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APOLLO RANGE SAFETY DESTRUCT TIME DELAY

SATURN IB AND SATURN V

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MANNED SPACECRAFT CENTER

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ADDENDUM

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SATURN IB AND SATURN V

(OFF-NOMINAL INITIAL ATTITUDES AND THRUST DISPERSIONS)

Prepared by: Charles Teixeira
Charles Teixeira
AST, Mission Feasibility Branch

Authorized for Distribution:

Warren Gillespie, Jr.
for Maxime A. Faget
Assistant Director for Engineering and Development

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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APOLLO RANGE SAFETY DESTRUCT TIME DELAY
SATURN IB AND SATURN V
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By Charles Teixeira

SUMMARY

The required Range Safety Destruct Time Delay was determined previously (ref. 1) for the cases of aborts at nominal initial attitudes ($\alpha_o = 0°$, $q_o = 0°$). The results of the second phase of the study in which off-nominal attitudes were studied is reported herein. Various combinations of angle of attack and pitch rate ($\alpha_o = \pm 15°$ $q_o = \pm 5°/sec$) were considered in addition to several off-nominal thrust conditions.

The off-nominal cases indicate a need for time delays of 3.40 seconds for the Saturn IB and 4.20 seconds for the Saturn V as compared to the nominal case times of 3.27 and 4.10 seconds, respectively. It is recommended that the time delays required for the off-nominal cases be the Range Safety Destruct Time Delays for the Saturn IB and V; namely 3.40 and 4.20 seconds, respectively.

INTRODUCTION

The required Range Safety Destruct Time Delay determined in the previous study assumed nominal aborts only, specifically, aborts at zero degrees initial angle of attack and zero degrees/second pitch rate. This simplifying assumption was made in order to obtain preliminary answers as quickly as possible. It is obvious that Range Safety Destruct Action will not be employed unless the launch vehicle exceeds its predetermined corridor. In almost every case this implies a LV failure resulting in some attitude-time history other than nominal. Consequently, this study was performed primarily to determine the effect of various initial attitudes (at time of abort) on the required time delays determined in the previous study. In order to limit the scope of the study to a reasonable level it was arbitrarily assumed that the aborts occurred at the present limits of ±15° angle of attack or a ±5°/sec pitch rate and combinations thereof. These attitude limits will obviously be the upper limits for the Range Safety case since any angle of attack or pitch rate at or above these limits will result in an abort whether or not the range safety corridor has been violated. In addition, several "worst" cases were studied which assumed that the LV thrust (Saturn V only) was at its 3σ high side and the LES thrust was at its 3σ low side. These thrust conditions together with the worst initial attitude condition resulted in the poorest separation histories and consequently the longest time delays.

The ground rules employed in this study were essentially the same ones used in the previous study and will be discussed in this paper only in regards to exceptions or additions.

SYMBOLS

C_P	Pressure coefficient
C_T	Escape motor thrust coefficient
M#	Mach number
P_A	Aerodynamic pressure, psi
P_{TOT}	Sum of aerodynamic pressure (P_A) and static equivalent of pressure associated with the shock front ($2\Delta P$), psi
$\bar{P}_{TOT}$	Average of above, psi
P_∞	Ambient pressure, psi
Δ_P	Peak pressure associated with the shock front, psi above ambient
q	Dynamic pressure, psf
q_o	Initial pitch rate, deg/sec
R	Separation distance, usually from center of detonation, ft
t	Time, sec
t_D	Time of detonation in seconds after command module-launch vehicle separation
t_{sa}	Time shock front reaches command module in seconds after command module-launch vehicle separation
V_{LV}	Launch vehicle velocity at time of abort, ft/sec

α Command module angle of attack during abort, deg

α_o Initial command module angle of attack at separation, deg

γ_o Flight path angle (launch vehicle) relative to horizontal at time of abort, deg

GROUND RULES

Abort Trajectories

Six combinations of initial angle of attack and pitch rate were studied for each LV on the pad and at 20, 30, and 40,000 feet.

$\alpha_o{}^\circ$	15	-15	0	0	-15	15
$q_o{}^\circ$/sec	0	0	-5	5	-5	5

The LV-CM separation trajectories (relative to the assumed center of explosion) are given in figures 1 to 4 for the Saturn IB and figures 5 to 8 for the Saturn V. The corresponding q, M#, and C_T histories were not included due to the large number of curves involved.

Trajectories of the off-nominal thrust cases are given in figures 9 to 11. Since current trajectory dispersion data was available only for the Saturn V at the time the study was performed, the cases studied were limited to the Saturn V. The initial attitudes chosen for the off-nominal thrust cases were the ones which resulted in the highest pressure loads for the nominal thrust cases.

PAD	$\alpha_o = 15^\circ$, $q_o = 5^\circ$/sec	3σ low LES thrust 3σ high LV thrust
20 000 ft	$\alpha_o = -15^\circ$, $q_o = -5^\circ$/sec	3σ low LES thrust 3σ high LV thrust
30 000 ft	$\alpha_o = -15^\circ$, $q_o = -5^\circ$/sec	3σ low LES thrust 3σ high LV thrust

Aerodynamic Loads

In the previous study, angle of attack oscillations during all of the aborts studied approached but did not exceed ±20°. The assumption was then made that the CM was at an angle of attack of 20° at the instant of shock front passage and the aerodynamic pressure distributions were calculated for this angle of attack. In the present study, the angle of attack oscillations frequently exceeded 20° and approached but did not exceed ±25°. Consequently, for these cases, aerodynamic pressure distributions were calculated at the maximum angle of attack attained of +25°.

PROCEDURE

Abort trajectories were run for each of the six initial attitude conditions at each altitude considered for both the Saturn IB and V[1]. A reiteration program was used as in the previous study to determine the shock arrival time. the flight parameters (q, M#, C_T, et cetera) at the instant of shock front passage, overpressure, et cetera. The results are presented in tables I to IV. The data is presented for each of the six combinations of angle of attack and pitch rate including for reference purposes, the nominal case of $\alpha_o = 0° \; q_o = 0°/sec$ from the previous study.

The procedure employed was to pick the particular initial attitude which resulted in the combination of highest aerodynamic and overpressure loads and to concentrate the study on these cases. For example, the Saturn IB pad case of $\alpha_o = 15° = q_o = 5°/sec$ ($t_D = 2.00$ seconds) results in a combination of aerodynamic pressures and overpressures which when combined are higher than the total pressures encountered in the other cases. The aerodynamic pressure distributions for these worst cases were calculated as in the previous study and are given in tables V to XI. The area around station 93 was again considered to be critical and the aerodynamic pressures at this station were totaled with the static equivalent of the overpressure in tables XII to IV. The total pressures acting on the CM are then averaged in order to obtain an average circumferential load at station 93. (The pressures are symmetrical about the pitch plane). This average total load (P_{TOT}) is then plotted

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[1]The 10 000 ft case was omitted in this study since the previous study indicated this altitude region did not present any time delay requirement above that of the pad or the 20 to 40 000 ft cases.

as a function of detonation time in figures 12 and 13. The total ... -age loads which equal the symmetrical limit of 6.1 psi is then the minimum acceptable detonation time as long as the unsymmetrical load limit is also not exceeded. The maximum acceptable detonation time (safe destruct time) plus the .5 second lag time is then the required Range Safety Destruct Time Delay.

The 30 000 foot case resulted in a discontinuity in the total pressure loading between detonation times (t_D) of 2.4 and 2.5 seconds for the IB and 2.9 and 3.0 seconds for the Saturn V. This is due to the CM's ability to outrun the shock front for a short time at this particular altitude. The CM is not able to remain ahead of the shock front for the 10 seconds under consideration until aborts at 40 000 feet and above. In order to better define the "knee" in the total pressure curves as a function of detonation time, several cases were run between detonation times of 2.00 and 3.00 seconds for the worst initial altitude conditions.

The off nominal thrust cases were studied by the same procedure discussed above. Altitudes of 0, 20, and 30 000 feet were considered for the Saturn V. The LES main motor thrust was assumed to be at the 3σ low level and the LV thrust was assumed to be at the 3σ high level. The initial attitudes assumed were the ones which resulted in the highest loads in the former cases. The shock arrival times, flight parameters, et cetera, for each assumed detonation time is given in table XVI, and the aerodynamic pressure distributions are given in table XVII. The total pressure load summary is given in table XVIII with the average total pressure (P_{TOT}) plotted as a function of detonation time in figure 14.

CONCLUSIONS

The safe destruct times obtained from figures 12 to 14 are summarized on the following page together with their corresponding required Range Safety Destruct Time Delays. (Safe destruct time +.5 sec = Range Safety Destruct Time Delay).

The time delays required by the off-nominal attitude aborts studied do not differ appreciably from the delays determined necessary in the previous study for the nominal attitude aborts. This is due to the small effect the initial attitude has on the separation-time histories during the early portion of the abort trajectory as can be seen from the table on the following page.

	Saturn IB		Saturn V			
	Nominal thrust				3σ Thrust dispersion	
	Safe destruct time, sec	Required range safety time delay, sec	Safe destruct time, sec	Required range safety time delay, sec	Safe destruct time, sec	Required range safety time delay, sec
Pad	2.90	3.40	3.70	4.20	3.73	4.23
20 000 ft.	2.64	3.14	3.05	3.55	3.92	4.42
30 000 ft.	2.44	2.94	2.90	3.40	3.49	3.99
40 000 ft.	2.00	2.50	<3.00	<3.50	----	----

	Saturn IB		Saturn V	
	Nominal	Off-nominal	Nominal	Off- nominal
Pad	3.27	3.40	4.10	4.20
20 000 ft.	2.79	3.14	3.26	3.55
30 000 ft.	3.00	2.94	3.61	3.40
40 000 ft.	2.50	2.50	3.50	3.50

The worst initial attitude at each altitude ($\alpha_o = -15^\circ$, $q_o = -5^\circ$/sec for altitude cases and $\alpha_o = +15^\circ$, $q_o = 5^\circ$/sec for the pad case) resulted in just slightly higher required time delays. The longest time delay required occurs on the pad and the recommended time delay will again be determined by the pad case.

The off-nominal thrust cases established the required time delay to be at $\approx$ 20 000 feet. This is near the altitude where the LEV experiences the severest drag loads and consequently the worst LV-CM separation-time history. In addition, the assumptions made were such as to produce a "worst case." The pitch up attitude ($\alpha_o = -15^\circ$, $q_o = -5^\circ$/sec) resulted in the CM being "chased" by the LV which together with the thrust conditions assumed (LV 3σ high side and LES 3σ low side) resulted in a particularly severe separation-time history with the subsequent high loading. The probability of these events occurring together is extremely small and consequently the required off nominal thrust time delays should be of academic interest only.

The recommended fixed time delays during first stage burn for the Saturn IB and the Saturn V are 3.40 and 4.20 seconds, respectively, as determined by the worst off nominal initial attitude case on the pad.

REFERENCE

1. NASA Apollo Program Working Paper No. 1161, Apollo Range Safety Destruct Time Delay – Saturn IB and Saturn V.

TABLE [illegible].- SHOCK ARRIVAL TIMES, OVERPRESSURES, AND FLIGHT

PARAMETERS AT TIME OF SHOCK ARRIVAL - SATURN IB AND V

PAD

	SATURN IB							SATURN V						
	t_D = 2.00													
α_0/β_0	t_{sa}	q	$M^{\#}$	C_T	R	ΔP	α_{MAX}	t_{sa}	q	$M^{\#}$	C_T	R	ΔP	α_{MAX}
[illegible]	[illegible]	[illegible]	0.43	3.[illegible]	[illegible]	[illegible]	[illegible]	2.24	268	0.43	3.92	700	19.1	15.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible].90	[illegible]	2.21	270	.43	3.90	670	21.3	[illegible]
-1[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]30	[illegible]	10.0	2.22	[illegible]	.42	4.06	[illegible]90	19.9	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.2[illegible]	263	.42	4.01	670	21.3	7.0
[illegible]	[illegible]	[illegible]	[illegible]	3.[illegible]	[illegible]	[illegible]	14.0	2.[illegible]	[illegible]	.42	4.14	670	21.3	14.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1[illegible]	2.22	2[illegible]2	.42	4.0[illegible]	700	19.[illegible]	10.0
15/5	[illegible]	[illegible]84	.44	3.70	[illegible]	3.20	13.0	2.20	270	.43	3.96	660	21.3	13.0
	t_D = 3.00													
0/0	4.[illegible]	521	0.62	0.59	1880	1.32	1[illegible].0	4.00	538	0.62	0.76	1740	3.55	1[illegible].0
15/0	4.[illegible]	[illegible]4	.63	.63	1805	1.40	8.0	4.01	562	.63	.73	1760	3.55	8.0
-15/0	4.18	[illegible]	.61	.68	1780	1.42	10.0	4.01	524	.61	.78	1760	3.55	10.0
0/-5	4.20	[illegible]	.62	.66	1805	1.40	7.0	4.06	537	.62	.73	1830	3.30	7.0
0/5	4.15	530	.61	.69	1740	1.48	14.0	4.05	534	.62	.74	1790	3.45	14.0
-15/-5	4.1[illegible]	[illegible]	.61	.69	1750	1.47	1[illegible].0	4.06	528	.62	.74	1910	3.35	10.0
15/5	4.10	[illegible]	.63	.68	[illegible]	1.52	13.0	3.98	565	.63	.76	1700	3.75	13.0
	t_D = 4.00													
0/0	6.[illegible]	[illegible]	0.51	0.1[illegible]	3110	0.79	15.0	5.98	374	0.52	0.17	3030	1.50	15.0
15/0	6.17	3[illegible]	.53	.13	3065	.80	8.0	6.00	402	.54	.15	3030	1.50	8.0
-15/0	6.10	344	.51	.16	[illegible]	.83	10.0	5.95	357	.52	.19	2960	1.57	10.0
0/-5	6.17	3[illegible]	.51	.15	3065	.80	7.0	6.00	364	.52	.17	30[illegible]0	1.50	7.0
0/5	6.06	37[illegible]	.52	.16	2925	.84	14.0	5.93	384	.53	.18	2950	1.56	14.0
-15/-5	6.12	340	.51	.16	3000	.82	10.0	6.00	352	.51	.18	3040	1.05	10.0
15/5	6.16	3[illegible]	.54	.13	3055	.81	13.0	5.95	417	.55	.16	2970	1.57	13.0

TABLE II.- SHOCK ARRIVAL TIMES, OVERPRESSURES, AND FLIGHT PARAMETERS AT TIME OF SHOCK ARRIVAL - SATURN IB AND V

20 000 FT

	Saturn IB							Saturn V						
	t_D = 2.00													
α_o/q_o	t_{sa}	q	M#	C_T	R	ΔP	α_{MAX}	t_{sa}	q	M#	C_T	R	ΔP	α_{MAX}
0/0	2.21	658	1.02	1.65	495	5.54	17.0	2.14	654	1.02	1.63	525	16.45	18.0
15/0	2.22	650	1.02	1.65	517	5.07	11.0	2.13	663	1.02	1.60	497	18.68	11.0
-15/0	2.18	644	1.01	1.64	459	6.50	23.0	2.11	658	1.02	1.62	472	20.98	24.0
0/-5	2.21	650	1.02	1.62	495	5.54	13.0	2.12	661	1.02	1.60	485	19.68	16.0
0/5	2.22	650	1.02	1.62	515	5.09	16.0	2.13	663	1.02	1.60	496	18.77	18.0
-15/-5	2.17	644	1.01	1.65	452	6.72	23.0	2.11	658	1.02	1.62	469	21.30	23.0
15/5	2.23	650	1.02	1.62	525	4.89	12.0	2.13	663	1.02	1.60	501	18.30	12.0
	t_D = 3.00													
0/0	4.83	517	0.95	0.37	2428	0.44	17.0	4.24	590	1.01	0.65	1928	1.29	18.0
15/0	4.91	508	.95	.34	2516	.42	11.0	4.22	610	1.02	.56	1898	1.32	11.0
-15/0	4.81	513	.95	.37	2402	.45	23.0	4.09	626	1.04	.61	1741	1.51	24.0
0/-5	4.86	510	.95	.36	2461	.44	13.0	4.15	618	1.03	.59	1815	1.41	16.0
0/5	4.90	504	.95	.35	2506	.43	16.0	4.22	608	1.02	.56	1897	1.32	18.0
-15/-5	4.79	515	.96	.38	2378	.46	23.0	4.05	633	1.04	.62	1692	1.57	23.0
15/5	4.92	507	.95	.34	2530	.42	12.0	4.24	607	1.02	.55	1926	1.29	12.0
	t_D = 4.00													
0/0	6.15	388	0.84	0.10	2810	0.35	17.0	5.92	410	0.85	0.17	2722	0.80	18.0
15/0	6.31	384	.85	.11	2987	.32	11.0	5.85	431	.89	.17	2635	.84	11.0
-15/0	6.16	380	.84	.14	2817	.35	23.0	5.72	427	.88	.21	2484	.90	24.0
0/-5	6.22	382	.85	.13	2881	.34	13.0	5.76	427	.88	.19	2542	.88	16.0
0/5	6.25	379	.84	.12	2928	.33	16.0	5.82	421	.88	.19	2603	.85	18.0
-15/-5	6.14	381	.84	.14	2789	.36	23.0	5.69	430	.88	.21	2452	.92	23.0
15/5	6.31	383	.85	.11	2995	.32	12.0	5.87	428	.88	.17	2662	.83	12.0

