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SONIC-BOOM MEASUREMENTS IN THE FOCUS REGION DURING THE ASCENT OF APOLLO 17

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16. Abstract

This paper presents sonic-boom pressure signatures recorded during the ascent phase of Apollo 17. The measurements were obtained onboard six U.S. Navy ships positioned along the ground track of the spacecraft vehicle in the area of expected focus resulting from the flight path and acceleration of the vehicle. Tracings of the measured signatures are presented along with values of the maximum positive overpressure, positive impulse, signature duration, and bow-shock rise time. Also included are brief descriptions of the ships and their location, the deployment of the sonic-boom instrumentation, flight profiles and operating conditions for the launch vehicle and spacecraft, surface-weather and sea-state information at the measuring sites, and high-altitude weather information for the general measurement areas. Comparisons of the measured and predicted sonic-boom overpressures for the Apollo 17 mission are presented. The measured data are also compared with data from the Apollo 15 and 16 missions and data from flight test programs of various aircraft.

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SUMMARY

This paper presents sonic-boom pressure signatures recorded during the ascent phase of Apollo 17. The measurements were obtained onboard six U.S. Navy ships positioned along the ground track of the spacecraft vehicle in the area of expected focus resulting from the flight path and acceleration of the vehicle. Tracings of the measured signatures are presented along with values of the maximum positive overpressure, positive impulse, signature duration, and bow-shock rise time. Also included are brief descriptions of the ships and their location, the deployment of the sonic-boom instrumentation, flight profiles and operating conditions for the launch vehicle and spacecraft, surface-weather and sea-state information at the measuring sites, and high-altitude weather information for the general measurement areas.

The characteristics of the sonic-boom overpressure signatures were typical of those observed for aircraft during maneuvering flight. Amplifications of the overpressure signatures were observed in the focus region. As in the case of maneuvering aircraft, the focus overpressures occur over very localized regions, the locations of which are quite predictable. Overpressure values ranging from about 63 N/m^2 to 420 N/m^2 were measured during ascent and are in very good agreement with predictions. The signatures were not simple N-wave shapes; in some cases a caustic signature was superposed on the normal signature. These caustic signatures are associated with the focus-boom regions resulting from a curved, accelerating flight profile. Signatures exhibited rise times which were of the order of those observed for supersonic aircraft and other Apollo space vehicles. However, the signatures are much longer than those for aircraft because of the effect of the very large exhaust plume from the rocket engine. The signatures obtained for the Apollo 17 spacecraft are generally similar in nature to those observed on previous Apollo missions.

INTRODUCTION

Sonic-boom research programs pertaining to supersonic aircraft resulted in a considerable accumulation of both experimental and theoretical information relating to sonic

booms produced in steady, level flight and in maneuvers. (See refs. 1 to 11.) These studies included aircraft of different size and weight operating in the Mach number range of 0.98 to 4.8 at altitudes from 15 m to more than 27 000 m with resulting overpressures from near 0 to greater than 6800 N/m^2. The maneuvers included longitudinal accelerations, pushovers, pull-ups, and turns. During these maneuvers, localized regions of boom-focus pressures were observed with focus factors ranging from 2 to 9. (See ref. 10.)

In recent years a significant amount of sonic-boom information has also been obtained on space vehicles including Apollo 12, 13, and 15. (See ref. 12.) These space vehicle missions extended the Mach number and altitude range of the sonic-boom data to much higher values (Mach number of 16 and altitude of 52 000 m) and also gave indications of the effects of the exhaust plume from the rocket engine. Most of the data obtained on these Apollo vehicles were measured downrange of focus areas during ascent, with some limited data obtained during reentry. The effort made to describe the focus region during the launch ascent of Apollo 16 (ref. 13) was rather limited.

The purpose of this paper is to present the results of a sonic-boom measurement program aimed at a better definition of the focus-boom region during the ascent phase of the Apollo 17 mission. Tracings of the sonic-boom signatures and tabulated values of positive overpressure, impulse, wave period, and shock rise times are given for six shipboard measuring stations. Also included are brief descriptions of the ships and their locations, the deployment of the sonic-boom instrumentation, vehicle and spacecraft flight profiles and operating conditions, surface-weather information at the measuring sites, and high-altitude weather information for the general measurement areas. Comparisons of the measured and predicted sonic-boom overpressures for the Apollo 17 mission are presented. The measured data are also compared with data from the Apollo 15 and 16 missions and with data from flight test programs of various aircraft. The results presented herein represent a joint effort involving the NASA Langley Research Center, the NASA Lyndon B. Johnson Space Center, the NASA George C. Marshall Space Flight Center, the NASA Wallops Flight Center, and the U.S. Navy (Manned Spacecraft Recovery Force, Atlantic).

SYMBOLS

Values are given in SI Units (Système International). The measurements and calculations were made in U.S. Customary Units and then converted to SI Units.

I_o impulse of positive phase of sonic-boom ground-pressure signature, newton-seconds per $meter^2$

Δp maximum pressure rise across bow shock wave measured at ground level, newtons per meter^2

Δt_o time duration of positive phase of sonic-boom ground-pressure signature, seconds

ΔT total time duration of sonic-boom ground-pressure signature, seconds

τ rise time of sonic-boom pressure signature (defined as time from onset of bow shock wave to its maximum positive value of overpressure), seconds

Abbreviation:

GMT Greenwich mean time

APPARATUS AND METHODS

Test Vehicle

A photograph of the night launch of the Apollo 17/Saturn V configuration is shown in figure 1 and a schematic diagram of the configuration is shown in figure 2. This configuration (which includes the total flight vehicle) had an overall length of 110.65 m and a gross mass of 2 962 314 kg, and developed an average thrust of 35 meganewtons at lift-off.

Test Area and Ship Arrangement

Sonic-boom measurements on the Atlantic Ocean were made by utilizing six U.S. Navy ships as measurement platforms. These ships were positioned along the ground track of the spacecraft vehicle to cover the region of focusing due to the launch-ascent phase of the flight. The expected focus region is indicated schematically by the hatched footprint region shown in figure 3. The schematic of figure 4 shows a profile of the flight path of the spacecraft vehicle and gives the locations of the ships relative to the launch site. Ship positions range from approximately 63 km to approximately 85 km from the launch site.

Ship Descriptions and Test Conditions

Shown in the photographs of figure 5 are the various ships used as mobile data-acquisition platforms. The U.S.S. Adroit (station 1), an Acme class ocean minesweeper, is 52 m long with a 10.6 m beam; the U.S.S. Alacrity (station 2) and the U.S.S. Assurance (station 4) are ocean minesweepers of the Ability class and are 57.9 m long with 10.9 m

beams. The U.S.S. Saginaw (station 3), a Newport class tank-landing ship, has a length of 159 m and a beam of 21 m. The U.S.S. Fidelity (station 5), an Agile class ocean minesweeper, is 52.4 m long with a 10.9 m beam. The U.S.S. Recovery (station 6), a Diver class salvage ship, is 64.9 m long with a 11.8 m beam. Also indicated in each photograph is the general area of the ship in which the sonic-boom microphone system was located. During the launch and ascent of the spacecraft vehicle, sonic-boom measurements were obtained as the ships traveled in the direction of flight along the ground track at slow speed, utilizing only enough power to maintain steerage. Indicated in table 1 are the ship's speed, surface weather, and sea-state conditions existing at each station during the measurement portion of the test. Sea-state conditions in the test area, as described by ship personnel, were essentially calm. Special efforts were made to keep the ship noise at a minimum during the time of measurements by reducing ship speed to the minimum required for steerage, keeping personnel below deck, etc.

Launch Vehicle and Spacecraft Flight

The launch of Apollo 17 occurred at night at 05:33:00 Greenwich mean time on December 7, 1972. The spacecraft was launched on an azimuth of approximately 90°, from Kennedy Space Center, Complex 39, Pad A. Boost to orbit was accomplished by a complete burn of the first stage of the Saturn V launch vehicle. Shown in figure 6 are altitude and velocity plotted as functions of time after launch, with an indication of significant events associated with the launch and ascent of the spacecraft. Double-headed arrows indicate the time period during which the booms measured aboard the ships were generated, the time period of the overhead passage of the vehicle, and the time period of boom arrival. For each of the ships, specific times and corresponding altitudes and velocities for these events are presented in table 2. The data of figure 6 and table 2 were obtained from the Saturn V final postflight trajectory data report (Saturn V final postflight trajectory data for AS-512 metric units, Boeing Co., Huntsville, Alabama, December 22, 1972) and from figure 5 of reference 14. It should be noted from figure 6 that the booms measured during ascent were generated by the complete Saturn V launch-vehicle configuration while thrusting and producing a plume of exhaust gases.

PRESSURE-MEASUREMENT INSTRUMENTATION

The instrumentation utilized for the Apollo 17 sonic-boom pressure measurements is commercially available and is similar to or identical to that used in measurements of aircraft sonic-boom signatures (refs. 1 and 5) and for measurements in the Apollo 15 and 16 sonic-boom measurement programs (refs. 12 and 13). The main components of the sonic-boom measuring systems were modified condenser microphones, a Dynagage system, d.c. amplifiers, and FM tape recorders. A representative frequency-response

curve of the data-acquisition system is shown in figure 7, and a pictorial block diagram of a typical system placed onboard each ship is shown in figure 8. The microphone operating range is approximately 0.09 N/m^2 to 282 N/m^2. The total sound-measuring system was calibrated onboard ship by means of acoustic pressure calibrators, which operated with a fixed frequency of 1 kHz and produced a root-mean-square sound-pressure level of 89 N/m^2 at the microphone diaphragm.

Utilizing existing prediction schemes, along with the previous Apollo 15 and 16 sonic-boom measurements (refs. 12 and 13), microphone level settings were provided to give the most desirable signal-noise ratio and to allow for the uncertainties associated with sonic-boom focus factors and for sonic-boom variations resulting from atmospheric effects. Three microphones were used, mounted in a cluster on each ship. The output of each microphone was routed through two separate amplifiers, which permitted six sensitivity settings and allowed for a wide range of overpressures.

Figure 9(a) is a photograph of the microphone mounting arrangements, with one unit shown complete with wind screen (consisting of two layers of cheese cloth). Shown in figure 9(b) is a photograph of the signal-conditioning and recording equipment as it was mounted in a compartment onboard each ship. Efforts were made to place the microphones on the deck of each ship in an uncluttered area to minimize the possibility of significant sonic-boom shock-wave reflection from the ship's superstructure.

The photographs of figure 10 illustrate typical microphone locations onboard the six ships. The microphones used at each measuring station were placed 0.15 m above the deck on each ship. Since the ray paths of the sonic-boom shock waves generated by the spacecraft vehicle arrived very nearly vertical, reflections from the various surfaces and superstructures of the ships were expected to be minimized. Also, since the microphones were mounted very close to the deck (0.15 m), the incident and reflected shocks were essentially in phase and the overpressure readings represented ground pressure values rather than free air values. The ocean surface also provides a reflecting surface and, as such, causes both the direct and reflected shocks to be observed at each measurement position to varying degrees, depending upon the ship height, the condition of the ocean surface, and the velocity of the space vehicle.

ATMOSPHERIC SOUNDINGS

Rawinsonde and rocketsonde observations from Cape Kennedy, Florida, were taken on December 7, 1972, at approximately 10 min and 162 min after lift-off, respectively. Measured values of wind direction and speed, temperature, dewpoint, pressure, relative and absolute humidity, speed of sound, and density as a function of altitude are listed in tables 3 and 4.

