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NIKE CAJUN SOUNDING ROCKET PERFORMANCE

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PREPARED BY
JOHN H. LANE and
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NASA

GODDARD SPACE FLIGHT CENTER
GREENBELT, MD.

RQT - 13830

NIKE CAJUN SOUNDING ROCKET

PERFORMANCE

DATE: April 17, 1962

TO : Files

FROM : Code 616.2 - John H. Lane and Nancy L. Kemmerer

SUBJECT : Nike-Cajun Sounding Rocket Performance

The Nike-Cajun (Figure 1) is the most widely used vehicle in the NASA National Sounding Rocket Program. It has also seen extensive service with other U.S. research agencies and with nations overseas.

Goddard's ability to accurately predict Nike-Cajun performance has increased significantly within the last year as a result of:

1. Completion of trajectory studies run on an IBM 7090 computer,
2. Analysis of Nike-Cajun radar data and comparison of theoretical and actual performance,
3. Preparation of curves for predicting performance of the Nike-Cajun system.

Because Nike-Cajun performance is highly sensitive to variations in Cajun drag, it was necessary to run calculations with what may be termed "low" "medium", and "high" drag coefficient inputs. The Cajun drag configurations considered were:

CASE I

<u>Low Drag</u>: Clean payload (no antennae) with 11° total angle (6.75 inch diameter) nose cone (see Cajun drawing, Fig. 2).

CASE II

<u>Medium Drag</u>: Two dovap antennae (Fig. 3) with 11° total angle (6.75 inch diameter) nose cone

or

<u>Medium Drag</u>: Clean payload (no antennae) with 20° total angle (6.75 inch diameter) nose cone.

CASE III
High Drag: Four 45° swept turnstile antennae (Fig. 4) with 11° total angle (6.75 inch diameter) nose cone.

Computer calculations were conducted for Nike-Cajun Rockets having the following characteristics:

1. Sea level launch altitude
2. Launch elevation angles of 70, 75, 80, 82,84, 86, and 90 degrees
3. Gross payload weights of 40, 50, 60, 70, 80, 90, 100, 110, and 120 lbs. (gross payload defined as all weight forward of the Cajun motor head).
4. Cajun ignition time of 17 seconds
5. Cajun drag configuration: Case I, Case II, Case III.

Additional information on assumptions and inputs for these calculations are given in Table 1 and Figures 5 through 8.

Results of the Nike-Cajun calculations are listed in Tables 2, 3, and 4. Major performance parameters at Nike burnout and Cajun ignition, burnout, apogee, and impact are plotted as a function of payload and launch angle in Figures 9 through 23. These curves are intended for use in predicting the performance of the Nike-Cajun having drag coefficient curves identical or similar to those of drag cases I, II, III.

A detailed evaluation of available Nike-Cajun radar data is now being conducted to determine adequacy of inputs to the theoretical calculations. Partial results, a comparison of theoretical and actual (radar) performance for eight rockets, are shown in Table 5. Here, the average discrepancies in

peak altitude and impact range were found to be only 3.5 and 2.9 statute miles respectively excluding results of NASA 10.74 which is known to have experienced pitch-roll coupling (roll lock-in) shortly after Cajun burnout. It should be emphasized that the theoretical values shown in Table 5 result from post-flight calculations using actual (radar) values for Cajun ignition time and effective flight path angle.

The accuracy of pre-flight estimates are often adversely affected by limitations of the firing range in predicting wind effects and, hence, effective launch elevation angle. For a typical Nike-Cajun, a 2° discrepancy in effective angle results in a peak altitude error of 2.5 miles and an impact range error of about 15 miles. It appears that, in general, peak altitude predictions within plus and minus six miles of actual can be expected if a very careful determination of weight and drag configuration is made.

Performance investigations have not yet been run for some Cajun payload geometries. The "grenade series" (4 dovap antennae and an 18 inch long nose cone with 100 lbs of extra weight in the Nike adapter) is in this category.

RECOMMENDATIONS FOR USE OF NIKE-CAJUN PERFORMANCE CURVES

1. Carefully determine the correct drag case, payload weight, and launch angle (desired effective launch angle) before entering curves.

2. Specify at least a plus-and-minus six mile tolerance on peak altitude predictions.

3. Consult with Code 616.2 in situations where drag configuration does not appear to match any of the three cases defined above, or where other deviations from normal Nike-Cajun input parameters are present.

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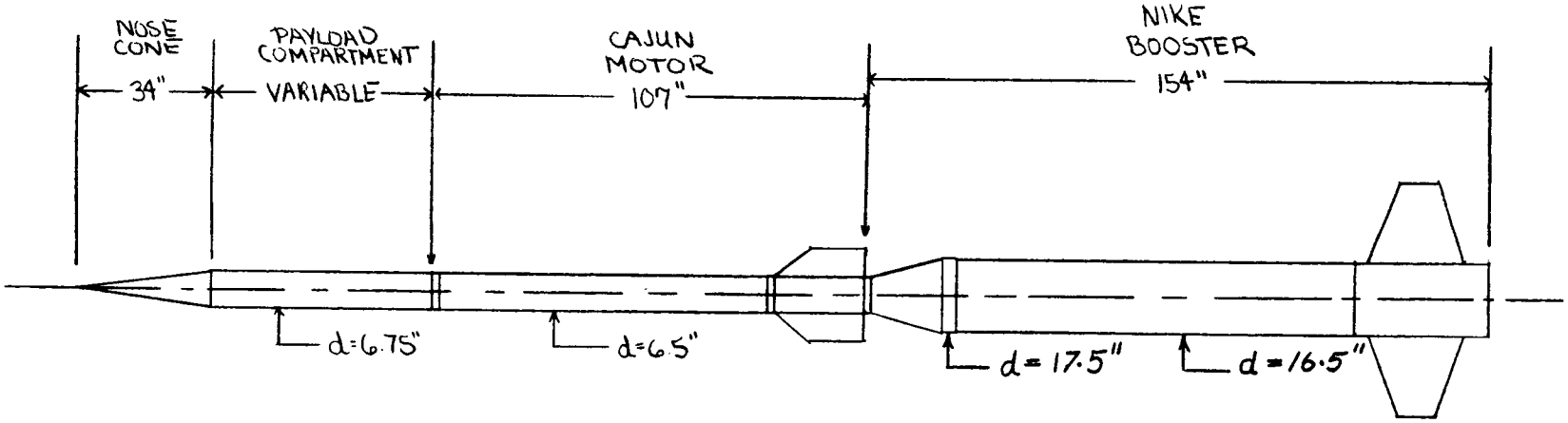
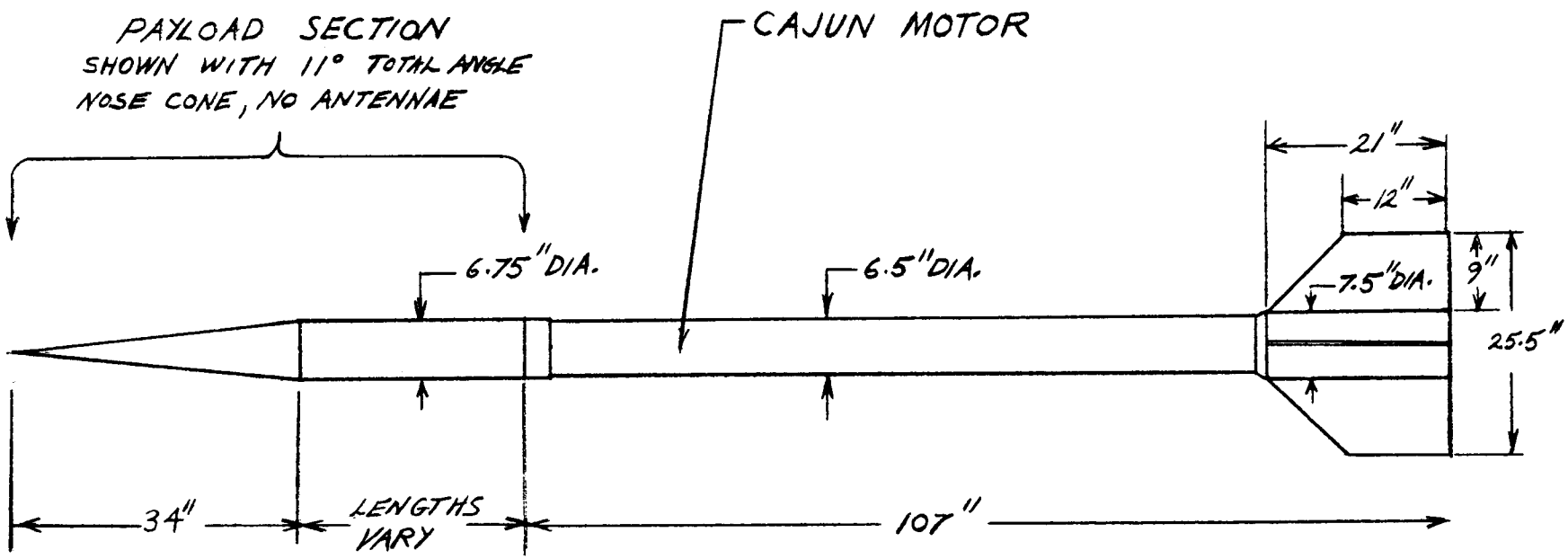
NIKE CAJUN



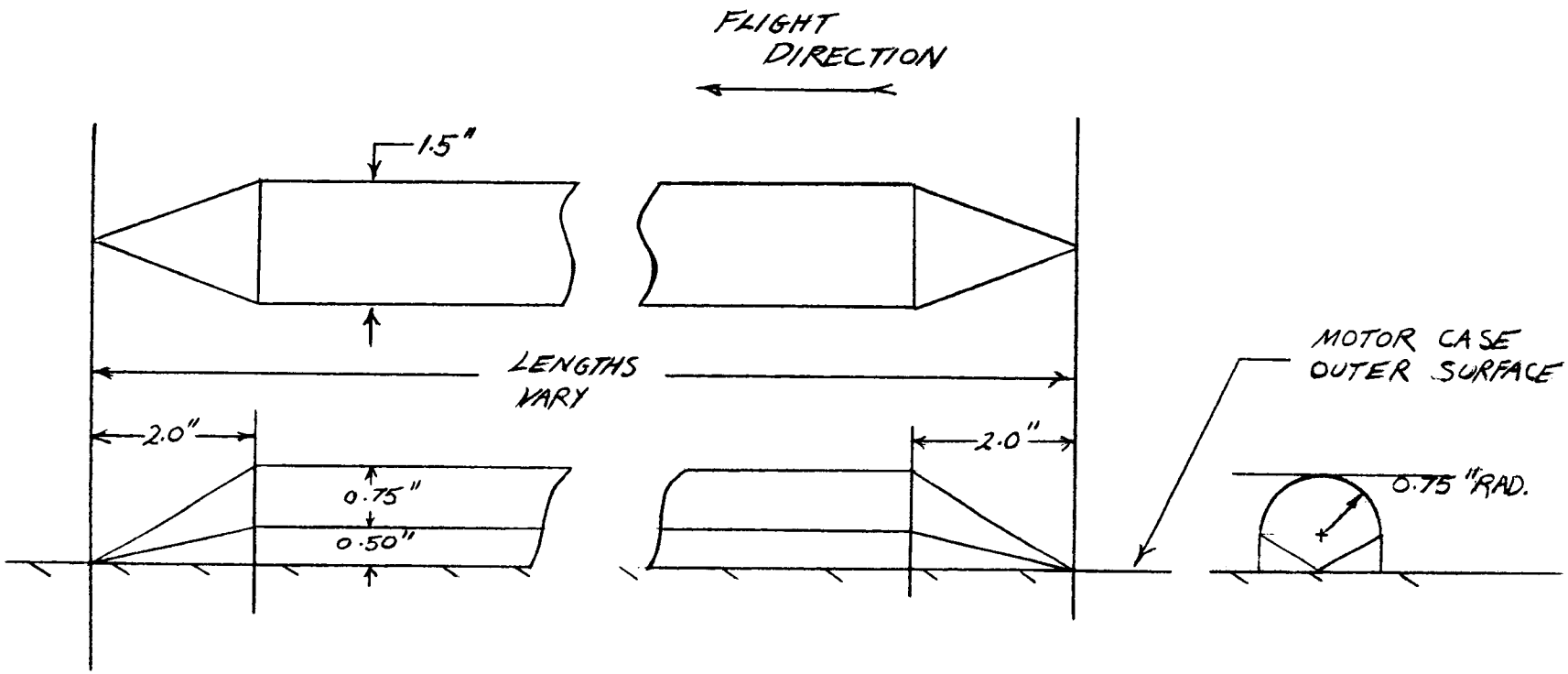
(LENGTHS TO NEAREST INCH)

FIGURE 1



CAJUN ROCKET

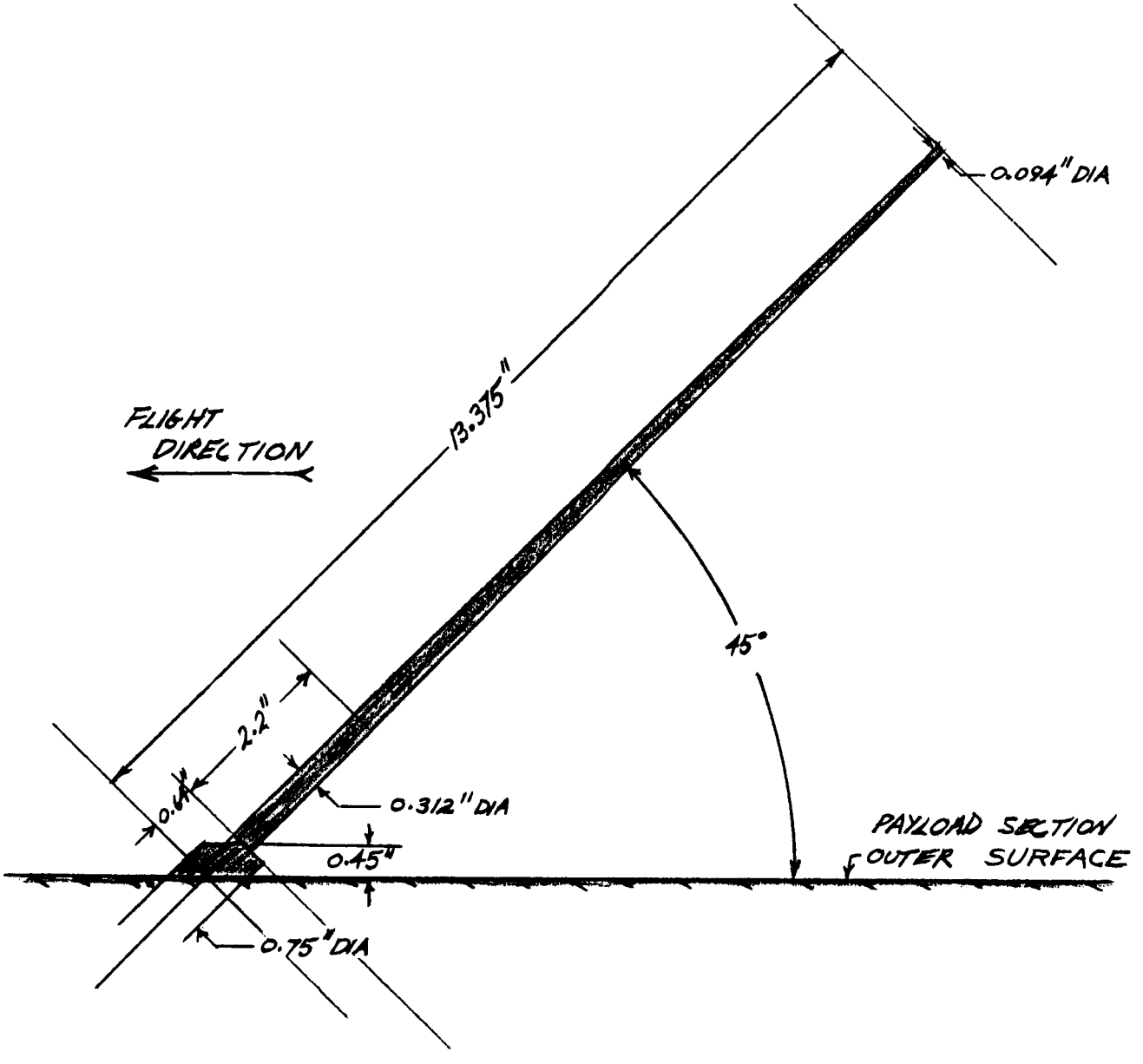
FIGURE 2



DOVAP ANTENNA

FIGURE 3

JHL MAR 62



45° SWEPT TURNSTILE ANTENNA

FIGURE 4

JHL MAR 62

TABLE I

ASSUMPTIONS AND INPUTS FOR NIKE-CAJUN TRAJECTORY CALCULATIONS

ASSUMPTIONS

1. Two dimensional point-mass trajectory.
2. Spherical, non-rotating Earth.
3. Inverse square gravitational field.
4. Standard Atmosphere, ICAO extension.
5. Sea level launch.
6. 17 second Cajun ignition.