TABLE III.- SHOCK ARRIVAL TIMES, OVERPRESSURES, AND FLIGHT

PARAMETERS AT TIME OF SHOCK ARRIVAL - SATURN IB AND V

30 000 FT

	SATURN IB							SATURN V						
	t_D = 2.00													
α_o/ψ_o	t_{sa}	q	M	C_T	R	ΔP	q_{MAX}	t_{sa}	q	M	C_T	R	ΔP	q_{MAX}
0/0	2.08	686	1.31	1.50	316	13.2	19.0	2.06	711	1.33	1.51	364	33.8	19.0
15/0	2.07	688	1.32	1.55	301	14.7	8.0	2.06	715	1.34	1.49	366	33.5	9.0
-15/0	2.05	677	1.30	1.58	266	19.6	25.0	2.06	704	1.33	1.52	349	37.5	21.0
0/-5	2.06	685	1.31	1.56	277	17.9	17.0	2.06	712	1.34	1.50	358	35.0	17.0
0/5	2.08	686	1.31	1.55	307	14.1	19.0	2.06	712	1.34	1.50	361	32.8	19.0
-15/-5	2.05	677	1.31	1.58	259	20.9	25.0	2.05	703	1.33	1.52	344	38.6	25.0
15/5	2.08	688	1.31	1.55	309	13.9	9.0	2.06	714	1.34	1.50	370	32.7	10.0
	t_D = 2.30													
-15/-5	2.44	637	1.32	1.53	416	7.05	25.0							
	t_D = 2.40													
-15/-5	2.67	690	1.33	1.51	600	3.18	25.0							
	t_D = 2.50													
-15/-5	8.51	239	.89	0	7116	0.02	25.0	2.63	722	1.36	1.40	520	14.86	25.0
	t_D = 2.70													
-15/-5								2.89	723	1.37	1.38	629	9.60	25.0
	t_D = 2.80													
-15/-5								3.04	725	1.37	1.36	722	7.04	25.0
	t_D = 3.00													
0/0	8.76	230	.89	0	6844	.02	19.0	8.40	255	0.92	0	6748	0.16	19.0
15/0	8.95	229	.89	0	7050	.02	8.0	8.72	251	.91	0	7013	.15	9.0
-15/0	8.49	239	.89	0	6526	.028	25.0	----	----	----	----	----	----	21.0
0/-5	8.72	230	.89	0	6790	.023	17.0	8.46	254	.92	0	6716	.16	17.0
0/5	8.75	229	.89	0	6816	.023	19.0	8.48	256	.92	0	6739	.16	19.0
-15/-5	8.50	239	.89	0	6541	.028	25.0	----	----	----	----	----	----	25.0
15/5	8.94	228	.89	0	7040	.019	9.0	8.70	252	.91	0	6984	.15	10.0
	t_D = 4.00													
0/0	8.77	230	.89	0	5719	2.05	19.0	8.39	261	0.92	0	5501	.24	19.0
15/0	8.98	227	.89	0	5954	.043	8.0	8.65	255	.92	0	5794	.22	9.0
-15/0	8.52	238	.89	0	5428	.060	25.0	----	----	----	----	----	----	21.0
0/-5	8.72	230	.89	0	5659	.053	17.0	8.35	260	.93	0	5457	.24	17.0
0/5	8.76	229	.89	0	5701	.050	19.0	8.39	260	.93	0	5500	.24	19.0
-15/-5	8.51	239	.89	0	5422	.060	25.0	----	----	----	----	----	----	25.0
15/5	8.98	226	.88	0	5950	.043	9.0	8.64	255	.92	0	5779	.22	10.0

TABLE IV.- SHOCK ARRIVAL TIMES, OVERPRESSURES, AND FLIGHT

PARAMETERS AT TIME OF SHOCK ARRIVAL - SATURN IB AND V

40 000 FT

	SATURN IB							SATURN V						
								t_D = 2.00						
α_0/β_0	t_{sa}	q	M#	C_T	R	ΔP	q_{MAX}	t_{sa}	q	M#	C_T	R	ΔP	q_{MAX}
0/0								2.13	768	1.78	1.38	561	11.0	14.0
15/0								2.13	774	1.79	1.37	545	11.85	9.0
-15/0								2.13	774	1.79	1.37	530	12.00	16.0
0/-5								2.13	775	1.79	1.37	550	11.57	11.0
0/5								2.13	775	1.79	1.37	563	10.99	13.0
-15/-5								2.10	760	1.77	1.40	495	14.75	22.0
15/5								2.13	774	1.79	1.37	547	11.76	9.0
								t_D = 3.00						
0/0														
15/0														
-15/0														
0/-5														
0/5														
-15/-5														
15/5														
								t_D = 4.00						
0/0														
15/0														
-15/0														
0/-5														
0/5														
-15/-5														
15/5														

CM outruns shock front

TABLE V.- AERODYNAMIC PRESSURE DISTRIBUTIONS PAD ABORT - SATURN IB

$\left[P_A = C_p q + 1, \text{psi}\right]$

STA	ψ	t_{sa} = 2.28 sec	t_{sa} = 4.10 sec	t_{sa} = 6.16 sec
93	0.0	0.871	0.922	0.945
	67.5	.771	1.925	1.655
	82.5	.680	1.961	1.679
	97.5	.436	2.050	1.742
	112.5	2.385	2.015	1.716
	157.5	2.970	4.740	3.640
	180.0	2.491	4.590	3.540
81	0.0	0.926	1.207	2.450
	22.5	.989	1.172	1.121
	45.0	.871	.672	.768
	82.5	.254	1.207	1.147
	97.5	1.127	1.656	1.464
	112.5	2.020	2.335	1.945
	135.0	2.730	2.820	2.290
	157.5	2.300	3.930	3.070
	180.0	2.140	4.080	3.190
44	0.0	0.644	0.403	.579
	22.5	.717	.348	.539
	45.0	.672	.134	.789
	67.5	-.250	.204	.436
	82.5	.379	.617	.729
	97.5	1.108	.957	.970
	112.5	1.374	1.262	1.185
	135.0	1.946	2.050	1.744
	157.5	2.520	2.730	2.225
	180.0	1.455	2.890	2.340

TABLE VI.- AERODYNAMIC PRESSURE DISTRIBUTIONS 20 000 FT ABORT - SATURN IB

$\left[P_A = C_p q + 1, \text{ psi} \right]$

STA	ϕ	t_{sa} = 2.17 sec	t_{sa} = 4.79 sec	t_{sa} = 6.14 sec
93	0.0	0.757	1.090	0.855
	67.5	.521	2.116	1.368
	82.5	1.304	2.472	1.408
	97.5	3.767	3.317	1.714
	120.0	5.460	3.767	1.910
	157.5	4.580	4.570	1.772
	180.0	4.760	4.380	2.012
81	0.0	1.415	1.226	1.045
	22.5	.714	1.411	1.076
	45.0	.019	.950	.595
	82.5	1.554	2.025	.923
	97.5	3.340	2.450	1.493
	120.0	4.620	3.140	2.100
	142.5	6.140	4.170	2.540
	157.5	3.320	5.510	3.470
	180.0	3.960	5.360	3.480
44	0.0	1.120	1.169	.653
	22.5	.920	.739	.593
	45.0	.554	.792	.444
	67.5	-.250	.889	.430
	82.5	1.094	1.200	.669
	97.5	2.060	1.620	.973
	120.0	2.900	3.140	1.410
	142.5	4.710	3.030	2.230
	157.5	4.400	4.090	3.050
	180.0	4.080	6.620	3.110

TABLE VII.- AERODYNAMIC PRESSURE DISTRIBUTIONS 30 000 FT ABORT - SATURN IB

$[P_A = C_p q + 1, \text{psi}]$

STA	ø	t_{sa} = 2.05 sec = 2.44 sec = 2.67 sec	t_{sa} = 8.50 sec	t_{sa} = 8.51 sec
93	0.0	0.411	0.924	0.924
	67.5	.509	1.239	1.239
	82.5	1.889	1.324	1.324
	97.5	4.740	1.329	1.329
	120.0	6.637	1.397	1.397
	157.5	5.000	2.732	2.732
	180.0	5.170	2.724	2.724
81	0.0	0.404	1.005	1.005
	22.5	.254	1.015	1.015
	45.0	.131	.759	.759
	82.5	2.550	1.002	1.002
	97.5	4.640	1.239	1.239
	120.0	5.890	1.612	1.612
	142.5	6.770	1.831	1.831
	157.5	3.780	2.555	2.555
	180.0	4.570	2.630	2.630
44	0.0	1.249	.769	.769
	22.5	.494	.698	.698
	45.0	.554	.642	.642
	67.5	.732	.628	.628
	82.5	2.110	.750	.750
	97.5	3.270	.970	.970
	120.0	4.200	1.242	1.242
	142.5	6.010	1.756	1.756
	157.5	4.880	2.210	2.210
	180.0	5.240	2.290	2.290

TABLE VIII. - AERODYNAMIC PRESSURE DISTRIBUTIONS PAD ABORT - SATURN V

$$\left[P_A = C_p q + 1, \text{ psi}\right]$$

STA	ϕ	t_{sa} = 2.20 sec	t_{sa} = 3.98 sec	t_{sa} = 5.95 sec
93	0.0	0.879	0.922	0.942
	67.5	.784	1.929	1.685
	82.5	.699	1.965	1.711
	97.5	1.530	2.050	1.779
	120.0	2.303	2.010	1.751
	157.5	2.851	4.760	3.770
	180.0	2.405	4.600	3.660
81	0.0	0.931	1.208	1.154
	22.5	.991	1.172	1.240
	45.0	.879	.670	.757
	82.5	.297	1.208	1.159
	97.5	1.119	1.660	1.486
	120.0	1.960	2.340	1.990
	142.5	2.628	2.830	2.350
	157.5	2.226	3.940	3.170
	180.0	2.072	4.100	3.290
44	0.0	0.665	0.400	.558
	22.5	.734	.345	.516
	45.0	.691	.130	.356
	67.5	-.176	.200	.310
	82.5	.416	.616	.716
	97.5	.102	.957	.369
	120.0	1.352	1.262	1.194
	142.5	1.891	2.050	1.779
	157.5	2.431	2.740	2.280
	180.0	1.428	2.900	2.400

TABLE IX.- AERODYNAMIC PRESSURE DISTRIBUTIONS 20 000 FT ABORT - SATURN V

$\left[P_A = C_p q + 1, \text{psi}\right]$

STA	ϕ	t_{sa} = 2.11 sec	t_{sa} = 4.05 sec	t_{sa} = 5.69 sec
93	0.0	0.751	1.312	0.852
	67.5	.675	2.082	1.425
	82.5	1.312	2.713	1.558
	97.5	3.840	4.080	1.869
	120.0	5.570	5.157	2.240
	157.5	4.667	3.966	3.740
	180.0	4.853	3.713	3.630
81	0.0	1.425	1.449	1.054
	22.5	.706	1.850	1.146
	45.0	.990	.872	.594
	82.5	1.568	2.180	1.135
	97.5	3.400	3.010	1.406
	120.0	4.710	3.910	2.310
	142.5	6.280	5.510	2.900
	157.5	3.380	5.080	3.740
	180.0	4.040	4.520	3.670
44	0.0	1.123	4.830	1.338
	22.5	.917	5.840	.554
	45.0	.543	.828	.375
	67.5	.280	1.110	.358
	82.5	1.096	1.338	.665
	97.5	2.090	1.861	1.045
	120.0	2.950	2.500	1.494
	142.5	4.810	3.780	2.450
	157.5	4.490	5.360	3.380
	180.0	4.160	5.710	3.890

TABLE X.- AERODYNAMIC PRESSURE DISTRIBUTIONS 30 000 FT ABORT - SATURN V

$[P_A = C_p q + 1, \text{psi}]$

STA	ϕ	t_{sa} = 2.05 sec	t_{sa} = 2.63 sec	t_{sa} = 2.89 sec = 3.04 sec	t_{sa} = 8.39 sec	t_{sa} = 8.48 sec
93	0.0	0.387	0.558	.366	0.919	0.919
	67.5	.285	.715	.261	1.255	1.261
	82.5	1.923	2.493	1.954	1.262	1.258
	97.5	4.893	5.154	5.020	1.350	1.346
	120.0	6.857	7.040	7.050	1.424	1.286
	157.5	5.047	5.203	5.170	2.847	2.827
	180.0	5.340	5.113	5.480	2.064	2.813
81	0.0	.380	0.545	0.360	1.005	1.005
	22.5	.225	.430	.200	1.016	1.016
	45.0	.099	.254	.070	.744	.746
	82.5	2.610	2.900	2.660	1.002	1.002
	97.5	4.780	4.860	4.900	1.255	1.252
	120.0	6.070	6.140	6.240	1.653	1.245
	142.5	7.000	7.240	7.200	1.888	1.876
	157.5	3.980	3.950	4.080	2.660	2.640
	180.0	4.720	4.660	4.840	.826	2.720
44	0.0	1.259	1.255	1.268	.754	.757
	22.5	.474	.720	.456	.678	.682
	45.0	.535	.750	.520	.618	.622
	67.5	.721	.825	.712	.604	.608
	82.5	2.160	2.150	2.200	.733	.636
	97.5	3.360	3.250	3.440	.968	.685
	120.0	4.330	4.270	4.440	1.258	1.255
	142.5	6.200	4.730	6.370	1.790	1.796
	157.5	5.030	5.610	5.160	2.290	2.270
	180.0	5.400	5.840	5.550	2.380	2.360

TABLE XI.- AERODYNAMIC PRESSURE DISTRIBUTIONS

40 000 FT ABORT - SATURN V

$\left[P_A = C_p q + 1, \text{ psi}\right]$

STA	ϕ	$t_{sa} = 2.10$
93	0.0	0.041
	67.5	- .033
	82.5	.048
	97.5	3.660
	112.5	3.596
	180.0	2.848
81	0.0	0.050
	22.5	- .120
	45.0	- .100
	82.5	.030
	97.5	5.030
	135.0	6.510
	157.5	3.260
	180.0	3.100
44	0.0	0.678
	22.5	.551
	45.0	.746
	67.5	.894
	82.5	2.780
	97.5	4.220
	112.5	5.610
	135.0	7.500
	157.5	6.720
	180.0	6.520

TABLE XII.- LOAD SUMMARY - PAD CASE

SATURN IB

	t_{sa} = 2.28 (t_D = 2.00)			t_{sa} = 4.10 (t_D = 3.00)			t_{sa} = 6.16 (t_D = 4.00)		
ϕ	P_A	$2\Delta P$	P_{TOT}	P_A	$2\Delta P$	P_{TOT}	P_A	$2\Delta P$	P_{TOT}
0.0	0.87	16.40	17.27	0.92	3.04	3.96	0.95	1.62	2.57
67.5	.77		17.17	1.93		4.97	1.66		3.28
82.5	.68		17.08	1.96		5.00	1.68		3.30
97.5	.44		16.84	2.05		5.09	1.74		3.36
112.5	2.39		18.79	2.02		5.06	1.72		3.34
157.5	2.97		19.37	4.74		7.78	3.64		5.26
180.0	2.49		18.89	4.59		7.63	3.54		5.16
		$\overline{P}_{TOT}$ =	17.88 psi		$\overline{P}_{TOT}$ =	5.61 psi		$\overline{P}_{TOT}$ =	3.73 psi

SATURN V

	t_{sa} = 2.20 (t_D = 2.00)			t_{sa} = 3.98 (t_D = 3.00)			t_{sa} = 5.95 (t_D = 4.00)		
ϕ	P_A	$2\Delta P$	P_{TOT}	P_A	$2\Delta P$	P_{TOT}	P_A	$2\Delta P$	P_{TOT}
0.0	0.88	42.60	43.48	0.92	7.50	8.42	0.94	3.14	4.08
67.5	.78		43.38	1.93		9.43	1.69		4.83
82.5	.70		43.30	1.97		9.47	1.71		4.85
97.5	1.53		44.13	2.05		9.55	1.78		4.92
112.5	2.30		44.90	2.01		9.51	1.75		4.89
157.5	2.85		45.45	4.76		12.26	3.77		6.91
180.0	2.41		45.01	4.60		12.10	3.66		6.80
		$\overline{P}_{TOT}$ =	44.07 psi		$\overline{P}_{TOT}$ =	10.08 psi		$\overline{P}_{TOT}$ =	5.31 psi

TABLE XIII.- LOAD SUMMARY - 20 000 FT CASE

SATURN IB

	t_{sa} = 2.17 (t_D = 2.00)			t_{sa} = 4.79 (t_D = 3.00)			t_{sa} = 6.14 (t_D = 4.00)		
ϕ	P_A	$2\Delta P$	P_{TOT}	P_A	$2\Delta P$	P_{TOT}	P_A	$2\Delta P$	P_{TOT}
0.0	0.76		14.20	1.09		2.01	0.86		1.58
67.5	.52		13.96	2.12		3.04	1.37		2.09
82.5	1.30		14.74	2.47		3.19	1.41		2.13
97.5	3.77	13.44	17.21	3.32	.92	4.24	1.71	.72	2.43
112.5	5.16		18.90	3.77		4.69	1.91		2.63
157.5	4.58		18.02	4.57		5.49	1.77		2.49
180.0	4.76		18.20	4.38		5.30	2.01		2.73
		$\bar{P}_{TOT}$ =	16.51 psi		$\bar{P}_{TOT}$ =	4.05 psi		$\bar{P}_{TOT}$ =	2.32 psi

