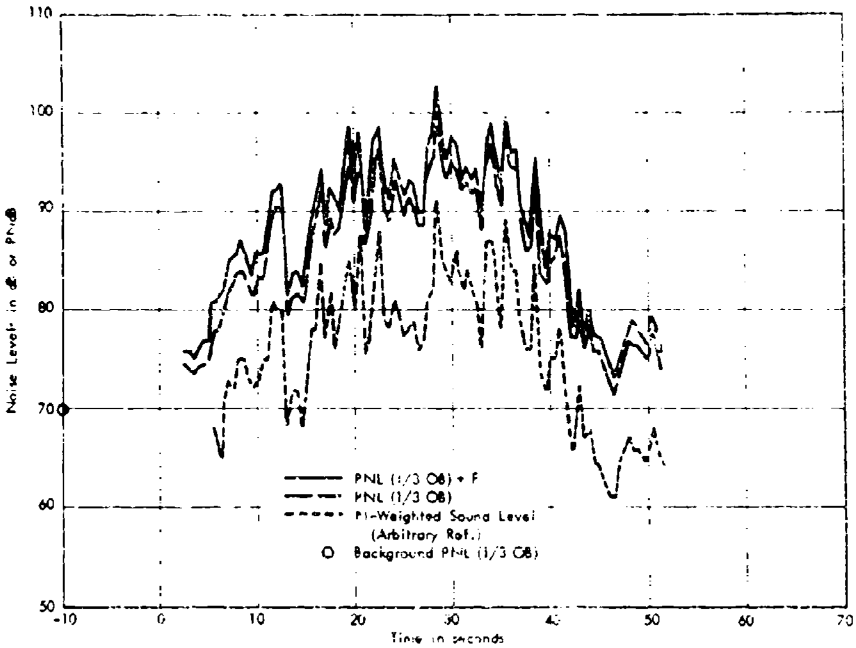


B. TIME HISTORY

FIGURE 6. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - CARAVELLE 6R TAKEOFF, 1264 FEET SLANT DISTANCE

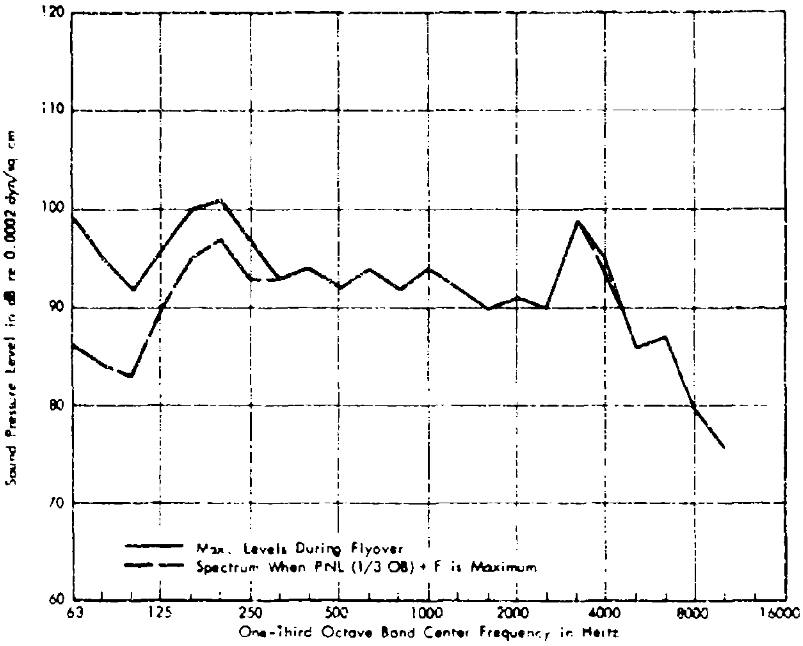


A. NOISE SPECTRUM

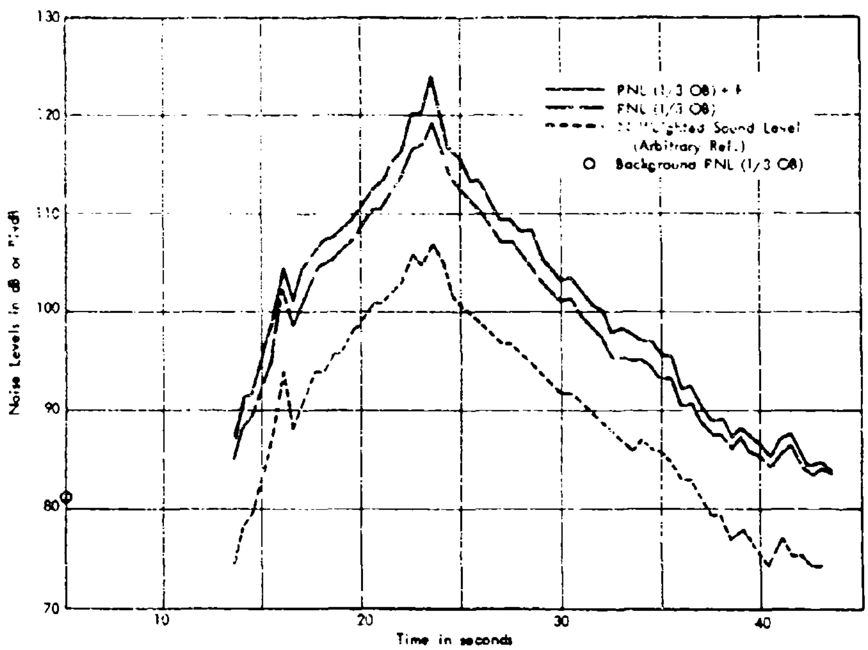


B. TIME HISTORY

FIGURE 7. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - CARAVELLE 6R TAKEOFF, 2394 FEET SLANT DISTANCE

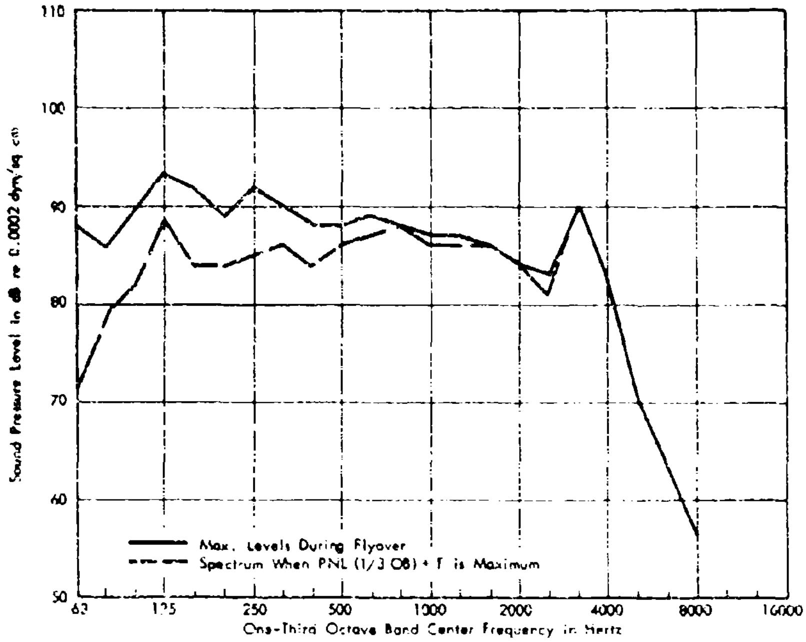


A. NOISE SPECTRUM

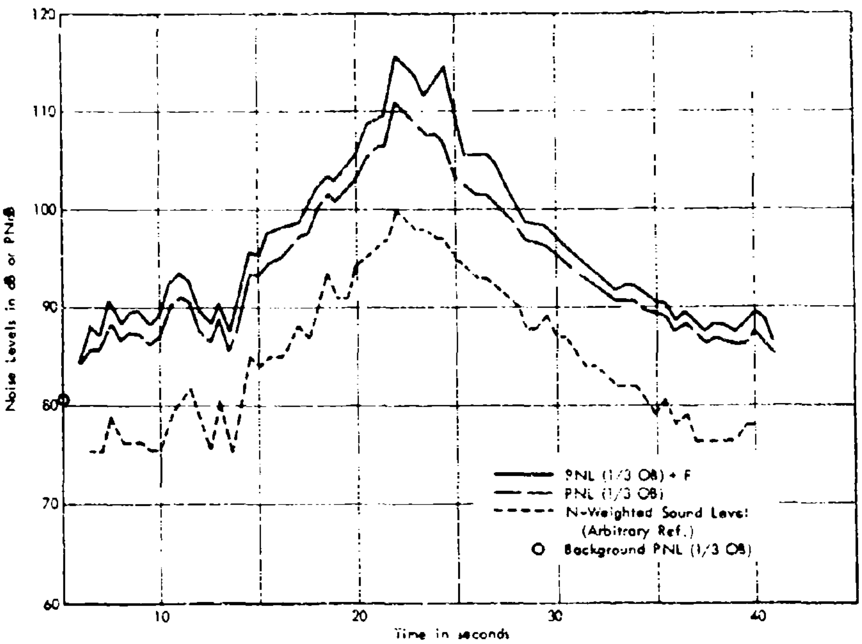


B. TIME HISTORY

FIGURE 8. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - BOEING 707 TAKEOFF, 870 FEET SLANT DISTANCE

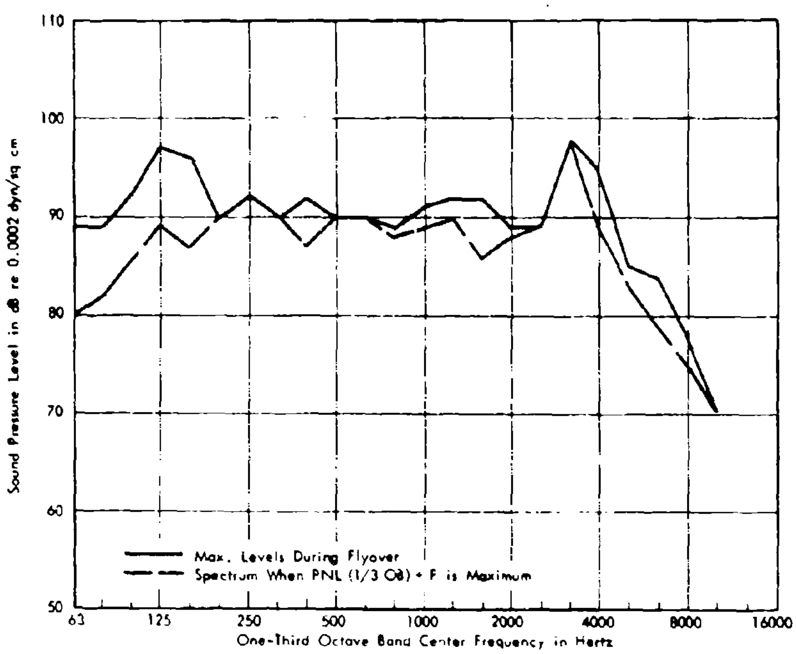


A. NOISE SPECTRUM

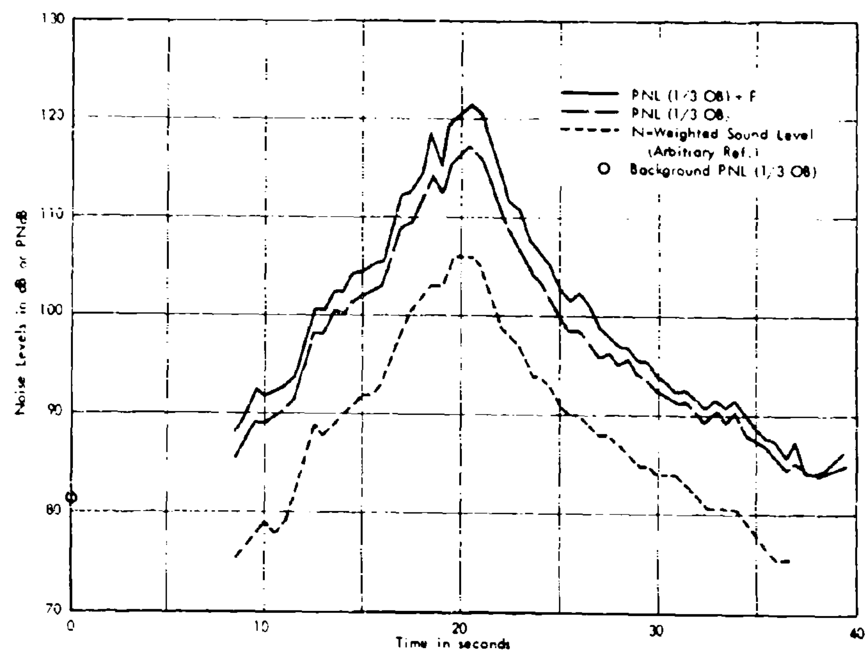


B. TIME HISTORY

FIGURE 9. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - BOEING 720B TAKEOFF, 1280 FEET SLANT DISTANCE

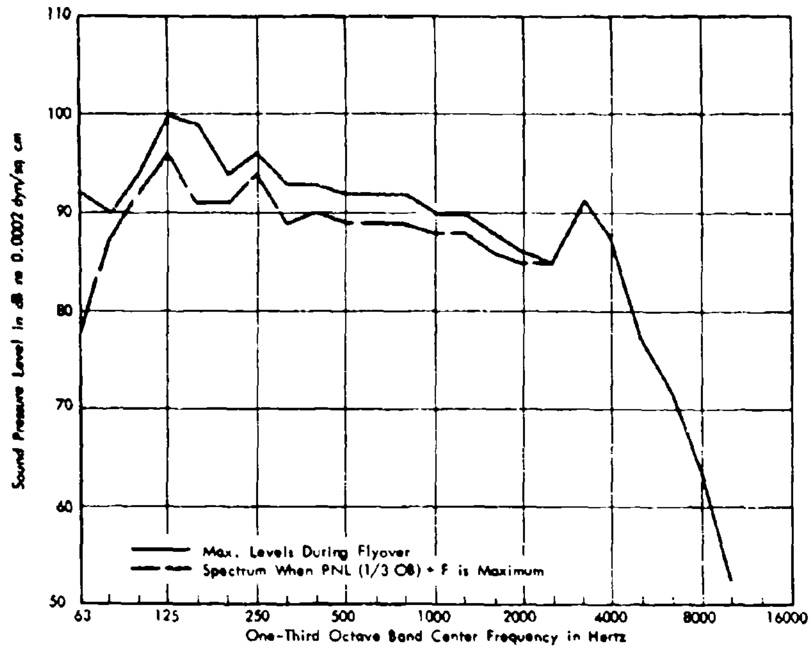


A. NOISE SPECTRUM

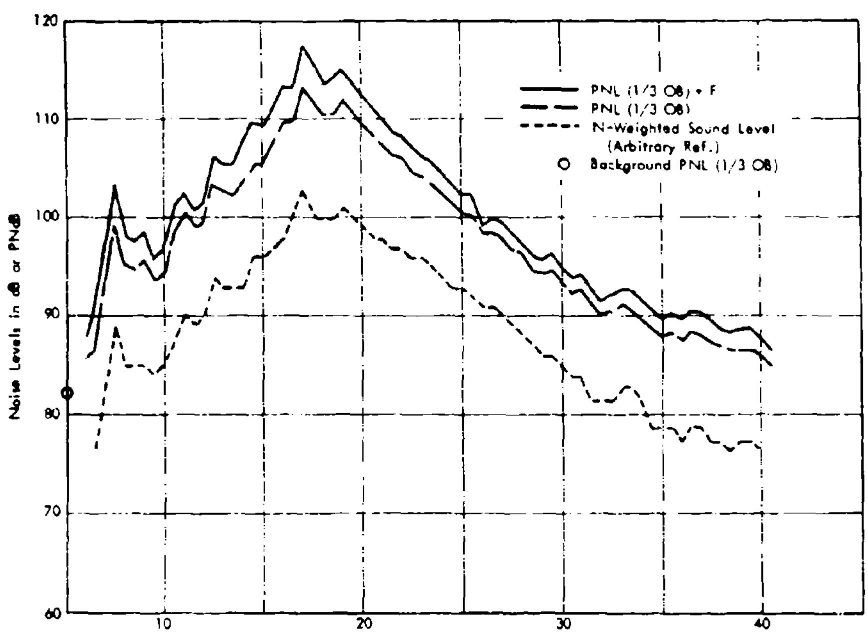


B. TIME HISTORY

FIGURE 10. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - BOEING 720B TAKEOFF, 880 FEET SLANT DISTANCE

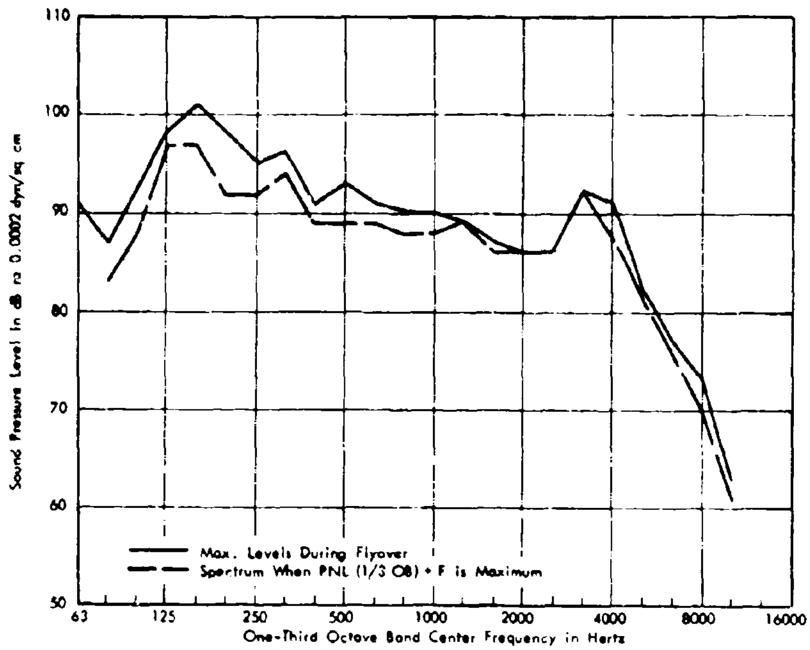


A. NOISE SPECTRUM

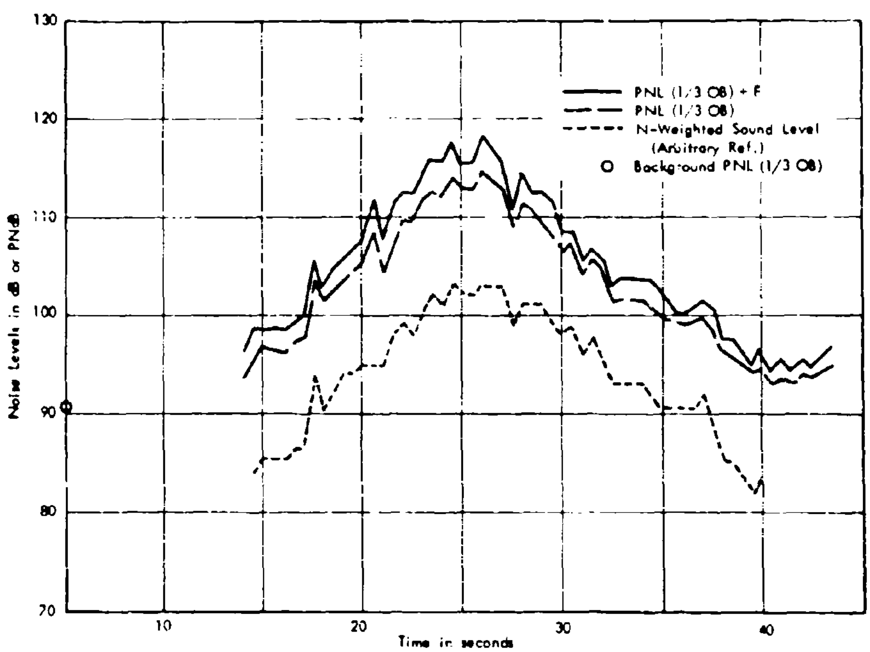


B. TIME HISTORY

