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SUMMARY

Noise measurement evaluations have been conducted on a four-engine turbojet transport airplane for several climbout profiles involving various climb speeds, flap settings, and engine pressure ratios; these data were correlated with airplane operations and position data.

The main result of these studies is that power reductions during second segment climb generally result in reduced noise levels on the ground compared with those associated with a full-power take-off climbout. The amount of noise reduction attained depends upon the amount of power reduction, and the noise level profile on the ground is related directly to the engine power schedule. Tables and figures are presented to show detailed comparisons.

INTRODUCTION

Noise produced during take-off by jet airplanes constitutes a serious problem with regard to community reaction. It is also known that the noise exposure in the community is closely related to the manner in which the airplane is operated. (See refs. 1 and 2.) The information presented in this paper was obtained from results of a series of experiments that were conducted jointly by the National Aeronautics and Space Administration and the Federal Aviation Agency to evaluate the noise exposures resulting from various take-off—climbout profiles of a four-engine turbojet transport airplane. These data were obtained under closely controlled conditions with the objective of correlating the noise measurements with the operations of the airplane.

APPARATUS AND METHODS

Test Conditions

Tests were conducted in the vicinity of the NASA Wallops Station January 12-13, 1966. Use was made of the runway and the generally flat terrain (elevation of 38 ft (11.4 m) above mean sea level) in the area of the Wallops Station to perform simulated take-off—climbout operations and to measure the associated noise at ground level. The general locations of the noise measuring stations with respect to the runway are noted in figure 1. Positions of the four noise measuring stations are given in figure 2 along with the location of the precision radar tracking station. The microphone arrays utilized at each of the four noise measuring stations are indicated schematically in figure 3. Two or three microphones were used at each of the four measuring stations. Measurements were made in accordance with the methods recommended in reference 3.

Airplane Description

The airplane used in these tests was operated by FAA personnel and is shown in figure 4. The gross weight of the airplane during these tests varied from approximately 196 000 to 215 000 lbm (89 306 to 97 524 kg). This airplane is powered by four turbojet engines equipped with exhaust noise suppressors. One of the suppressors is shown in the insert of figure 4.

Airplane Operations

Schematic illustrations of the seven flight profiles used in the test evaluations are shown in table I. The airplane climb speeds for the seven climbout profiles are given in table I along with the various flap settings and a description of the procedures for the profiles. Briefly, these profiles were as follows:

Profile 1 involved take-off power

Profiles 2 and 3 involved power reductions corresponding to 1000 ft/min (305 m/min) and 500 ft/min (152 m/min) rate of climb, respectively

Profile 4 involved power reduction for 10 sec followed by application of take-off—climb power

Profiles 5 and 6 involved power reduction corresponding to 500 ft/min (152 m/min) rate of climb (differed from profile 3 in that flap and climb speed were varied, whereas for profile 3 flaps and climb speed were fixed)

Profile 7 was a standard operating procedure take-off climbout involving a power reduction upon reaching a given climb speed

Profiles 1 to 4 were conducted at climb speeds of V_2, $V_2 + 20$, and $V_2 + 40$ knots (where V_2 is the initial climb speed).

The simulated take-off climbouts were performed as closely as possible to the profiles of table I. In an attempt to expedite the test program, however, touch-and-go type operations were used for the landing—take-off procedure. The take-off distance required to rotate and lift-off was determined prior to beginning the test flights and this point was marked accordingly. During the actual test flights the airplane reached the desired conditions of engine power and speed at this point. (The test flights of January 12 involved the touch-and-go type procedures, whereas the test flights of January 13 did not involve touch down (wheels about 6 to 10 ft (1.63 to 3.05 m) above the runway) due to a tire problem.)

During these operations accurate positioning information was obtained with regard to airplane altitude, lateral distance from the runway center line extended, and distance from the tracking station. Acquisition by the radar was accomplished near the time of rotation and was continued until the airplane was out of the test area. Verbal instructions were relayed to the pilot with regard to the time of initiation of power cutback where appropriate (the power reduction procedures occurred midway between stations 1 and 2 for profiles 2 to 6). Complete radar tracking data for all the test flights are included in figures 5 to 11. From plots such as those of figures 5 to 11, aircraft altitude, lateral displacement, and calculated slant range from each noise measuring station were determined and these data are tabulated in table II.

Additional information regarding the operating conditions of the airplane was determined from photographs of the airplane flight deck instrumentation panel. An example of such a photograph is shown as figure 12. Such photographs were made periodically during the flight in order to provide engine pressure ratio and compressor rotational speed and airplane climb rate, altitude, climb speed, and flap setting to correlate with airplane position data from the ground radar. Airplane weight was estimated for each flight. The data obtained from the series of photographs are included in table III.

Atmospheric Observations

During the time of the experiments, observations of surface temperature, wind velocity and direction, and relative humidity were made at the control tower which is located close to the active runway. Conventional radiosonde data were also recorded during the morning of each of the two days of tests. These data are tabulated in table IV. Generally calm and hazy conditions with relatively low wind velocities prevailed for the period of the tests. During data recording periods the wind velocities did not exceed 12 knots and, in addition, microphone wind screens were used at all times.

Noise Measurements

The noise measuring instrumentation used in these tests is illustrated by means of the block diagram of figure 13. The microphones were conventional condenser type having a frequency response flat to within ±3 dB over the frequency range of 20 to 12 000 cps. The microphones were located about 5 ft (1.53 m) above ground level, the longitudinal axis being parallel to the ground and generally perpendicular to the vertical projection of the flight path. The outputs of all the microphones at each measuring station were recorded on multichannel tape recorders. The entire sound measurement system was calibrated in the field by means of conventional discrete frequency calibrators before and after the flight measurements. The data records were played back from the tape (with the playback system shown in fig. 13) in the form of sound pressure level time histories similar to the one illustrated in figure 14. Perceived noise levels were determined by conventional calculation schemes based on octave band frequency analyses of the data for specific flights of each measuring station. These data were then used to provide an amplitude calibration for a filter device (which is indicated in fig. 13) which weighs the frequency spectrum in such a way as to provide a perceived noise level reading.

MEASUREMENT RESULTS

The measured results of this study are presented in terms of overall sound pressure levels (OASPL) and perceived noise levels (PNdB) in figures 5 to 11 and 15 to 26.

Sound Pressure Levels

The maximum overall sound pressure levels obtained by the microphones at each measuring station (without any normalizing operations having been performed) are tabulated in figures 5 to 11, along with the associated airplane position information as determined from ground radar tracking data. Three repeat flights were accomplished for each test condition. At the top of the figures are shown the altitude-distance profiles for each of the three flights at the various flight profiles illustrated in table I. At the bottom of the figures are shown the plots of lateral distance of the flight track from the runway center line extended as a function of distance from the start of roll. The overall sound pressure levels given are the maximum values determined from time histories of the form of figure 14, as obtained from playback of the magnetic tape records into a graphic level recorder for convenience in data processing.

These maximum sound pressure levels for each particular flight profile are plotted as a function of distance from start of take-off roll in figures 15 to 19. In each of these figures the data from three separate test flights shown in figures 5 to 11 have been normalized with respect to slant range. Data from the two extreme (in terms of altitude) flights have been normalized with respect to the slant range corresponding to the other flight of that particular climbout profile. The flight used for normalization along with the values of slant range at each of the four measuring stations is indicated. The normalizing operations involved only inverse square law adjustments and did not involve any minor adjustments for excess atmospheric attenuation or for jet velocity variations due to climb speed. In figure 20 the sound pressure levels for climb speeds V_2, $V_2 + 20$, and $V_2 + 40$ knots for profiles 1 to 4 can be compared directly for comparable distances from the measuring stations. They have been normalized with respect to those slant ranges chosen in part (b) of figures 15 to 18. These slant ranges relate to the climb speed $V_2 + 20$ knots.

Perceived Noise Levels

Also included in figures 5 to 11 are tables of maximum perceived noise levels. These values were obtained from a calibrated filter system having the proper frequency characteristic to permit direct determination of perceived noise levels from playback of the sound pressure level time histories. This special filter device (ref. 2) is believed to give good results for the broadband type of noise data of the present paper. Spot-check long-hand calculations of perceived noise levels (ref. 4) based on octave band spectral analyses suggest that the perceived noise level data of the present paper as obtained with the above filter network are accurate to within about $\pm 1\frac{1}{2}$ PNdB. The perceived noise level data which are presented in the tables in figures 5 to 11 were normalized with respect to slant range in the same manner as that described for the sound pressure levels for presentation in figures 21 to 26.

DISCUSSION OF RESULTS

Examination of the data of figures 5 to 11 shows that even though an attempt was made to repeat the test conditions for each of the three flights, some variations occurred in the flight track and the associated noise levels. In order to correlate the noise level data from the various runs of a given profile, adjustments made to take into account variations of slant range result in reduced scatter for comparable flight conditions. (See figs. 15 to 19 and tables in figs. 5 to 11.)

Curves have been faired through the data of figure 15 which relate to full-power take-off climbout with no power reduction procedures involved and these curves are carried over as dashed lines for reference to figures 16 to 19. The data of table III include indications of the engine pressure ratio settings for each of the test conditions of these figures. Inspection of the data of figures 16 to 19 shows that a power reduction results in noise reduction and the amount of noise reduction is related to the amount of power reduction.

Similar results are obtained for climb speeds of V_2, $V_2 + 20$, and $V_2 + 40$ knots. Particular attention is directed toward the data of figure 18 for a profile which has sometimes been used for noise reduction and involves a power reduction for about 10 seconds with subsequent return to climb power (see profile 4 of table I). Noise level reductions are obtained only for the period during which the power was reduced.

The data of figure 19(c), which represent a standard operating procedure, seem to fit into the same general pattern of all the data. This particular procedure involves a power reduction at the point at which a specified climb speed is reached. Note that the resulting noise reduction is dependent upon power reduction and the point at which the power reduction is accomplished.

It is a general result of the data of figures 15 to 19 and table III that the greater altitude (distance) over a given point during climbout is associated with greater engine power or lower airplane velocity or both. The effect of increased altitude is beneficial in reducing noise, whereas increased power at a given altitude results in an increase in noise. For the ranges of engine power and altitude of the present tests, engine power appears to be the dominant factor with regard to noise levels on the ground.

With regard to the effect of climb speed of the airplane on the ground noise (i.e., V_2, $V_2 + 20$, and $V_2 + 40$ knots for profiles 1 to 4), the data of figure 20 are presented. In this figure the data presented previously for different climb speeds are all normalized with respect to the slant ranges associated with the climb speed $V_2 + 20$ knots. In figure 20(a) a curve is faired through the data for the take-off power condition and this curve is carried in figures 20(b) to (d) as the dashed curve for reference. In general, within the range of climb speeds of the current tests, the effect of airplane speed is a relatively minor one. Increased airplane speed at a given distance and power setting results in slightly lower noise levels as would be expected because of the decrease in relative velocity at the boundary of the engine jet exhaust. As in figures 15 to 19, it is obvious that generally lower noise levels are associated with engine power reduction.

Perceived noise level data corresponding to the test conditions of figures 15 to 20 have been determined and are presented in figures 21 to 26. In general, for the broadband noise spectra involved in these tests, the perceived noise levels are approximately 2 to 10 dB higher than the corresponding measured sound pressure levels. Aside from these differences in the absolute decibel values, the same general conclusions can be drawn from the perceived noise level plots as were drawn from the overall sound pressure level plots.

CONCLUDING REMARKS

Noise measurement evaluations have been conducted on a four-engine turbojet transport airplane for several climbout profiles involving various climb speeds, flap settings, and engine pressure ratios; these data were correlated with airplane operations and position data.

The main result of these studies is that power reductions during second segment climb generally result in reduced noise levels on the ground compared with those associated with a full-power take-off climbout. The amount of noise reduction attained depends upon the amount of power reduction, and the noise level profile on the ground is related directly to the engine power schedule. Tables and figures are presented to show the detailed comparisons.

Langley Research Center,
National Aeronautics and Space Administration,
Langley Station, Hampton, Va., July 20, 1966,
126-16-03-01-23.

REFERENCES

1. Hubbard, Harvey H.; Cawthorn, Jimmy M.; and Copeland, W. Latham: Factors Relating to the Airport-Community Noise Problem. Conference on Aircraft Operating Problems, NASA SP-83, 1965, pp. 73-81.

2. Galloway, W. J.; Pietrasanta, A. C.; and Pearsons, K. S.: Study of the Effect of Departure Procedures on the Noise Produced by Jet Transport Aircraft. ADS-41, FAA, Oct. 1965.

3. Anon.: Measurements of Aircraft Exterior Noise in the Field. ARP 796, Soc. Automotive Engrs., June 15, 1965.

4. Anon.: Definitions and Procedures for Computing the Perceived Noise Level of Aircraft Noise. ARP 865, Soc. Automotive Engrs., Oct. 15, 1964.

TABLE I

SCHEMATICS AND DESCRIPTIONS OF VARIOUS FLIGHT PROFILES USED FOR TAKE-OFF—CLIMBOUT NOISE TESTS

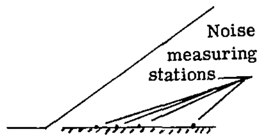
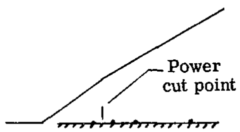
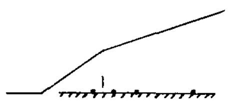
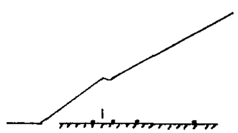
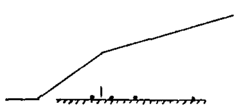
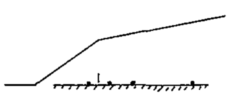
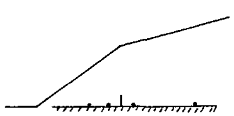
Schematic	Profile	Climb speed, knots	Flap setting, deg	Description of procedure
	1	V_2 $V_2 + 20$ $V_2 + 40$	30	Take-off power and 30° flaps maintained until clear of station 4; tests made at climb speeds of V_2, $V_2 + 20$, and $V_2 + 40$ knots
	2	V_2 $V_2 + 20$ $V_2 + 40$	30	Take-off power to power reduction point; reduced power to 1000 ft/min (305 m/min) rate of climb and maintained until clear of station 4; fixed flaps at 30°; tests made at climb speeds of V_2, $V_2 + 20$, and $V_2 + 40$ knots
	3	V_2 $V_2 + 20$ $V_2 + 40$	30	Take-off power to power reduction point; reduced power to 500 ft/min (152 m/min) rate of climb and maintained until clear of station 4; fixed flaps at 30°; tests made at climb speeds of V_2, $V_2 + 20$, and $V_2 + 40$ knots
	4	V_2 $V_2 + 20$ $V_2 + 40$	30 to 0	Take-off power and 30° flaps to power reduction point; reduced power to 1.90 engine pressure ratio and held for 10 sec; returned to take-off power; retracted flaps to 0° and accelerated in climb to 200 knots; reduced power to en route climb speed; tests made at V_2, $V_2 + 20$, and $V_2 + 40$ knots
	5	$V_2 + 10$ to $V_2 + 20$	30 to 20	Take-off power at $V_2 + 10$ knots with 30° flaps; at 400 to 800 ft (122 to 244 m) retracted flaps to 20° and climbed at $V_2 + 20$ knots; at power reduction point reduced power to 500 ft/min (152 m/min) rate of climb at $V_2 + 20$ knots and maintained until clear of station 4
	6	$V_2 + 20$ to $V_2 + 30$	30 to 20	Take-off power at $V_2 + 20$ knots with 30° flaps; at 400 to 800 ft (122 to 244 m) retracted flaps to 20° and climbed at $V_2 + 30$ knots; at power reduction point reduced power to 500 ft/min (152 m/min) rate of climb at $V_2 + 30$ knots and maintained until clear of station 4
	7	$V_2 + 10$ to $V_2 + 30$ to $V_2 + 50$	30 to 20 to 0	Take-off power with 30° flaps; initial climb speed of $V_2 + 10$ knots; retracted flaps to 20° after 400 ft (122 m); accelerated to $V_2 + 30$ knots; retracted flaps to 0° and accelerated to en route climb speed of 290-knot indicated airspeed; at approximately $V_2 + 50$ knots reduced to climb power

TABLE II

MEASURED ALTITUDE AND LATERAL DISPLACEMENT AND CALCULATED SLANT RANGE FOR FOUR-ENGINE TURBOJET TRANSPORT AIRPLANE AT EACH NOISE MEASURING STATION

Profile	Climb velocity, knots	Flight	Station 1						Station 2						Station 3						Station 4					
			Altitude		Lateral displacement		Slant range		Altitude		Lateral displacement		Slant range		Altitude		Lateral displacement		Slant range		Altitude		Lateral displacement		Slant range	
			ft	m	ft	m	ft	m	ft	m	ft	m	ft	m	ft	m	ft	m	ft	m	ft	m	ft	m	ft	m
1	V_2	1	1150	351	980	299	1500	457	1480	451	1200	366	1905	581	1990	607	1300	396	2380	725	2860	872	380	116	2883	879
		2	1300	396	250	76	1325	404	1540	469	300	91	1570	479	2130	649	200	61	2140	652	3020	920	100	30	3025	922
		3	1380	421	200	61	1395	425	1710	521	250	76	1730	527	2180	664	280	85	2200	671	3200	975	150	46	3225	983
	$V_2 + 20$	1	750	229	200	61	787	240	1100	335	220	67	1120	341	1600	488	280	85	1625	495	2690	820	280	85	2710	826
		2	840	256	20	6	842	257	1140	347	0	0	1140	347	1720	524	100	30	1725	526	2680	817	40	12	2680	817
		3	785	239	100	30	785	239	1140	347	160	49	1162	354	1690	515	120	37	1700	518	2620	799	100	30	2620	799
	$V_2 + 40$	1	390	119	180	55	429	131	700	213	300	91	762	232	1235	376	800	244	1470	448	2285	696	1800	549	2900	884
		2	360	110	220	67	422	129	650	198	140	43	665	203	1170	357	350	107	1220	372	2190	668	320	98	2215	675
		3	640	195	150	46	656	200	900	274	0	0	900	274	1350	411	20	6	1360	415	2470	753	300	91	2485	757
2	V_2	1	1220	372	80	24	1262	385	1485	453	50	15	1485	453	1695	517	200	61	1710	521	2240	683	40	12	2240	683
		2	1140	347	0	0	1140	347	1360	415	0	0	1360	415	1705	520	0	0	1705	520	2275	693	40	12	2275	693
		3	1170	357	100	30	1174	358	1495	456	100	30	1495	456	1820	555	0	0	1820	555	2400	732	40	12	2400	732
	$V_2 + 20$	1	830	253	0	0	830	253	1145	349	40	12	1150	351	1610	491	60	18	1610	491	2260	689	0	0	2260	689
		2	930	283	60	18	950	290	1275	389	60	18	1277	389	1630	497	180	55	1640	500	2350	716	120	37	2360	719
		3	900	274	20	6	904	276	1145	349	20	6	1150	351	1590	485	120	37	1592	485	2260	689	40	12	2260	689
	$V_2 + 40$	1	680	207	100	30	687	209	980	299	50	15	982	299	1220	372	320	98	1259	384	1900	579	180	55	1910	582
		2	510	155	160	49	535	163	760	232	60	18	762	232	1125	343	80	24	1129	344	1970	600	100	30	1978	603
		3	595	181	150	46	614	187	900	274	100	30	907	276	1350	411	150	46	1359	414	2040	622	680	207	2148	655
3	V_2	1	1270	387	260	79	1300	396	1600	488	100	30	1604	489	1725	526	40	12	1725	526	2010	613	40	12	2010	613
		2	1270	387	0	0	1270	387	1450	442	40	12	1450	442	1660	506	0	0	1660	506	1960	597	50	15	1960	597
		3	1170	357	0	0	1170	357	1420	433	0	0	1420	433	1555	474	50	15	1555	474	1820	555	0	0	1820	555
	$V_2 + 20$	1	850	259	120	37	857	261	1190	363	20	6	1190	363	1400	427	40	12	1400	427	1700	518	20	6	1700	518
		2	970	296	0	0	970	296	1310	399	50	15	1310	399	1480	451	20	6	1480	451	1840	561	100	30	1842	561
		3	1020	311	0	0	1020	311	1390	424	80	24	1412	430	1465	447	20	6	1465	447	1910	582	0	0	1910	582
	$V_2 + 40$	1	600	183	100	30	610	186	925	282	40	12	927	283	1120	341	80	24	1125	343	1450	442	200	61	1463	446
		2	560	171	260	79	617	188	880	268	260	79	907	276	1020	311	120	37	1030	314	1310	399	60	18	1310	399
		3	660	201	140	43	675	206	825	251	200	61	850	259	1140	347	250	76	1168	356	1450	442	80	24	1450	442
4	V_2	1	1060	323	350	107	1107	337	1250	381	350	107	1300	396	1375	419	420	128	1400	427	1500	457	200	61	1507	459
		2	1020	311	0	0	1020	311	1310	399	0	0	1310	399	1365	416	220	67	1382	421	1665	507	160	49	1670	509
		3	1090	332	40	12	1090	332	1360	415	40	12	1360	415	1445	440	200	61	1459	445	1875	572	200	61	1885	575
	$V_2 + 20$	1	820	250	60	18	822	251	1145	349	40	12	1145	349	1210	369	40	12	1200	366	1690	515	160	49	1700	518
		2	860	262	140	43	872	266	1200	366	250	76	1225	373	1255	383	100	30	1260	384	1400	427	0	0	1400	427
		3	860	262	100	30	865	264	1220	372	80	24	1220	372	1260	384	200	61	1278	390	1460	445	300	91	1490	454
	$V_2 + 40$	1	690	210	160	49	708	216	910	277	200	61	932	284	1170	357	0	0	1170	357	1570	479	260	79	1590	485
		2	510	155	180	55	540	165	830	253	100	30	835	255	1080	329	60	18	1080	329	1350	411	380	116	1400	427
		3	770	235	0	0	770	235	1080	329	0	0	1080	329	1095	334	100	30	1098	335	1550	472	200	61	1565	477
5	$V_2 + 10$ to $V_2 + 20$	1	805	245	80	24	810	247	1108	338	50	15	1108	338	1370	418	120	37	1375	419	1510	460	150	46	1519	463
		2	805	245	100	30	812	247	1110	338	120	37	1118	341	1375	419	40	12	1375	419	1560	475	---	---	----	---
		3	880	268	20	6	880	268	1265	386	60	18	1265	386	1435	437	20	6	1435	437	1950	594	120	37	1955	596
6	$V_2 + 20$ to $V_2 + 30$	1	670	204	250	76	715	218	1010	308	300	91	1055	322	1320	402	220	67	1340	408	1605	489	100	30	1609	490
		2	850	259	100	30	855	261	1215	370	0	0	1215	370	1360	415	140	43	1365	416	1700	518	---	---	----	---
		3	820	250	240	73	855	261	1250	381	200	61	1265	386	1470	448	20	6	1470	448	1880	573	120	37	1883	574
7	$V_2 + 10$ to $V_2 + 30$ to $V_2 + 50$	1	760	232	40	12	760	232	840	256	100	30	845	258	1065	325	0	0	1065	325	1460	445	340	104	1500	457
		2	860	262	180	55	880	268	1080	329	20	6	1080	329	1600	488	0	0	1600	488	2660	811	200	61	2663	812
		3	1045	319	80	24	1045	319	1360	415	340	104	1400	427	1790	546	500	152	1860	567	2360	719	200	61	2362	720

