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CARDE BLACK BRANT
DATA BOOKLET ADI-23

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PRE-FLIGHT PERFORMANCE CALCULATIONS AND
WIND SENSITIVITY DATA FOR
AD I 23 ROCKET VEHICLE

ON LOAN
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Radio & E.F. Division
Document Control Section

PRE-FLIGHT PERFORMANCE CALCULATIONS AND

WIND SENSITIVITY DATA FOR

AD ^I~~23~~ 23 ROCKET VEHICLE

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INTRODUCTION

^I Pre-flight performance calculations and wind sensitivity data for AD ~~22~~^I 23 rocket vehicle are presented in the following form:

- TABLE I - Weight, Mass, Pitch Inertia, Dynamic Pressure, Velocity, Acceleration and Altitude as functions of Time.
- TABLE II - Mach No., Zero Lift Curve Slope, Center of Pressure, Center of Gravity, Stability as functions of Time.
- TABLE III - Zero Lift Curve Slope (Nose & Body), Center of Pressure (Nose & Body), Zero Lift Curve Slope (Fins), Center of Pressure (Fins), Zero Lift Curve Slope (Vehicle), Combined Center of Pressure as functions of Mach No.
- TABLE IV - Trajectory Data.
- TABLE V - Wind Sensitivity Data.
- FIGURE 1 - Vehicle Configuration for AD ~~22~~^I 23.
- FIGURE 2. - Velocity versus Time.
- FIGURE 3 - Mach No. versus Time.
- FIGURE 4 - Acceleration, Velocity and Altitude versus Time.
- FIGURE 5 - Altitude versus Total Flight Time.
- FIGURE 6 - Trajectory.

Pre-flight performance data were based upon a vehicle launch weight of 2808 lb. and a zero wind 80° launch elevation angle and a static stability margin of 1.88 calibers (body dia.) at burnout.

Wind Sensitivity Data, given in Table V should be substituted for Tables I & III in the Wind Weighting Data for Black Brant Vehicles and used in conjunction with the latter for determining the Wind Weighting Data of AD ~~22~~^I 23 rocket vehicle.

2.

TABLE I

Time Dependent DataNRC AD ^I~~22~~ 23

<u>Time</u> <u>sec.</u>	<u>Weight</u> <u>lb.</u>	<u>Mass</u> <u>Slugs</u>	<u>Pitch</u> <u>Inertia</u> <u>Slugs ft²</u>	<u>Dynamic</u> <u>Pressure</u> <u>lb/ft²</u>	<u>Velocity</u> <u>ft/sec.</u>	<u>Acceleration</u> <u>ft/sec²</u>	<u>Altitude</u> <u>ft.</u>
0	2808	87.19	3591	0	0	0	0
1	2678	83.15	3445	99	290	290	145
2	2555	79.33	3382	396	583	293	577
3	2432	75.51	3290	871	884	301	1,278
4	2309	71.69	3220	1,540	1187	303	2,286
5	2187	67.91	3157	2,399	1494	307	3,589
6	2066	64.15	3061	3,375	1811	317	5,192
7	1946	60.42	2994	4,453	2142	331	7,108
8	1826	56.70	2919	5,548	2486	344	9,350
9	1708	53.03	2847	6,716	2848	362	11,931
10	1593	49.46	2769	7,799	3233	385	14,872
11	1479	45.92	2715	8,842	3625	392	18,185
12	1367	42.44	2626	9,605	4041	416	21,887
13	1262	39.18	2558	10,326	4497	456	26,008
14	1162	36.08	2501	10,733	4975	478	30,578
15	1092	33.90	2451	11,364	5370	395	33,030
16	1055	32.76	2435	11,097	5572	202	35,576
17	1037	32.20	2420	8,902	5627	55	40,862
18	1028	31.92	2417	5,204	5590	-37	51,675
19	1028	31.92	2417	3,962	5513	-77	57,019
20	1028	31.92	2417	3,096	5446	-67	62,292

TABLE II

Time Dependent DataNRC AD ~~41~~ 23

<u>Time sec.</u>	<u>Mach No.</u>	<u>C_{1α} Comb.</u>	<u>X_{cp} Comb. inches</u>	<u>X_{cg} in.</u>	<u>X_{cp} - X_{cg} in.</u>
0	0	22.40	299.2	200.57	98.63
1	.260	22.68	295.3	200.14	95.16
2	.523	23.03	292.1	199.71	92.39
3	.796	23.95	290.6	199.22	91.38
4	1.074	25.32	291.0	198.69	92.31
5	1.355	23.70	289.2	198.10	91.10
6	1.652	19.20	284.6	197.45	87.15
7	1.967	16.66	278.1	196.72	81.38
8	2.302	14.65	271.2	195.90	75.30
9	2.662	13.00	263.8	194.97	68.83
10	3.053	11.70	256.0	193.94	62.06
11	3.469	10.73	248.3	192.76	55.54
12	3.927	9.94	239.3	191.41	47.89
13	4.443	9.30	231.7	189.92	41.78
14	5.013	8.70	225.0	188.26	36.74
15	5.469	8.33	220.4	186.91	33.49
16	5.738	8.12	218.6	186.13	32.47
17	5.796	8.10	218.1	185.73	32.37
18	5.757	8.11	218.5	185.52	32.98
19	5.677	8.19	219.2	185.52	33.68
20	5.608	8.22	219.6	185.52	34.08
Ref. Area ft ² .		1.614			