FIGURE 11. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - DOUGLAS DC-8-50 TAKEOFF, 1160 FEET SLANT DISTANCE

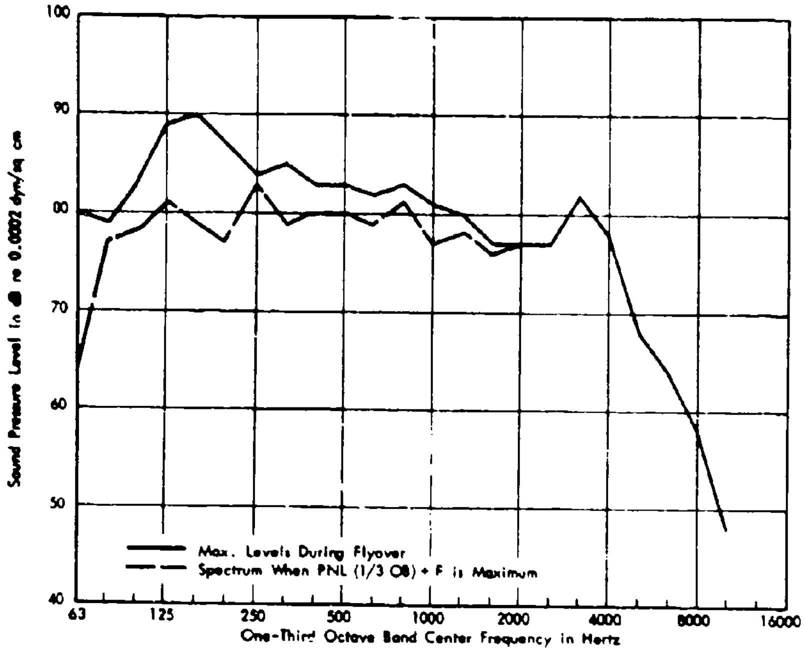


A. NOISE SPECTRUM

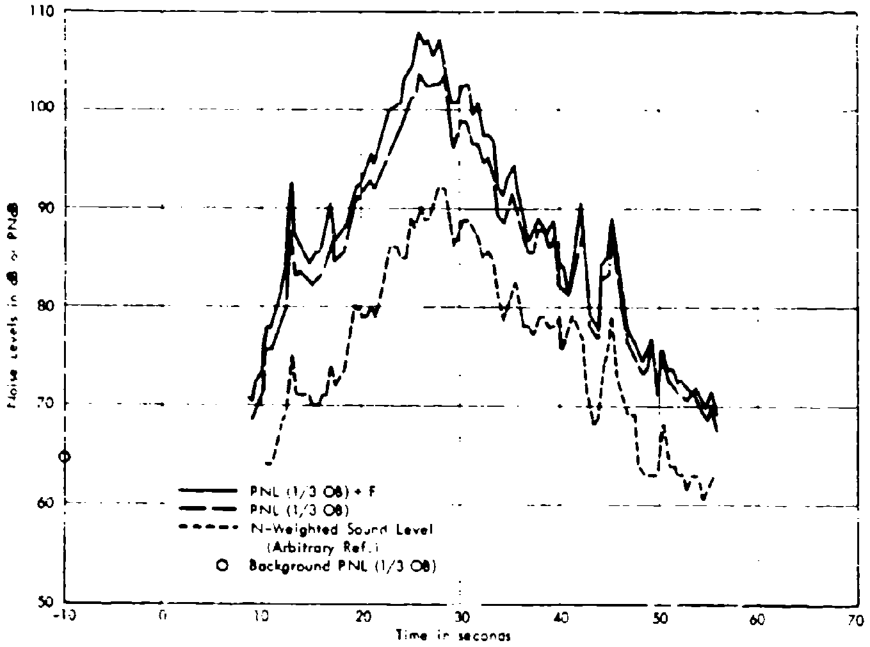


B. TIME HISTORY

FIGURE 12. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - DOUGLAS DC-8-50 TAKEOFF, 1325 FEET SLANT DISTANCE

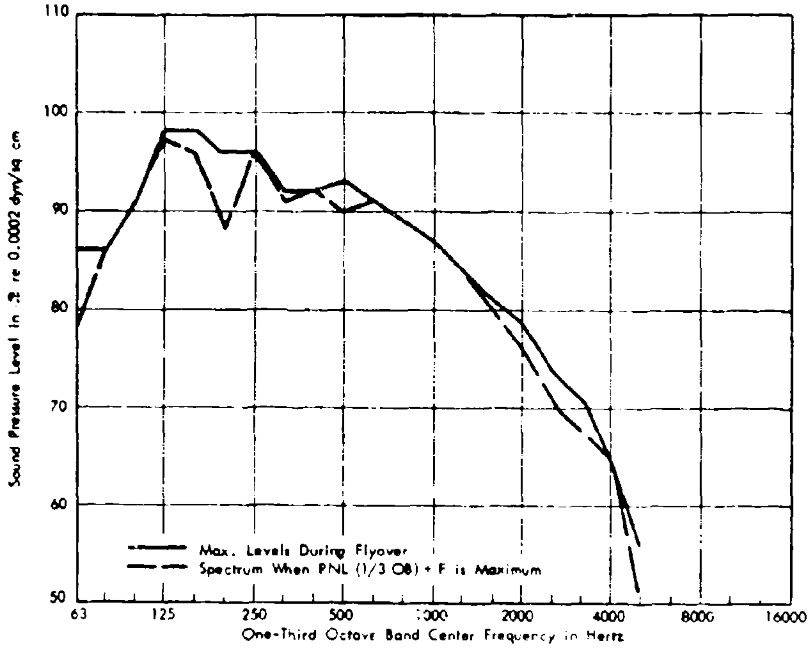


A. NOISE SPECTRUM

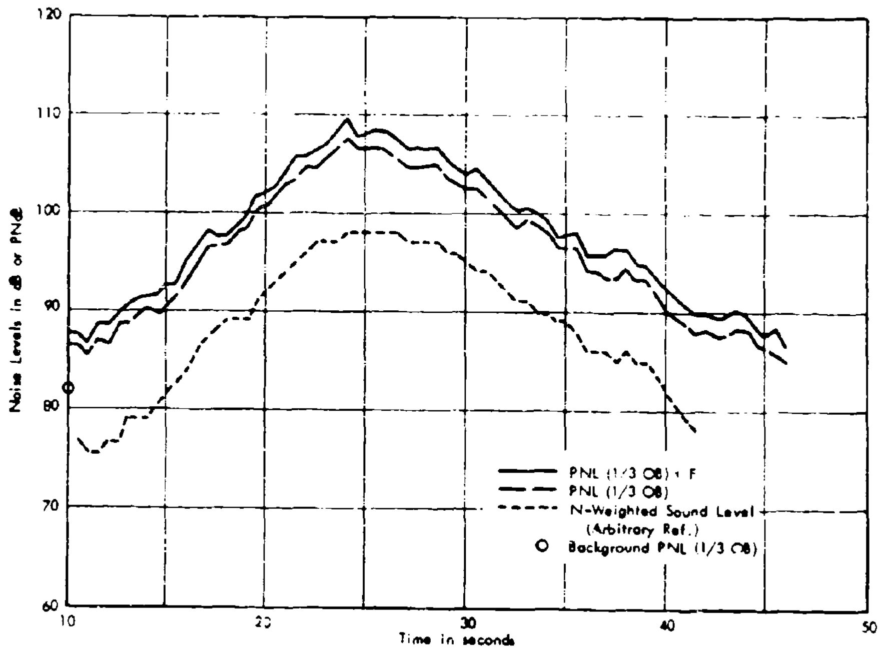


B. TIME HISTORY

FIGURE 13 FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - DOUGLAS DC-8-50 TAKEOFF, 1343 FEET SLANT DISTANCE

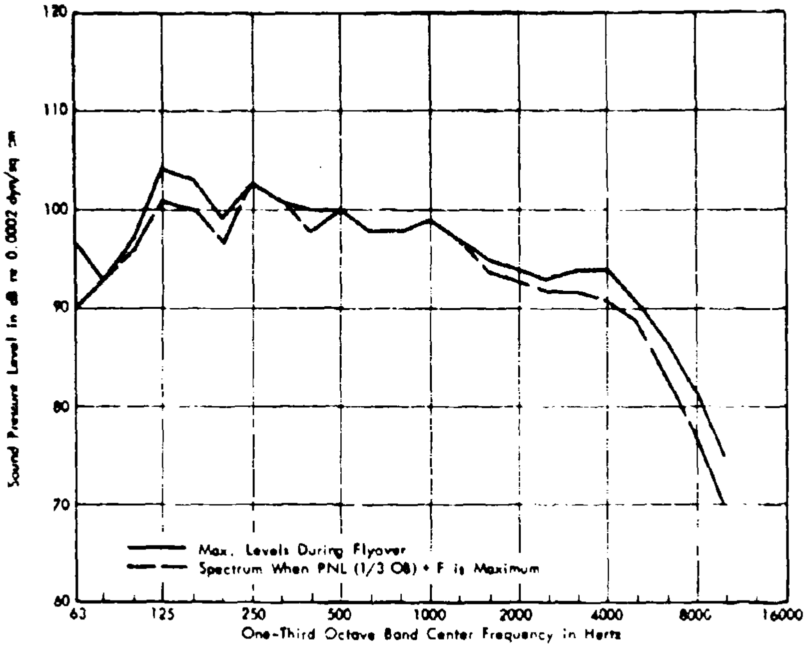


A. NOISE SPECTRUM

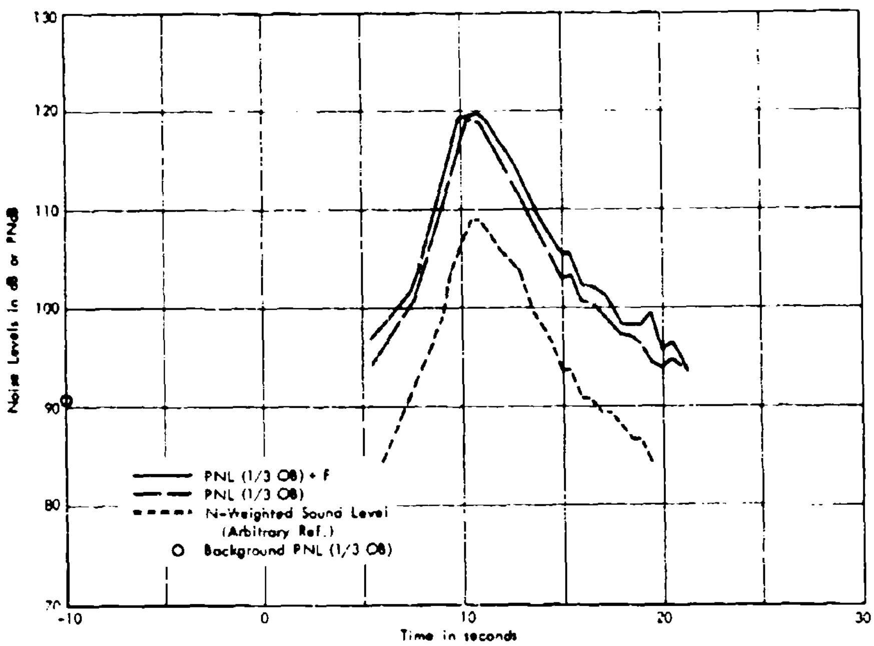


B. TIME HISTORY

FIGURE 14. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - BOEING 727 TAKEOFF, 1590 FEET SLANT DISTANCE

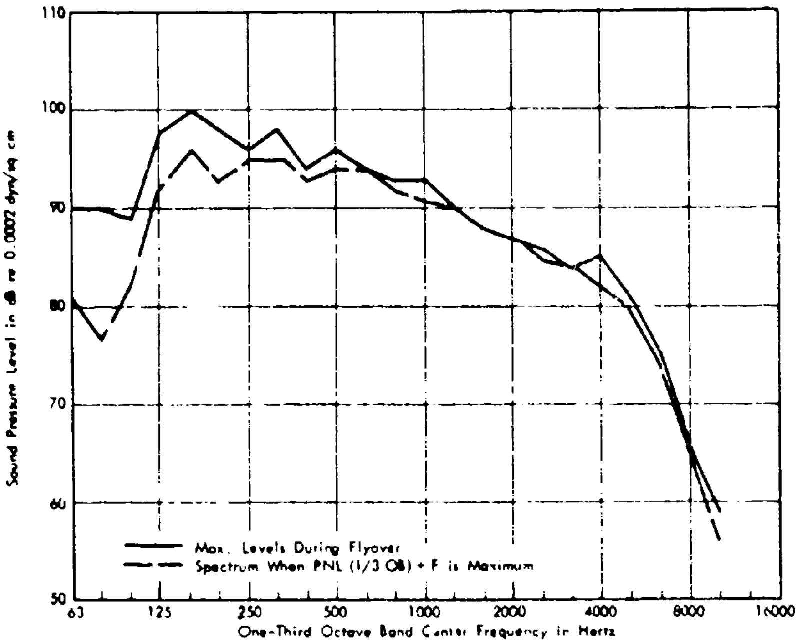


A. NOISE SPECTRUM

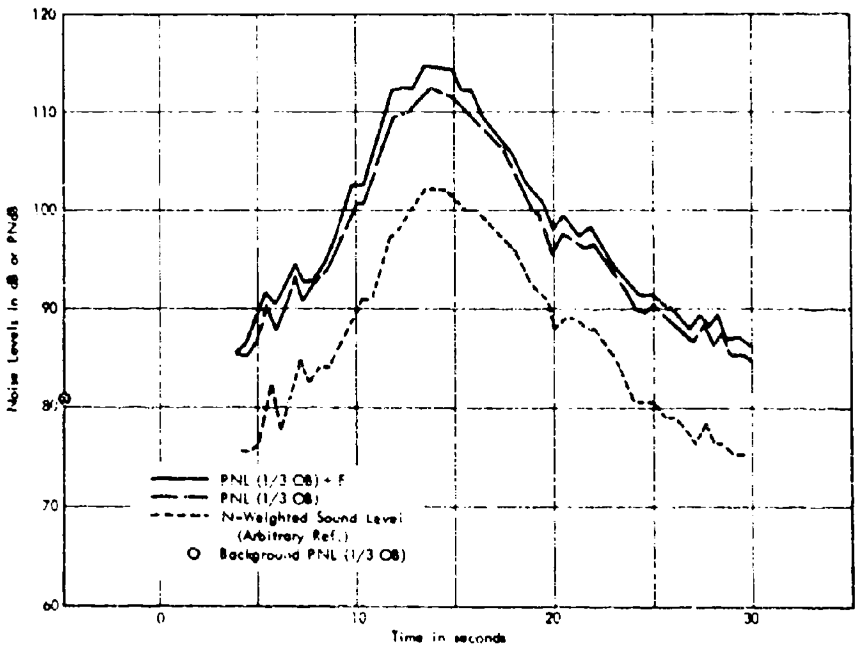


B. TIME HISTORY

FIGURE 15 FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - BOEING 727 TAKEOFF, 530 FEET SLANT DISTANCE



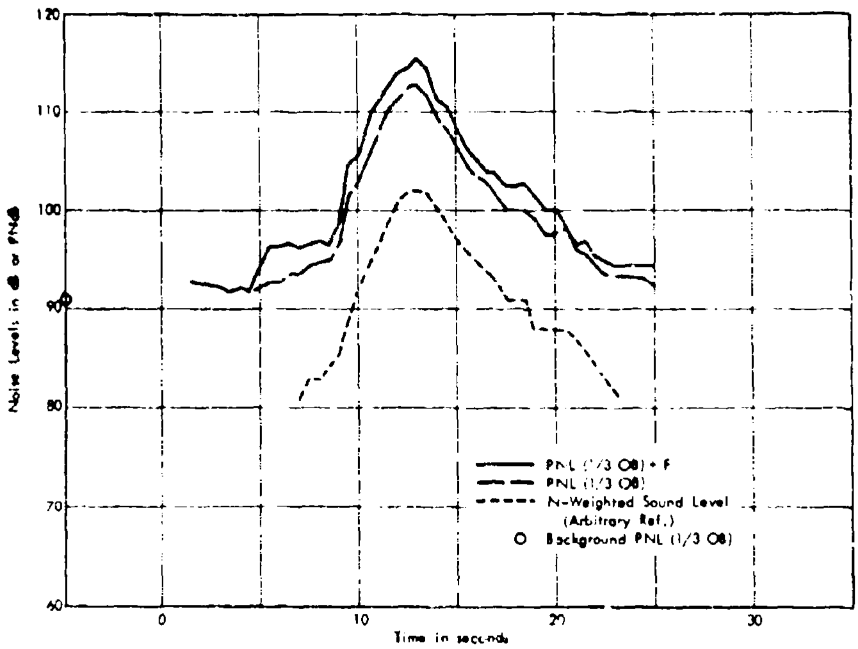
A. NOISE SPECTRUM



B TIME HISTORY

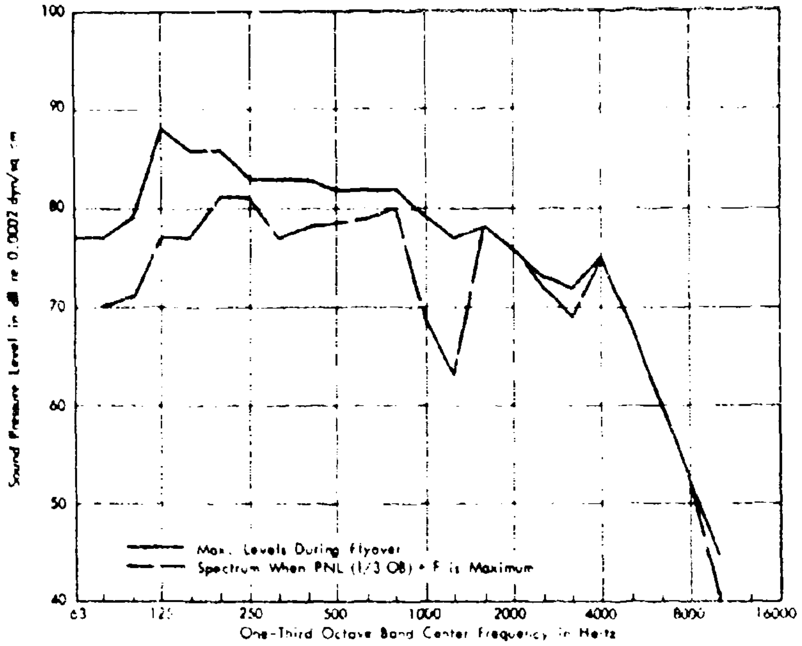
FIGURE 16. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - BOEING 727 TAKEOFF, 1000 FEET SLANT DISTANCE

