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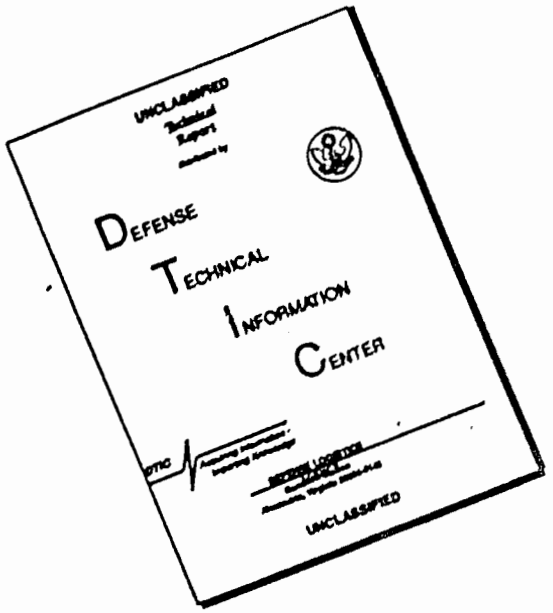

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U. S. ARMY
TRANSPORTATION RESEARCH COMMAND
FORT EUSTIS, VIRGINIA

TCREC TECHNICAL REPORT 61-92

NOISE SURVEY HU-1A HELICOPTER WITH MODIFIED EXHAUST SYSTEM

Task 9R38-01-017-54

Contract DA 44-177-TC-562

July 1961

prepared by :

VERTOL DIVISION
THE BOEING COMPANY
Morton, Pennsylvania

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Mr. J. E. Forehand/bsb/2297

HEADQUARTERS
U. S. ARMY TRANSPORTATION RESEARCH COMMAND
TRANSPORTATION CORPS
Fort Eustis, Virginia

TCREC-ADS 9R38-01-017-54

SUBJECT: Noise Survey HU-1A Helicopter with Modified Exhaust System

TO: See Distribution List

1. During the course of aircraft research or development programs, modifications are occasionally made which may affect the noise level of the aircraft.

2. A research program was recently conducted which resulted in a modified engine exhaust system for HU-1A helicopter number 9-1632. The purpose of the following report is to present a comparison of noise output of this helicopter with that of a similar helicopter in standard configuration.

3. The conclusions made by the contractor are concurred in by this Command.

4. This report is a supplement to TREC Technical Report 61-72 and is the first report of a continuing program to maintain up-to-date information on the internal and external noise levels of current and future Army aircraft. Additional reports of this type will be submitted as the data become available.

FOR THE COMMANDER:

Approved by:
Everette Forehand
Project Engineer

EARL A. WIRTH
CWO-4 USA
Adjutant

Task 9R38-01-017-54

Contract DA 44-177-TC-562

July 1961

NOISE SURVEY HU-1A HELICOPTER WITH MODIFIED EXHAUST SYSTEM

REPORT 247

Prepared By

VERTOL DIVISION

THE BOEING COMPANY

MORTON, PENNSYLVANIA

FOR

U. S. ARMY TRANSPORTATION RESEARCH COMMAND

FORT EUSTIS, VIRGINIA

FOREWARD

This report was prepared by the Dynamics Department of Vertol Division of The Boeing Company, under Contract DA44-177-TC-562, Project 9R38-01-017-52, Amendment 4. It was funded by U. S. Army Transportation Research Command, and was under the technical cognizance of Mr. J. Everette Forehand, USA TRECOM, Ft. Eustis, Virginia.

Sound level tests were conducted at Hayes Aircraft Corporation, Birmingham, Alabama. Aircraft Project Engineer was Mr. J. Davenport. Mr. C. Shakespeare of Vertol supervised field measurements.

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MODEL HU-1A

CONCLUSIONS

Noise levels of Army HU-1A helicopters 9-1632 (equipped with a modified exhaust system) and 58-2080 (standard configuration) were recorded under similar operating and ambient conditions and are, therefore, directly comparable. Some difference exists in the 200 ft directivity patterns of the aircraft in hover, along with an increase in high frequency noise in take-off and landing. The latter may be due to various pilot techniques in achieving the requirements of Test 2. Except for these, however, sound pressure levels of the aircraft, under similar operating conditions, are considered the same. Other differences lie within the envelope of repeatability.

It is, therefore, concluded that the modified exhaust system of HU-1A No. 9-1632 does not significantly affect the acoustic characteristics of the aircraft.

INTRODUCTION

A noise level survey of an Army HU-1A helicopter with a modified exhaust system (Ser. 9-1632) was made in conformance with tests and procedures reported in Reference 1. Data have been presented in a manner similar to Reference 1 and a comparison is made with HU-1A (Ser. 58-2080) noise levels reported therein.

The aircraft and operating conditions were similar, so that sound levels of the two aircraft may be directly compared. Gross weight, engine torque, gas generator rpm and rotor rpm have been compared and found to be similar in each instance.

DISCUSSION

Figure 1 is an illustration of HU-1A S/N 9-1632. Measurement equipment is shown installed in the aircraft in Figure 2.

Sound levels of the HU-1A in hover are shown in Figure 4. A noticeable difference exists in the directivity pattern in the high frequencies (1200 - 2400 cps, 2400 - 4800 cps and 4800 - 10,000 cps octave bands) on the port side of the aircraft. The remaining differences, however, are not of real significance, and are felt to lie in the range of repeatability.

Take-off and landing noise is shown in Figure 6. No large differences are noted between aircraft except in the high frequency (2400 - 4800 cps and 4800 - 10,000 cps) bands where HU-1A Serial 9-1632 shows an increase (about 10 db) at locations 1 and 2.

Noise levels of the aircraft in flyby are plotted in Figures 8, 9 and 10. Again, no significant difference is noted.

Internal sound levels are plotted in Figures 12, 13 and 14. While sound pressure levels inside aircraft 9-1632 are less than aircraft 58-2080, this may be due to a difference in interior configurations of the aircraft. Aircraft 58-2080 contained an auxiliary, range-extension fuel tank which considerably altered the internal acoustics of the aircraft. As a result, sound levels inside the two aircraft are not directly comparable. Comparison plots of the two aircraft are presented for hover and overhead flyby conditions in Figures 18, 19 and 20, respectively. Each spectrum level in Figure 18 represents an average value of three locations. This was done so that no one point would indicate a false trend. Note that the aft locations for 9-1632 have a somewhat higher SPL. Finally, overhead flyby comparisons do not indicate any significant trend, although at the 500 ft. altitudes, 9-1632 does have a lower SPL.

Figures 15, 16 and 17 are narrow band (continuous spectrum) charts which are directly comparable with those appearing in Reference 1.

Figure 21 is a comparison of fundamental frequencies and harmonics for each identifiable noise source at position 23, Test 1.

BIBLIOGRAPHY

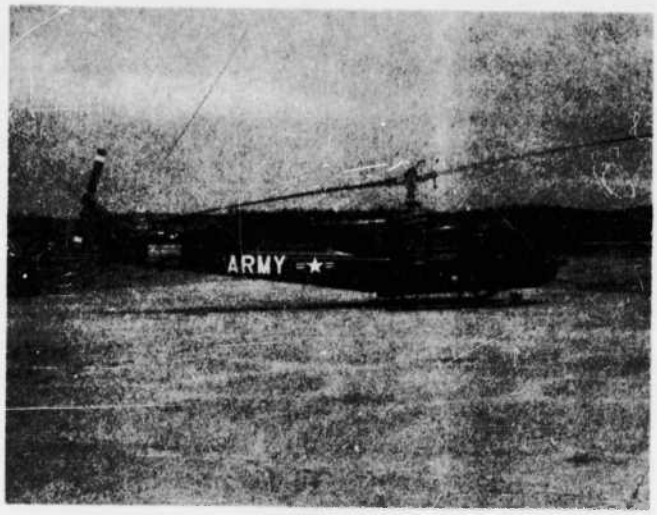
1. Sternfeld, H., Spencer, R. H., and Schaeffer, E. G., Study to Establish Realistic Acoustic Design Criteria for Future Army Aircraft. TREC TR 61-72 July 1961.

2. Wiener, F. M., "Sound Propagation Outdoors", Chapter 9, Noise Reduction, L. L. Beranek, Ed., McGraw-Hill Book Co., Inc., New York, 1960.

3. Rudnick, I., "Propagation of Sound in the Open Air" Chapter 3, Handbook of Noise Control, C. M. Harris, Ed., McGraw-Hill Book Co., Inc., New York, 1957.