TABLE III

OPERATING CONDITIONS OF FOUR-ENGINE TURBOJET TRANSPORT AIRPLANE OBTAINED FROM FLIGHT DECK PHOTOGRAPH READOUTS

Profile	Climb velocity, knots	Flight	Date	Airplane gross weight		Flight deck readouts															
						Photo	Indicated airspeed, knots	Altitude		Rate of climb		Flap setting, deg	Compressor N_1, % rpm, for engine				Engine pressure ratio for engine			
				lbm	kg			ft	m	ft/min	m/min		1	2	3	4	1	2	3	4
1	V_2	1	1-12-66	212 000	96	1	150	1110	338	1600	488	30	100	100	102	101	2.64	2.62	2.62	2.65
						2	150	1590	485	1600	488	30	100	100	101	101	2.65	2.65	2.62	2.65
						3	150	1940	591	1200	366	30	100	100	101	101	2.66	2.64	2.63	2.65
		2	1-12-66	208 000	94	1	148	780	238	2000	610	30	100	100	101	101	2.62	2.62	2.58	2.63
						2	148	1330	405	1500	457	30	100	100	101	101	2.63	2.62	2.62	2.65
						3	145	1750	533	1400	427	30	100	100	101	101	2.63	2.62	2.60	2.65
						4	143	3060	933	1500	457	30	100	100	101	100	2.61	2.60	2.60	2.64
		3	1-12-66	204 000	93	1	148	510	155	2100	640	30	100	100	101	102	2.62	2.62	2.60	2.65
						2	140	1000	305	1800	549	30	100	100	101	101	2.65	2.62	2.60	2.65
						3	146	1310	399	1400	427	30	100	100	101	101	2.65	2.60	2.61	2.66
						4	143	2440	744	1100	335	30	100	100	101	101	2.62	2.61	2.61	2.66
	$V_2 + 20$	1	1-12-66	215 000	98	1	166	250	76	900	274	30	102	101	103	102	2.65	2.62	2.62	2.65
						2	169	970	296	2200	671	30	102	102	103	102	2.66	2.62	2.65	2.68
						3	169	2930	893	1300	396	30	102	101	103	103	2.72	2.66	2.70	2.72
		2	1-12-66	211 000	96	1	159	350	107	900	274	30	102	102	103	103	2.67	2.62	2.61	2.67
						2	165	1010	308	1800	549	30	101	101	103	102	2.64	2.62	2.62	2.66
						3	167	2890	881	1300	396	30	101	101	103	102	2.67	2.65	2.65	2.70
						4	164	3670	1119	1500	457	30	101	101	103	102	2.66	2.63	2.63	2.68
		3	1-12-66	207 000	94	1	162	460	140	850	259	30	102	101	103	102	2.65	2.60	2.60	2.65
						2	169	1100	335	1900	579	30	101	101	103	102	2.66	2.62	2.63	2.66
						3	169	2620	799	1700	518	30	101	101	102	102	2.70	2.65	2.65	2.70
	$V_2 + 40$	1	1-12-66	213 000	97	1	190	570	174	1900	579	30	102	101	102	101	2.62	2.60	2.62	2.63
						2	190	1500	457	1600	488	30	102	101	102	102	2.62	2.60	2.62	2.63
						3	189	2840	866	1700	518	30	102	101	102	101	2.60	2.58	2.60	2.62
		2	1-12-66	210 000	95	1	188	830	253	1800	549	30	102	101	103	102	2.59	2.56	2.61	2.63
						2	190	1640	500	1700	518	30	101	101	103	102	2.60	2.58	2.62	2.64
						3	190	----	---	1300	396	30	101	101	103	102	2.56	2.55	2.60	2.62
		3	1-12-66	207 000	94	1	183	750	229	1600	488	30	101	101	103	102	2.62	2.58	2.62	2.66
						2	188	1580	482	2200	671	30	101	101	103	102	2.62	2.58	2.63	2.68
						3	185	2860	872	1600	488	30	101	101	103	101	2.56	2.55	2.60	2.61

TABLE III.- Continued

OPERATING CONDITIONS OF FOUR-ENGINE TURBOJET TRANSPORT AIRPLANE OBTAINED FROM FLIGHT DECK PHOTOGRAPH READOUTS

Profile	Climb velocity, knots	Flight	Date	Airplane gross weight		Flight deck readouts															
						Photo	Indicated airspeed, knots	Altitude		Rate of climb		Flap setting, deg	Compressor N_1, % rpm, for engine				Engine pressure ratio for engine			
				lbm	kg			ft	m	ft/min	m/min		1	2	3	4	1	2	3	4
2	V_2	1	1-12-66	215 000	98	1	140	780	238	1500	457	30	100	100	102	102	2.63	2.61	2.62	2.63
						2	152	1700	518	650	198	30	94	94	95	95	2.34	2.30	2.28	2.34
						3	147	2340	713	600	183	30	94	95	96	95	2.35	2.35	2.35	2.35
		2	1-12-66	212 000	96	1	154	400	122	2000	610	30	101	101	103	102	2.66	2.64	2.62	2.65
						2	150	1410	430	1000	305	30	94	95	97	96	2.32	2.36	2.36	2.35
						3	150	1660	506	1000	305	30	94	95	96	95	2.34	2.34	2.33	2.35
						4	152	1900	579	650	198	30	94	95	96	95	2.34	2.34	2.32	2.35
		3	1-12-66	208 000	94	1	145	700	213	2000	610	30	101	102	102	102	2.66	2.65	2.64	2.66
						2	147	1610	491	1350	411	30	95	96	98	97	2.34	2.36	2.40	2.40
						3	146	1960	597	900	274	30	94	95	96	95	2.32	2.34	2.32	2.32
						4	143	2620	799	850	259	30	94	95	96	95	2.32	2.35	2.33	2.32
	$V_2 + 20$	1	1-12-66	204 000	93	1	158	480	146	1600	488	30	102	102	103	103	2.66	2.65	2.64	2.65
						2	173	1080	329	1000	305	30	96	96	98	97	2.36	2.35	2.39	2.38
						3	167	2330	2539	1300	396	30	96	96	98	97	2.37	2.39	2.42	2.42
		2	1-12-66	202 000	92	1	160	380	116	1700	518	30	102	102	103	103	2.64	2.62	2.62	2.65
						2	162	1300	396	1200	366	30	96	96	98	97	2.34	2.32	2.37	2.37
						3	164	1680	512	750	229	30	95	96	97	96	2.35	2.34	2.35	2.36
		3	1-12-66	212 000	96	1	169	390	119	1400	427	30	102	101	103	102	2.65	2.62	2.61	2.65
						2	164	1120	341	1000	305	30	96	96	98	97	2.36	2.35	2.39	2.36
						3	163	1740	530	1000	305	30	96	96	98	96	2.40	2.39	2.40	2.38
	$V_2 + 40$	1	1-12-66	205 000	93	1	184	700	213	2200	671	30	100	101	103	102	2.62	2.59	2.62	2.64
						2	186	1360	415	1000	305	30	96	96	98	97	2.36	2.36	2.38	2.36
						3	189	2240	683	1300	396	30	96	96	98	97	2.35	2.36	2.40	2.35
		2	1-12-66	202 000	92	1	190	660	201	1400	427	30	98	98	100	100	2.45	2.42	2.45	2.46
						2	181	1860	567	1300	396	30	96	97	98	96	2.38	2.38	2.35	2.36
						3	185	2230	680	1000	305	30	96	97	97	97	2.36	2.35	2.35	2.34
		3	1-12-66	199 000	90	1	183	870	265	2000	610	30	97	97	99	100	2.37	2.36	2.40	2.42
						2	182	1470	448	1000	305	30	95	96	97	96	2.30	2.32	2.31	2.32
						3	184	2310	704	950	290	30	95	96	97	96	2.30	2.32	2.30	2.32

TABLE III.- Continued

OPERATING CONDITIONS OF FOUR-ENGINE TURBOJET TRANSPORT AIRPLANE OBTAINED FROM FLIGHT DECK PHOTOGRAPH READOUTS

Profile	Climb velocity, knots	Flight	Date	Airplane gross weight		Flight deck readouts													
						Photo	Indicated airspeed, knots	Altitude		Rate of climb		Flap setting, deg	Compressor N_1, % rpm, for engine				Engine pressure ratio for engine			
				lbm	kg			ft	m	ft/min	m/min		1	2	3	4	1	2	3	4
						1	148	770	235	2000	610	30	101	101	103	102	2.67	2.64	2.66	2.71
		1	1-12-66	205 000	93	2	144	1730	527	1500	457	30	92	93	96	96	2.10	2.13	2.24	2.20
						3	143	1970	600	500	152	30	90	90	91	90	2.05	2.05	2.05	2.03
						4	145	2220	677	400	122	30	90	90	90	90	2.05	2.05	2.05	2.03
						1	145	780	238	1900	579	30	101	101	103	102	2.65	2.62	2.62	2.70
	V_2	2	1-12-66	201 000	91	2	140	1540	469	750	229	30	90	90	93	93	2.06	2.05	2.13	2.12
						3	140	1810	552	450	137	30	90	90	91	90	2.03	2.04	2.05	2.03
						4	142	2100	640	150	46	30	90	90	91	90	2.03	2.05	2.05	2.05
						1	150	420	128	2000	610	30	101	101	103	103	2.65	2.63	2.68	2.70
		3	1-12-66	215 000	98	2	152	750	229	1400	427	30	101	101	103	103	2.62	2.62	2.66	2.70
						3	144	1480	451	1300	396	30	90	91	93	96	2.05	2.07	2.15	2.18
						4	148	1710	521	250	76	30	90	90	92	92	2.06	2.06	2.14	2.15
						1	164	340	104	1000	305	30	101	102	103	103	2.63	2.62	2.60	2.65
		1	1-12-66	206 000	93	2	164	1150	351	2000	610	30	93	93	95	95	2.16	2.20	2.20	2.20
3						3	161	1370	418	550	168	30	90	92	93	92	2.07	2.10	2.10	2.10
						1	165	430	131	1000	305	30	101	101	103	102	2.61	2.59	2.62	2.65
	$V_2 + 20$	2	1-12-66	203 000	92	2	164	1270	387	1900	579	30	92	92	95	95	2.12	2.12	2.16	2.15
						3	164	1600	488	500	152	30	92	91	92	92	2.10	2.10	2.10	2.10
						1	161	650	198	1400	427	30	101	101	103	102	2.65	2.58	2.60	2.64
		3	1-12-66	200 000	91	2	159	1350	411	1900	579	30	92	92	93	93	2.10	2.07	2.12	2.13
						3	160	1890	576	650	198	30	90	90	92	92	2.10	2.09	2.12	2.12
						1	185	710	216	1900	579	30	100	100	101	102	2.47	2.40	2.46	2.50
		1	1-12-66	210 000	95	2	181	1210	369	400	122	30	92	93	94	93	2.15	2.15	2.16	2.15
						3	185	2030	619	850	259	30	93	93	94	94	2.16	2.18	2.19	2.18
						1	184	670	204	1900	579	30	100	101	101	101	2.48	2.41	2.45	2.45
	$V_2 + 40$	2	1-12-66	207 000	94	2	182	1060	323	320	98	30	92	92	94	93	2.11	2.13	2.12	2.12
						3	186	1830	558	500	152	30	93	92	94	93	2.15	2.15	2.15	2.15
						1	185	530	162	1500	457	30	101	103	104	103	2.64	2.62	2.64	2.68
		3	1-12-66	205 000	93	2	181	1200	366	470	143	30	92	92	93	92	2.10	2.08	2.09	2.08
						3	186	----	---	400	122	30	92	92	94	93	2.14	2.13	2.11	2.11

TABLE III.- Continued

OPERATING CONDITIONS OF FOUR-ENGINE TURBOJET TRANSPORT AIRPLANE OBTAINED FROM FLIGHT DECK PHOTOGRAPH READOUTS

Profile	Climb velocity, knots	Flight	Date	Airplane gross weight		Flight deck readouts															
						Photo	Indicated airspeed, knots	Altitude		Rate of climb		Flap setting, deg	Compressor N_1, % rpm, for engine				Engine pressure ratio for engine			
				lbm	kg			ft	m	ft/min	m/min		1	2	3	4	1	2	3	4
4	V_2	1	1-13-66	210 000	95	1	148	500	152	1700	518	30	102	103	104	103	2.63	2.62	2.62	2.65
						2	150	1260	384	1200	366	30	96	97	99	100	2.30	2.32	2.35	2.35
						3	150	1310	399	350	107	30	90	90	90	90	1.90	1.92	1.94	1.92
		2	1-13-66	208 000	94	1	150	310	94	1900	579	30	102	102	104	104	2.65	2.60	2.62	2.66
						2	153	1290	393	1500	457	30	92	92	93	95	1.98	1.93	1.97	2.06
						3	149	1380	421	2300	701	30	89	88	90	90	1.90	1.85	1.90	1.90
		3	1-13-66	205 000	93	1	150	710	216	1500	457	30	102	103	104	103	2.65	2.62	2.61	2.63
						2	144	1380	421	1200	366	30	90	90	92	92	1.95	1.92	1.99	2.00
						3	150	1410	430	50	15	30	90	89	90	90	1.90	1.90	1.92	1.92
	$V_2 + 20$	1	1-13-66	209 000	95	1	170	300	91	1000	305	30	102	103	105	104	2.65	2.65	2.65	2.70
						2	165	1130	344	1700	518	30	95	---	---	---	2.17	2.22	2.26	2.26
						3	164	1220	372	200	61	30	90	89	90	90	1.90	1.88	1.95	1.92
		2	1-13-66	207 000	94	1	160	350	107	1600	488	30	102	104	105	104	2.67	2.65	2.65	2.72
						2	165	1170	357	1700	518	30	91	91	---	---	1.96	1.95	1.98	2.04
						3	162	1330	405	250	76	30	90	90	90	90	1.90	1.91	1.91	1.92
		3	1-13-66	204 000	93	1	171	680	207	2100	640	30	102	103	105	105	2.68	2.64	2.67	2.67
						2	169	1180	360	1800	549	30	98	99	100	101	2.37	2.36	2.36	2.40
						3	165	1320	402	300	91	30	90	89	90	90	1.90	1.88	1.91	1.91
	$V_2 + 40$	1	1-13-66	202 000	92	1	185	480	146	750	229	30	102	103	104	103	2.63	2.62	2.62	2.66
						2	187	870	265	1400	427	30	93	92	95	97	2.05	2.02	2.05	2.07
						3	285	2270	692	1000	305	0	98	98	100	100	2.45	2.40	2.42	2.44
		2	1-13-66	199 000	90	1	191	780	238	1900	579	30	92	90	92	92	1.97	1.89	1.95	1.95
						2	178	1060	323	1000	305	30	90	88	91	90	1.95	1.90	1.95	1.92
						3	292	1860	567	1100	335	0	92	92	93	94	1.90	1.88	1.86	1.85
		3	1-13-66	195 000	88	1	176	1080	329	1800	549	30	90	88	90	91	1.92	1.88	1.92	1.95
						2	175	1170	357	100	30	30	90	89	90	90	2.00	2.00	1.99	1.95
						3	285	2710	826	1700	518	0	90	89	100	100	2.42	2.42	2.40	2.45

TABLE III.- Concluded

OPERATING CONDITIONS OF FOUR-ENGINE TURBOJET TRANSPORT AIRPLANE OBTAINED FROM FLIGHT DECK PHOTOGRAPH READOUTS

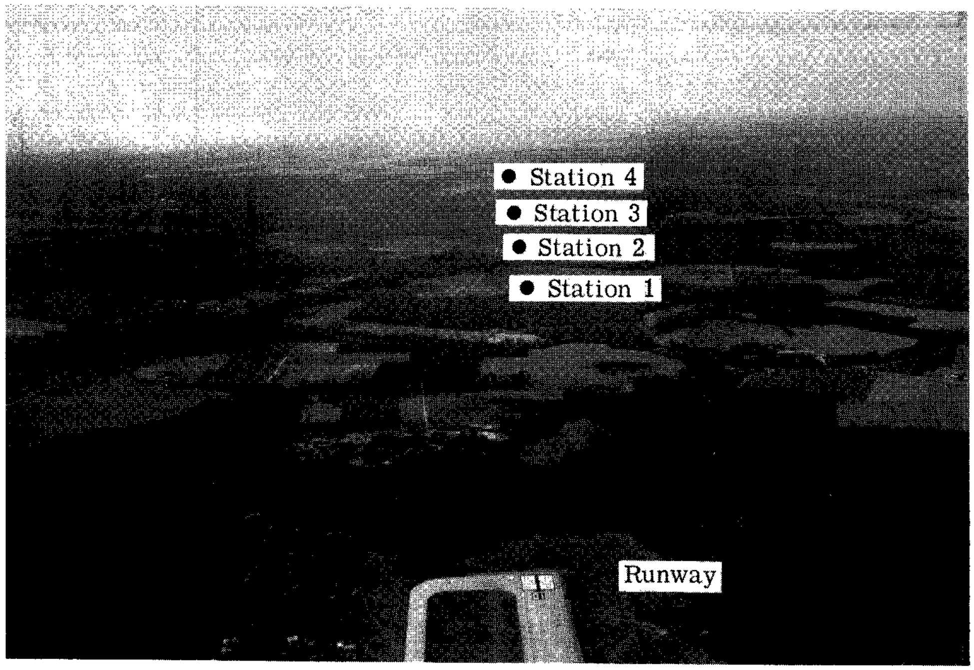
Profile	Climb velocity, knots	Flight	Date	Airplane gross weight		Flight deck readouts															
						Photo	Indicated airspeed, knots	Altitude		Rate of climb		Flap setting, deg	Compressor N_1, % rpm, for engine				Engine pressure ratio for engine			
				lbm	kg			ft	m	ft/min	m/min		1	2	3	4	1	2	3	4
5	$V_2 + 10$ to $V_2 + 20$	1	1-12-66	212 000	96	1	157	440	134	1700	518	28	102	101	103	103	2.68	2.62	2.65	2.70
						2	167	1110	338	1700	518	20	90	90	93	92	1.99	1.95	2.05	2.07
						3	165	1530	466	330	101	20	88	87	89	88	1.86	1.86	1.89	1.88
						4	165	1660	506	440	134	20	88	87	89	88	1.86	1.87	1.88	1.87
		2	1-12-66	210 000	95	1	161	270	82	1500	457	30	102	101	103	103	2.65	2.62	2.63	2.68
						2	170	1100	335	1800	549	20	90	90	93	92	1.98	2.00	2.10	2.03
						3	166	----	---	550	168	20	90	88	90	90	1.97	1.92	1.96	1.97
						4	170	1620	494	300	91	20	90	88	90	90	1.98	1.92	1.98	1.97
		3	1-12-66	202 000	92	1	152	160	49	1000	305	30	102	103	105	104	2.62	2.61	2.63	2.67
						2	164	1250	381	2100	640	20	92	92	94	94	2.00	2.00	2.06	2.13
						3	165	1470	448	450	137	20	90	90	92	91	1.97	1.98	1.99	1.99
6	$V_2 + 20$ to $V_2 + 30$	1	1-12-66	207 000	94	1	160	300	91	1100	335	30	101	101	103	102	2.65	2.60	2.63	2.66
						2	181	1010	308	1900	579	20	90	90	93	92	2.00	2.00	2.03	2.05
						3	170	1390	424	500	152	20	89	89	90	90	1.96	1.95	1.97	1.96
						4	177	1760	536	450	137	20	90	90	90	90	1.97	1.97	2.00	1.97
		2	1-12-66	204 000	93	1	175	500	152	1200	366	22	101	102	103	102	2.64	2.62	2.62	2.66
						2	174	1210	369	1800	549	20	90	89	91	90	1.95	1.92	1.98	1.97
						3	173	----	---	550	168	20	88	88	90	89	1.92	1.92	1.90	1.90
						4	172	1700	518	000	000	20	89	88	90	89	1.93	1.94	1.92	1.90
		3	1-12-66	198 000	90	1	154	250	76	1400	427	30	101	102	104	103	2.61	2.58	2.63	2.63
						2	176	1150	351	2200	671	20	92	92	96	96	2.00	1.98	2.03	2.05
						3	170	1500	457	500	152	20	90	90	90	90	1.92	1.90	1.90	1.92
7	$V_2 + 10$ to $V_2 + 30$ to $V_2 + 50$	1	1-12-66	201 000	91	1	150	490	149	2100	640	26	103	103	105	105	2.65	2.65	2.66	2.71
						2	180	730	223	500	152	15	102	103	105	104	2.62	2.64	2.65	2.70
						3	245	1360	415	1300	396	0	97	97	98	98	2.38	2.32	2.33	2.36
		2	1-12-66	199 000	90	1	153	480	146	2200	671	28	102	104	105	104	2.66	2.66	2.67	2.70
						2	182	890	271	1200	366	18	102	103	104	104	2.62	2.65	2.63	2.69
						3	239	2770	844	1500	457	0	97	97	98	98	2.35	2.30	2.30	2.35
		3	1-12-66	196 000	89	1	152	350	107	2200	671	30	102	103	105	104	2.63	2.62	2.63	2.68
						2	205	1730	527	1300	396	0	99	99	101	101	2.45	2.42	2.44	2.45
						3	230	2280	695	1000	305	0	98	97	99	98	2.37	2.32	2.32	2.35

TABLE IV

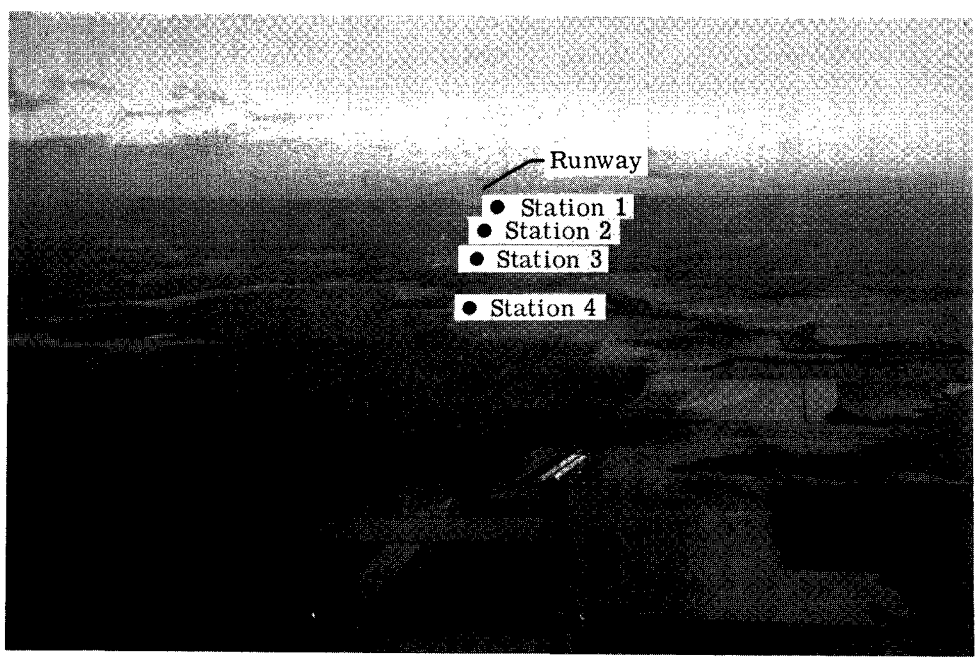
SURFACE AND UPPER AIR ATMOSPHERIC CONDITIONS DURING TIME OF NOISE TESTS

Date	Upper air data									Surface winds		
	Altitude		Atmospheric pressure		Temperature		Percent relative humidity	Wind velocity, knots	Wind direction,* deg	Time of day, hr	Velocity, knots	Direction,* deg
	ft	m	lb/ft^2	N/m^2	^{o}F	^{o}K						
1-12-66	0	0	2145	102 703	20	266	62	10	330	0900	12	320
	1000	305	2036	97 484	14	263	61	23	330			
	2000	610	1962	93 941	12	262	60	25	340	1200	9	290
	3000	914	1885	90 254	15	264	36	23	340			
	4000	1219	1825	87 381	15	264	34	24	330	1500	8	310
	5000	1524	1755	84 030	15	264	30	26	320			
1-13-66	0	0	2135	102 224	23	268	68	0	195	0900	2	120
	1000	305	2036	97 484	27	270	48	17	180			
	2000	610	1962	93 941	30	272	28	18	180	1200	12	180
	3000	914	1885	90 254	32	273	15	20	165			
	4000	1219	1825	87 381	32	273	16	19	180	1500	12	180
	5000	1524	1755	84 030	33	274	17	18	165			

*Direction from which wind is blowing.



(a) View looking west.



(b) View looking east.

L-66-4562

Figure 1.- NASA Wallops Station test area used for take-off—climbout noise studies showing runway and terrain in vicinity of measuring stations.