A. NOISE SPECTRUM

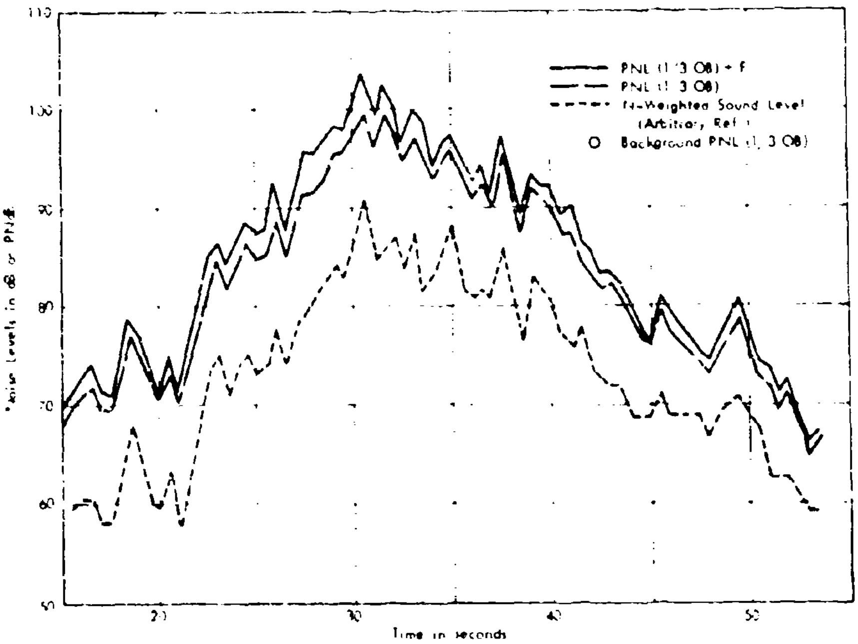


B. TIME HISTORY

FIGURE 17. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - DOUGLAS DC-9 TAKEOFF, 770 FEET SLANT DISTANCE

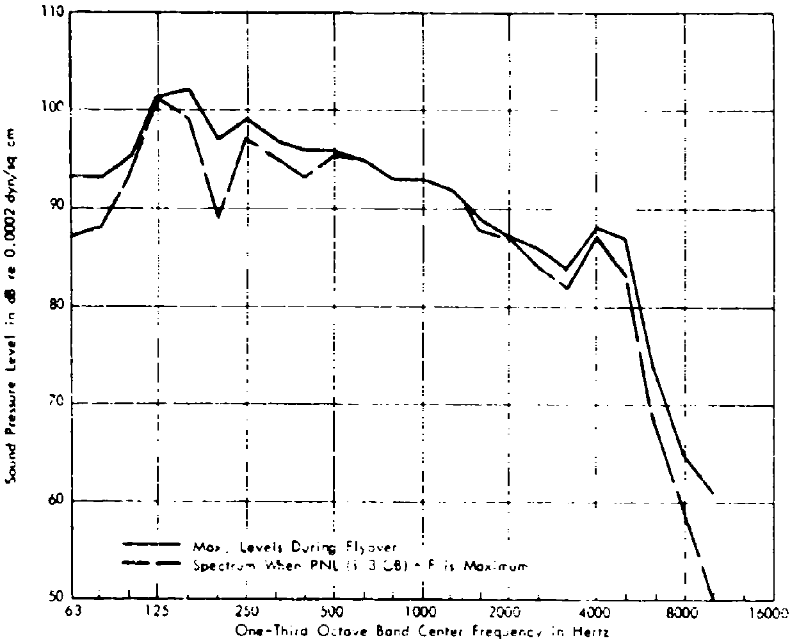


A NOISE SPECTRUM

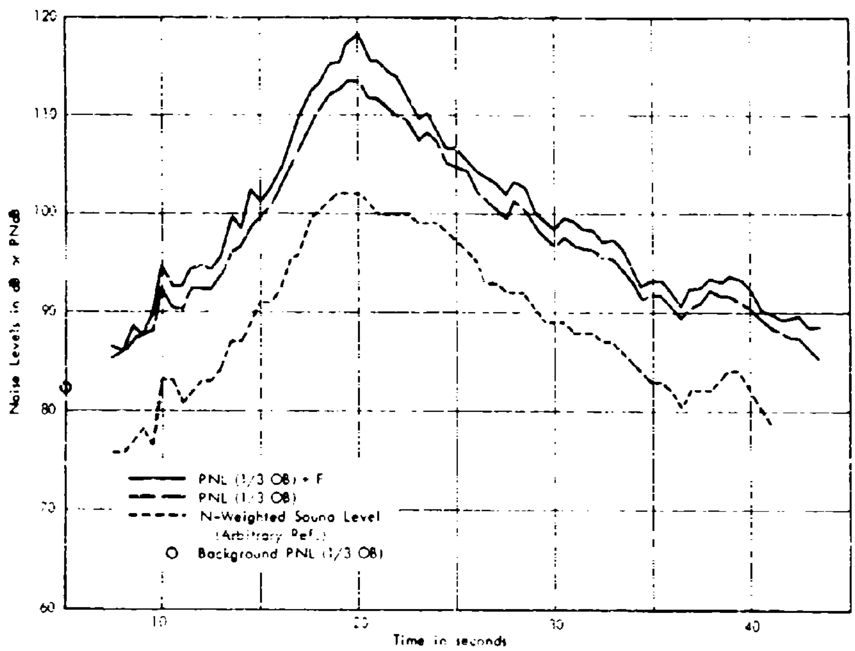


B TIME HISTORY

FIGURE 18 FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY – DOUGLAS DC-9 TAKEOFF, 1323 FEET SLANT DISTANCE

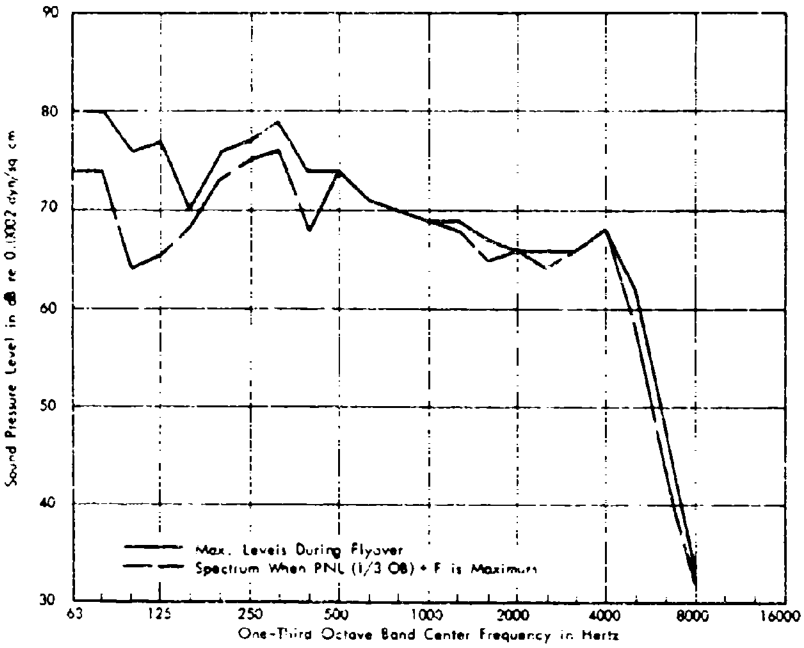


A NOISE SPECTRUM

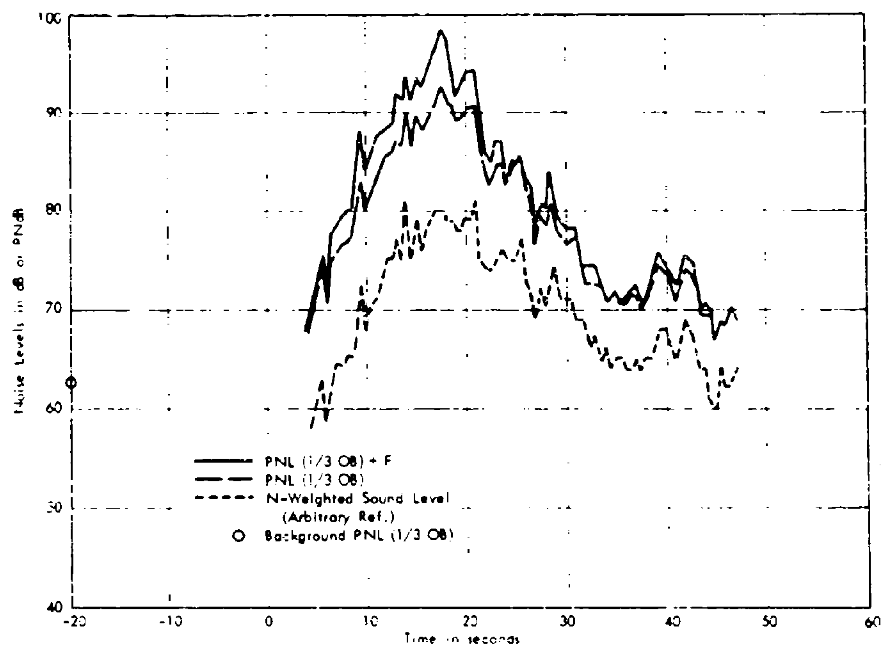


B TIME HISTORY

FIGURE 19. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - CONVAIR 990
TAKEOFF, 990 FEET SLANT DISTANCE

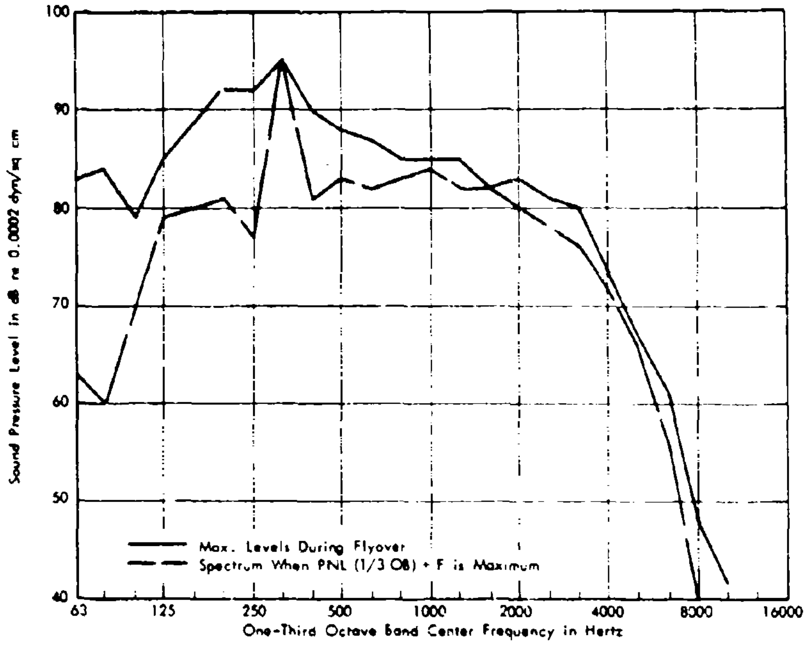


A. NOISE SPECTRUM

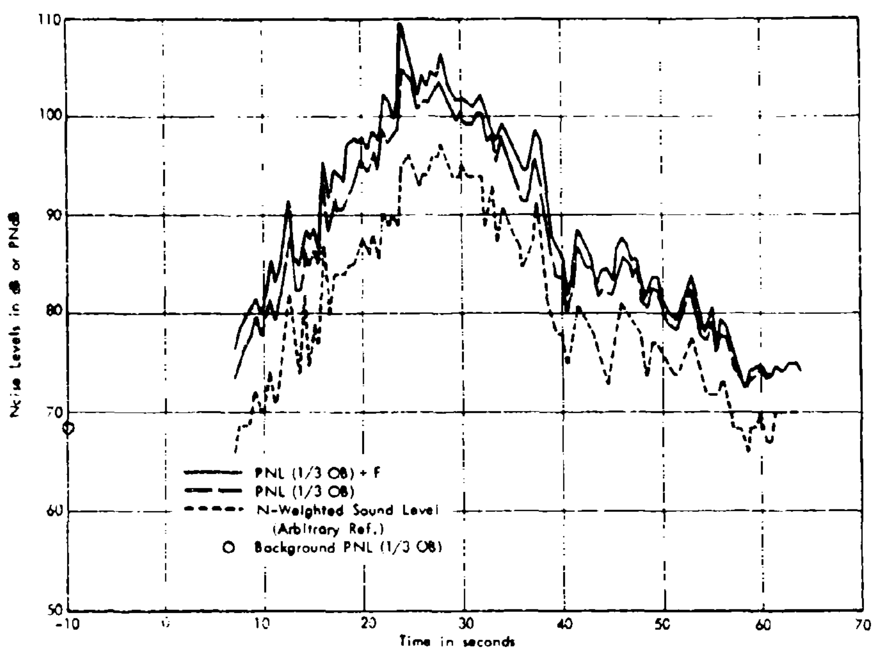


B. TIME HISTORY

FIGURE 20. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - CONVAIR 990 TAKEOFF, 1861 FEET SLANT DISTANCE

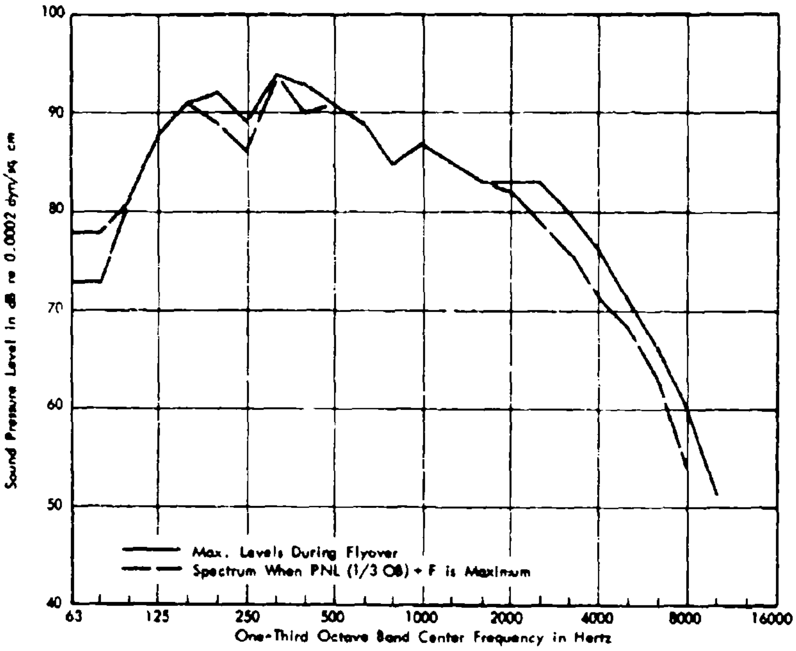


A. NOISE SPECTRUM

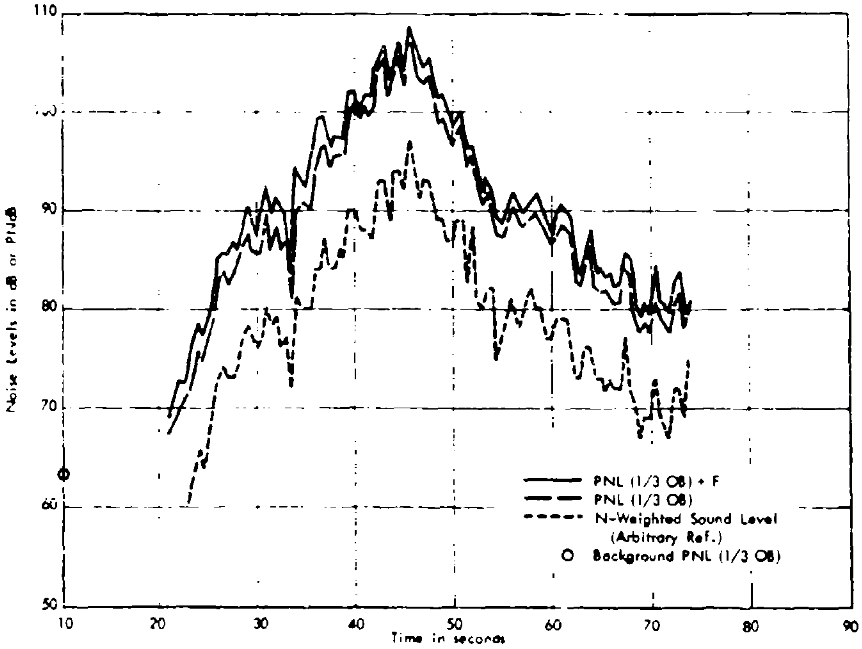


B. TIME HISTORY

FIGURE 21. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - BAC 111 TAKEOFF, 1326 FEET SLANT DISTANCE