INPUTS

Mass

$W = w + w_{P/L}$ = total mass (lbs. mass) where w is mass without payload; $w_{P/L}$ is payload mass.

At t = 0 sec. (Nike Ignition) w = 1520 lbs. mass
At t = 3.5 sec. (Nike Burnout before separation) w= 765 lbs. mass.

From 0 to 3.5 sec. mass flow rate is assumed constant,

$$\dot{w} = \frac{755}{3.5} = 215.714 \text{ lbs. mass/sec}$$

From 3.5 seconds (after stage separation) to 17.0 seconds, w = 202 lbs. mass.

From 17.0 to 21.0 seconds (Cajun burning) w is as given in figure 5.

From 21.0 seconds to impact, w = 83 lbs. mass.

Payload weights, $w_{P/L}$ are taken at 10 lbs. mass intervals from 40 to 120 lbs. mass.

Thrust

$$T = T_{SL} + A_E (P_E - P_A)$$

where

T = total thrust (lbs)
T_{SL} = thrust at sea level (lbs)
A_E = nozzle exit area (square inches)
P_E = nozzle exit pressure = 14.7 psia
P_A = ambient pressure (psia)

Nike Burning:

Burning period : 0 to 3.5 seconds
T_{SL} = 42,500 lbs. = constant
$A_E = \frac{\pi}{4} (16.333)^2 = 209.4$ inches ^{2}

TABLE I Cont.

Cajun Burning:

Burning period: 17.0 to 21.0 seconds

T_{SL} = as per figure 6

A_E = 37.1 inches ^{2}

Drag

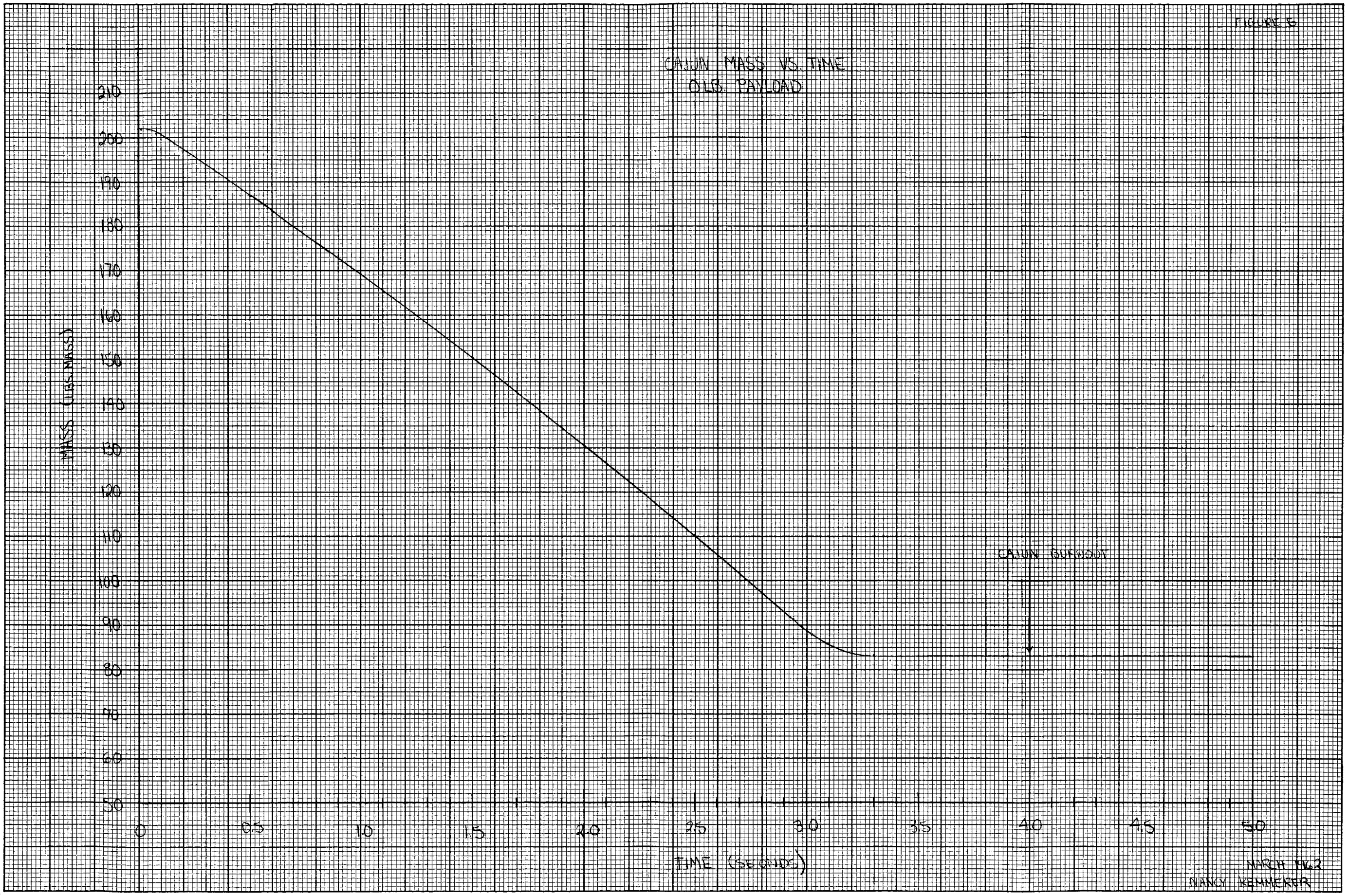
Drag coefficients for Nike thrusting period as given in figure 7.

Drag coefficients for Cajun coasting and thrusting periods as given in figure 8 (for Cajun payload configuration I, II, and III).

Launch Elevation Angles

Taken as 70°, 75°, 80°, 82°, 84°, 86°, and 90°.

FIGURE 5



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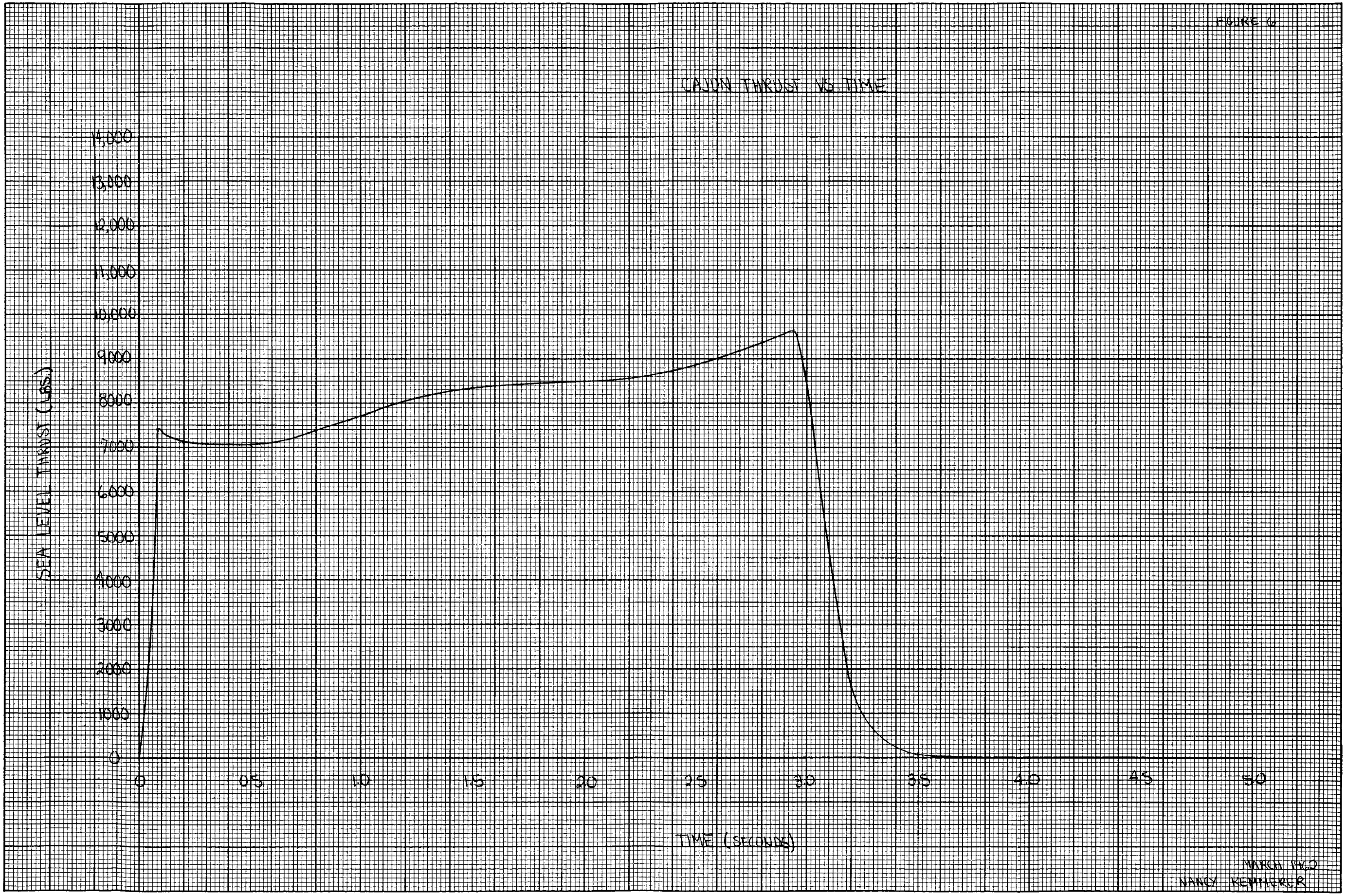
FIGURE 6
CAJUN THRUST VS TIME
SEA LEVEL THRUST (LBS.)
14,000
13,000
12,000
11,000
10,000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
TIME (SECONDS)
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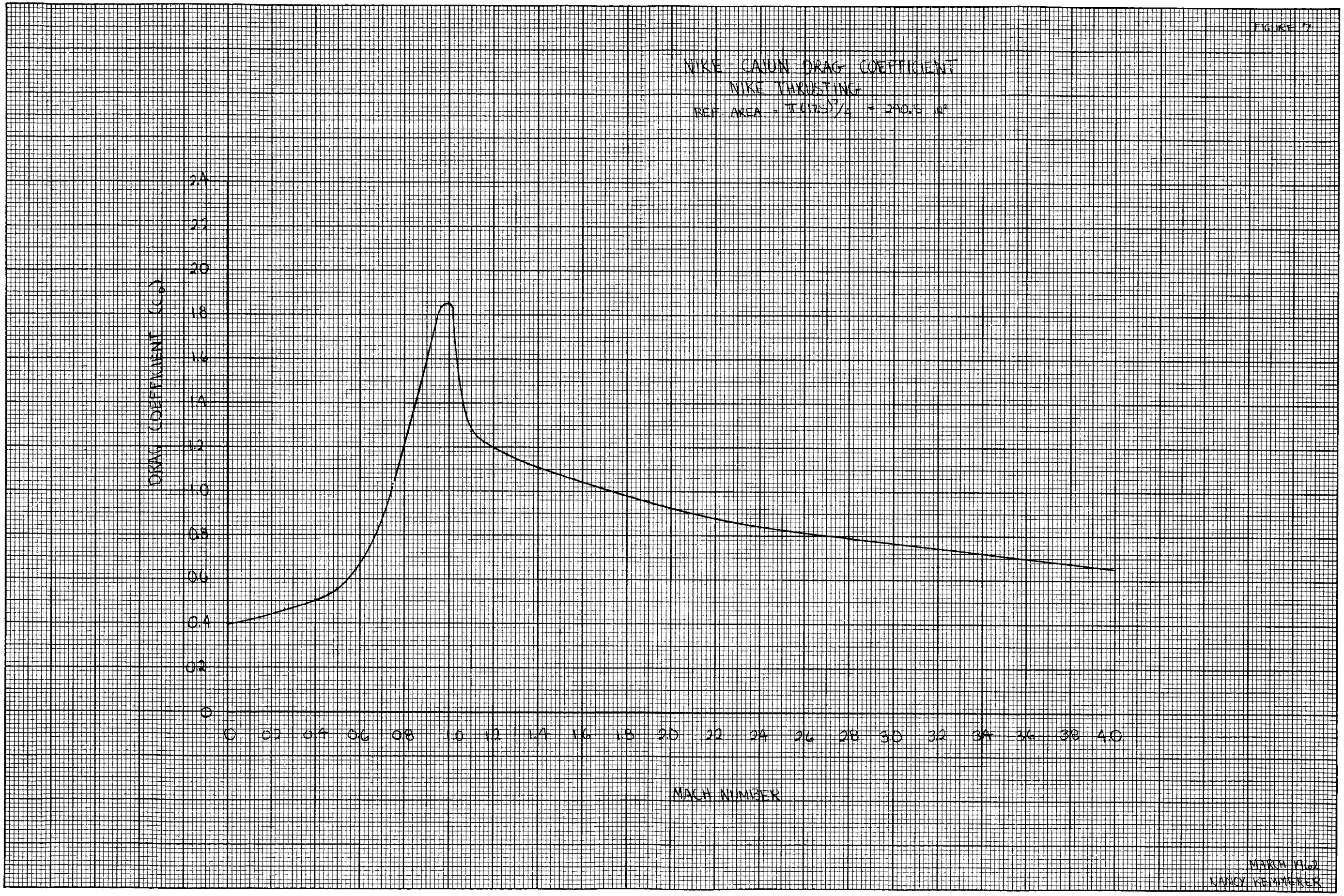
FIGURE 7


NIKE CAJUN DRAG COEFFICIENT
NIKE THRUSTING
REF AREA = π(17.5)²/4 = 240.5 in²
DRAG COEFFICIENT (C_D)
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0
MACH NUMBER
MARCH 1962
NANCY KEMMERER

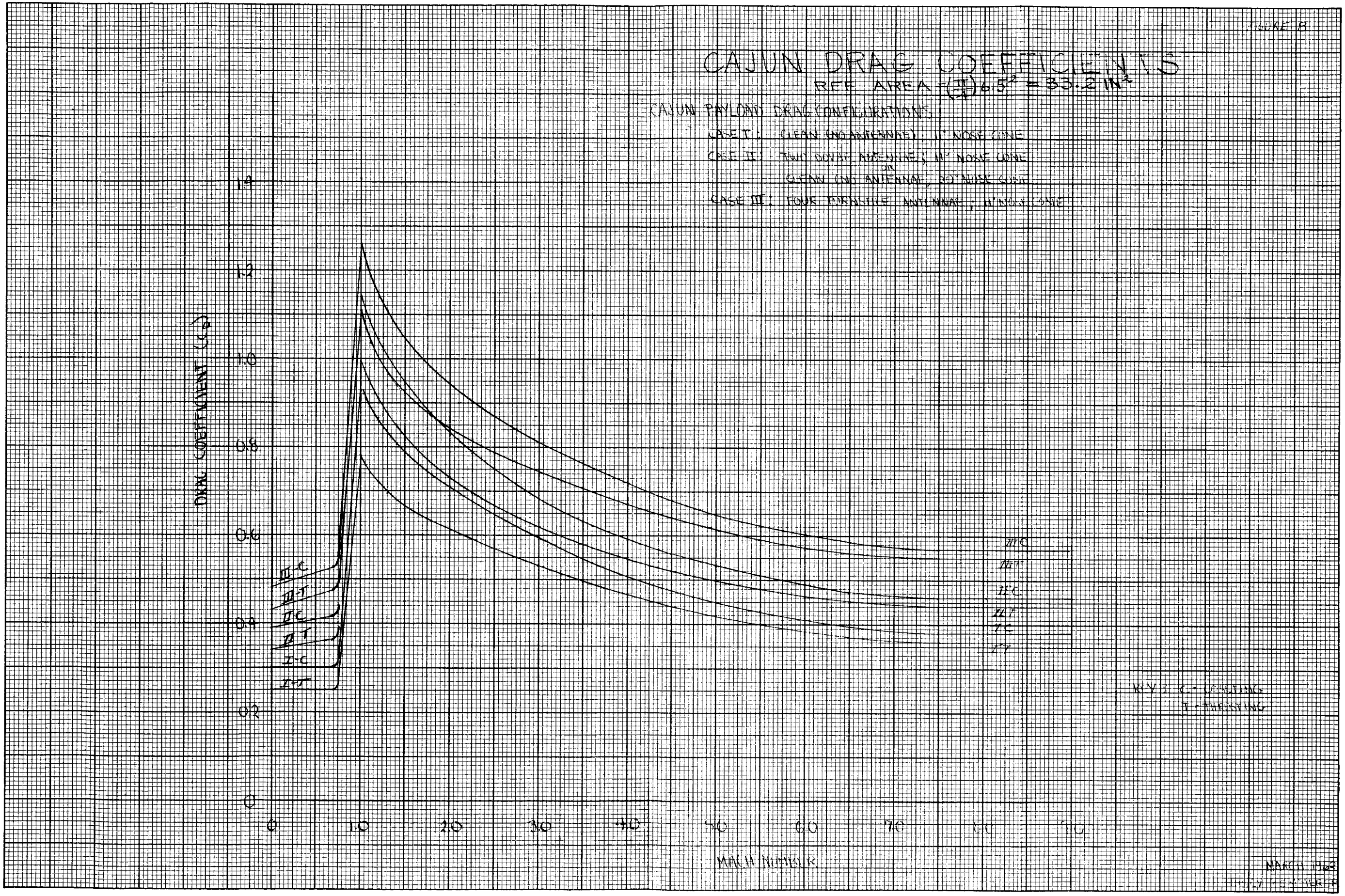


FIGURE 8
CAJUN DRAG COEFFICIENTS
REF AREA = (π/4) 6.5² = 33.2 IN²
CAJUN PAYLOAD DRAG CONFIGURATIONS
CASE I: CLEAN (NO ANTENNAE); 11° NOSE CONE
CASE II: TWO DOVAL ANTENNAE; 11° NOSE CONE
OR
CLEAN (NO ANTENNAE, 20° NOSE CONE
CASE III: FOUR FORMSTILE ANTENNAE; 11° NOSE CONE
DRAG COEFFICIENT (CD)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
III-C
III-T
II-C
II-T
I-C
I-T
0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
MACH NUMBER
KEY: C - COASTING
T - THRUSTING
MARCH 1962