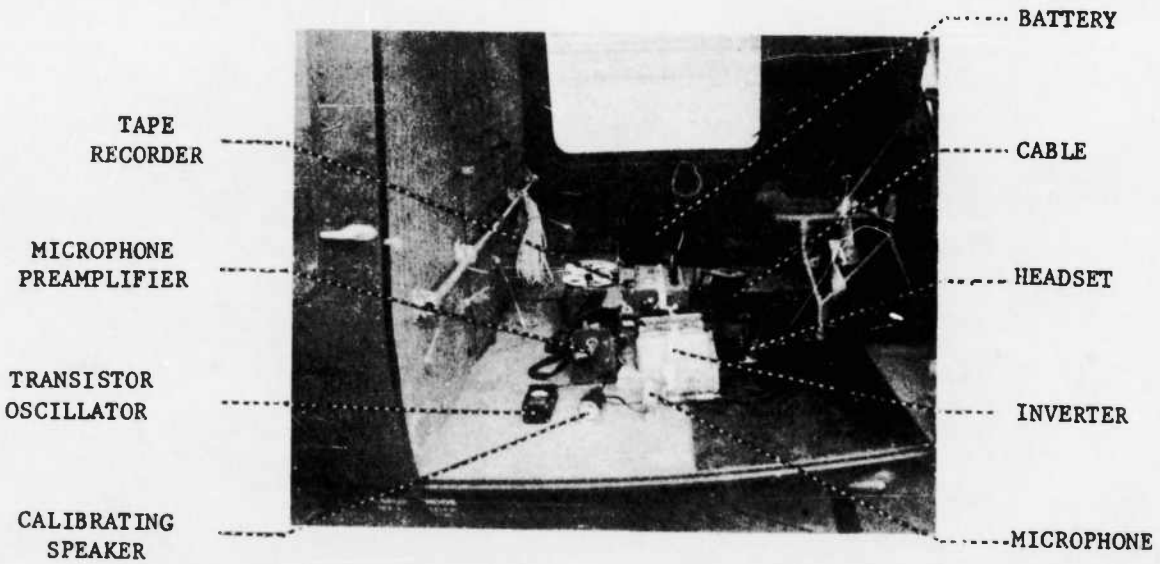
APPENDIX I

ILLUSTRATIONS



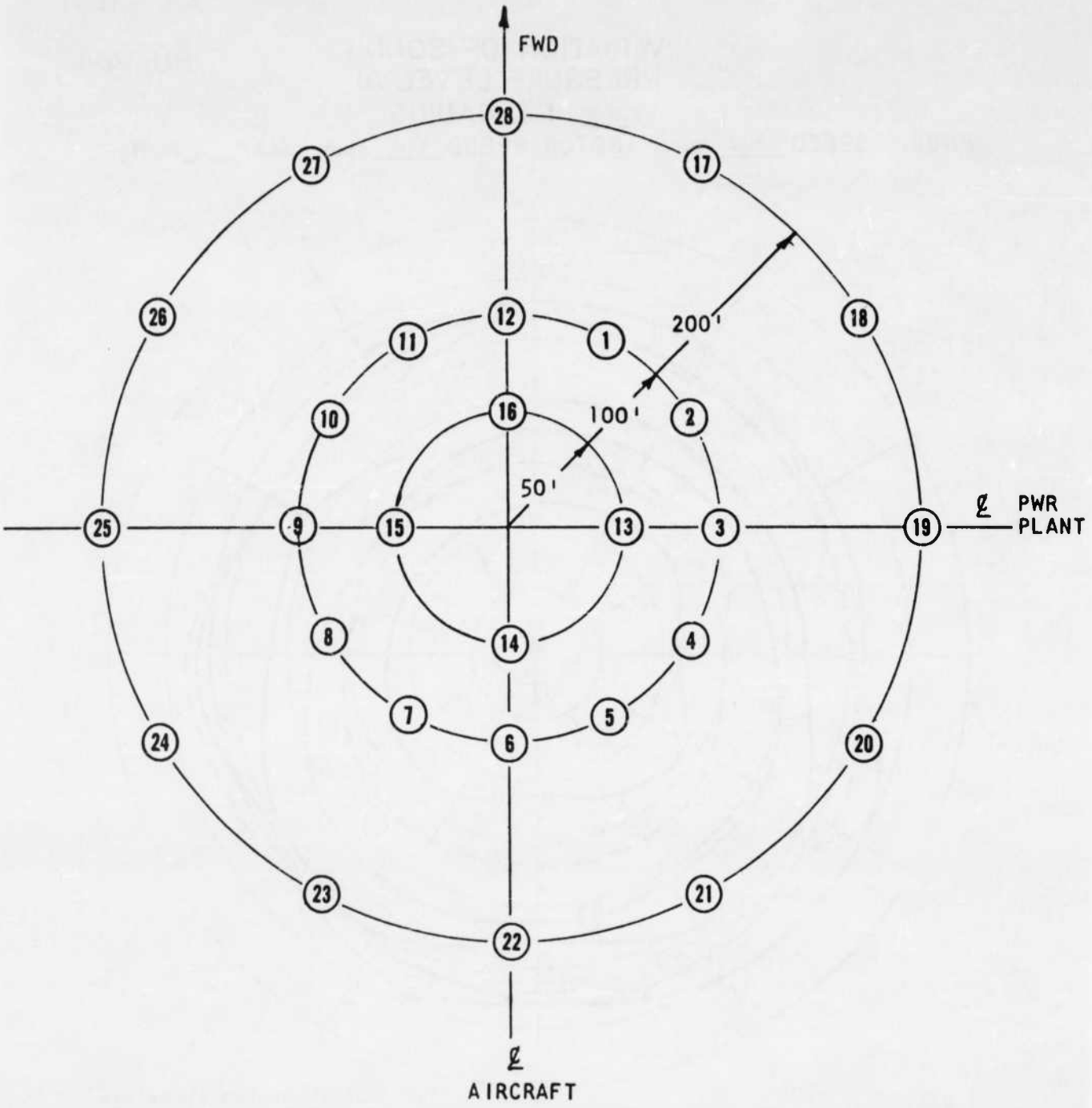
HU-1A HELICOPTER
S/N 91632

FIGURE 1



SOUND LEVEL RECORDING EQUIPMENT

FIGURE 2



MEASUREMENT LOCATIONS - TEST 1

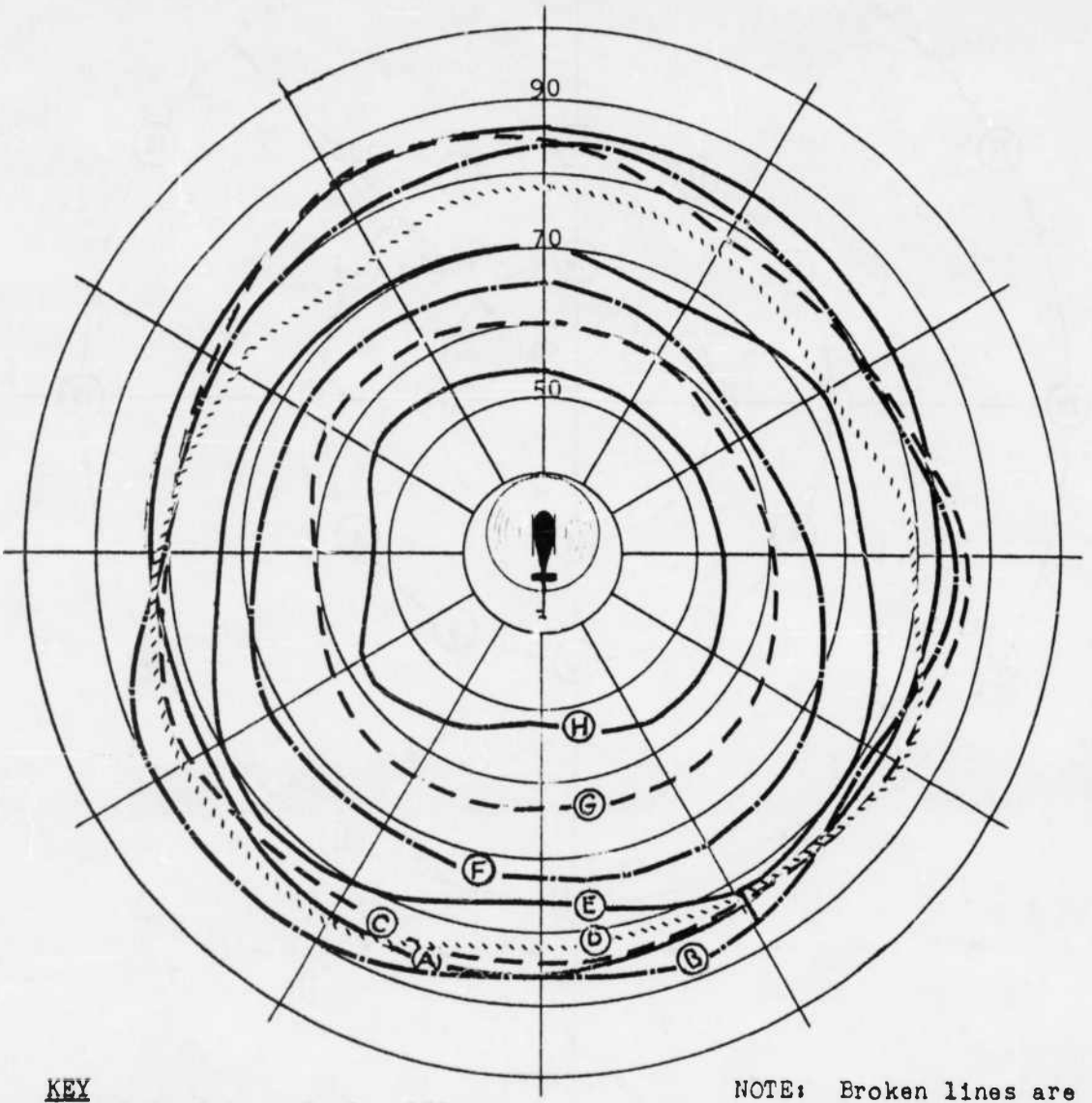
FIGURE 3

A/C - TEST

HU-1A-1

VARIATION OF SOUND PRESSURE LEVEL AT 200 FT. RADIUS

ENGINE SPEED 6400 rpm ROTOR SPEED 320 rpm MAP ___ in. Hg

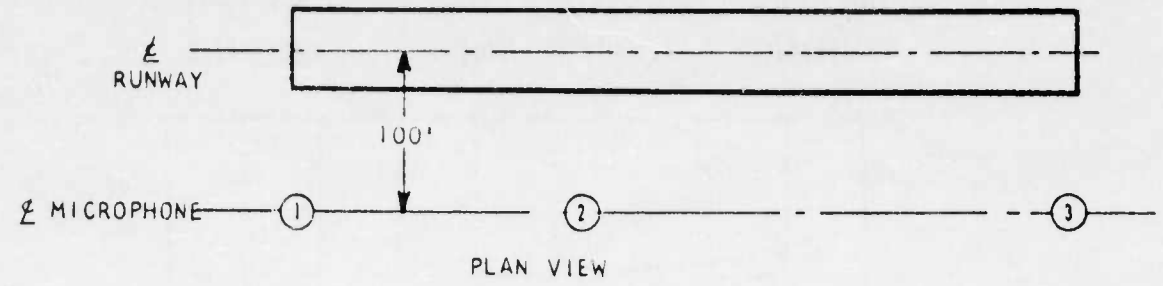


KEY

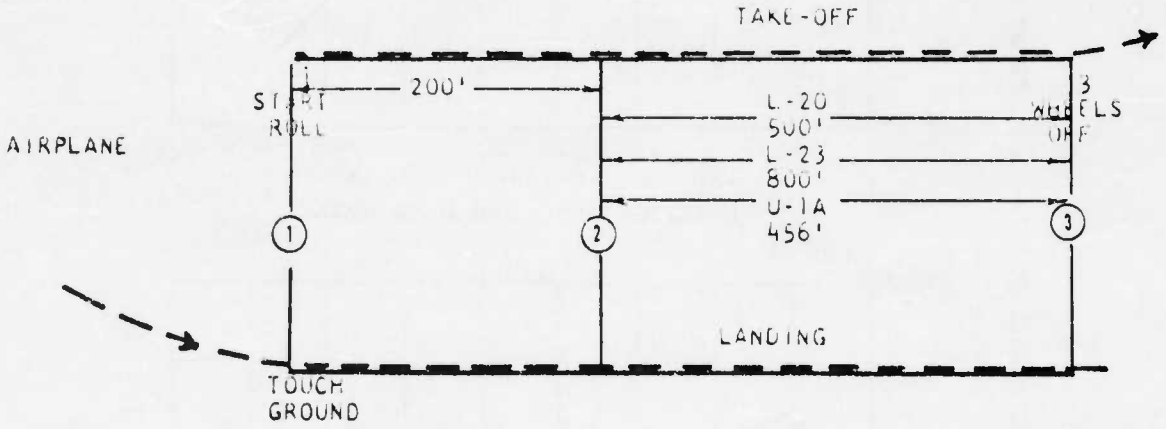
Symbol	Octave Band - CPS
A	20-75
B	75-150
C	150-300
D	300-600
E	600-1200
F	1200-2400
G	2400-4800
H	4800-10 KC

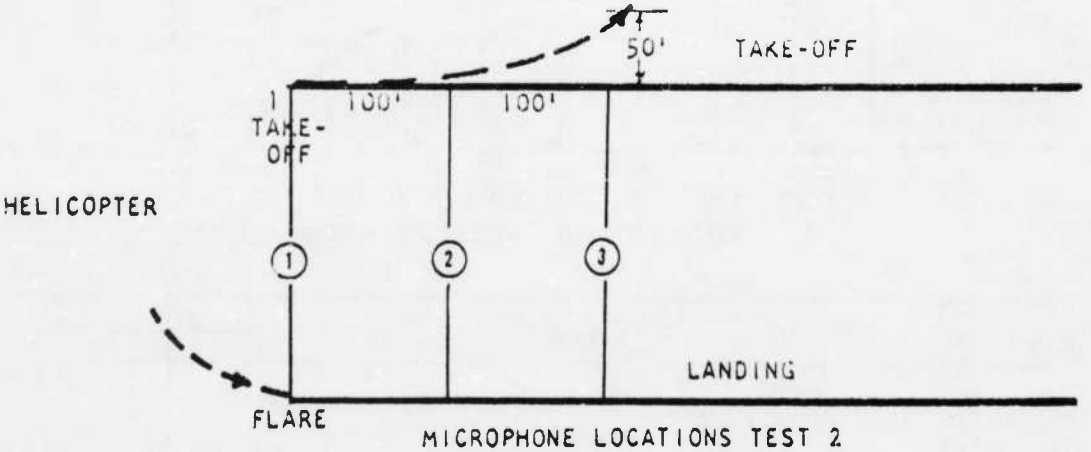
NOTE: Broken lines are for clarity only.