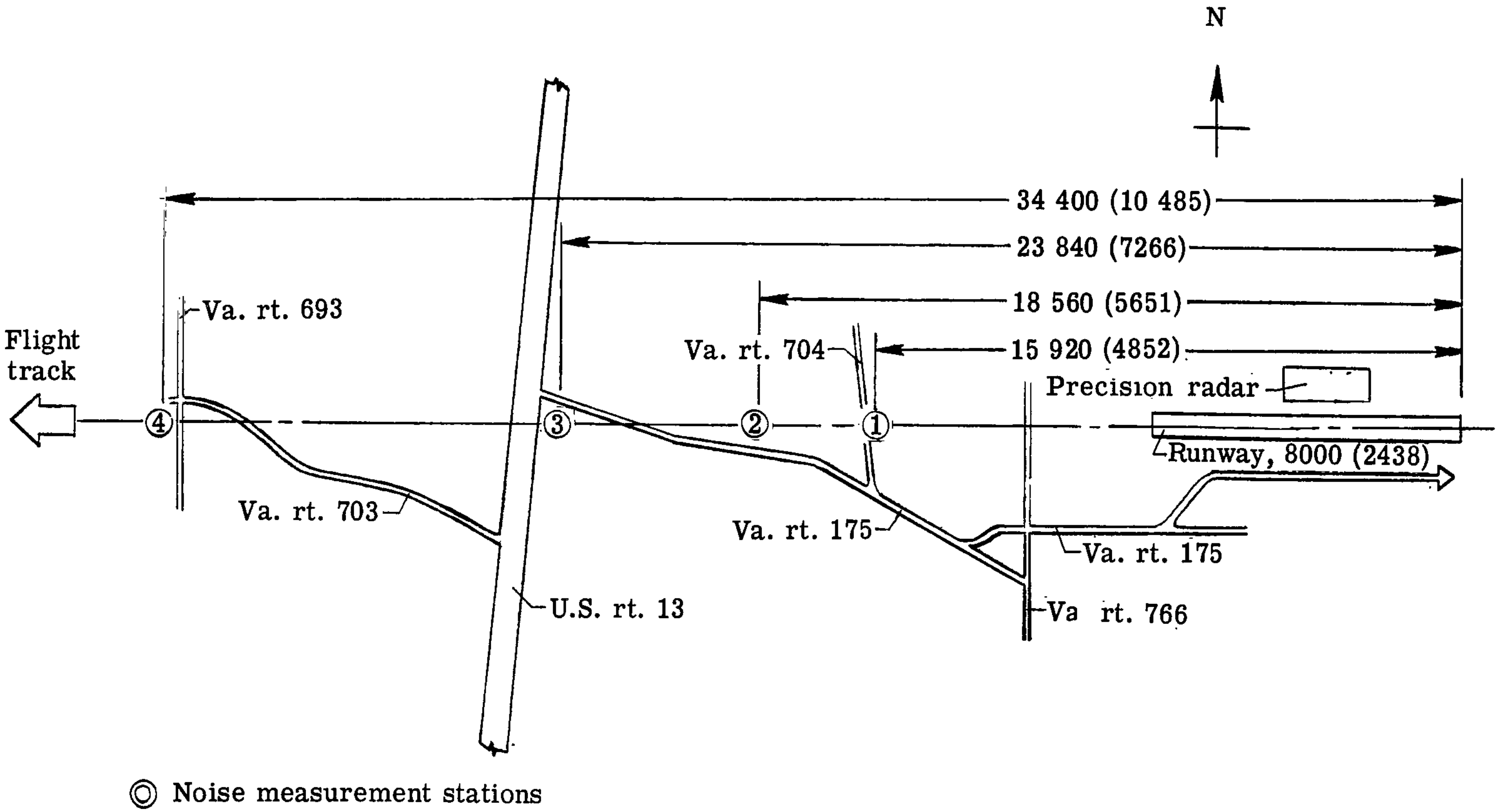


Figure 2.- Schematic diagram of NASA Wallops Station test area showing locations of runway, radar, flight track, and noise measuring stations. Dimensions are in ft (m).

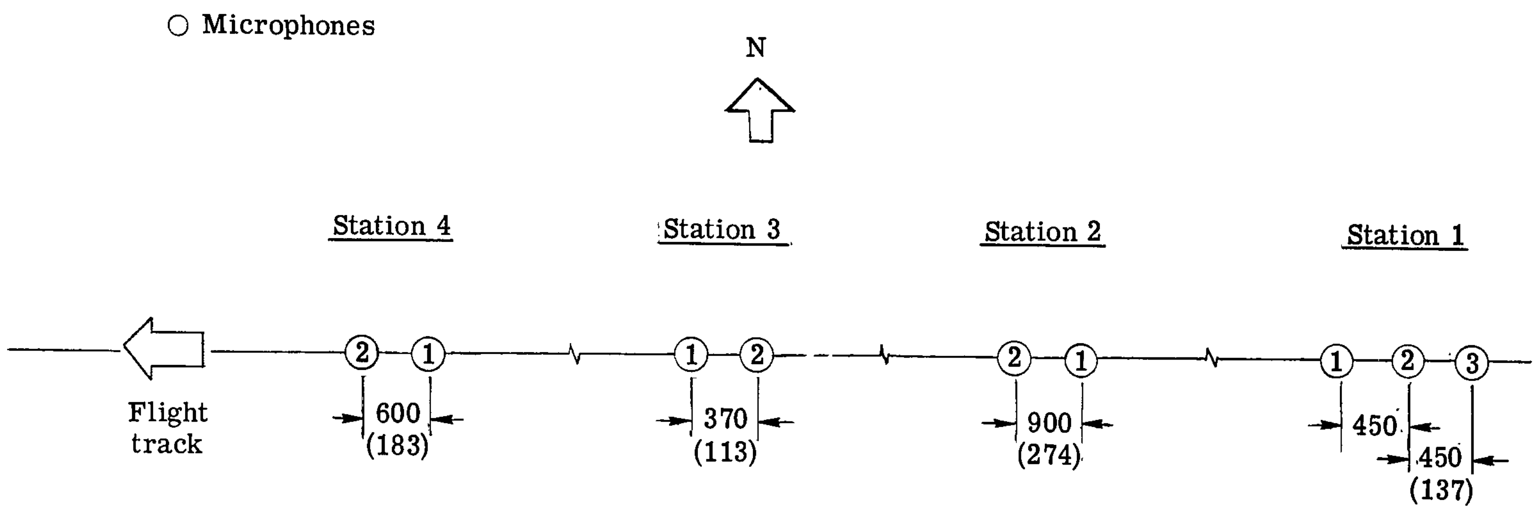
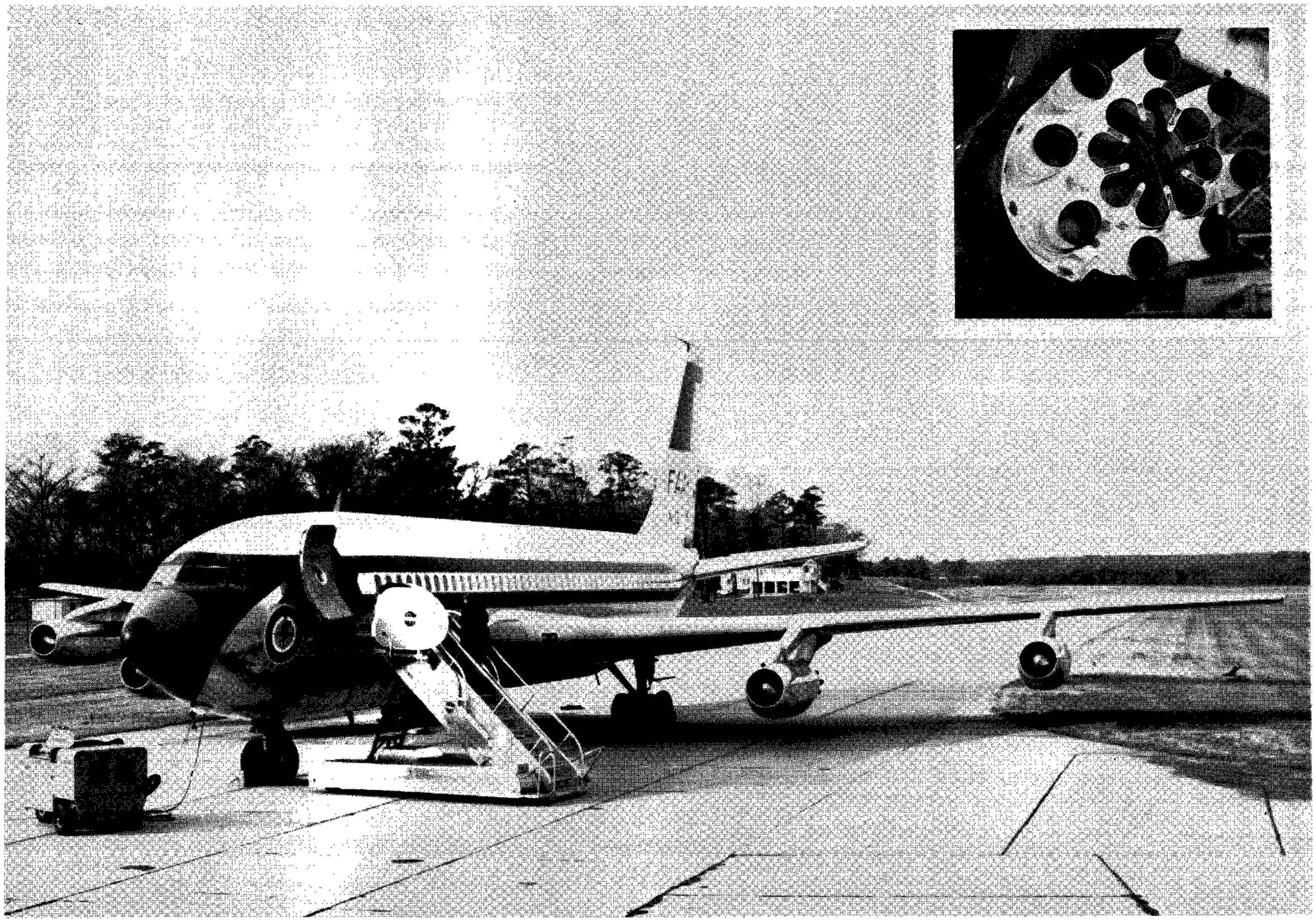
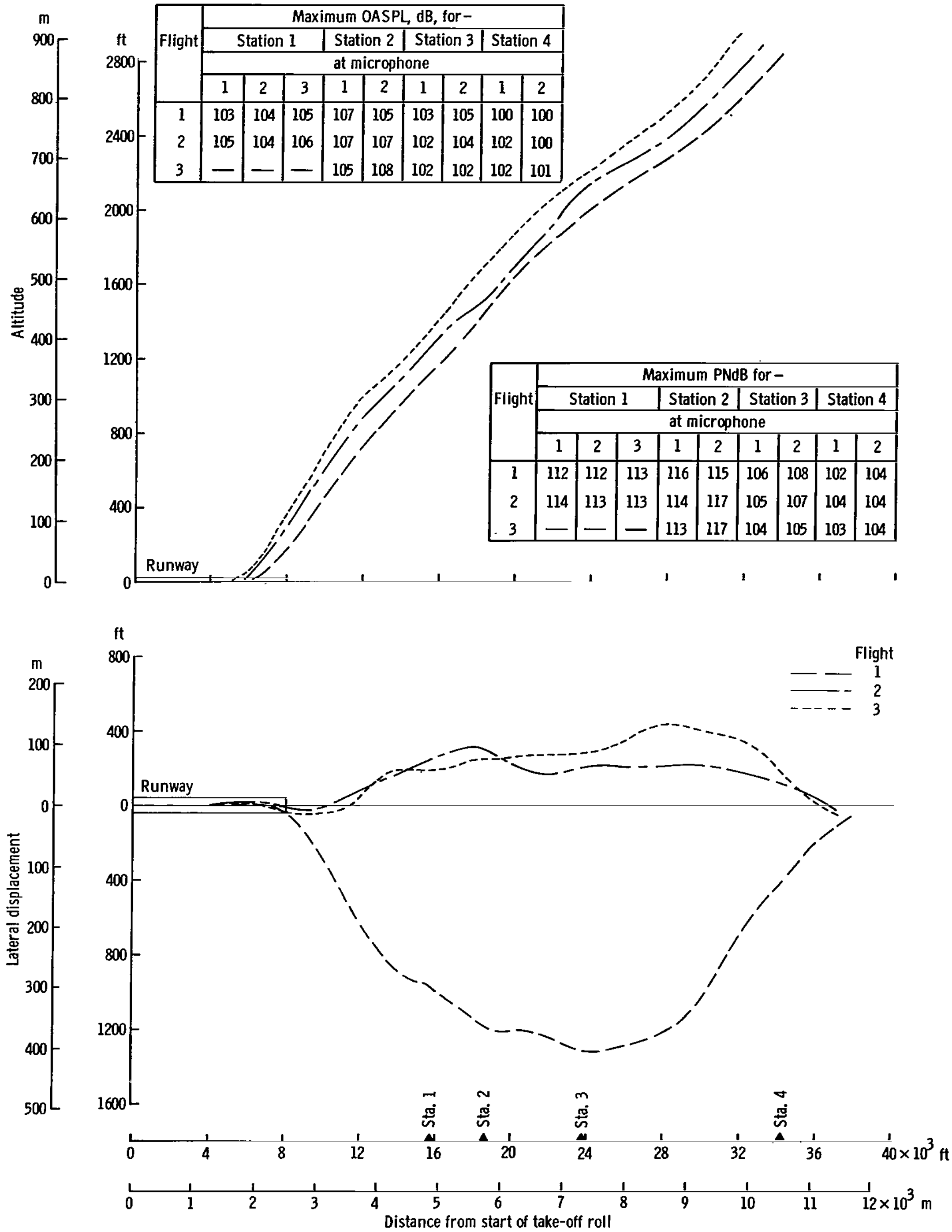


Figure 3.- Microphone layout of four measuring stations used for take-off—climbout noise tests. Dimensions are in ft (m).



L-66-732.1

Figure 4.- Four-engine turbojet transport airplane used for take-off—climbout noise measurements. Insert shows exhaust noise suppressor.

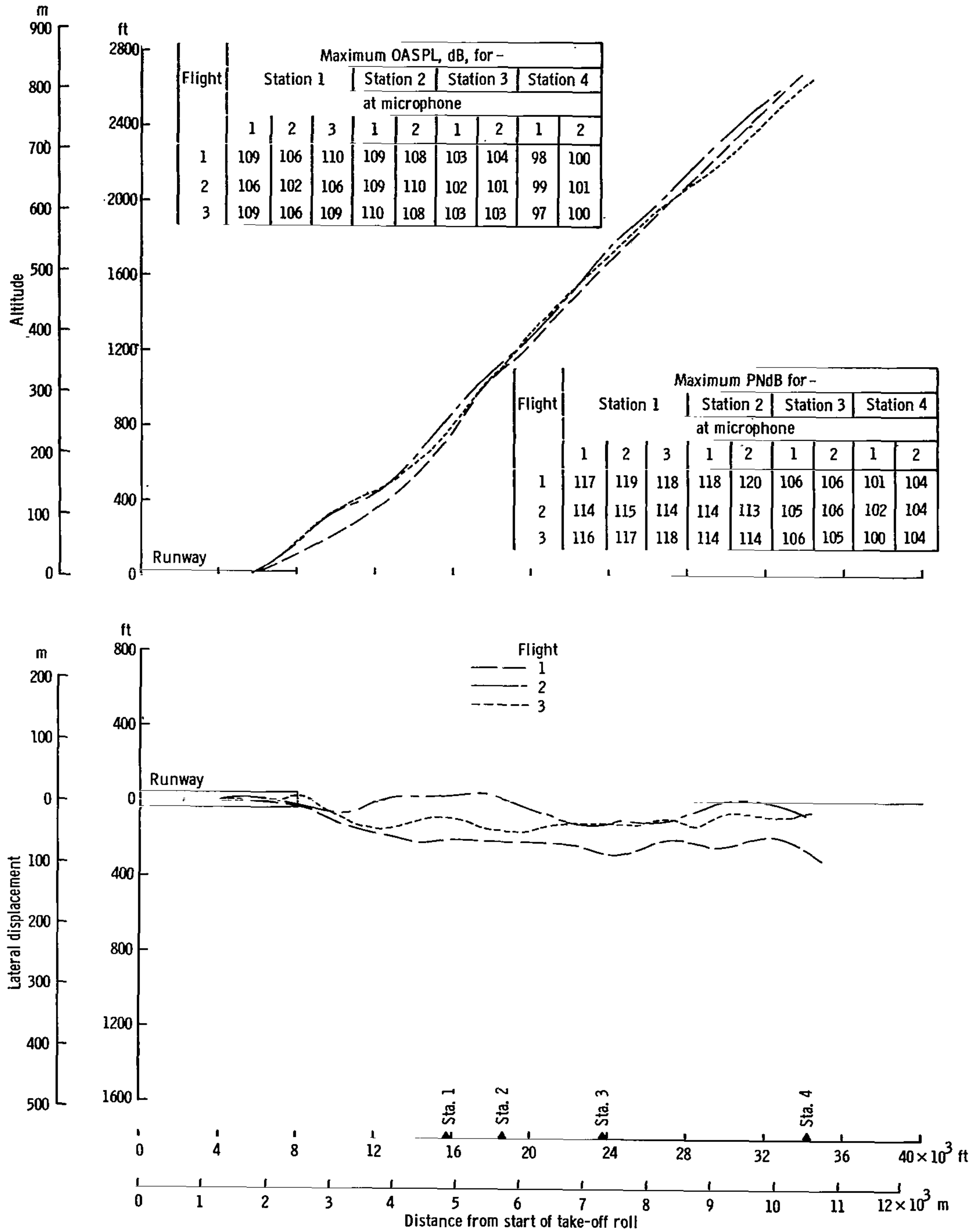


Flight	Maximum OASPL, dB, for–								
	Station 1			Station 2		Station 3		Station 4	
	at microphone								
	1	2	3	1	2	1	2	1	2
1	103	104	105	107	105	103	105	100	100
2	105	104	106	107	107	102	104	102	100
3	—	—	—	105	108	102	102	102	101

Flight	Maximum PNdB for–								
	Station 1			Station 2		Station 3		Station 4	
	at microphone								
	1	2	3	1	2	1	2	1	2
1	112	112	113	116	115	106	108	102	104
2	114	113	113	114	117	105	107	104	104
3	—	—	—	113	117	104	105	103	104

(a) Climb speed, V_2.

Figure 5.- Altitude—plan-position data from ground-based radar along with tabulated noise levels as obtained at each measuring station from flight profile 1.

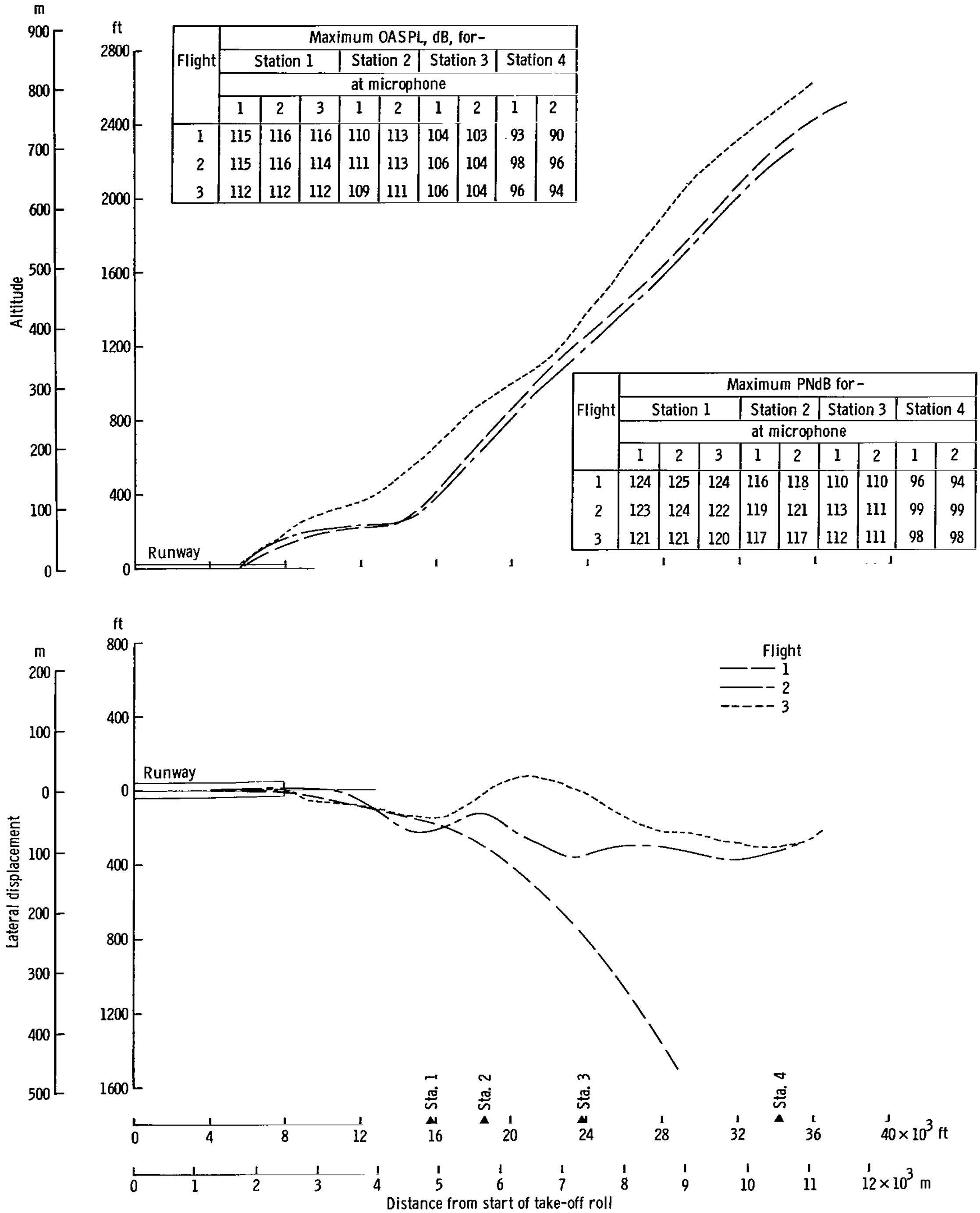


Flight	Maximum OASPL, dB, for – Station 1 at microphone 1	2	3	Station 2, 1	2	Station 3, 1	2	Station 4, 1	2
1	109	106	110	109	108	103	104	98	100
2	106	102	106	109	110	102	101	99	101
3	109	106	109	110	108	103	103	97	100

Flight	Maximum PNdB for – Station 1 at microphone 1	2	3	Station 2, 1	2	Station 3, 1	2	Station 4, 1	2
1	117	119	118	118	120	106	106	101	104
2	114	115	114	114	113	105	106	102	104
3	116	117	118	114	114	106	105	100	104

(b) Climb speed, V_2 + 20 knots.

Figure 5.- Continued.