Radiosonde observations from station 3, which was positioned approximately 65 km downrange from the launch site, were taken at approximately 2 min before launch and 18 min after launch on December 7, 1972. Measured values of temperature, dewpoint, pressure, relative and absolute humidity, speed of sound, and density as a function of altitude are given in tables 5 and 6. In addition to these weather measurements, local climatological data (surface temperature, relative humidity, surface wind and direction) were obtained from each ship in the test area at the time of the sonic-boom arrival and are presented in table 1. All stations experienced surface temperatures of approximately 296 K and surface winds ranged from 5 to 10 knots. As indicated previously, sea conditions were calm at all ship locations.

RESULTS AND DISCUSSION

Signature Characteristics

The descriptive terms used for the present signature measurements are illustrated in figure 11. These characteristics include the measured quantities of peak overpressure Δp, total time ΔT, positive duration Δt_o, positive impulse I_o, and rise time τ. For the purpose of this paper Δt_o is the total time from the onset of the initial positive phase of the signature to the first crossing of the ambient pressure line during the expansion phase. The total time ΔT is defined as the time from the onset of the initial positive phase of the signature to the first indication of the return to ambient pressure during the recompression phase. For the signatures observed in the present studies, the total time ΔT is not well defined. This difficulty in defining ΔT is consistent with data obtained from previous Apollo vehicles and is due to the effects of the large exhaust plume from the rocket engine. These five parameters were measured for each sonic-boom signature as recorded at each of the six measuring stations and are listed in table 7.

Ascent Measurements

Figure 12 presents measured sonic-boom signatures obtained in the Atlantic downrange from the launch site at stations 1 to 6. These stations were located to lie within the focus regions associated with the flight-path angle and acceleration profile of the space vehicle during ascending flight. Listed in the figure are the velocity and the altitude of the launch vehicle along the flight path at the time that the initial sonic boom was generated for each of the measurement stations (taken from fig. 5, ref. 14). Also indicated in the figure are the measured overpressures and a time scale, both of which are consistent for all signatures.

The signatures as measured at stations 1 to 6 are not of the normal N-wave type but display several significant features typical of the shock-wave phenomena that have been observed during the Apollo 15 and 16 missions (refs. 12 and 13), and in previous aircraft studies (ref. 10) in which accelerations and maneuvers were being performed.

The duration times for the signatures measured at all six stations are 1.37 s, 1.42 s, 1.51 s, 1.27 s, 2.04 s, and 1.87 s, respectively, and are generally comparable with those measured for the Apollo 15 and 16 launch vehicles (refs. 12 and 13) during the ascent phase. The physical length of the Saturn V launch vehicle does not nearly account for the long signature duration observed; these long duration signatures are a result of the effects of the large exhaust plume from the rocket engine, which provided an even larger effective body than the launch vehicle itself.

As mentioned previously, signatures with these characteristics have been measured in previous investigations of booms generated by Apollo vehicles in ascent (refs. 12 and 13) and in wind-tunnel tests of bodies of revolution with simulated exhaust plumes. The spiked overpressure peaks observed in two of the signatures are reminiscent of characteristics noted in aircraft flight test programs (refs. 1, 10, and 11) in which deliberate attempts also were made to measure focused sonic booms or superbooms. These focus booms occur at locations where disturbances created by the vehicle over a period of time travel in such a way as to arrive at the same instant of time. Discussions of the nature of such focus phenomena and means of calculating their occurrence are given in references 4 and 10.

The signature of figure 12(a) (station 1) is significantly different from those at stations 2 to 6; the onset of the positive pressure occurs at a much slower rate. This slower rise time has also been observed for aircraft signature measurements taken at ground positions just prior to the point on the ground where the focus or superboom occurs. (For example, see fig. 39, ref. 9.) The signature shape and maximum overpressure observed indicates stations 2 and 3 (figs. 12(b) and 12(c)) were very close to the focus area. In figures 12(d) and 12(e) (stations 4 and 5) the separation of the positive peaks of the two signatures indicates the measurement locations were downrange of the focus area. In figure 12(f) (station 6) it can be seen that the second peak of the signature is very weak and occurred approximately 16 s after the arrival of the primary signature, which indicates that this station, as planned, was located well out of the focus region. (See fig. 6, ref. 14.)

The rise times of the bow-shock wave ranged from 18 to 416 ms. (See table 7.) The overpressure signatures measured during ascent at stations 1 and 6 exhibited rather long rise times of 310 and 214 ms, respectively. Those signatures measured at stations 2, 3, 4, and 5 exhibited moderate rise times and were of the same order of magnitude as those previously measured for large spacecraft vehicles. (See refs. 12 and 13.)

Presented in figure 13 are the maximum overpressure values as a function of the downrange position of the six ships on which the respective measurements were made. Also shown are the predicted location of the focus region and the predicted overpressure values downrange; these predicted values were taken from figure 7 of reference 14. These data indicate that the first measurement obtained was uprange of the focus. The second and third ships were located very close to the focus, as indicated by the very high pressures and the very rapid rate of increase in overpressures. The pressures measured on the last three ships are lower than the focus pressures and decrease very rapidly. It should also be noted that the downrange location of the focus area is predicted very well and the overpressure values are also in good agreement, except in the region of the focus. Previous flight studies involving aircraft indicate similar agreement between predicted and measured overpressures. (See refs. 9 and 10.)

Comparison With Other Data

Presented in figure 14 is a summary of predicted and measured overpressure data as a function of altitude for several aircraft of various sizes and weights (ref. 6), along with measured data for the launch and reentry phases of the Apollo 15 and 16 spacecraft vehicles (refs. 12 and 13), and ascent data of the present paper on the Apollo 17. Good correlation exists between measured and predicted values of overpressure for the aircraft cases. In addition, the sonic-boom levels, in general, increased with increasing aircraft size and decreased with increasing altitude.

For the case of measurements made during the reentry of spacecraft flights (Apollo 15 and 16), shown within the hatched region of figure 14, the measured data are consistent with data obtained for aircraft in that they appear to be comparable in magnitude to extropolated levels for fighter or medium bomber aircraft and display a similar decrease with increasing altitude.

The measured overpressure values for the launch and ascent portion of the spacecraft flights, shown within the crosshatched region in figure 14, in general indicate the same trend of decreasing pressure with increasing altitude. However, the magnitudes of the overpressure values are considerably higher than those measured during the reentry case. Since the physical size of the launch vehicle is considerably larger than the reentry vehicle, higher overpressure levels can be expected. However, the largest portion of the increased overpressures results from the effect of the large exhaust plume from the rocket engine, which provides an even larger effective body than the launch vehicle itself. The two data points that fall well above the crosshatched region are those that were measured in the focus region resulting from the vehicle acceleration and flight-path angle.

CONCLUDING REMARKS

Sonic-boom pressure signatures recorded onboard ships positioned along the ground track of the ascent phase of the Apollo 17 mission displayed overpressures ranging from about 63 N/m^2 to 420 N/m^2. None of the signatures were simple N-wave shapes, and in some cases, a second signature was superimposed on the normal signature. These second signatures are associated with the focus-boom region resulting from the curved, accelerating flight profile of the launch vehicle.

The characteristics of sonic-boom overpressure signatures measured in the focus region were found to be similar to those observed for maneuvering aircraft. As in the case of the results of aircraft flight tests, the region of focus amplification was relatively narrow. The signatures observed for the Apollo 17 spacecraft outside of the focus region were found to be similar in nature to those observed on previous Apollo missions. The total durations of these signatures are longer than those observed for aircraft because of the effect of the large exhaust plume from the rocket engine. Signatures exhibited rise times which are of the order of those observed for supersonic aircraft and for other Apollo space vehicles.

Langley Research Center,
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TABLE 1.- SUMMARY OF SHIP SPEED, SURFACE-WEATHER DATA, AND SEA CONDITIONS AT TIME OF SONIC-BOOM MEASUREMENTS

[All measurement locations were in the Atlantic Ocean]

Date	Ship	Ship speed, knots	Surface temperature, K	Relative humidity, percent	Surface wind, knots	Wind direction, deg	Sea condition
12-7-72	U.S.S. Adroit, station 1	2	297	98	6	220	0.37 m swells
12-7-72	U.S.S. Alacrity, station 2	3	296	98	4	167	.30 m swells
12-7-72	U.S.S. Saginaw, station 3	3	296	98	4	287	.30 m swells
12-7-72	U.S.S. Assurance, station 4	4	297	99	6	250	.37 m swells
12-7-72	U.S.S. Fidelity, station 5	3	296	99	5	220	.30 m swells
12-7-72	U.S.S. Recovery, station 6	3	297	98	10	313	.61 m swells

TABLE 2.- APOLLO 17 OPERATIONAL PARAMETERS

Ship	Time at boom generation, GMT	Spacecraft altitude, m, and velocity, m/s, at time initial boom was generated (from fig. 5, ref. 14)		Spacecraft overhead time, GMT	Spacecraft altitude, m, and velocity, m/s, at overhead time		Boom arrival time, GMT	Spacecraft altitude, m, and velocity, m/s, at boom arrival time	
U.S.S. Adroit, station 1	5:34:54	28 956	1035.29	5:35:27	53 535.4	1927.12	5:37:36.1	143 384.2	3016.9
U.S.S. Alacrity, station 2	5:34:56.5	30 480	1091.98	5:35:27.5	53 970.3	1941.04	5:37:39.4	144 649.0	3041.3
U.S.S. Saginaw, station 3	5:34:58.5	31 821	1138.92	5:35:28	54 406.7	1955.05	5:37:40.6	145 473.7	3057.7
U.S.S. Assurance, station 4	5:35:00	32 736	1175.08	5:35:28.5	54 844.5	1969.11	5:37:42.3	145 880.4	3065.9
U.S.S. Fidelity, station 5	5:35:03.5	35 204	1262.7	5:35:29	55 233.9	1983.31	5:37:47.0	147 859.1	3107.7
U.S.S. Recovery, station 6	5:35:17.5	45 537	1663.41	5:35:37	62 522.1	2225.55	5:38:17.8	158 166.2	3386.7