Figure 4



PLAN VIEW

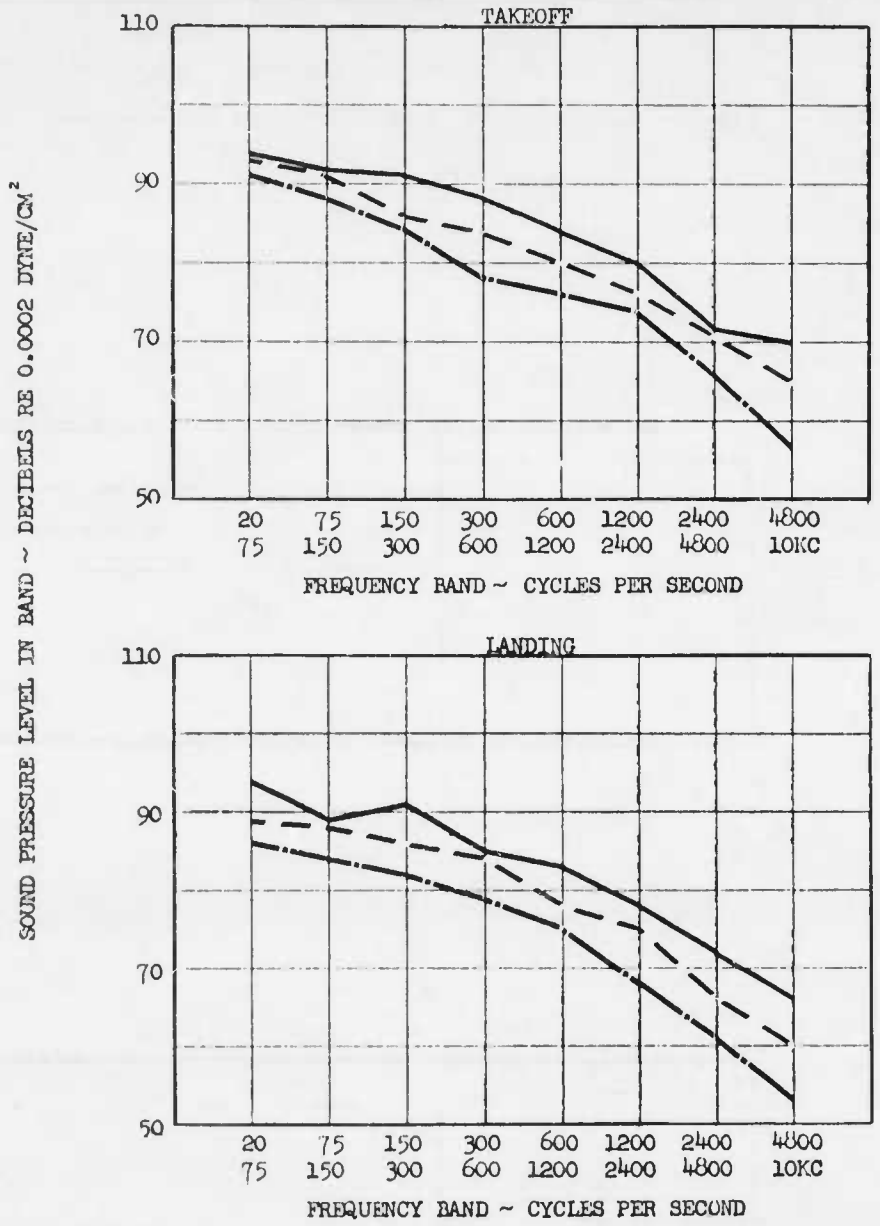




MICROPHONE LOCATIONS TEST 2

FIGURE 5

MAXIMUM SOUND PRESSURE LEVELS DURING TAKEOFF AND/OR LANDING



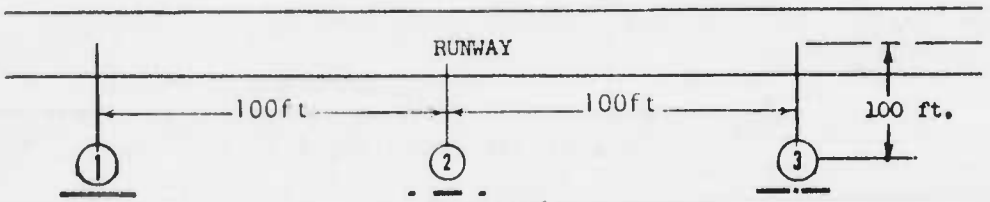
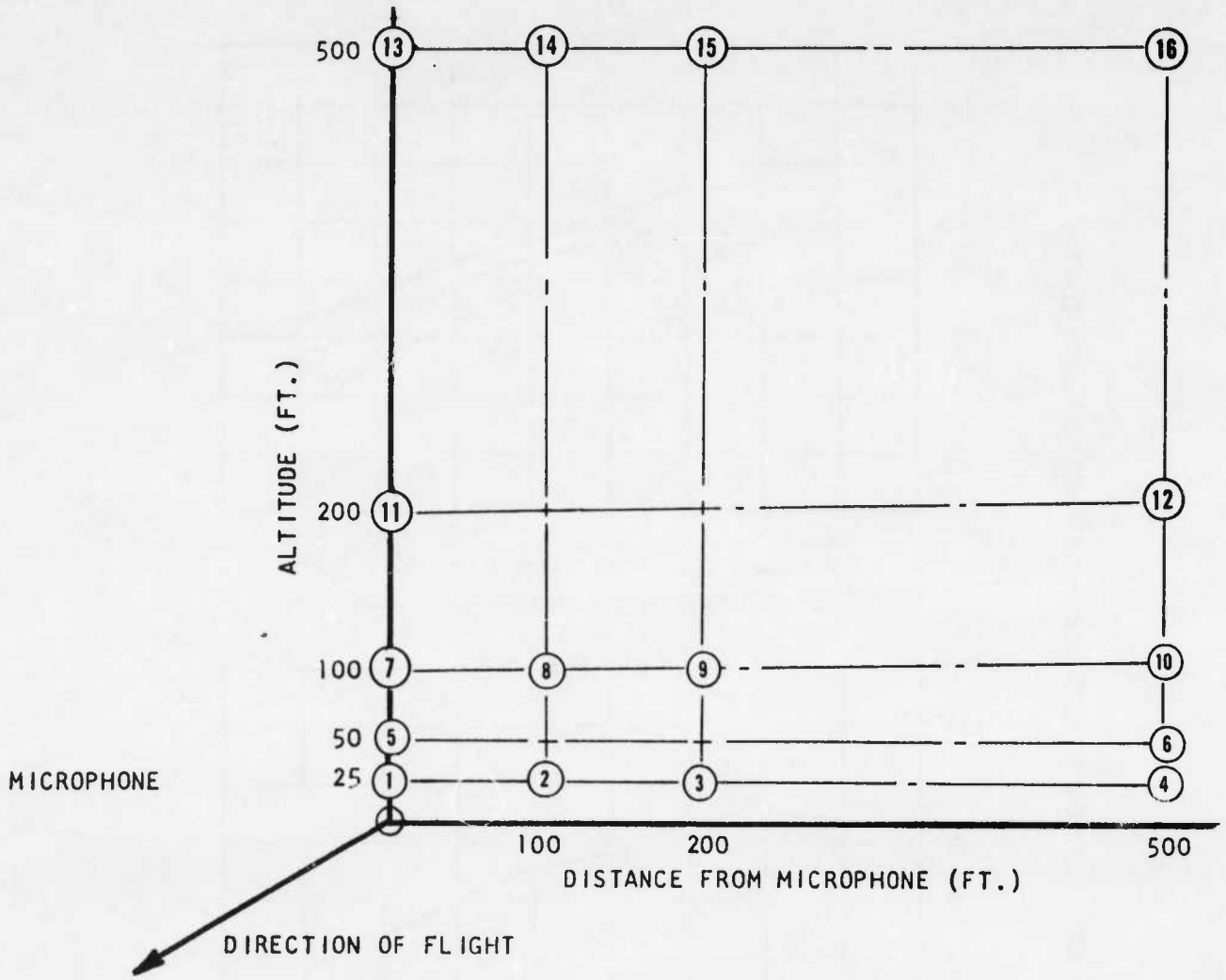