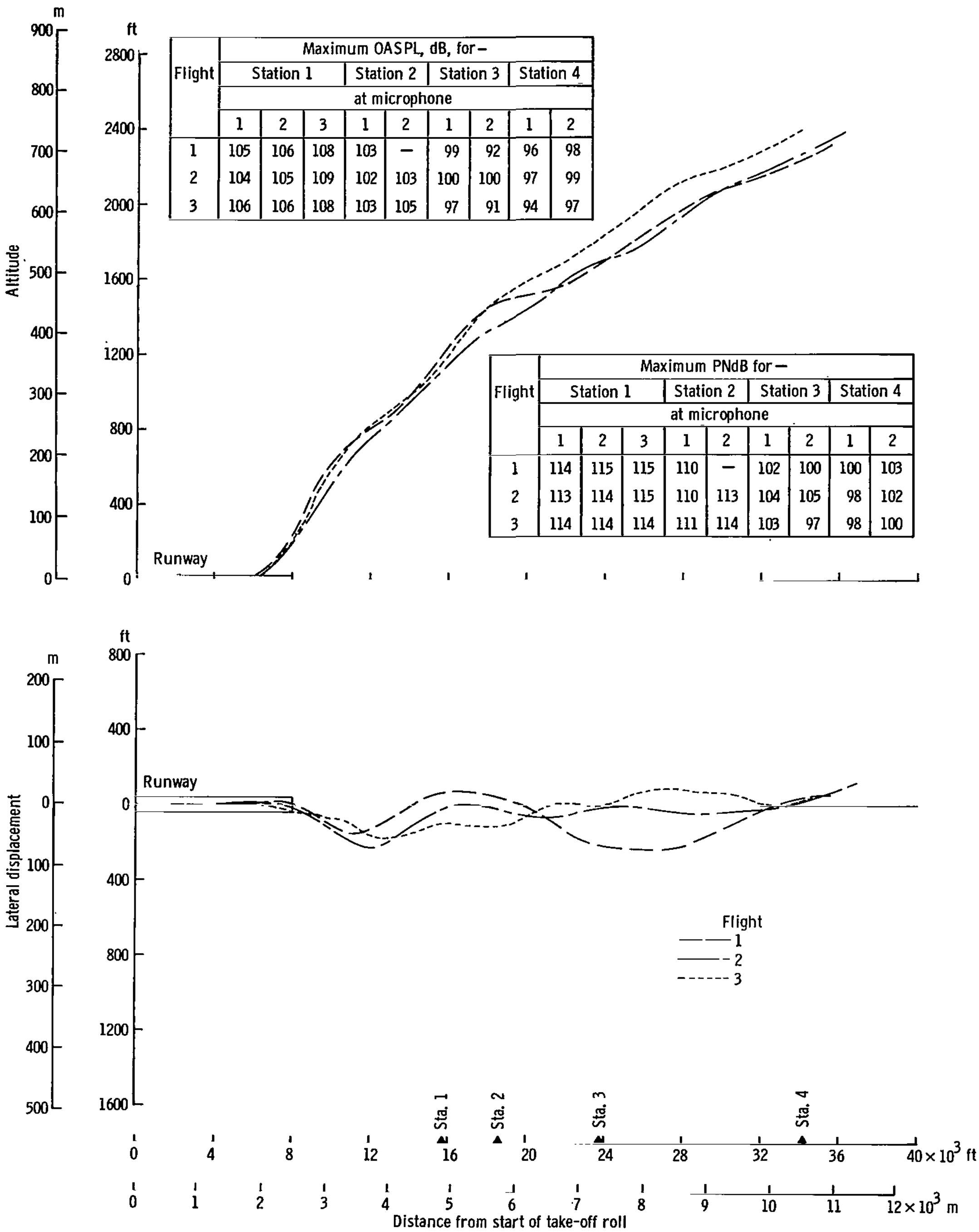


Flight	Maximum OASPL, dB, for–								
	Station 1			Station 2		Station 3		Station 4	
	at microphone								
	1	2	3	1	2	1	2	1	2
1	115	116	116	110	113	104	103	93	90
2	115	116	114	111	113	106	104	98	96
3	112	112	112	109	111	106	104	96	94

Flight	Maximum PNdB for–								
	Station 1			Station 2		Station 3		Station 4	
	at microphone								
	1	2	3	1	2	1	2	1	2
1	124	125	124	116	118	110	110	96	94
2	123	124	122	119	121	113	111	99	99
3	121	121	120	117	117	112	111	98	98

(c) Climb speed, V_2 + 40 knots.

Figure 5.- Concluded.

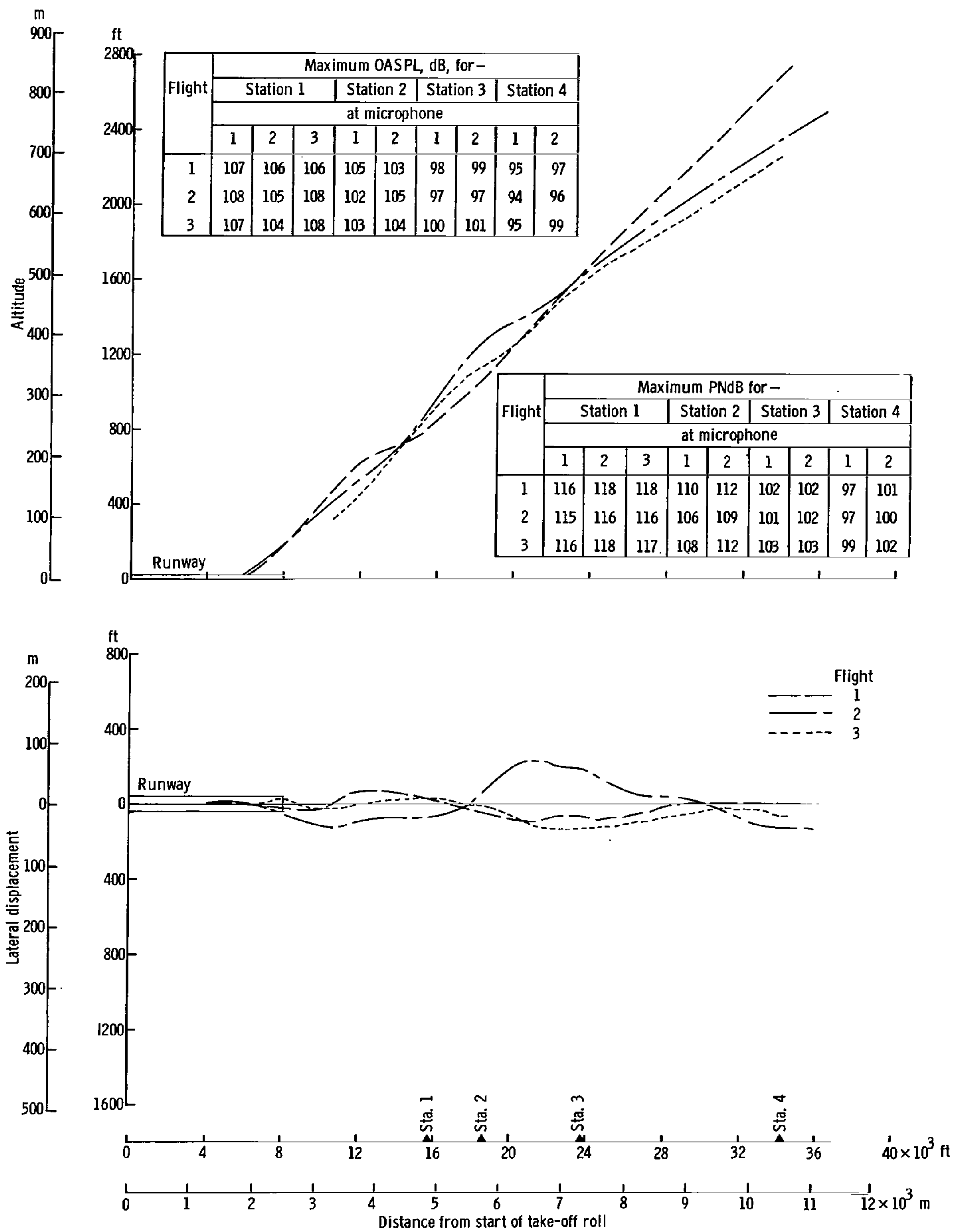


Flight	Maximum OASPL, dB, for– Station 1 at microphone 1	2	3	Station 2 at microphone 1	2	Station 3 at microphone 1	2	Station 4 at microphone 1	2
1	105	106	108	103	—	99	92	96	98
2	104	105	109	102	103	100	100	97	99
3	106	106	108	103	105	97	91	94	97

Flight	Maximum PNdB for– Station 1 at microphone 1	2	3	Station 2 at microphone 1	2	Station 3 at microphone 1	2	Station 4 at microphone 1	2
1	114	115	115	110	—	102	100	100	103
2	113	114	115	110	113	104	105	98	102
3	114	114	114	111	114	103	97	98	100

(a) Climb speed, V_2.

Figure 6.- Altitude—plan-position data from ground-based radar along with tabulated noise levels as obtained at each measuring station from flight profile 2.

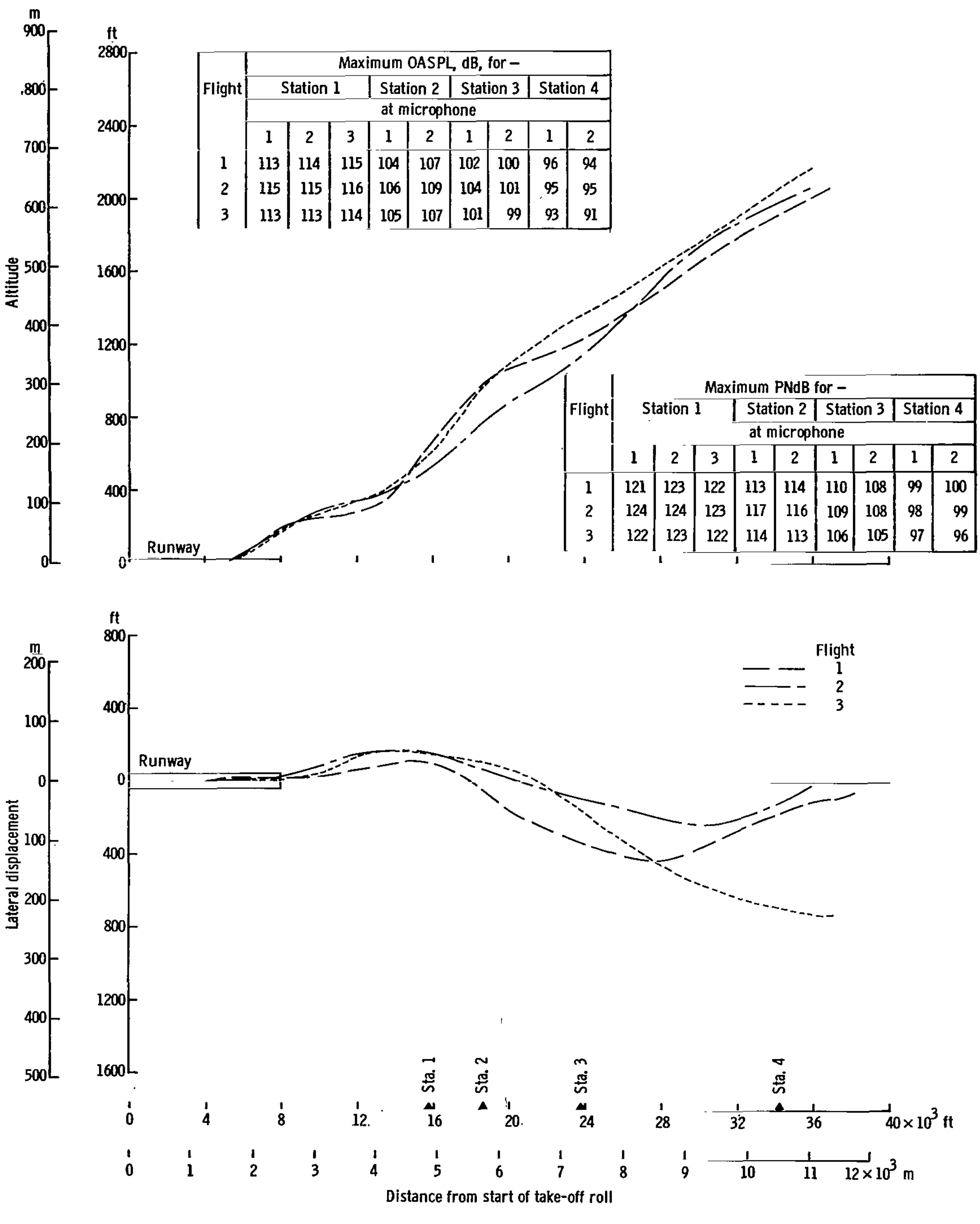


Flight	Maximum OASPL, dB, for– Station 1 at microphone 1	Station 1, 2	Station 1, 3	Station 2, 1	Station 2, 2	Station 3, 1	Station 3, 2	Station 4, 1	Station 4, 2
1	107	106	106	105	103	98	99	95	97
2	108	105	108	102	105	97	97	94	96
3	107	104	108	103	104	100	101	95	99

Flight	Maximum PNdB for– Station 1 at microphone 1	Station 1, 2	Station 1, 3	Station 2, 1	Station 2, 2	Station 3, 1	Station 3, 2	Station 4, 1	Station 4, 2
1	116	118	118	110	112	102	102	97	101
2	115	116	116	106	109	101	102	97	100
3	116	118	117	108	112	103	103	99	102

(b) Climb speed, V_2 + 20 knots.

Figure 6.- Continued.

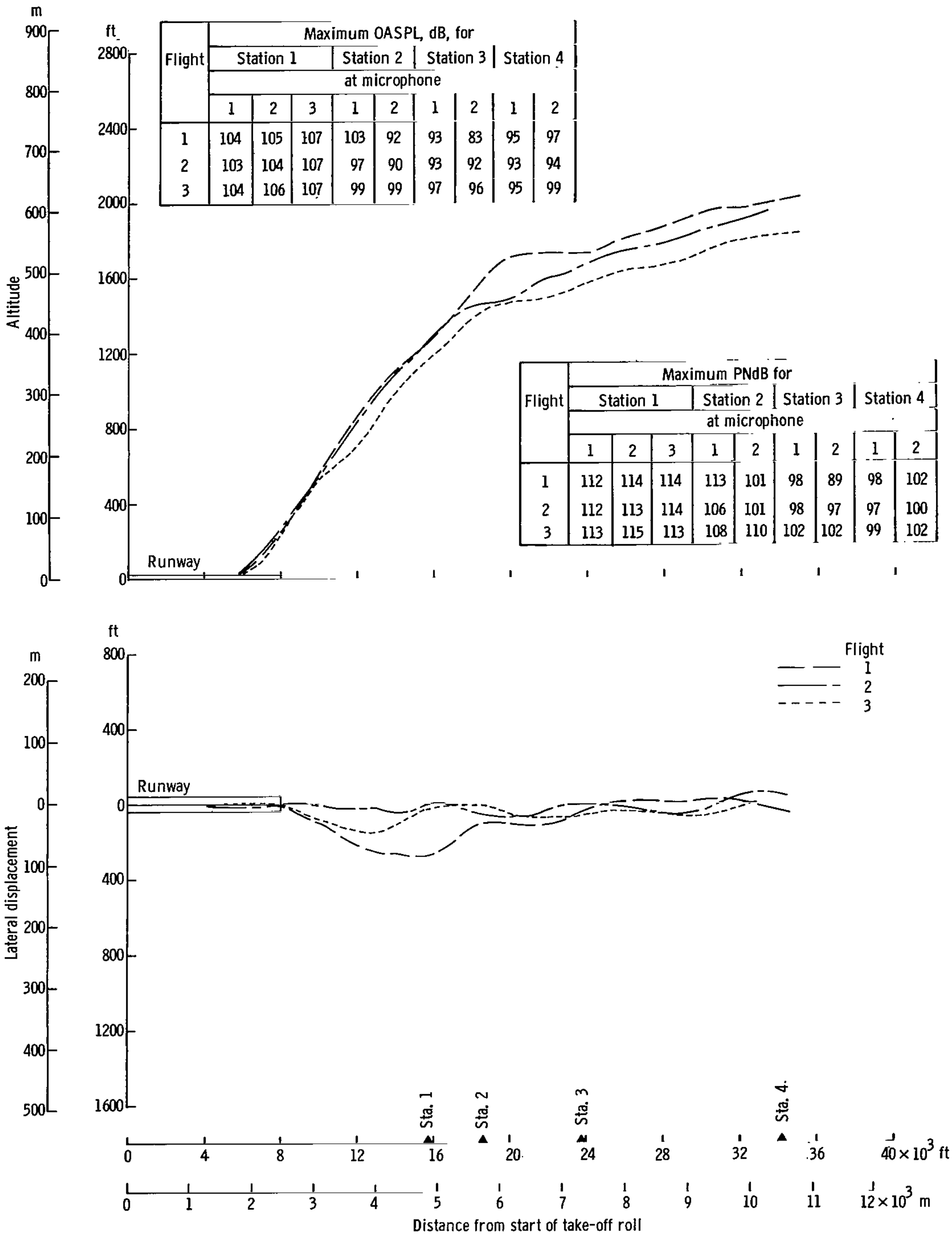


Flight	Maximum OASPL, dB, for – Station 1 at microphone 1	2	3	Station 2 at microphone 1	2	Station 3 at microphone 1	2	Station 4 at microphone 1	2
1	113	114	115	104	107	102	100	96	94
2	115	115	116	106	109	104	101	95	95
3	113	113	114	105	107	101	99	93	91

Flight	Maximum PNdB for – Station 1 at microphone 1	2	3	Station 2 at microphone 1	2	Station 3 at microphone 1	2	Station 4 at microphone 1	2
1	121	123	122	113	114	110	108	99	100
2	124	124	123	117	116	109	108	98	99
3	122	123	122	114	113	106	105	97	96

(c) Climb speed, V_2 + 40 knots.

Figure 6.- Concluded.

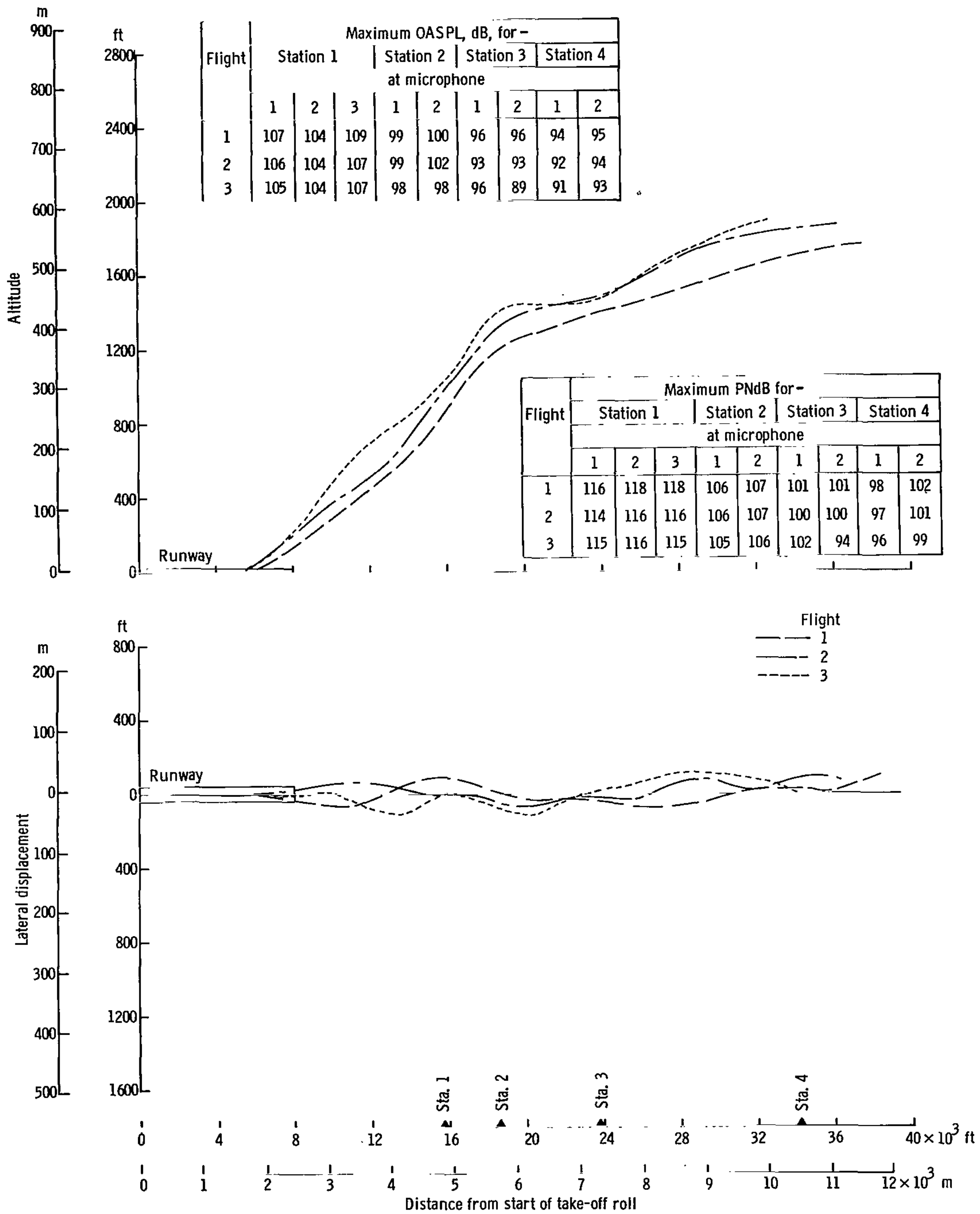


Flight	Maximum OASPL, dB, for Station 1 at microphone 1	2	3	Station 2, 1	2	Station 3, 1	2	Station 4, 1	2
1	104	105	107	103	92	93	83	95	97
2	103	104	107	97	90	93	92	93	94
3	104	106	107	99	99	97	96	95	99

Flight	Maximum PNdB for Station 1 at microphone 1	2	3	Station 2, 1	2	Station 3, 1	2	Station 4, 1	2
1	112	114	114	113	101	98	89	98	102
2	112	113	114	106	101	98	97	97	100
3	113	115	113	108	110	102	102	99	102

(a) Climb speed, V_2.

Figure 7.- Altitude—plan-position data from ground-based radar along with tabulated noise levels as obtained at each measuring station from flight profile 3.

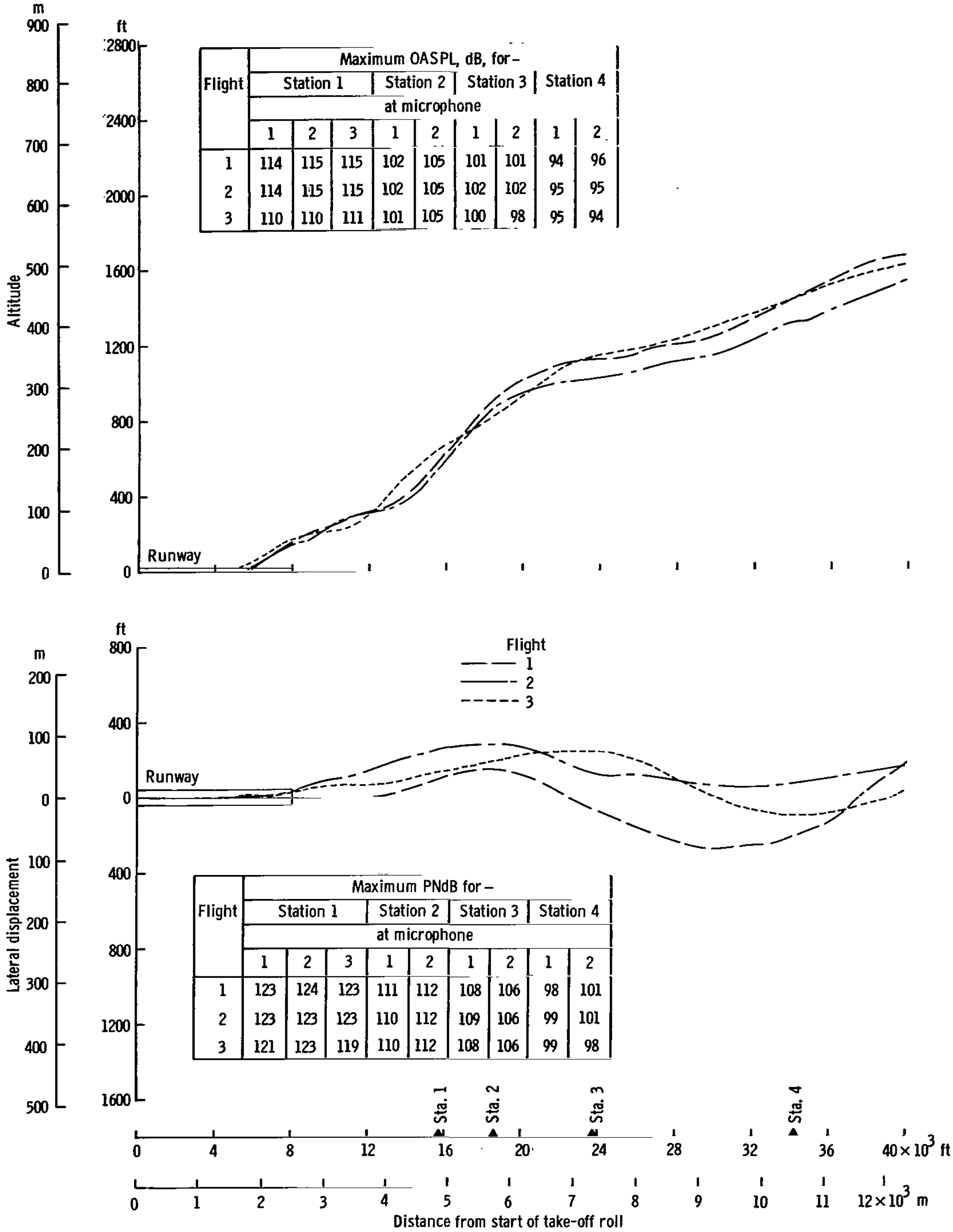


Flight	Maximum OASPL, dB, for – Station 1 at microphone 1	Station 1, 2	Station 1, 3	Station 2, 1	Station 2, 2	Station 3, 1	Station 3, 2	Station 4, 1	Station 4, 2
1	107	104	109	99	100	96	96	94	95
2	106	104	107	99	102	93	93	92	94
3	105	104	107	98	98	96	89	91	93

Flight	Maximum PNdB for – Station 1 at microphone 1	Station 1, 2	Station 1, 3	Station 2, 1	Station 2, 2	Station 3, 1	Station 3, 2	Station 4, 1	Station 4, 2
1	116	118	118	106	107	101	101	98	102
2	114	116	116	106	107	100	100	97	101
3	115	116	115	105	106	102	94	96	99

(b) Climb speed, V_2 + 20 knots.