CASE I DRAG CONFIGURATION

CLEAN (NO ANTENNAE) WITH 11° NOSE CONE

TABLE 2

THEORETICAL NIKE CAJUN - PERFORMANCE

CASE I

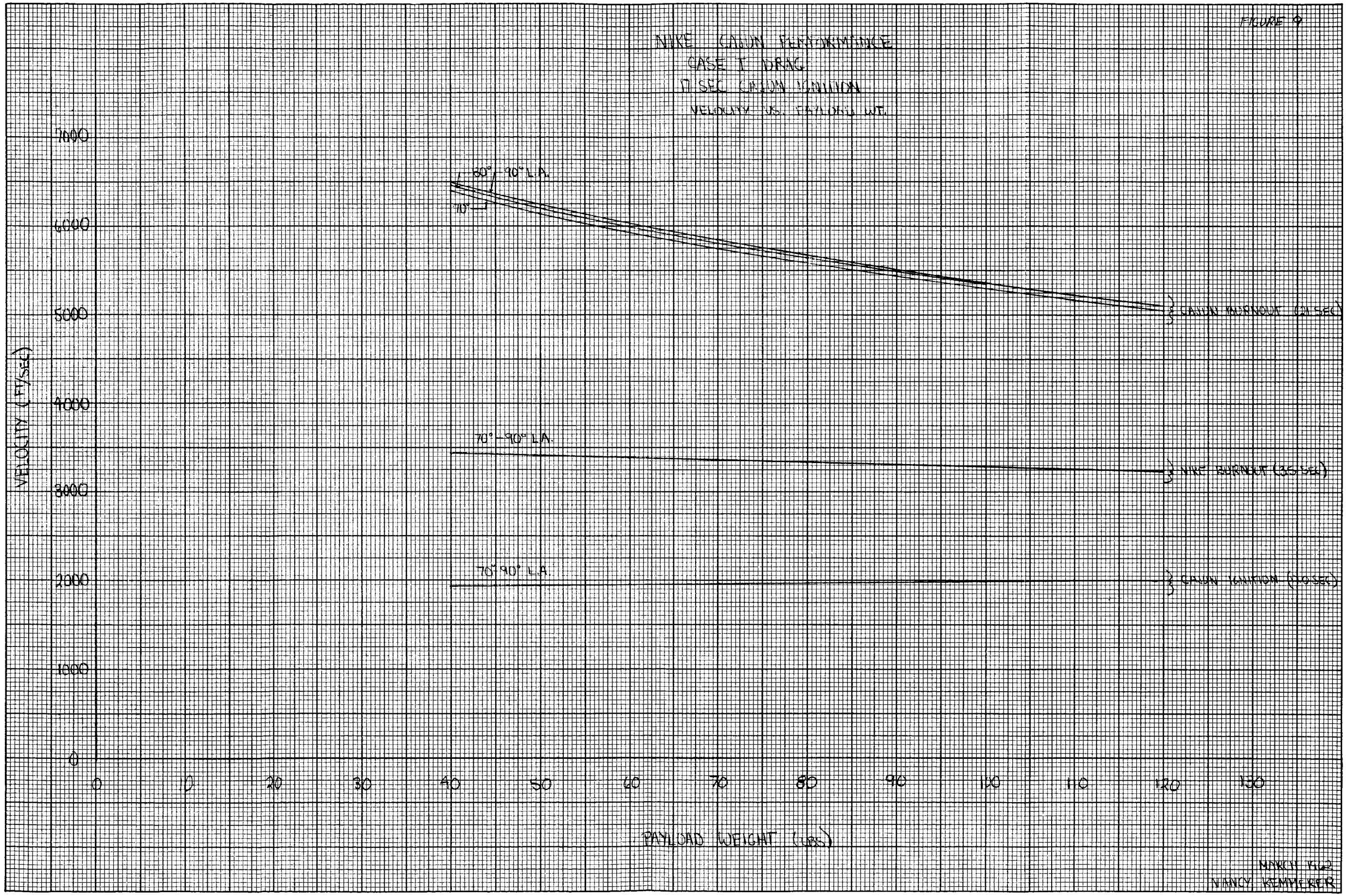
CAJUN P/L WT.	θ_L (DEG)	h_{BO_1} (FT)	V_{BO_1} (FT/SEC)	H.R.$_{BO_1}$ (FT)	θ_{BO} (DEG)	h_{IGN_2} (FT)	V_{IGN_2} (FT/SEC)	H.R.$_{IGN_2}$ (FT)	θ_{IGN_2} (DEG)	h_{BO_2} (FT)	V_{BO_2} (FT/SEC)	H.R.$_{BO_2}$ (FT)	θ_{BO_2} (DEG)	$t_{h\,max}$ (SEC)	h_{max} (ST. MI)	H.R.$_{h\,max}$ (ST. MI)	t_i (SEC)	H.R.$_i$ (ST. MI)
40	70	5311	3432	2279	66.4	35,668	1911	16,634	62.0	51,032	6384	25,013	61.0	184.7	87.9	88.9	364.9	177.9
	75	5509	3432	1732	72.3	37,317	1919	12,705	68.9	53,676	6432	19,163	68.2	199.2	102.5	75.4	392.4	150.8
	80	5653	3432	1166	78.2	38,525	1925	8582	75.9	55,617	6464	12,911	75.4	209.6	113.9	54.5	412.5	109.2
	82	5695	3432	935	80.5	38,876	1927	6891	78.7	56,182	6473	10,423	78.3	212.7	117.3	44.7	418.3	89.4
	84	5728	3432	703	82.9	39,151	1928	5184	81.5	56,626	6480	7894	81.2	215.1	120.0	34.1	422.9	68.2
	86	5751	3432	469	85.3	39,347	1929	3463	84.3	56,992	6485	5242	84.1	216.7	122.0	23.0	426.2	46.1
	90	5769	3432	0	90.0	39,507	1929	0	90.0	57,198	6489	0	90.0	218.1	123.5	0	428.8	0
50	70	5272	3408	2265	66.4	35,687	1929	16,668	61.9	50,587	6131	24,800	61.0	178.3	82.1	82.8	352.0	165.8
	75	5470	3407	1721	72.3	37,338	1936	12,730	68.9	53,198	6174	18,996	68.1	192.0	95.4	70.1	377.9	140.2
	80	5614	3407	1158	78.2	38,543	1941	8598	75.9	55,111	6202	12,856	75.4	201.9	105.8	50.7	396.9	101.4
	82	5655	3407	929	80.5	38,892	1943	6904	78.7	55,667	6210	10,330	78.3	204.7	108.9	41.4	402.5	83.0
	84	5688	3407	698	82.9	39,168	1944	5193	81.5	56,104	6216	7774	81.2	207.0	111.4	31.6	406.8	63.3
	86	5711	3407	466	85.3	39,363	1945	347	84.3	56,417	6220	5195	84.1	208.6	113.2	21.3	409.9	42.7
	90	5730	3407	0	90.0	39,523	1945	0	90.0	56,670	6224	0	90.0	209.9	114.6	0	412.4	0
60	70	5236	3384	2251	66.4	35,689	1944	16,694	61.9	50,247	5932	24,645	61.0	173.5	77.8	78.4	342.1	157.0
	75	5432	3384	1711	72.2	37,339	1951	12,748	68.9	52,829	5970	18,874	68.1	186.5	90.2	66.2	366.8	132.4
	80	5574	3383	1151	78.1	38,541	1956	8609	75.9	54,719	5996	12,772	75.4	195.9	99.8	47.7	385.0	95.6
	82	5616	3383	924	80.5	38,891	1957	6913	78.7	55,271	6003	10,261	78.3	198.6	102.7	39.0	390.3	78.2
	84	5649	3383	694	82.9	39,166	1958	5200	81.5	55,704	6008	7722	81.2	200.8	105.0	29.8	394.4	59.7
	86	5672	3383	463	85.3	39,362	1959	3474	84.3	56,014	6012	5160	84.1	202.3	106.6	20.1	397.3	40.3
	90	5690	3383	0	90.0	39,521	1959	0	90.0	56,263	6015	0	90.0	203.5	107.9	0	399.7	0
70	70	5199	3360	2238	66.3	35,675	1958	16,711	61.9	49,919	5752	24,499	60.9	169.1	74.0	74.5	333.1	149.1
	75	5394	3360	1701	72.2	37,322	1964	12,760	68.8	52,475	5786	18,758	68.1	181.5	85.5	62.7	356.9	125.5
	80	5535	3360	1145	78.1	38,522	1968	8617	75.9	54,345	5809	12,692	75.3	190.5	94.5	45.2	374.2	90.5
	82	5577	3360	918	80.5	38,872	1969	6919	78.7	54,891	5815	10,197	78.3	193.2	97.2	37.0	379.3	74.0
	84	5610	3360	690	82.9	39,146	1970	5204	81.5	55,319	5820	7673	81.2	195.2	99.3	28.2	383.2	56.4
	86	5633	3360	460	85.2	39,343	1971	3477	84.3	55,626	5823	5128	84.1	196.7	100.9	19.0	386.1	38.1
	90	5651	3360	0	90.0	39,499	1971	0	90.0	55,870	5826	0	90.0	197.8	102.1	0	388.3	0
80	70	5162	3337	2225	66.3	35,644	1970	16,722	61.9	49,598	5588	24,360	60.9	165.0	70.5	71.0	329.9	142.1
	75	5357	3336	1691	72.2	37,287	1975	12,768	68.8	52,129	5619	18,648	68.1	177.0	81.4	59.6	347.7	119.4
	80	5498	3336	1138	78.1	38,487	1978	8621	75.8	53,984	5639	12,616	75.3	185.6	89.8	42.9	364.4	86.0
	82	5539	3336	913	80.5	38,836	1979	6922	78.7	54,525	5644	10,136	78.2	188.2	92.3	35.1	369.3	70.3
	84	5572	3336	686	82.9	39,110	1980	5207	81.5	54,949	5649	7627	81.2	190.1	94.3	26.8	373.1	53.6
	86	5595	3336	458	85.2	39,306	1981	3478	84.3	55,252	5652	5097	84.1	191.5	95.8	18.1	375.8	36.2
	90	5612	3336	0	90.0	39,461	1981	0	90.0	55,494	5654	0	90.0	192.7	96.9	0	378.0	0

THEORETICAL NIKE CAJUN - PERFORMANCE

CASE I

CAJUN P/L WT	θ_L (DEG)	h_{BO_1} (FT)	V_{BO_1} (FT/SEC)	$H.R_{BO_1}$ (FT)	θ_{BO_1} (DEG)	h_{IGN_2} (FT)	V_{IGN_2} (FT/SEC)	$H.R_{IGN_2}$ (FT)	θ_{IGN_2} (DEG)	h_{BO_2} (FT)	V_{BO_2} (FT/SEC)	$H.R._{BO_2}$ (FT)	θ_{BO_2} (DEG)	$t_{h\,MAX}$ (SEC)	h_{MAX} (ST. MI)	$H.R._{h\,MAX}$ (ST. MI)	t_i (SEC)	$H.R._i$ (ST. MI)
90	70																	
	75																	
	80																	
	82																	
	84																	
	86																	
	90																	
100	70	5091	3291	2199	66.3	35,544	1989	16,726	61.8	48,981	5298	24,100	60.8	157.8	64.6	64.9	310.4	129.9
	75	5283	3291	1671	72.2	37,180	1992	12,768	68.8	51,465	5323	18,443	68.0	168.9	74.3	54.4	331.6	108.8
	80	5423	3290	1125	78.1	38,374	1995	8621	75.8	53,287	5340	12,474	75.3	177.0	81.8	39.1	347.2	78.2
	82	5465	3290	902	80.5	38,723	1995	6922	78.7	53,819	5344	10,021	78.2	179.3	84.0	31.9	351.7	63.9
	84	5496	3290	678	82.8	38,995	1996	5206	81.5	54,236	5347	7541	81.2	181.2	85.8	24.3	355.3	48.7
	86	5519	3290	453	85.2	39,190	1996	3478	84.3	54,534	5350	5039	84.1	182.5	87.1	16.4	357.8	32.9
	90	5536	3290	0	90.0	39,345	1996	0	90.0	54,771	5352	0	90.0	183.5	88.1	0	359.8	0
110	70	5056	3269	2186	66.2	35,477	1996	16,720	61.8	48,680	5169	23,976	60.8	154.5	62.0	62.3	303.9	124.7
	75	5248	3268	1662	72.1	37,110	1999	12,763	68.8	51,146	5192	18,346	68.0	165.3	71.2	52.1	324.5	104.3
	80	5387	3268	1118	78.1	38,302	2001	8617	75.8	52,952	5207	12,408	75.3	173.1	78.3	37.4	339.5	74.9
	82	5427	3268	897	80.5	38,647	2001	6918	78.6	53,478	5211	9967	78.2	175.4	80.5	30.6	343.9	61.2
	84	5459	3268	674	82.8	38,919	2002	5203	81.5	53,890	5214	7500	81.1	177.2	82.1	23.3	347.3	46.6
	86	5481	3268	450	85.2	39,114	2002	3476	84.3	54,187	5216	5011	84.1	178.4	83.4	15.7	349.8	31.5
	90	5500	3268	0	90.0	39,270	2002	0	90.0	54,423	5218	0	90	179.5	84.4	0	351.8	0
120	70	5023	3247	2174	66.2	35,901	2002	16,710	61.8	48,381	5048	23,854	60.7	151.5	59.6	59.8	297.8	119.8
	75	5213	3246	1652	72.1	37,027	2004	12,753	68.7	50,826	5068	18,250	67.9	161.9	68.4	50.0	317.7	100.1
	80	5351	3246	1112	78.1	38,215	2005	8610	75.8	52,615	5082	12,342	75.2	169.5	75.1	35.9	332.3	71.8
	82	5391	3245	892	80.4	38,562	2006	6913	78.6	53,137	5085	9914	78.2	171.7	77.1	29.3	336.5	58.7
	84	5422	3245	670	82.8	38,832	2006	5199	81.5	53,596	5088	7459	81.1	173.4	78.8	22.3	339.9	44.7
	86	5445	3245	447	85.2	39,027	2006	3473	84.3	53,841	5090	4984	84.1	174.6	79.9	15.1	342.3	30.1
	90	5462	3245	0	90.0	39,181	2006	0	90.0	54,073	5091	0	90.0	175.6	80.9	0	344.2	0