Figure 6



MEASUREMENT LOCATIONS - TEST 3

FIGURE 7

MAXIMUM EXTERNAL SOUND PRESSURE LEVELS MEASURED AT GROUND STATION

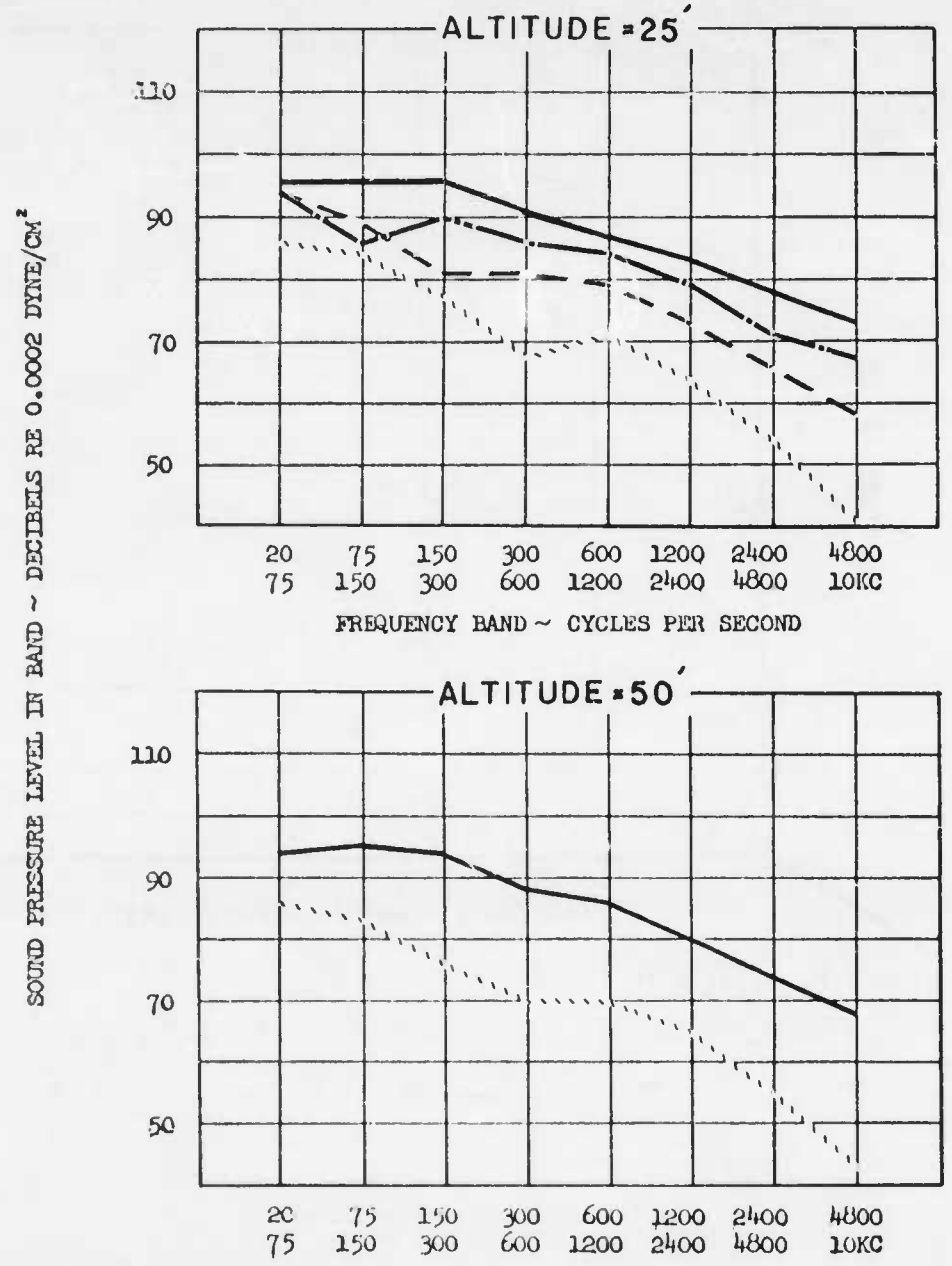


Figure 8

MAXIMUM EXTERNAL SOUND PRESSURE LEVELS MEASURED AT GROUND STATION

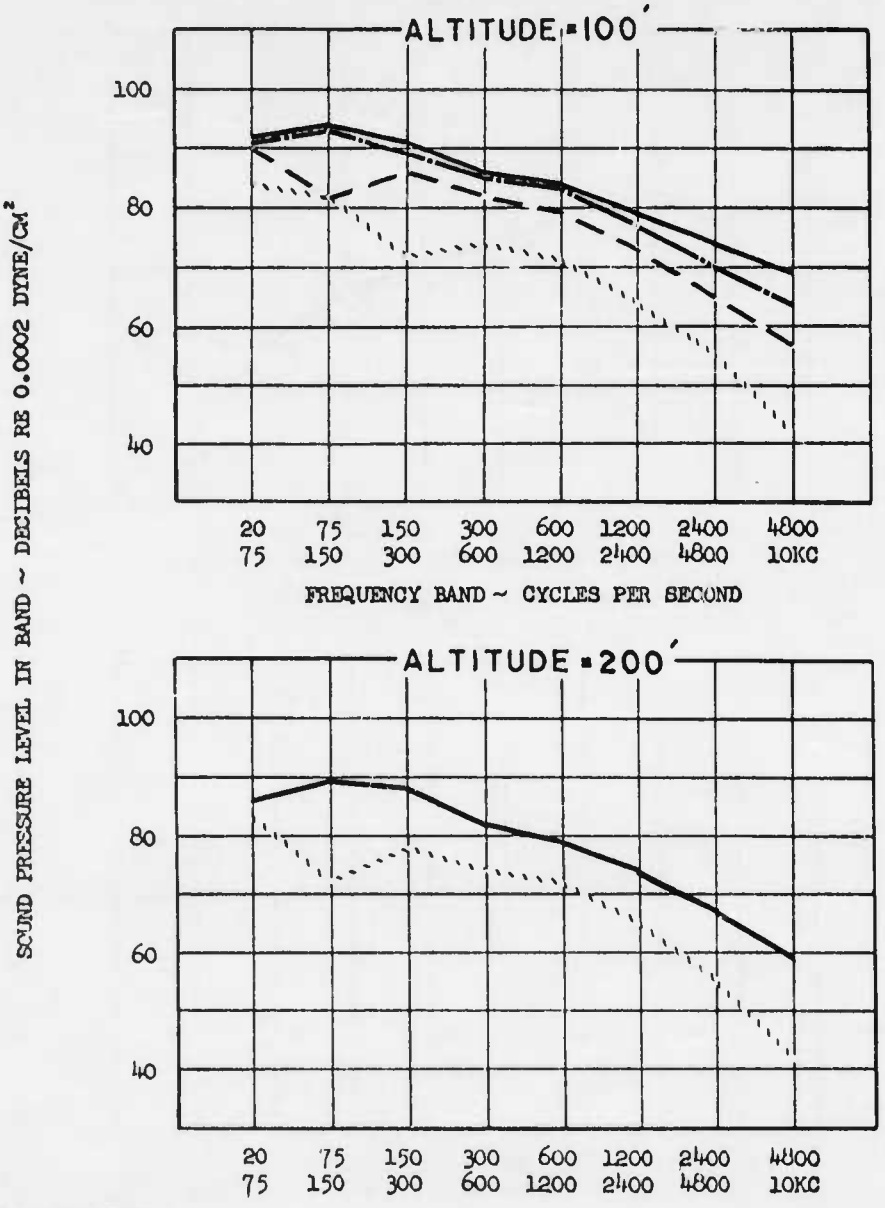
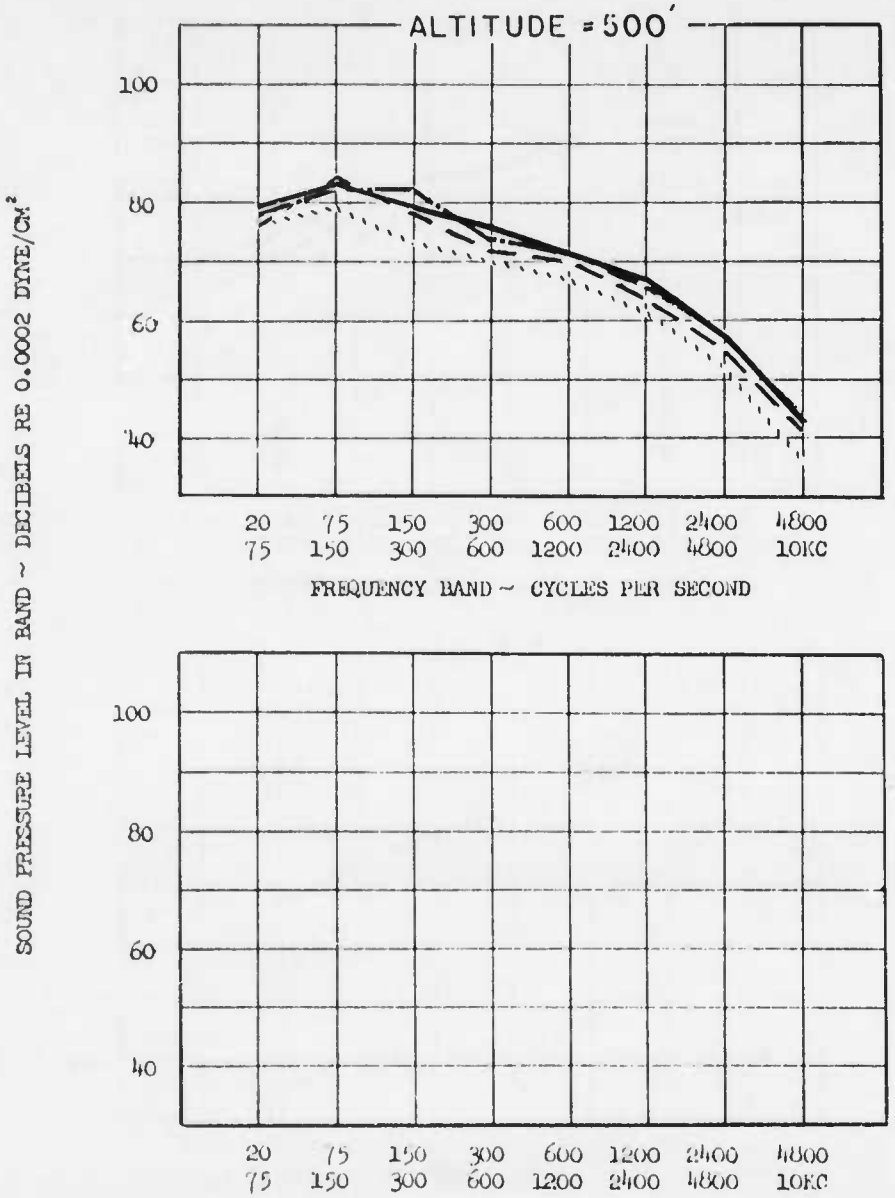


Figure 9

MAXIMUM EXTERNAL SOUND PRESSURE LEVELS MEASURED AT GROUND STATION

A/C - TEST

HU-1A-3



DISTANCES

0'- ——

100'- —·——·—

200'- · — —

500'- ·····

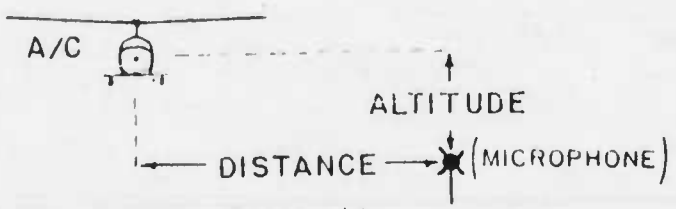
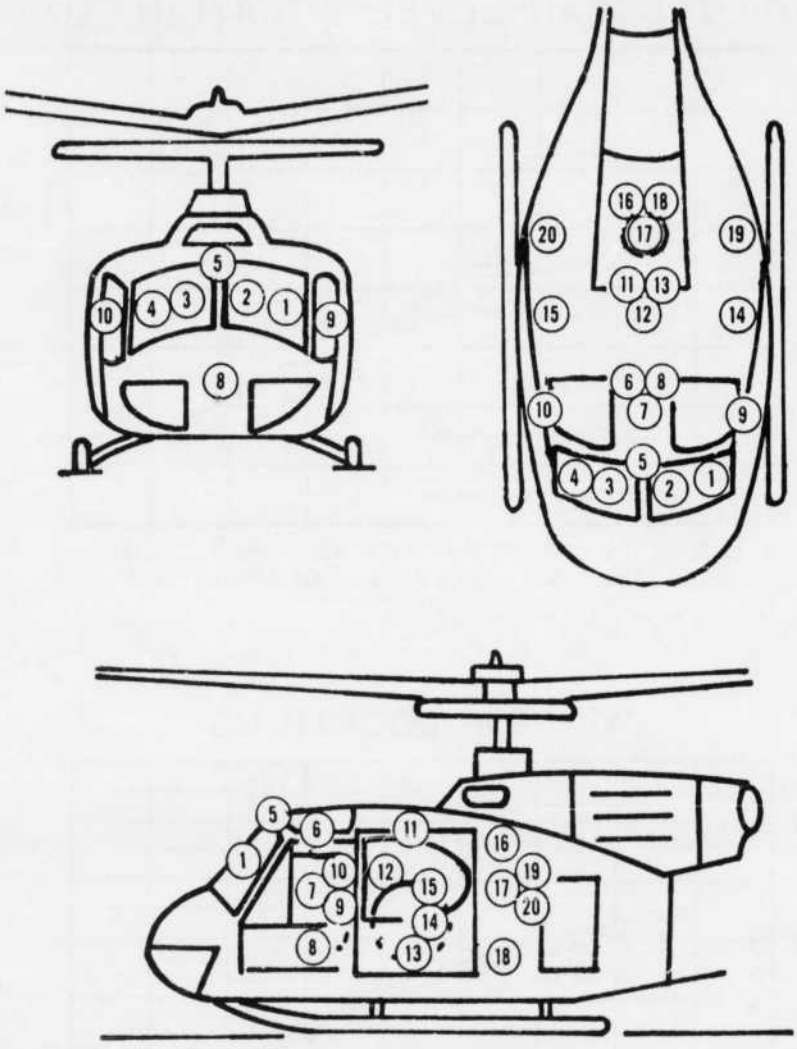