SATURN V

	t_{sa} = 2.11 (t_D = 2.00)			t_{sa} = 4.05 (t_D = 3.00)			t_{sa} = 5.69 (t_D = 4.00)		
ϕ	P_A	$2\Delta P$	P_{TOT}	P_A	$2\Delta P$	P_{TOT}	P_A	$2\Delta P$	P_{TOT}
0.0	0.75		43.35	1.31		4.45	0.85		2.69
67.5	.68		43.28	2.08		5.22	1.43		3.27
82.5	1.31		43.91	2.71		5.85	1.56		3.40
97.5	3.84	42.60	46.44	4.08	3.14	7.22	1.87	4	3.71
112.5	5.57		48.17	5.16		8.30	2.24		4.08
157.5	4.67		47.27	3.97		7.11	3.74		5.58
180.0	4.85		47.45	3.71		6.85	3.63		5.47
		$\bar{P}_{TOT}$ =	45.75 psi		$\bar{P}_{TOT}$ =	6.06 psi		$\bar{P}_{TOT}$ =	4.02 psi

TABLE XIV.- LOAD SUMMARY - 30 000 FT CASE

SATURN II

	t_{sa} = 2.05 (t_D = 2.00)			t_{sa} = 2.44 (t_D = 2.30)			t_{sa} = 2.67 (t_D = 2.40)		
ϕ	P_A	$2\Delta P$	P_{TOT}	P_A	$2\Delta P$	P_{TOT}	P_A	$2\Delta P$	P_{TOT}
0.0	0.41		42.21	0.41		14.51	0.41		6.79
67.5	.51		42.31	.51		14.61	.51		[illegible]
82.5	1.89	41.80	43.69	1.89	14.10	15.99	1.89	[illegible]	8.27
97.5	4.74		46.54	4.74		18.84	4.74		11.12
112.5	6.64		48.44	6.64		20.74	6.64		13.02
157.5	5.00		46.80	5.00		19.10	5.00		11.38
180.0	5.17		46.97	5.17		19.27	5.17		11.55
		$\bar{P}_{TOT}$ =	45.33 psi		$\bar{P}_{TOT}$ =	17.69 psi		$\bar{P}_{TOT}$ =	9.98 psi

SATURN V

	t_{sa} = 2.05 (t_D = 2.00)			t_{sa} = 2.63 (t_D = 2.50)			t_{sa} = 2.89 (t_D = 2.70)		
ϕ	P_A	$2\Delta P$	P_{TOT}	P_A	$2\Delta P$	P_{TOT}	P_A	$2\Delta P$	P_{TOT}
0.0	0.39		77.59	0.56		30.26	0.37		[illegible]
67.5	.29		77.49	.72		30.44	.26		19.46
82.5	1.92		79.12	2.49		32.21	1.95		21.15
97.5	4.89	77.20	82.09	5.15	29.72	34.87	5.02	19.20	24.22
112.5	6.86		84.06	7.04		36.76	7.05		26.25
157.5	5.05		82.25	5.20		34.92	5.17		24.37
180.0	5.34		82.54	5.11		34.83	5.48		24.68
		$\bar{P}_{TOT}$ =	80.85 psi		$\bar{P}_{TOT}$ =	33.62 psi		$\bar{P}_{TOT}$ =	22.93 psi

TABLE XIV.- LOAD SUMMARY - 30 000 FT CASE - Concluded

SATURN IB

	t_{sa} = 8.51 (t_D = 2.50)			t_{sa} = 8.50 (t_D = 3.00)			t_{sa} = 8.51 (t_D = 4.00)		
ϕ	P_A	$2\Delta P$	P_{TOT}	P_A	$2\Delta P$	P_{TOT}	P_A	$2\Delta P$	P_{TOT}
0.0	0.92		0.96	0.92		0.98	0.92		1.04
67.5	1.24		1.28	1.24		1.30	1.24		1.36
82.5	1.32		1.36	1.32		1.38	1.32		1.44
97.5	1.33	0.04	1.37	1.33	0.06	1.39	1.33	0.12	1.45
112.5	1.40		1.44	1.40		1.46	1.40		1.52
157.5	2.73		2.77	2.73		2.79	2.73		2.85
180.0	2.73		2.77	2.72		2.78	2.72		2.84
		$\bar{P}_{TOT}$ =	1.68 psi		$\bar{P}_{TOT}$ =	1.70 psi		$\bar{P}_{TOT}$ =	1.76 psi

SATURN V

	t_{sa} = 3.04 (t_D = 2.80)			t_{sa} = 8.48 (t_D = 3.00)			t_{sa} = 8.39 (t_D = 4.00)		
ϕ	P_A	$2\Delta P$	P_{TOT}	P_A	$2\Delta P$	P_{TOT}	P_A	$2\Delta P$	P_{TOT}
0.0	0.37		14.45	0.92		1.24	0.92		1.40
67.5	.26		14.34	1.26		1.58	1.26		1.74
82.5	1.95		16.03	1.26		1.58	1.26		1.74
97.5	5.02	14.08	19.10	1.35	0.32	1.67	1.35	0.48	1.83
112.5	7.05		21.13	1.42		1.74	1.29		1.77
157.5	5.17		19.25	2.85		3.15	2.83		3.31
180.0	5.48		19.56	2.06		2.38	2.81		3.29
		$\bar{P}_{TOT}$ =	17.81 psi		$\bar{P}_{TOT}$ =	1.91 psi		$\bar{P}_{TOT}$ =	2.12 psi

TABLE XV.- LOAD SUMMARY - 40 000 FT CASE

SATURN V

ϕ	t_{sa} = 2.10 (t_D = 2.00)		
	P_A	$2\Delta P$	P_{TOT}
0.0	0.04	29.50	29.54
67.5	-.03		29.47
82.5	.05		29.55
97.5	3.66		33.16
112.5	3.60		33.10
180.0	2.85		32.35

$\bar{P}_{TOT}$ = 26.04 psi

TABLE XVI.- SHOCK ARRIVAL TIMES, OVERPRESSURES AND FLIGHT PARAMETERS AT TIME OF SHOCK ARRIVAL

SATURN V

(OFF NOMINAL THRUST)

t_{sa}	q	$M^{\#}$	C_T	R	ΔP	α_{MAX}
PAD						
$t_D = 2.00$						
2.20	240	0.41	4.18	645	22.0	20
$t_D = 3.00$						
3.85	516	0.60	0.98	1540	4.30	20
$t_D = 4.00$						
5.42	433	0.55	0.26	2670	1.82	20
20 000 ft						
$t_D = 2.00$						
2.07	657	1.02	1.55	374	36.25	25
$t_D = 3.00$						
3.31	669	1.06	1.27	794	6.54	25
$t_D = 4.00$						
4.99	486	.93	.30	1628	1.68	25

TABLE XVI.- SHOCK ARRIVAL TIMES, OVERPRESSURES AND

FLIGHT PARAMETERS AT TIME OF SHOCK ARRIVAL

SATURN V

(OFF NOMINAL THRUST) - Concluded

t_{sa}	q	M#	C_T	R	ΔP	α_{MAX}
30 000 ft						
t_D = 2.00						
2.04	711	1.33	1.43	282	60.38	25
t_D = 2.50						
2.57	719	1.36	1.34	395	28.29	25
t_D = 3.00						
3.15	718	1.38	1.23	568	12.25	25
t_D = 3.40						
3.82	713	1.39	1.18	978	3.65	25
t_D = 3.50						
CM out runs shock front						

TABLE XVII.- AERODYNAMIC PRESSURE DISTRIBUTIONS OFF-NOMINAL THRUST ABORTS - SATURN V

$\left[P_A = C_p q + 1, \text{ psi}\right]$

		PAD			20 000 ft			30 000 ft		
STA	ϕ	t_{sa}=2.20 sec.	t_{sa}=3.86 sec.	t_{sa}=5.42 sec.	t_{sa}=2.07 sec.	t_{sa}=3.31 sec.	t_{sa}= 4.99 sec.	t_{sa}=2.04 sec.	t_{sa}=3.15 sec.	t_{sa}= 3.82 sec.
93	0.0	0.880	0.926	0.413	0.468	0.678	1.070	0.411	0.611	1.883
	67.5	.622	1.316	1.460	.423	.820	.966	.652	1.005	1.004
	82.5	.356	1.403	1.547	1.311	1.783	1.374	2.030	2.633	2.620
	97.5	.792	2.278	1.652	3.823	3.967	2.365	4.974	5.213	5.197
	120.0	2.075	2.737	1.864	5.570	5.590	2.923	6.940	7.070	7.020
	157.5	2.455	4.377	3.663	4.660	4.777	3.720	5.214	5.283	5.247
	180.0	2.145	3.680	3.633	4.847	4.507	3.483	5.327	5.137	5.167
81	0.0	0.915	1.101	1.159	0.575	0.824	1.642	0.406	0.651	4.460
	22.5	.962	1.201	1.132	.608	.995	1.291	.254	7.990	7.930
	45.0	.870	.820	.748	-.005	.249	.598	1.880	.387	.391
	82.5	-.010	.817	1.159	1.566	1.882	1.261	2.670	3.180	3.160
	97.5	1.088	1.793	1.505	3.390	3.280	1.875	4.820	4.920	4.890
	120.0	1.886	2.670	2.030	4.710	4.590	2.690	6.120	6.110	6.060
	142.5	2.470	3.590	2.400	6.250	6.310	3.540	7.110	7.340	7.300
	157.5	2.025	3.770	3.250	3.370	3.410	4.040	3.920	3.970	3.940
	180.0	1.899	3.520	3.380	4.020	4.240	3.730	4.740	4.810	4.780
44	0.0	0.685	0.530	0.540	1.123	1.000	.676	1.262	4.490	1.346
	22.5	.762	.565	.499	.918	0.740	.765	.515	.855	.856
	45.0	.710	.400	.334	.544	.451	.296	.516	.850	.852
	67.5	-.050	.090	.388	-.270	.703	.273	.738	1.997	1.990
	82.5	.464	.763	.706	1.096	1.696	.719	2.170	2.[illegible]30	2.270
	97.5	1.118	1.183	.967	2.090	2.280	1.132	3.360	3.300	3.280
	120.0	1.338	1.495	1.201	2.950	2.960	1.650	4.340	4.260	4.230
	142.5	2.080	3.920	2.920	4.800	4.730	2.700	6.260	6.100	6.060
	157.5	2.150	3.480	2.330	4.480	4.920	3.880	5.170	5.540	5.100
	180.0	1.248	3.120	2.450	4.150	4.980	3.810	5.510	6.060	6.040

TABLE XVIII.- LOAD SUMMARY OFF-NOMINAL THRUST CASE

SATURN V

PAD

	t_{sa} = 2.20 (t_D = 2.00)			t_{sa} = 3.86 (t_D = 3.00)			t_{sa} = 5.42 (t_D = 4.00)		
ϕ	P_A	$2\Delta P$	P_{TOT}	P_A	$2\Delta P$	P_{TOT}	P_A	$2\Delta P$	P_{TOT}
0.0	0.88	44.00	44.88	0.93	8.60	9.53	0.41	3.64	4.05
67.5	.62		44.6[illegible]	1.32		9.92	1.46		5.10
82.5	.36		[illegible].30	1.40		10.00	1.55		5.19
97.5	.79		44.79	2.28		10.88	1.65		5.29
120.0	2.08		46.0[illegible]	2.79		11.39	1.86		5.50
157.5	2.46		46.4[illegible]	4.38		12.98	3.66		7.30
180.0	2.15		46.15	3.68		12.28	3.63		7.27

$\bar{P}_{TOT}$ = 45.30 psi $\bar{P}_{TOT}$ = 11.01 psi $\bar{P}_{TOT}$ = 5.67 psi

20 000 ft

	t_{sa} = 2.07 (t_D = 2.00)			t_{sa} = 3.31 (t_D = 3.00)			t_{sa} = 4.99 (t_D = 4.00)		
ϕ	P_A	$2\Delta P$	P_{TOT}	P_A	$2\Delta P$	P_{TOT}	P_A	$2\Delta P$	P_{TOT}
0.0	0.47	72.50	72.97	0.68	13.08	13.76	1.07	3.36	4.43
67.5	.42		72.92	.82		13.90	.97		4.33
82.5	1.31		73.81	1.78		14.86	1.37		4.73
97.5	3.82		76.32	3.97		17.05	2.37		5.73
120.0	5.57		78.07	5.59		18.67	2.92		6.28
157.5	4.66		77.16	4.78		17.86	3.72		7.08
180.0	4.85		77.35	4.51		17.59	3.48		6.84

$\bar{P}_{TOT}$ = 75.57 psi $\bar{P}_{TOT}$ = 16.34 psi $\bar{P}_{TOT}$ = 5.63 psi

30 000 ft

	t_{sa} = 2.04 (t_D = 2.00)			t_{sa} = 2.57 (t_D = 2.50)			t_{sa} = 3.15 (t_D = 3.00)		
ϕ	P_A	$2\Delta P$	P_{TOT}	P_A	$2\Delta P$	P_{TOT}	P_A	$2\Delta P$	P_{TOT}
0.0	0.41	120.76	121.17	0.41	56.58	56.99	0.61	24.50	25.11
67.5	.65		121.41	.65		57.23	1.01		25.51
82.5	2.03		122.79	2.03		58.61	2.63		27.13
97.5	4.97		125.73	4.97		61.48	5.21		29.71
120.0	6.94		127.70	6.94		63.52	7.07		31.57
157.5	5.21		125.97	5.21		61.79	5.28		29.78
180.0	5.33		126.09	5.33		61.91	5.14		29.64

$\bar{P}_{TOT}$ = 1[illegible].53 psi $\bar{P}_{TOT}$ = 55.53 psi $\bar{P}_{TOT}$ = 28.51 psi

TABLE XVIII.- LOAD SUMMARY OFF-NOMINAL THRUST CASE - Concluded

SATURN V

30 000 ft

	t_{sa} = 3.82 (t_D = 3.40)			t_{sa} = —— (t_D = 3.50)		
∅	A	$2\Delta P$	P_{TOT}	P_A*	$2\Delta P$	P_{TOT}
0.0	1.89		9.19	1.89		1.89
67.5	1.00		8.30	1.00		1.00
82.5	2.62		9.92	2.62		2.62
97.5	5.19	7.30	12.49	5.19	0.0	5.19
120.0	7.02		14.32	7.02		7.02
157.5	5.25		12.55	5.25		5.25
180.0	5.17		12.47	5.17		5.17

$\bar{P}_{TOT}$ = 11.40 psi $\qquad$ $\bar{P}_{TOT}$ = 4.10 psi

* Aerodynamic pressures from t_D = 3.40 sec used.

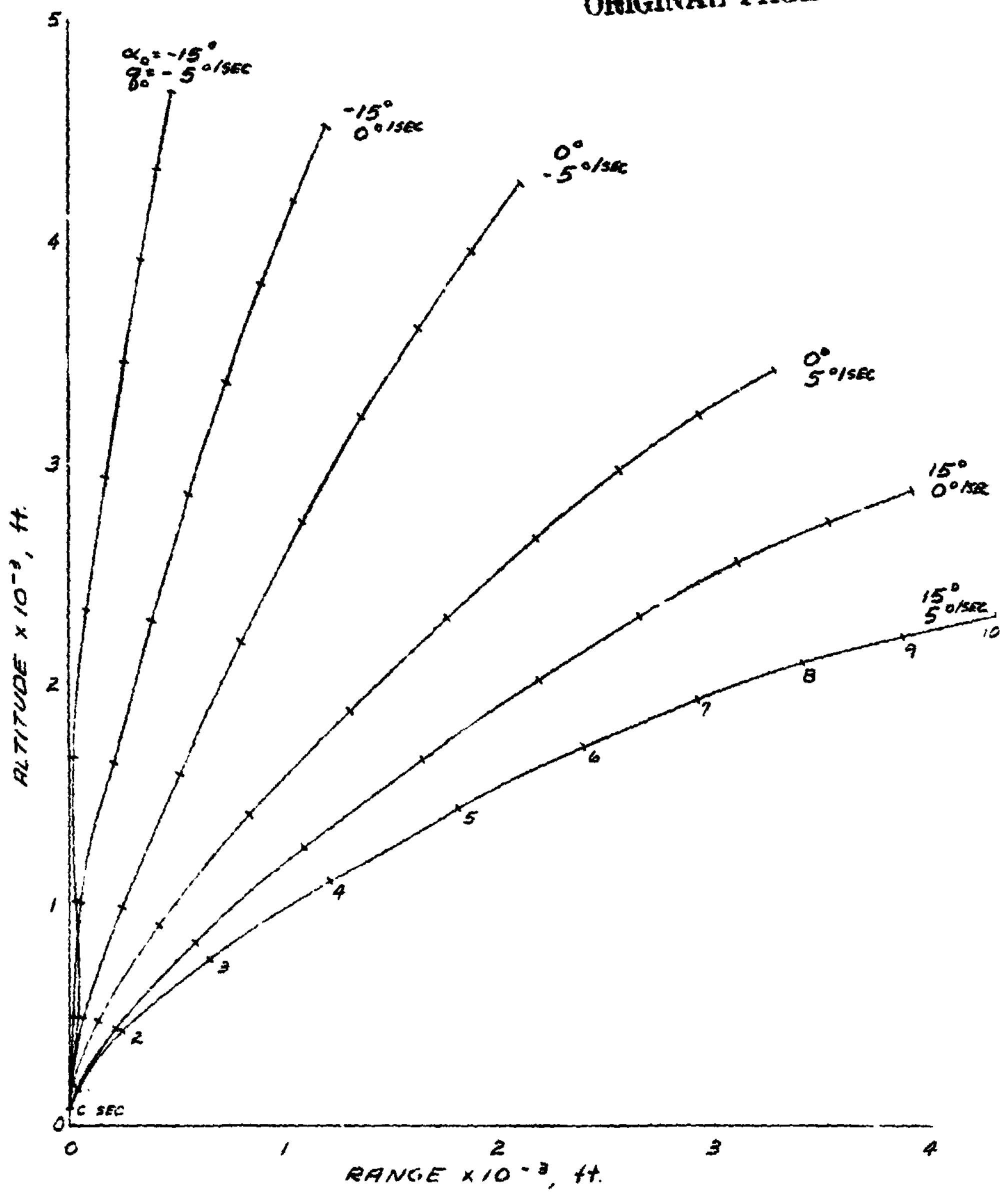

Figure [illegible].- Pad [illegible] - Saturn IB.