FIGURE 9



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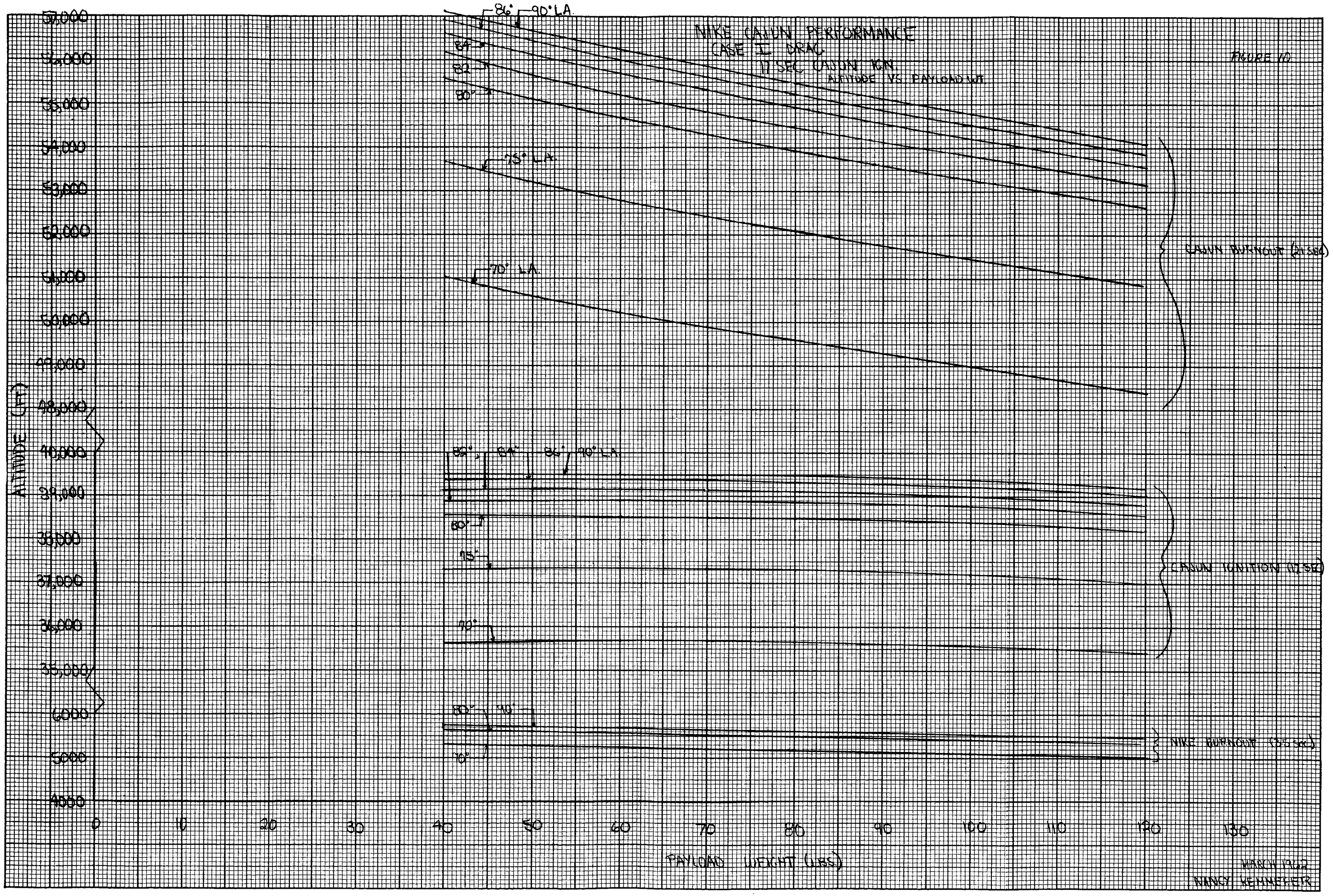
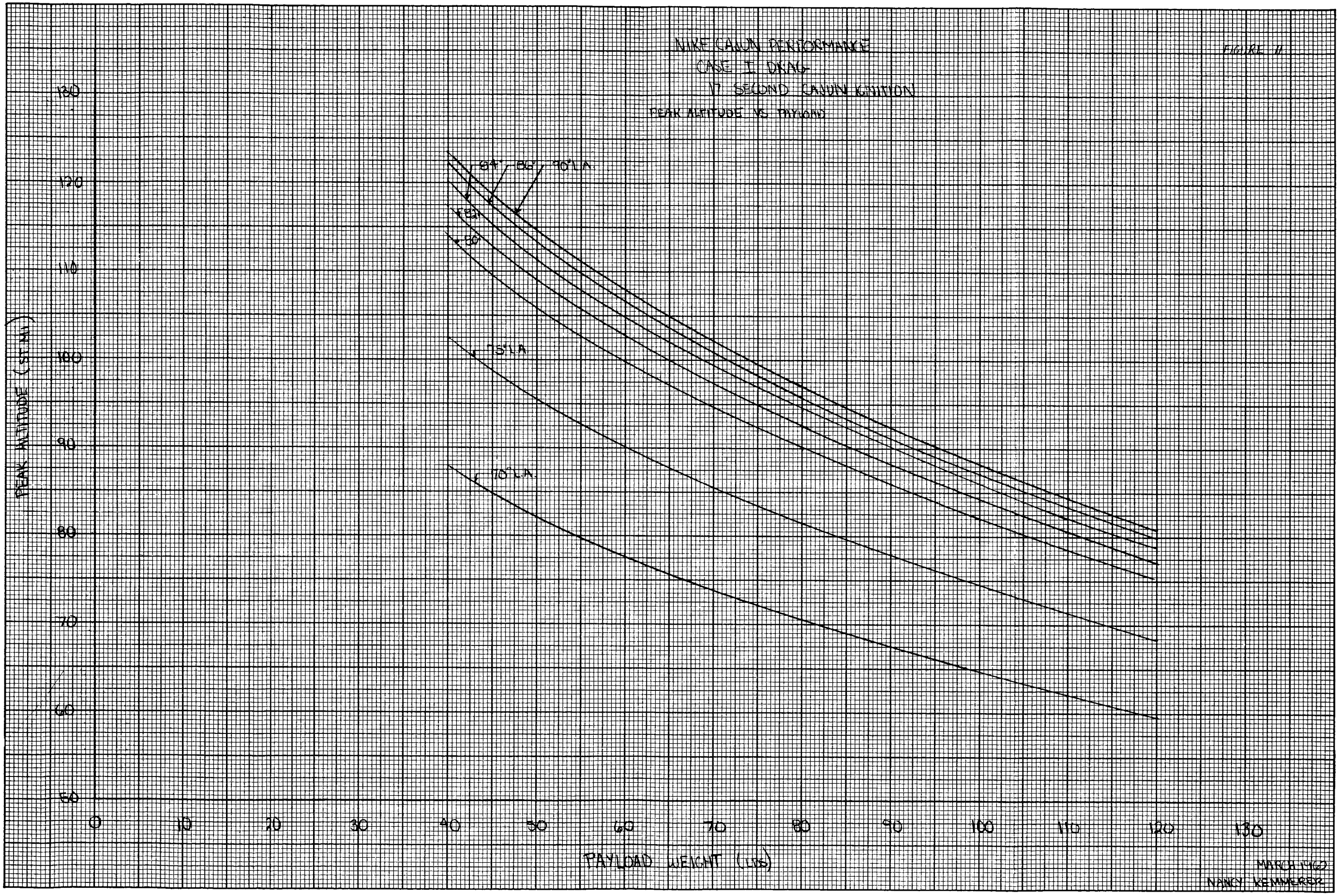

NIKE CAJUN PERFORMANCE
CASE I DRAG
17 SEC CAJUN IGN
ALTITUDE VS PAYLOAD WT
FIGURE 10
86°
90° L.A.
84°
82°
80°
75° L.A.
70° L.A.
CAJUN BURNOUT (21 SEC)
82°
84°
86°
90° L.A.
80°
75°
70°
CAJUN IGNITION (17 SEC)
80°
90°
70°
NIKE BURNOUT (3.5 sec)
ALTITUDE (FT)
57,000
56,000
55,000
54,000
53,000
52,000
51,000
50,000
49,000
48,000
40,000
39,000
38,000
37,000
36,000
35,000
6000
5000
4000
0
10
20
30
40
50
60
70
80
90
100
110
120
130
PAYLOAD WEIGHT (LBS)
MARCH 1962
NANCY KEMMEFER

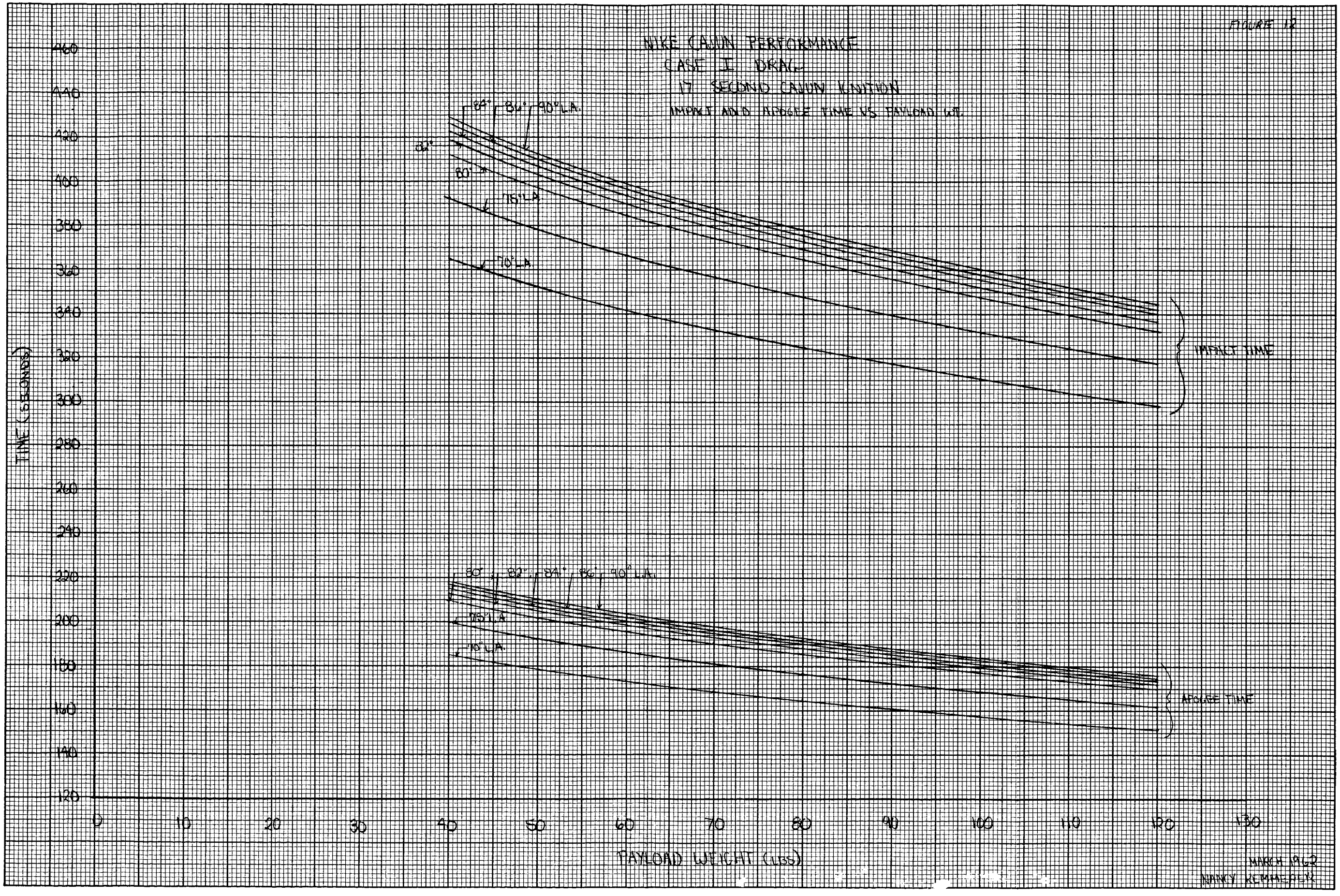
FIGURE 11

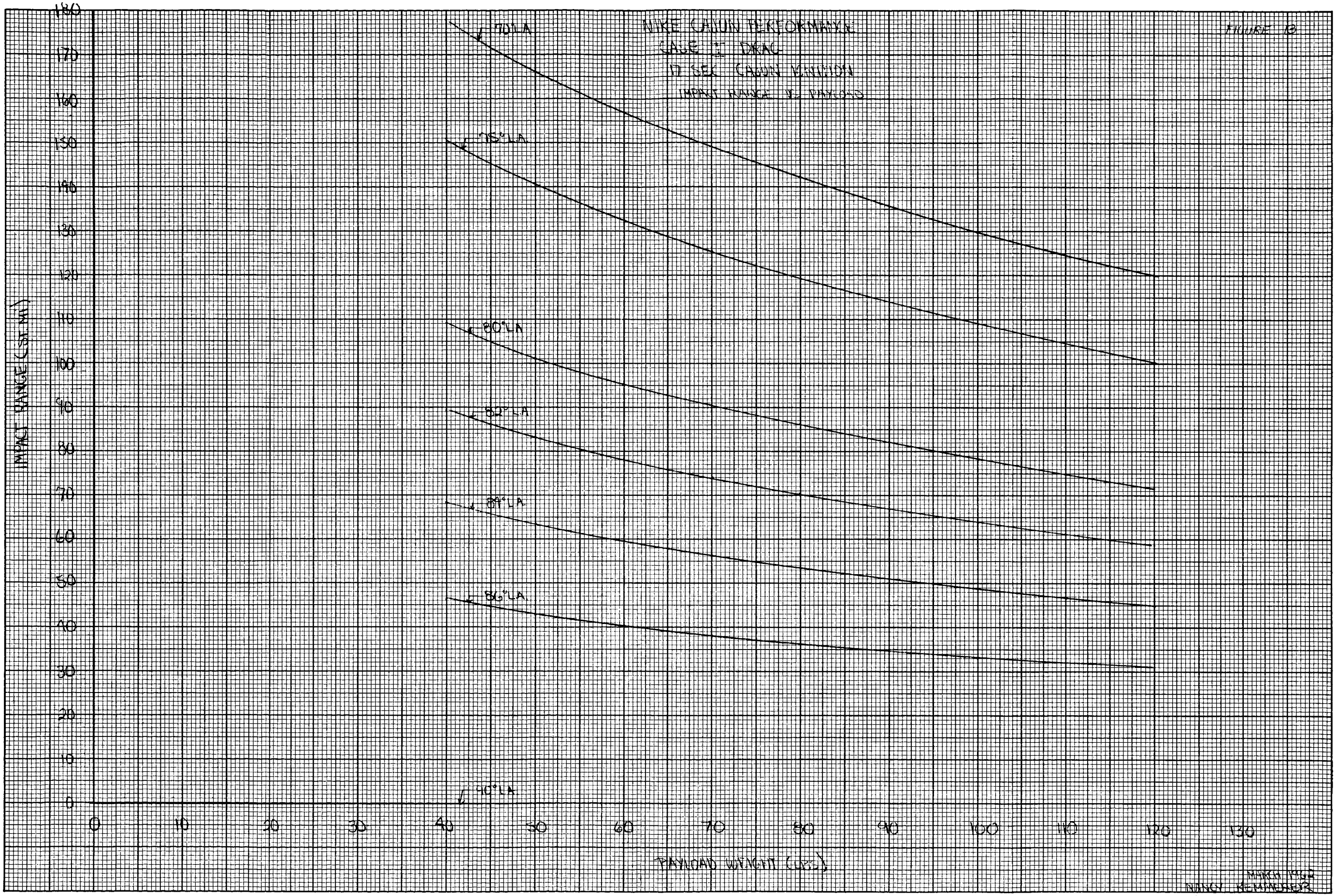
NIKE CALJUN PERFORMANCE
CASE I DRAG
17 SECOND CANJUN IGNITION
PEAK ALTITUDE VS PAYLOAD



MARCH 1962
NANCY KENNEDY

FIGURE 12


NIKE CAJUN PERFORMANCE
CASE I DRAG
17 SECOND CAJUN IGNITION
IMPACT AND APOGEE TIME VS PAYLOAD WT.
TIME (SECONDS)
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
0
10
20
30
40
50
60
70
80
90
100
110
120
130
PAYLOAD WEIGHT (LBS)
84°
86°
90° L.A.
82°
80°
78° L.A.
70° L.A.
IMPACT TIME
80°
82°
84°
86°
90° L.A.
78° L.A.
70° L.A.
APOGEE TIME
MARCH 1962
NANCY KEMPARTER



NIKE CAJUN PERFORMANCE
CASE II DRAG
17 SEC CAJUN IGNITION
IMPACT RANGE VS PAYLOAD
FIGURE 13
70° LA
75° LA
80° LA
82° LA
84° LA
86° LA
90° LA
IMPACT RANGE (ST. MI)
PAYLOAD WEIGHT (LBS)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
MARCH 1962
NANCY KEMMERER