Figure 10



APPROXIMATE MICROPHONE POSITIONS USED FOR VARIOUS NOISE MEASUREMENTS INSIDE AIRCRAFT

FIGURE 11

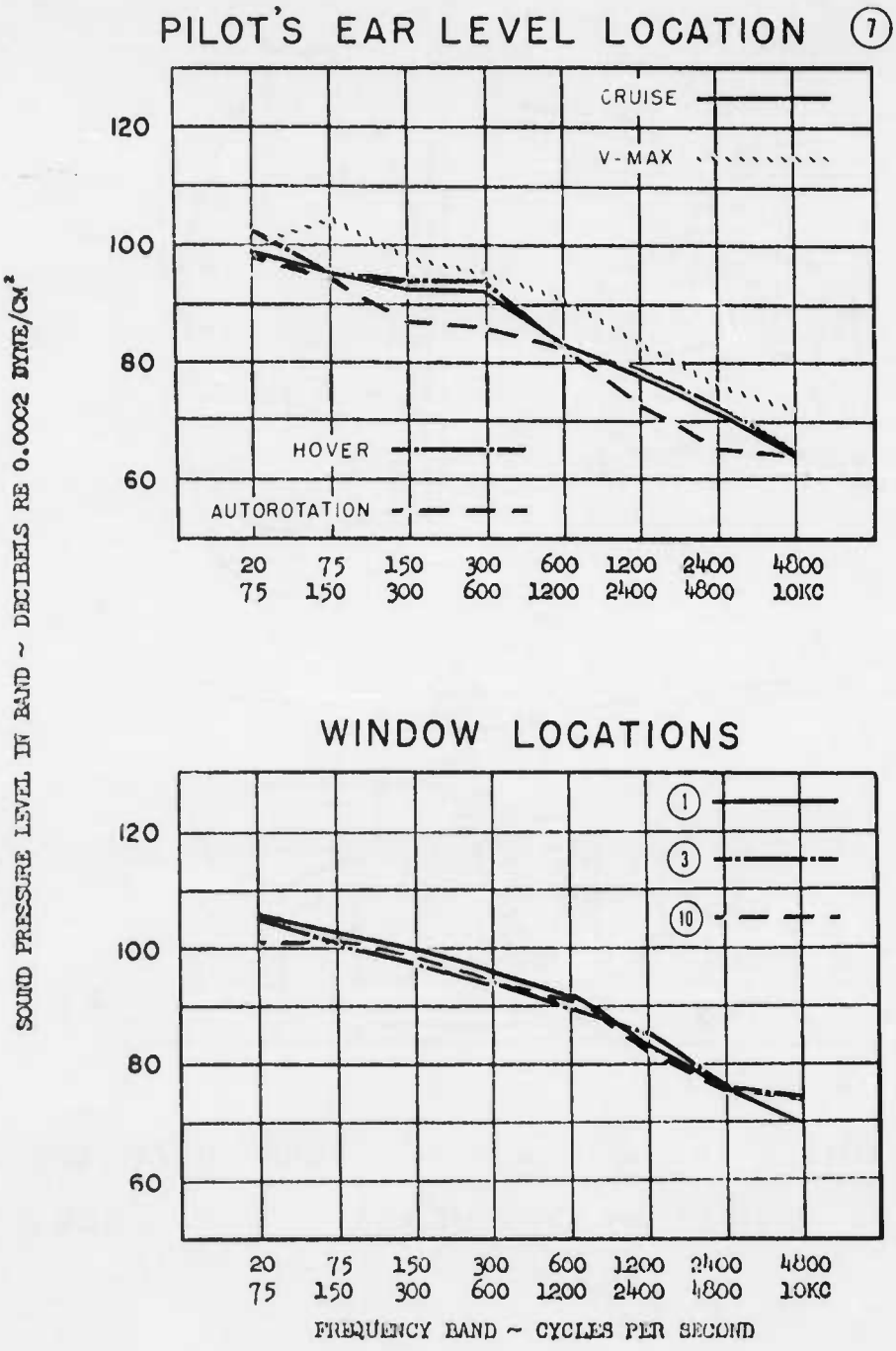

PILOT'S EAR LEVEL LOCATION (7)
CRUISE
V-MAX
HOVER
AUTOROTATION
120
100
80
60
20 75 150 300 600 1200 2400 4800
75 150 300 600 1200 2400 4800 10KC
WINDOW LOCATIONS
(1)
(3)
(10)
120
100
80
60
20 75 150 300 600 1200 2400 4800
75 150 300 600 1200 2400 4800 10KC
SOUND PRESSURE LEVEL IN BAND ~ DECIBELS RE 0.0002 DYNE/CM²
FREQUENCY BAND ~ CYCLES PER SECOND

Figure 12

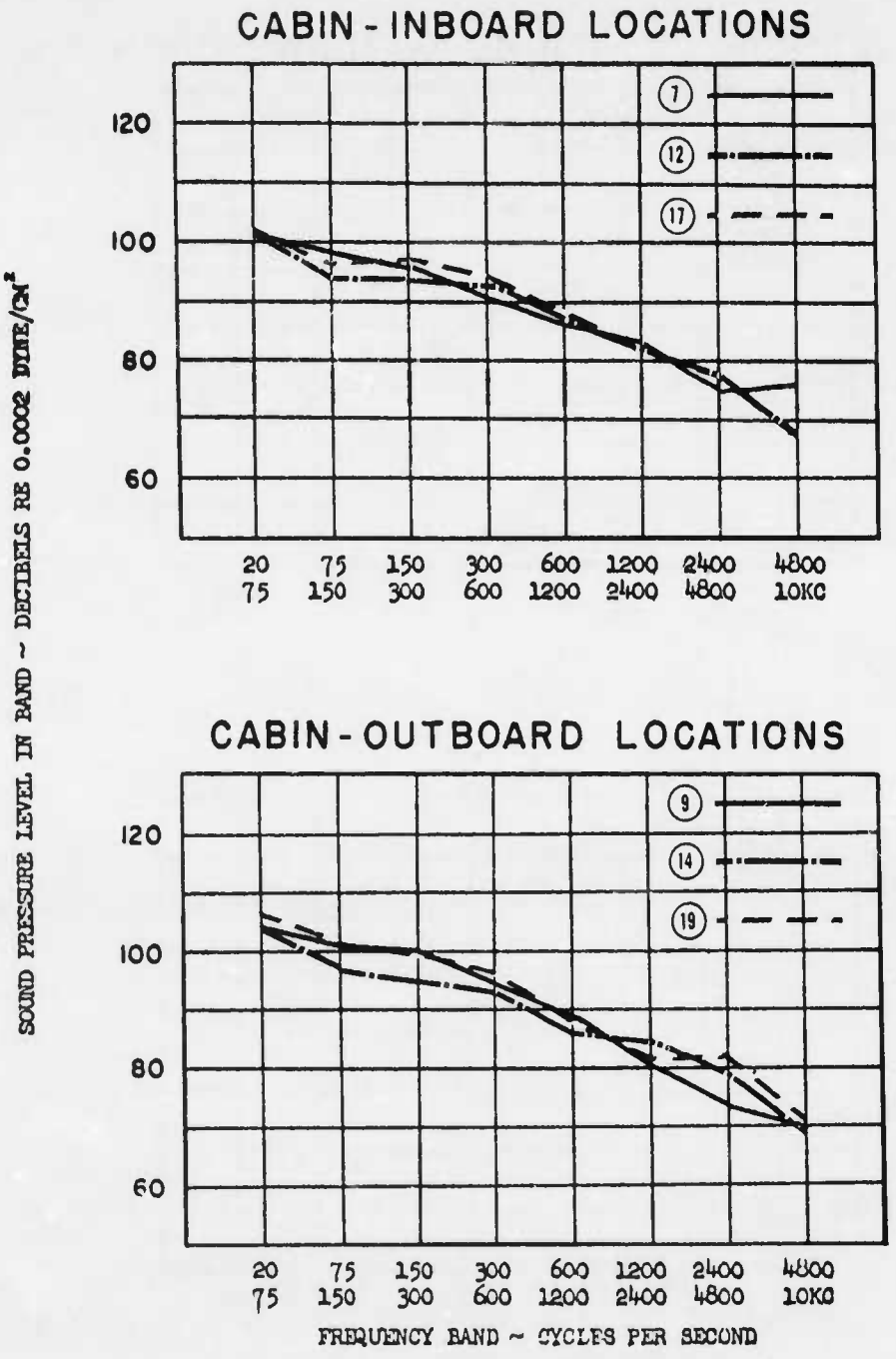

CABIN - INBOARD LOCATIONS
7
12
17
120
100
80
60
20 75 150 300 600 1200 2400 4800
75 150 300 600 1200 2400 4800 10KC
CABIN - OUTBOARD LOCATIONS
9
14
19
120
100
80
60
20 75 150 300 600 1200 2400 4800
75 150 300 600 1200 2400 4800 10KC
SOUND PRESSURE LEVEL IN BAND ~ DECIBELS RE 0.0002 DYNE/CM²
FREQUENCY BAND ~ CYCLES PER SECOND

Figure 13

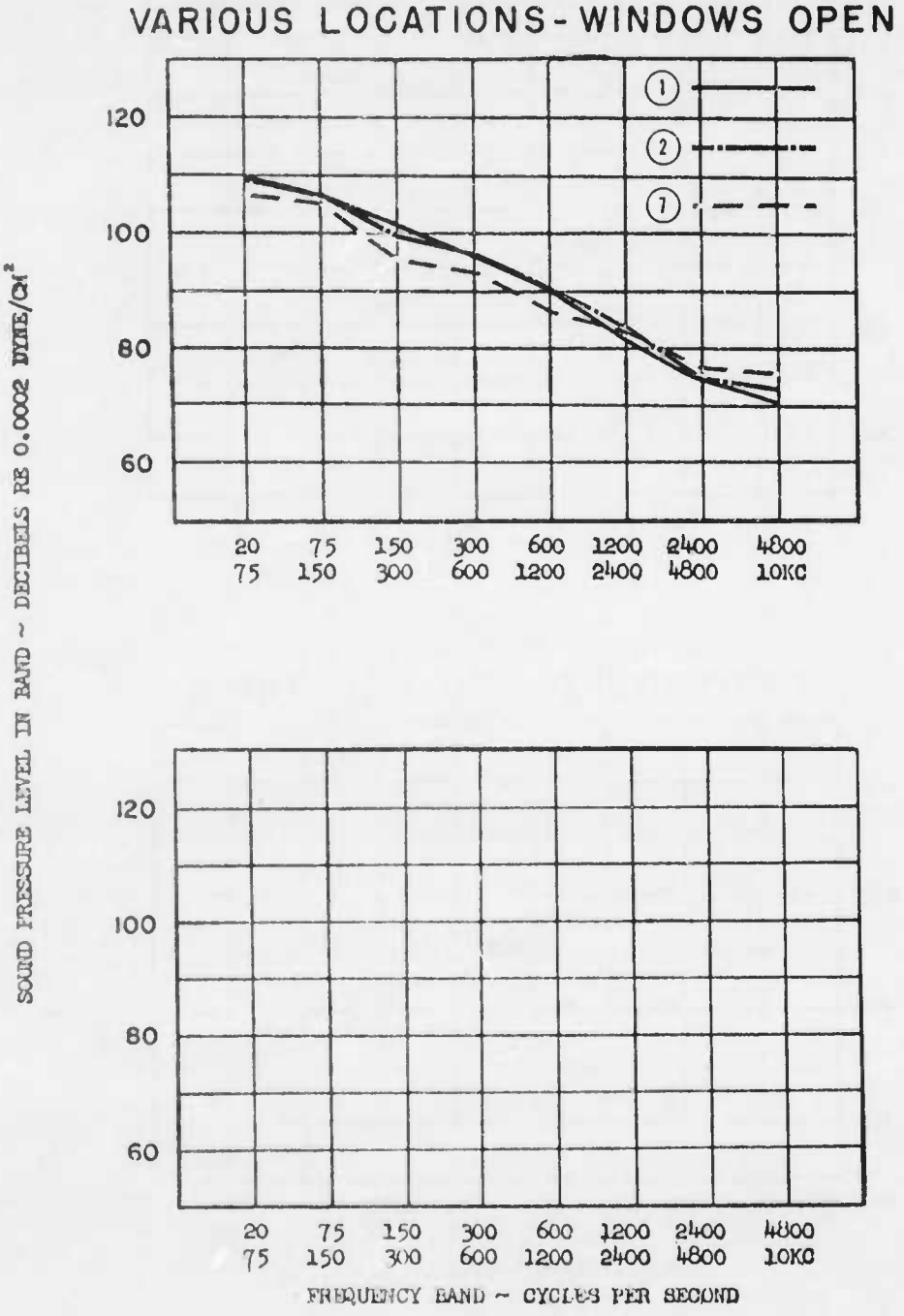

VARIOUS LOCATIONS - WINDOWS OPEN
SOUND PRESSURE LEVEL IN BAND ~ DECIBELS RE 0.0002 DYNE/CM²
120
100
80
60
1
2
7
20 75
75 150
150 300
300 600
600 1200
1200 2400
2400 4800
4800 10KC
FREQUENCY BAND ~ CYCLES PER SECOND