TABLE III

Aerodynamic Data

NRC AD ~~40~~ 23

Mach No.	$C_{L\alpha}$ (Nose)	X_{cp} (Nose) in.	$C_{L\alpha}$ (Fins)	X_{cp} Fin in.	$C_{L\alpha}$ Comb.	X_{cp} Comb. in.
0	.86	48	21.54	309.2	22.40	299.17
.5	1.52	54.5	21.50	309.2	23.02	292.38
.8	1.81	58.3	22.24	309.8	24.05	290.86
.9	1.91	59.8	22.61	310.4	24.52	290.87
1.0	1.98	61.2	23.00	310.8	24.98	290.72
1.1	2.05	62.6	23.27	311.5	25.32	201.34
1.2	2.12	64.0	22.44	312.3	24.56	290.86
1.3	2.17	65.4	20.91	313.3	23.08	290.0
1.5	2.28	68.0	18.37	313.2	20.65	286.12
2.0	2.46	74.3	14.16	312.2	16.62	276.98
2.5	2.59	79.8	11.11	311.6	13.70	267.73
3.0	2.77	84.7	9.11	311.2	11.88	258.38
3.5	3.03	88.8	7.60	310.9	10.63	247.59
4.0	3.27	92.8	6.58	310.6	9.85	238.29
4.5	3.40	95.2	5.80	310.4	9.20	230.86
5.0	3.48	97.4	5.21	310.2	8.69	224.98
5.5	3.51	99.1	4.76	310.0	8.27	220.48
6.0	3.50	100.0	4.43	309.8	7.93	217.20
6.5	3.49	100.6	4.13	309.6	7.62	213.87
7.0	3.49	100.9	3.84	309.3	7.33	210.07
Ref. Area ft ² .	1.614		1.614		1.614	

TABLE IV

Trajectory DataNRC AD ~~22~~ 23

<u>Time</u> <u>sec.</u>	<u>Altitude</u> <u>ft.</u>	<u>Range</u> <u>ft.</u>	<u>Time</u> <u>sec.</u>	<u>Altitude</u> <u>ft.</u>	<u>Range</u> <u>ft.</u>	<u>Time</u> <u>sec.</u>	<u>Altitude</u> <u>ft.</u>	<u>Range</u> <u>ft.</u>
5	3,588	873	125	425,541	169,157	245	421,982	343,070
10	14,871	3,774	130	434,245	176,403	250	412,207	350,316
15	35,575	9,378	135	442,178	183,649	255	401,659	357,563
20	62,292	16,839	140	449,339	190,896	260	390,337	364,809
25	87,824	24,192	145	455,729	198,142	265	378,240	372,056
30	112,293	31,469	150	461,350	205,389	270	365,366	379,302
35	135,873	38,721	155	466,200	212,635	275	351,716	386,548
40	158,636	45,968	160	470,281	219,881	280	337,288	393,795
45	180,606	53,214	165	473,592	227,128	285	322,081	401,041
50	201,785	60,461	170	476,135	234,374	290	306,094	408,288
55	222,175	67,707	175	477,908	241,621	295	289,326	415,534
60	241,778	74,953	180	478,913	248,867	300	271,775	422,780
65	260,595	82,200	185	479,149	256,113	305	253,441	430,027
70	278,628	89,446	190	478,617	263,360	310	234,321	437,273
75	295,877	96,693	195	477,316	270,606	315	214,415	444,520
80	312,344	103,939	200	475,246	277,852	320	193,721	451,766
85	328,031	111,185	205	472,408	285,099	325	172,237	459,012
90	342,937	118,432	210	468,800	292,345	330	149,962	466,259
95	357,066	125,678	215	464,423	299,592	335	126,895	473,505
100	370,417	132,925	220	459,276	306,838	340	103,032	480,752
105	382,991	140,171	225	453,359	314,084	345	78,374	487,998
110	394,790	147,417	230	446,672	321,331	350	52,917	495,244
115	405,814	154,664	235	439,214	328,577	355	26,659	502,491
120	416,064	161,910	240	430,984	335,824			

Peak altitude: 479,152 ft.