CASE II DRAG CONFIGURATION

TWO DOVAP ANTENNAE WITH 11° NOSE CONE

OR

CLEAN (NO ANTENNAE) WITH 20° NOSE CONE

THEORETICAL NIKE CAJUN - PERFORMANCE

CASE II

CAJUN P/L WT.	θ_L (DEG.)	h_{BO_1} (FT)	V_{BO_1} (FT/SEC)	H.R. $_{BO_1}$ (FT)	θ_{BO_1} (DEG)	h_{IGN_2} (FT)	V_{IGN_2} (FT/SEC)	H.R. $_{IGN_2}$ (FT)	θ_{IGN} (DEG)	h_{BO_2} (FT)	V_{BO_2} (FT/SEC)	H.R. $_{BO_2}$ (FT)	θ_{BO_2} (DEG)	t_{HMAX} (SEC)	h_{MAX} (ST. MI)	H.R. $_{HMAX}$ (ST. MI)	t_i (SEC)	H.R. $_i$ (ST. MI)
40	70	5311	3432	2279	66.4	34,547	1779	16,125	61.7	49,305	6157	24,263	60.8	172.7	77.1	78.3	344.1	156.6
	75	5509	3432	1732	72.3	36,166	1789	12,323	68.7	51,914	6213	18,603	68.0	187.6	91.1	67.4	371.8	134.8
	80	5653	3432	1166	78.2	37,345	1796	8327	75.8	53,823	6251	12,599	75.3	198.3	102.1	49.3	392.2	98.6
	82	5695	3432	935	80.5	37,692	1798	6687	78.6	54,383	6262	10,126	78.2	201.5	105.5	40.4	398.1	80.9
	84	5728	3432	703	82.9	37,963	1800	5030	81.4	54,823	6270	7621	81.1	203.9	108.1	30.9	402.8	61.9
	86	5751	3432	469	85.3	38,157	1801	3361	84.3	55,136	6276	5094	84.1	205.7	110.0	20.9	406.1	41.9
	90	5769	3432	0	90.0	38,310	1802	0	90.0	55,387	6281	0	90.0	207.1	111.6	0	408.8	0
50	70	5272	3408	2265	66.4	34,601	1801	16,174	61.7	48,923	5920	24,073	60.7	167.4	72.5	73.5	333.0	147.0
	75	5470	3407	1721	72.3	36,220	1810	12,359	68.7	51,496	5970	18,453	67.9	181.4	85.4	61.8	359.1	126.1
	80	5614	3407	1158	78.2	37,904	1816	8350	75.8	53,384	6004	12,496	75.3	191.6	95.4	46.0	378.4	92.0
	82	5655	3407	929	80.5	37,747	1818	6706	78.6	53,933	6013	10,092	78.2	194.5	98.5	37.7	384.0	75.5
	84	5688	3407	698	82.9	38,017	1819	5045	81.4	54,365	6020	7558	81.1	196.8	100.9	28.8	388.4	57.7
	86	5711	3407	466	85.3	38,211	1820	3370	84.3	54,676	6025	5051	84.1	198.5	102.6	19.5	391.5	39.0
	90	5730	3407	0	90.0	38,366	1821	0	90.0	54,924	6030	0	90.0	199.8	104.0	0	394.1	0
60	70	5236	3384	2251	66.4	34,638	1820	16,215	61.7	48,638	5784	23,940	60.7	163.3	69.1	69.9	324.4	139.9
	75	5432	3384	1711	72.2	36,256	1828	12,388	68.7	51,184	5779	18,347	67.9	176.7	81.1	59.8	349.4	119.6
	80	5574	3383	1151	78.1	37,438	1834	8369	75.8	53,051	5809	12,422	75.2	186.4	90.4	43.5	367.8	87.1
	82	5616	3383	924	80.5	37,783	1835	6721	78.6	53,597	5817	9982	78.2	189.2	93.2	35.7	373.1	71.4
	84	5649	3383	694	82.9	38,055	1837	5056	81.4	54,027	5824	7512	81.1	191.4	95.5	27.3	377.3	54.6
	86	5672	3383	463	85.3	38,245	1838	3378	84.3	54,329	5828	5021	84.1	193.0	97.1	18.4	380.3	36.9
	90	5690	3383	0	90.0	38,401	1838	0	90.0	54,575	5832	0	90.0	194.2	98.4	0	382.8	0
70	70	5199	3360	2238	66.3	34,655	1836	16,246	61.7	48,361	5564	23,814	60.7	159.6	66.0	66.7	316.6	133.5
	75	5394	3360	1701	72.2	36,269	1844	12,411	68.7	50,880	5604	18,246	67.9	172.3	77.2	56.8	340.5	113.8
	80	5535	3360	1145	78.1	37,450	1849	8383	75.8	52,728	5632	12,352	75.2	181.6	85.9	41.3	358.1	82.7
	82	5577	3360	918	80.5	37,794	1851	6732	78.6	53,268	5639	9925	78.2	184.3	88.6	33.9	363.2	67.8
	84	5610	3360	690	82.9	38,064	1852	5064	81.4	53,690	5645	7470	81.1	186.4	90.7	25.9	367.2	51.8
	86	5633	3360	461	85.2	38,257	1853	3383	84.3	53,993	5649	4992	84.1	187.9	92.2	17.5	370.1	35.0
	90	5651	3360	0	90.0	38,412	1853	0	90.0	54,238	5652	0	90.0	189.1	93.4	0	372.4	0
80	70																	
	75																	
	80																	
	82																	
	84																	
	86																	
	90																	

THEORETICAL NIKE CAJUN PERFORMANCE

CASE II

CAJUN P/L WT.	θ_L (DEG.)	h_{BO_1} (FT)	V_{BO_1} (FT/SEC)	H.R. $_{BO_1}$ (FT)	θ_{BO_1} (DEG)	h_{IGN_2} (FT)	V_{IGN_2} (FT/SEC)	H.R $_{IGN_2}$ (FT)	θ_{IGN_2} (DEG)	h_{BO_2} (FT)	V_{BO_2} (FT/SEC)	H.R $_{BO_2}$ (FT)	θ_{BO_2} (DEG)	$t_{h\,max}$ (SEC)	h max (ST MI)	H.R $_{h\,max}$ (ST. MI)	ti (SEC.)	H.R. i (ST. MI)
• 90	70	5126	3314	2212	66.3	34,637	1864	16,287	61.7	47,822	5265	23,579	60.6	152.9	60.7	61.2	302.7	122.4
	75	5321	3313	1681	72.2	36,251	1871	12,440	68.7	50,299	5299	18,060	67.9	164.6	70.6	51.9	329.8	103.8
	80	5461	3313	1131	78.1	37,929	1875	8902	75.7	52,113	5321	12,222	75.2	173.2	78.3	37.6	341.1	75.2
	82	5502	3313	907	80.5	37,770	1876	6747	78.6	52,641	5327	9820	78.1	175.7	80.6	30.8	345.8	61.6
	84	5534	3313	682	82.9	38,039	1877	5075	81.4	53,056	5332	7390	81.1	177.6	82.5	23.5	349.6	47.1
	86	5556	3313	456	85.2	38,231	1877	3390	84.3	53,352	5335	4939	84.1	179.0	83.8	15.9	352.2	31.8
	90	5574	3313	0	90.0	38,386	1878	0	90.0	53,592	5338	0	90.0	180.1	84.9	0	354.4	0
100	70	5091	3291	2199	66.3	34,609	1876	16,298	61.7	47,562	5134	23,469	60.6	149.8	58.4	58.7	296.5	117.5
	75	5283	3291	1671	72.2	36,216	1881	12,996	68.7	50,011	5164	17,972	67.8	161.2	67.7	49.7	317.8	99.5
	80	5423	3290	1125	78.1	37,393	1885	8906	75.7	51,812	5184	12,161	75.2	169.5	75.0	36.0	333.6	72.0
	82	5465	3290	902	80.5	37,737	1886	6750	78.6	52,339	5190	9771	78.1	171.9	77.2	29.5	338.1	59.0
	84	5496	3290	678	82.8	38,006	1887	5077	81.4	52,751	5194	7353	81.1	173.7	79.0	22.5	341.7	45.0
	86	5519	3290	453	85.2	38,197	1887	3392	84.3	53,044	5197	4914	84.1	175.1	80.2	15.2	344.3	30.4
	90	5536	3290	0	90.0	38,351	1888	0	90.0	53,280	5200	0	90.0	176.2	81.3	0	346.4	0
110	70	5056	3269	2186	66.2	34,566	1886	16,303	61.6	47,299	5012	23,361	60.6	147.0	56.3	56.5	290.7	113.1
	75	5248	3268	1662	72.1	36,172	1890	12,449	68.6	49,732	5039	17,887	67.8	158.0	65.1	47.8	311.4	95.6
	80	5387	3268	1118	78.1	37,347	1894	8907	75.7	51,518	5058	12,102	75.1	166.0	72.0	34.5	326.6	69.1
	82	5427	3268	897	80.5	37,690	1895	6751	78.6	52,040	5063	9724	78.1	168.3	74.1	28.3	331.0	56.6
	84	5459	3268	674	82.8	37,956	1895	5078	81.4	52,446	5067	7317	81.1	170.1	75.8	21.6	334.5	43.2
	86	5481	3268	450	85.2	38,147	1896	3392	84.3	52,738	5069	4890	84.1	171.4	77.0	14.6	337.0	29.1
	90	5500	3268	0	90.0	38,3001	1896	0	90.0	52,972	5072	0	90.0	172.5	77.9	0	339.0	0
120	70	5023	3247	2174	66.2	34,513	1894	16,303	61.6	47,037	4897	23,254	60.5	144.3	54.2	54.4	285.1	108.9
	75	5213	3246	1652	72.1	36,116	1898	12,448	68.6	49,452	4922	17,802	67.8	154.9	62.7	45.9	305.2	91.9
	80	5351	3246	1112	78.1	37,287	1901	8906	75.7	51,221	4938	12,044	75.1	162.7	69.3	33.2	319.9	66.4
	82	5391	3245	892	80.4	37,626	1902	6750	78.5	51,736	4943	9676	78.1	164.9	71.2	27.1	324.2	54.3
	84	5422	3245	670	82.8	37,894	1902	5077	81.4	52,141	4946	7281	81.1	166.7	72.8	20.7	327.6	41.5
	86	5445	3245	447	85.2	38,087	1903	3392	84.3	52,432	4949	4866	84.0	167.9	73.9	14.0	330.0	28.0
	90	5462	3245	0	90.0	38,238	1903	0	90.0	52,663	4951	0	90.0	169.0	74.9	0	332.0	0

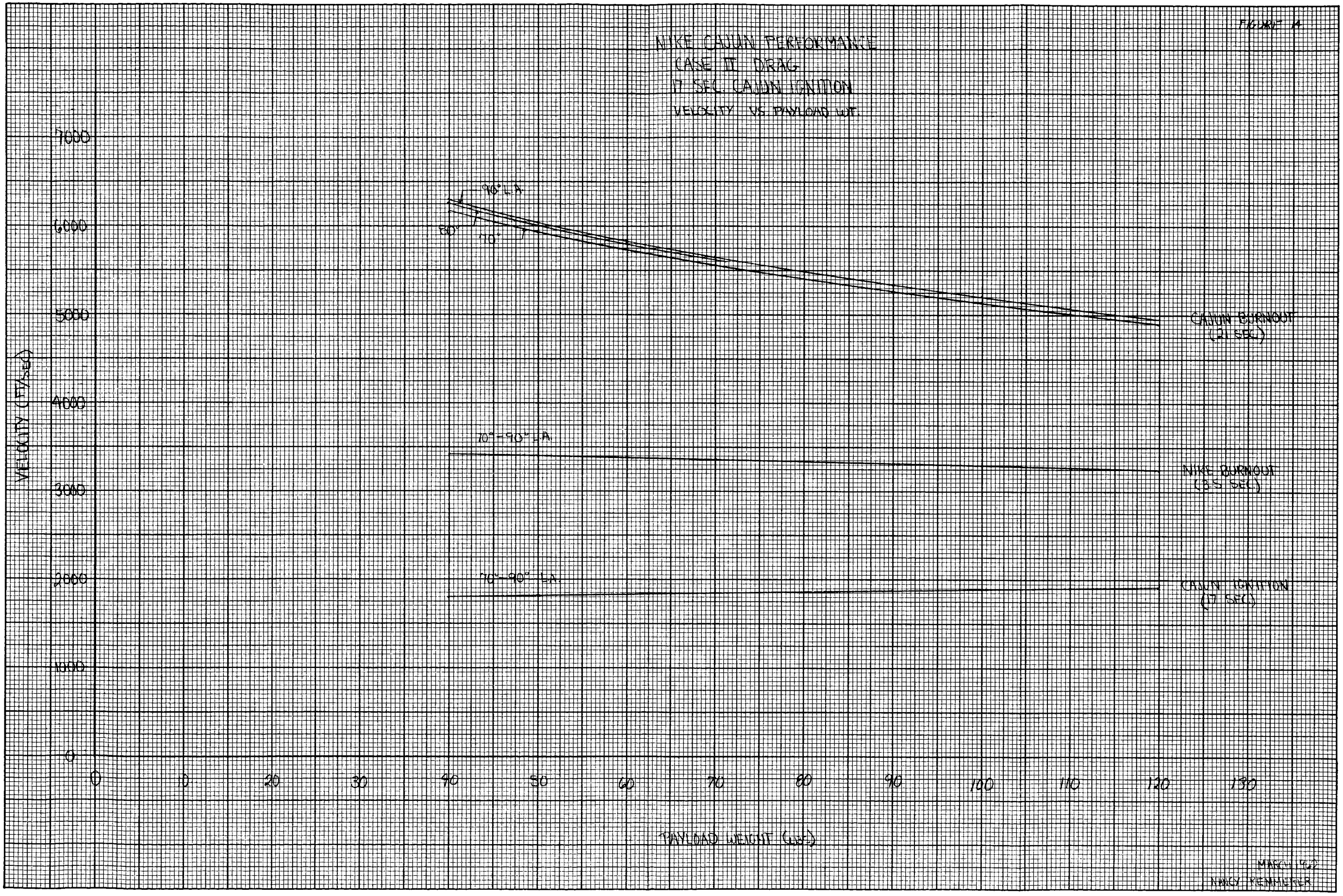
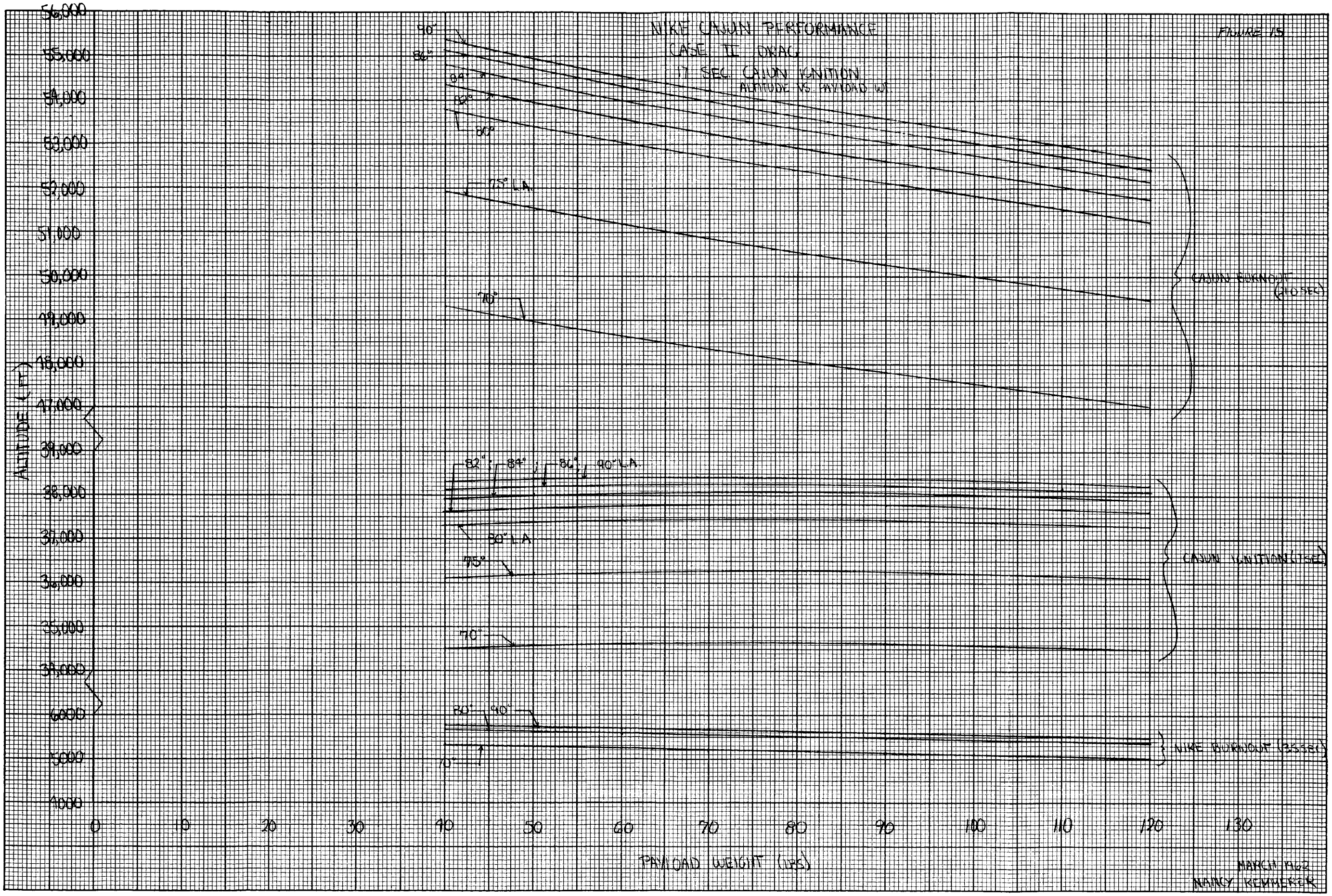
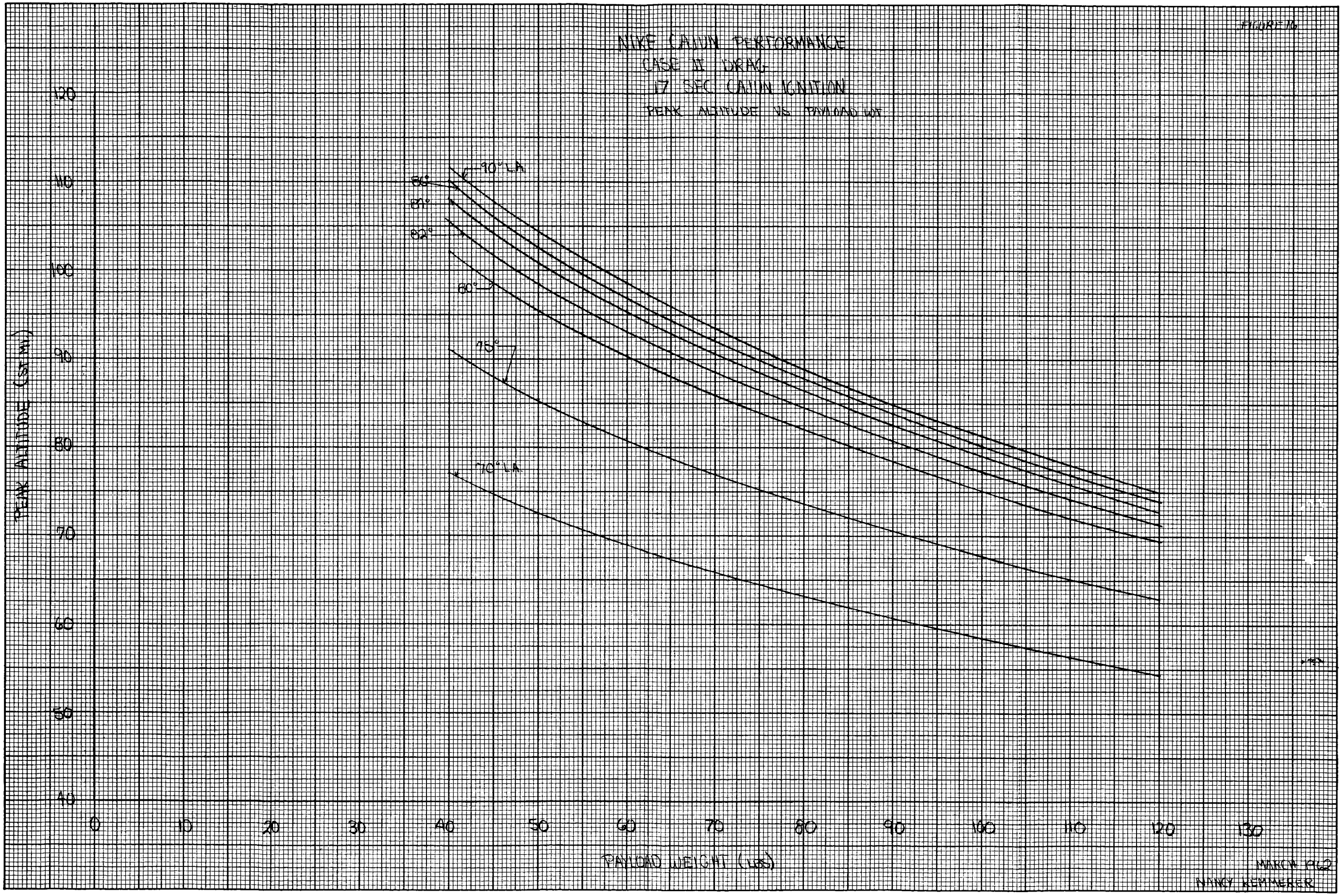