Figure 14

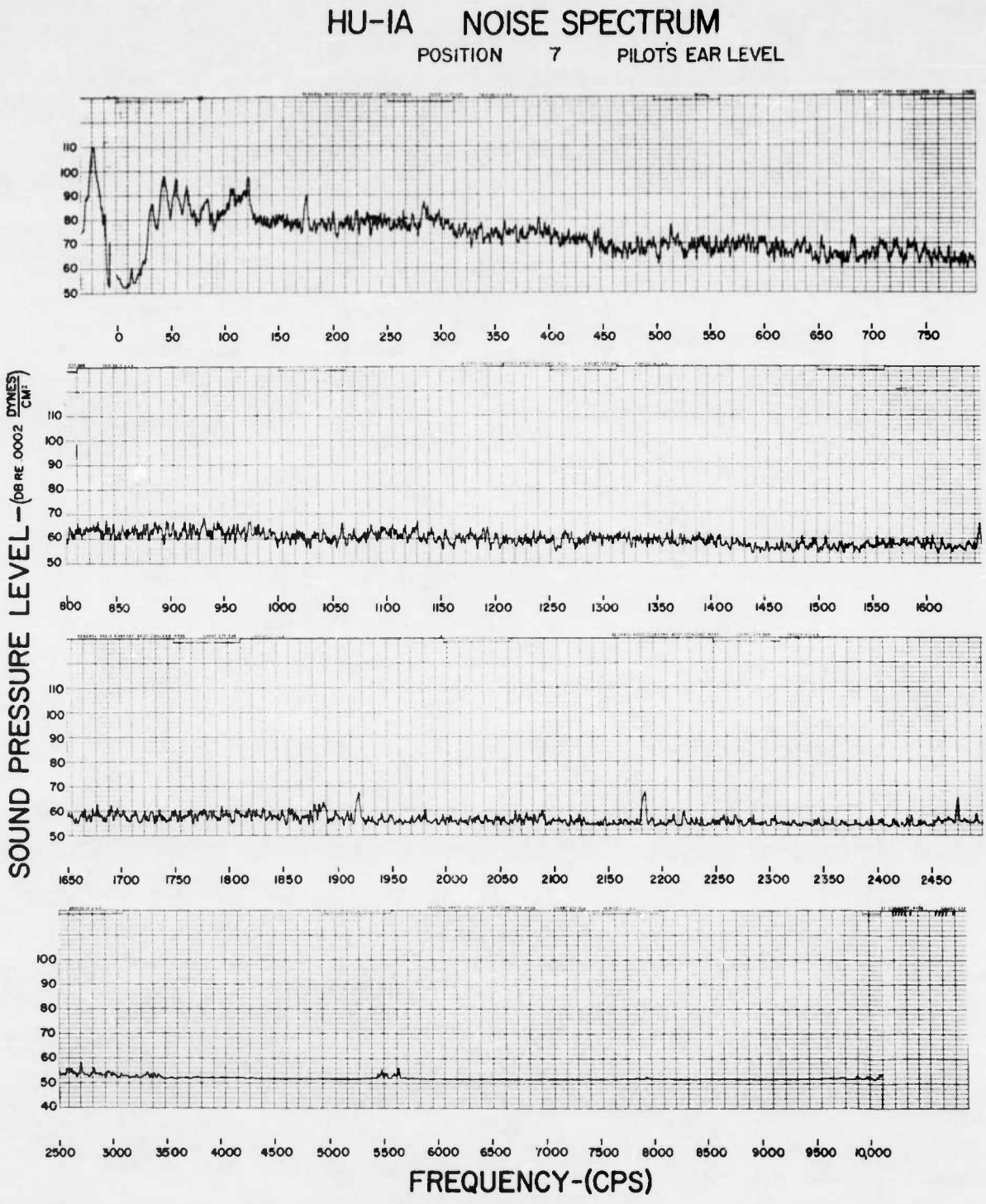

HU-IA NOISE SPECTRUM
POSITION 7 PILOTS EAR LEVEL
SOUND PRESSURE LEVEL - (DB RE 0002 DYNES/CM²)
FREQUENCY-(CPS)

FIGURE 15

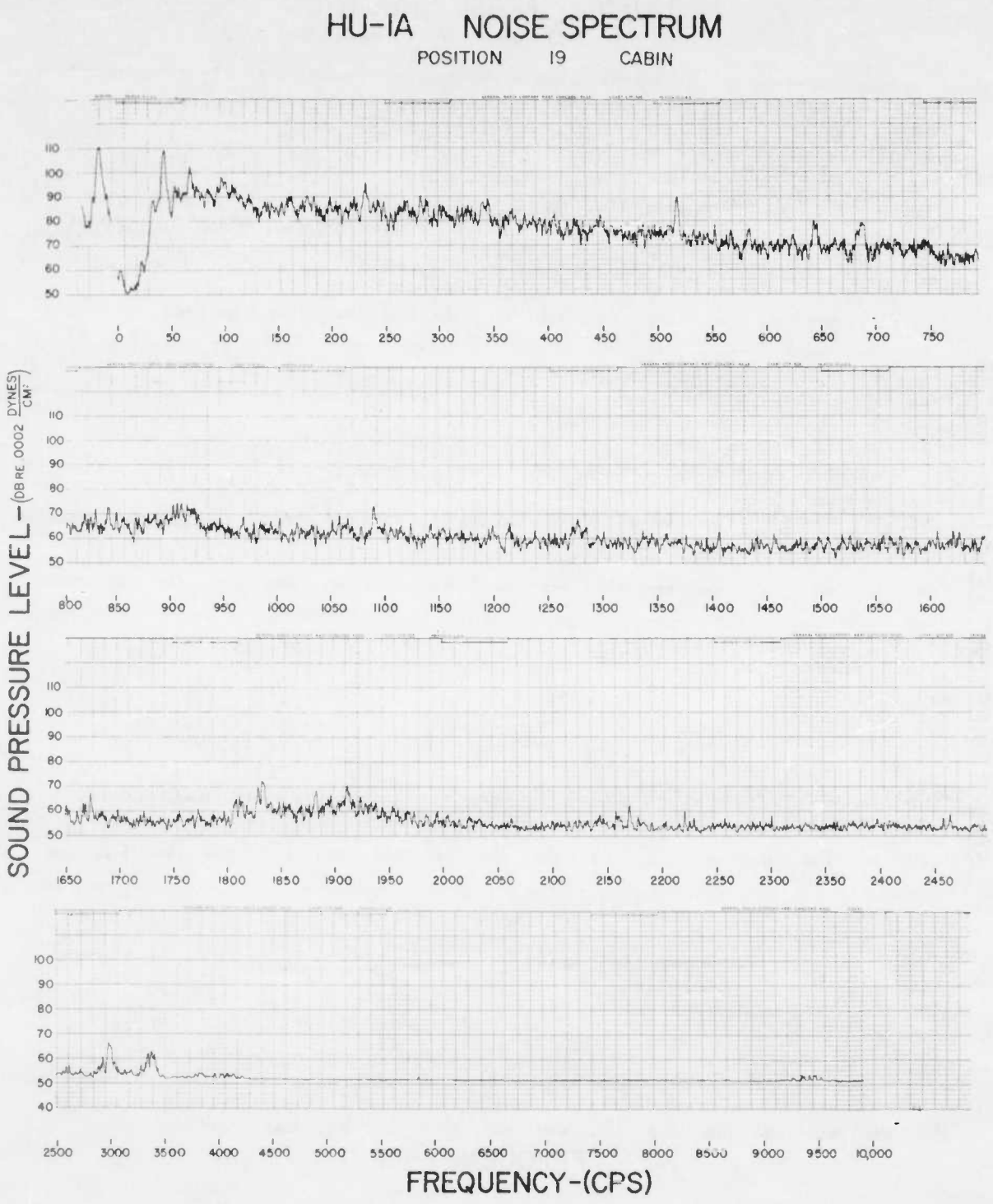

HU-IA NOISE SPECTRUM
POSITION 19 CABIN
SOUND PRESSURE LEVEL-(DB RE 0002 DYNES/CM²)
FREQUENCY-(CPS)

FIGURE 16

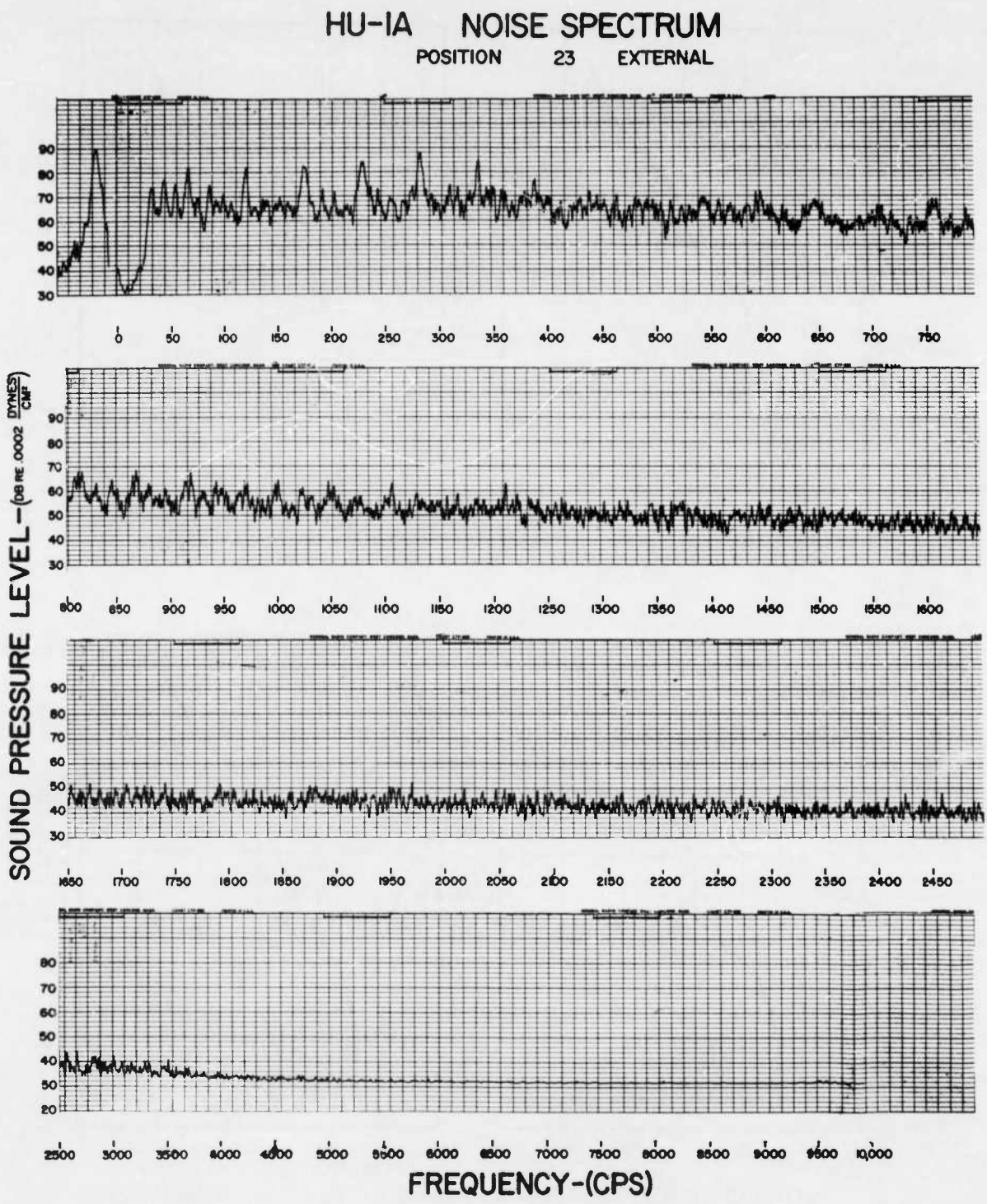

HU-IA NOISE SPECTRUM
POSITION 23 EXTERNAL
SOUND PRESSURE LEVEL—(DB RE .0002 DYNES/CM²)
FREQUENCY-(CPS)