TABLE 3.- SUMMARY OF WEATHER DATA OBTAINED BY RAWINSONDE AFTER APOLLO 17 LAUNCH

Altitude, m	Wind direction, deg	Wind speed, m/s	Temperature, K	Dewpoint, K	Pressure, N/m^2	Relative humidity, percent	Absolute humidity, g/m^3	Speed of sound, m/s	Density, g/m^3
5	320	2	295.05	294.85	102 000	99	19.12	344.16	1192.82
305	352	2	297.15	295.35	98 579	90	19.53	345.71	1144.02
610	72	.5	295.15	293.85	95 216	92	17.95	344.16	1112.90
914	100	1	292.35	292.35	91 938	100	16.45	342.61	1085.82
1 219	136	1	290.15	290.05	88 742	99	14.34	341.59	1056.80
1 524	204	2	288.05	287.85	85 638	99	12.61	340.00	1028.02
1 829	215	4	286.55	286.45	82 618	99	11.53	339.53	997.31
2 134	213	5	285.85	283.75	79 690	87	9.70	339.01	965.45
2 438	223	4	285.25	279.25	76 858	67	7.16	338.50	934.44
2 743	245	5	284.45	264.45	74 113	24	2.41	337.99	906.23
3 048	241	7	281.95	265.05	71 450	28	2.41	336.45	881.47
3 353	250	6	266.45	265.05	68 862	34	2.58	335.42	855.63
3 658	258	5	277.75	-----	66 350	---	----	333.87	831.99
3 962	284	5	275.95	242.85	63 910	7	.38	332.84	806.59
4 267	294	9	273.85	-----	61 543	---	----	331.82	782.84
4 572	288	12	271.75	-----	59 245	---	----	330.27	759.59
4 877	284	12	269.45	-----	57 017	---	----	328.73	737.31
5 182	277	10	267.15	-----	54 853	---	----	327.70	715.24
5 486	264	9	264.95	247.75	52 757	23	.63	326.16	693.25
5 791	275	7	263.85	-----	50 727	---	----	325.64	669.61
6 096	299	7	261.85	-----	48 766	---	----	324.10	648.89
6 401	307	9	259.75	-----	46 864	---	----	323.07	628.24
6 706	312	13	257.15	243.45	45 023	32	.47	321.53	609.56
7 010	307	11	254.55	226.45	43 236	7	.09	319.98	591.61
7 315	300	15	253.75	239.45	41 508	29	.33	319.47	569.68
7 620	294	20	252.05	231.85	39 841	14	.14	317.93	550.59
7 925	290	25	250.05	220.75	38 230	14	.11	316.90	532.53
8 230	291	28	247.35	231.15	36 670	20	.13	315.35	516.42
8 534	291	29	244.55	234.15	35 158	36	.18	313.29	500.67
8 839	291	28	243.25	225.15	33 696	15	.07	312.78	482.59
9 144	290	24	240.75	217.95	32 283	8	.03	310.72	467.14
9 449	290	21	238.65	214.95	30 917	7	.02	309.69	451.10
9 754	293	19	235.75	211.45	29 595	6	.01	307.63	437.42
10 058	303	20	233.35	209.95	28 316	6	.01	306.09	422.74
10 363	310	24	230.65	207.45	27 079	6	.01	304.55	409.08
10 668	313	27	228.05	207.55	25 883	8	.01	302.49	395.38
10 973	315	30	225.45	207.15	24 728	10	.01	300.95	382.14
11 278	316	35	222.85	205.95	23 611	11	.01	298.89	369.19
11 582	315	40	220.75	204.85	22 534	12	.01	297.86	355.54
11 887	313	41	219.15	203.85	21 497	13	.00	296.83	341.81
12 192	312	42	217.15	202.25	20 503	13	.00	295.29	328.96
12 497	316	39	214.55	200.15	19 543	14	.00	293.75	317.35
12 802	318	34	212.65	-----	18 619	---	----	292.20	305.04
13 106	315	32	210.65	-----	17 730	---	----	290.66	293.27
13 411	313	31	209.45	-----	16 878	---	----	290.15	280.72
13 716	311	30	208.25	-----	16 062	---	----	289.12	268.68
14 021	308	27	207.45	-----	15 282	---	----	288.60	256.65
14 326	306	27	206.65	-----	14 537	---	----	288.07	245.08
14 630	303	28	205.25	-----	13 825	---	----	287.06	234.69
14 935	299	28	204.65	-----	13 146	---	----	286.55	223.77
15 240	289	26	203.85	-----	12 196	---	----	286.03	213.56
15 545	279	24	203.65	-----	11 877	---	----	286.03	203.17
15 850	281	24	202.95	-----	11 288	---	----	285.52	193.73
16 154	291	22	202.35	-----	10 727	---	----	285.00	184.67
16 459	293	16	201.45	-----	10 192	---	----	284.49	176.27
16 764	276	14	198.55	-----	9 679	---	----	282.43	169.85
17 069	275	15	197.75	-----	9 184	---	----	281.93	161.67
17 374	267	11	198.25	-----	8 718	---	----	281 92	153.22
17 678	246	9	198.35	-----	8 275	---	----	282.43	145.37
17 983	229	9	199.95	-----	7 856	---	----	283.46	136.87

TABLE 3. - SUMMARY OF WEATHER DATA OBTAINED BY RAWINSONDE AFTER APOLLO 17 LAUNCH – Concluded

Altitude, m	Wind direction, deg	Wind speed, m/s	Temperature, K	Dewpoint, K	Pressure, N/m^2	Relative humidity, percent	Absolute humidity, g/m^3	Speed of sound, m/s	Density, g/m^3
18 288	222	9	202.45	---	7462	---	---	285.00	128.43
18 593	221	9	204.55	---	7093	---	---	286.55	120.79
18 898	214	10	205.85	---	6745	---	---	287.57	114.14
19 202	214	9	208.35	---	6416	---	---	289.12	107.28
19 507	228	7	209.05	---	6107	---	---	289.63	101.77
19 812	248	5	208.75	---	5812	---	---	289.63	97.01
20 117	248	3	208.25	---	5531	---	---	289.12	92.56
20 422	223	3	207.55	---	5263	---	---	288.60	88.34
20 726	220	3	207.35	---	5008	---	---	288.60	84.16
21 031	160	2	208.35	---	4765	---	---	289.12	79.67
21 336	156	4	208.85	---	4535	---	---	289.63	75.67
21 641	211	4	211.25	---	4318	---	---	291.18	71.22
21 946	214	2	211.95	---	4112	---	---	291.69	67.58
22 250	158	1	211.75	---	3917	---	---	291.69	64.43
22 555	106	1	210.45	---	3730	---	---	290.66	61.73
22 860	59	.5	210.65	---	3551	---	---	290.66	58.73
23 165	310	1	210.45	---	3382	---	---	290.66	55.97
23 470	286	4	210.75	---	3220	---	---	291.18	53.21
23 774	302	6	212.85	---	3067	---	---	292.20	50.20
24 079	303	8	211.75	---	2922	---	---	291.69	48.06
24 384	292	9	210.25	---	2782	---	---	290.66	46.10
24 689	279	9	210.95	---	2649	---	---	291.18	43.75
24 994	271	11	213.35	---	2524	---	---	292.72	41.20
25 298	275	12	213.75	---	2405	---	---	293.23	39.20
25 603	280	11	214.65	---	2292	---	---	293.75	37.19
25 908	282	11	214.15	---	2184	---	---	293.23	35.54
26 213	281	10	214.95	---	2082	---	---	293.75	33.74
26 518	270	9	215.75	---	1984	---	---	294.26	32.05
26 822	256	11	215.85	---	1892	---	---	294.26	30.53
27 127	258	15	216.15	---	1804	---	---	294.77	29.06
27 432	265	19	217.55	---	1720	---	---	295.81	27.54
27 737	273	20	218.55	---	1641	---	---	296.32	26.16
28 042	275	21	218.55	---	1565	---	---	296.32	24.95
28 346	274	20	220.15	---	1493	---	---	297.35	23.63
28 651	274	20	220.95	---	1425	---	---	297.86	22.47
28 956	277	20	221.05	---	1360	---	---	297.86	21.44
29 261	277	20	221.45	---	1298	---	---	298.38	20.43
29 566	277	21	222.75	---	1240	---	---	298.89	19.39
29 870	277	21	224.05	---	1184	---	---	299.92	18.41
30 175	277	23	225.05	---	1131	---	---	300.43	17.51
30 480	273	25	225.15	---	1080	---	---	300.95	16.71
30 785	269	27	225.65	---	1032	---	---	300.95	15.93
31 090	268	27	227.35	---	987	---	---	301.98	15.13
31 394	264	27	227.05	---	943	---	---	301.98	14.46
31 699	256	28	228.15	---	901	---	---	302.49	13.76
32 004	254	29	228.85	---	861	---	---	303.01	13.11
32 309	257	28	227.65	---	823	---	---	302.49	12.60
32 613	260	27	227.85	---	787	---	--	302.49	12.03
32 918	262	28	228.35	---	753	---	---	303.01	11.49
33 223	263	28	229.75	---	719	---	---	304.04	10.90
33 528	262	29	230.55	---	688	---	---	304.55	10.39
33 833	262	30	230.95	---	658	---	---	304.55	9.92
34 138	262	32	231.55	---	629	---	---	305.07	9.47
34 442	262	34	230.95	---	602	---	---	304.55	9.08
34 747	263	35	230.75	---	576	---	---	304.55	8.69
35 052	261	35	231.65	---	551	---	---	305.07	8.26
35 357	---	---	231.95	---	527	---	---	305.07	7.91

TABLE 4.- SUMMARY OF WEATHER DATA OBTAINED BY ROCKETSONDE AFTER APOLLO 17 LAUNCH

[Values were not obtained for dewpoint, relative humidity, and absolute humidity]

Altitude, m	Wind direction, deg	Wind speed, m/s	Temperature, K	Pressure, N/m^2	Speed of sound, m/s	Density, g/m^3
25 000	---	--	213.35	2521	292.93	41.1655
25 250	---	--	213 90	2424	293.31	39.4721
25 500	---	--	214.45	2330	293 69	37.8485
25 750	---	--	215.00	2240	294 06	36.2920
26 000	273	10	215 .6	2153	294.44	34.7998
26 250	269	10	215.20	2070	994.20	33.5151
26 500	267	11	215.02	1991	294.07	32.2515
26 750	266	12	214.96	1914	294.03	31.0167
27 000	266	13	215.31	1840	294.27	29.7732
27 250	267	14	215.88	1769	294.66	28.5538
27 500	266	16	216.64	1702	295.18	27.3639
27 750	268	17	217.54	1637	295.79	26.2096
28 000	270	18	218.64	1574	296.54	25.0867
28 250	272	19	220.15	1515	297.56	23.9732
28 500	275	20	221.51	1458	298.48	22.9315
28 750	275	20	222.19	1404	298.94	22.0071
29 000	275	20	222.57	1351	299.20	21.1508
29 250	276	21	223.18	1301	299.60	20.3090
29 500	274	22	224.07	1253	300.20	19.4790
29 750	274	22	225.02	1207	300.84	18.6804
30 000	274	23	225.93	1162	301.44	17.9219
30 250	272	23	226.83	1120	302.04	17.1969
30 500	269	24	227.62	1079	302.57	16.5121
30 750	266	25	228.14	1040	302.92	15.8752
31 000	263	25	228.44	1002	303.11	15.2792
31 250	261	27	228.65	966	303.25	14.7118
31 500	259	27	228.85	931	303.38	14.1667
31 750	259	27	229.04	897	303.51	13.6426
32 000	258	28	229.23	864	303.64	13.1381
32 250	258	28	229.51	833	303.82	12.6484
32 500	259	29	229.92	803	304.09	12.1704
32 750	259	30	230.44	774	304.44	11.7058
33 000	259	30	230.85	747	304.71	11.2655
33 250	260	31	231.03	720	304.83	10.8530
33 500	260	31	231.13	694	304.90	10.4596
33 750	259	32	231.29	669	305.00	10.0780
34 000	258	33	231.70	645	305.27	9.7001
34 250	257	34	232.16	622	305.57	9.3354
34 500	256	34	232.72	600	305.94	8.9810
34 750	254	35	233.44	579	306.41	8.6354
35 000	253	37	234.43	558	307.06	8.2945
35 250	253	38	235.39	538	307.69	7.9695
35 500	254	40	236.29	520	308.28	7.6604
35 750	253	42	237.08	501	308.79	7.3677
36 000	253	44	238.17	484	309.50	7.0784
36 250	253	47	239.18	467	310.16	6.8041
36 500	254	48	240.49	451	311.00	6.5334
36 750	255	50	242.18	436	312.09	6.2653
37 000	255	52	243.58	421	312.99	6.0169
37 250	255	54	243.72	406	313.09	5.8090
37 500	253	56	243.71	393	313.08	5.6119
37 750	251	57	243.85	379	313.17	5.4183
38 000	251	59	244.11	366	313.34	5.2287
38 250	250	60	244.42	354	313.54	5.0451
38 500	250	62	244.49	342	313.58	4.8729
38 750	249	64	244.45	330	313.55	4.7087
39 000	249	66	244.37	319	313.50	4.5507
39 250	250	66	243.83	308	313.16	4.4062
39 500	251	66	243.14	298	312.71	4.2686
39 750	253	66	242.53	288	312.32	4.1358
40 000	256	66	243.81	278	313.14	3.9780
40 250	258	66	245.54	269	314.25	3.8105
40 500	261	67	247.21	260	315.32	3.6577
40 750	263	67	248.49	251	316.13	3.5174
41 000	265	66	249.51	243	316.79	3.3863
41 250	267	68	250.50	235	317.41	3.2615
41 500	267	69	251.70	227	318.17	3.1391
41 750	268	69	254.15	219	319.78	3.0071
42 000	269	69	256.88	212	321.61	2.8790
42 250	269	69	259.49	205	323.05	2.7568