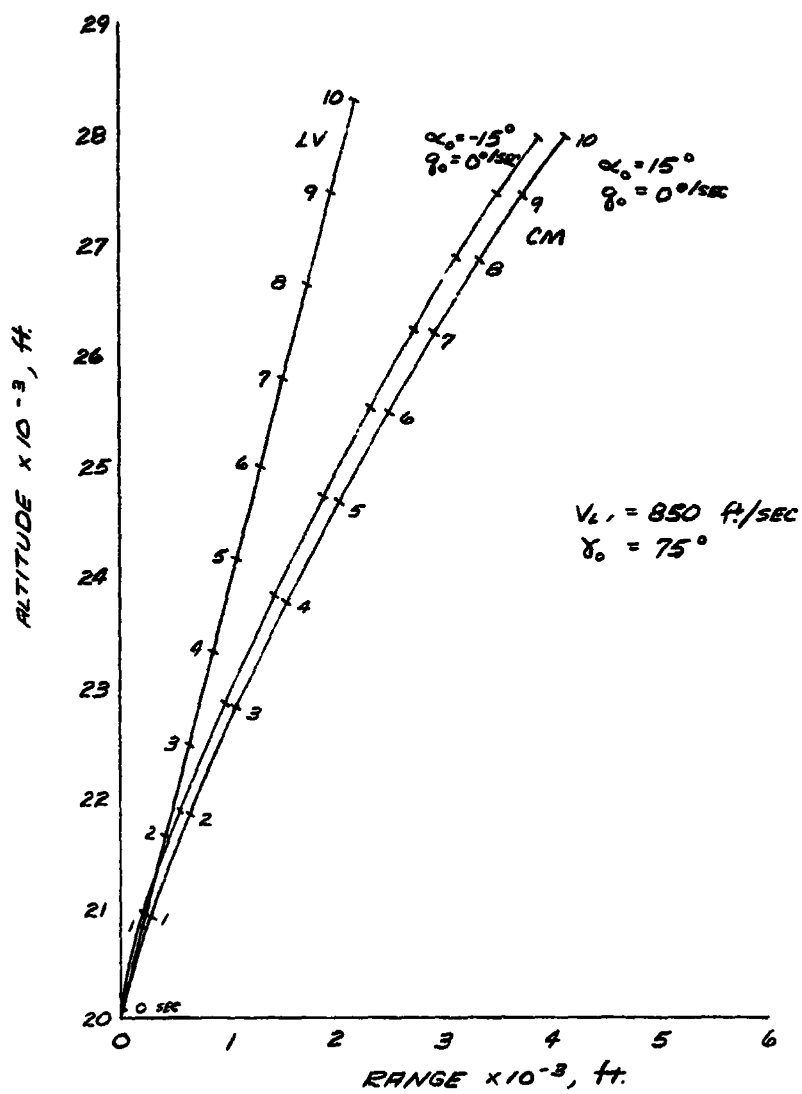

Figure 2.- 20 000 ft abort - Saturn IB.

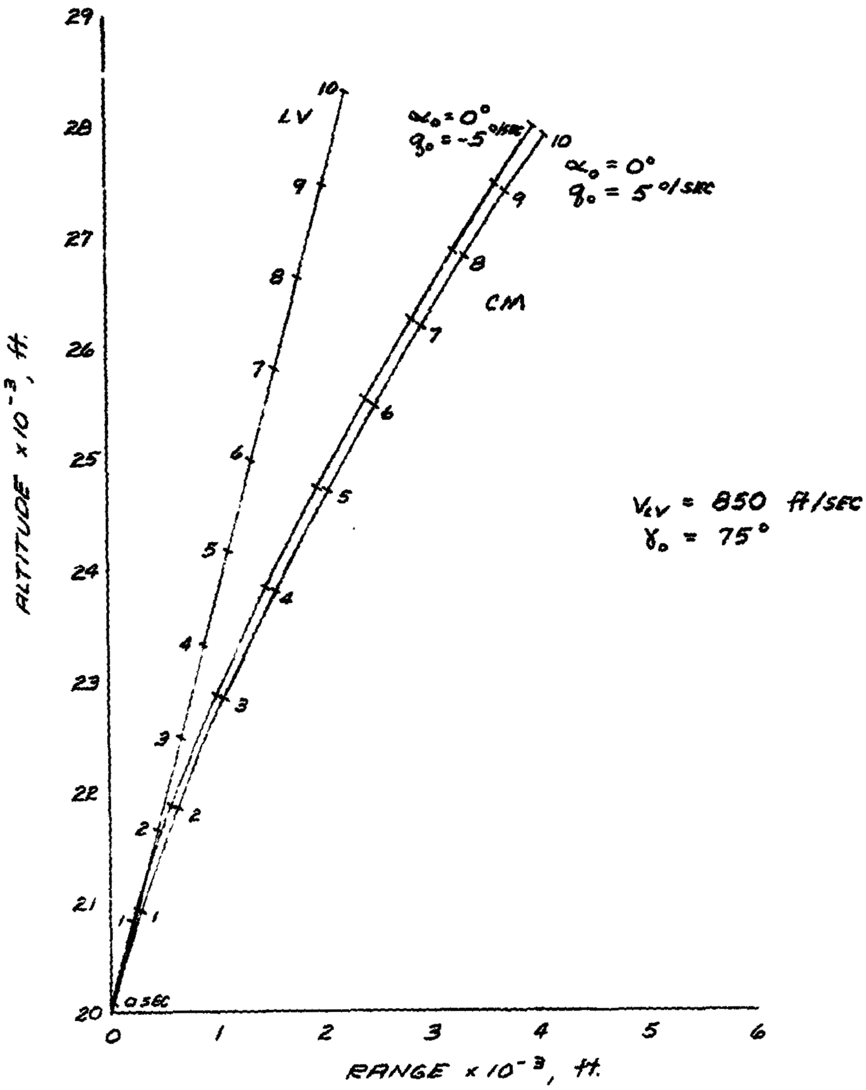

Figure 2.- Continued.

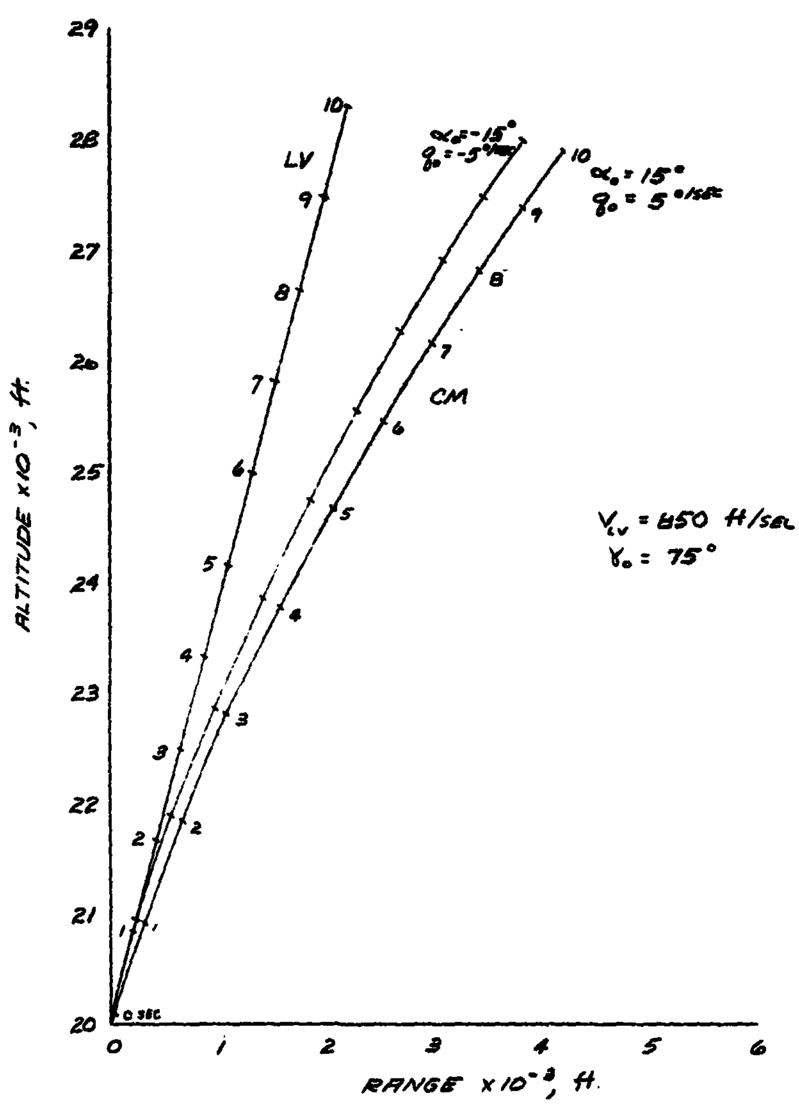

Figure 2.- Concluded.

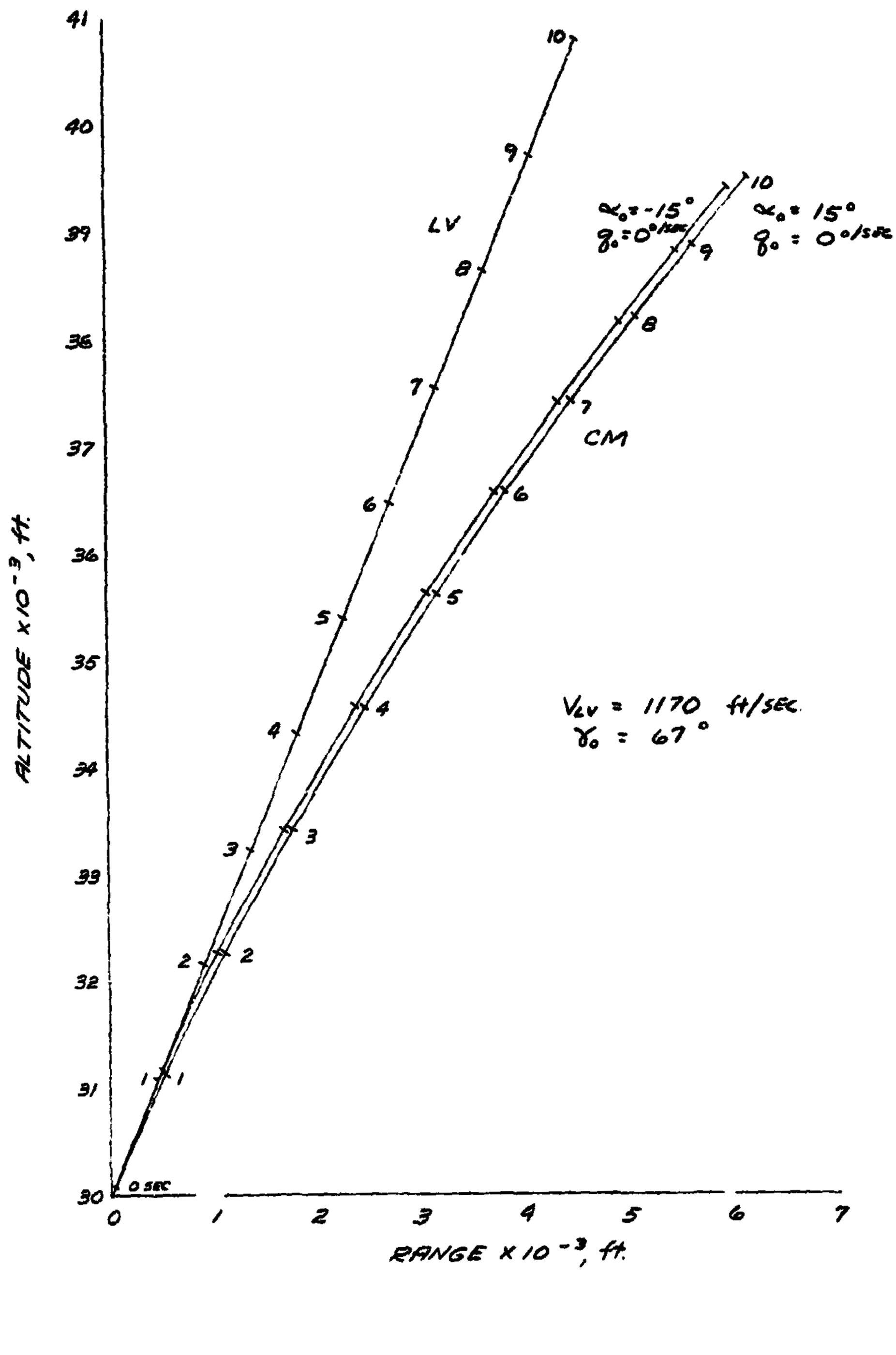

Figure 3. - 30 000 ft abort - Saturn IB.

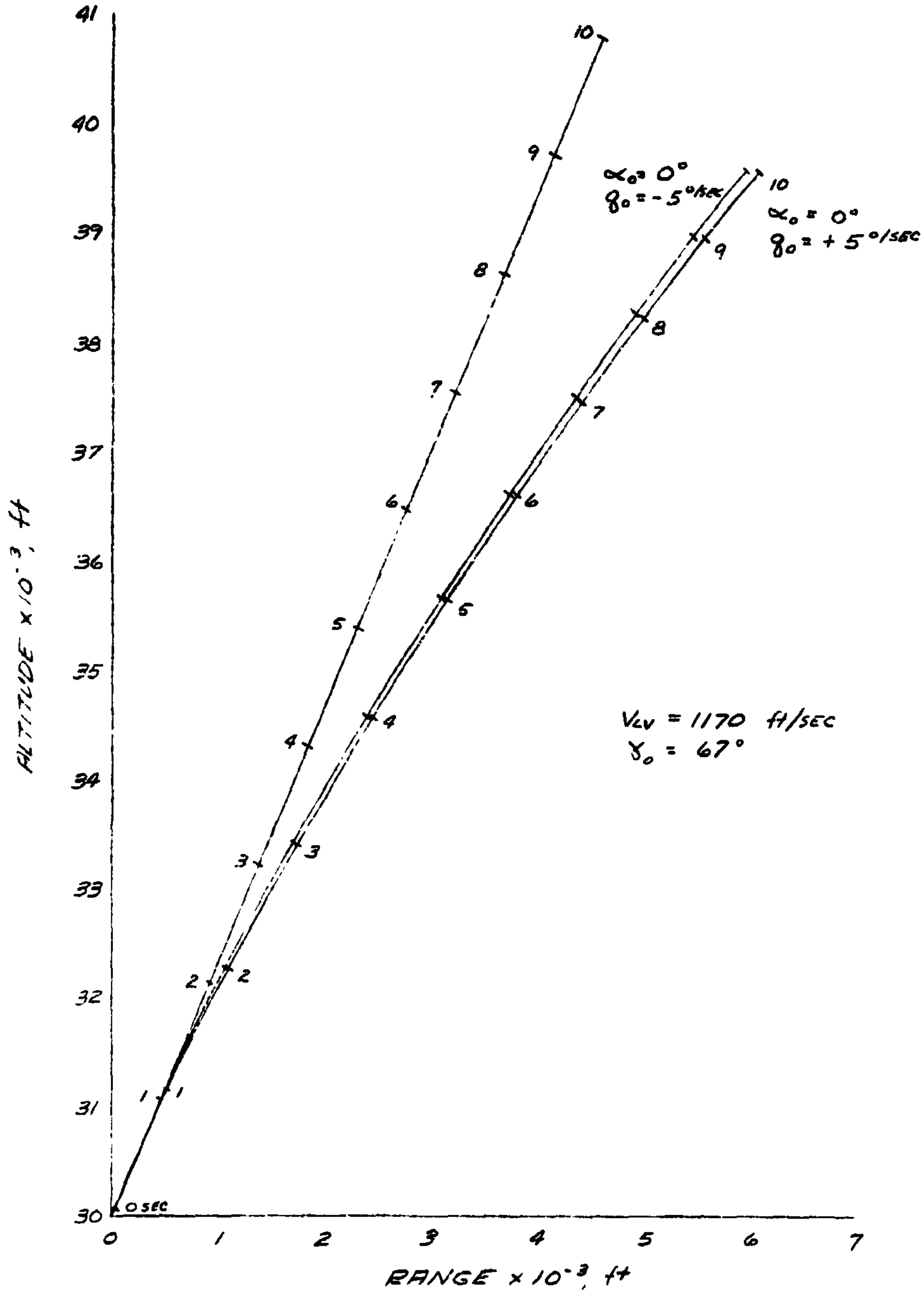

Figure 3.- Continued.