FIGURE 17

COMPARISON OF
EXTERNAL SOUND PRESSURE LEVELS
AT 200 FT. RADIUS

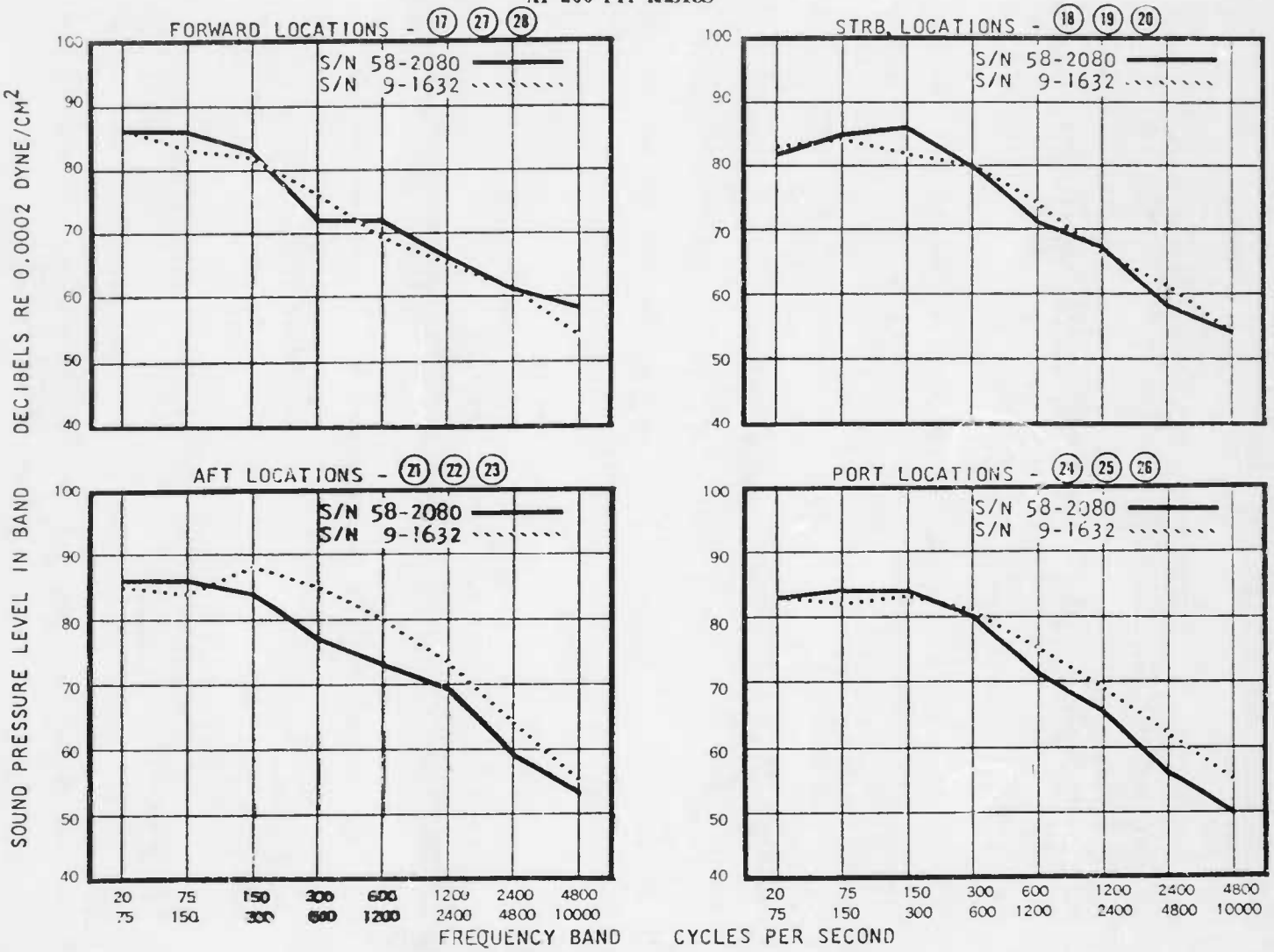
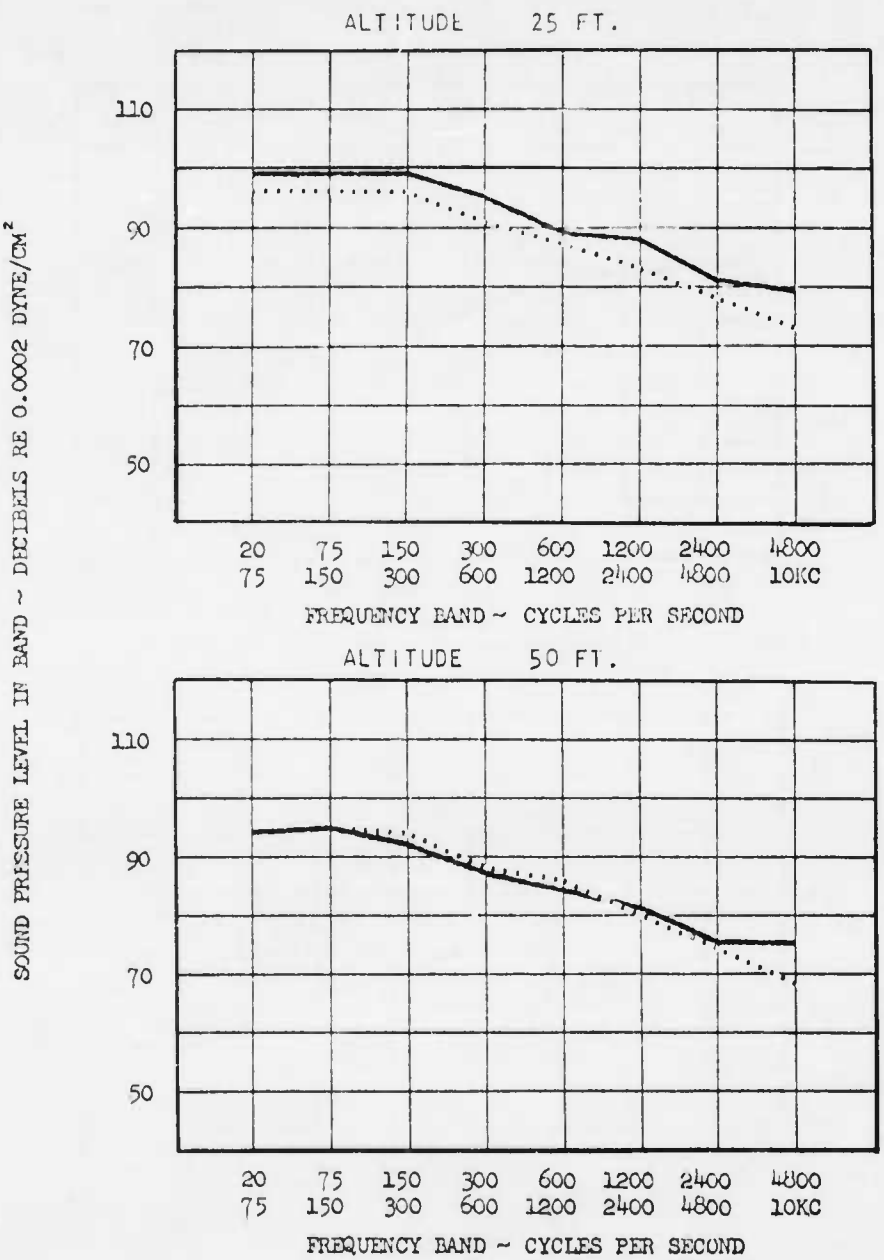