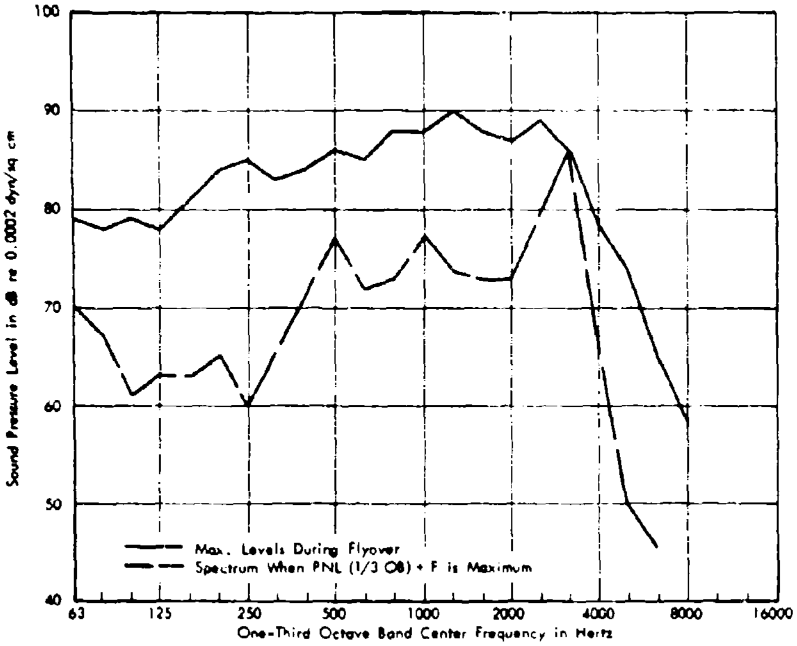


A. NOISE SPECTRUM

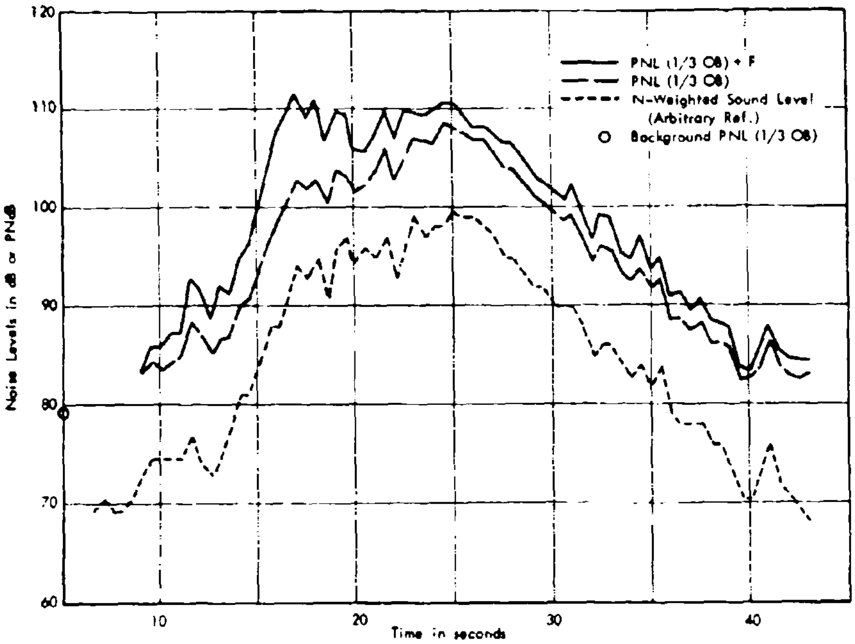


B. TIME HISTORY

FIGURE 22. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - BAC 111 TAKEOFF, 1122 FEET SLANT DISTANCE