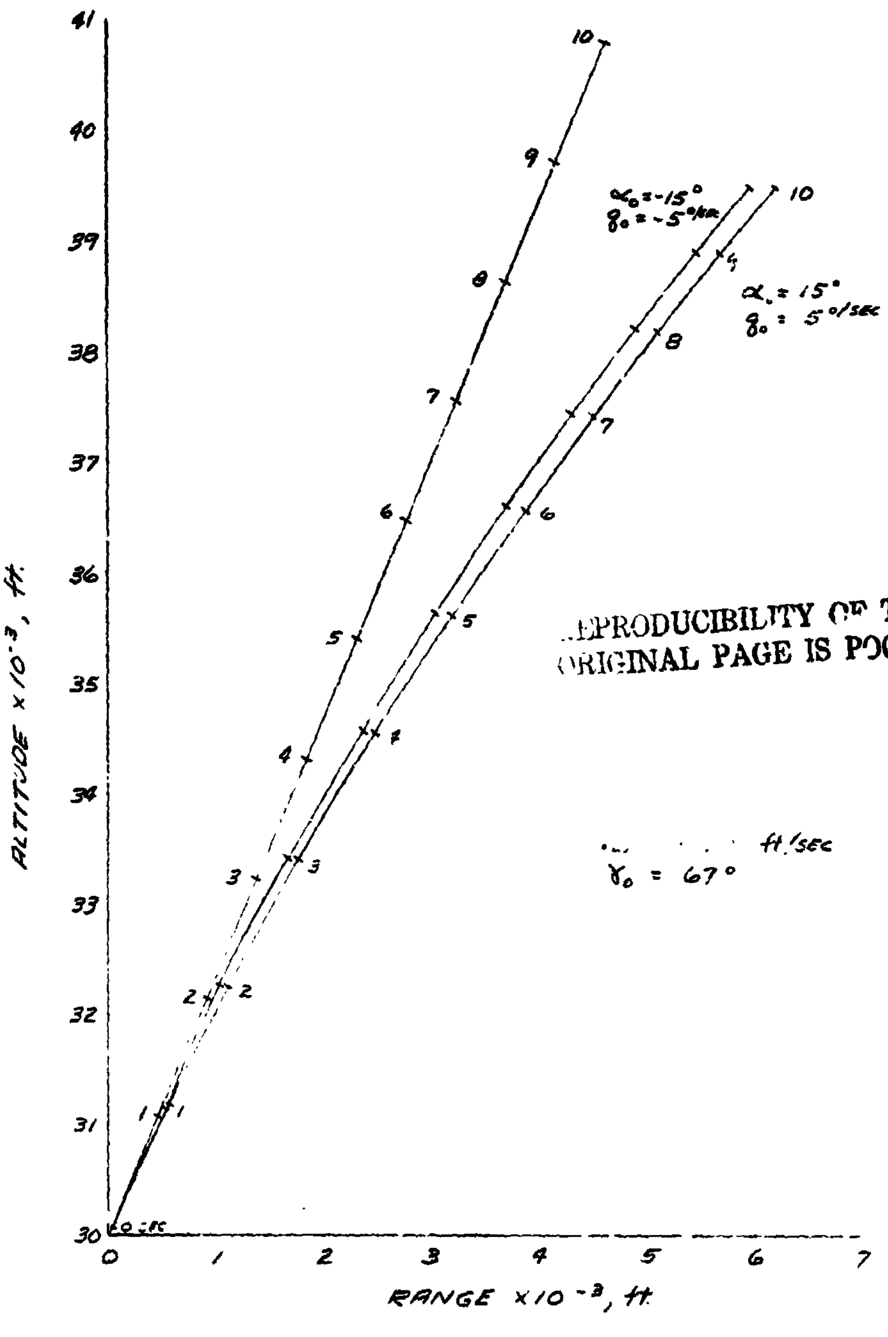

Figure 3.- Concluded.

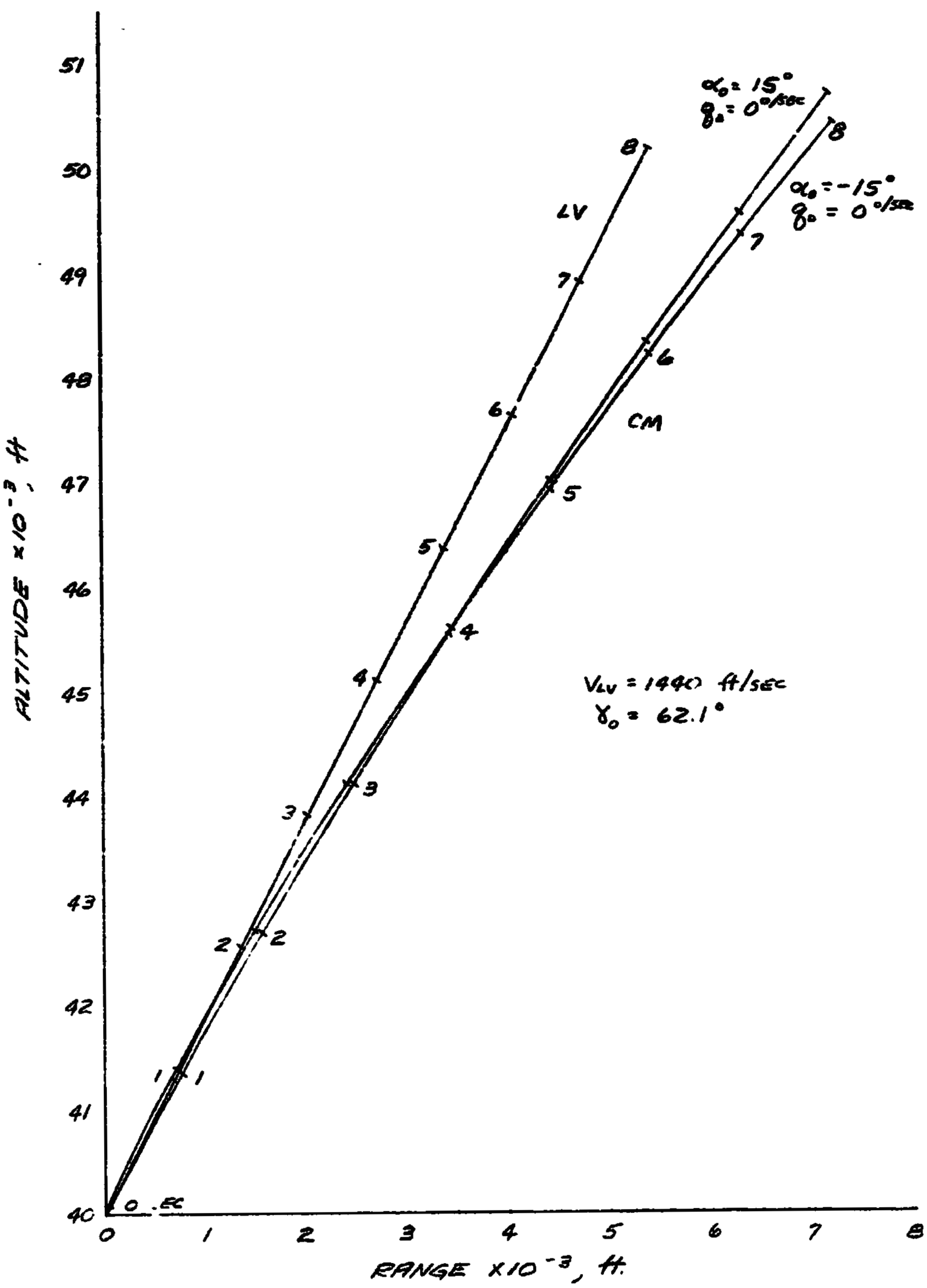

Figure 4.- 40 000 ft abort - Saturn IB.

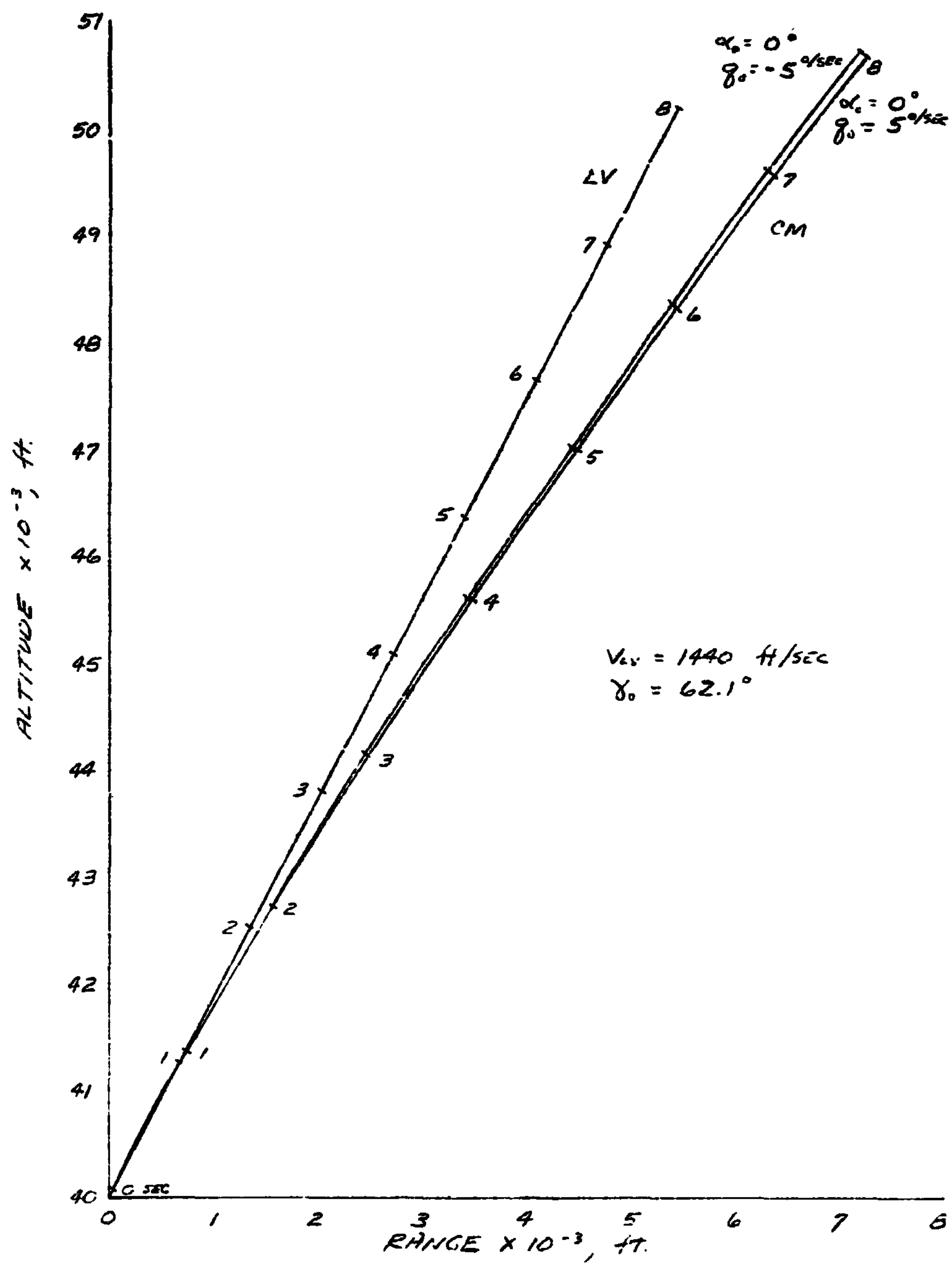

Figure 4.- Continued

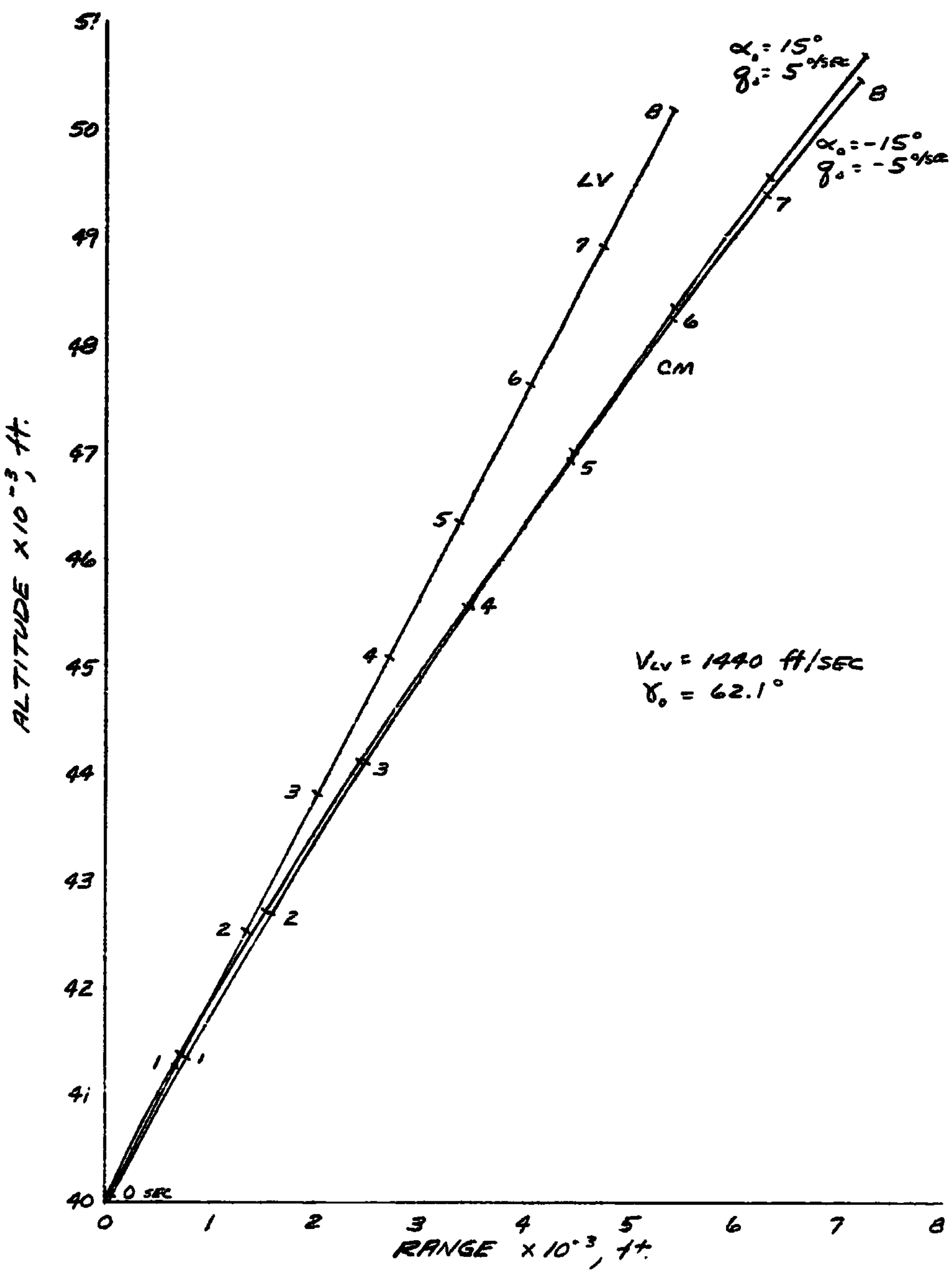

Figure 4.- Concluded.

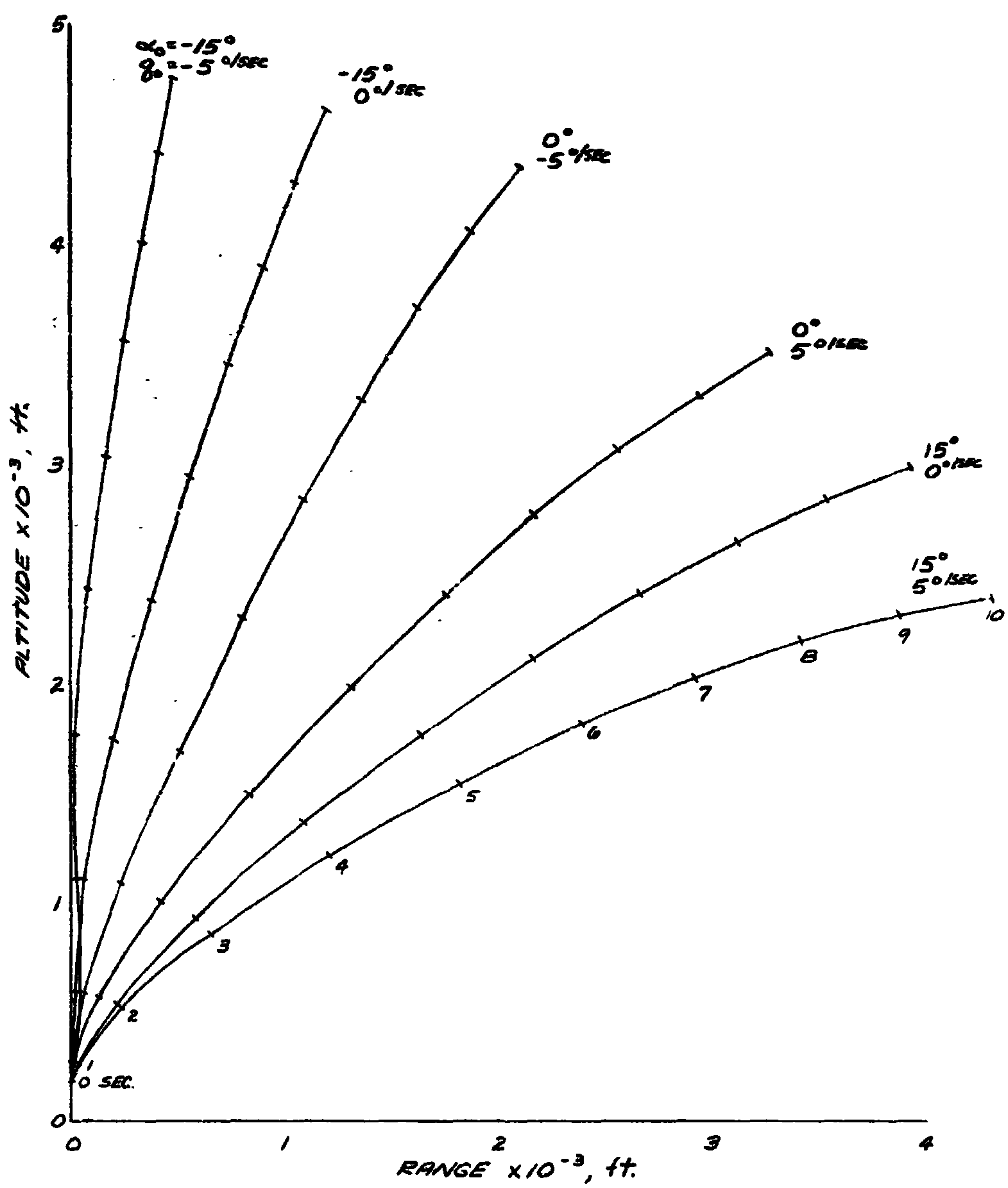

Figure 5.- Pad abort - Saturn V.