Figure 7.- Continued.

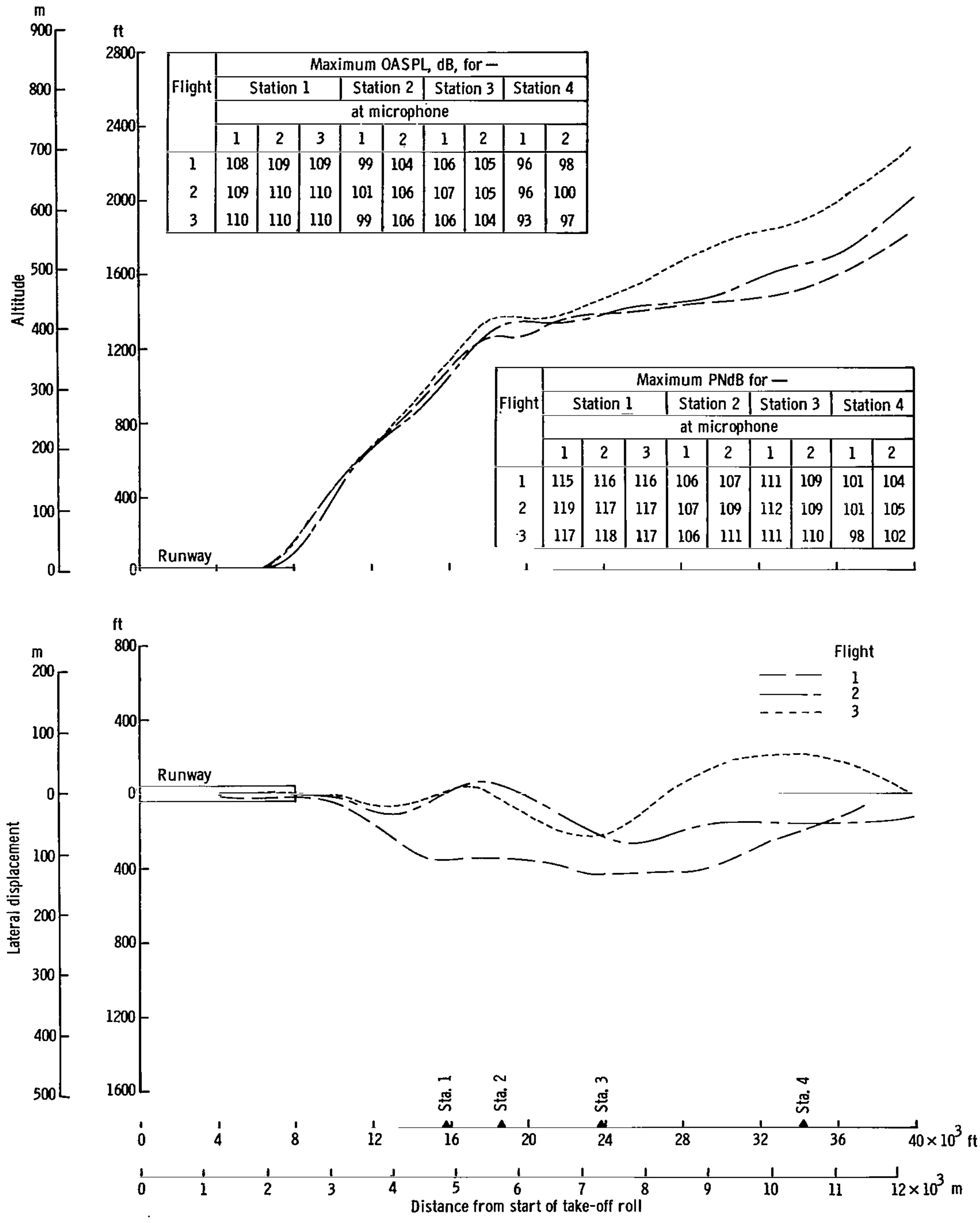


Flight	Maximum OASPL, dB, for– Station 1 at microphone 1	Station 1, 2	Station 1, 3	Station 2, 1	Station 2, 2	Station 3, 1	Station 3, 2	Station 4, 1	Station 4, 2
1	114	115	115	102	105	101	101	94	96
2	114	115	115	102	105	102	102	95	95
3	110	110	111	101	105	100	98	95	94

Flight	Maximum PNdB for– Station 1 at microphone 1	Station 1, 2	Station 1, 3	Station 2, 1	Station 2, 2	Station 3, 1	Station 3, 2	Station 4, 1	Station 4, 2
1	123	124	123	111	112	108	106	98	101
2	123	123	123	110	112	109	106	99	101
3	121	123	119	110	112	108	106	99	98

(c) Climb speed, V_2 + 40 knots.

Figure 7.- Concluded.

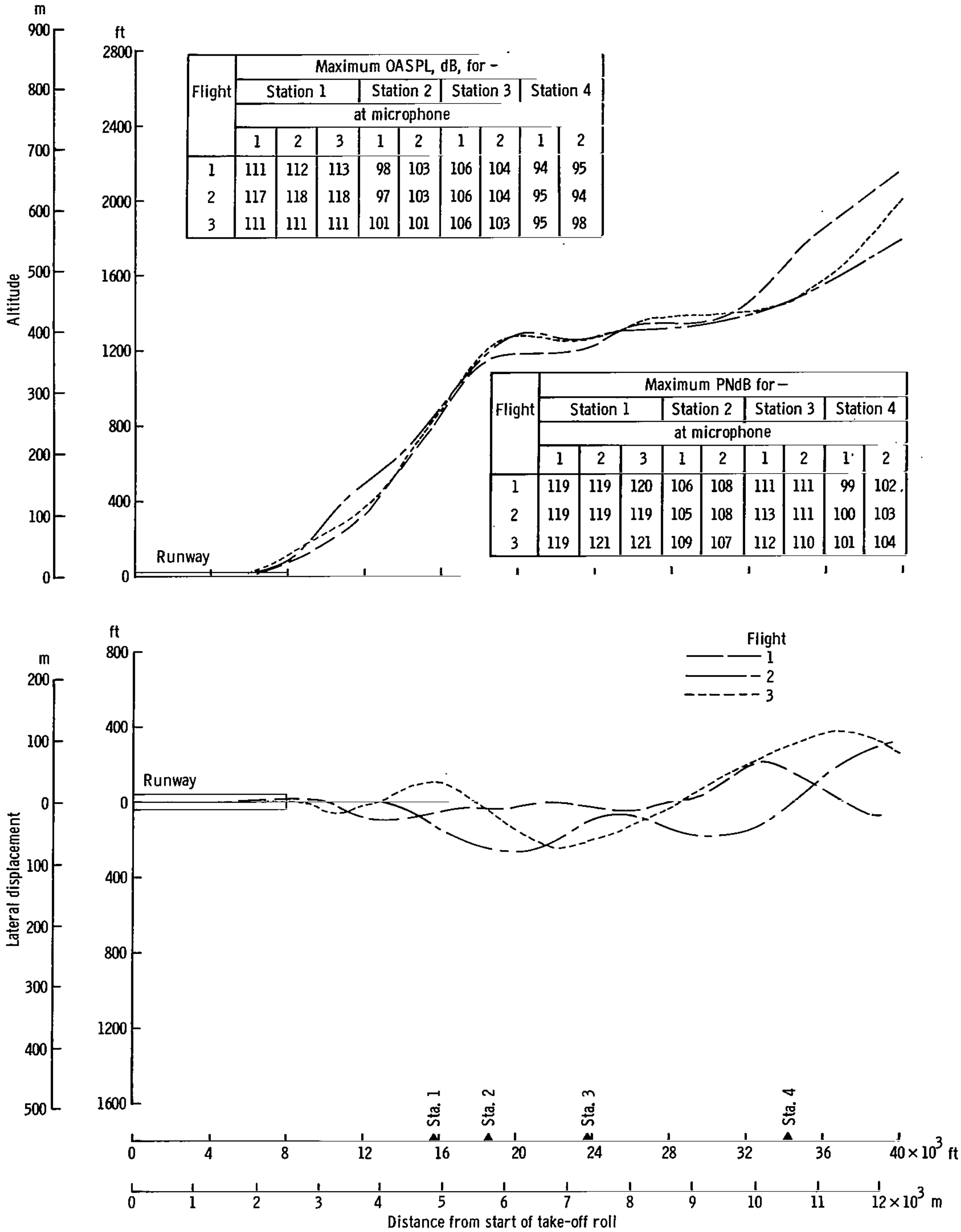


Flight	Maximum OASPL, dB, for —								
	Station 1			Station 2		Station 3		Station 4	
	at microphone								
	1	2	3	1	2	1	2	1	2
1	108	109	109	99	104	106	105	96	98
2	109	110	110	101	106	107	105	96	100
3	110	110	110	99	106	106	104	93	97

Flight	Maximum PNdB for —								
	Station 1			Station 2		Station 3		Station 4	
	at microphone								
	1	2	3	1	2	1	2	1	2
1	115	116	116	106	107	111	109	101	104
2	119	117	117	107	109	112	109	101	105
3	117	118	117	106	111	111	110	98	102

(a) Climb speed, V_2.

Figure 8.- Altitude—plan-position data from ground-based radar along with tabulated noise levels as obtained at each measuring station from flight profile 4.

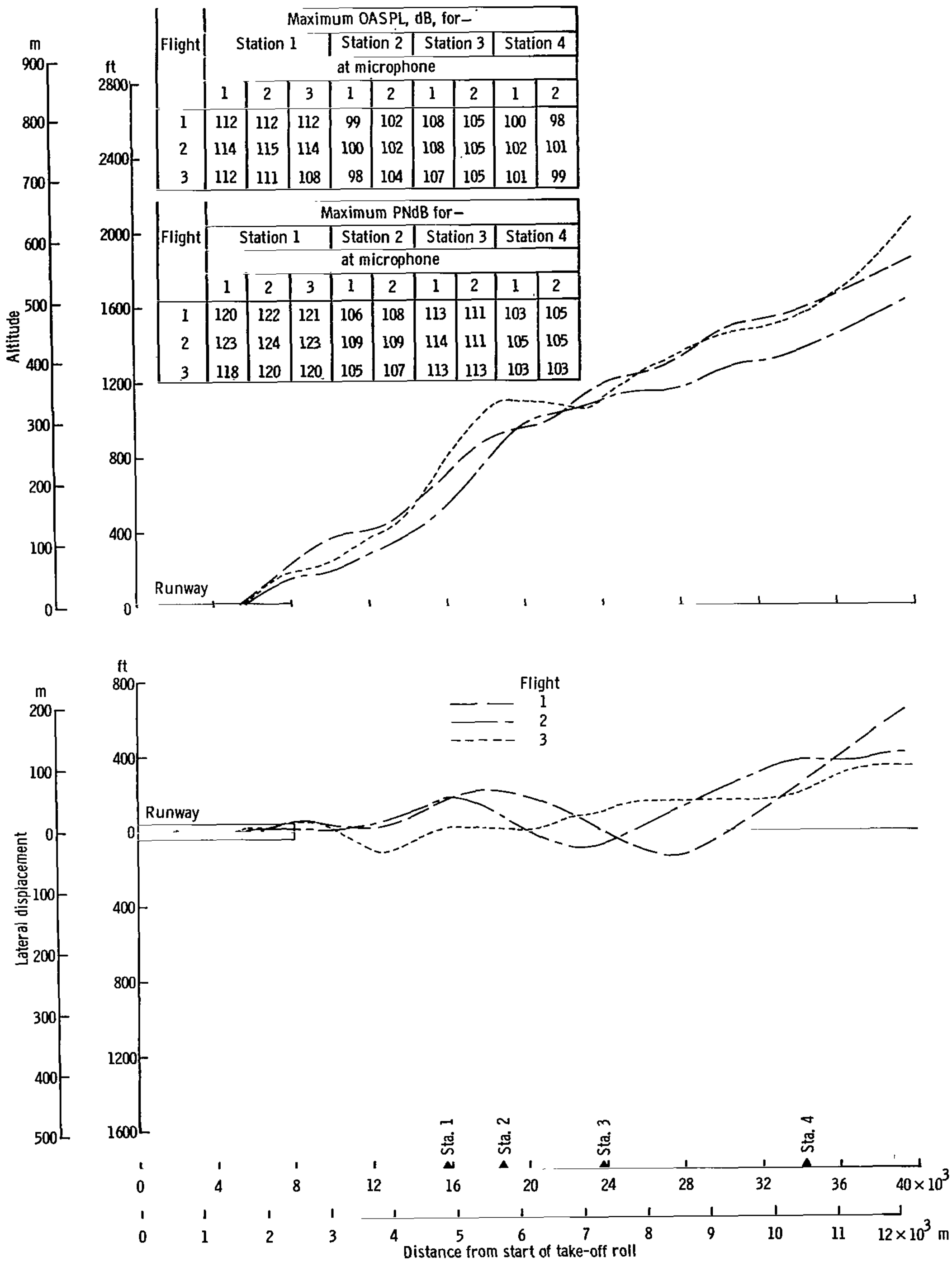


Flight	Maximum OASPL, dB, for – Station 1 at microphone 1	2	3	Station 2 at microphone 1	2	Station 3 at microphone 1	2	Station 4 at microphone 1	2
1	111	112	113	98	103	106	104	94	95
2	117	118	118	97	103	106	104	95	94
3	111	111	111	101	101	106	103	95	98

Flight	Maximum PNdB for – Station 1 at microphone 1	2	3	Station 2 at microphone 1	2	Station 3 at microphone 1	2	Station 4 at microphone 1	2
1	119	119	120	106	108	111	111	99	102
2	119	119	119	105	108	113	111	100	103
3	119	121	121	109	107	112	110	101	104

(b) Climb speed, V_2 + 20 knots.

Figure 8.- Continued.

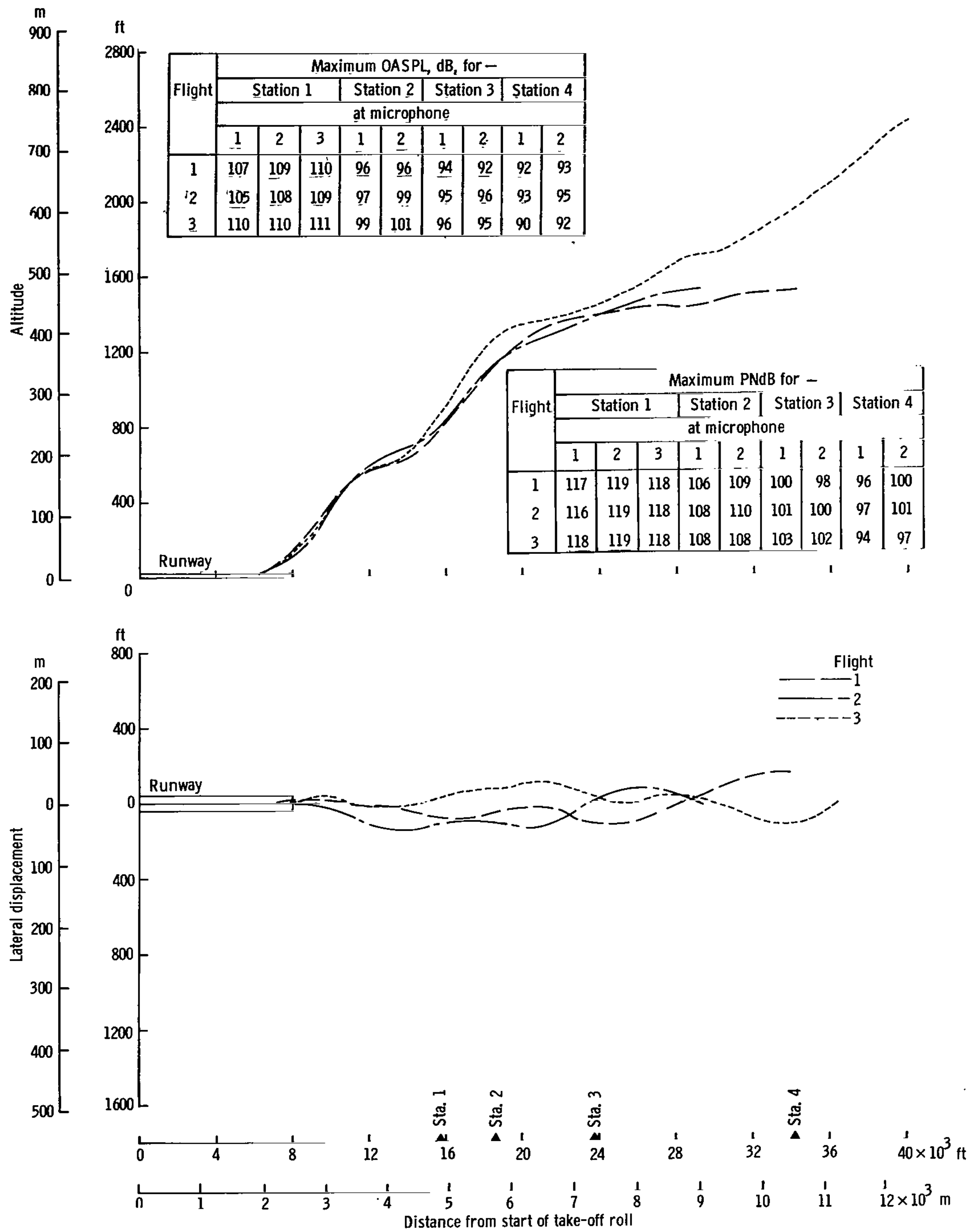


Flight	Maximum OASPL, dB, for— Station 1 at microphone 1	2	3	Station 2 at microphone 1	2	Station 3 at microphone 1	2	Station 4 at microphone 1	2
1	112	112	112	99	102	108	105	100	98
2	114	115	114	100	102	108	105	102	101
3	112	111	108	98	104	107	105	101	99

Flight	Maximum PNdB for— Station 1 at microphone 1	2	3	Station 2 at microphone 1	2	Station 3 at microphone 1	2	Station 4 at microphone 1	2
1	120	122	121	106	108	113	111	103	105
2	123	124	123	109	109	114	111	105	105
3	118	120	120	105	107	113	113	103	103

(c) Climb speed, V_2 + 40 knots.

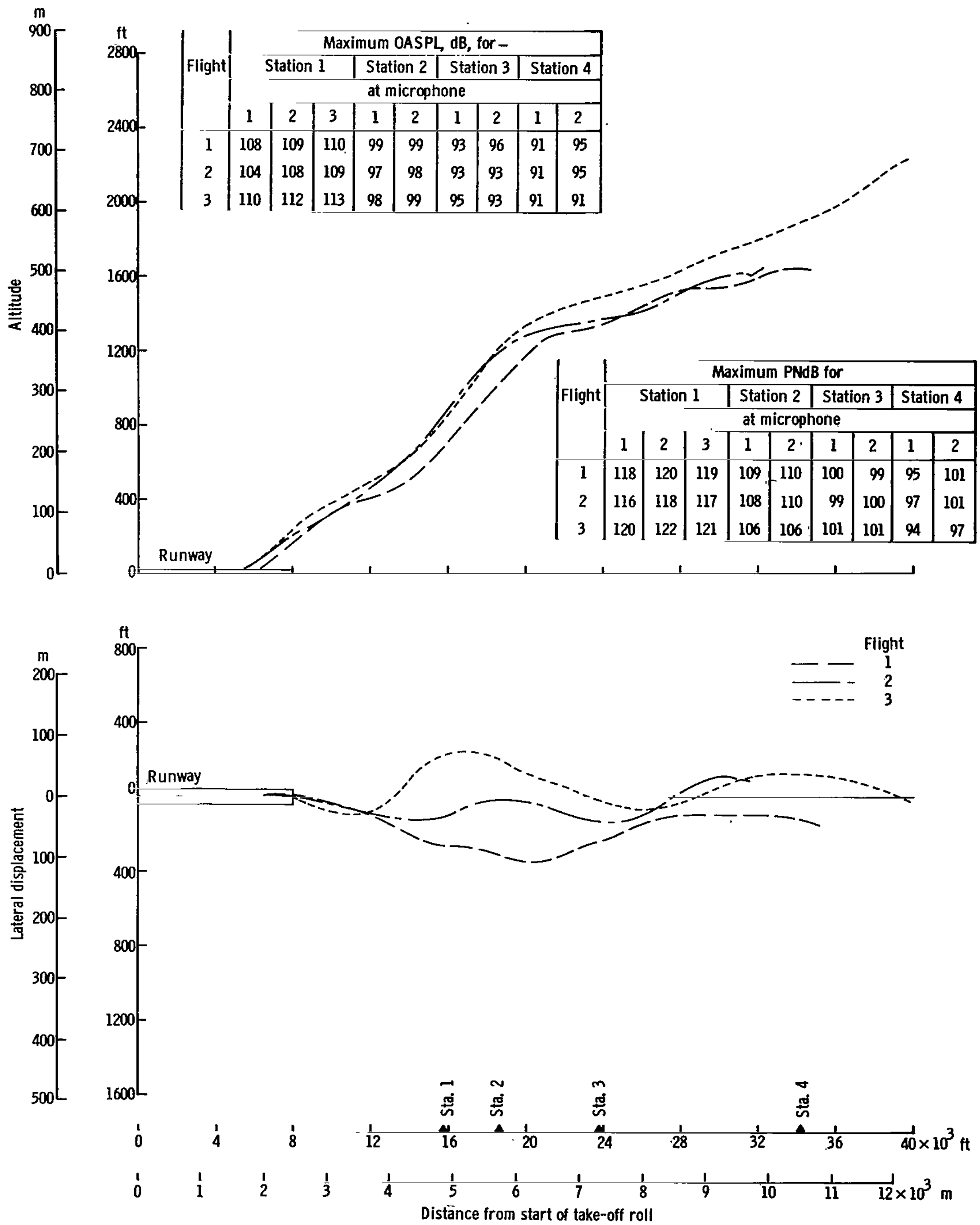
Figure 8.- Concluded.