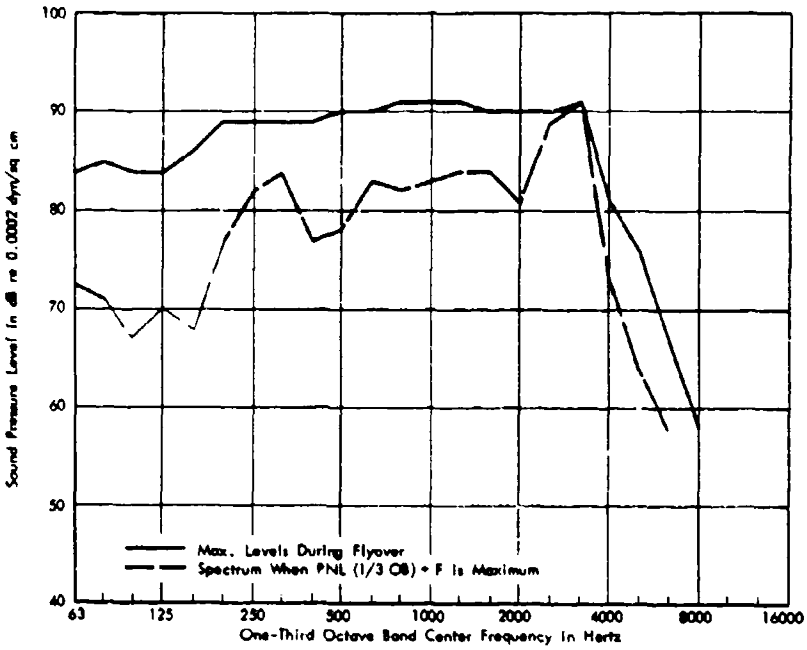


A. NOISE SPECTRUM

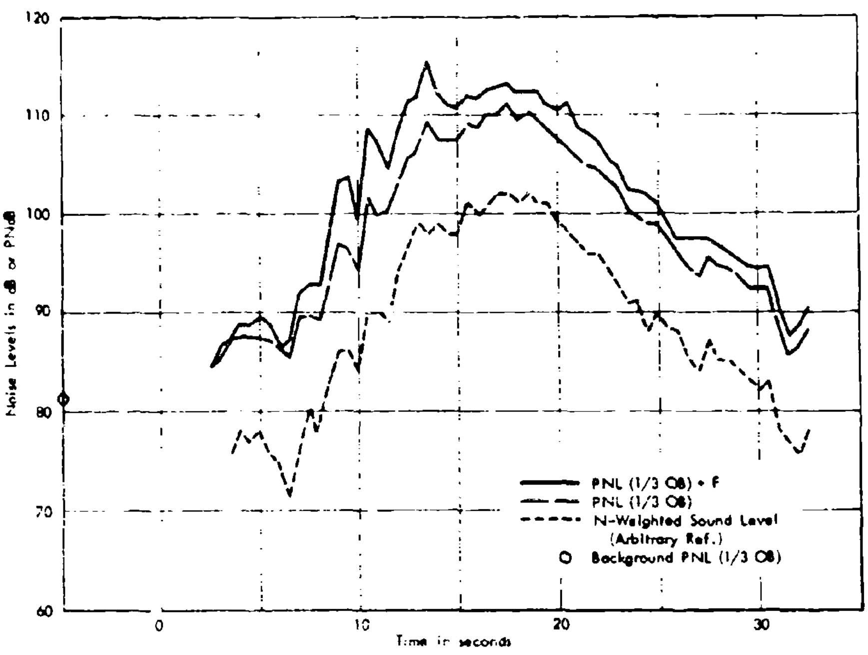


B. TIME HISTORY

FIGURE 23. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - BOEING 720 LANDING, 1020 FEET SLANT DISTANCE

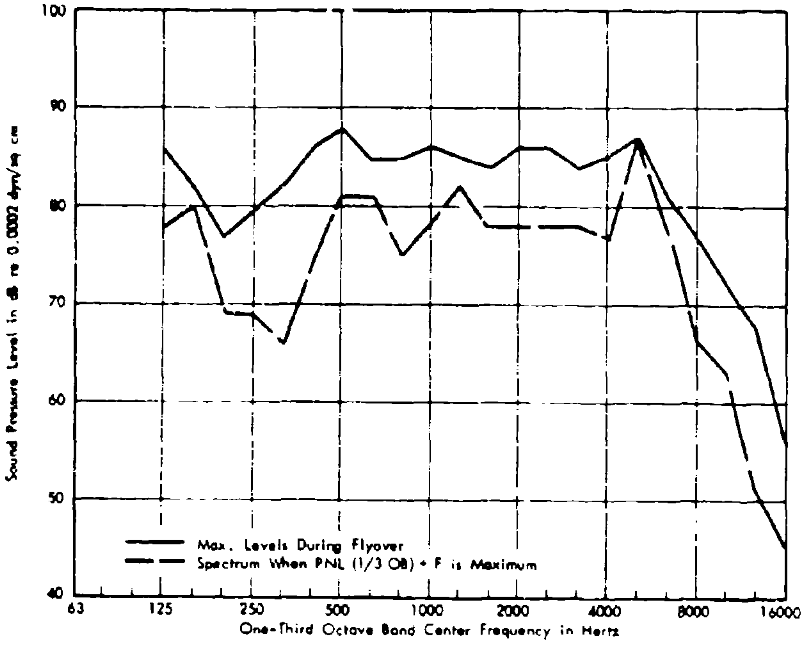


A. NOISE SPECTRUM

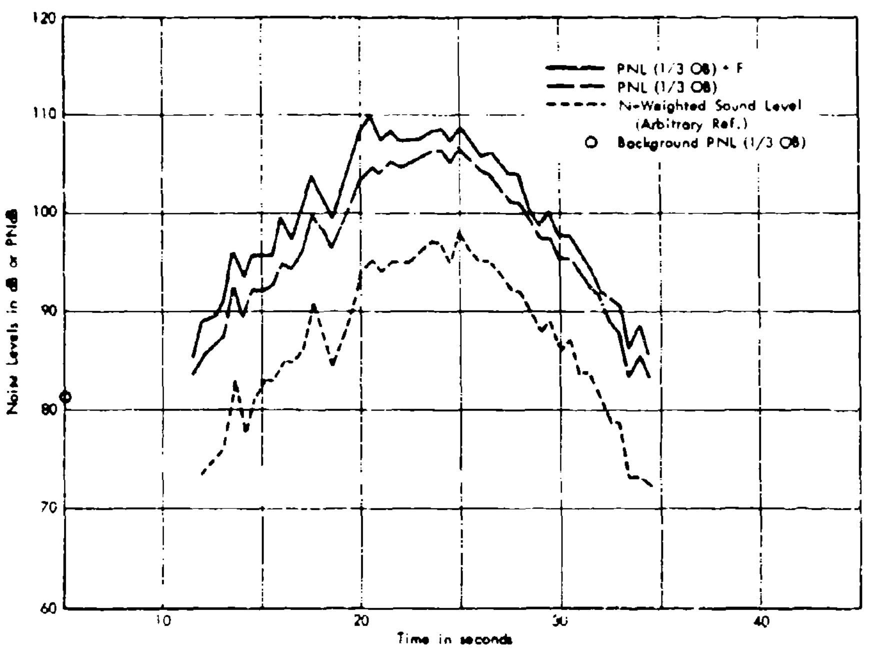


B. TIME HISTORY

FIGURE 24. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - BOEING 720 LANDING, 890 FEET SLANT DISTANCE

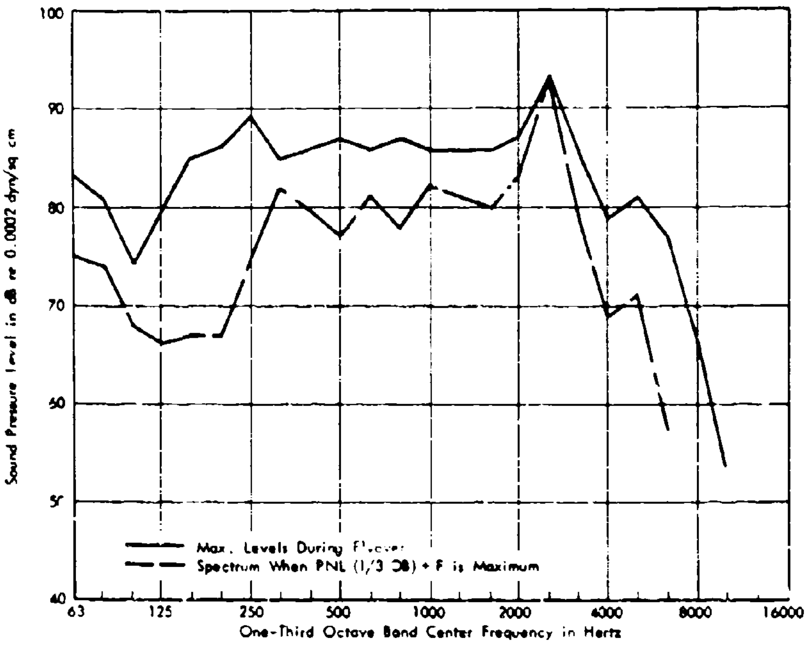


A. NOISE SPECTRUM

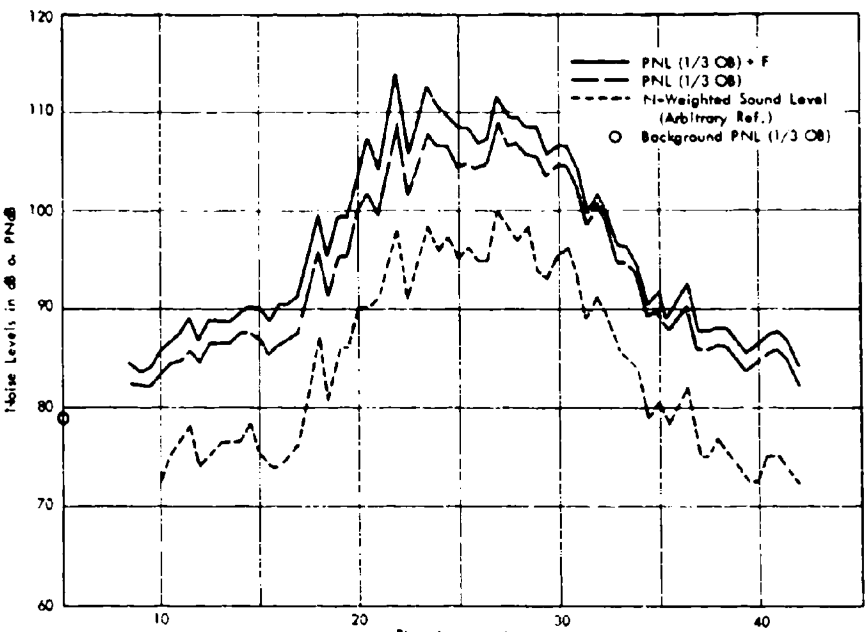


B. TIME HISTORY

FIGURE 25. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - DOUGLAS DC-8 LANDING, 1160 FEET SLANT DISTANCE

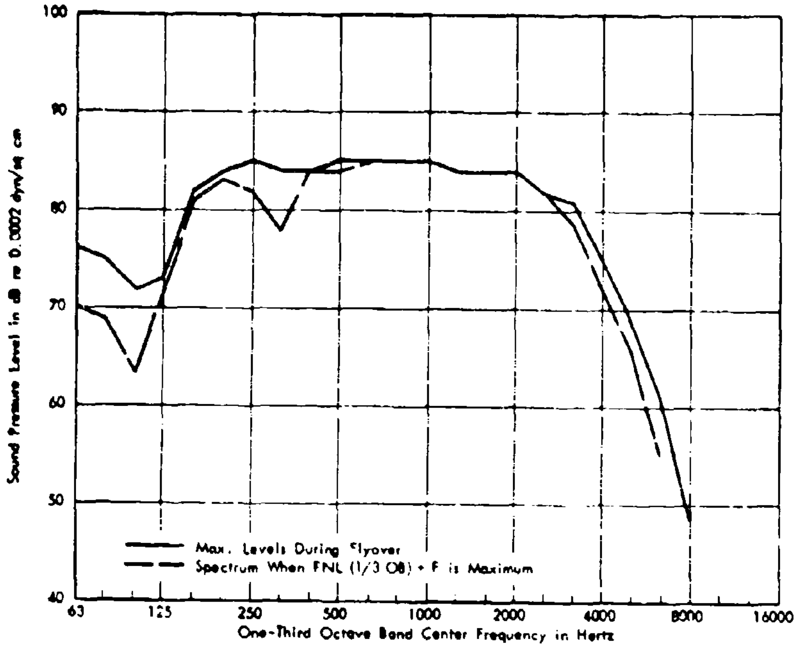


A NOISE SPECTRUM

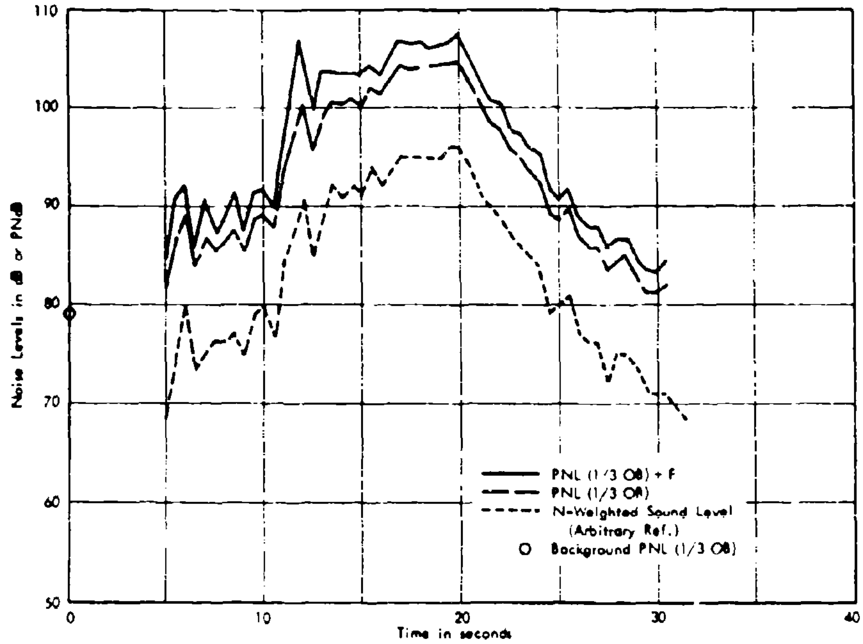


B TIME HISTORY

FIGURE 26. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - DOUGLAS DC-8 LANDING, 1020 FEET SLANT DISTANCE

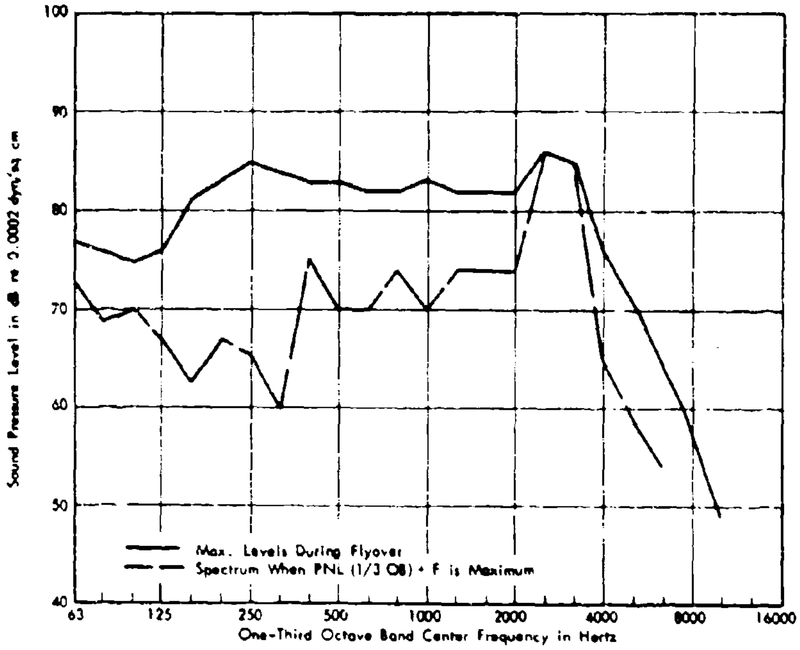


A NOISE SPECTRUM

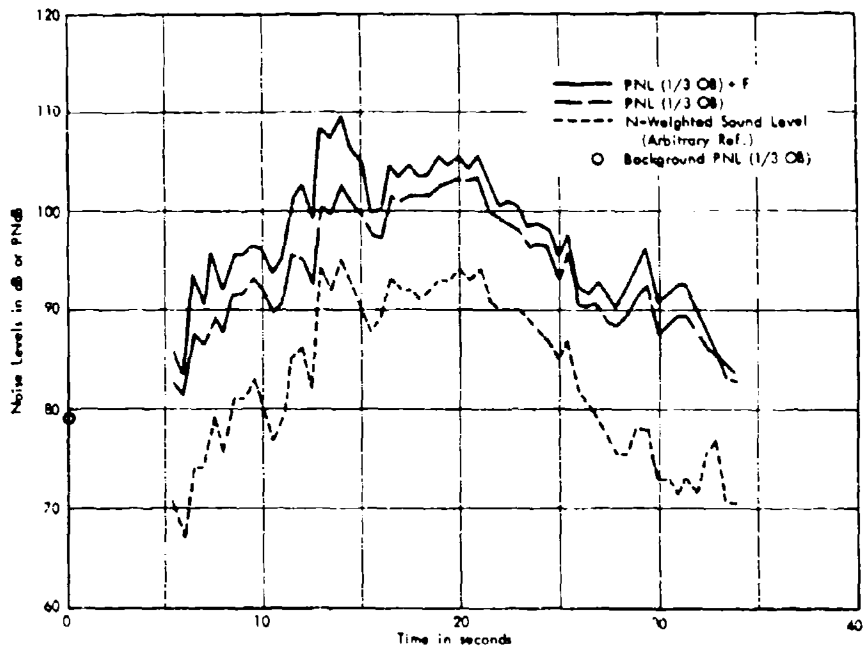


B TIME HISTORY

FIGURE 27. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - CONVAIR 880 LANDING, 990 FEET SLANT DISTANCE

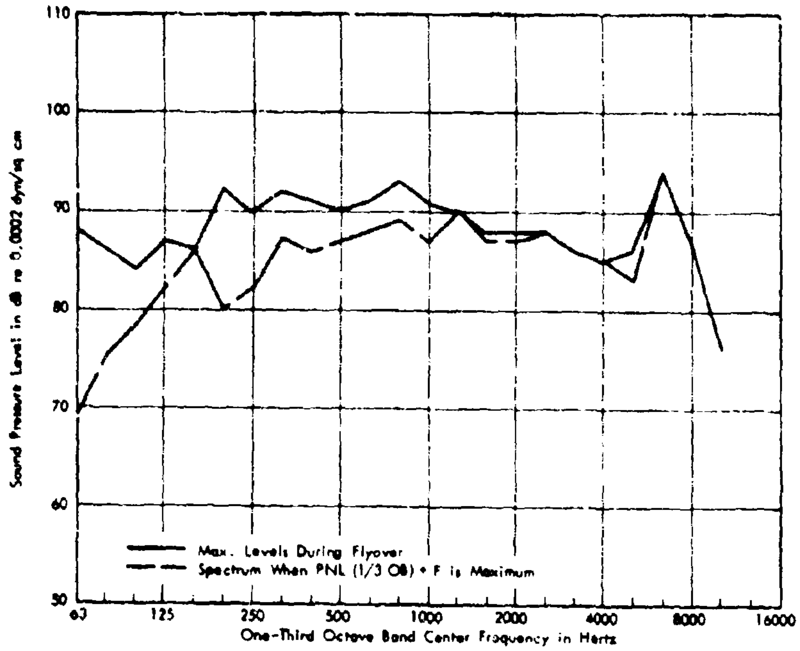


A. NOISE SPECTRUM

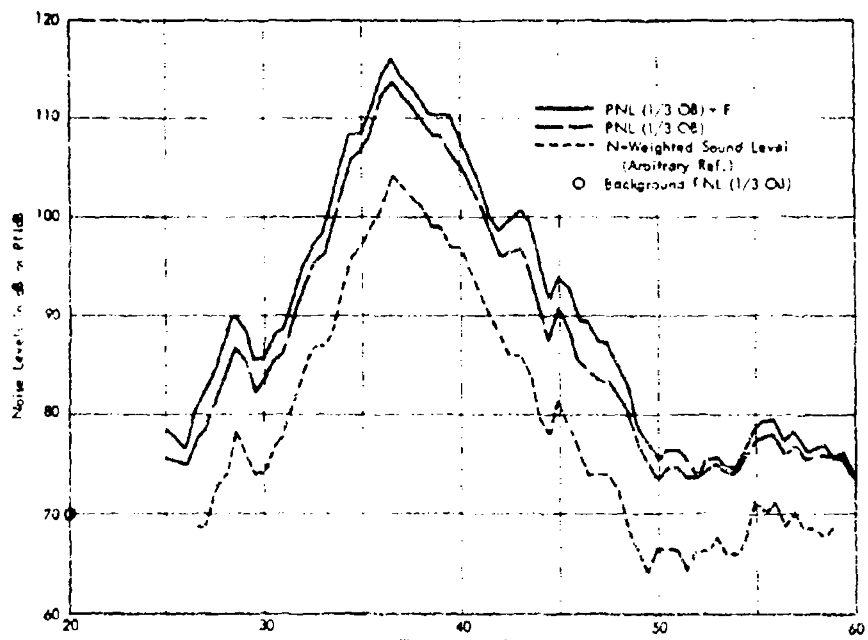


B. TIME HISTORY

FIGURE 28. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - CONVAIR 880 LANDING, 960 FEET SLANT DISTANCE

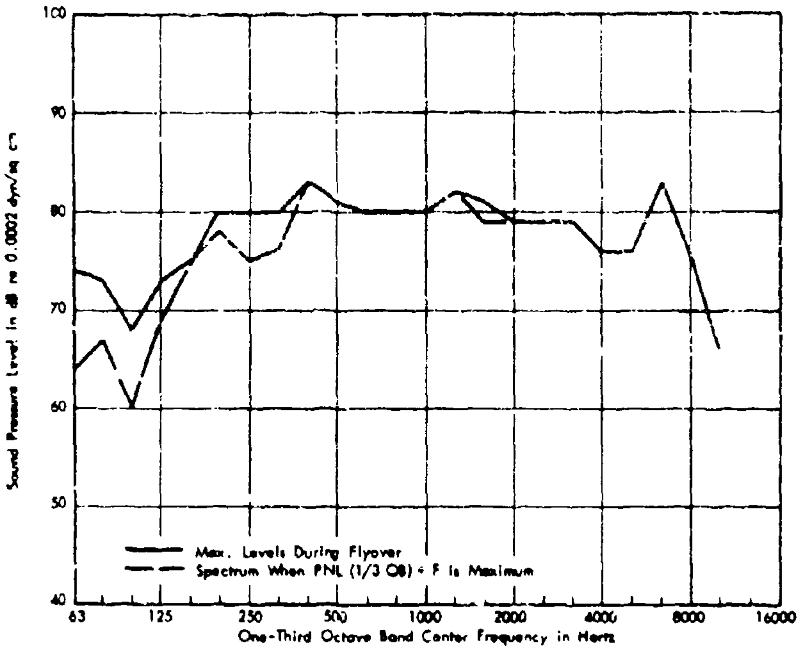


A. NOISE SPECTRUM

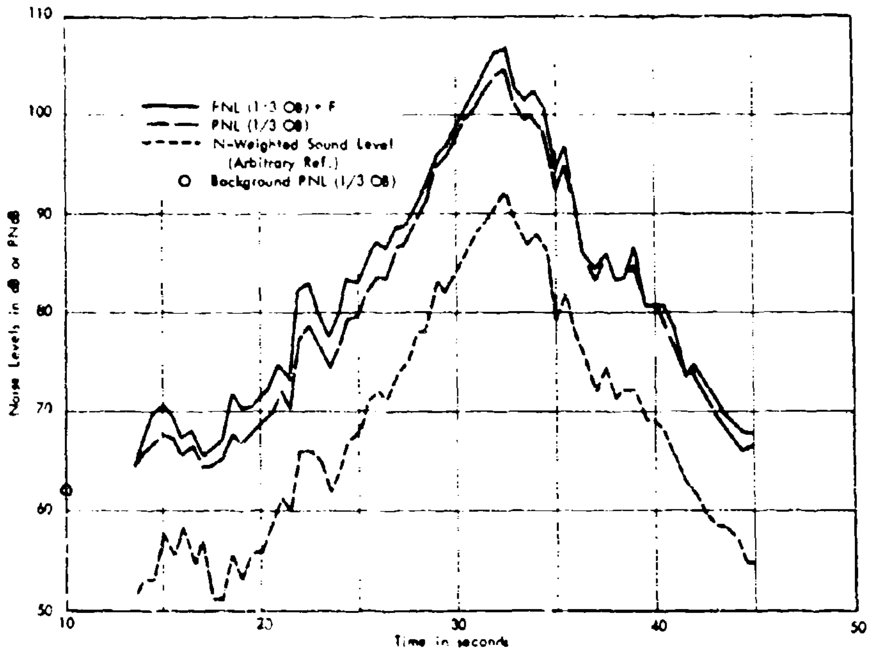


B. TIME HISTORY

FIGURE 29. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - CARAVELLE 6R LANDING, 374 FEET SLANT DISTANCE



A. NOISE SPECTRUM



B. NOISE HISTORY

FIGURE 30. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - CARAVELLE 6R LANDING 42H FEET SLANT DISTANCE

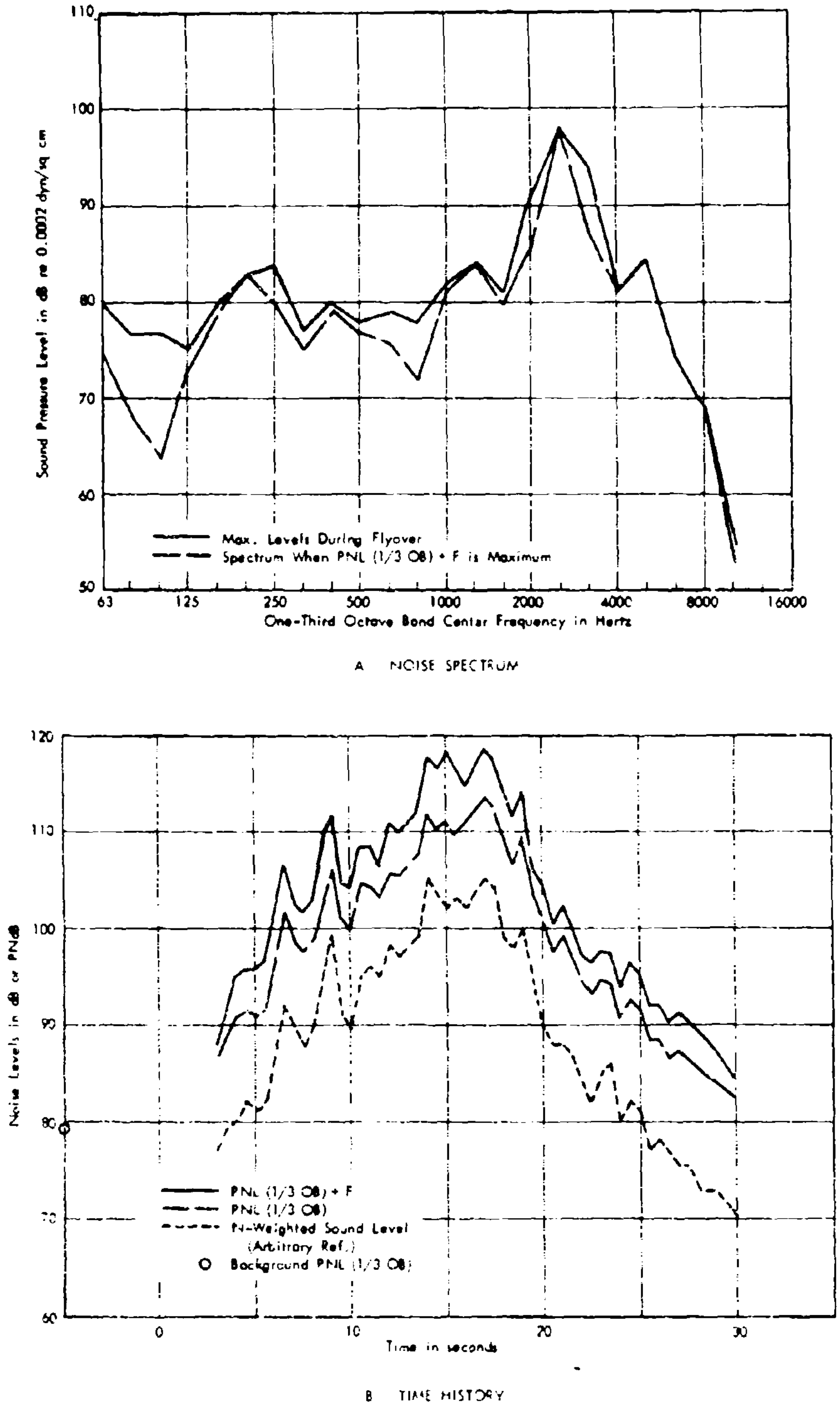
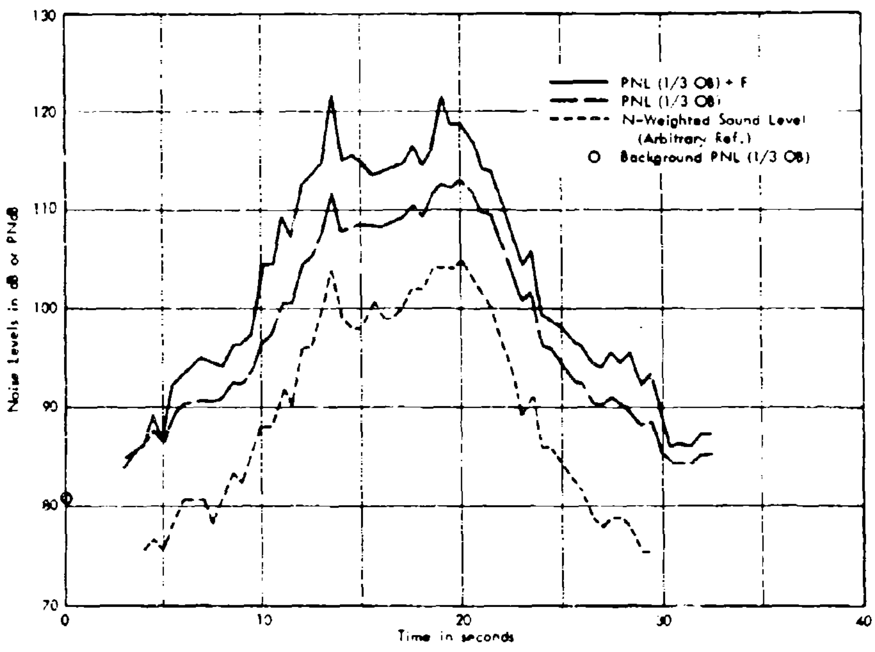


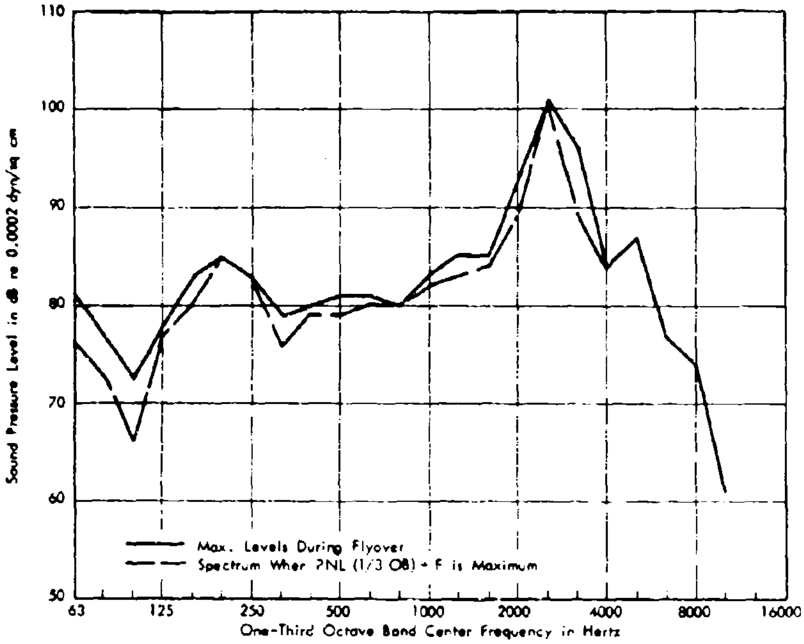
FIGURE 31. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - BOEING 707 LANDING, 1020 FEET SLANT DISTANCE