Range at Peak 254,711 Time to Peak Alt. 184 sec. Impact Range 502,491 ft.

TABLE V

Wind Sensitivity Data

NRC AD ~~23~~ ^I 23

Altitude Z ft.	S/V sec/ft	Altitude Z ft.	S/V sec/ft	Altitude ft.	S/V sec/ft
15	.00683	300	.00233	4,500	.00059
20	.00647	350	.00217	5,000	.00056
25	.00611	400	.00203	6,000	.00050
30	.00586	450	.00192	7,000	.00047
35	.00560	500	.00181	8,000	.00043
40	.00537	600	.00166	9,000	.00041
45	.00520	700	.00153	10,000	.00039
50	.00502	800	.00144	12,000	.00035
60	.00470	900	.00136	14,000	.00032
70	.00445	1,000	.00128	16,000	.00029
80	.00422	1,200	.00117	18,000	.00027
90	.00404	1,400	.00108	20,000	.00026
100	.00385	1,600	.00101	25,000	.00023
120	.00358	1,800	.00095	30,000	.00020
140	.00334	2,000	.00089	35,000	.00018
160	.00315	2,500	.00080	40,000	.00018
180	.00297	3,000	.00073	50,000	.00018
200	.00283	3,500	.00067	60,000	.00018
250	.00255	4,000	.00063		