Flight	Maximum OASPL, dB, for— Station 1 at microphone 1	Station 1, 2	Station 1, 3	Station 2, 1	Station 2, 2	Station 3, 1	Station 3, 2	Station 4, 1	Station 4, 2
1	107	109	110	96	96	94	92	92	93
2	105	108	109	97	99	95	96	93	95
3	110	110	111	99	101	96	95	90	92

Flight	Maximum PNdB for — Station 1 at microphone 1	Station 1, 2	Station 1, 3	Station 2, 1	Station 2, 2	Station 3, 1	Station 3, 2	Station 4, 1	Station 4, 2
1	117	119	118	106	109	100	98	96	100
2	116	119	118	108	110	101	100	97	101
3	118	119	118	108	108	103	102	94	97

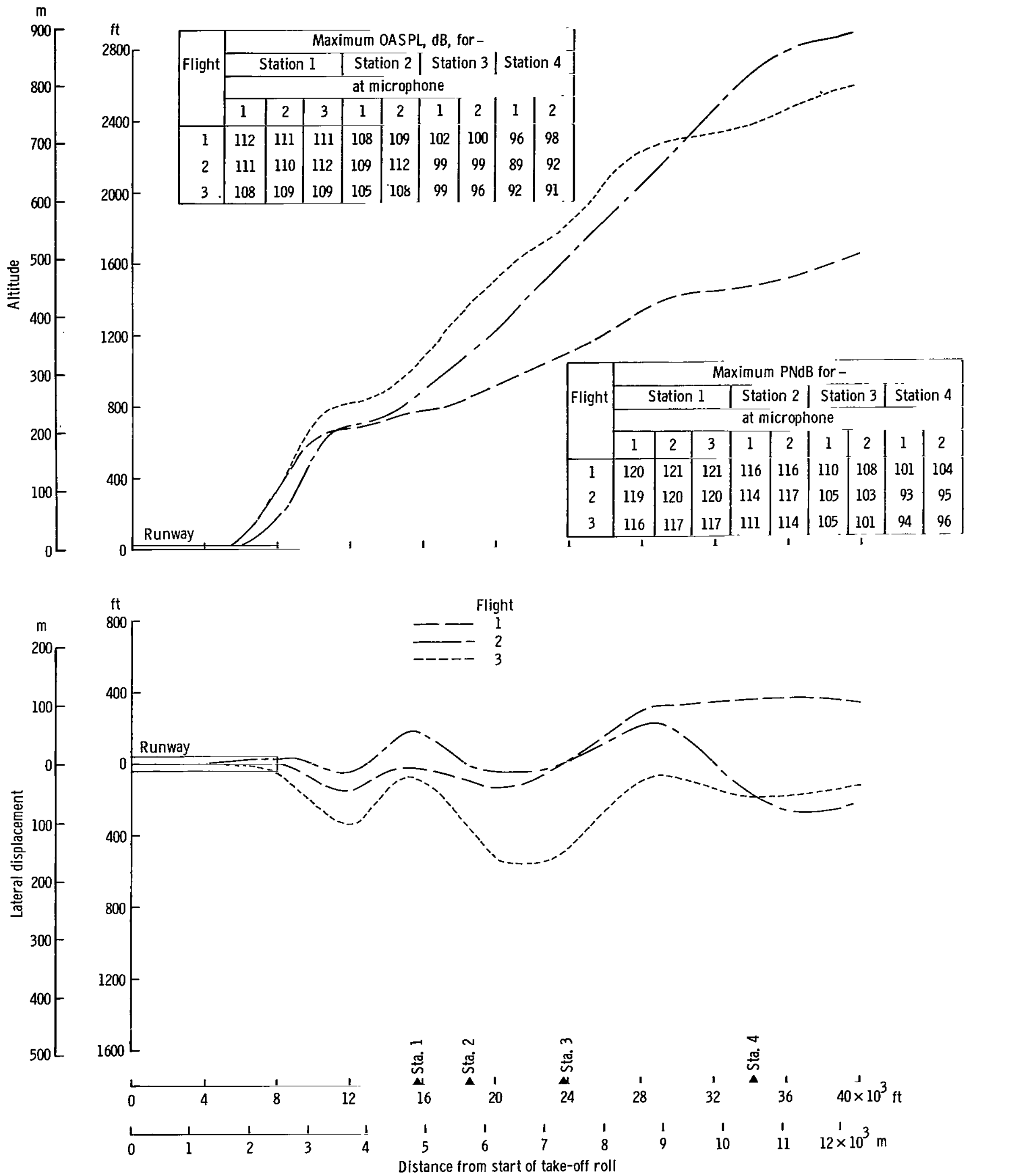
Figure 9.- Altitude—plan-position data from ground-based radar along with tabulated noise levels as obtained at each measuring station from flight profile 5.



Flight	Maximum OASPL, dB, for – Station 1 at microphone 1	Station 1, 2	Station 1, 3	Station 2, 1	Station 2, 2	Station 3, 1	Station 3, 2	Station 4, 1	Station 4, 2
1	108	109	110	99	99	93	96	91	95
2	104	108	109	97	98	93	93	91	95
3	110	112	113	98	99	95	93	91	91

Flight	Maximum PNdB for Station 1 at microphone 1	Station 1, 2	Station 1, 3	Station 2, 1	Station 2, 2	Station 3, 1	Station 3, 2	Station 4, 1	Station 4, 2
1	118	120	119	109	110	100	99	95	101
2	116	118	117	108	110	99	100	97	101
3	120	122	121	106	106	101	101	94	97

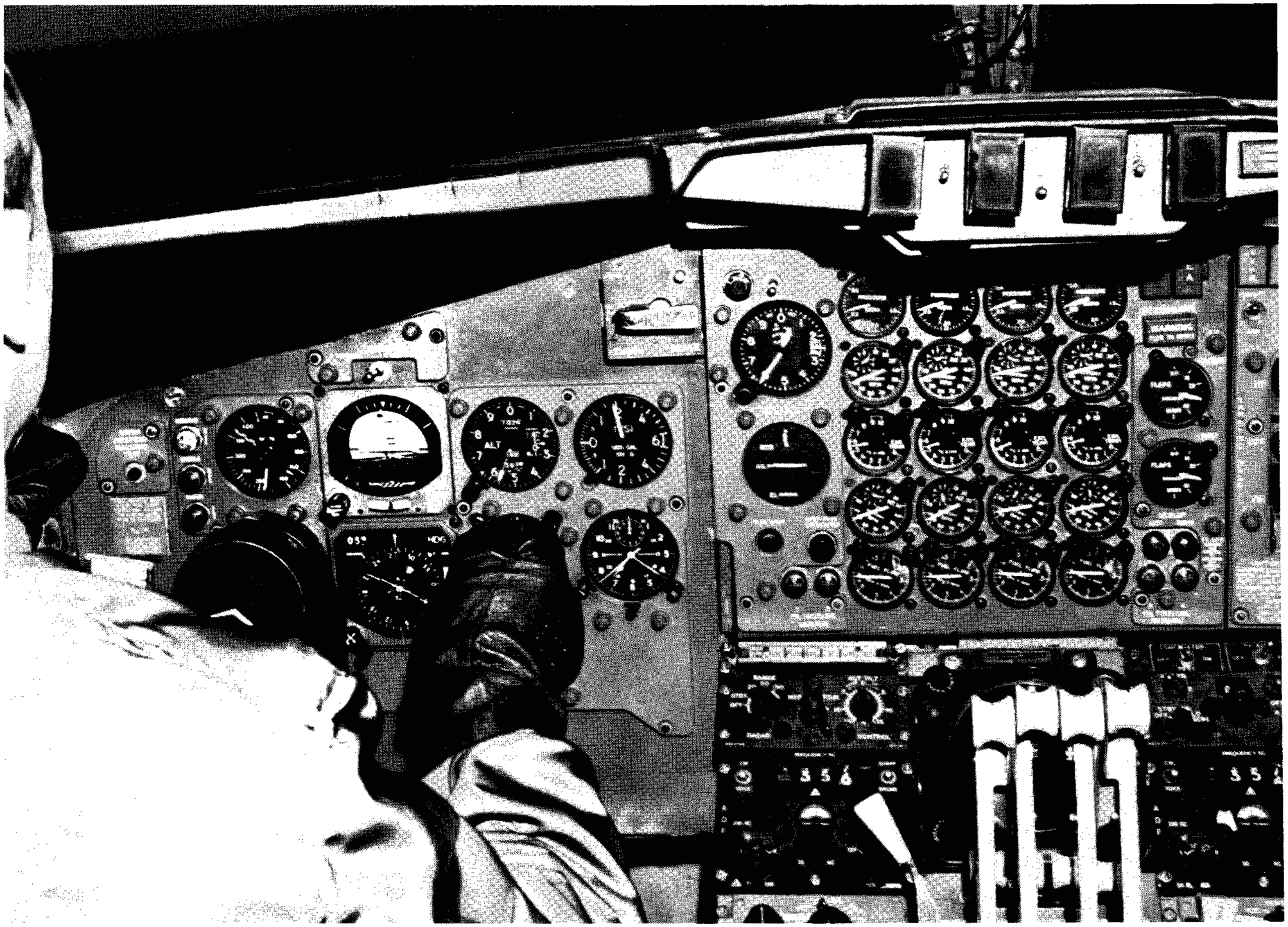
Figure 10.- Altitude—plan-position data from ground-based radar along with tabulated noise levels as obtained at each measuring station from flight profile 6.



Flight	Maximum OASPL, dB, for– Station 1 at microphone 1	Station 1, 2	Station 1, 3	Station 2, 1	Station 2, 2	Station 3, 1	Station 3, 2	Station 4, 1	Station 4, 2
1	112	111	111	108	109	102	100	96	98
2	111	110	112	109	112	99	99	89	92
3	108	109	109	105	108	99	96	92	91

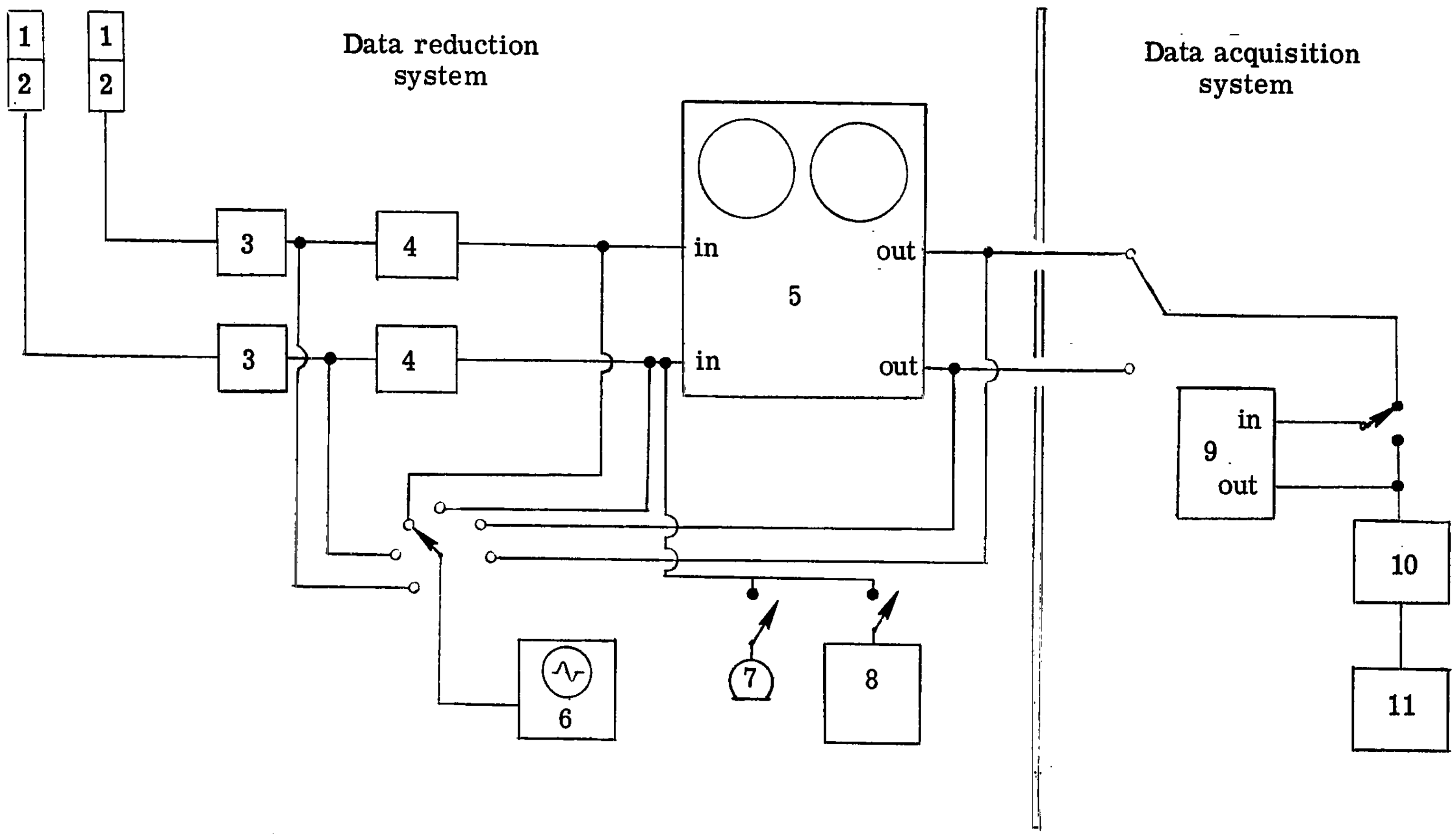
Flight	Maximum PNdB for– Station 1 at microphone 1	Station 1, 2	Station 1, 3	Station 2, 1	Station 2, 2	Station 3, 1	Station 3, 2	Station 4, 1	Station 4, 2
1	120	121	121	116	116	110	108	101	104
2	119	120	120	114	117	105	103	93	95
3	116	117	117	111	114	105	101	94	96

Figure 11.- Altitude—plan-position data from ground-based radar along with tabulated noise levels as obtained at each measuring station from flight profile 7.



L-66-4563

Figure 12.- Flight deck instrumentation panel of four-engine turbojet transport airplane. Photograph taken during take-off—climbout noise tests; profile 1, flight 1; climb speed, V_2 + 40 knots; photo 1.



1. Condenser microphone
2. Microphone adapter
3. Dynagage
4. Decade amplifier
5. Multichannel tape recorder
6. Oscilloscope
7. "Voice" microphone
8. 8-watt transceiver
9. Perceived noise level filter
10. Octave-band analyzer
11. Graphic level recorder

When item 9 was in use, item 10 was used as an amplifier only.

Figure 13.- Block diagram of a typical noise measuring station showing system layout for data acquisition and data reduction.

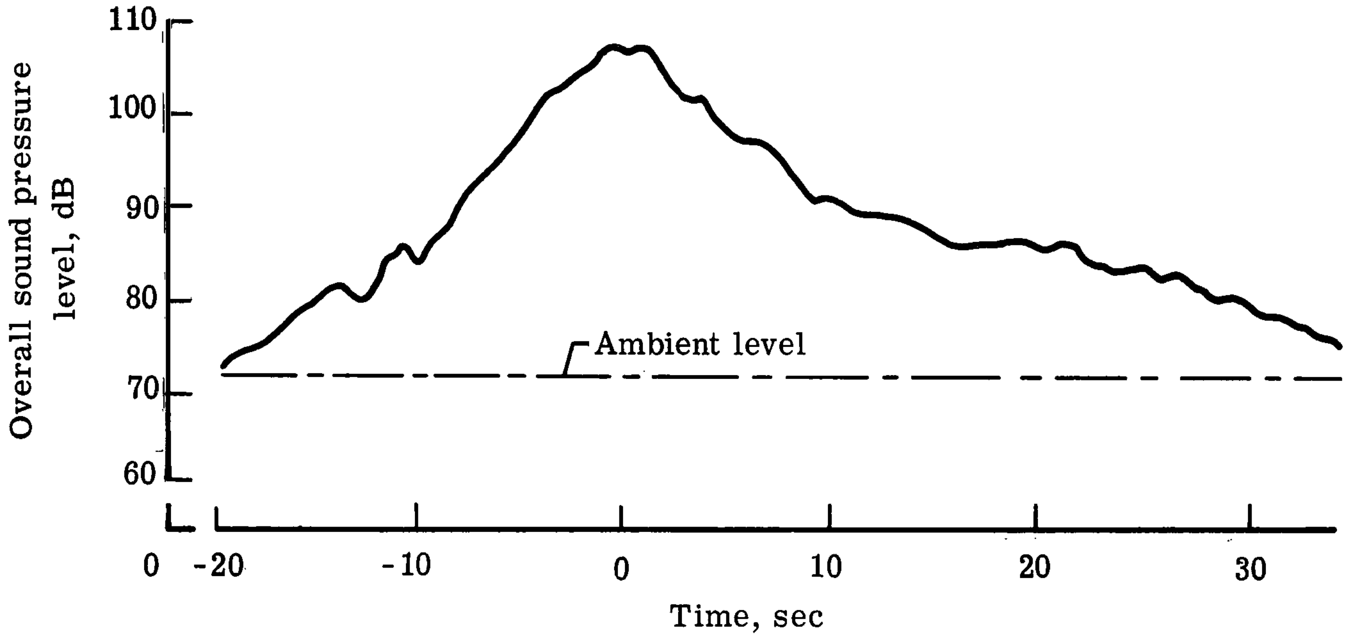


Figure 14.- Typical time history of sound pressure level as obtained during take-off—climbout noise tests. Profile 1, flight 1; station 1; climb speed, V_2 + 20 knots.

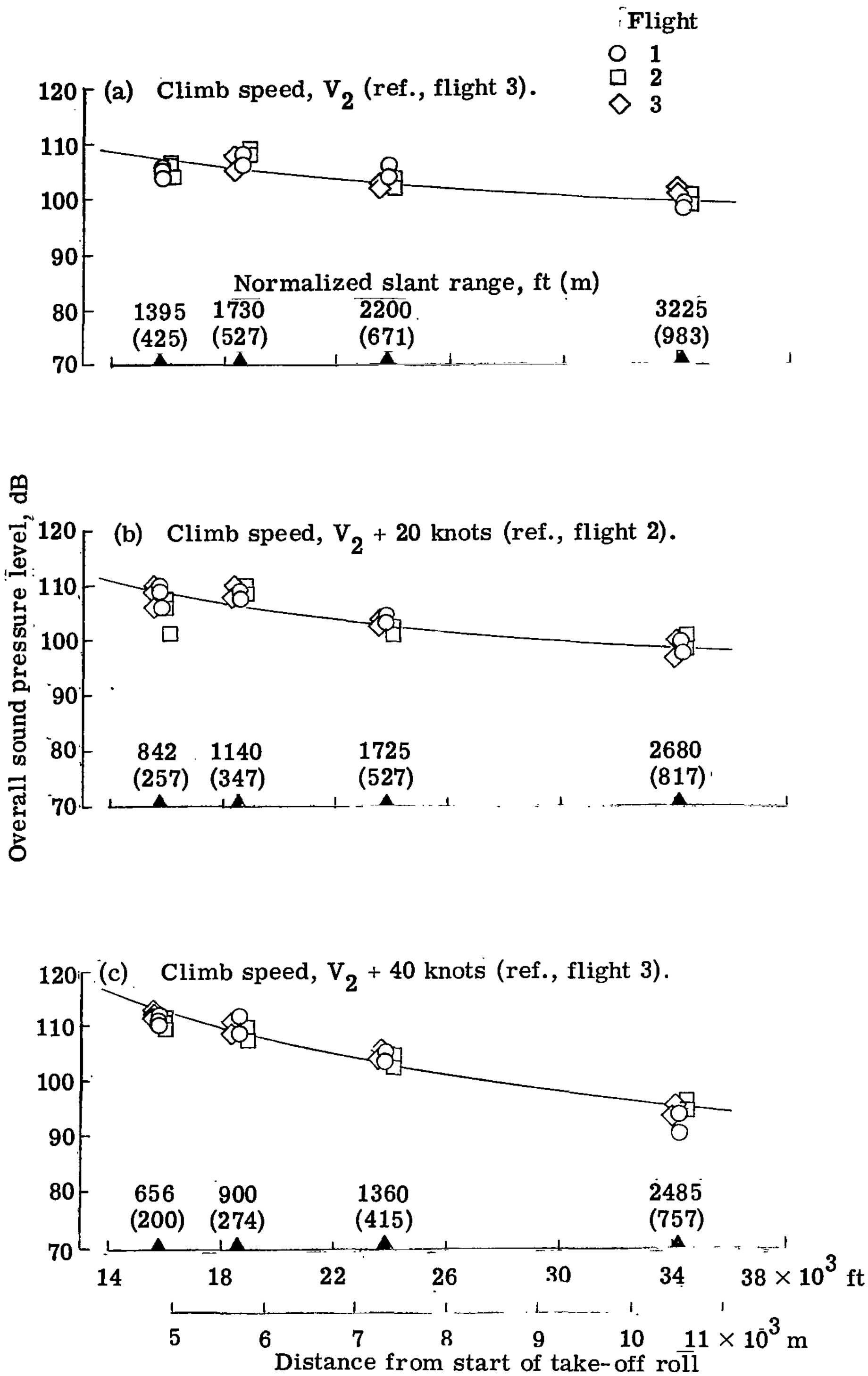


Figure 15.- Normalized overall sound pressure levels along ground track of airplane for profile 1 (take-off power) at climb speeds of V_2, V_2 + 20, and V_2 + 40 knots.

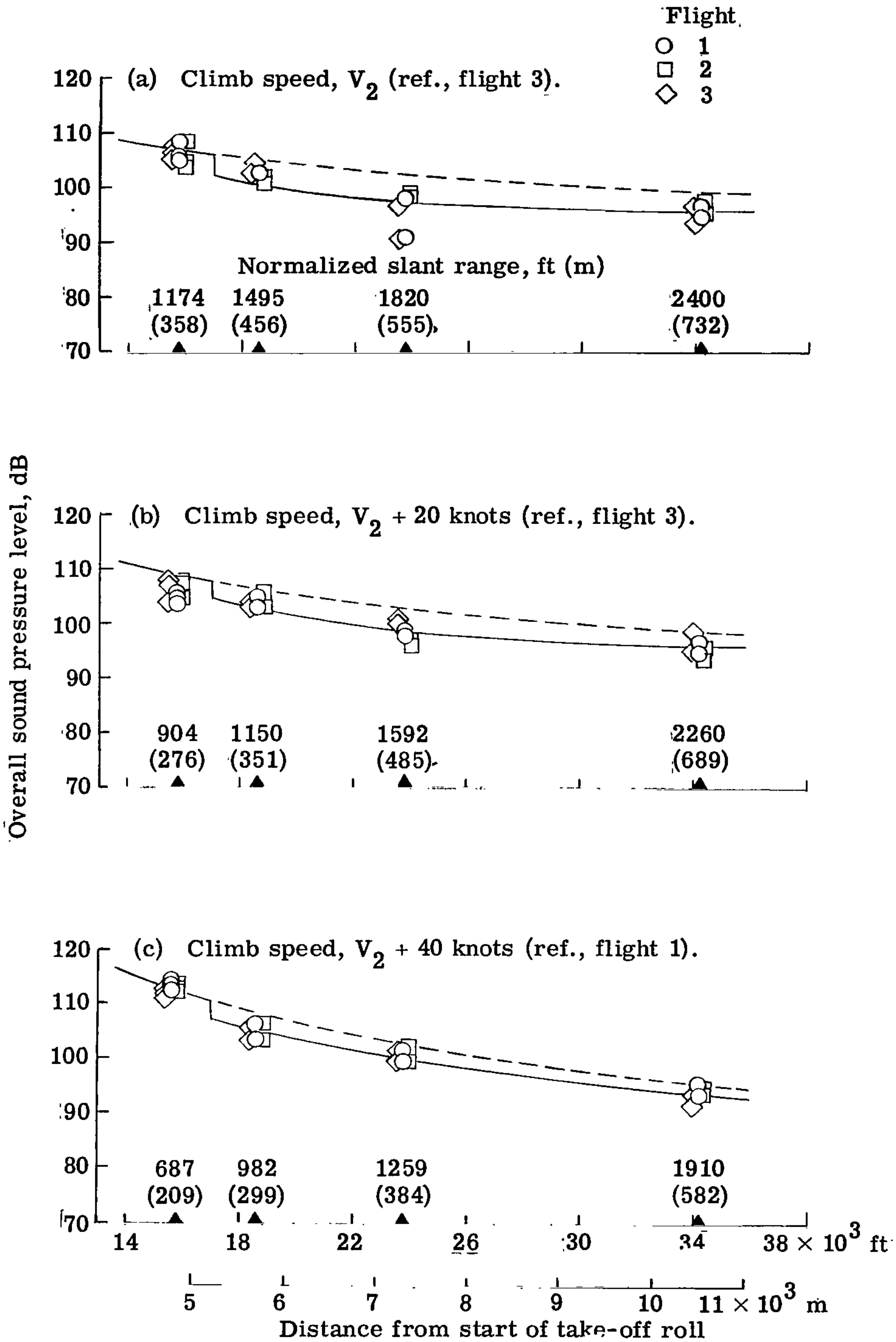


Figure 16.- Normalized overall sound pressure levels along ground track of airplane for profile 2 (power reduction for 1000 ft/min (305 m/min) rate of climb) at climb speeds of V_2, V_2 + 20, and V_2 + 40 knots.