FIGURE 14
NIKE CAJUN PERFORMANCE
CASE II DRAG
17 SEC. CAJUN IGNITION
VELOCITY VS PAYLOAD WT.
90° L.A.
80°
70°
70°-90° L.A.
70°-90° L.A.
CAJUN BURNOUT (21 SEC)
NIKE BURNOUT (3.5 SEC)
CAJUN IGNITION (17 SEC)
VELOCITY (FT/SEC)
7000
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
100
110
120
130
PAYLOAD WEIGHT (LBS)
MARCH 1962
NANCY REMMERER



NIKE CAJUN PERFORMANCE
CASE II DRAG
17 SEC. CAJUN IGNITION
ALTITUDE VS. PAYLOAD WT.
FIGURE 15
ALTITUDE (FT)
PAYLOAD WEIGHT (LBS)
CAJUN BURNOUT (210 SEC)
CAJUN IGNITION (17 SEC)
NIKE BURNOUT (35 SEC)
75° L.A.
90° L.A.
80° L.A.
MARCH 1962
NANCY KEMMERER

FIGURE 16


NIKE CAJUN PERFORMANCE
CASE II DRAG
17 SEC CAJUN IGNITION
PEAK ALTITUDE VS. PAYLOAD WT
90° LA
86°
81°
82°
80°
75°
70° LA
PEAK ALTITUDE (STMI)
120
110
100
90
80
70
60
50
40
0
10
20
30
40
50
60
70
80
90
100
110
120
130
PAYLOAD WEIGHT (LBS)
MARCH 1962
NANCY KEMMERER

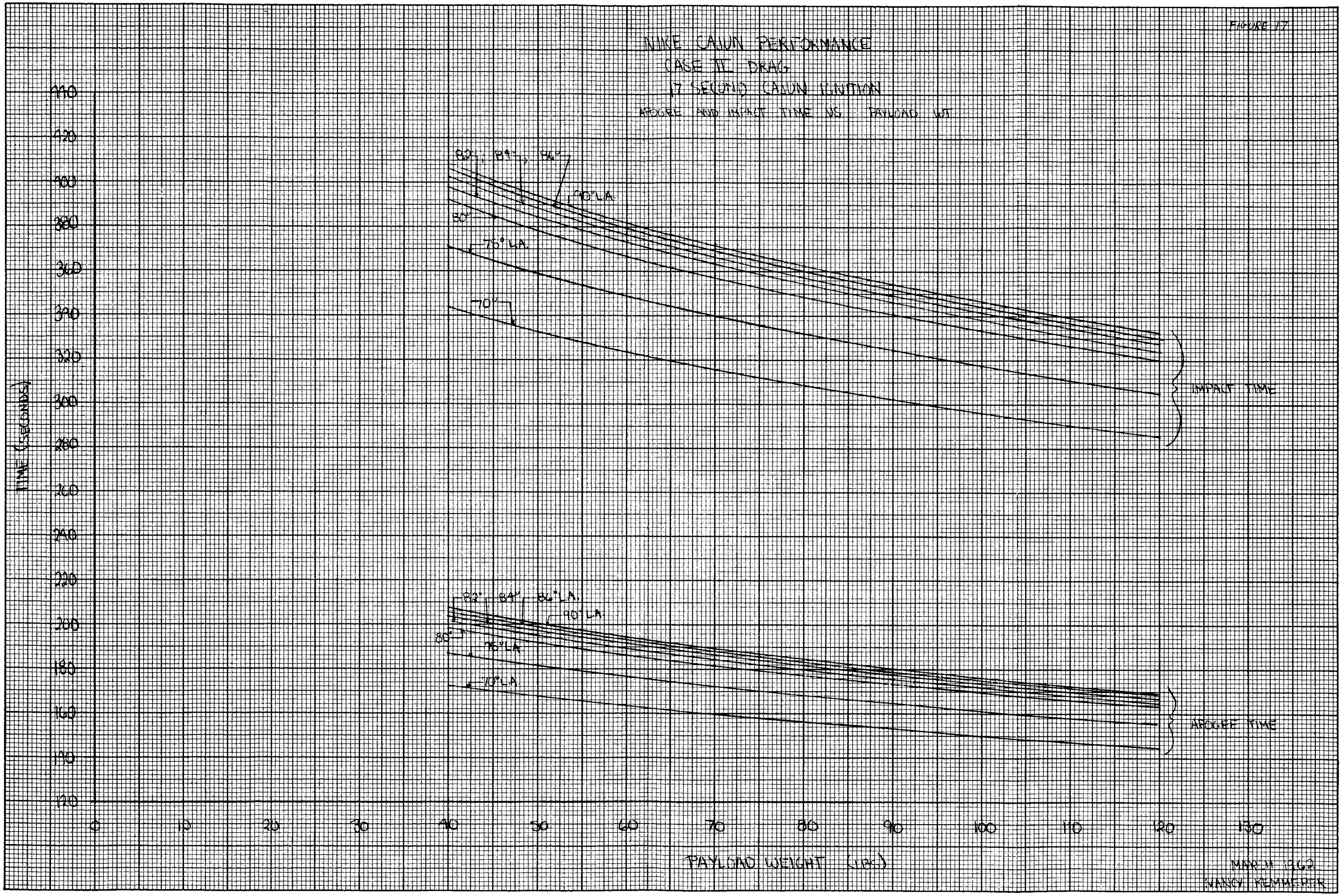
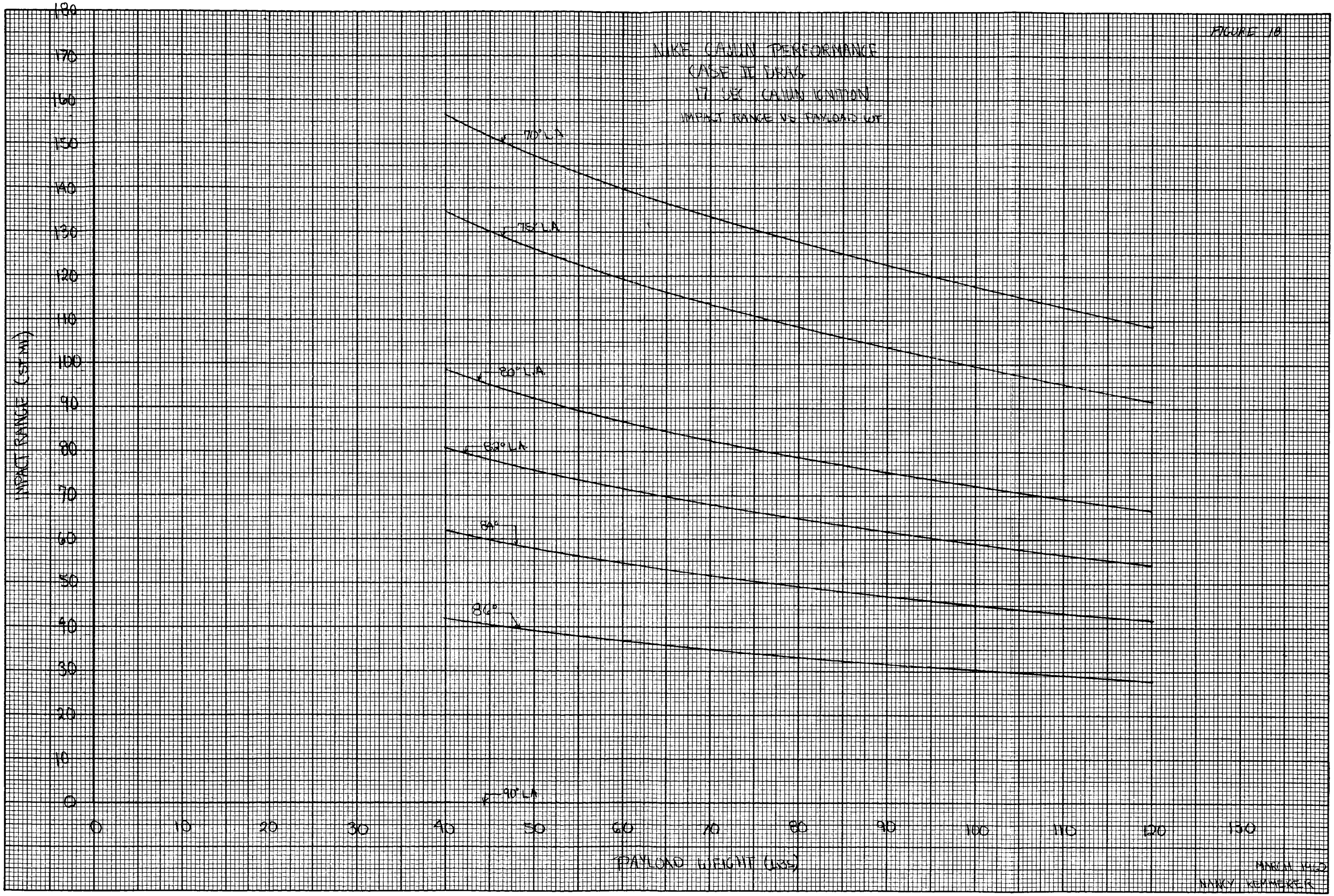


FIGURE 17
NIKE CAJUN PERFORMANCE
CASE II DRAG
17 SECOND CAJUN IGNITION
APOGEE AND IMPACT TIME VS PAYLOAD WT
TIME (SECONDS)
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
0
10
20
30
40
50
60
70
80
90
100
110
120
130
PAYLOAD WEIGHT (LBS)
82°, 84°, 86°
90° L.A.
80°
75° L.A.
70°
IMPACT TIME
82°
84°
86° L.A.
90° L.A.
80°
75° L.A.
70° L.A.
APOGEE TIME
MARCH 1962
NANCY KEMMERER