Burnout velocity, ft/sec. 5627

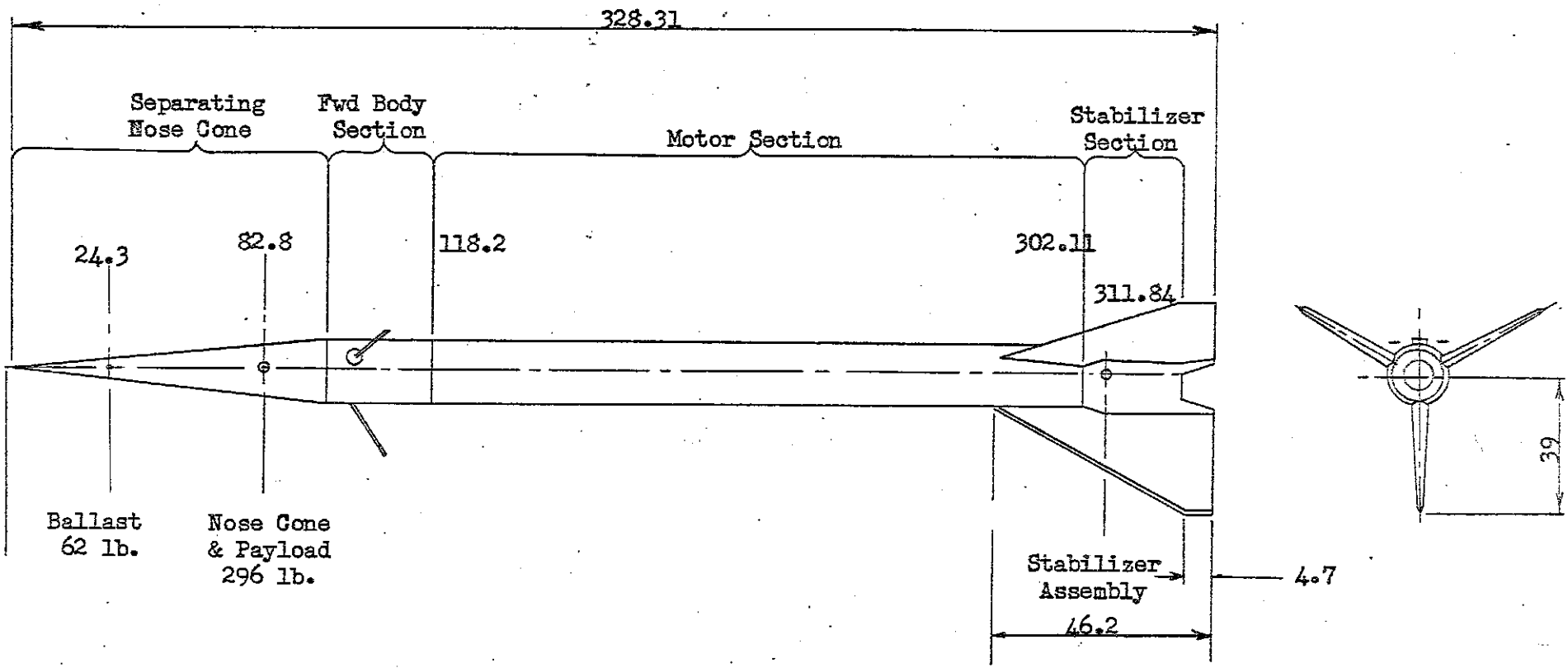
 $K(\theta_s = K \theta_0)$ 1.50

Elevation angles for which K may be used 70 - 90°

Launcher leaving velocity ft/sec. 94 Sensitivity leaving launcher .642

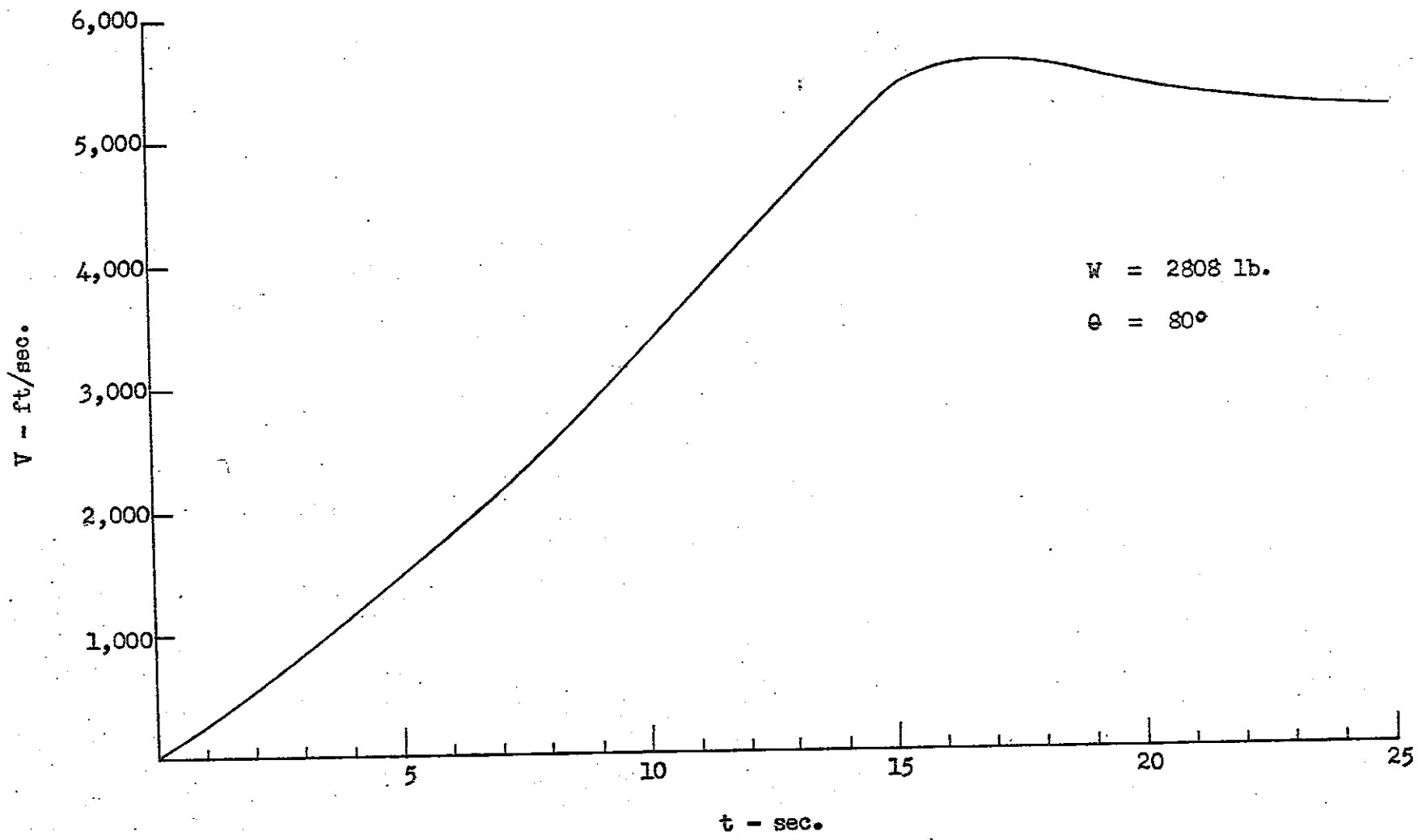
 $\theta_0 = 90^\circ$ - launcher elevation angle

NOTE:- Wind Sensitivity Data given above should be substituted for Tables I & III in the Wind Weighting Data for Black Brant Vehicles and used in conjunction with the latter for determining the Wind Weighting Data of AD ~~23~~ ^I 23 rocket vehicles.