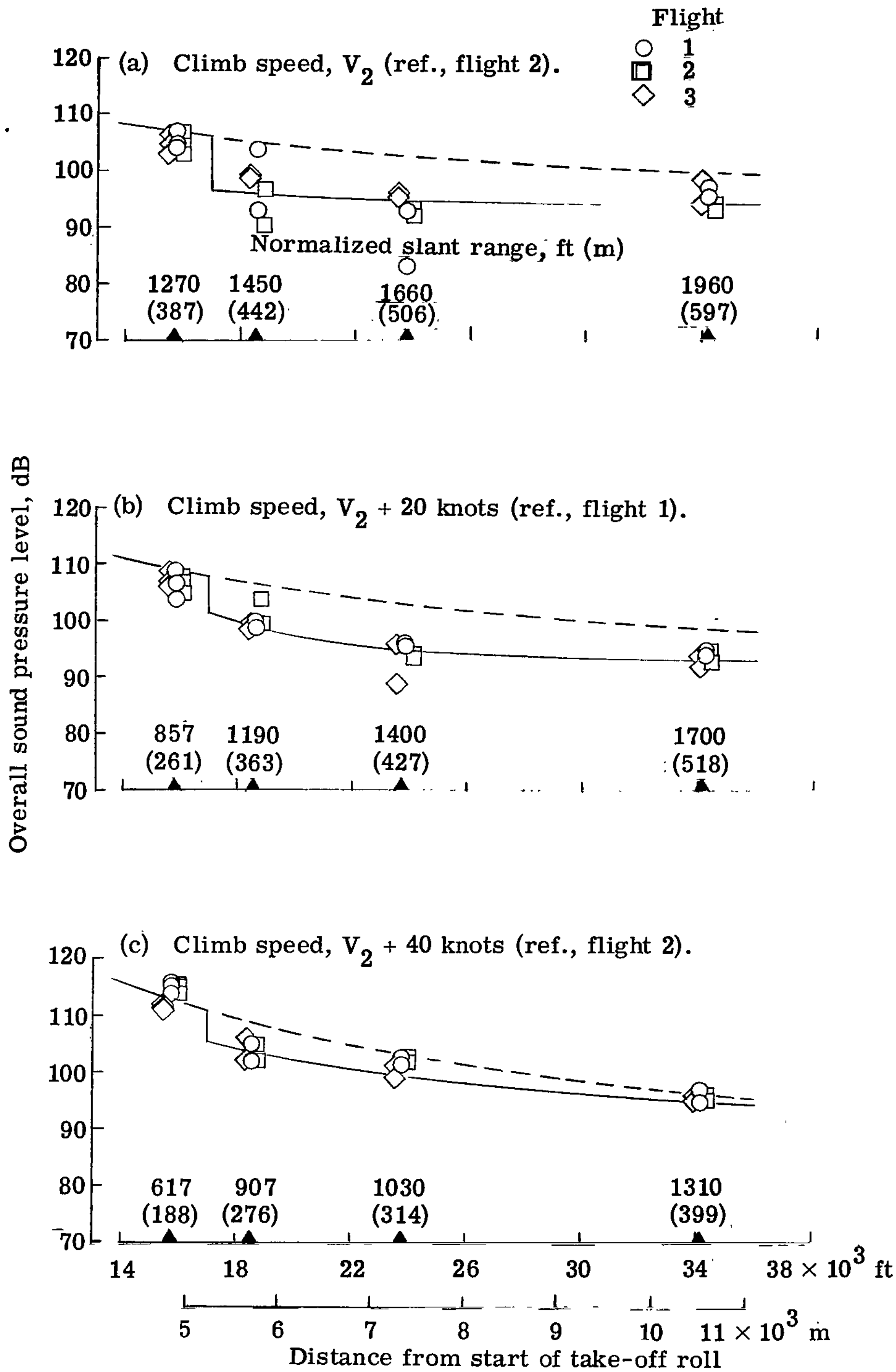


Figure 17.- Normalized overall sound pressure levels along ground track of airplane for profile 3 (power reduction for 500 ft/min (152 m/min) rate of climb) at climb speeds of V_2, V_2 + 20, and V_2 + 40 knots.

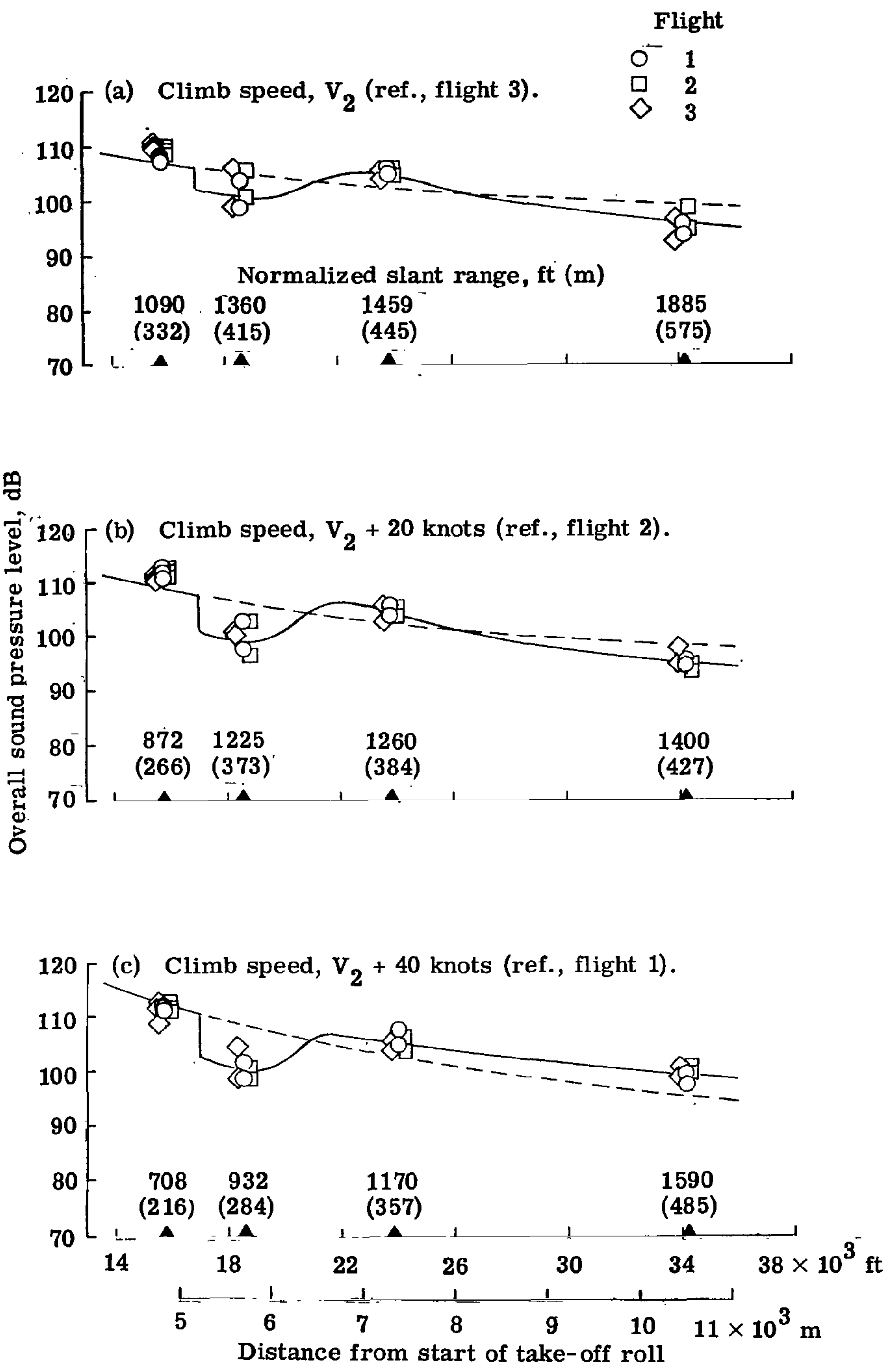


Figure 18.- Normalized overall sound pressure levels along ground track of airplane for profile 4 (power reduction for 10 sec) at climb speeds of V_2, V_2 + 20, and V_2 + 40 knots.

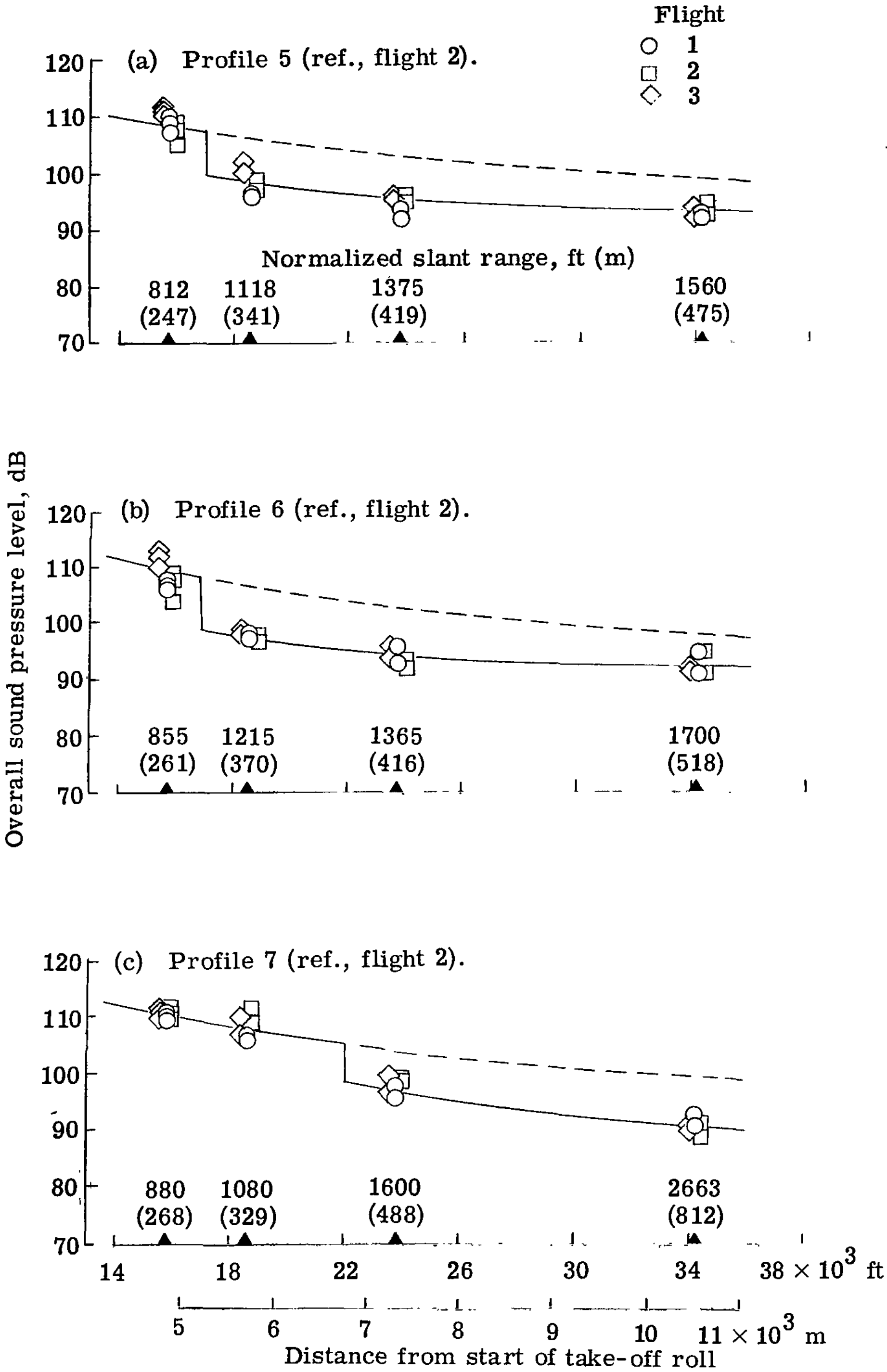


Figure 19.- Normalized sound pressure levels along ground track of airplane for profiles 5 and 6 (power reduction for 500 ft/min (152 m/min) rate of climb) and 7 (standard operating procedure type profile).

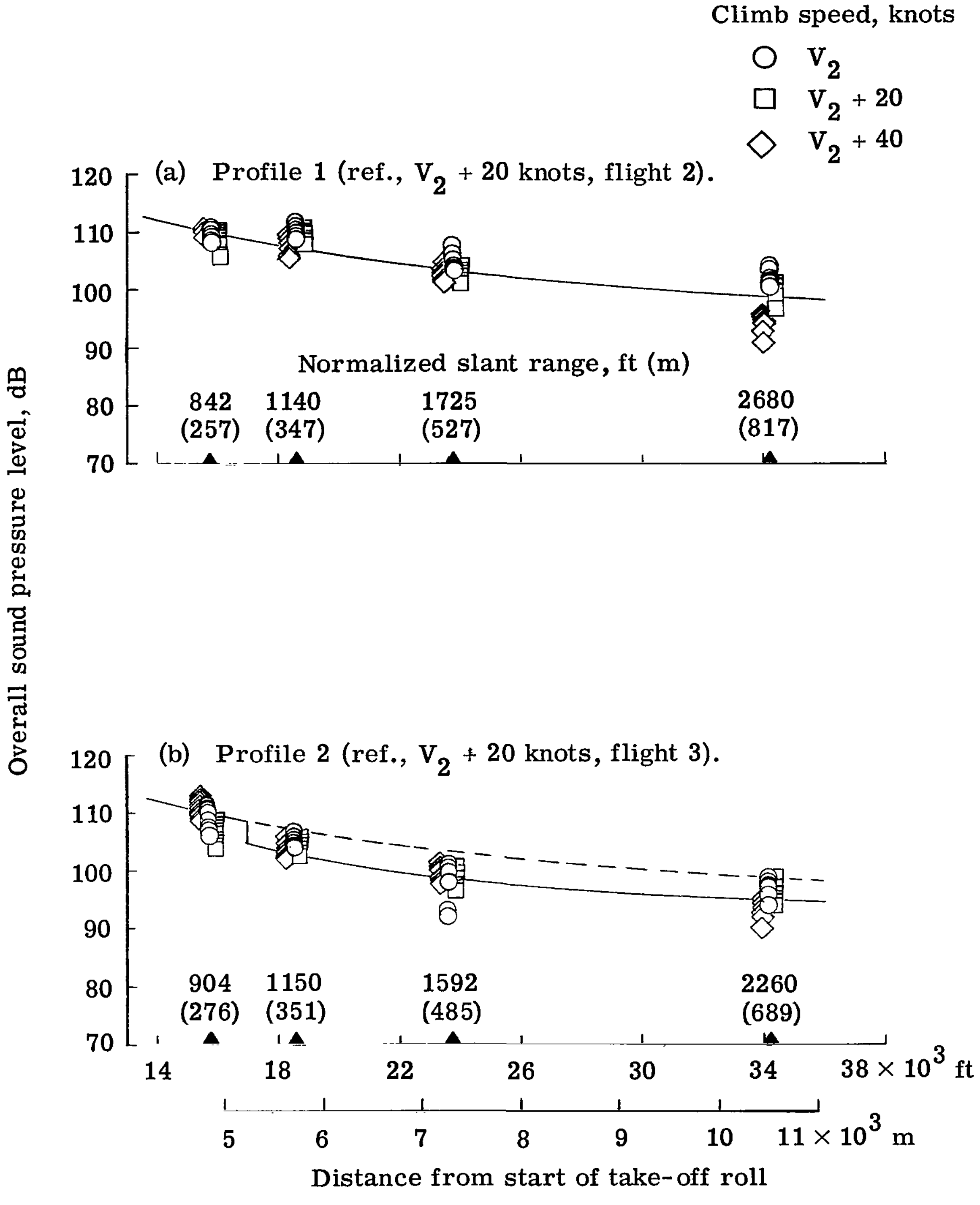


Figure 20.- Normalized sound pressure levels along ground track of airplane for profiles 1, 2, 3, and 4 showing effect of climb speed on the ground noise.

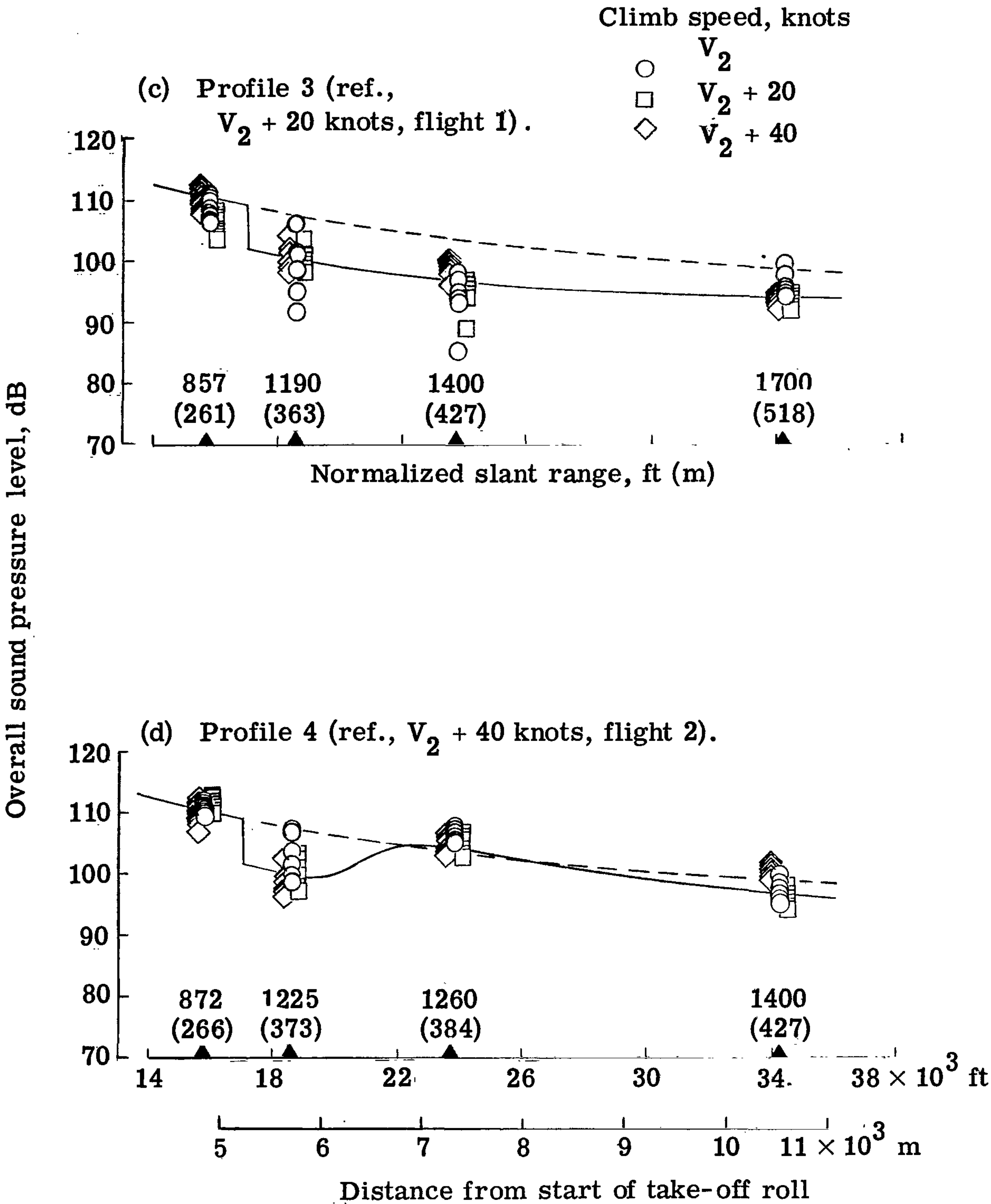


Figure 20.- Concluded.

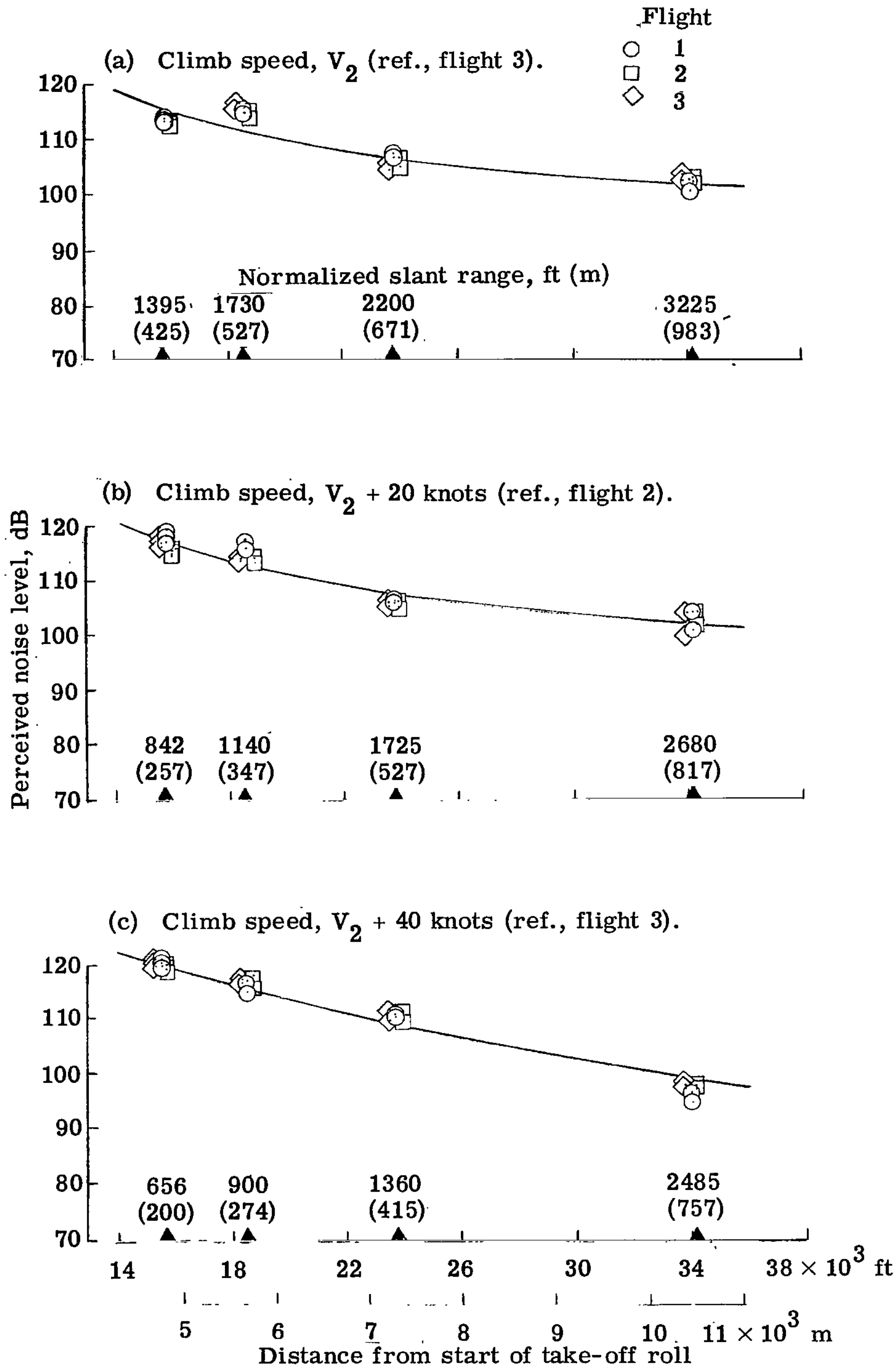


Figure 21.- Normalized perceived noise levels along ground track of airplane for profile 1 (take-off power) at climb speeds of V_2, V_2 + 20, and V_2 + 40 knots.