FIGURE 10



MARCH 1962
NANCY KEMMERER

CASE III DRAG CONFIGURATION

FOUR 45° SWEPT TURNSTILE ANTENNAE WITH 11° NOSE CONE

TABLE 4

THEORETICAL NIKE CAJUN PERFORMANCE
CASE III

CAJUN P/L WT	θ_L (DEG.)	h_{BO_1} (FT)	V_{BO_1} (FT/SEC)	$H.R._{BO_1}$ (FT)	θ_{BO_1} (DEG)	h_{IGN_2} (FT)	V_{IGN_2} (FT/SEC)	$H.R._{IGN_2}$ (FT)	θ_{IGN_2} (DEG)	h_{BO_2} (FT)	V_{BO_2} (FT/SEC)	$H.R._{BO_2}$ (FT)	θ_{BO_2} (DEG)	$t_{h_{MAX}}$ (SEC)	h_{MAX} (ST. MI)	$H.R._{h_{MAX}}$ (ST. MI)	t_L (SEC)	$H.R._L$ (ST. MI)
40	70	5311	3432	2279	66.4	33,292	1642	15,536	61.5	47,329	5886	23,911	60.4	157.4	64.4	65.5	319.1	130.8
	75	5509	3432	1732	72.3	34,813	1652	11,877	68.5	49,877	5951	17,962	67.7	172.8	77.6	57.7	346.8	115.2
	80	5653	3432	1166	78.2	35,961	1659	8027	75.6	51,751	5996	12,172	75.1	183.9	88.1	42.7	367.3	85.5
	82	5695	3432	935	80.5	36,295	1661	6447	78.5	52,297	6008	9783	78.1	187.2	91.3	35.2	373.3	70.5
	84	5728	3432	703	82.9	36,560	1663	4850	81.4	52,728	6018	7364	81.0	189.7	93.8	27.0	378.1	54.1
	86	5751	3432	469	85.3	36,747	1664	3240	84.2	53,035	6025	4922	84.0	191.5	95.6	18.3	381.4	36.6
	90	5769	3432	0	90.0	36,896	1665	0	10.0	53,280	6030	0	90.0	193.0	97.1	0	384.1	0
50	70	5272	3408	2265	66.4	33,336	1666	15,603	61.5	47,015	5668	23,248	60.4	153.4	61.2	62.1	310.0	123.9
	75	5470	3407	1721	72.3	34,908	1676	11,926	68.5	49,531	5726	17,832	67.7	167.8	73.3	54.3	336.1	108.6
	80	5614	3407	1158	78.2	36,060	1682	8060	75.6	51,379	5765	12,081	75.1	178.3	82.9	40.1	355.5	80.3
	82	5655	3407	929	80.5	36,396	1684	6473	78.5	51,923	5777	9710	78.1	181.4	85.8	33.1	361.2	66.1
	84	5688	3407	698	82.9	36,657	1686	4870	81.4	52,343	5785	7309	81.0	183.8	88.1	25.3	365.6	50.7
	86	5711	3407	466	85.3	36,844	1687	3253	84.2	52,646	5791	4885	84.0	185.5	89.8	17.2	368.8	34.3
	90	5730	3407	0	90.0	36,997	1687	0	90.0	52,891	5796	0	90.0	186.9	91.2	0	371.4	0
60	70	5236	3384	2251	66.4	33,411	1688	15,659	61.5	46,795	5497	23,139	60.4	150.4	58.9	59.6	303.0	118.0
	75	5432	3384	1711	72.2	34,985	1697	11,968	68.5	49,286	5549	17,743	67.7	164.1	70.2	51.9	328.0	103.8
	80	5574	3383	1151	78.1	36,134	1703	8087	75.6	51,113	5585	12,019	75.1	174.1	79.1	38.2	346.5	76.5
	82	5616	3383	924	80.5	36,471	1705	6495	78.5	51,649	5595	9660	78.0	177.0	81.8	31.5	351.9	63.0
	84	5649	3383	694	82.9	36,736	1706	4886	81.4	52,071	5603	7271	81.0	179.3	89.0	24.1	356.2	48.2
	86	5672	3383	463	85.3	36,922	1707	3264	84.2	52,369	5608	4860	84.0	180.9	85.5	16.3	359.2	32.7
	90	5690	3383	0	90.0	37,074	1708	0	90.0	52,612	5612	0	90.0	182.2	86.8	0	361.7	0
70	70	5199	3360	2238	66.3	33,464	1708	15,707	61.5	46,578	5341	23,036	60.4	147.5	56.7	57.3	296.5	114.4
	75	5394	3360	1701	72.2	35,040	1716	12,003	68.5	49,047	5388	17,661	67.7	160.6	67.3	49.7	320.5	99.4
	80	5535	3360	1145	78.1	36,188	1722	8110	75.6	50,855	5420	11,962	75.1	170.2	75.6	36.5	338.2	73.1
	82	5577	3360	918	80.5	36,524	1723	6513	78.5	51,386	5429	9613	78.0	173.0	78.2	30.0	343.4	60.1
	84	5610	3360	690	82.9	36,789	1725	4900	81.4	51,803	5436	7235	81.0	175.2	80.2	23.0	347.5	46.0
	86	5633	3360	461	85.2	36,978	1726	3274	84.2	52,102	5441	4836	84.0	176.7	81.7	15.6	350.4	31.1
	90	5651	3360	0	90.0	37,128	1726	0	90.0	52,337	5445	0	90.0	178.0	82.8	0	352.8	0
80	70	5162	3337	2225	66.3	33,500	1726	15,746	61.5	46,365	5197	22,939	60.4	144.8	54.7	55.1	290.5	110.1
	75	5357	3336	1691	72.2	35,075	1733	12,032	68.5	48,811	5241	17,583	67.7	157.4	64.7	47.7	313.6	95.3
	80	5498	3336	1138	78.1	36,225	1738	8129	75.6	50,606	5270	11,907	75.1	166.6	72.5	35.0	330.6	69.9
	82	5539	3336	913	80.5	36,560	1740	6528	78.5	51,131	5278	9568	78.0	169.2	74.9	28.7	335.6	57.5
	84	5572	3336	686	82.9	36,825	1741	4911	81.4	51,543	5284	7202	81.0	171.3	76.8	22.0	339.5	44.0
	86	5595	3336	458	85.2	37,013	1742	3281	84.2	51,838	5289	4813	84.0	172.8	78.1	14.9	342.3	29.8
	90	5612	3336	0	90.0	37,161	1743	0	90.0	52,071	5292	0	90.0	174.0	79.3	0	344.6	0

THEORETICAL NIKE CAJUN PERFORMANCE

CASE III

CAJUN P/L WT	θ_L (DEG.)	h_{BO_1} (FT)	V_{BO_1} (FT/SEC)	H.R $_{BO_1}$ (FT)	θ_{BO_1} (DEG)	h_{IGN_2} (FT)	V_{IGN_2} (FT/SEC)	H.R $_{IGN_2}$ (FT)	θ_{IGN_2} (DEG)	h_{BO_2} (FT)	V_{BO_2} (FT/SEC)	H.R $_{BO_2}$ (FT)	θ_{BO_2} (DEG)	$t_{h\,MAX}$ (SEC)	h_{MAX} (ST MI)	H.R $_{h\,MAX}$ (ST. MI)	t_i (SEC)	H.R $_i$ (ST. MI)
90	70	5126	3314	2212	66.3	33,519	1742	15,779	61.5	46,150	5065	22,545	60.3	142.3	52.8	58.1	289.9	106.1
	75	5321	3313	1681	72.2	35,094	1749	12,056	68.5	48,579	5104	17,508	67.6	154.3	62.2	45.8	307.1	91.6
	80	5461	3313	1131	78.1	36,244	1753	8144	75.6	50,358	5131	11,854	75.0	163.2	69.6	33.5	323.5	67.1
	82	5502	3313	907	80.5	36,580	1755	6540	78.5	50,880	5138	9526	78.0	165.7	71.9	27.5	328.3	55.1
	84	5534	3313	682	82.9	36,890	1756	4920	81.4	51,285	5144	7169	81.0	167.7	73.7	21.1	332.1	42.2
	86	5556	3313	456	85.2	37,028	1757	3287	84.2	51,577	5148	4791	84.0	169.2	74.9	14.3	334.8	28.5
	90	5575	3313	0	90.0	37,181	1757	0	90.0	51,815	5151	0	90.0	170.3	76.0	0	337.0	0
100	70	5091	3291	2199	66.3	33,523	1756	15,804	61.4	45,940	4942	22,755	60.3	139.8	51.1	51.3	279.7	102.5
	75	5283	3291	1671	72.2	35,094	1762	12,073	68.5	48,396	4978	17,436	67.6	151.5	60.0	44.1	301.1	88.2
	80	5423	3290	1125	78.1	36,245	1767	8156	75.6	50,114	5003	11,804	75.0	160.0	67.0	32.2	317.0	64.5
	82	5465	3290	902	80.5	36,582	1768	6550	78.5	50,632	5010	9485	78.0	162.4	69.1	26.4	321.6	52.9
	84	5496	3290	678	82.8	36,894	1769	4927	81.4	51,036	5015	7138	81.0	164.4	70.8	20.2	325.2	40.5
	86	5519	3290	453	85.2	37,031	1769	3292	84.2	51,325	5018	4771	84.0	165.8	72.0	13.7	327.8	27.4
	90	5536	3290	0	90.0	37,181	1770	0	90.0	51,556	5021	0	90	166.9	73.0	0	329.9	0
110	70	5056	3269	2186	66.2	33,512	1769	15,823	61.4	45,728	4829	22,667	60.3	137.5	49.5	49.6	274.8	99.1
	75	5248	3268	1662	72.1	35,087	1775	12,087	68.5	48,121	4862	17,366	67.6	148.8	57.9	42.5	295.5	85.0
	80	5387	3268	1118	78.1	36,234	1778	8165	75.6	49,873	4884	11,755	75.0	157.0	64.6	31.0	310.8	62.1
	82	5427	3268	897	80.5	36,571	1780	6557	78.5	50,387	4890	9445	78.0	159.4	66.5	25.5	315.3	50.9
	84	5459	3268	674	82.8	36,830	1780	4932	81.3	50,784	4895	7108	81.0	161.2	68.2	19.5	318.8	38.9
	86	5481	3268	450	85.2	37,018	1781	3295	84.2	51,073	4898	4750	84.0	162.6	69.3	13.2	321.4	26.3
	90	5500	3268	0	90.0	37,169	1781	0	90.0	51,305	4900	0	90.0	163.7	70.3	0	323.4	0
120	70	5023	3247	2174	66.2	33,493	1780	15,837	61.4	45,518	4722	22,580	60.3	135.3	47.9	48.0	270.1	95.8
	75	5213	3246	1652	72.1	35,061	1785	12,096	68.5	47,888	4752	17,296	67.6	146.2	56.0	41.0	290.2	82.0
	80	5351	3246	1112	78.1	36,208	1789	8171	75.6	49,628	4772	11,706	75.0	154.1	62.3	29.9	305.0	59.8
	82	5391	3245	892	80.4	36,542	1790	6561	78.5	50,136	4777	9406	78.0	156.4	64.2	24.5	309.4	49.1
	84	5422	3245	670	82.8	36,802	1790	4935	81.3	50,530	4782	7078	81.0	158.3	65.7	18.7	312.8	37.5
	86	5445	3245	447	85.2	36,992	1791	3297	84.2	50,820	4785	4731	84.0	159.6	66.8	12.7	315.2	25.3
	90	5462	3245	0	90.0	37,141	1791	0	90.0	51,047	4787	0	90.0	160.6	67.7	0	317.2	0

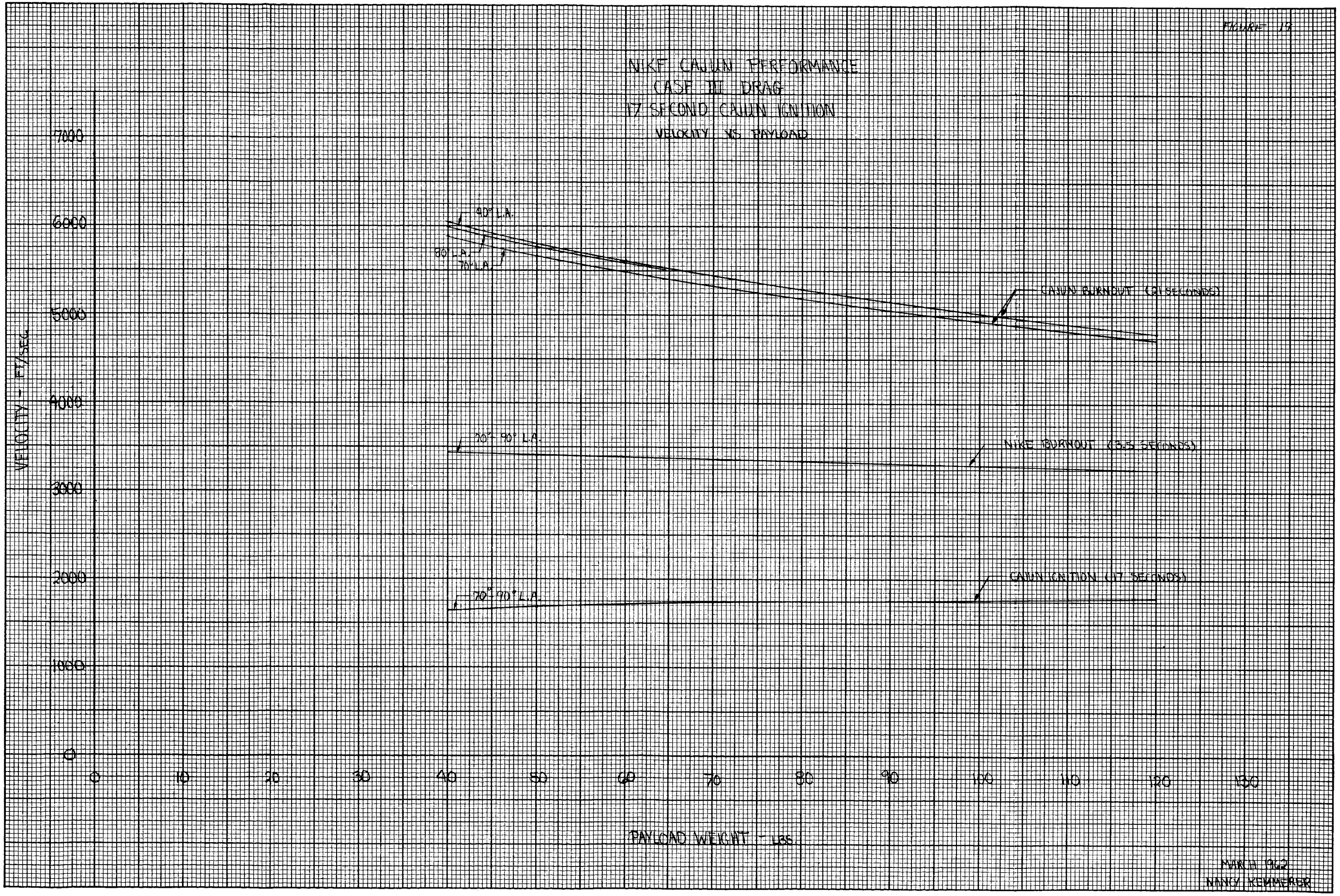


FIGURE 19
NIKE CAJUN PERFORMANCE
CASE III DRAG
17 SECOND CAJUN IGNITION
VELOCITY VS PAYLOAD
90° L.A.
80° L.A.
70° L.A.
CAJUN BURNOUT (21 SECONDS)
70°-90° L.A.
NIKE BURNOUT (3.5 SECONDS)
70°-90° L.A.
CAJUN IGNITION (17 SECONDS)
VELOCITY - FT/SEC.
7000
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
100
110
120
130
PAYLOAD WEIGHT - LBS.
MARCH 1962
NANCY KEMMERER

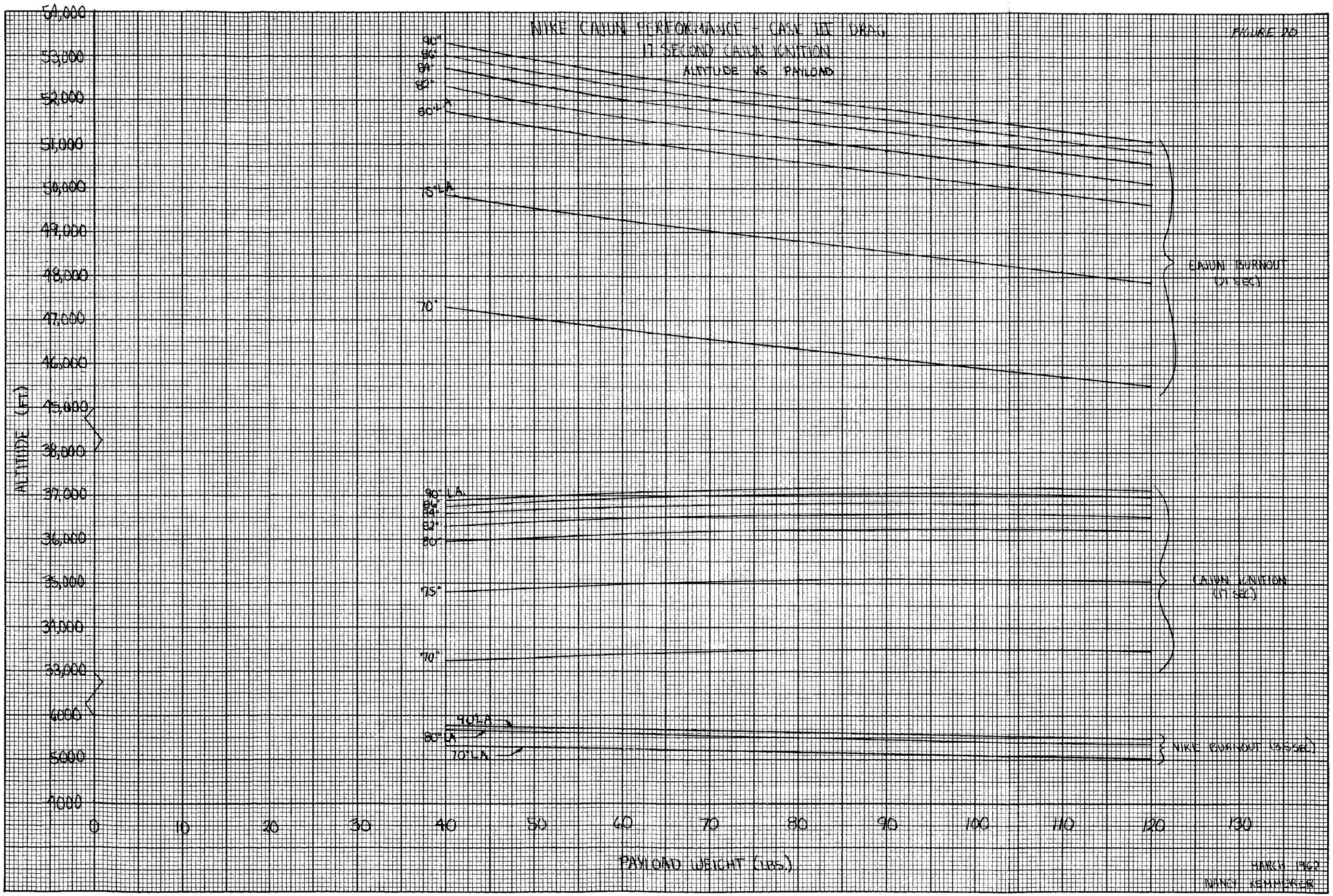

NIKE CAJUN PERFORMANCE - CASE III DRAG
17 SECOND CAJUN IGNITION
ALTITUDE VS PAYLOAD
FIGURE 20
90°
86°
84°
82°
80°
80° LA
85° LA
70°
90° LA
80° LA
70° LA
90° LA
86°
84°
82°
80°
75°
70°
CAJUN BURNOUT (17 SEC)
CAJUN IGNITION (17 SEC)
NIKE BURNOUT (35 SEC)
ALTITUDE (FT.)
54,000
53,000
52,000
51,000
50,000
49,000
48,000
47,000
46,000
45,000
38,000
37,000
36,000
35,000
34,000
33,000
6000
5000
4000
0
10
20
30
40
50
60
70
80
90
100
110
120
130
PAYLOAD WEIGHT (LBS.)
MARCH 1962
NANCY KEMMERER