TABLE 4 - SUMMARY OF WEATHER DATA OBTAINED BY ROCKETSONDE AFTER APOLLO 17 LAUNCH - Concluded

[Values were not obtained for dewpoint, relative humidity, and absolute humidity]

Altitude, m	Wind direction, deg	Wind speed, m/s	Temperature, K	Pressure, N/m^2	Speed of sound, m/s	Density, g/m^3
42 500	270	69	261.99	199	324.61	2.6454
42 750	271	70	263.45	193	325.51	2.5479
43 000	271	71	264.83	187	326.36	2.4552
43 250	271	72	266.13	181	327.16	2.3670
43 500	272	73	267.39	175	327.93	2.2828
43 750	273	73	268.01	170	328.32	2.2071
44 000	274	74	268.45	165	328.59	2.1355
44 250	274	76	268.86	159	328.83	2.0666
44 500	275	77	269.28	155	329.10	1.9998
44 750	275	77	269.67	150	329.33	1.9357
45 000	275	77	270.23	145	329.67	1.8724
45 250	275	77	270.66	141	329.94	1.8123
45 500	275	76	271.13	137	330.22	1.7539
45 750	275	75	271.65	132	330.54	1.6971
46 000	274	74	272.11	128	330.82	1.6427
46 250	273	72	272.47	124	331.04	1.5907
46 500	272	70	272.84	121	331.26	1.5404
46 750	271	69	273.19	117	331.47	1.4918
47 000	270	67	273.50	113	331.66	1.4450
47 250	268	66	273.85	110	331.87	1.3995
47 500	266	65	274.14	107	332.05	1.3559
47 750	265	65	274.40	103	332.21	1.3137
48 000	264	64	274.77	100	332.43	1.2725
48 250	263	65	275.12	97	332.64	1.2326
48 500	263	65	275.39	94	332.81	1.1944
48 750	262	65	275.44	92	332.83	1.1584
49 000	262	65	275 23	89	332.71	1.1244
49 250	262	65	275.01	86	332.58	1.0915
49 500	263	64	274.77	106	332.43	1.0596
49 750	263	64	274.44	103	332.23	1.0290
50 000	263	63	274.24	100	332.11	.9987
50 250	262	62	274.01	97	331.97	.9694
50 500	262	62	273.85	94	331.87	.9407
50 750	261	62	273.74	91	331.81	.9127
51 000	261	62	273.64	89	331.75	.8855
51 250	261	62	273.61	86	331.73	.8588
51 500	262	62	273.50	83	331.66	.8332
51 750	263	61	273.42	81	331.62	.8083
52 000	264	61	273.06	78	331.40	.7849
52 250	266	61	272.25	76	330.90	7634
52 500	267	60	271.21	74	330.27	.7431
52 750	269	60	270.15	72	329.63	.7232
53 000	270	59	269.22	70	329.06	.7035
53 250	270	58	268.25	68	328.46	.6844
53 500	269	57	267.16	67	327.80	.6660
53 750	268	56	266.12	65	327.16	.6479
54 000	266	54	265.42	63	326.72	.6294
54 250	262	53	264.98	61	326.46	.6109
54 500	259	52	264.43	59	326.11	.5931
54 750	257	52	263.61	58	325.61	.5763
55 000	254	52	262.49	56	324.92	.5606
55 250	253	52	261.31	55	324.19	.5454
55 500	252	53	260.19	53	323.49	.5305
55 750	252	53	259.10	52	322.81	.5158
56 000	253	53	258.26	50	322.29	.5010
56 250	254	52	257.75	49	321.97	.4859
56.500	257	52	257.46	47	321.79	.4709
56 750	260	52	257.07	46	321.54	.4565
57 000	263	51	256.20	44	321.00	.4434
57 250	266	51	255.01	43	320.26	.4311
57 500	270	51	253.58	42	319.36	.4195
57 750	274	51	251.91	41	318.30	.4085
58 000	277	51	249.97	40	317.07	.3982
58 250	280	52	247.91	39	315.76	.3882
58 500	---	--	245.94	38	314.51	.3783
58 750	---	--	244.35	37	313.49	.3680
59 000	---	--	243.03	36	312.64	.3575
59 250	---	--	241.92	35	311.93	.3469
59 500	---	--	241.09	34	311.39	.3363
59 750	---	--	241.20	33	311.46	.3247
60 000	---	--	241.44	31	311.62	.3133
60 243	---	--	241.77	30	311.83	.3025

TABLE 5.- SUMMARY OF WEATHER DATA OBTAINED BY RADIOSONDE FROM STATION 3 AT 2 min BEFORE LAUNCH

[Wind direction at an altitude of 3 m was 230°. Values for wind direction were not obtained at other altitudes. Wind speed was not measured]

Altitude, m	Temperature, K	Dewpoint, K	Pressure, N/m^2	Relative humidity, percent	Absolute humidity, g/m^3	Speed of sound, m/s	Density, g/m^3
3	298.65	296.66	101 860	87	20.81	346.22	1175.66
305	294.55	293.84	93 410	94	17.80	343.65	1153.26
610	291.85	291.16	95 010	94	15.23	342.11	1124.93
914	291.05	289.57	91 700	90	13.80	341.59	1089.13
1 219	289.05	286.49	88 490	84	11.41	340.56	1059.57
1 524	287.25	284.78	85 370	84	10.28	339.53	1028.98
1 829	285.25	283.45	82 340	88	9.48	337.99	999.91
2 134	283.65	281.54	79 400	86	8.40	337.48	970.14
2 438	282.15	276.45	76 550	67	6.01	336.45	941.43
2 743	281.55	274.05	73 780	59	5.02	335.93	909.95
3 048	279.15	271.36	71 100	57	4.17	334.39	884.89
3 353	276.55	269.19	68 490	58	3.58	332.85	860.55
3 658	274.85	266.59	65 960	54	2.98	331.82	834.27
3 962	273.55	262.82	63 510	44	2.23	331.30	807.59
4 267	270.95	266.73	61 130	41	1.73	329.76	784.91
4 572	269.25	257.19	58 820	38	1.43	328.73	760.14
4 877	267.25	255.26	56 590	38	1.22	327.19	737.01
5 182	265.05	254.68	54 420	43	1.17	326.16	714.50
5 486	263.45	253.94	52 320	46	1.12	325.13	691.16
5 791	262.45	250.56	50 290	37	.83	324.61	667.02
6 096	260.45	250.67	48 330	44	.85	323.07	646.06
6 401	257.95	247.66	46 430	41	.65	321.53	626.59
6 706	256.15	247.77	44 590	48	.66	320.50	606.13
7 010	254.65	247.88	42 810	55	.67	319.47	585.13
7 315	252.95	244.38	41 100	46	.49	318.44	565.57
7 620	250.85	241.50	39 430	42	.38	316.90	547.42
7 925	248.35	239.51	37 830	43	.31	315.35	530.27
8 230	246.05	237.27	36 270	43	.25	314.33	513.29
8 534	243.65	234.98	34 760	43	.20	312.78	496.83
8 839	240.95	232.29	33 300	42	.16	310.72	481.26
9 144	238.15	229.26	31 880	40	.11	309.18	466.17
9 449	235.65	226.72	30 510	39	.09	307.64	450.91
9 754	232.75	-----	29 180	---	----	305.58	436.77
10 058	230.35	-----	27 900	---	----	304.04	421.86
10 363	227.25	-----	26 660	---	----	301.98	408.77
10 668	224.75	-----	25 460	---	----	300.43	394.63
10 973	222.05	-----	24 300	---	----	298.38	381.24
11 278	219.55	-----	23 180	---	----	296.83	367.83
11 582	218.05	-----	22 110	---	----	295.81	353.17

TABLE 5.- SUMMARY OF WEATHER DATA OBTAINED BY RADIOSONDE FROM STATION 3 AT 2 min BEFORE LAUNCH – Concluded

[Wind direction at an altitude of 3 m was 210°. Values for wind direction were not obtained at other altitudes. Wind speed was not measured]

Altitude, m	Temperature, K	Dewpoint, K	Pressure, N/m^2	Relative humidity, percent	Absolute humidity, g/m^3	Speed of sound, m/s	Density, g/m^3
11 887	215.65	---	21 070	---	---	293.75	340.63
12 192	212.85	---	20 070	---	---	292.20	328.56
12 497	210.75	---	19 110	---	---	290.66	315.90
12 802	209.25	---	18 180	---	---	289.63	302.79
13 106	208.25	---	17 300	---	---	289.12	289.40
13 411	208.45	---	16 460	---	---	289.12	275.04
13 716	210.15	---	15 660	---	---	289.12	262.01
14 021	206.25	---	14 890	---	---	287.57	251.46
14 326	204.45	---	14 150	---	---	286.55	241.15
14 630	203.45	---	13 450	---	---	285.52	230.34
14 935	202.35	---	12 780	---	---	285.00	219.95
15 240	201.85	---	12 140	---	---	284.48	209.40
15 545	201.45	---	11 530	---	---	283.97	199.31
15 850	201.15	---	10 950	---	---	283.97	189.55
16 154	200.75	---	10 390	---	---	283.97	180.32
16 459	200.55	---	9 870	---	---	283.46	171.43
16 764	200.25	---	9 370	---	---	283.46	162.96
17 069	200.05	---	8 890	---	---	283.46	154.89
17 374	200.35	---	8 440	---	---	283.46	146.77
17 678	202.15	---	8 020	---	---	284.48	138.17
17 983	204.05	---	7 620	---	---	286.03	130.08
18 288	204.45	---	7 240	---	---	286.03	123.38
18 593	205.05	---	6 880	---	---	286.55	116.88
18 898	206.65	---	6 540	---	---	287.57	110.31
19 202	207.15	---	6 220	---	---	288.09	104.64
19 507	207.15	---	5 920	---	---	288.09	99.46
19 812	205.25	---	5 620	---	---	287.06	95.44
20 117	207.05	---	5 350	---	---	288.09	89.94
20 422	208.35	---	5 090	---	---	289.12	85.03
20 726	209.35	---	4 840	---	---	289.63	80.33
21 031	208.55	---	4 600	---	---	289.12	76.91
21 336	207.95	---	4 380	---	---	288.60	73.36
21 641	207.65	---	4 170	---	---	288.60	69.87
21 946	210.05	---	3 960	---	---	288.60	66.33
22 250	209.65	---	3 770	---	---	290.15	62.62
22 555	210.05	---	3 590	---	---	290.15	59.49
22 860	209.65	---	3 410	---	---	290.15	56.73
23 165	209.75	---	3 250	---	---	290.15	53.96
23 470	210.45	---	3 090	---	---	290.66	51.17
23 774	210.85	---	2 940	---	---	290.66	48.60
24 079	210.85	---	2 800	---	---	290.66	46.27

TABLE 6.- SUMMARY OF WEATHER DATA OBTAINED BY RADIOSONDE FROM STATION 3 AT 18 min AFTER LAUNCH

[Wind direction at an altitude of 3 m was 230°. Values for wind direction were not obtained at other altitudes. Wind speed was not measured]