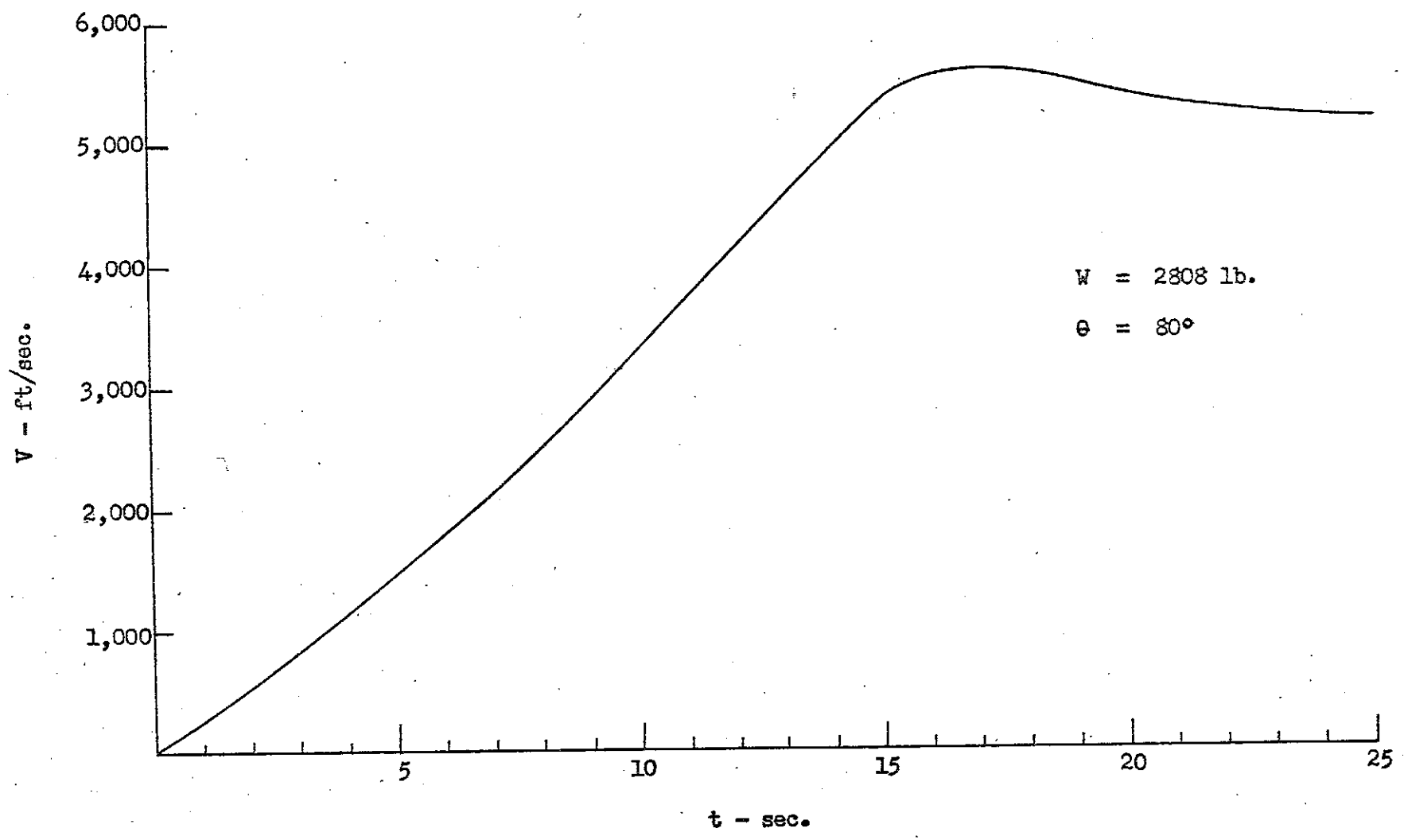
Vehicle Configuration AD ^Z 23

FIGURE 1



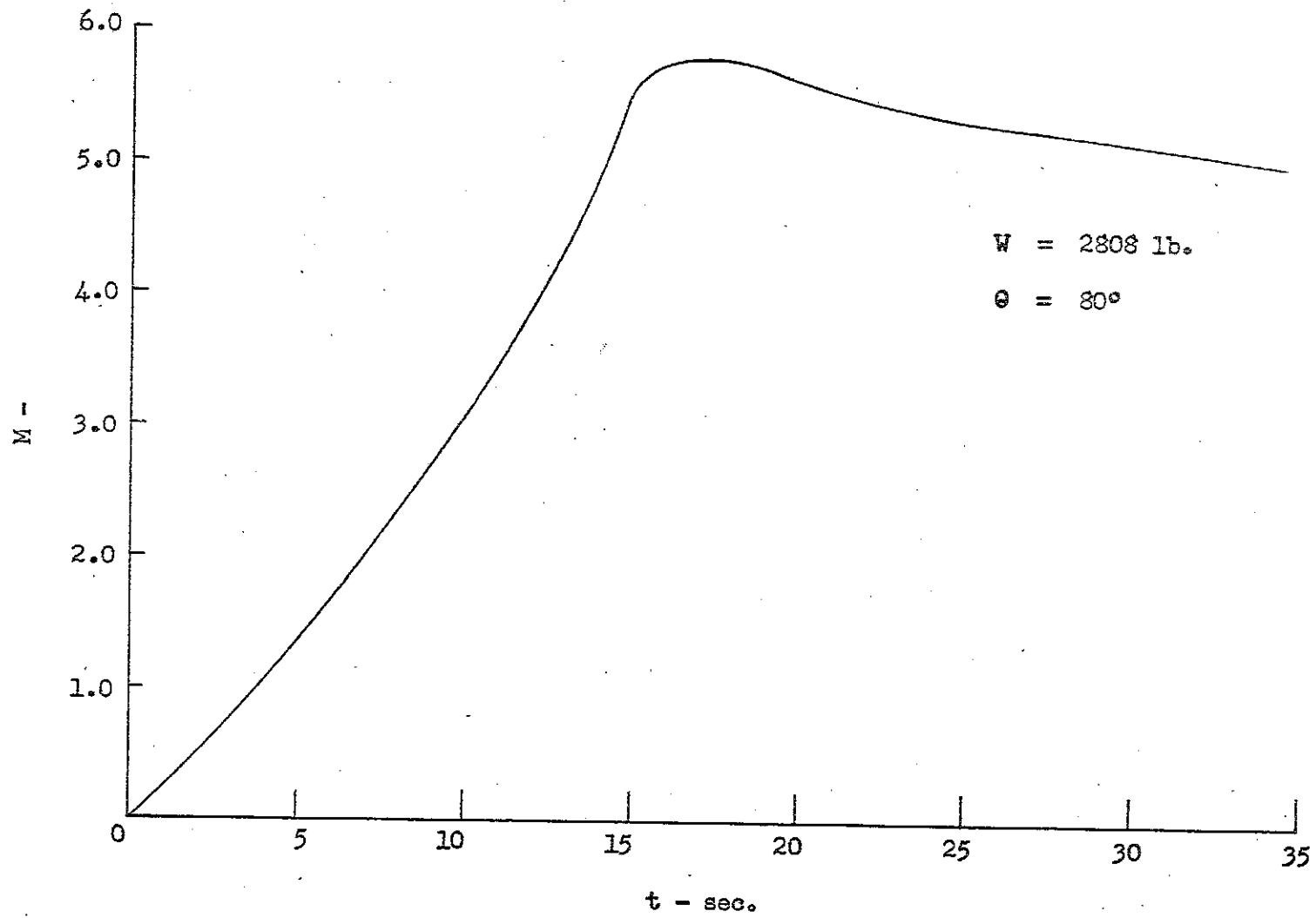