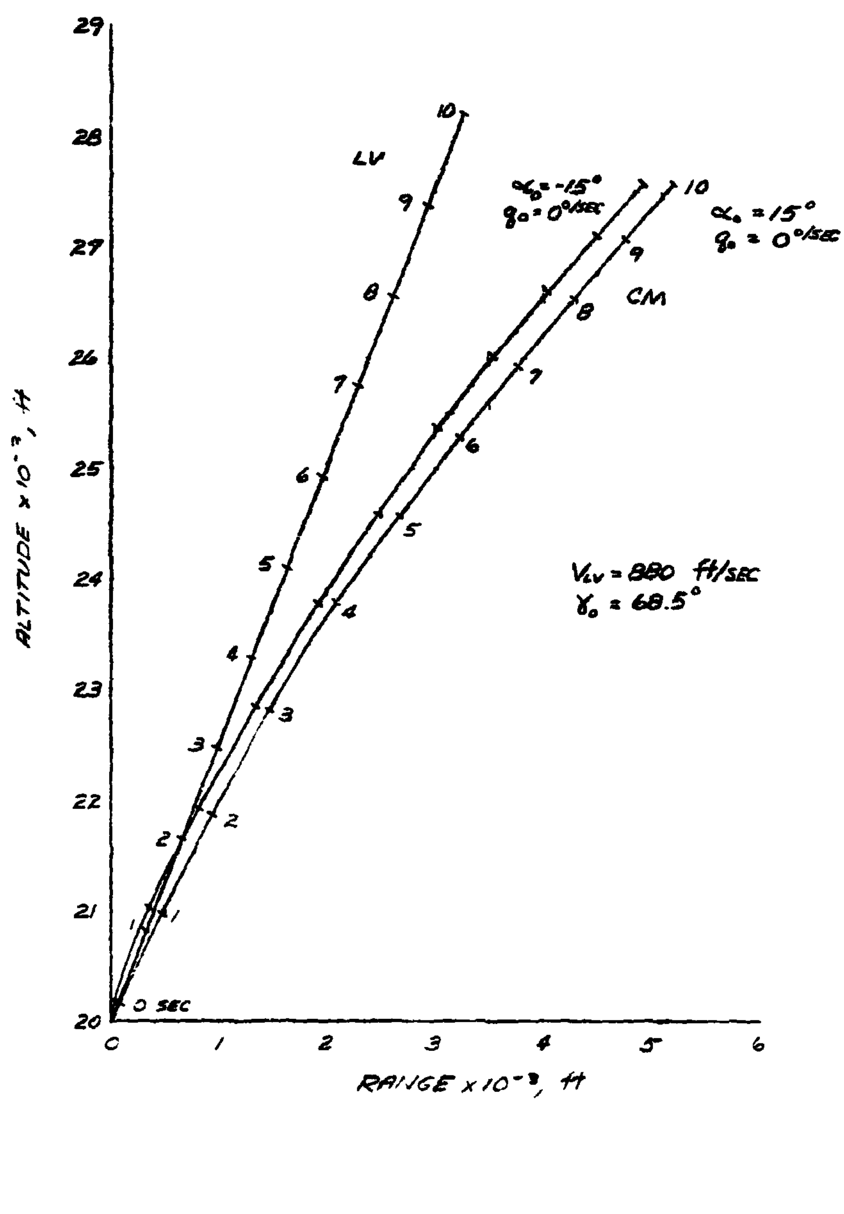

Figure 6.- 20 000 ft abort - Saturn V.

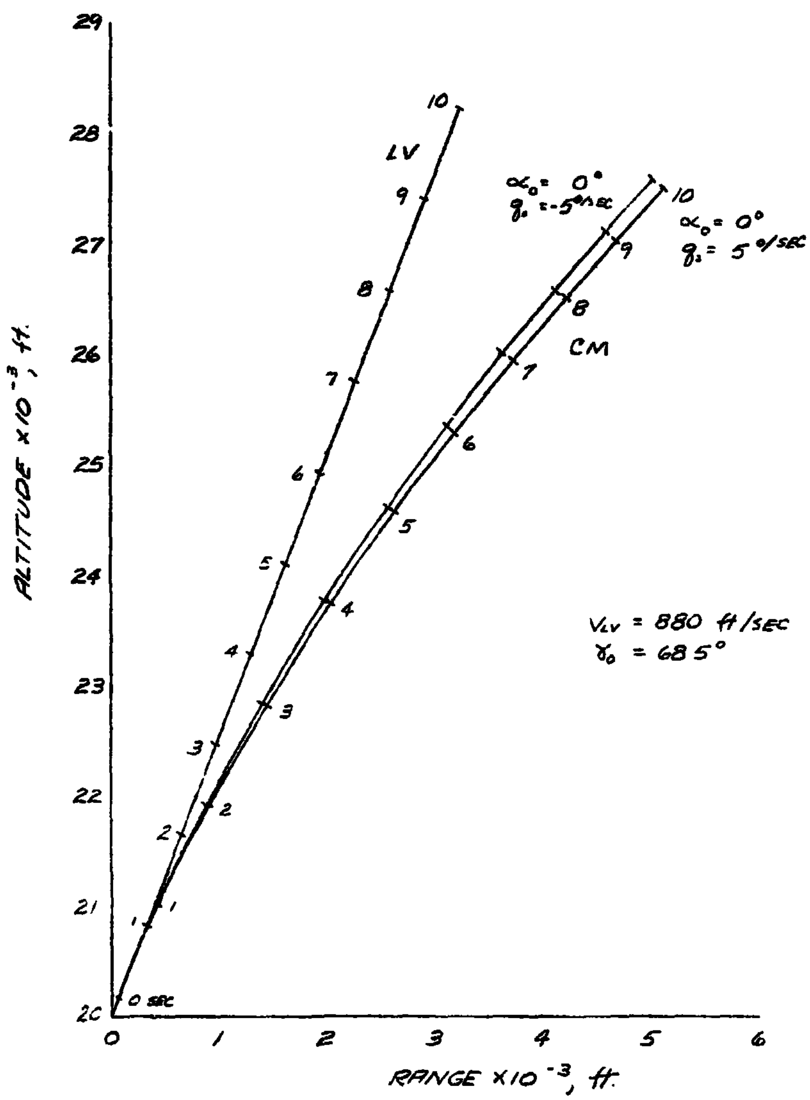

Figure 6.- Continued.

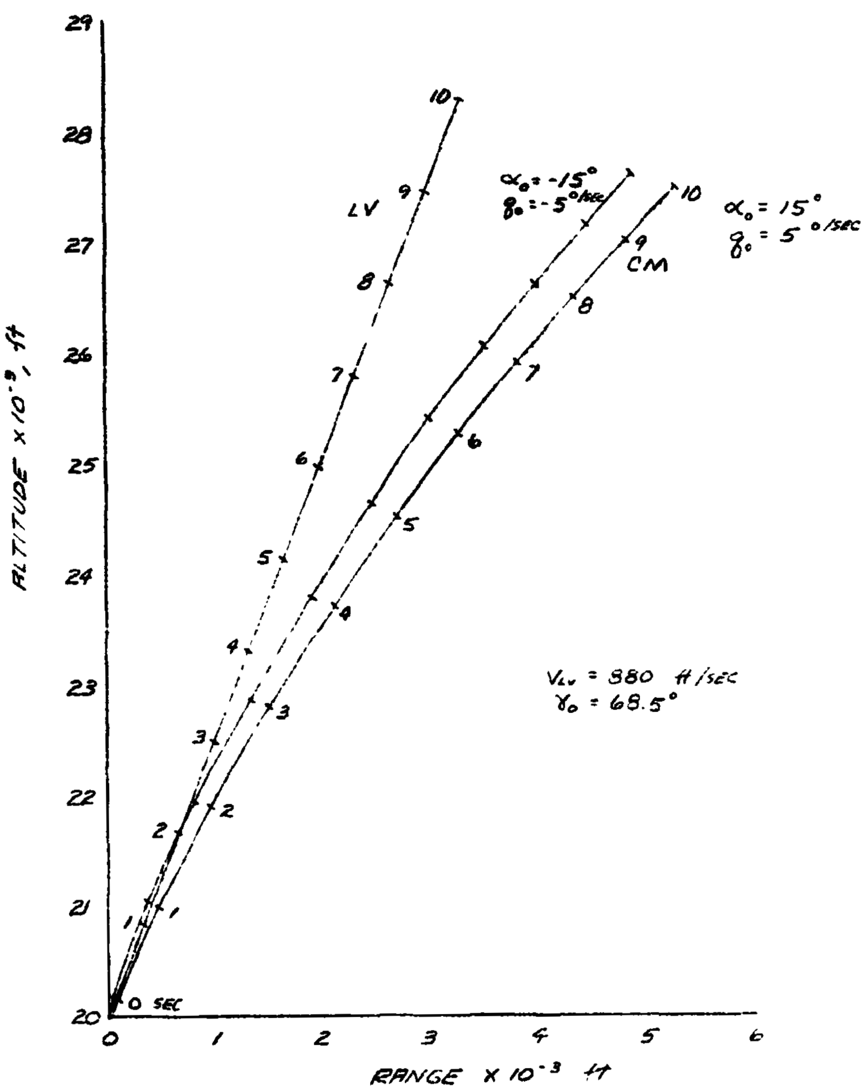

Figure 6.- Concluded.

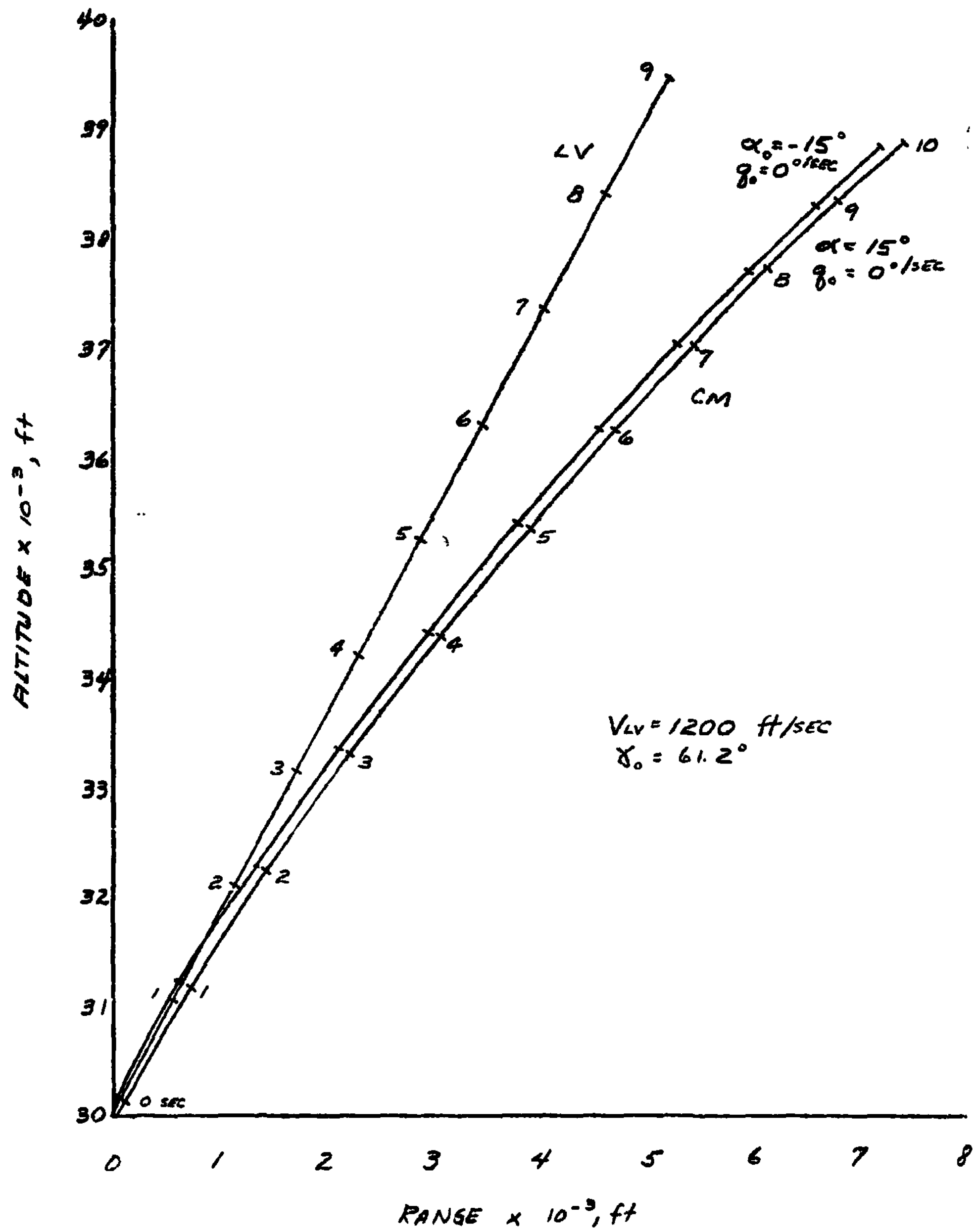

Figure 7.- 30 000 ft abort – Saturn V.

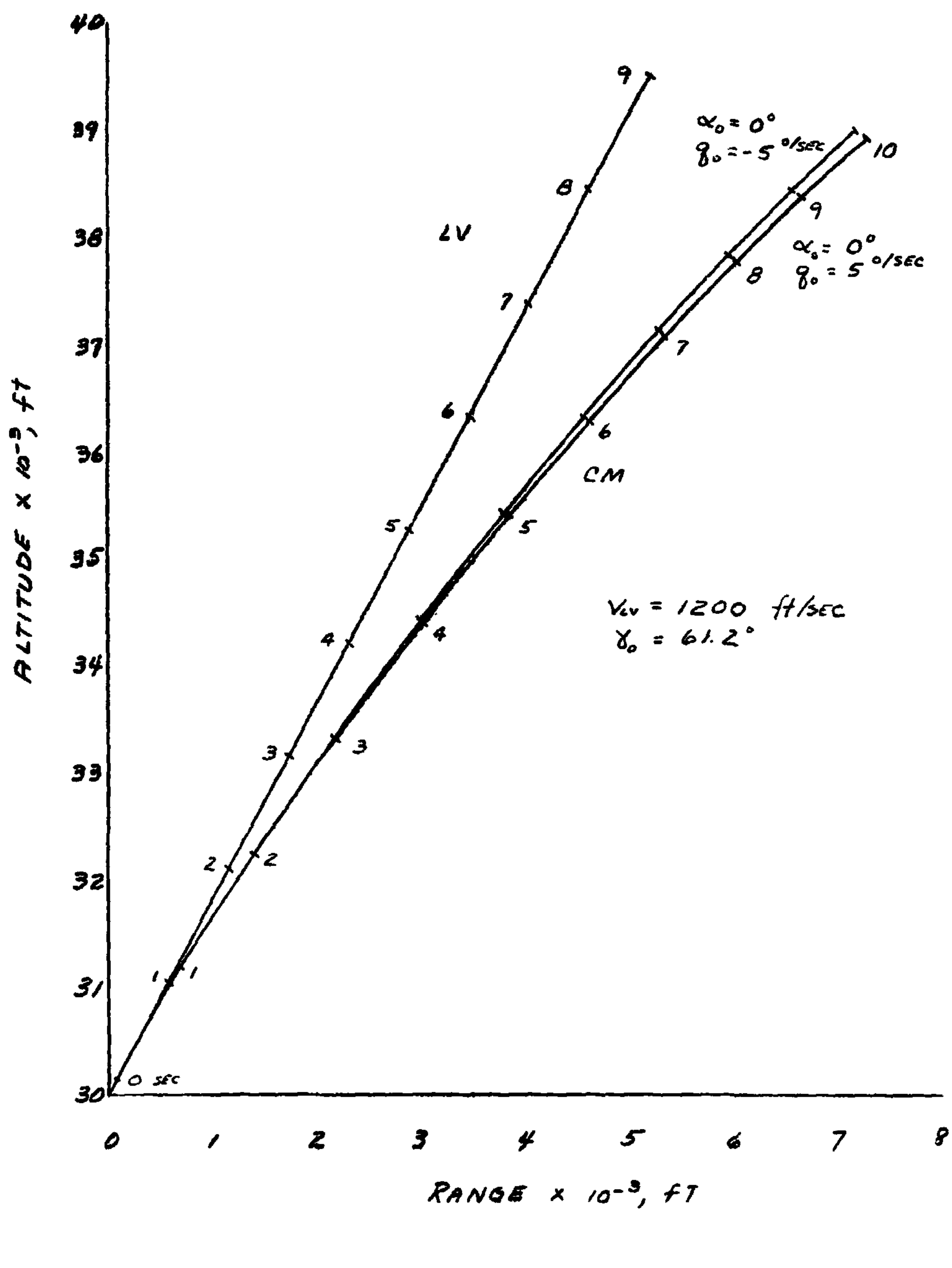

Figure 7.- Continued.