A NOISE SPECTRUM

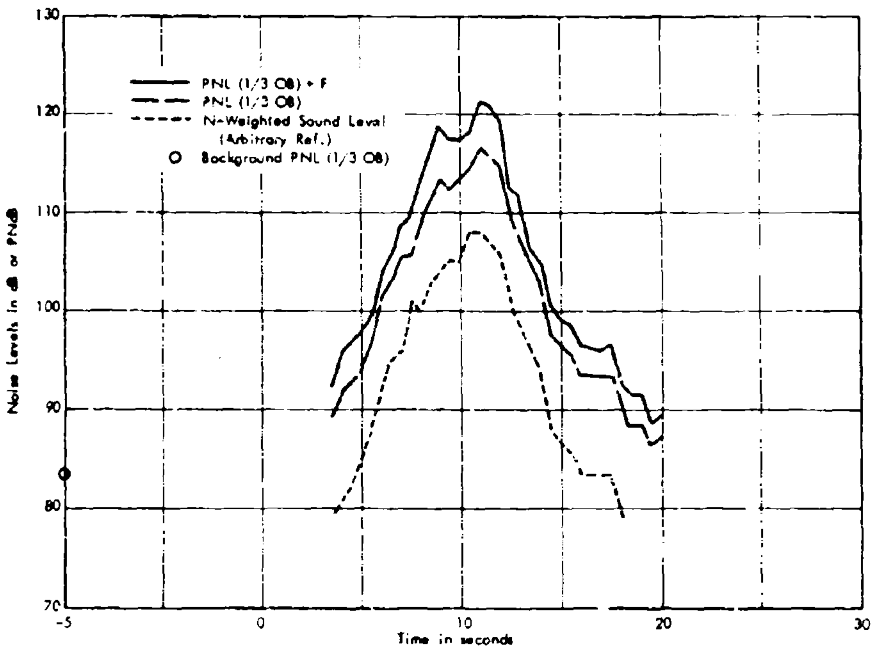


B TIME HISTORY

FIGURE 32 FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - BOEING 707 LANDING, 1010 FEET SLANT DISTANCE

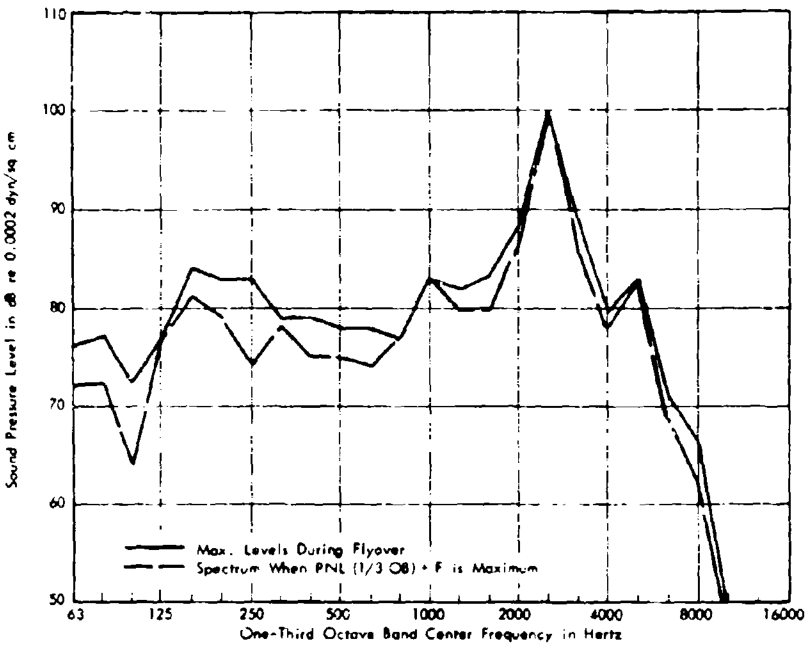


A NOISE SPECTRUM

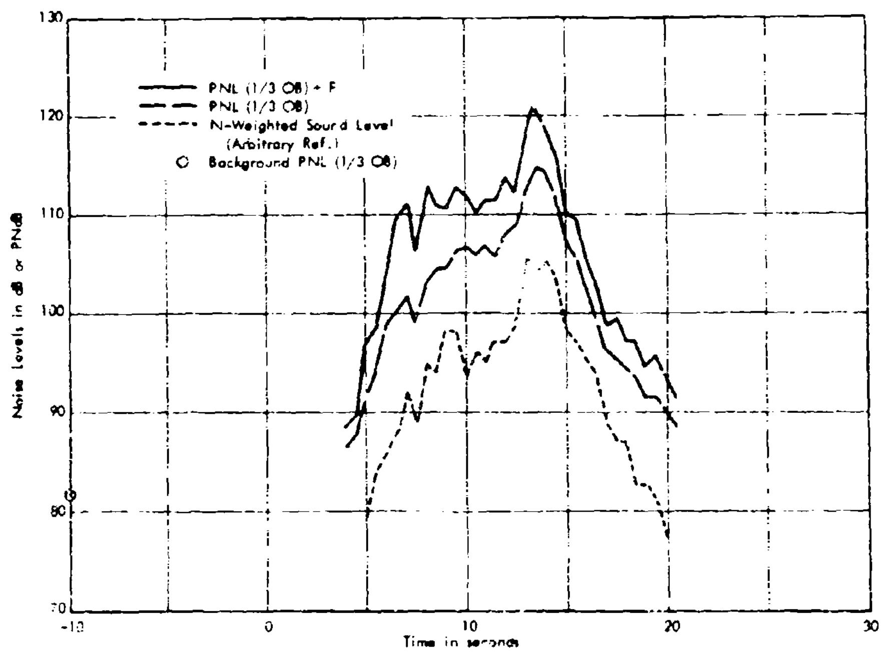


B TIME HISTORY

FIGURE 33. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - BOEING 720B LANDING, 775 FEET SLANT DISTANCE

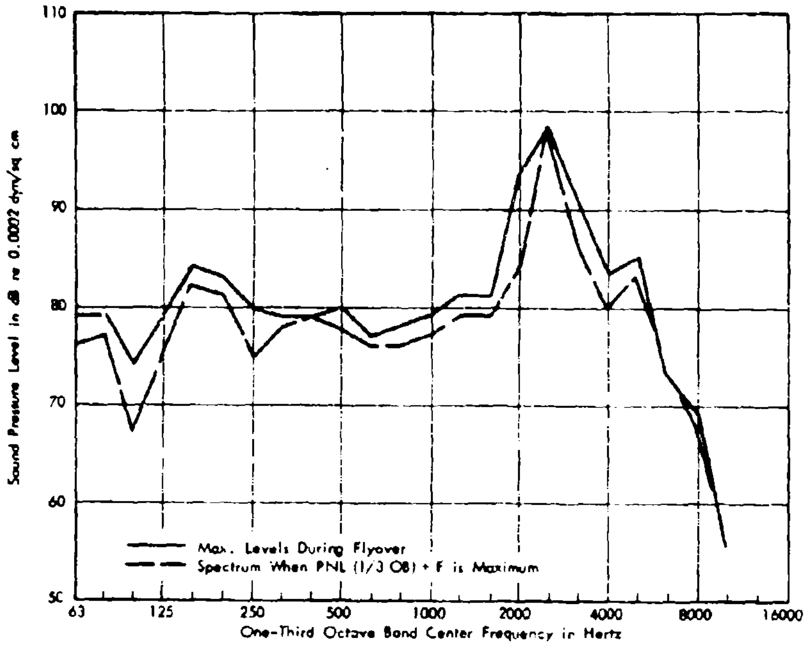


A. NOISE SPECTRUM

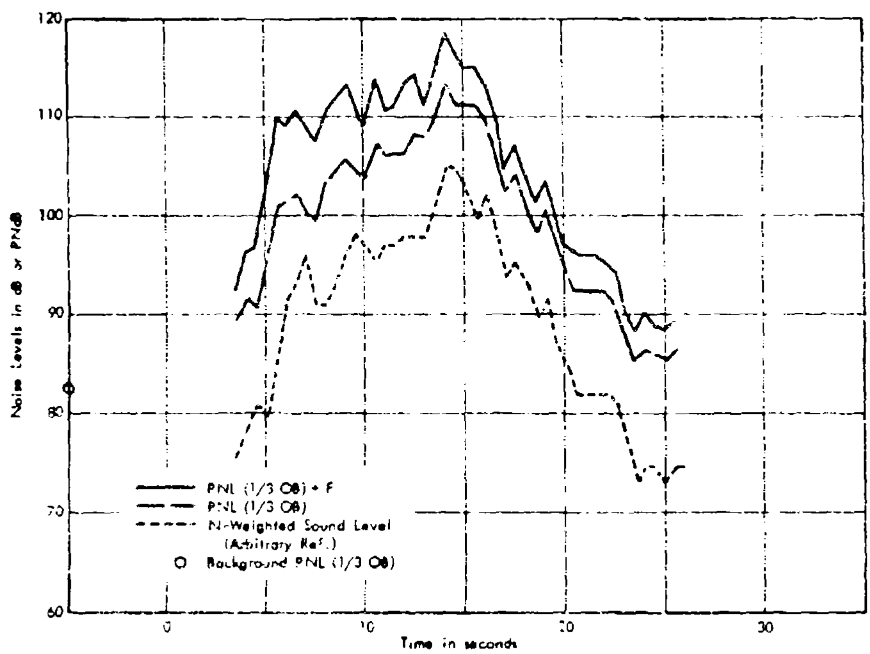


B. TIME HISTORY

FIGURE 34. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - BOEING 720B LANDING, 865 FEET SLANT DISTANCE

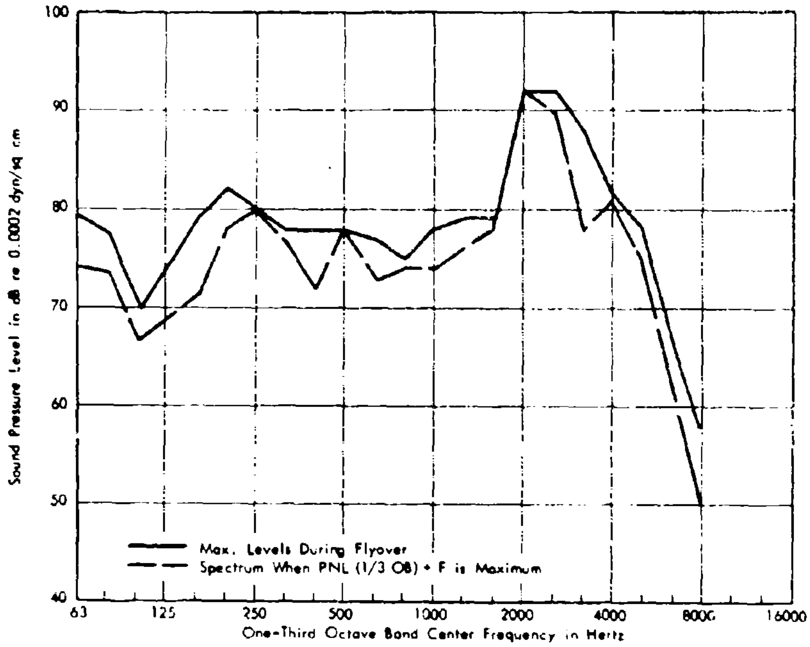


A. NOISE SPECTRUM

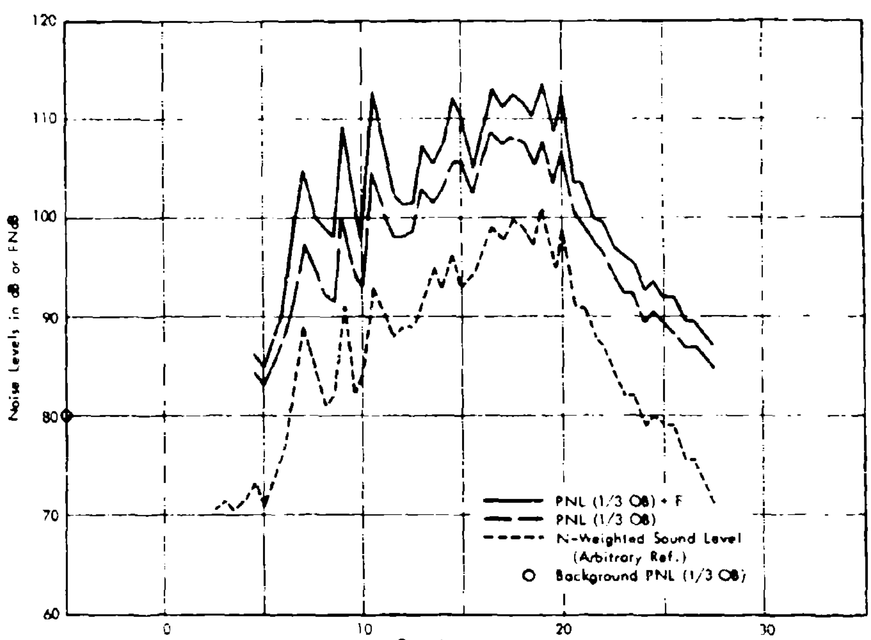


B. TIME HISTORY

FIGURE 35. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - DOUGLAS DC-8-50 LANDING, 930 FEET SLANT DISTANCE

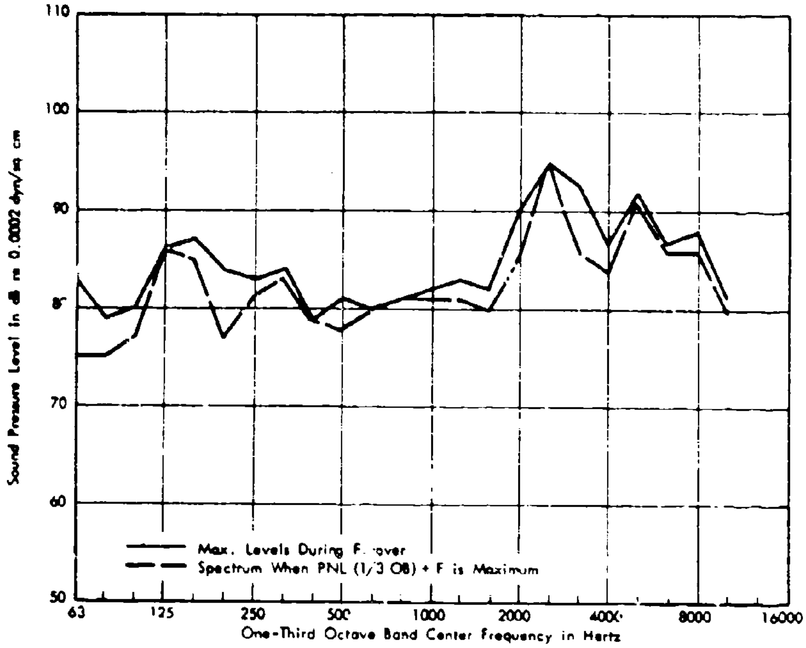


A. NOISE SPECTRUM

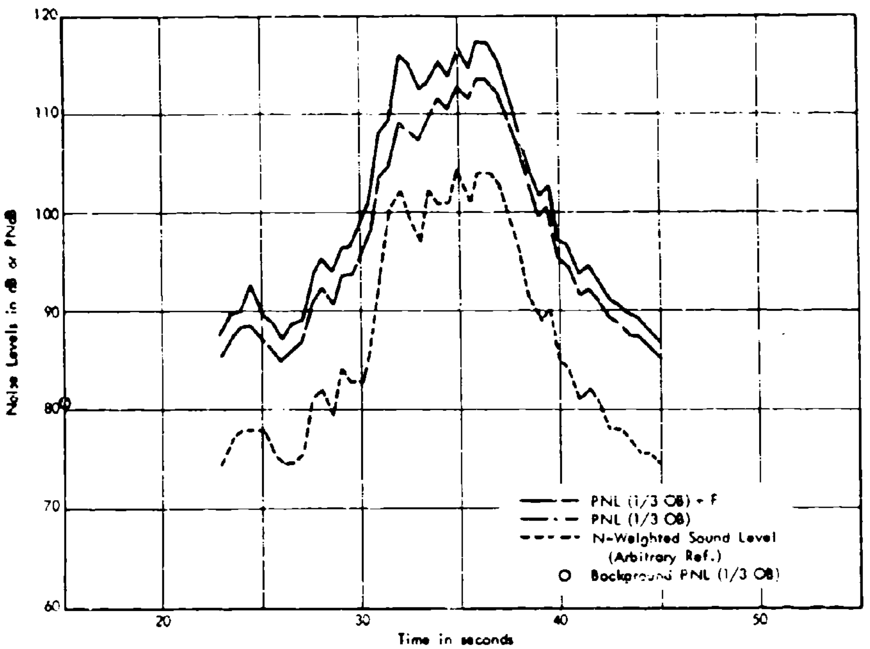


B. TIME HISTORY