Altitude, m	Temperature, K	Dewpoint, K	Pressure, N/m^2	Relative humidity, percent	Absolute humidity, g/m^3	Speed of sound, m/s	Density, g/m^3
3	298.35	296.23	101 850	87	20.30	345.71	1177.11
305	296.85	293.91	98 420	82	17.74	345.19	1144.37
610	295.05	291.64	95 050	80	15.[illegible]	344.16	1112.82
914	292.65	287.63	91 770	72	12.1[illegible]	342.62	1085.07
1 219	290.55	284.62	88 570	67	10.05	341.59	1055.81
1 524	288.85	283.73	85 470	71	9.53	340.56	1025.13
1 829	287.65	282.02	82 450	68	8.55	339.53	993.48
2 134	284.95	278.64	79 520	65	6.85	337.99	968.08
2 438	284.05	276.87	76 680	61	6.08	337.48	936.64
2 743	282.65	274.71	73 920	57	5.25	336.45	907.82
3 048	281.05	273.16	71 250	57	4.71	335.93	880.20
3 353	278.85	270.80	68 660	56	4.00	334.39	855.43
3 658	276.95	268.73	66 140	54	3.46	333.36	829.79
3 962	275.25	265.67	63 700	49	2.76	332.33	804.48
4 267	273.85	260.97	61 330	37	1.91	331.30	779.01
4 572	272.25	260.10	59 050	39	1.79	330.27	754.47
4 877	269.45	257.55	56 820	39	1.48	328.73	733.63
5 182	267.75	255.01	54 670	36	1.20	327.70	710.47
5 486	265.45	252.83	52 570	36	1.00	326.16	689.46
5 791	263.15	255.53	50 550	54	1.27	324.61	668.42
6 096	260.35	253.69	48 580	57	1.11	323.07	649.38
6 401	258.65	248.90	46 670	44	.73	322.04	628.11
6 706	257.95	244.88	44 830	32	.51	321.53	605.12
7 010	255.35	242.96	43 050	33	.43	319.98	587.10
7 315	253.05	241.83	41 320	36	.39	318.44	568.72
7 620	250.85	243.66	39 650	53	.46	316.90	550.41
7 925	249.15	240.97	38 030	47	.36	315.87	531.53
8 230	246.85	238.51	36 470	46	.29	314.84	514.60
8 534	244.45	234.53	34 960	38	.19	313.30	497.96
8 839	242.45	235.95	33 500	53	.23	311.75	481.22
9 144	240.05	234.99	32 080	61	.21	310.21	465.53
9 449	237.25	232.74	30 710	64	.17	308.67	450.93
9 754	234.85	230.41	29 390	63	.13	307.12	435.80
10 058	231.65	0	28 110	0	0	304.55	422.60
10 363	229.05	0	26 870	0	0	303.01	408.53

TABLE 7.- SUMMARY OF MEASURED SONIC-BOOM DATA FROM LAUNCH OF APOLLO 17

Ship	Δp, N/m^2	I_o, $N\text{-}s/m^2$	τ, s	Δt_o, s	ΔT, s
U.S.S. Adroit, station 1	130	38.2	0.310	0.725	1.375
U.S.S. Alacrity, station 2	421	64.7	0.018	0.410	1.427
U.S.S. Saginaw, station 3	420	91.5	0.144	0.541	1.519
U.S.S. Assurance, station 4	216	73.4	0.416	0.565	1.278
U.S.S. Fidelity, station 5	195	134.8	0.065	1.470	2.046
U.S.S. Recovery, station 6	63	29.5	0.214	0.866	1.878

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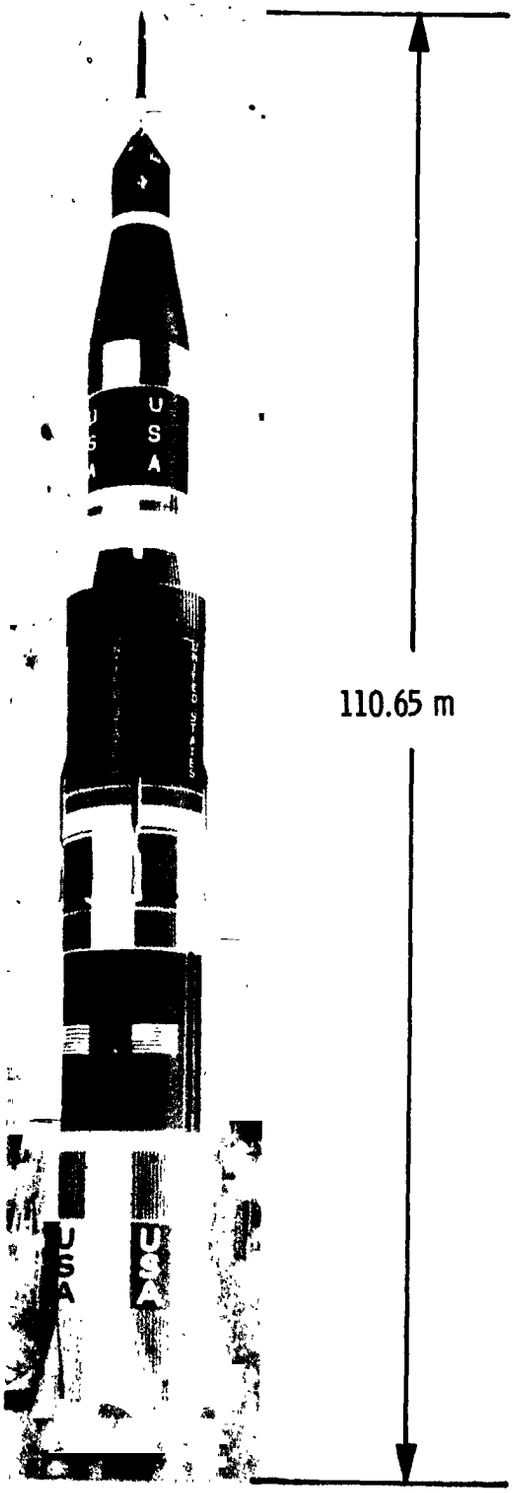
Figure 1.- Night launch of Apollo 17, December 7, 1972.



L-74-8530

Figure 2.- Configuration of Apollo 17/Saturn V launch vehicle.

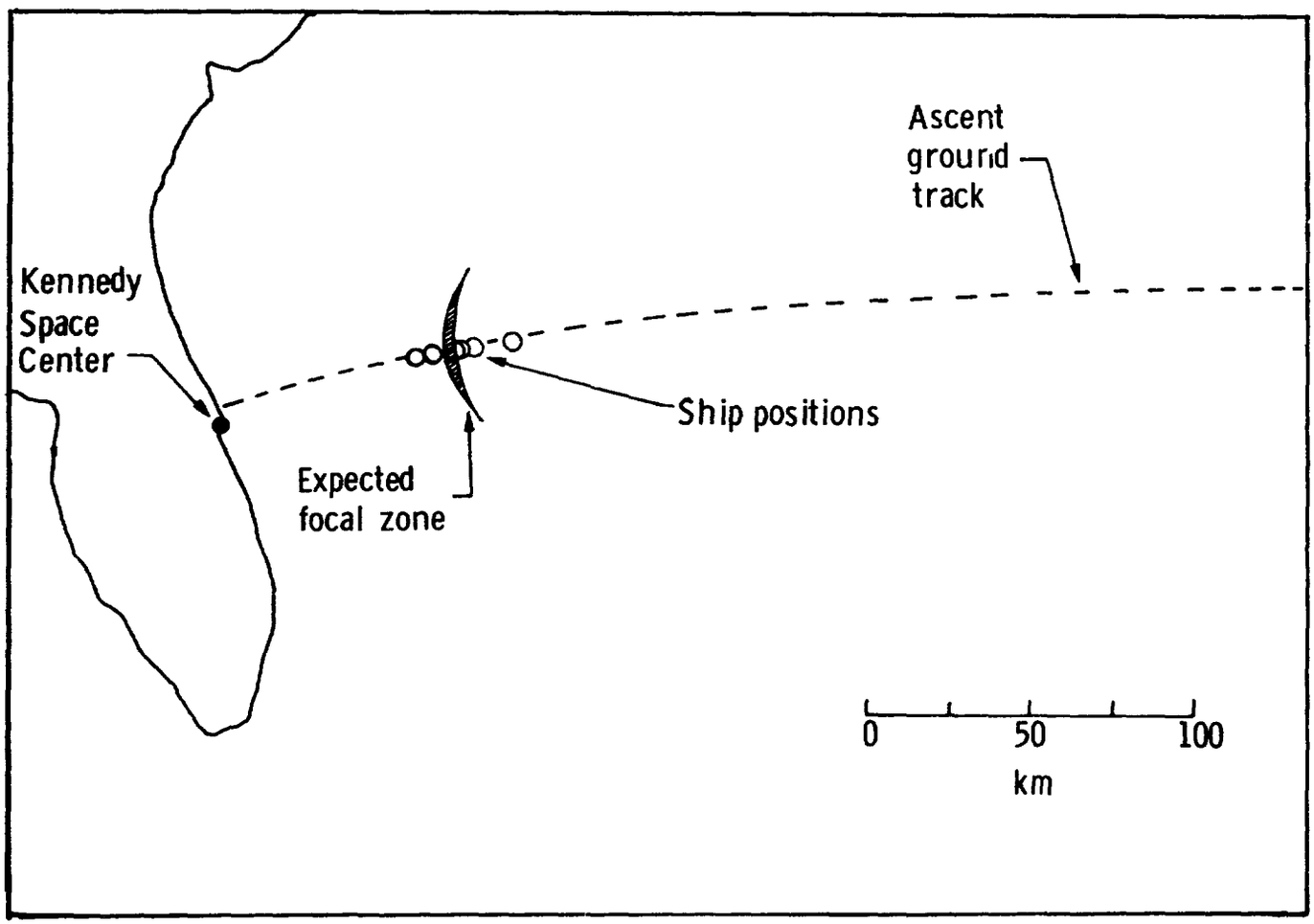


Figure 3.- Map of launch area showing positions of the six measurement ships along with Apollo 17 ground track and expected region of sonic-boom focusing.