Velocity versus time

FIGURE 2



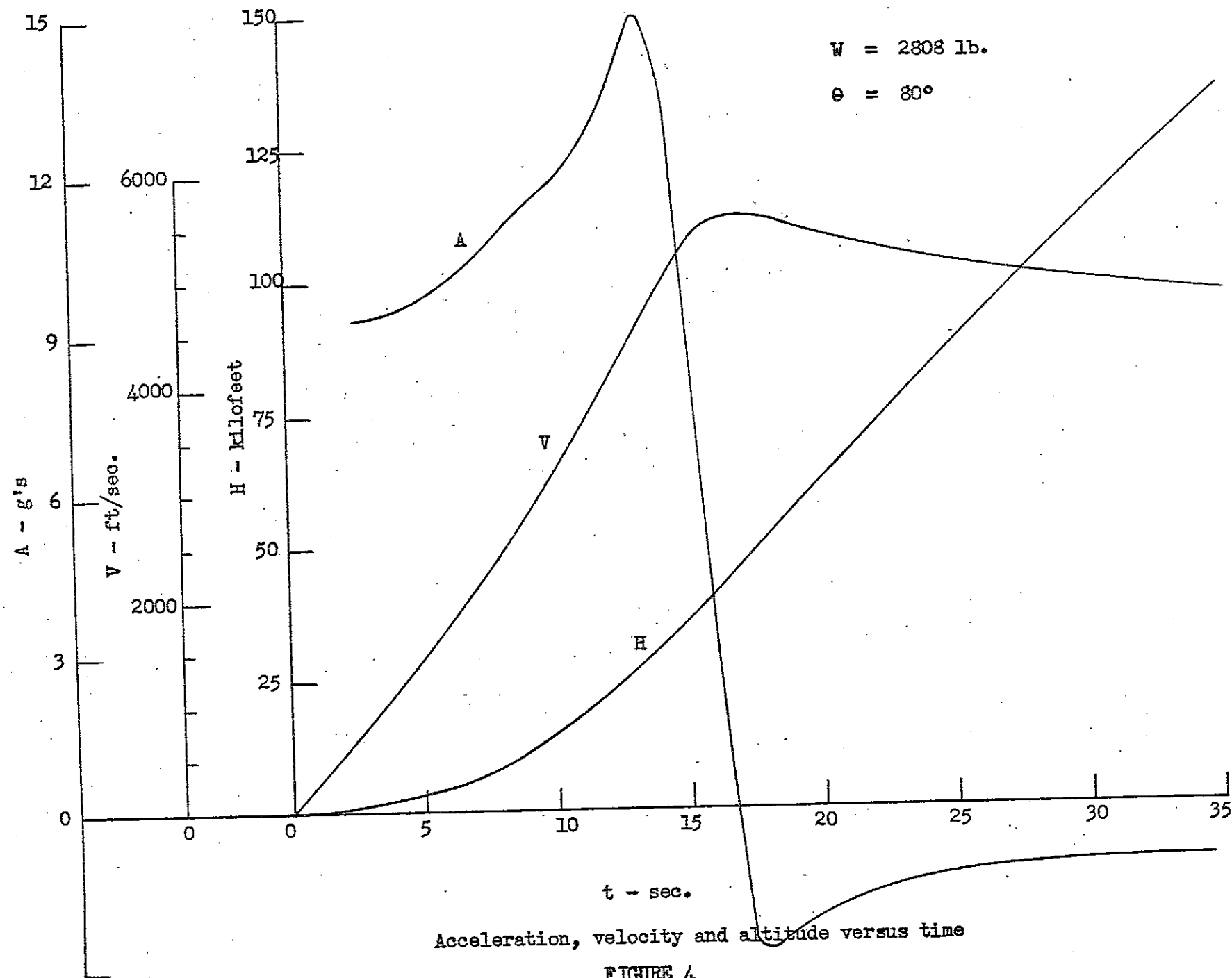
Velocity versus time