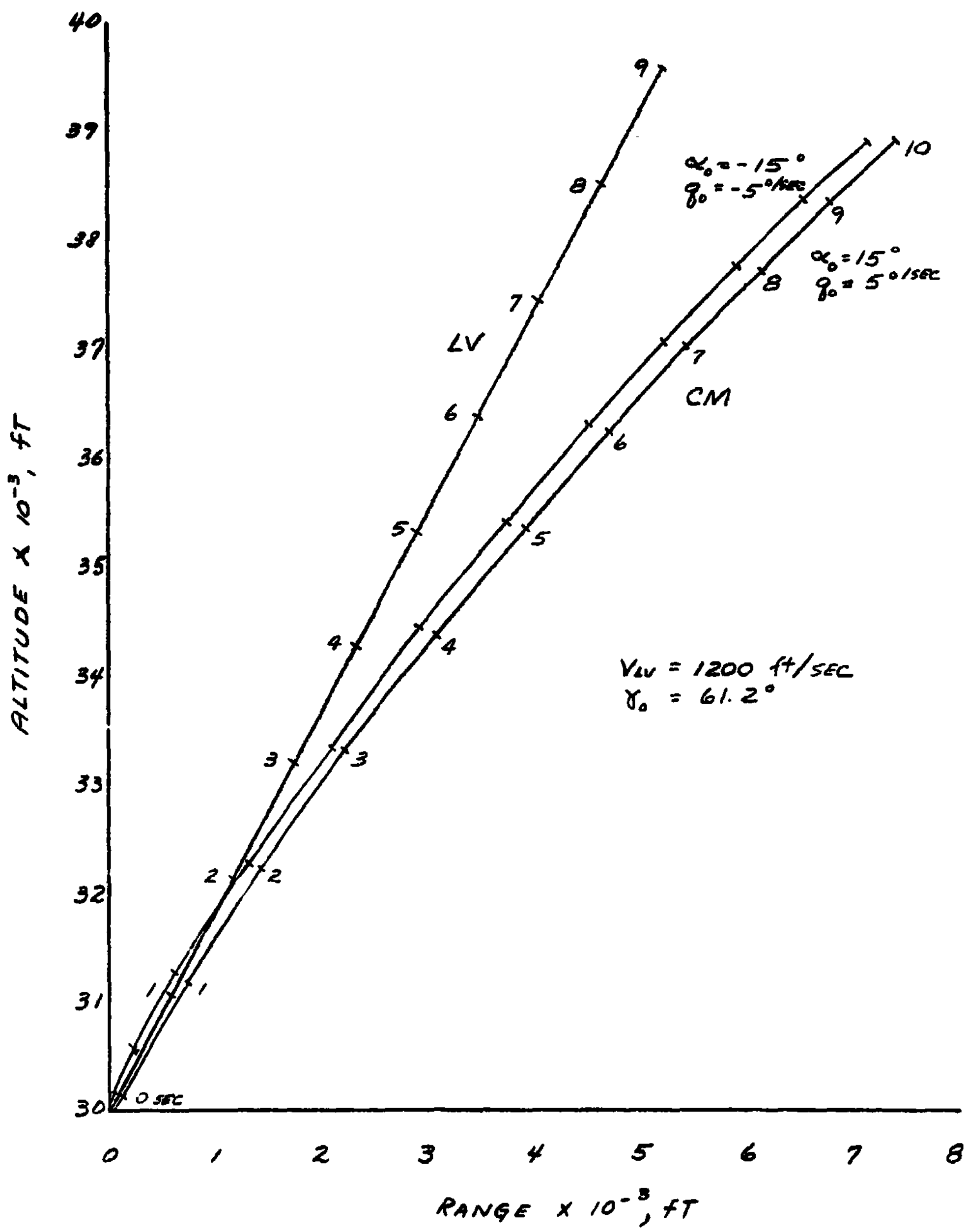

Figure 7.- Concluded.

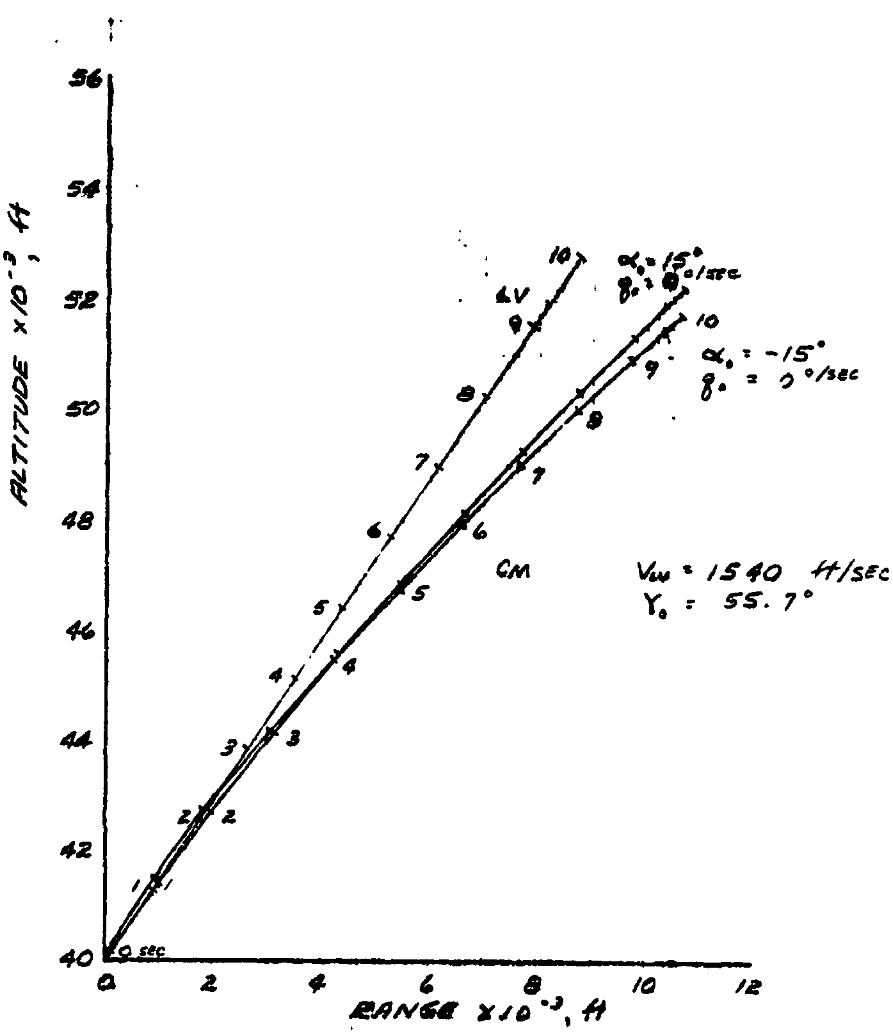

Figure 8.- 40 000 ft abort - Saturn V.

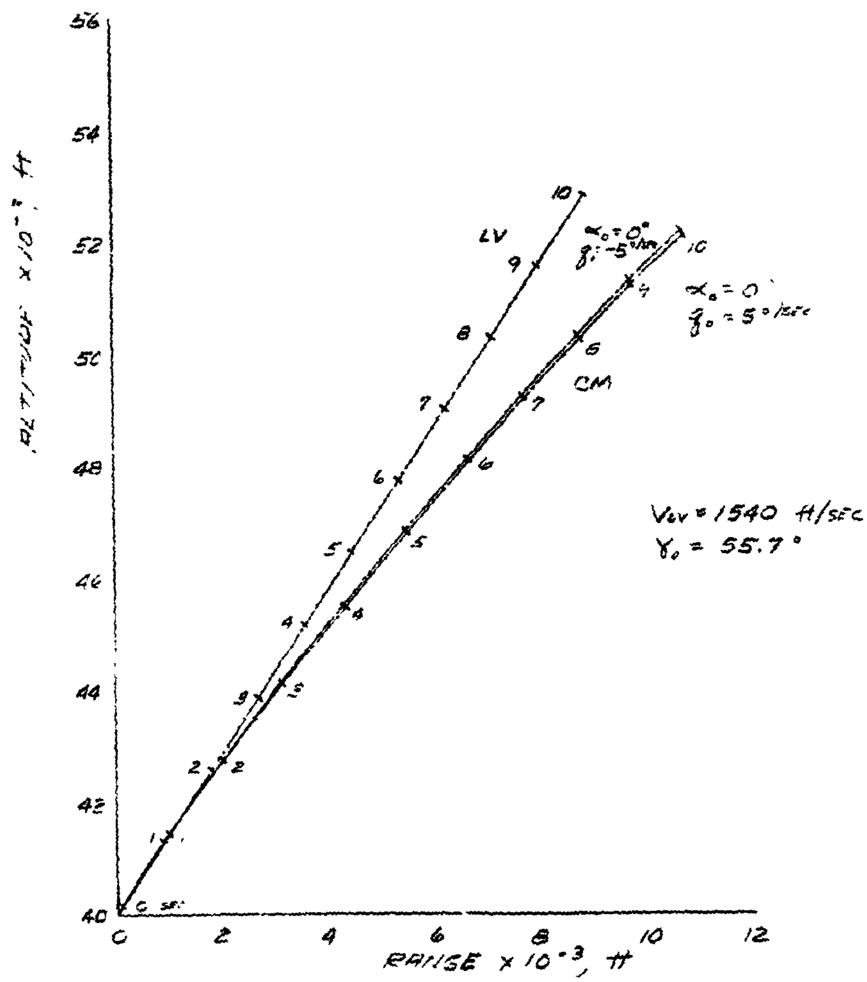

Figure 8.- Continued.

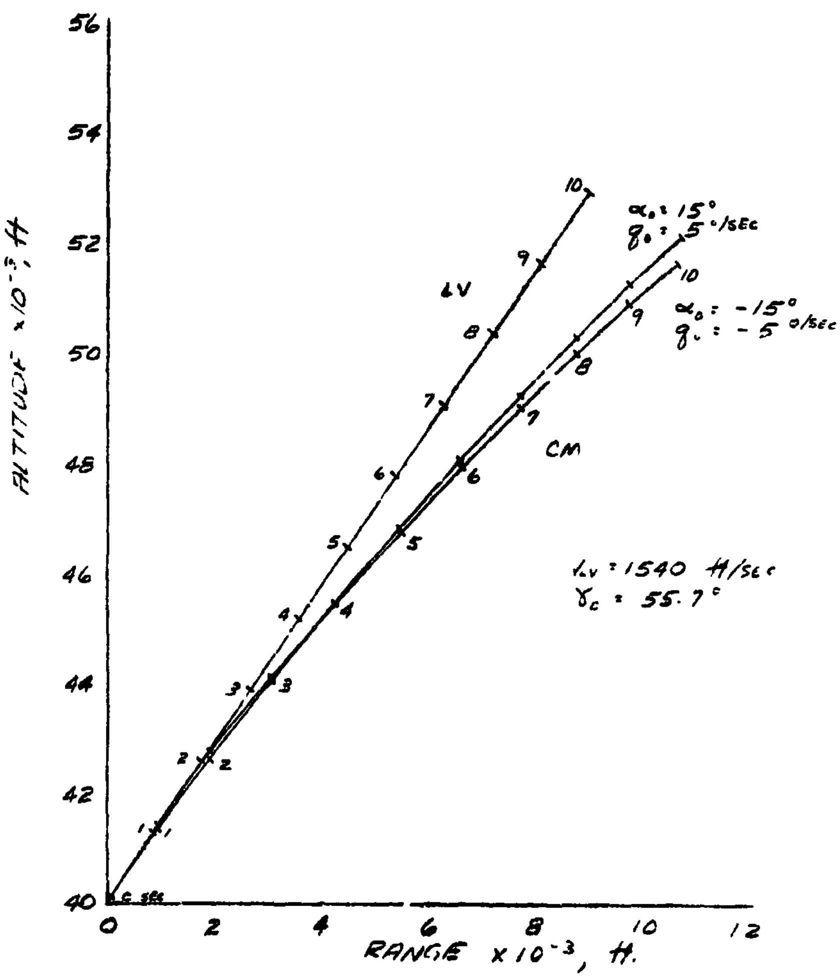

Figure 8.- Concluded.

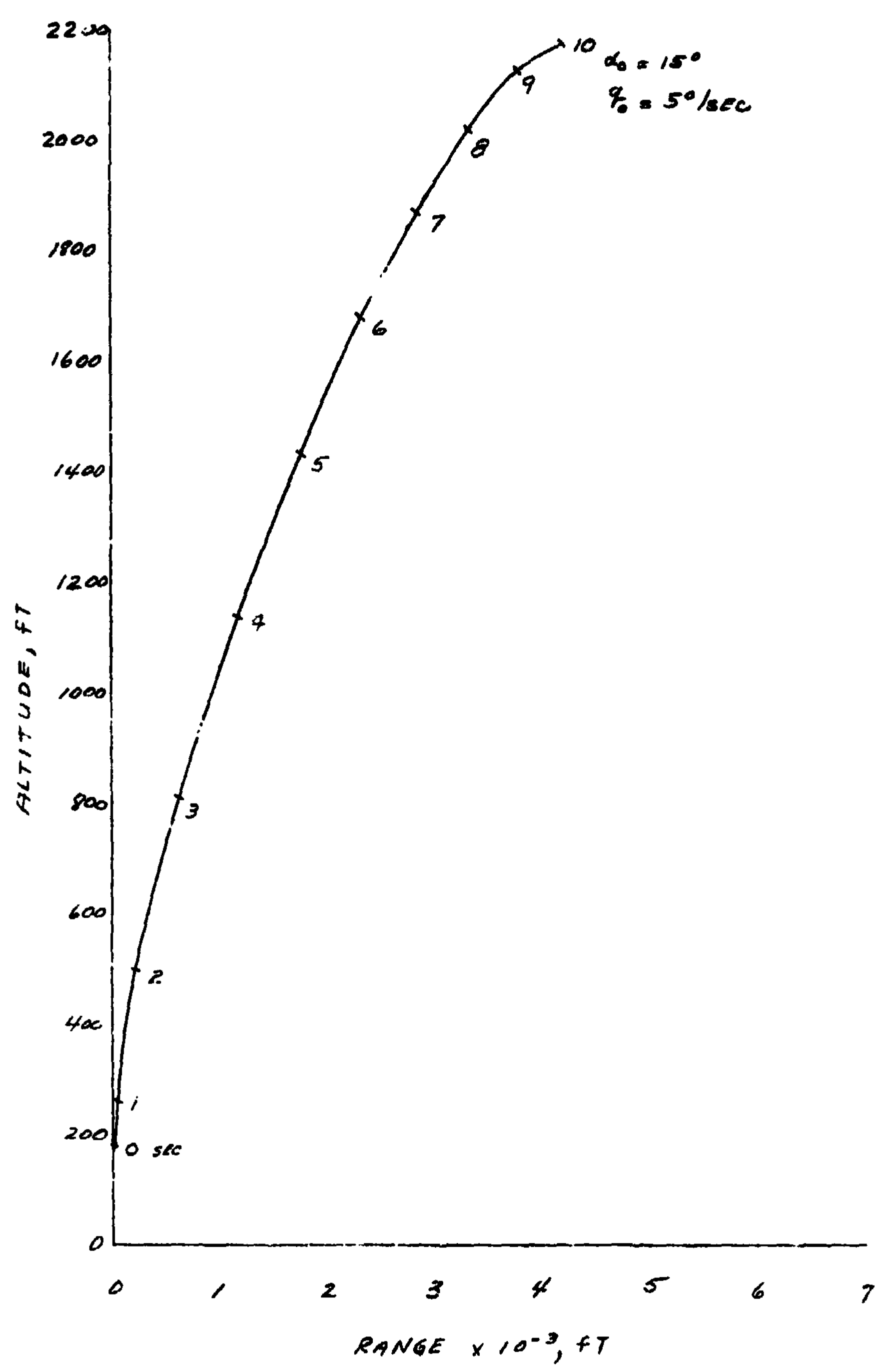

Figure 4.- Pad abort – 3σ low LES thrust.