FIGURE 18

COMPARISON OF OVERHEAD FLYBYS

Measurement Location Directly Under Aircraft

S/N 58-2080 ····· S/N 9-1632 ——



SOUND PRESSURE LEVEL IN BAND ~ DECIBELS RE 0.0002 DYNE/CM^2

FIGURE 19

COMPARISON OF OVERHEAD FLYBYS

Measurement Location Directly Under Aircraft

S/N 58-2080 ····· S/N 3-1632 ——

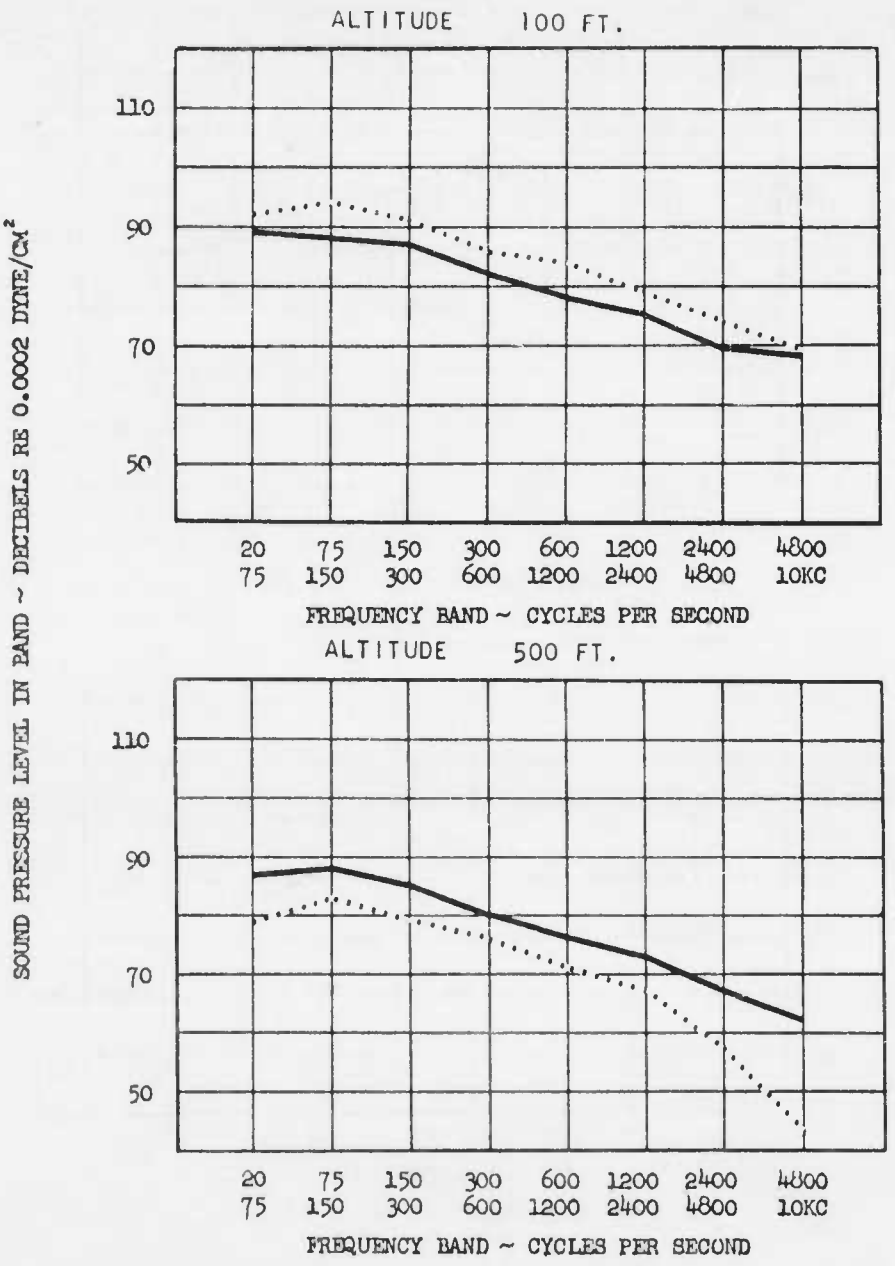


FIGURE 20

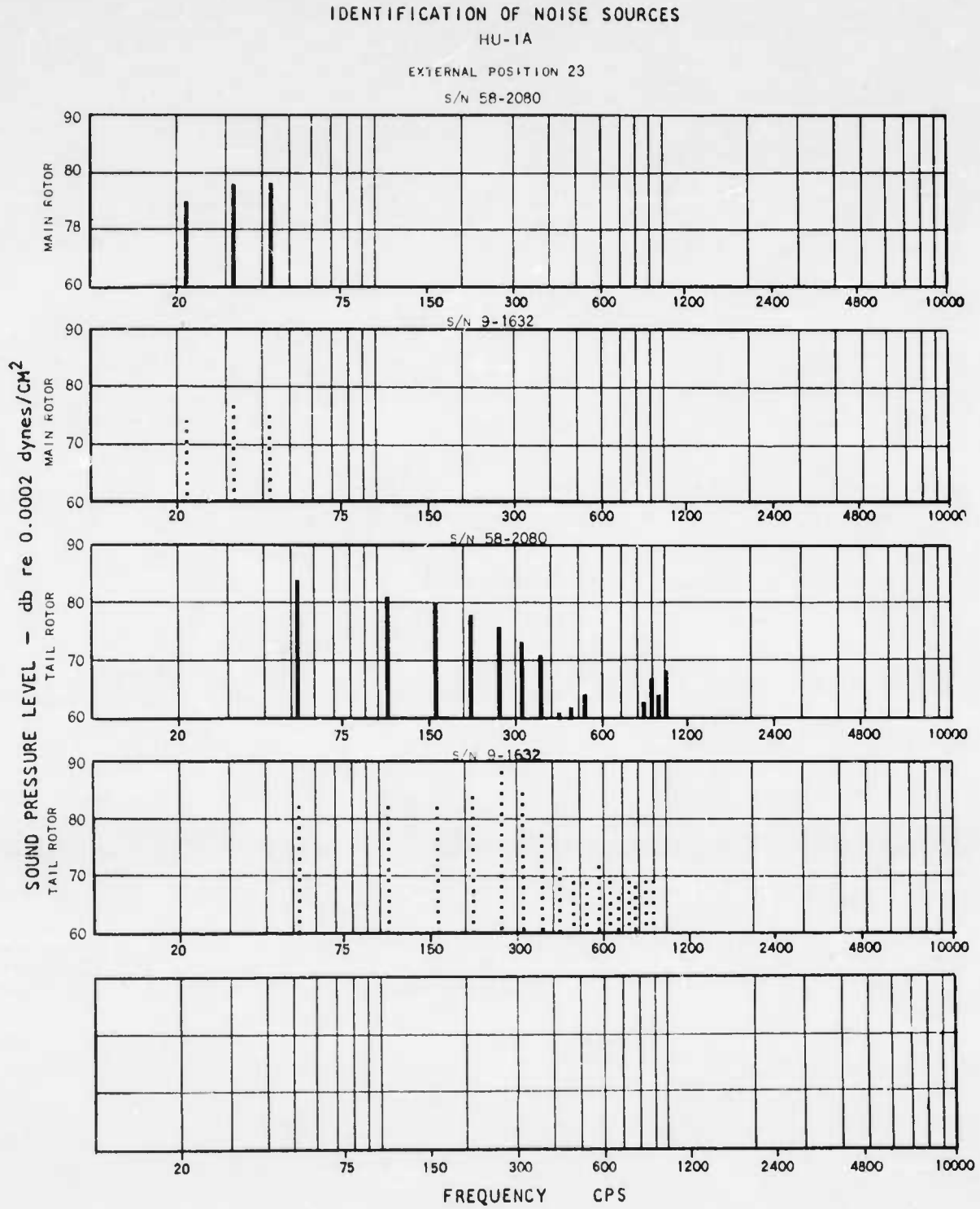

IDENTIFICATION OF NOISE SOURCES
HU-1A
EXTERNAL POSITION 23
S/N 58-2080
MAIN ROTOR
S/N 9-1632
MAIN ROTOR
S/N 58-2080
TAIL ROTOR
S/N 9-1632
TAIL ROTOR
SOUND PRESSURE LEVEL - db re 0.0002 dynes/CM²
90
80
78
70
60
20
75
150
300
600
1200
2400
4800
10000
FREQUENCY CPS

FIGURE 21

APPENDIX II

DATA SHEETS

A/C - TEST
HU-1A-1

OCTAVE-BAND ANALYSIS SHEET

Analyzed By_____ DATE_____

LOC.	COND.		Octave-Band Pressure Levels Re. .0002 microbar							
			20-75	75-150	150-300	300-600	600-1200	1200-2400	2400-4800	above 4800
1	HOVER		96	90	90	86	82	75	68	64
2	HOVER		100	94	94	87	84	78	70	65
3	HOVER		100	98	100	92	90	84	76	68
4	HOVER		98	98	101	96	92	76	76	69
5	HOVER		99	94	94	87	86	72	70	65
6	HOVER		101	96	92	85	82	70	71	62
7	HOVER		99	93	95	90	88	83	73	67
8	HOVER		98	94	96	94	88	82	73	68
9	HOVER		96	92	94	93	86	80	71	65
10	HOVER		95	90	94	91	85	78	70	66
11	HOVER		98	96	92	86	83	75	70	65
12	HOVER		98	94	90	86	78	73	67	64
13	HOVER		106	102	99	100	95	90	80	75
14	HOVER		103	101	98	96	92	88	82	74
15	HOVER		101	98	101	97	95	93	80	75
16	HOVER		106	98	96	95	90	83	76	73
17	HOVER		85	78	81	76	67	63	60	53
18	HOVER		84	80	79	74	68	61	58	53

REV

A/C - TEST
HU-1A-1

OCTAVE-BAND ANALYSIS SHEET

Analyzed By_____ DATE_____

LOC.	COND.		Octave-Band Pressure Levels Re. .0002 microbar							
			20-75	75-150	150-300	300-600	600-1200	1200-2400	2400-4800	above 4800
19	HOVER		83	87	85	80	73	66	61	54
20	HOVER		83	85	81	85	80	72	64	56
21	HOVER		84	84	87	86	82	75	64	56
22	HOVER		86	86	86	82	76	72	63	52
23	HOVER		86	83	90	87	81	72	64	56
24	HOVER		82	85	90	86	81	73	62	58
25	HOVER		83	80	80	81	73	68	60	52
26	HOVER		83	81	80	77	72	67	63	56
27	HOVER		86	87	81	75	71	66	62	55
28	HOVER		86	85	84	78	70	65	60	54

REV

A/C - TEST
HU-1A-2

OCTAVE-BAND ANALYSIS SHEET

Analyzed By_____ DATE_____

LOC.	COND.		Octave-Band Pressure Levels Re. .0002 microbar							
			20-75	75-150	150-300	300-600	600-1200	1200-2400	2400-4800	above 4800
1	TAKE OFF		94	92	91	88	84	80	72	70
1	LAND		94	89	91	85	83	78	72	66
2	TAKE OFF		93	91	86	84	80	76	71	65
2	LAND		89	88	86	84	78	75	66	60
3	TAKE OFF		91	88	84	78	76	74	66	57
3	LAND		86	84	82	79	75	68	61	53

REV

A/C - TEST
HU-1A-3

OCTAVE-BAND ANALYSIS SHEET

Analyzed By_____ DATE_____

LOC.	COND.		Ocatve-Band Pressure Levels Re. ,0002 microbar							
			20-75	75-150	150-300	300-600	600-1200	1200-2400	2400-4800	above 4800
1	CRUISE		96	96	96	91	87	83	78	73
2	CRUISE		94	86	90	86	84	79	71	67
3	CRUISE		94	89	81	81	79	73	66	58
4	CRUISE		86	84	77	68	71	64	54	41
5	CRUISE		94	95	94	88	86	80	74	68
6	CRUISE		86	83	76	70	70	65	55	43
7	CRUISE		92	94	91	86	84	79	74	69
8	CRUISE		91	93	89	85	83	77	70	64
9	CRUISE		90	82	86	82	79	73	65	57
10	CRUISE		84	82	72	74	71	64	55	42
11	CRUISE		86	89	88	82	79	74	67	59
12	CRUISE		83	74	78	74	72	65	55	42
13	CRUISE		79	83	73	74	71	67	57	43
14	CRUISE		78	82	82	74	71	66	58	44
15	CRUISE		76	84	78	72	70	64	55	41
16	CRUISE		76	79	73	70	67	61	52	36

REV

A/C - TEST
HU-1A-4

OCTAVE-BAND ANALYSIS SHEET

Analyzed By_____ DATE_____

LOC.	COND.		Octave-Band Pressure Levels Re. .0002 microbar							
			20-75	75-150	150-300	300-600	600-1200	1200-2400	2400-4800	above 4800
1	CRUISE		106	103	100	96	91	82	75	70
2	CRUISE		106	101	98	96	90	83	75	71
3	CRUISE		105	101	97	95	90	85	75	74
4	CRUISE		102	100	97	94	88	80	75	74
5	CRUISE		105	102	101	98	92	85	75	71
6	CRUISE		103	100	98	93	88	82	75	71
7	CRUISE		101	99	96	91	86	83	75	76
8	CRUISE		99	96	97	92	86	82	74	72
9	CRUISE		104	101	100	94	89	81	74	70
10	CRUISE		101	101	99	94	91	82	75	74
11	CRUISE		101	96	96	96	91	83	76	67
12	CRUISE		102	94	94	92	87	82	78	68
13	CRUISE		101	97	95	93	87	82	77	69
14	CRUISE		104	98	95	93	86	84	79	69
15	CRUISE		103	100	97	97	89	83	79	72
16	CRUISE		102	97	98	98	92	88	78	66
17	CRUISE		102	97	97	95	89	82	78	67
18	CRUISE		104	99	98	94	89	83	76	68

REV

A/C - TEST
HU-1A-4

OCTAVE-BAND ANALYSIS SHEET

Analyzed By_____ DATE_____

LOC.	COND.		Octave-Band Pressure Levels Re. .0002 microbar							
			20-75	75-150	150-300	300-600	600-1200	1200-2400	2400-4800	above 4800
19	CRUISE		106	101	99	96	88	82	82	71
20	CRUISE		104	101	96	95	87	85	84	74
1	PILOT WINDOW COPILOT OPEN		109	106	102	96	90	82	75	70
2			109	106	100	96	91	83	75	73
7			106	105	96	93	87	83	77	76
7	HOVER		99	95	92	92	83	78	72	64
2	CLIMB OUT		100	93	91	102	80	77	73	65
2	Vmax		102	105	102	100	94	86	79	78
2	Auto Rotation		102	95	91	91	83	75	68	66

REV

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Serial No. 9-1632 by R. H. Spencer and H. Sternfeld, Jr.

TCREC Report No. 61-92, Vertol Report No. 247, July 1961, 38 pp-illus.
Contract DA 44-177-TC-562 (Amend. 4)

Unclassified Report

Internal and external noise levels measured during typical operations of an Army type HU-1A helicopter, Serial No. 9-1632 are presented. A comparison of sound levels is made with HU-1A Serial No. 58-2080. The sound pressure levels of the two aircraft during similar operating conditions are found to be essentially the same.

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   (S/N 9-1632)
2. Helicopters
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