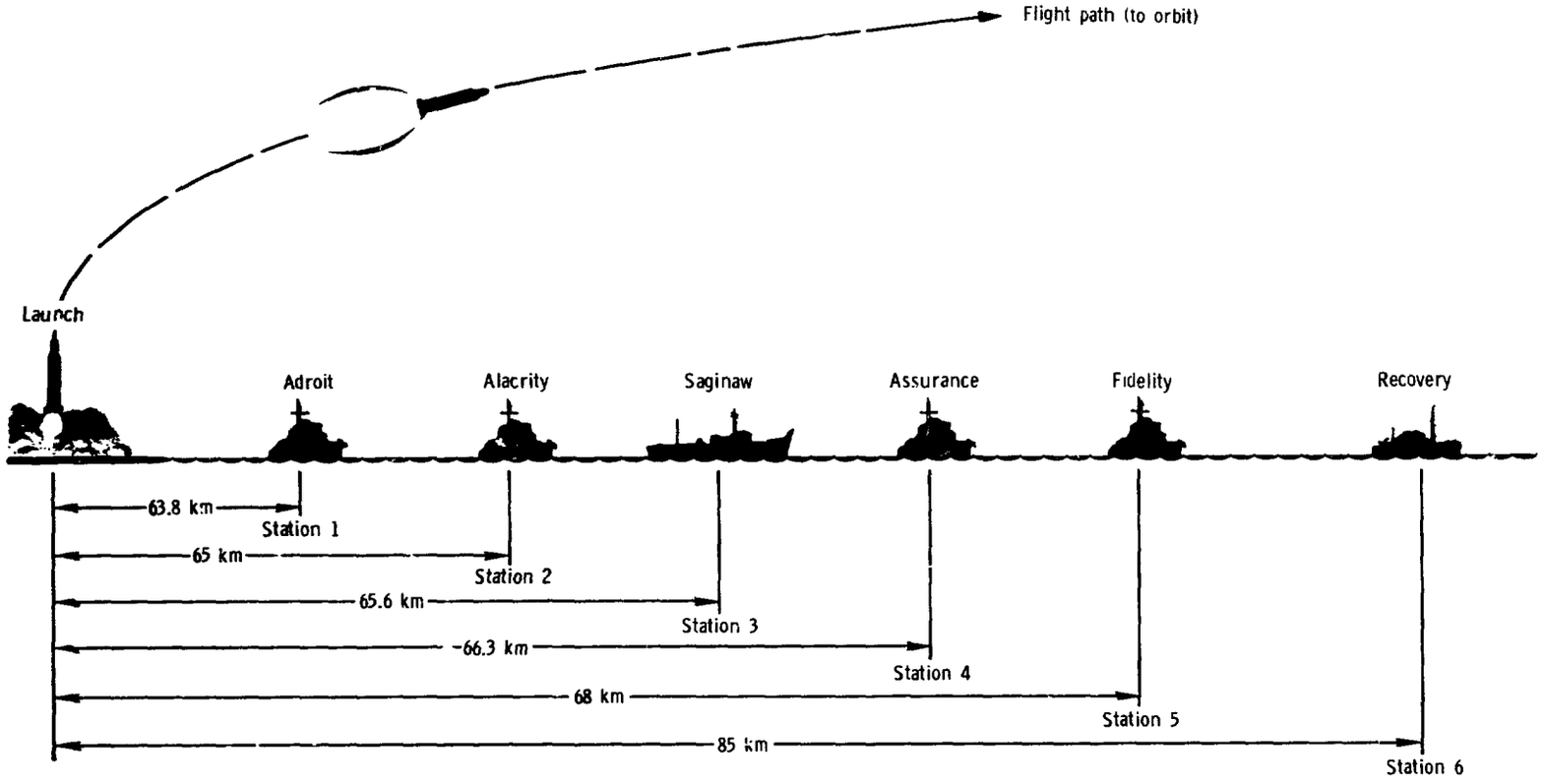


Figure 4.- Schematic showing ship position for data acquisition during ascent.

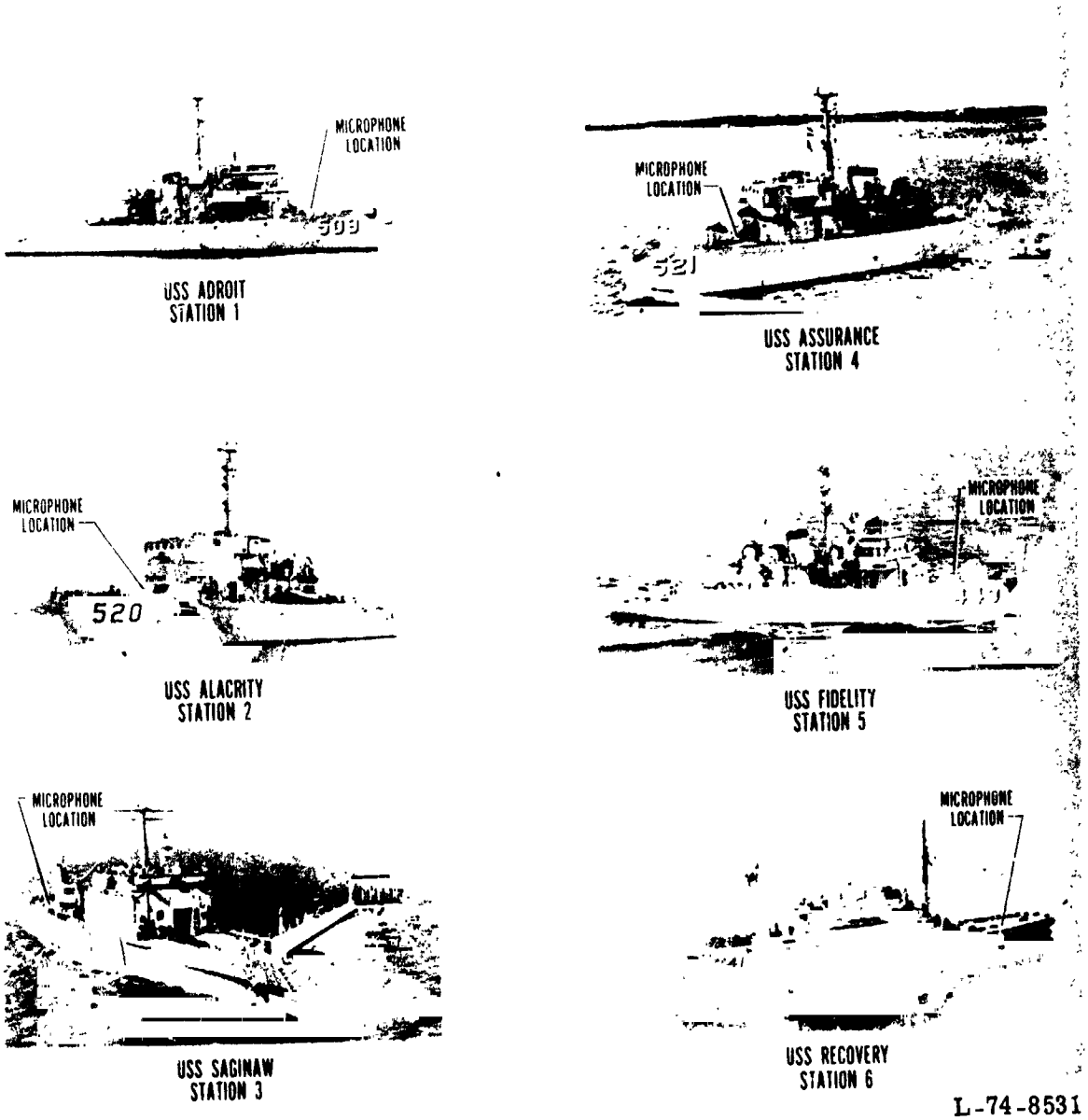


Figure 5.- Photographs of the ships used during the test, with approximate microphone locations indicated.

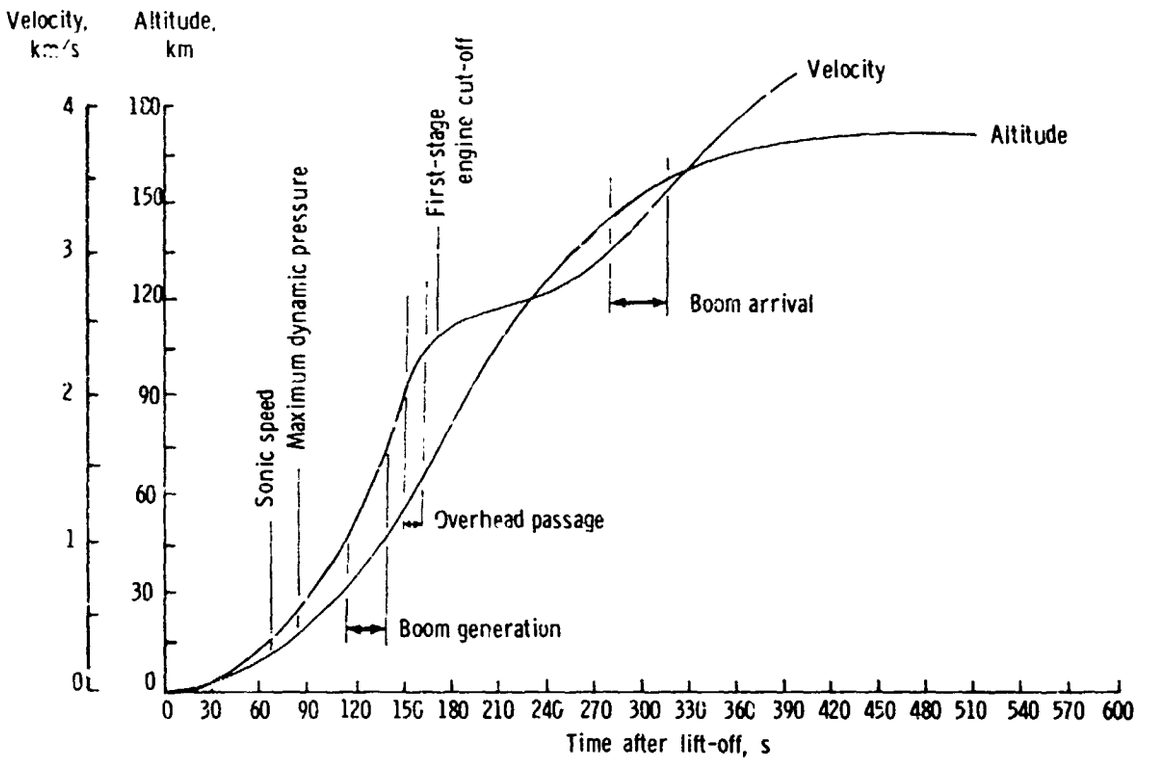


Figure 6.- Apollo 17 launch and ascent profiles.

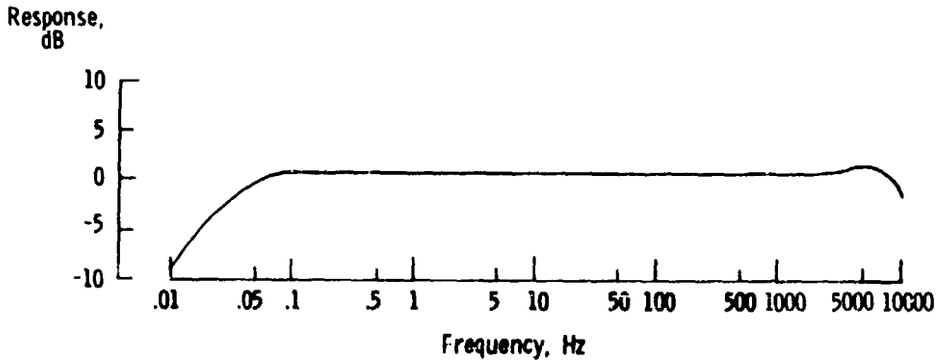


Figure 7.- Typical system response of sonic-boom measurement equipment used for data acquisition.