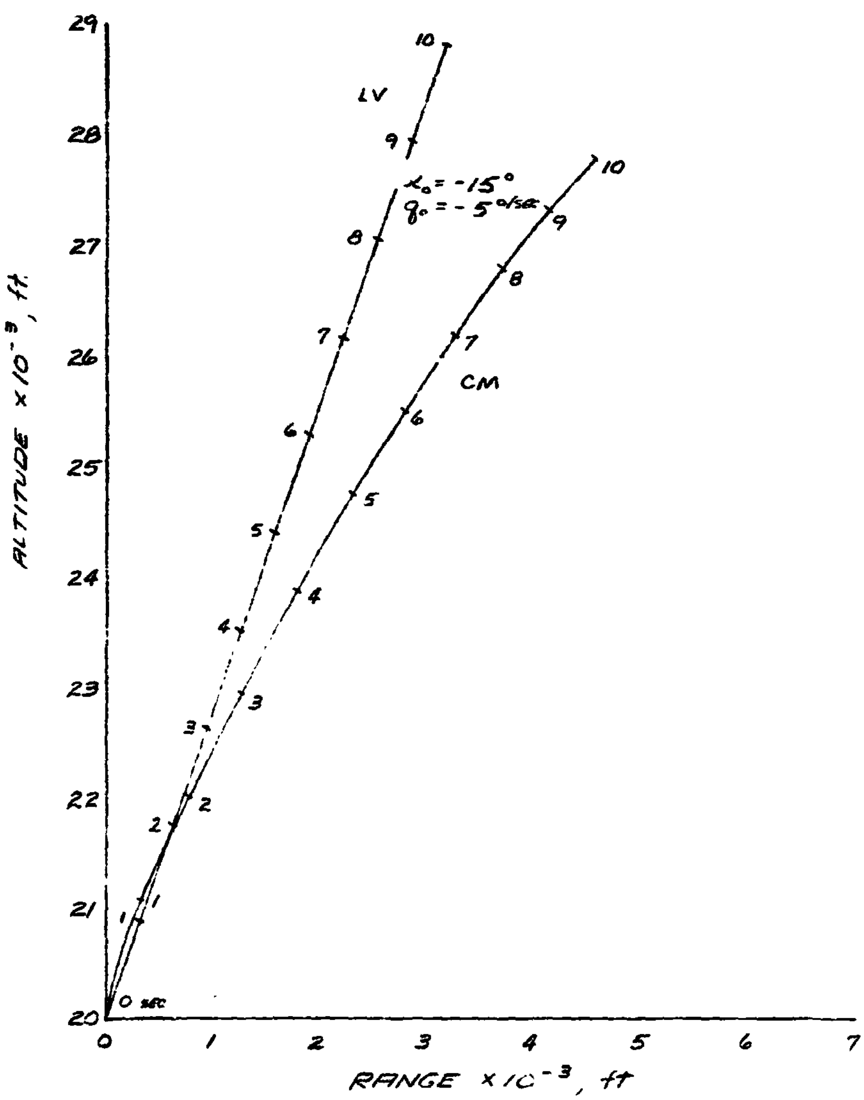

Figure 10.- 20 000 ft abort - 5σ thrust deviation - Saturn V.

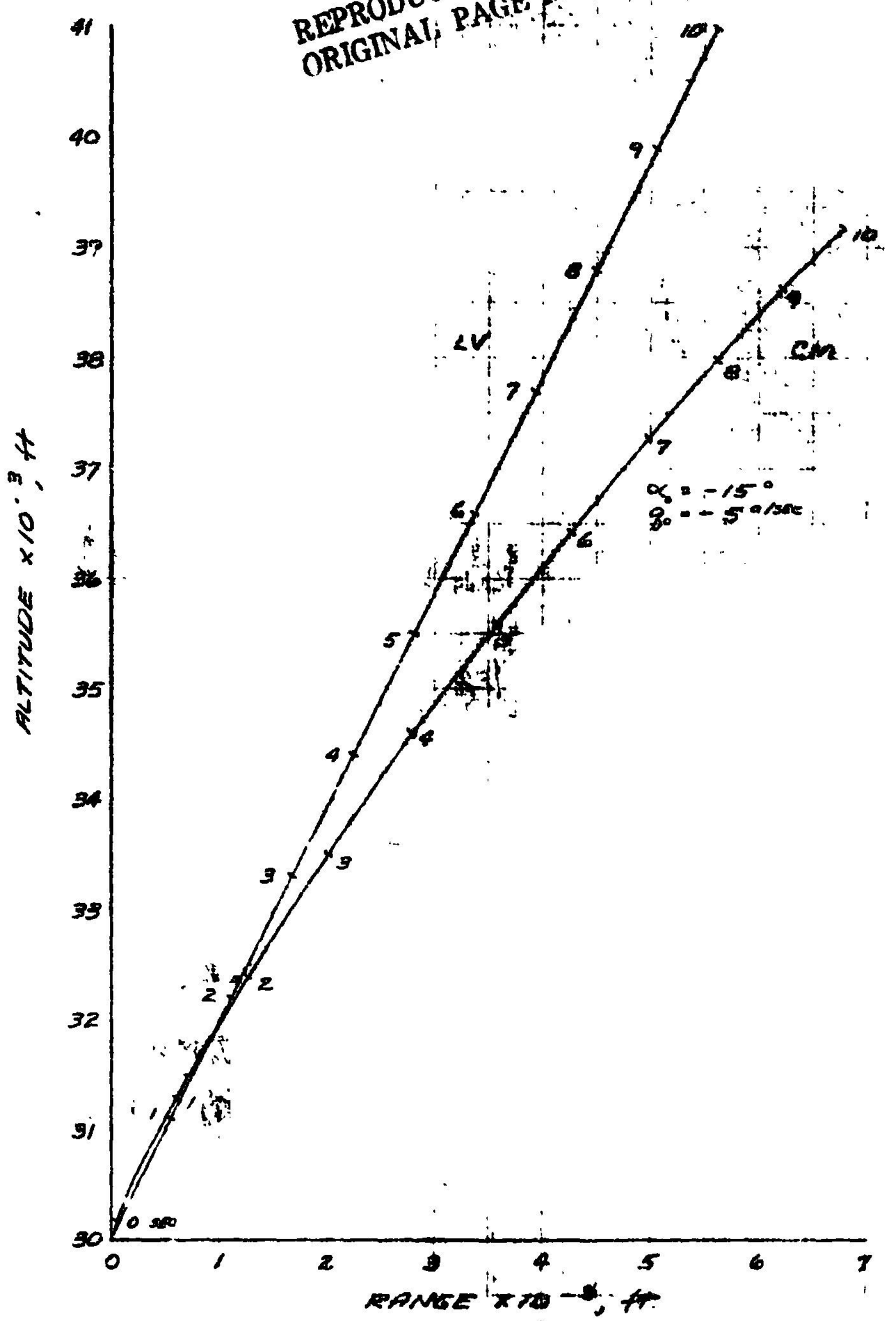

Figure 11.- 30 000 ft abort - 3σ thrust deviation - Saturn V.

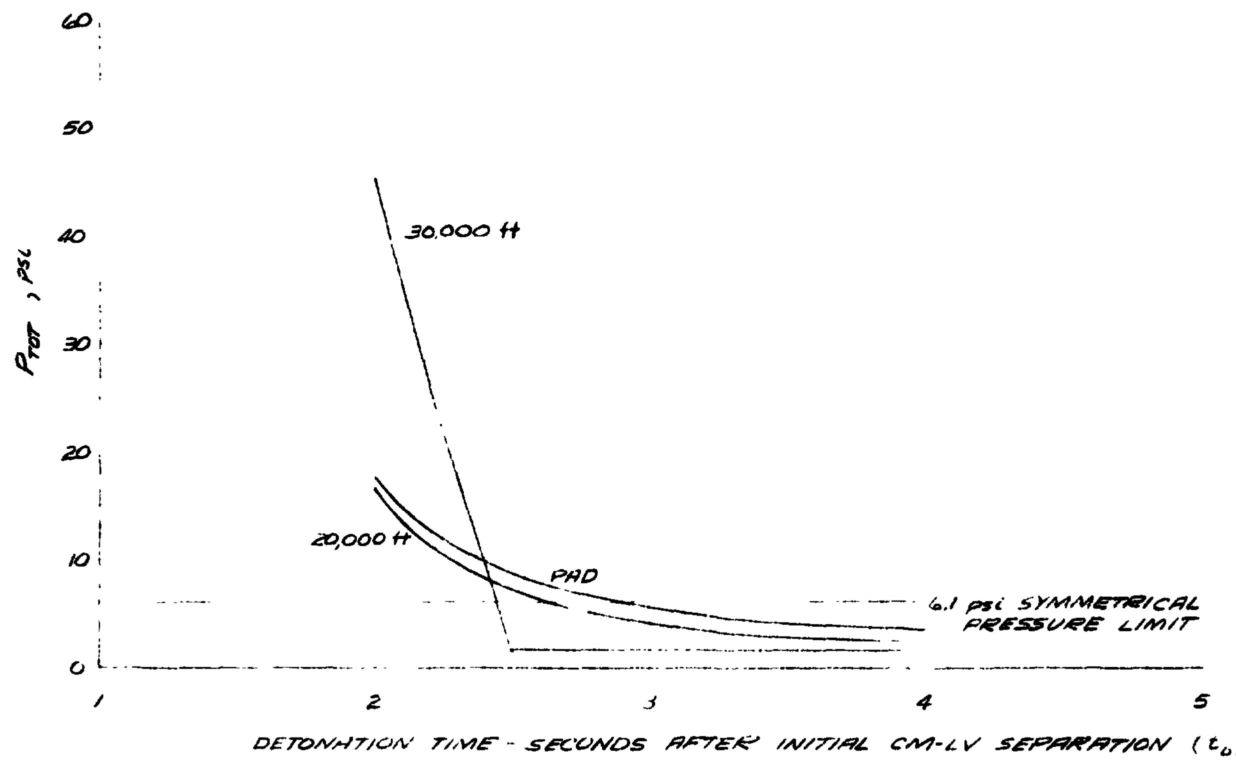

Figure [illegible].- Total pressure load summary - Saturn IB.

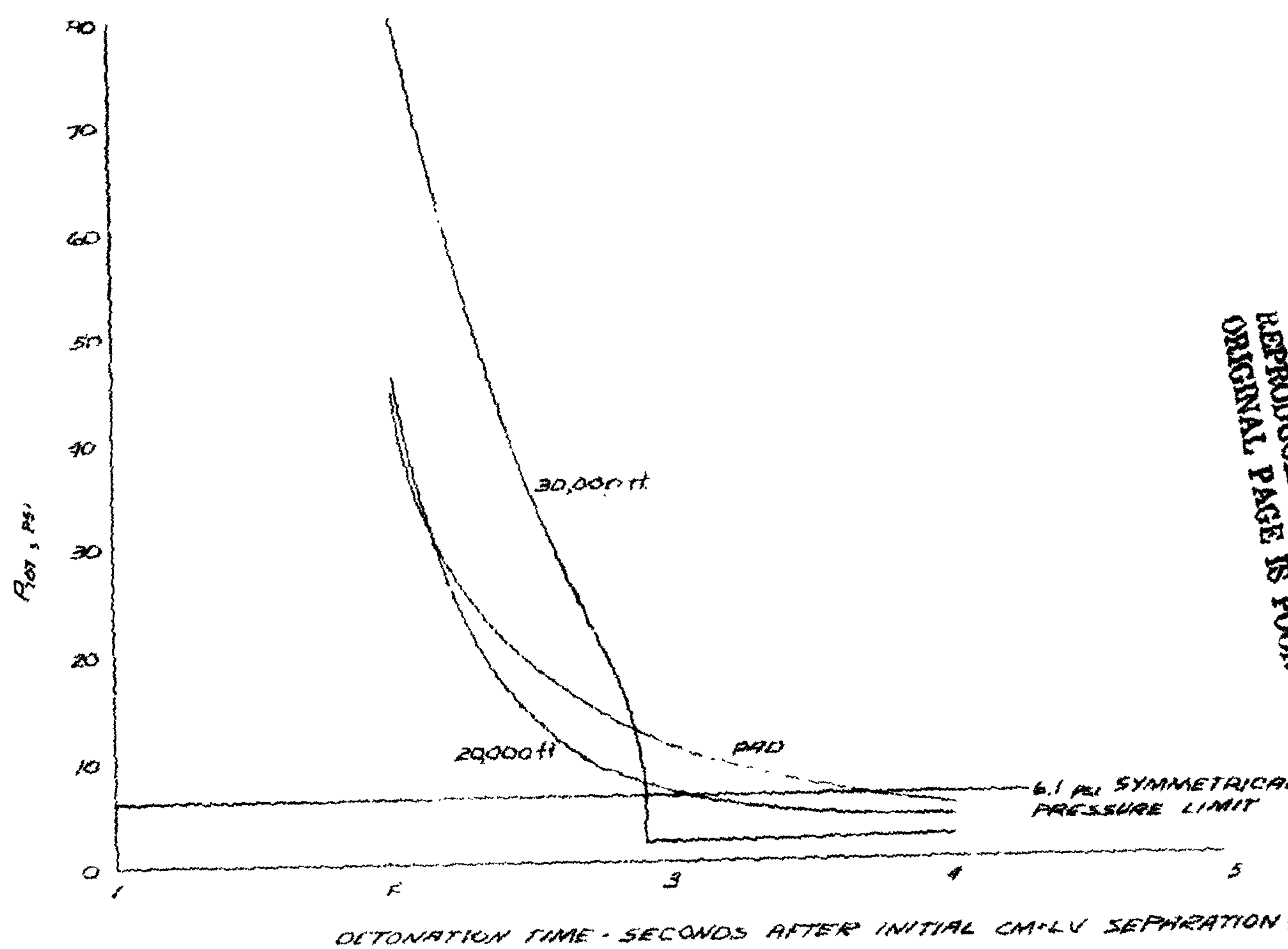

Figure 15. - Total pressure load summary - Saturn V.

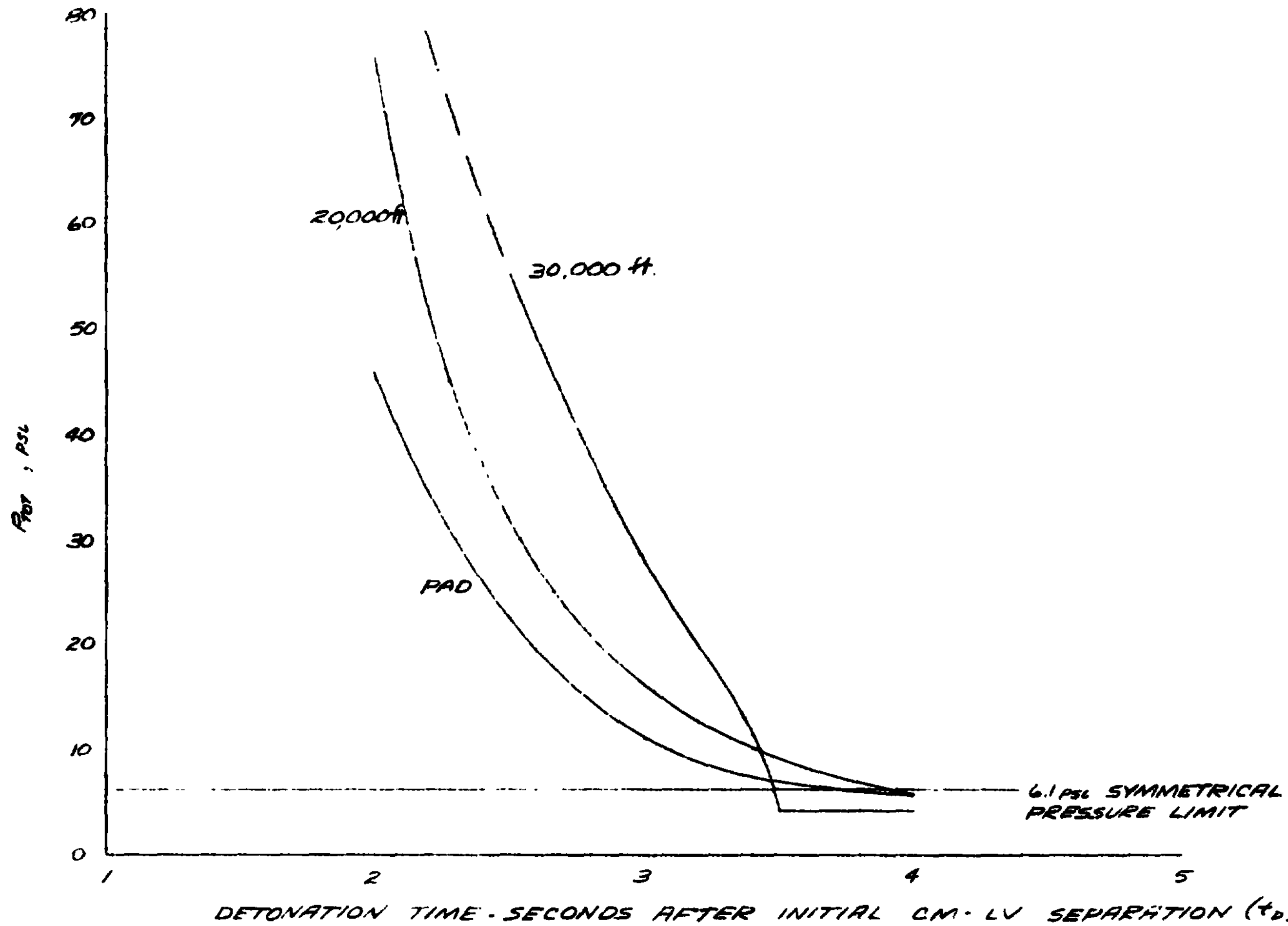

Figure 14.- Total pressure load summary – Saturn V – 3σ thrust dispersion.