FIGURE 36. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - DOUGLAS DC-8-50 LANDING, 1120 FEET SLANT DISTANCE

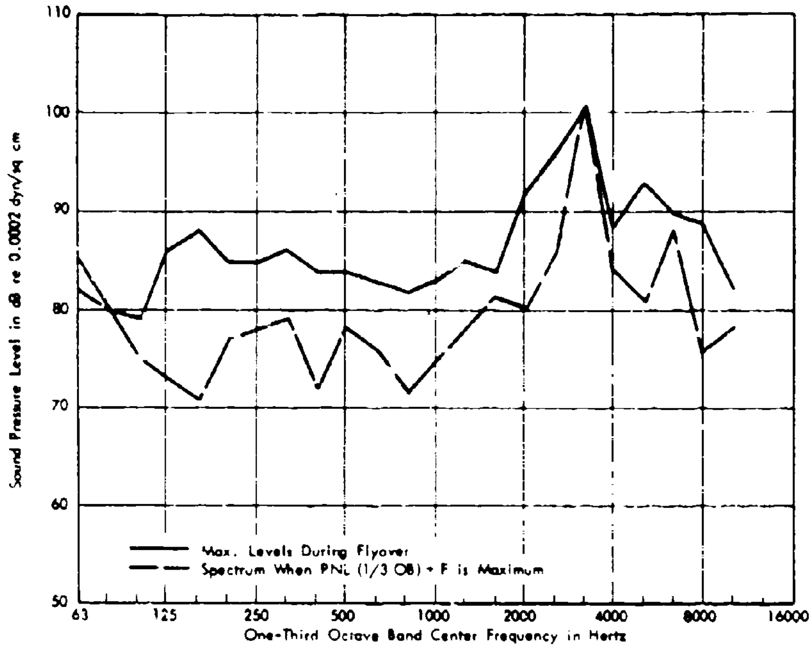


A NOISE SPECTRUM

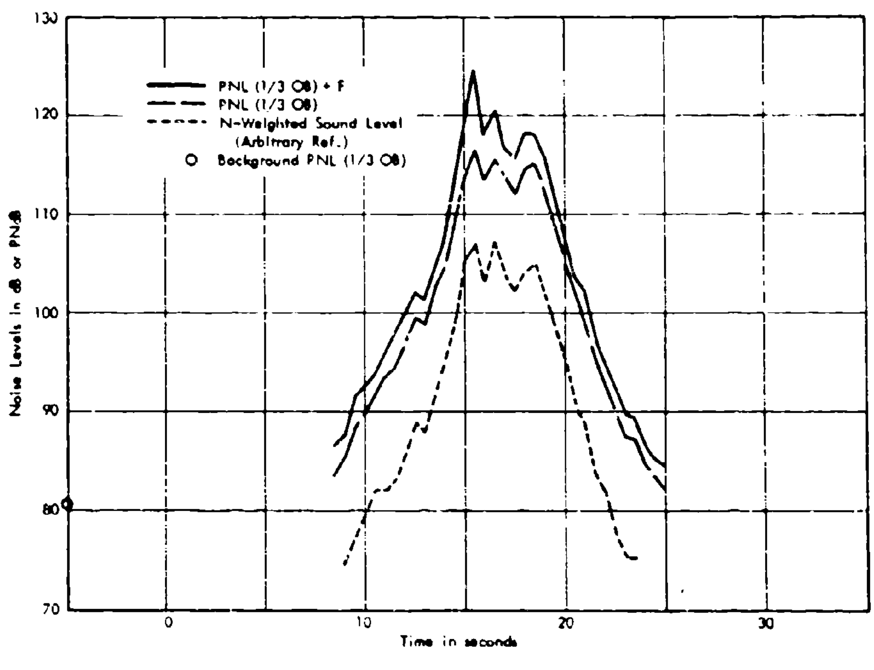


B. TIME HISTORY

FIGURE 37. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - DOUGLAS DC-8-50 LANDING, 480 FEET SLANT DISTANCE

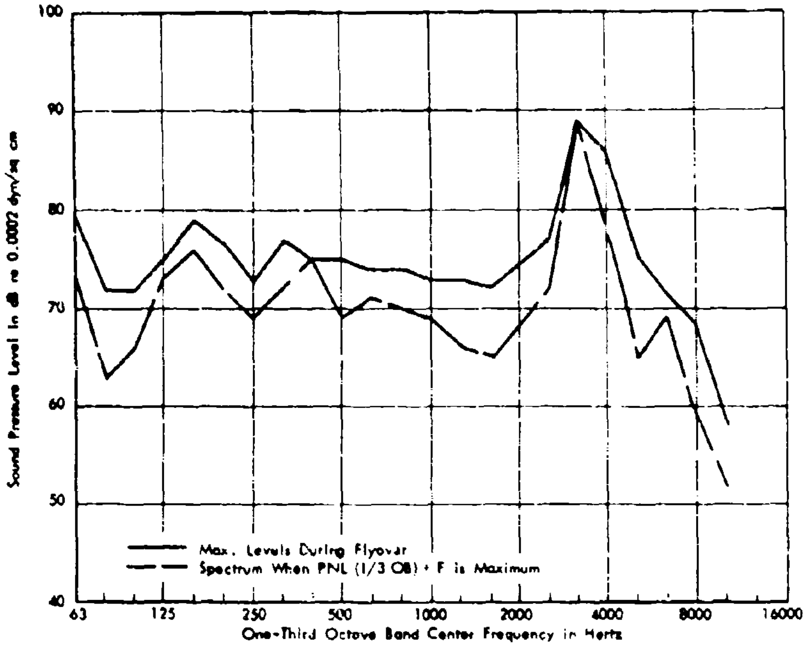


A. NOISE SPECTRUM

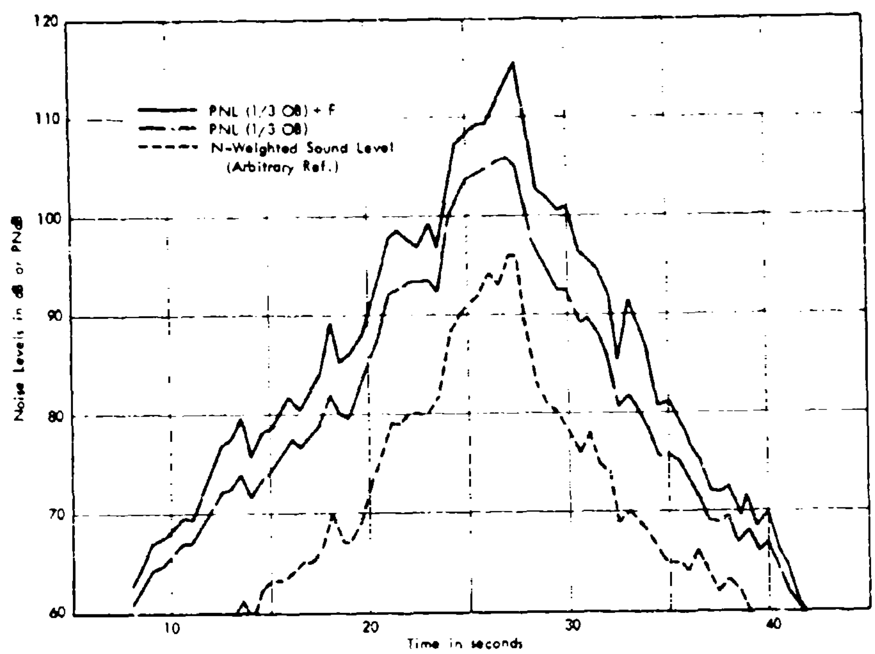


B. TIME HISTORY

FIGURE 38 FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - DOUGLAS DC-8-61 LANDING

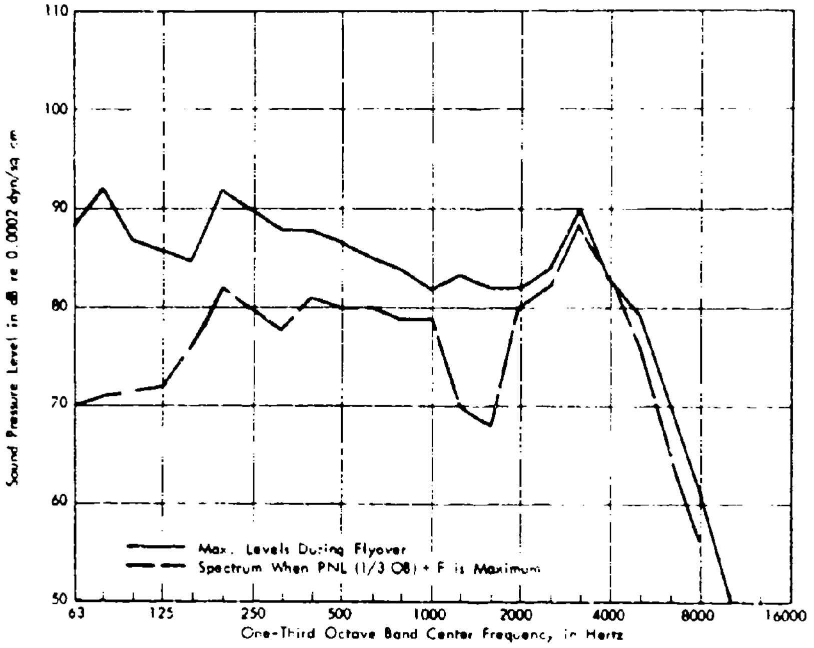


A. NOISE SPECTRUM

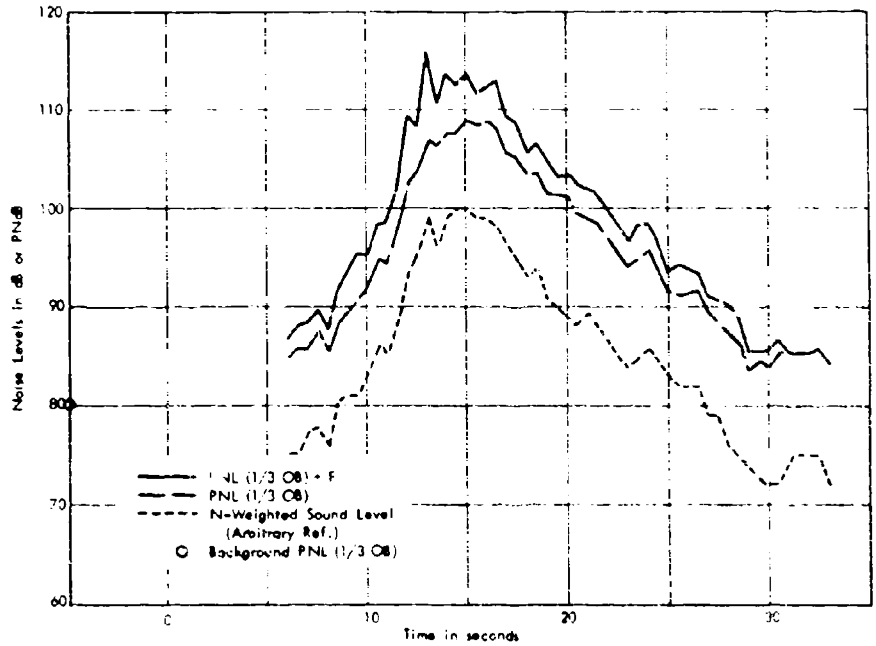


B. TIME HISTORY

FIGURE 39. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - CONVAIR 990A LANDING, 575 FEET SLANT DISTANCE



A NOISE SPECTRUM



B TIME HISTORY

FIGURE 40. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - BOEING 727 LANDING, 850 FEET SLANT DISTANCE

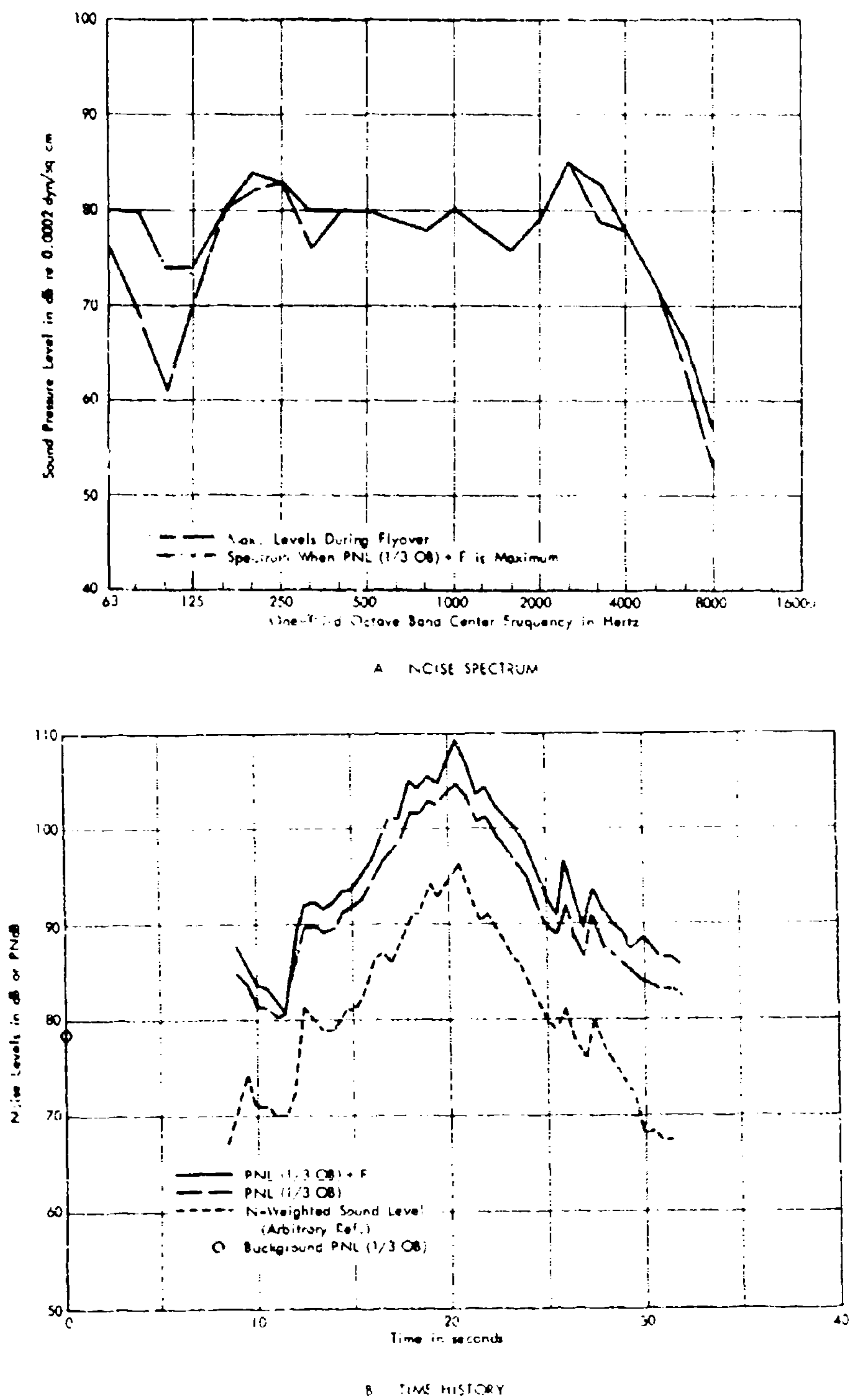
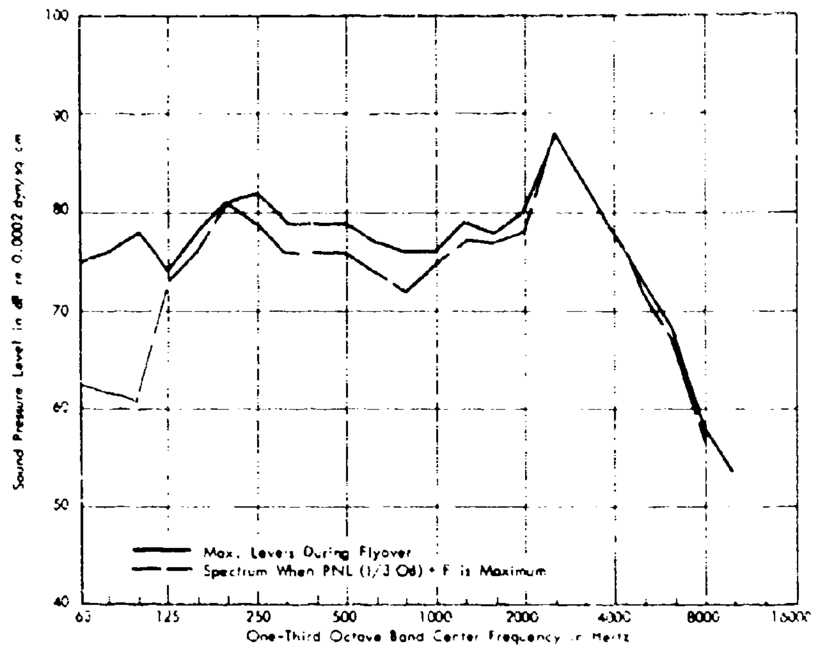
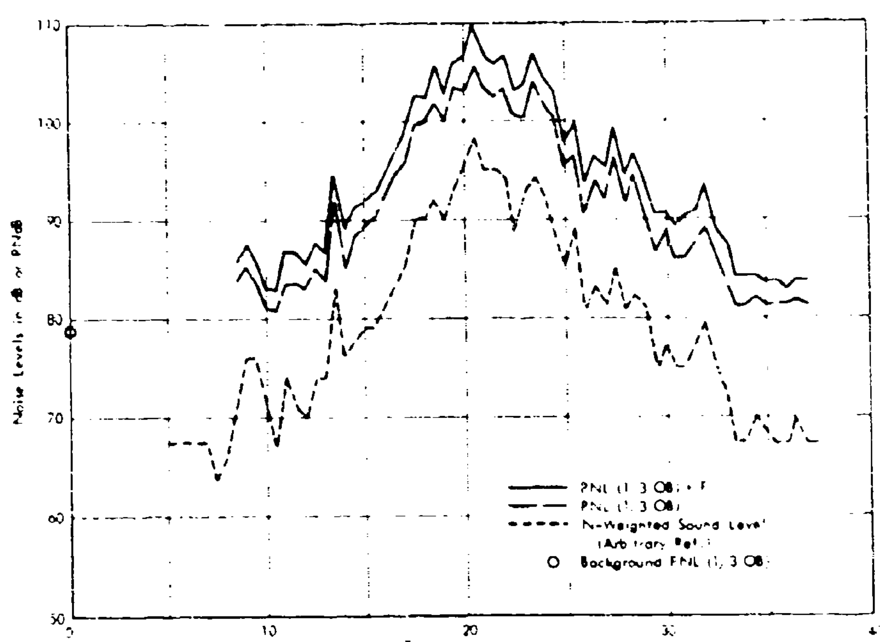