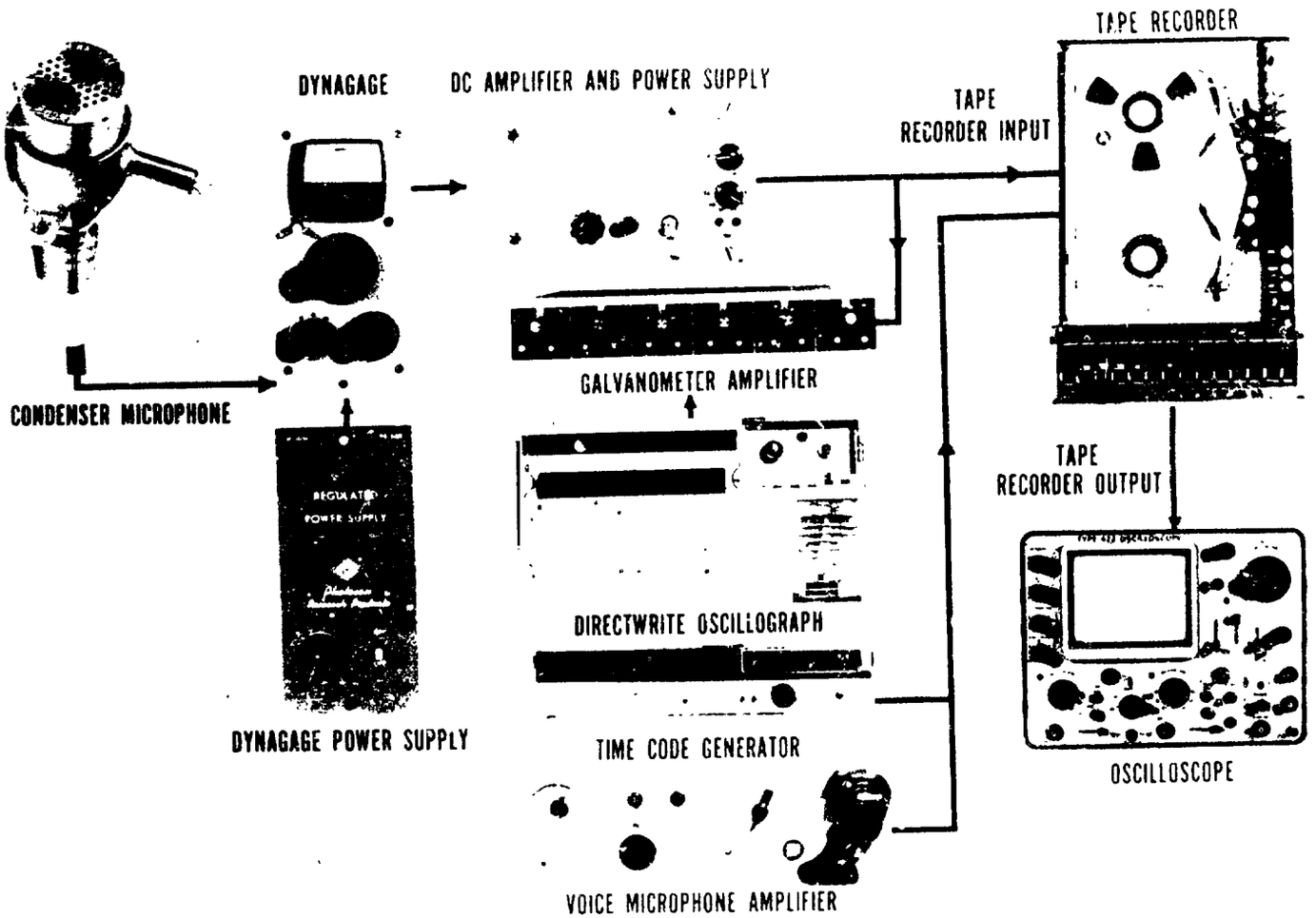


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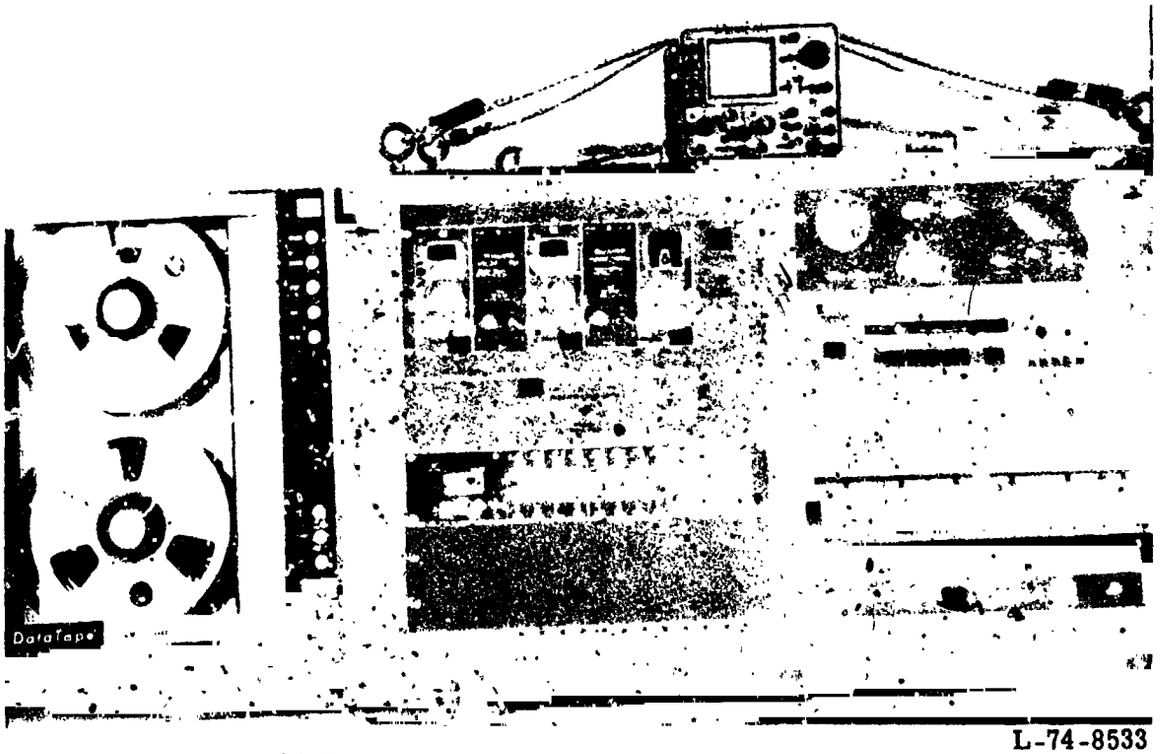
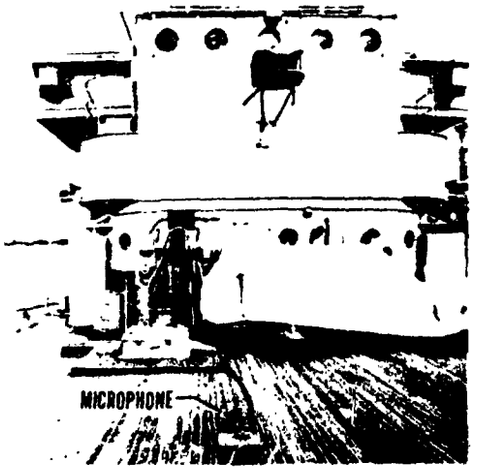
Figure 8.- Pictorial diagram of instrumentation recording system for sonic-boom data acquisition.

(a) Microphone, mount, and wind screen.

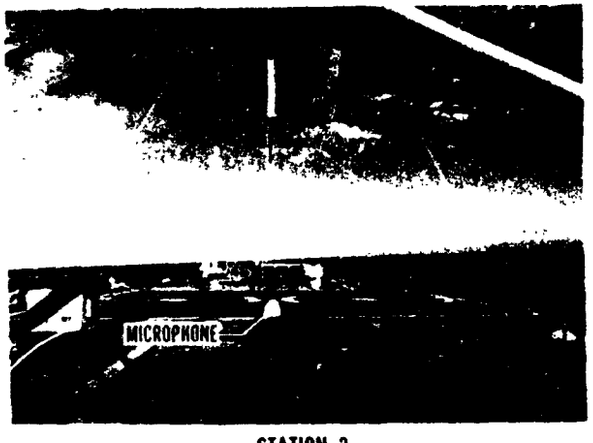


(b) Signal conditioning and recording console.

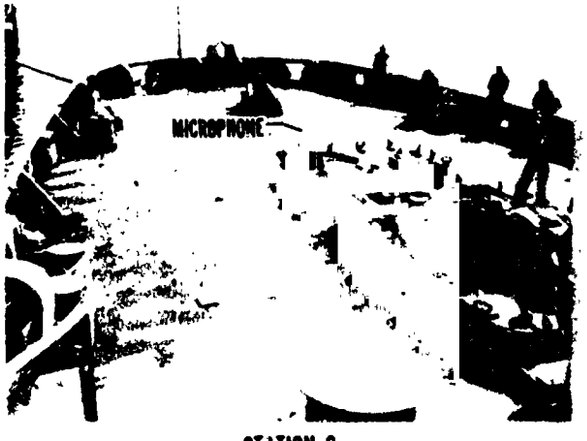
Figure 9.- Typical data acquisition system as mounted on each ship.



TYPICAL MICROPHONE LOCATIONS
FOR STATIONS 1, 2, 4 AND 5



STATION 3



STATION 6

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Figure 10.- Details of microphone locations onboard measurement ships.

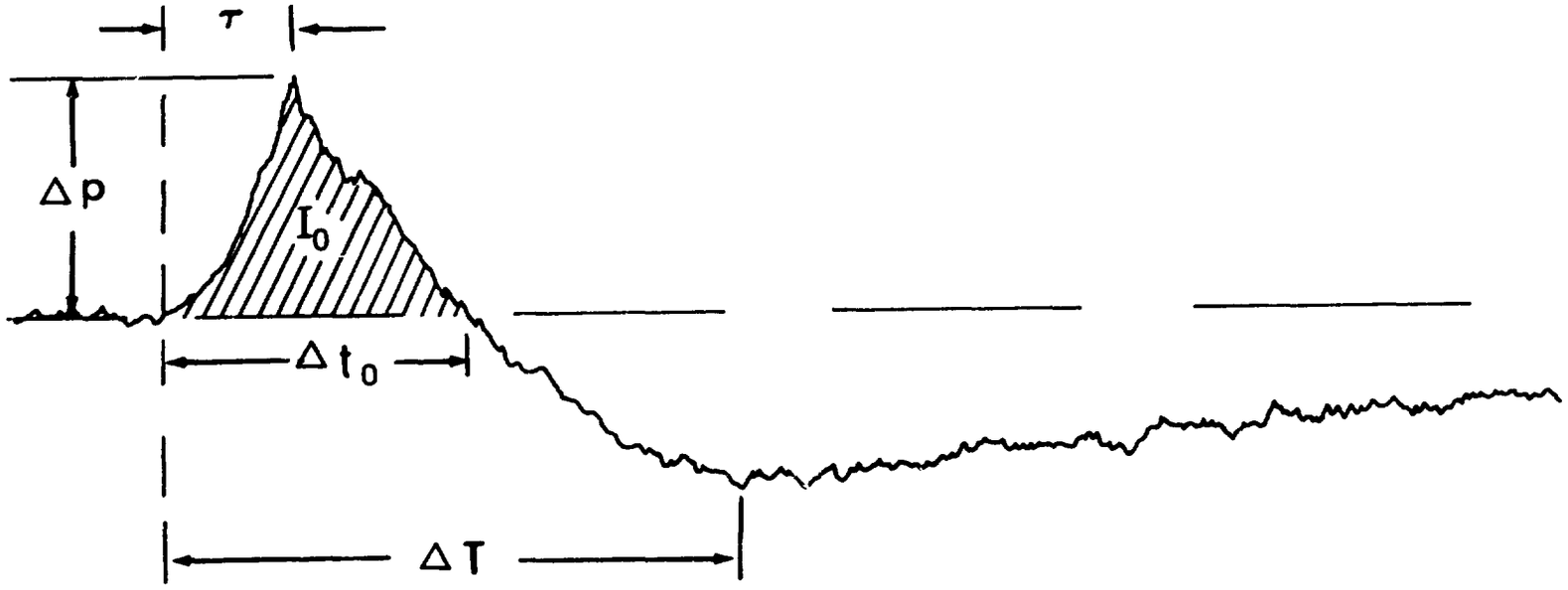

Figure 11.- Tracing of Apollo 17 sonic-boom signature measured during ascent and identification of various signature characterizations.