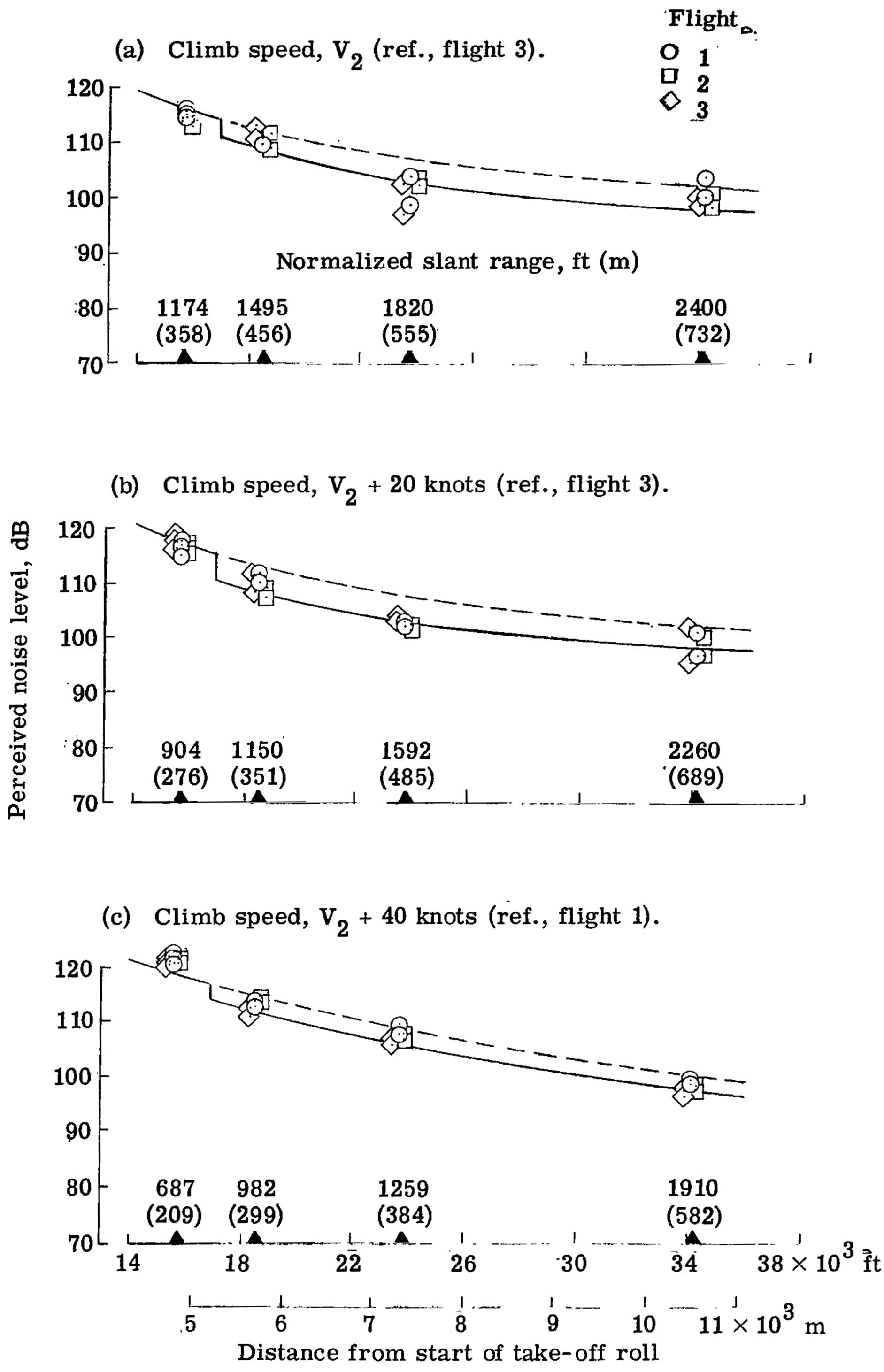


Figure 22.- Normalized perceived noise levels along ground track of airplane for profile 2 (power reduction for 1000 ft/min (305 m/min) rate of climb) at climb speeds of V_2, V_2 + 20, and V_2 + 40 knots.

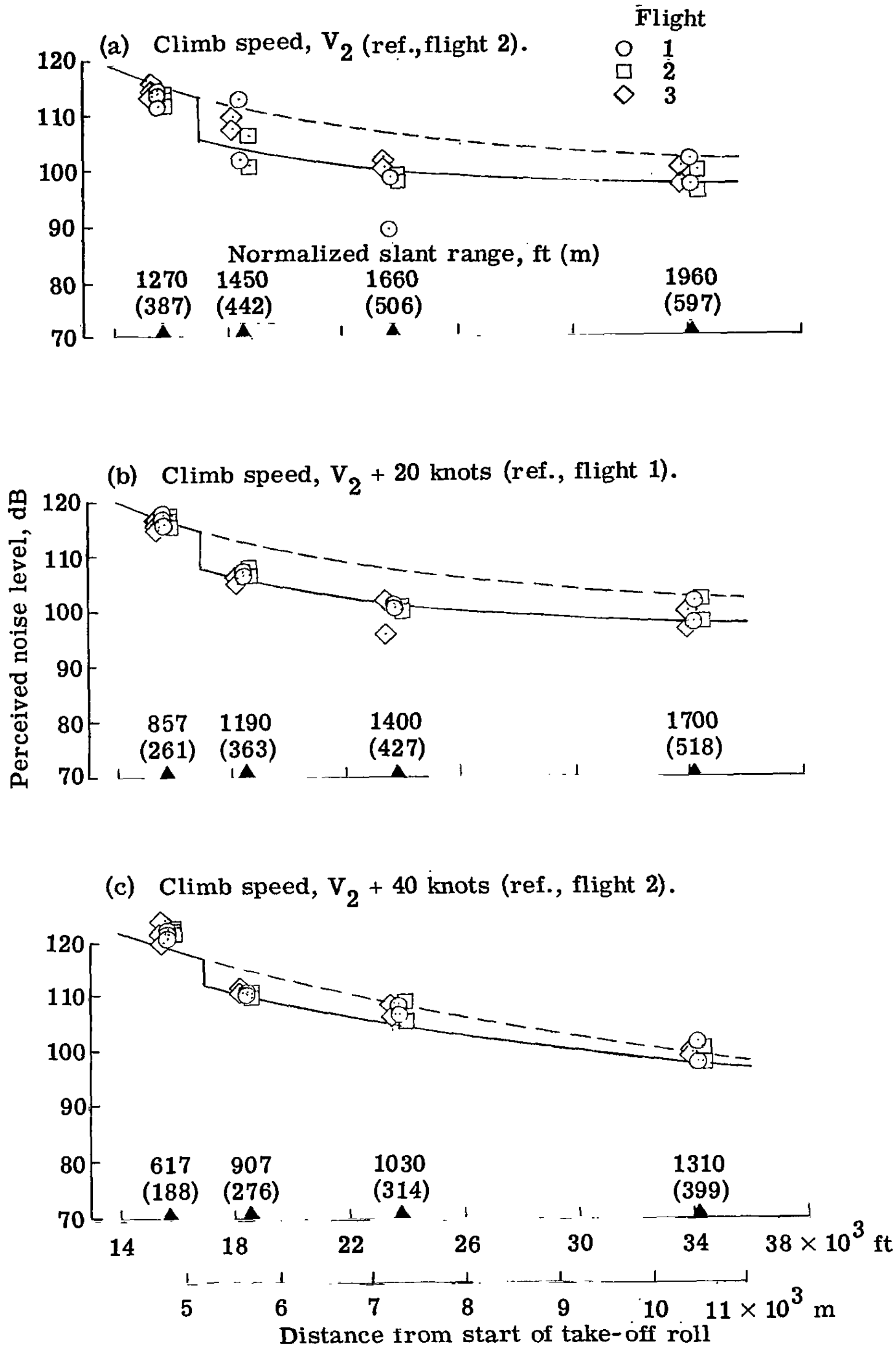


Figure 23.- Normalized perceived noise levels along ground track of airplane for profile 3 (power reduction for 500 ft/min (152 m/min) rate of climb) at climb speeds of V_2, V_2 + 20, and V_2 + 40 knots.

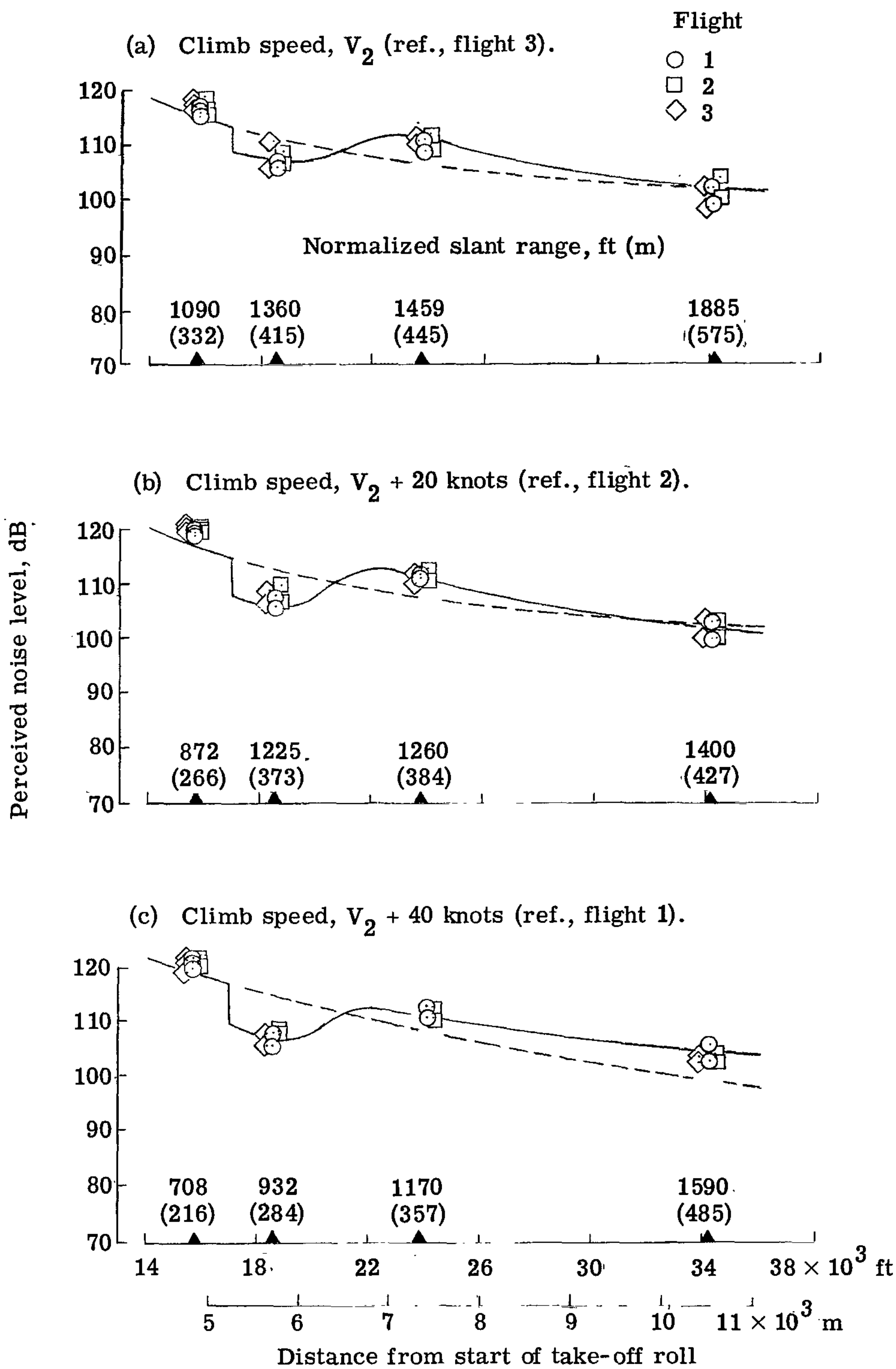


Figure 24.- Normalized perceived noise levels along ground track of airplane for profile 4 (power reduction for 10 sec) at climb speeds of V_2, V_2 + 20, and V_2 + 40 knots.

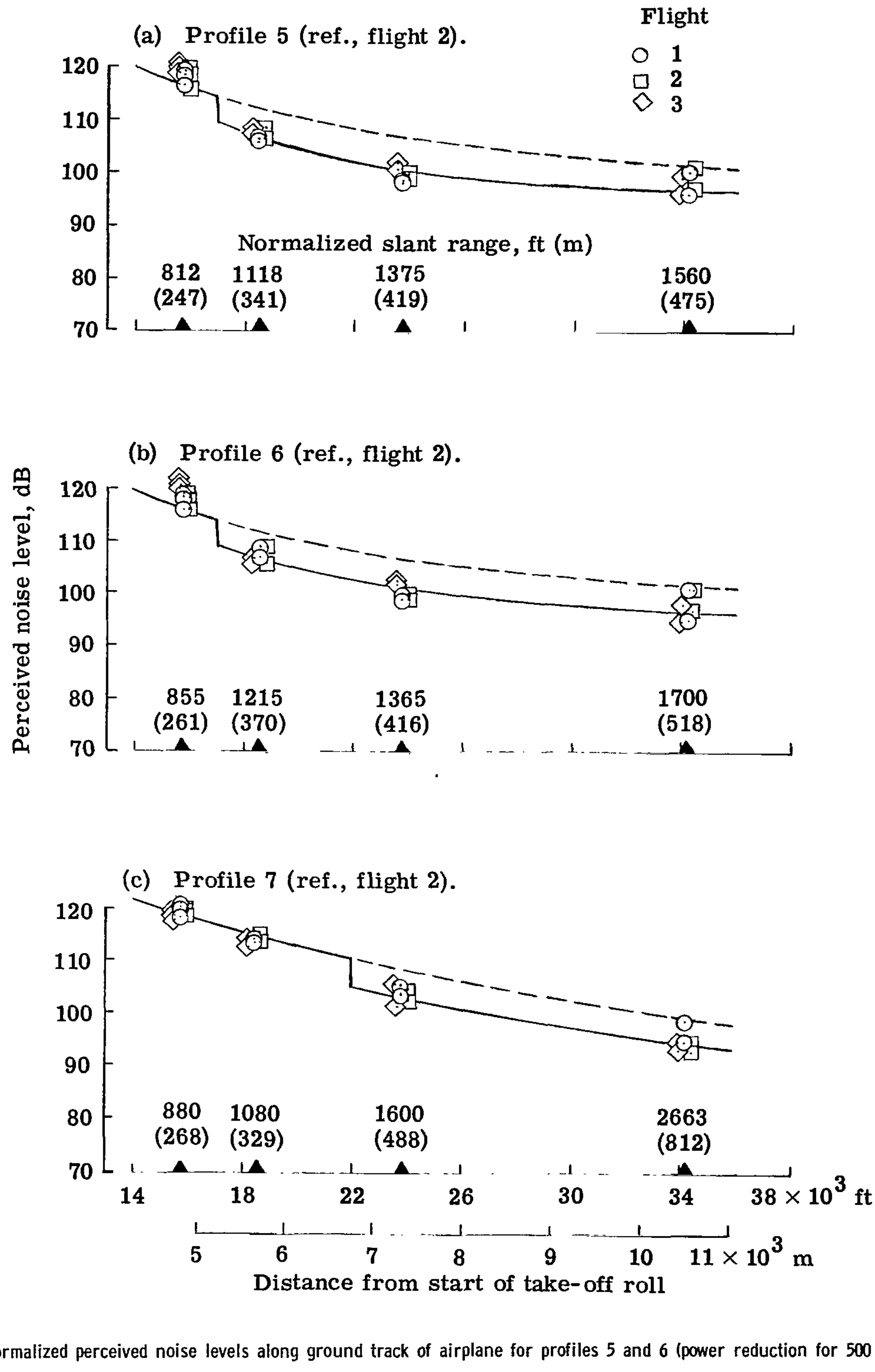


Figure 25.- Normalized perceived noise levels along ground track of airplane for profiles 5 and 6 (power reduction for 500 ft/min (152 m/min) rate of climb) and 7 (standard operating procedure type profile).

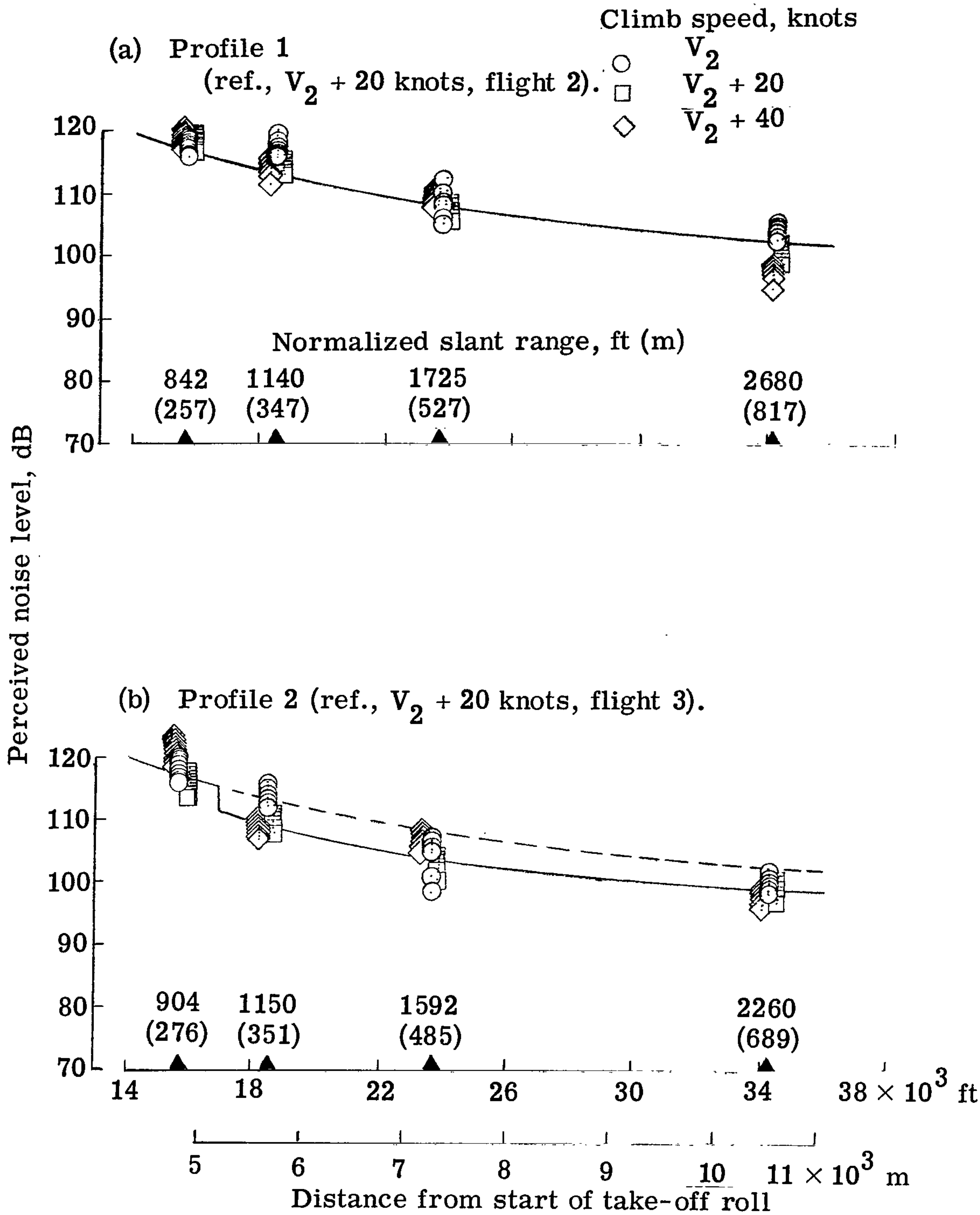


Figure 26.- Normalized perceived noise levels along ground track of airplane for profiles 1, 2, 3, and 4 showing effect of climb speed on the ground noise.

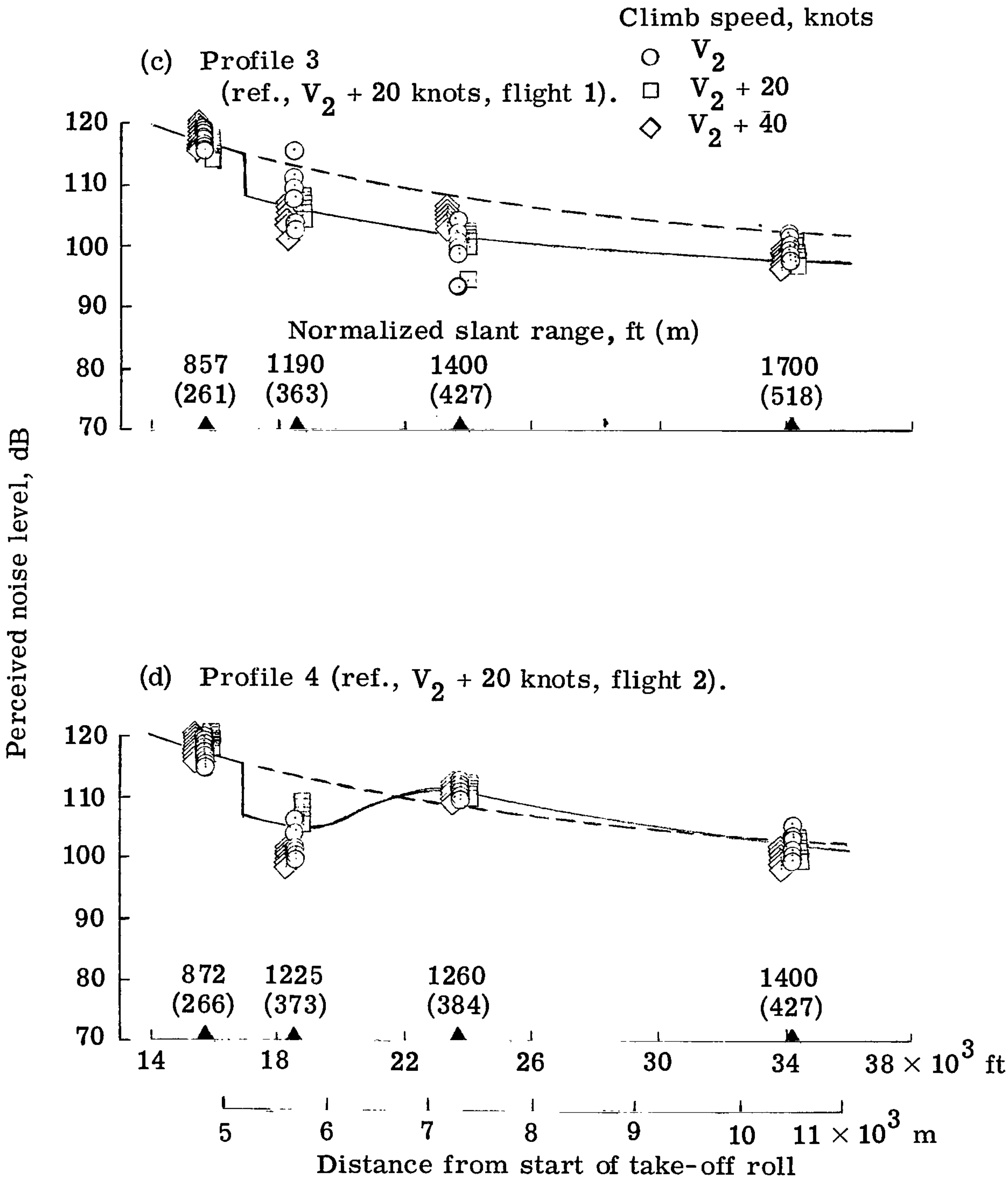


Figure 26.- Concluded.

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—NATIONAL AERONAUTICS AND SPACE ACT OF 1958

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