FIGURE 41. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - BOEING 727 LANDING, 950 FEET SLANT DISTANCE

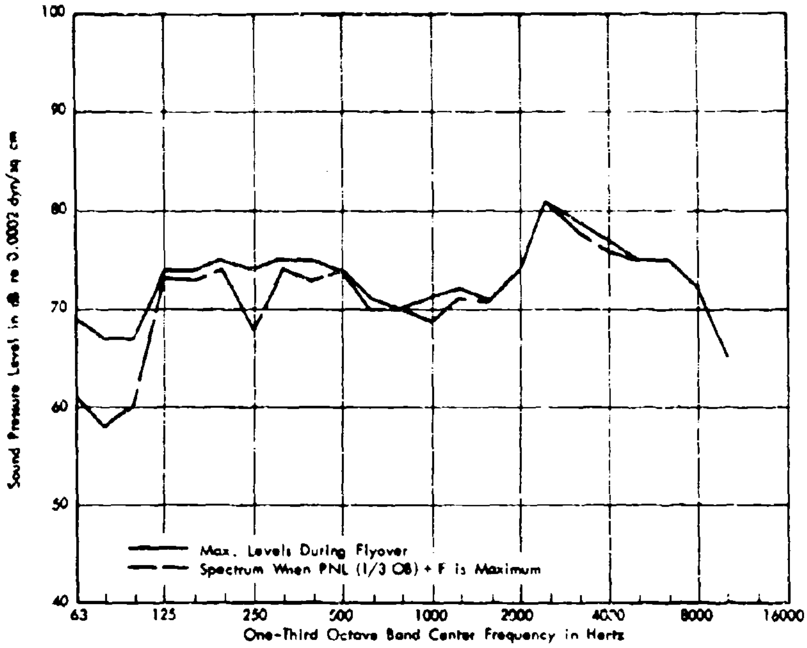


A NOISE SPECTRUM

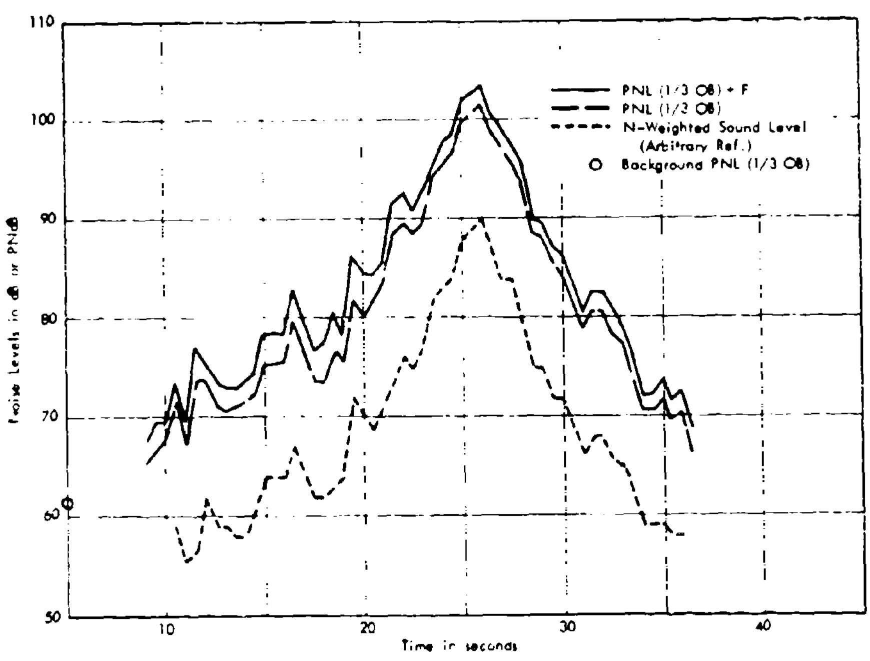


B TIME HISTORY

FIGURE 42. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY – DOUGLAS DC-9 LANDING, 1020 FEET SLANT DISTANCE

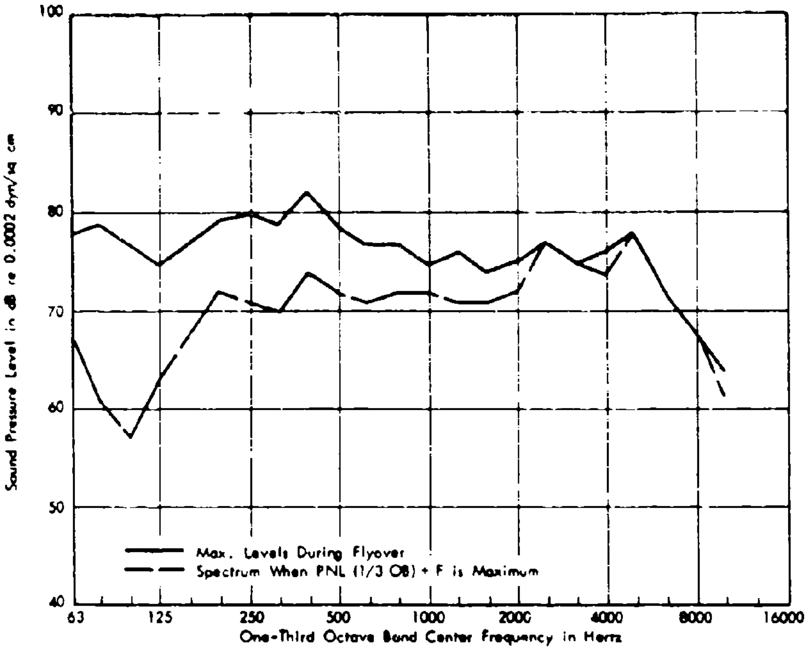


A. NOISE SPECTRUM

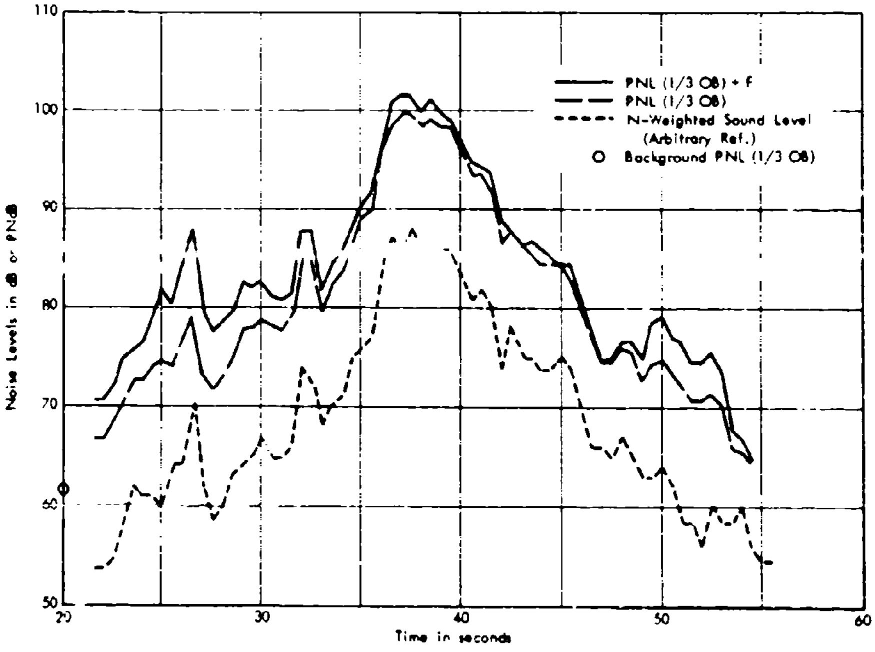


B. TIME HISTORY

FIGURE 43. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - DOUGLAS DC-9 LANDING, 539 FEET SLANT DISTANCE

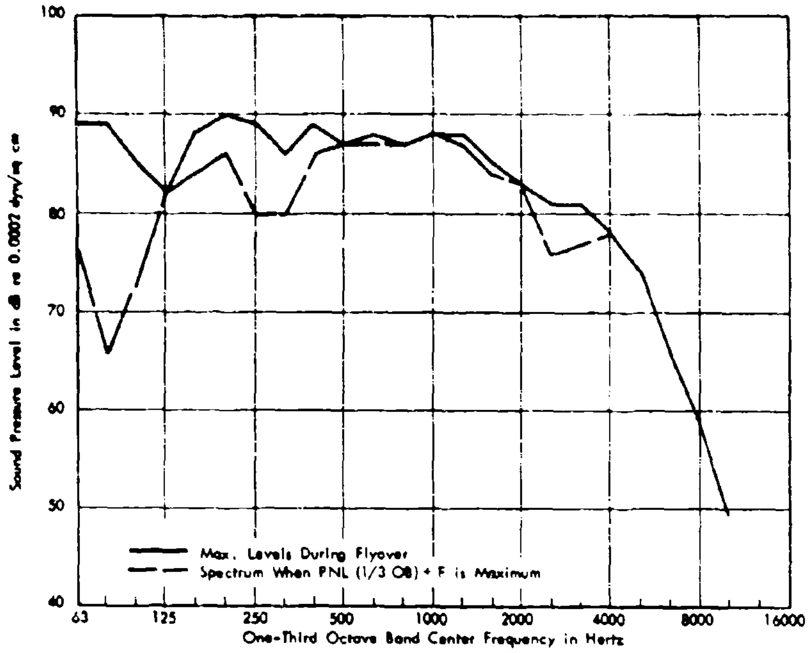


A. NOISE SPECTRUM

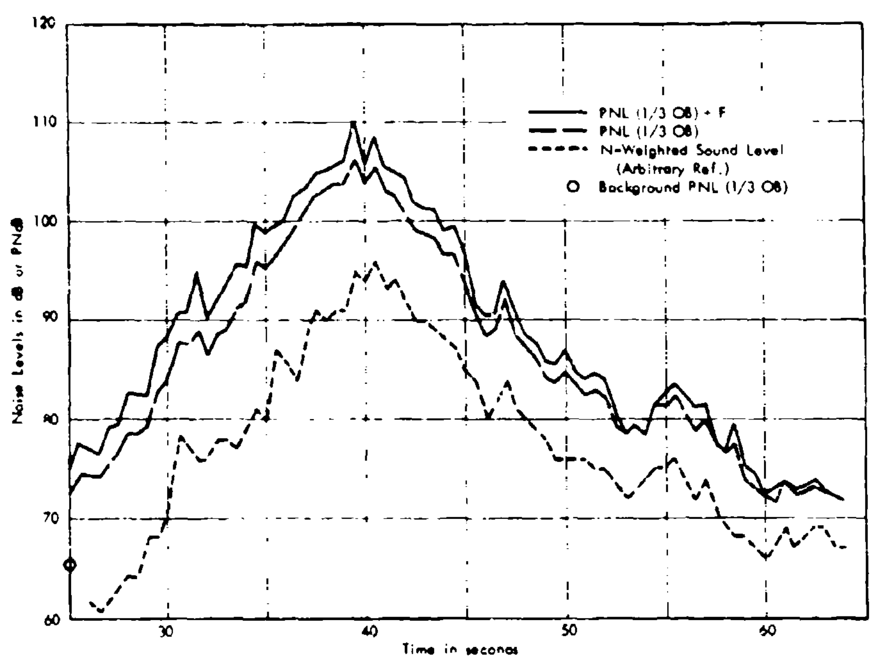


B TIME HISTORY

FIGURE 44. FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - BAC 111 LANDING, 447 FEET SLANT DISTANCE



A. NOISE SPECTRUM



B. TIME HISTORY

FIGURE 45 FLYOVER NOISE SIGNAL SPECTRUM AND TIME HISTORY - BAC 111 LANDING

APPENDIX A

SUMMARY OF DATA ACQUISITION AND REDUCTION PROCEDURES AND INSTRUMENTATION

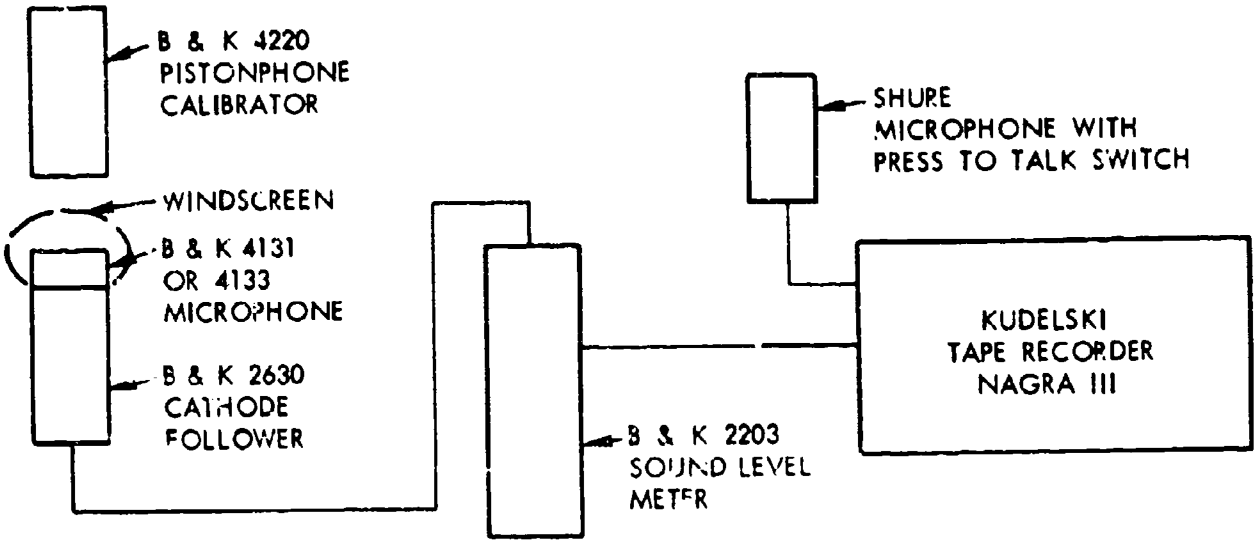
The flyover noise levels were initially recorded in the field on magnetic tape using the data acquisition system indicated in the upper portion of Fig. A-1. Field recordings during scheduled operations were obtained at several airports including Los Angeles International Airport, Long Beach Municipal Airport, Westchester County Airport, Long Island, and O'Hare International Airport in Chicago. A large number of flyover recordings were examined and selection of the data for analysis was based primarily upon "clean" recordings of identifiable aircraft having a dynamic range (overall sound pressure level or N-weighted sound level) of 25 dB or greater.

A Kudelski Nagra III Tape Recorder, a Bruel and Kjaer 2203 Sound Level Meter, and a Bruel and Kjaer 2630 Cathode Follower equipped with a Bruel and Kjaer 4133 Condenser Microphone were used to record the data. Acoustic calibration signals obtained with a Bruel and Kjaer 4220 Pistonphone were recorded on the data tapes at intervals during the recordings. The pistonphone signals were analyzed later during data reduction as a check on system performance and as a calibration standard for the noise recordings. In addition, sweep frequency signals were recorded on the tape prior to field use; the sweep signals were later utilized to obtain detailed frequency response corrections for the electrical portion of the combined data acquisition-playback system.

The data reduction employed the conventional analog system shown in the lower portion of Fig. A-1 to obtain time histories of each one-third octave band from 63 to 10,000 Hz and the N-weighted sound level. Time markers were placed at the beginning of each flyover to permit time synchronization of the histories in the various frequency bands. A writing speed of 80 mm/sec and a paper speed of 10 mm/sec with a lower limiting frequency of 10 Hz were employed with the Bruel and Kjaer 2305 Graphic Level Recorder.

The sound pressure levels were then read from the graphic level charts at each one-half second interval. After tabulating and checking, the time-history data including background noise level information was entered into a digital computer. The computer calculated corrections for background noise levels, calculated the perceived noise level for each one-third octave band spectrum, the corrections for discrete frequency components (in accordance with Appendix B procedures) and the various measures of time duration.

DATA ACQUISITION SYSTEM



DATA REDUCTION SYSTEM

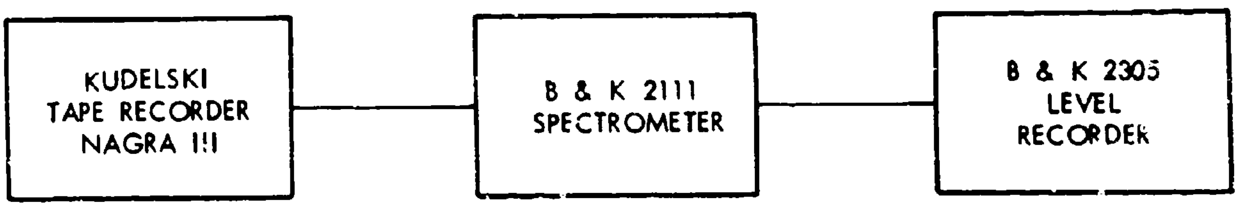


FIGURE A-1. NOISE MEASUREMENT SYSTEMS

APPENDIX B

CALCULATION OF DISCRETE FREQUENCY CORRECTION FOR EACH THIRD-OCTAVE BAND SPECTRUM

Step 1

Compute for each third-octave band determined at 0.5 second intervals, a value composed of the arithmetic average of the levels the nearest two bands above the given band and the nearest two bands below.

Note:

The value for the two lowest frequency bands, and the two highest bands is based on only the average of available adjacent bands.

Step 2

Mark all bands that exceed this computed value by 3 dB or more. Recompute for all bands a second average value as in Step 1, omitting the marked bands in calculations of the average. (The average may now be based on several non-contiguous bands.) A discrete frequency is said to exist if the SPL in any band exceeds this recomputed average value by 3 dB or more.

Step 3

The difference in dB between the second computed average value and actual SPL in each marked band is used as the number to enter the tone correction table (Table B-I). Thus, a tone correction is determined for each third-octave band that exceeds its "average" by 3 dB or more.

Step 4

The final tone correction for any third-octave band spectrum is taken to be only the maximum tone correction determined in Step 3. Thus, the final value of discrete frequency correction for any third-octave band spectrum is determined by only the "worst" third-octave band.

TABLE B-1

CORRECTIONS TO BE ADDED* TO ONE-THIRD OCTAVE BAND PERCEIVED NOISE LEVELS TO ACCOUNT FOR DISCRETE FREQUENCY COMPONENTS

1/3 Octave Band Center Frequency Hz	SPL of Toned Band Above Non-Toned Adjacent Bands											
	3	4	6	8	10	12	14	16	18	20	25	30
100	0.0	0.0	.1	.4	.6	.8	.9	1.1	1.2	1.4	1.8	2.3
125	0.0	0.0	.4	.7	.9	1.1	1.2	1.4	1.6	1.8	2.4	3.1
160	0.0	.3	.7	.9	1.2	1.4	1.6	1.8	2.1	2.4	3.2	4.2
200	.4	.6	.9	1.2	1.4	1.7	2.0	1.3	1.7	3.1	4.2	5.4
250	.7	.9	1.1	1.4	1.7	2.0	2.4	2.8	3.2	3.7	5.0	6.5
315	.9	1.1	1.3	1.7	2.0	2.4	2.8	3.3	2.8	4.4	6.0	7.8
400	1.1	1.2	1.5	1.9	2.3	2.8	3.3	3.9	4.5	5.2	7.0	9.2
500	1.2	1.4	1.8	2.2	2.7	3.3	3.9	4.5	5.3	6.0	8.2	10.7
630	1.3	1.5	2.0	2.4	3.0	3.6	4.3	5.0	5.8	6.7	9.1	11.9
800	1.4	1.6	2.0	2.5	3.1	3.7	4.4	5.2	6.0	6.9	9.4	12.2
1000	1.3	1.5	1.9	2.4	3.0	3.6	4.2	5.0	5.8	6.6	9.0	11.8
1250	1.2	1.4	1.8	2.3	2.8	3.4	4.0	4.7	5.4	6.2	8.4	11.0
1600	1.2	1.4	1.8	2.3	2.8	3.4	4.0	4.7	5.4	6.2	8.5	11.0
2000	1.3	1.5	1.9	2.4	2.9	3.5	4.1	4.8	5.6	6.4	8.8	11.5
2500	1.4	1.6	2.1	2.6	3.2	3.9	4.6	5.4	6.3	7.2	9.8	12.8
3150	1.6	1.9	2.4	3.0	3.8	4.5	5.4	6.3	7.4	8.5	11.5	15.1
4000	1.5	1.8	2.3	2.8	3.5	4.2	5.0	5.9	6.9	7.9	10.7	14.1
5000	1.3	1.5	1.9	2.4	3.0	3.6	4.2	5.0	5.8	6.6	9.0	11.8
6300	1.1	1.3	1.6	2.0	2.4	2.9	3.4	4.0	4.7	5.4	7.3	9.5
8000	0.0	0.0	1.2	1.5	1.8	2.2	2.5	3.0	3.4	3.9	5.3	6.9
10000	0.0	0.0	0.0	0.0	1.2	1.5	1.7	2.0	2.3	2.6	3.5	4.5

* Corrections for tones are added <u>after</u> the usual PNL calculation