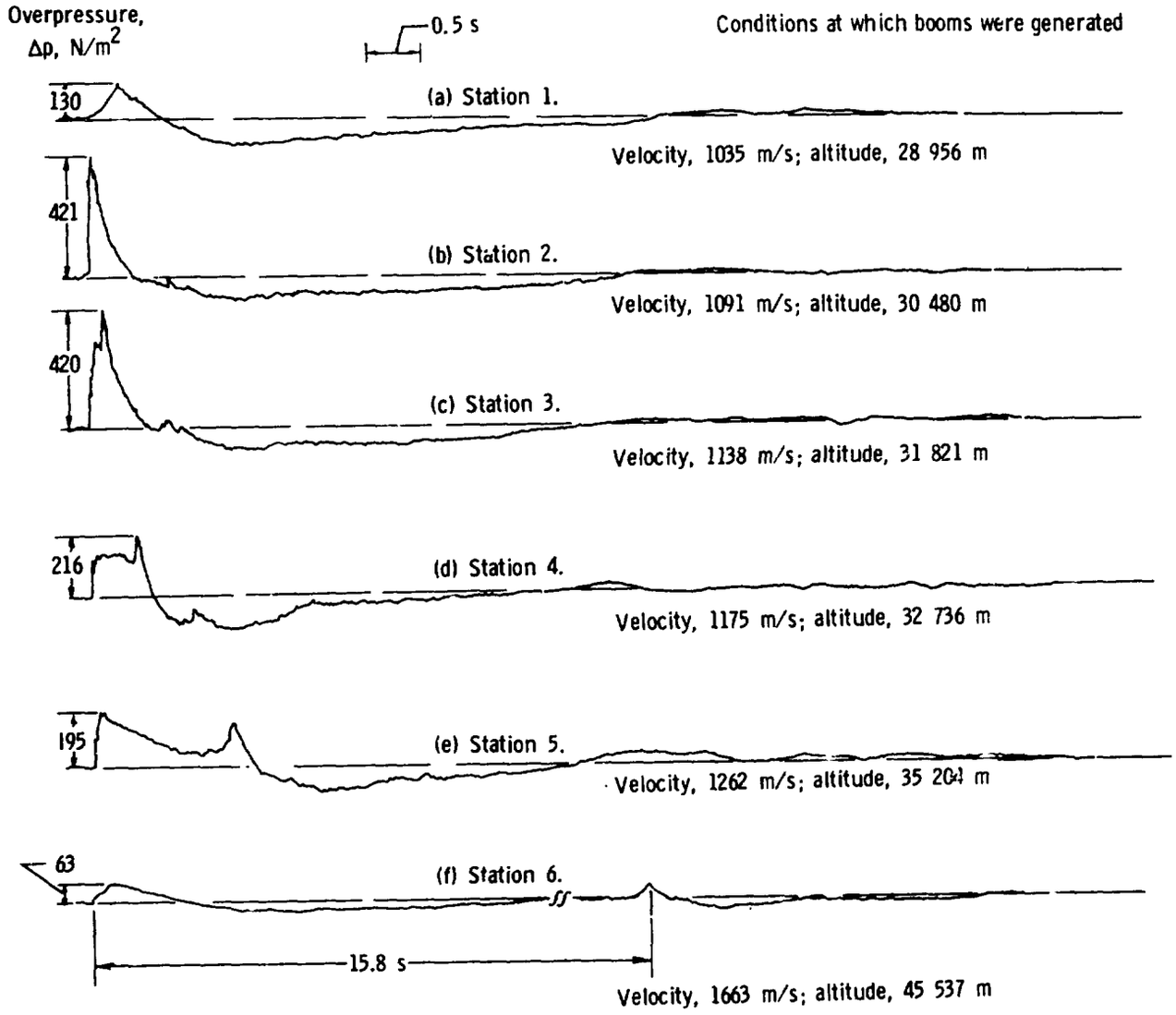

Figure 12.- Sonic-boom signatures measured during ascent of Apollo 17 as recorded at stations 1 to 6.

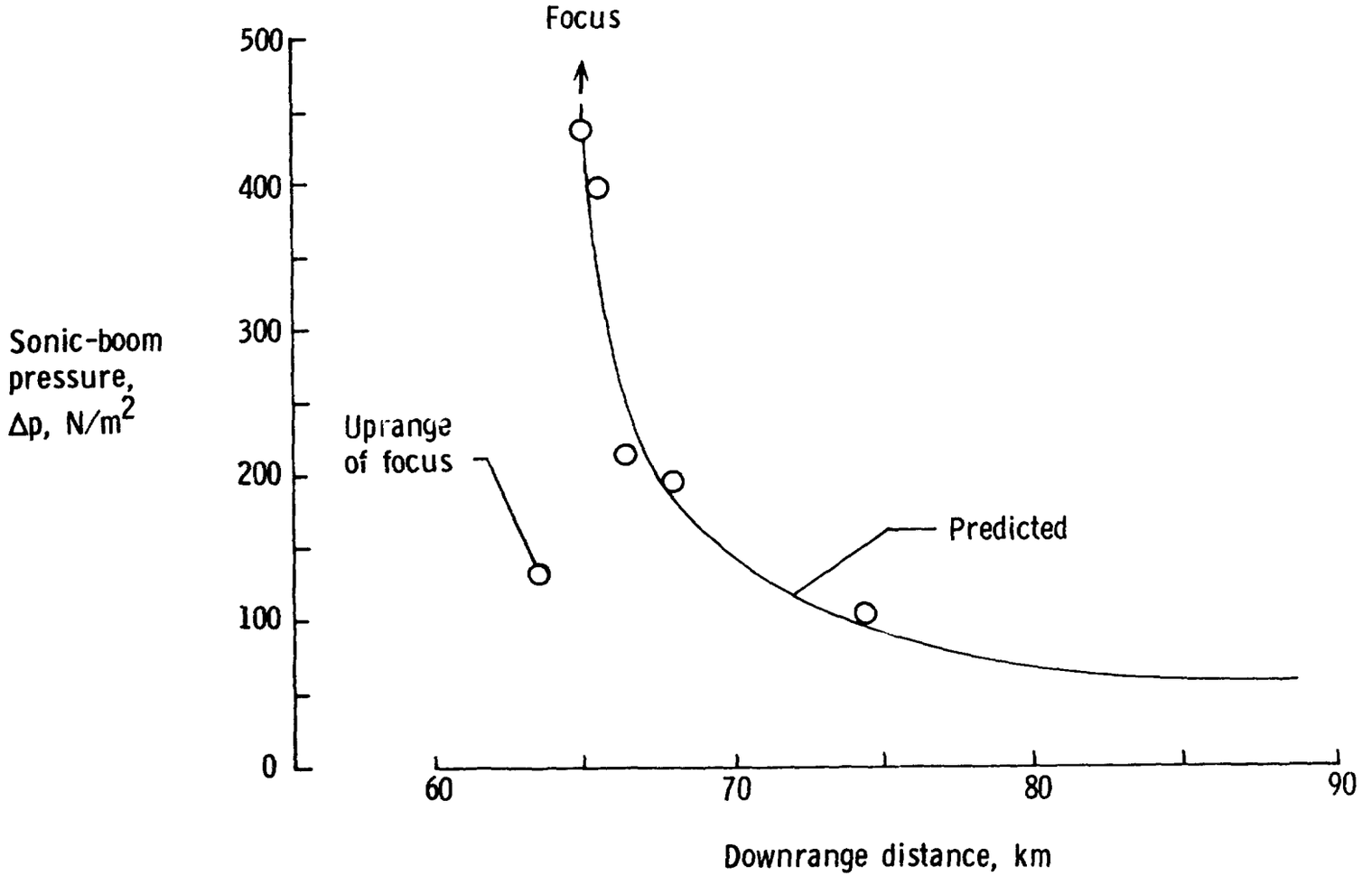

Figure 13.- Overpressure data as a function of downrange distance as measured in the focus-boom region during ascent.

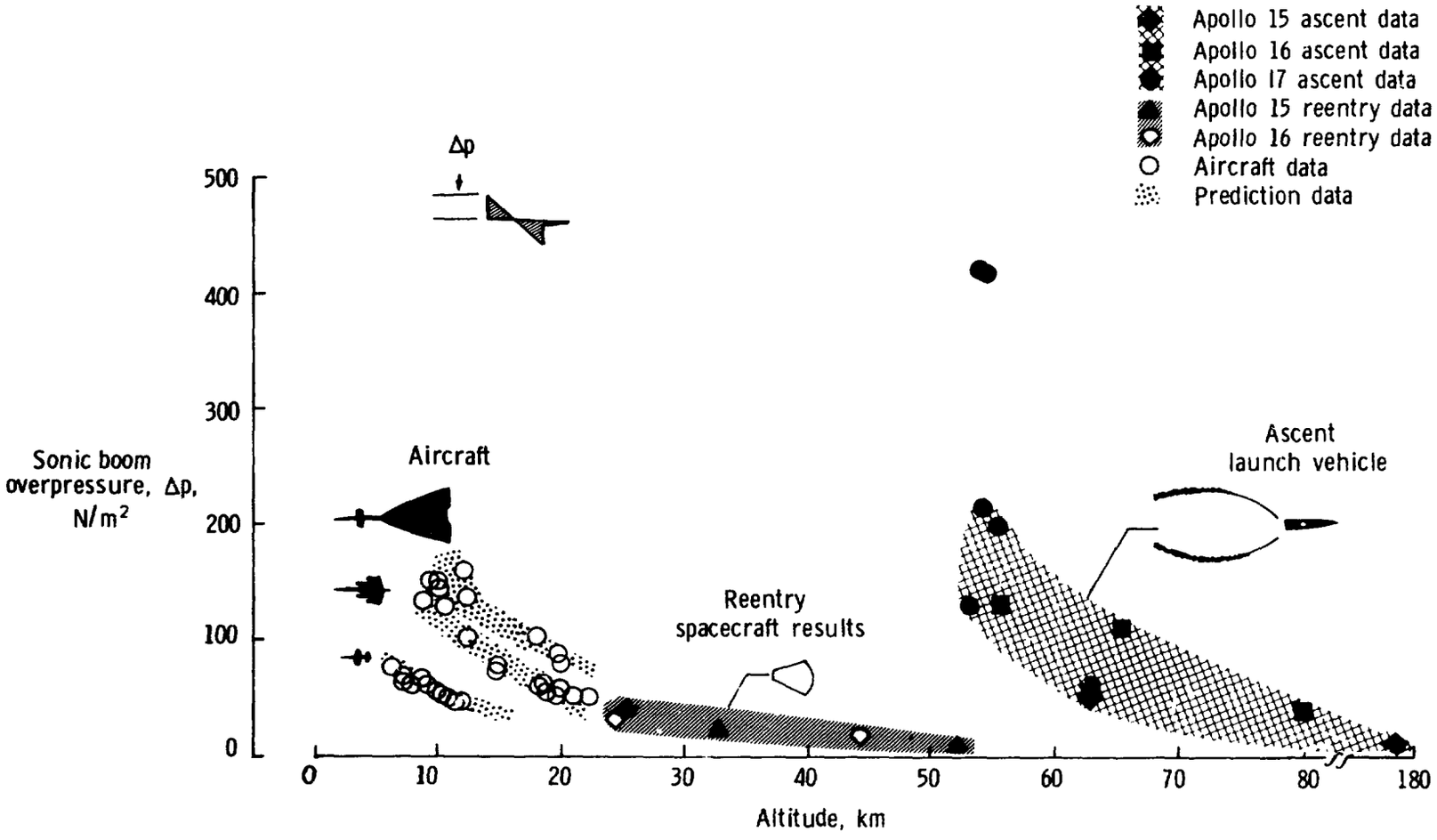

Figure 14 · Predicted and measured overpressure data as a function of altitude for various aircraft and Apollo space vehicles.