FIGURE 21

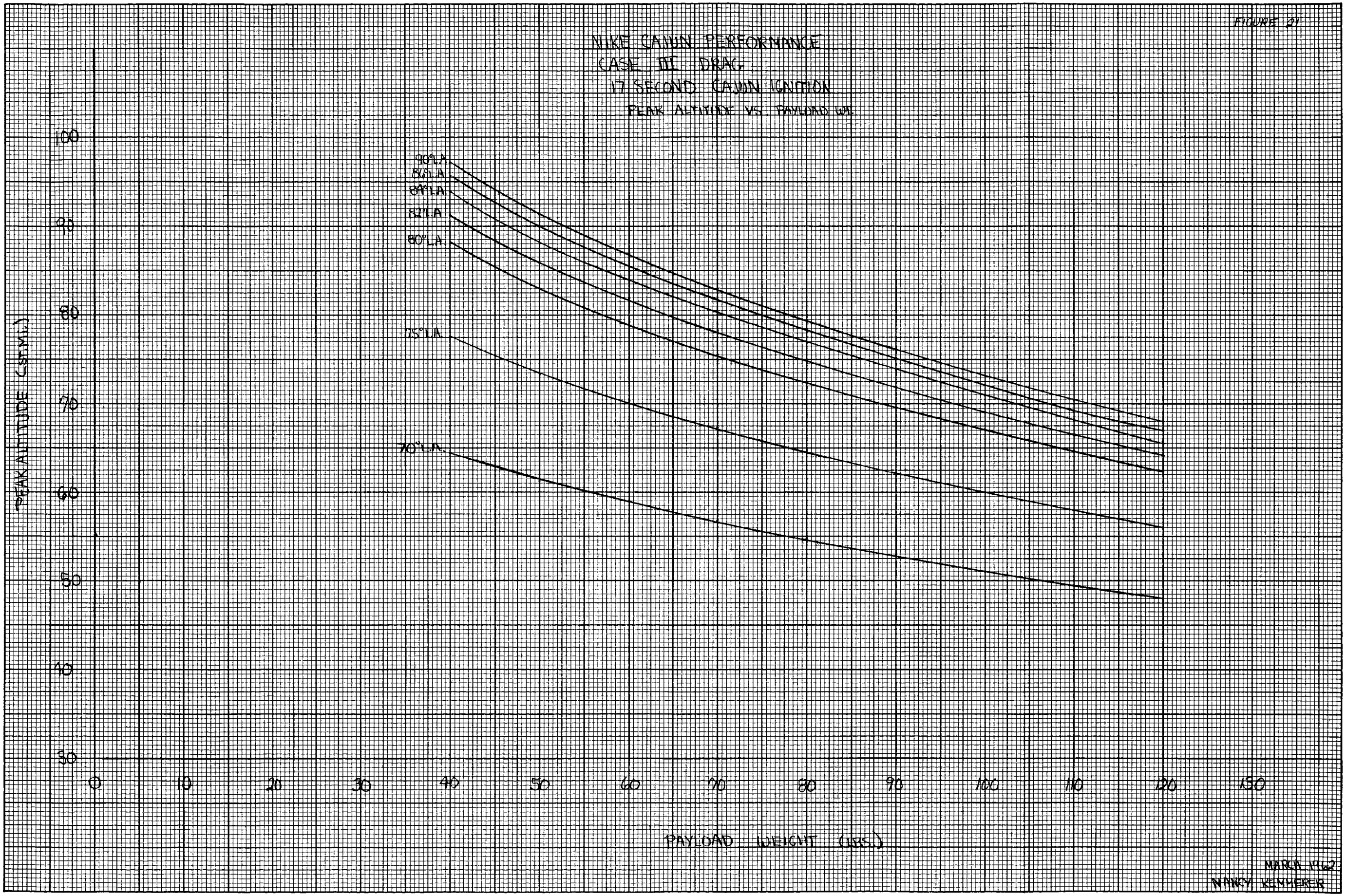
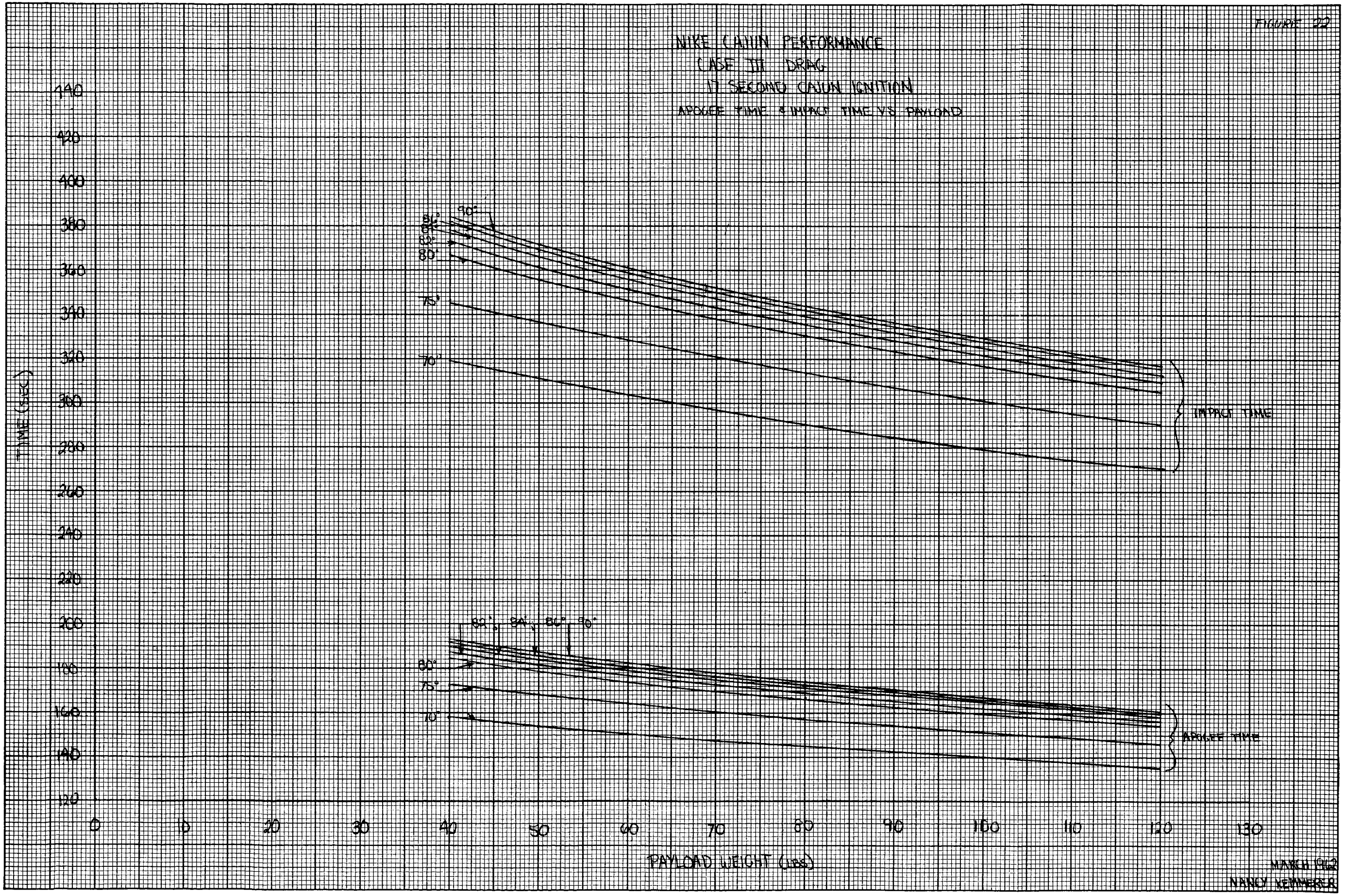

NIKE CAJUN PERFORMANCE
CASE III DRAG
17 SECOND CAJUN IGNITION
PEAK ALTITUDE VS. PAYLOAD WT.
90°LA
86°LA
84°LA
82°LA
80°LA
75°LA
70°LA
PEAK ALTITUDE (S.M.)
100
90
80
70
60
50
40
30
0
10
20
30
40
50
60
70
80
90
100
110
120
130
PAYLOAD WEIGHT (LBS.)
MARCH 1962
NANCY KENNEREER

FIGURE 22



MARCH 1962
NANCY KENNEDY

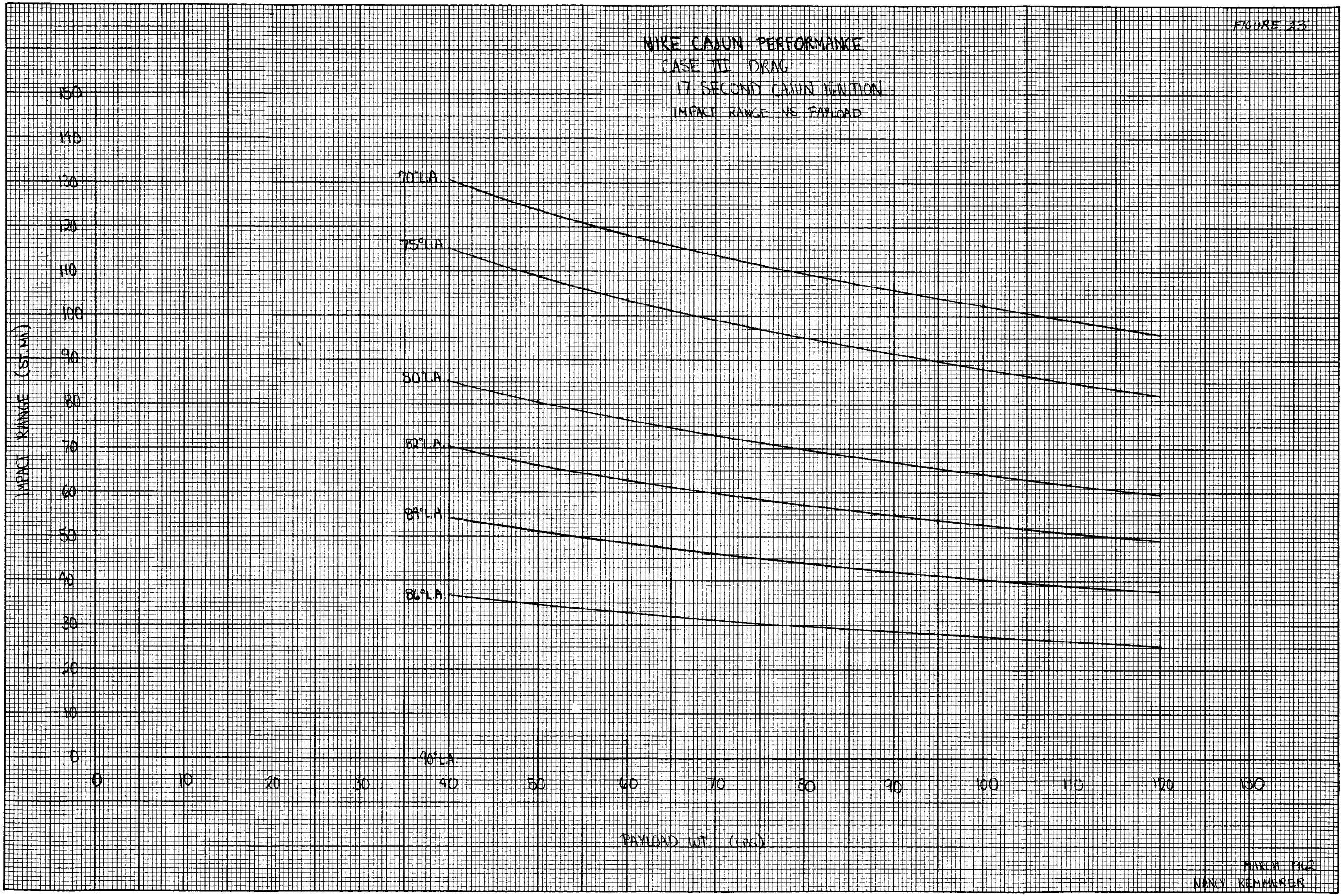


FIGURE 23
NIKE CAJUN PERFORMANCE
CASE III DRAG
17 SECOND CAJUN IGNITION
IMPACT RANGE VS PAYLOAD
70°LA
75°LA
80°LA
82°LA
84°LA
86°LA
90°LA
IMPACT RANGE (ST. MI.)
PAYLOAD WT. (LBS)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
MARCH 1962
NANCY KEMMERER

TABLE 5

NIKE-CAJUN SOUNDING ROCKET

COMPARISON OF THEORETICAL AND ACTUAL PERFORMANCE

NASA ROCKET NUMBER	CAJUN DRAG		EFFECTIVE PAYLOAD WEIGHT (LBS.)	EFFECTIVE LAUNCH ELEVATION ANGLE (DEG.)	CAJUN IGNITION TIME	PEAK ALTITUDE (ST. MI.)			IMPACT RANGE (ST. MILES)		
	CONFIGURATION	CASE				THEORETICAL	ACTUAL	COMMENTS ON THEORETICAL	THEORETICAL	ACTUAL	COMMENTS ON THEORETICAL
10.25	2 QUADRALOOP ANTENNAE 11° CONE	II	62	88	20.5	98.6	94.5 E	+4.1	19.9	20.3 E	-0.4
10.50	2-40"x1½" PODS BETWEEN FINS 11° CONE	II	57.4	83.5	17.3	96.2	94.6 E	+1.6	59.9	63.7 E	-3.8
10.51	2 QUADRALOOP ANTENNAE 11° CONE	II	~58	79.5	17.5	90.7	87.8 E	+2.9	92.7	87.6 E	+5.1
10.56	2 BRL SHROUD ANTENNAE 11° CONE	II	72	81	23.9	86.9	82.5 E	+4.4	85.2	87.0 E	-1.8
10.57	2 BRL SHROUD ANTENNAE 11° CONE	II	72	81.3	17.0	88.0	86.8 E	-1.2	72.3	75.2 E	-2.9
10.49	4-45° TURNSTILE ANTENNAE 11° CONE	III	60	79.1	17.6	77.8	80.7 R	-2.9	82.2	82.6 E	-0.4
10.64	4-45° TURNSTILE ANTENNAE 11° CONE	III	71.5	79.6	17.0	74.5	81.7 R	-7.2	75.0	81.0 R	-6.0
10.74	4-45° TURNSTILE ANTENNAE 20° CONE	III	93.5	81	17.0	69.7	62.0 R ★	+7.7 ★	60.0	49.2 R ★	+10.8 ★

R. RADAR

E. EXTRAPOLATED RADAR

★ CAJUN ENCOUNTERED ROLL LOCK-IN AFTER BURNOUT

BPM APR. '62