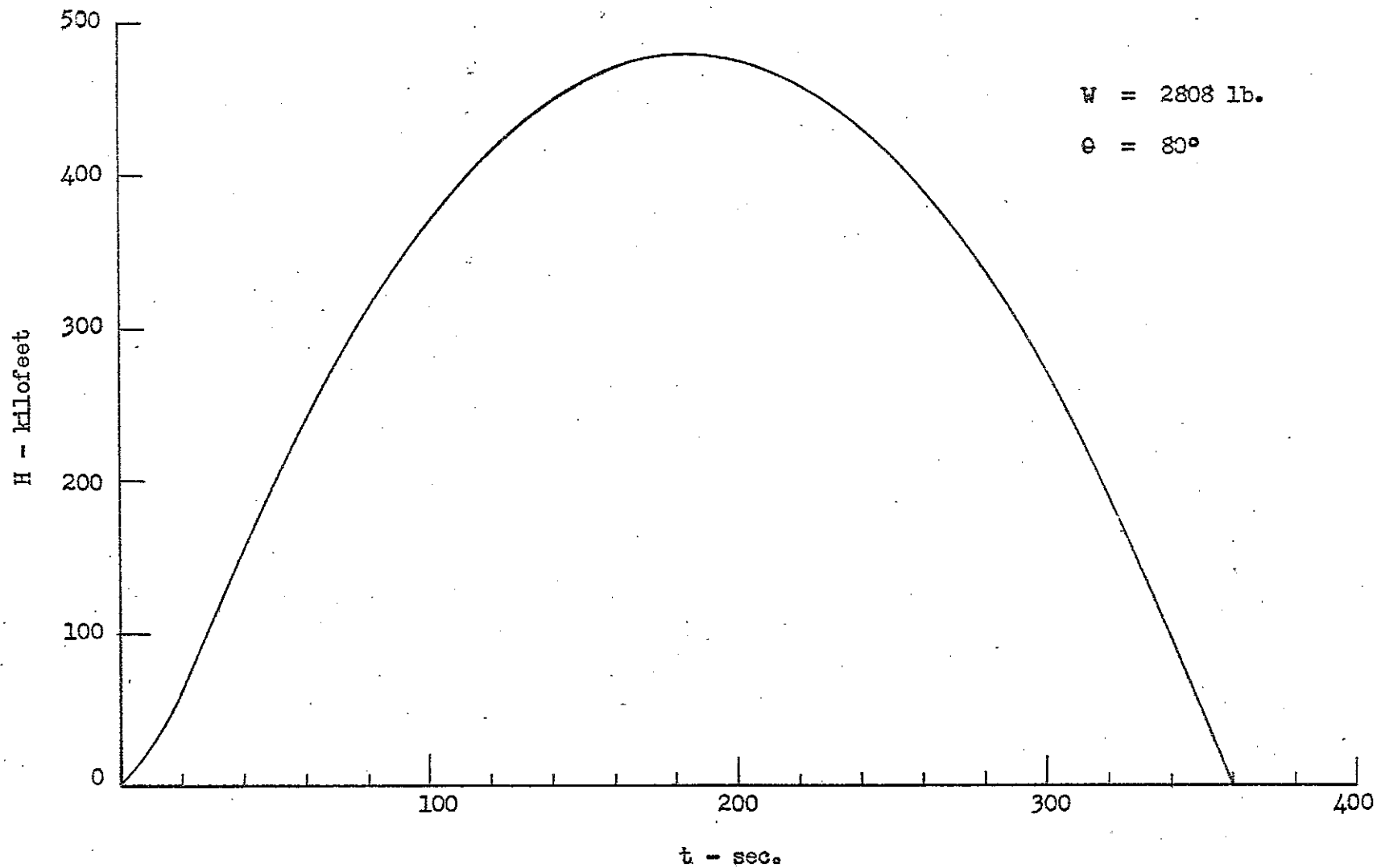
FIGURE 2



Mach No. versus time

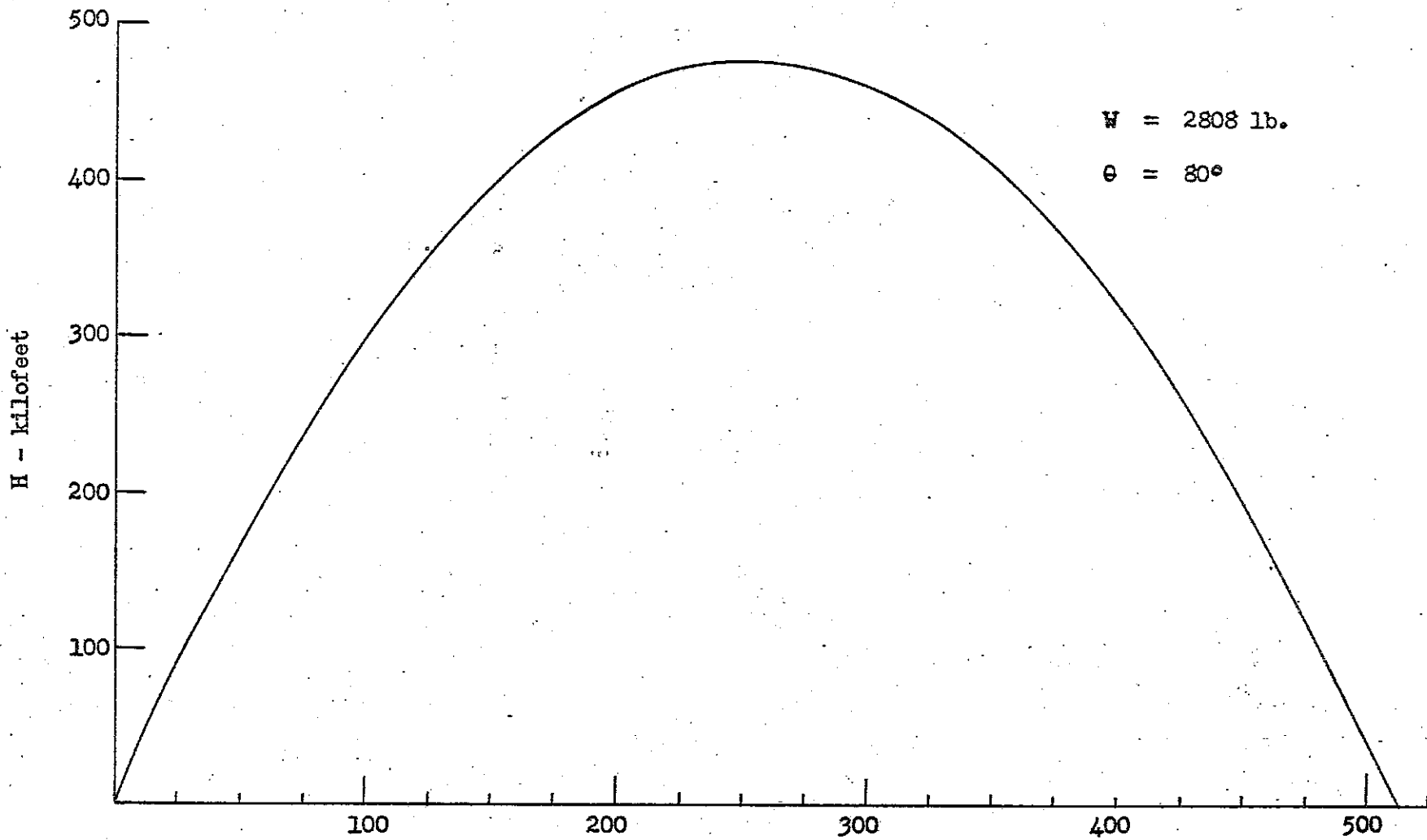
FIGURE 3





Altitude versus total flight time

FIGURE 5



R - kilofeet

Trajectory

FIGURE 6