PERIODIC PERFORMANCE REPORT 14

PERFORMANCE OF THE ARROW 2

Unclassified

SECRET

AUGUST 1958

AVRO AIRCRAFT LIMITED

MALTON – ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

SECRET

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ARROW PERIODIC PERFORMANCE REPORT 14

PERFORMANCE OF THE ARROW 2

(C.G. at 29.5% MAC)

SUMMARY

The performance data given in this report are based on the drag and engine data given in Periodic Performance Reports 12 and 13. They represent the best estimate of the ultimate performance of the Arrow 2 as at present evisaged, with nominal engine performance of the Iroquois assumed as in EMS 8 Issue 2.

The operational weight empty used in this report is 557 lb. lighter than the figure quoted in the August 1 weight report No. 7-0400-34 Issue 22. The principal reason for this difference is that, in this performance report, no allowance has been made for the increase in engine weight included in the current weight report.

The main differences between this report and Periodic Performance Report No. 12 are:-

1. Revised mission profiles and combat weight definition.
2. The inclusion of a Thermodynamic envelope.
3. The inclusion of Flight envelope limitation curves.
4. The inclusion of acceleration performance.
5. An increase in operational weight empty of 1,489 lb.
6. Revised input data - based on flight test - for take-off and landing distances.

The loading and performance data and flight envelopes are given in Figs. 1 to 9(b) and in Tables 1 to 8 inclusive.

The Thermodynamic envelope is based on a recovery factor of 0.90. The Flight envelope limitations are based on strength and control considerations only, and do not necessarily represent the steady performance capabilities of the aircraft.

It should be noted that the mission format is as agreed to at an informal meeting with the R.C.A.F. (S/L Landry, F/L Hall) but has not yet been formally approved. In the ferry mission, no consideration has been given to tail plugs, or to fuel in the weapon pack, since neither of these schemes have had formal approval for operational use. However the performance achievable with these schemes will be covered in Addenda.

This report should be considered as a draft for R.C.A.F. approval as to data presentation and mission format. If approved, it is anticipated that this format would comprise the basis for the WSC 1-2 performance requirements, to which subsequent Periodic Performance Reports would be prepared.

TABLE 1 - LOADING AND PERFORMANCE

UNDER ICAO STANDARD ATMOSPHERE CONDITIONS

(Clean aircraft, i.e. no ventral tank, unless otherwise stated)

Weight

Operation weight empty	lb.	46,650
Maximum useable internal fuel	lb.	19,443
Gross Take-off weight (max.internal fuel)	lb.	66,093
Combat weight ($\frac{1}{2}$ max.internal fuel weight)	lb.	56,372
Maximum external fuel and tank (500 gallons at 7.8 lb/gall. and drop tank)	lb.	4,242
Maximum gross take-off weight (Combat mission)	lb.	70,335
† Maximum gross take-off weight (Ferry mission)	lb.	68,607
Normal design landing gross weight	lb.	49,783
Maximum landing gross weight (Combat mission)	lb.	66,093
Wing loading at gross take-off weight	lb/sq.ft.	54.0
Power loading at gross take-off weight	lb/lb thrust	1.52

Speed

True airspeed in level flight at combat weight			
Sea Level (i) Maximum thrust, A/B lit	kts.	700	*
(ii) Maximum thrust, A/B unlit	kts.	665	
50,000 ft.(i) Maximum thrust, A/B lit	kts.	1,147	*

* Placard Speed

Ceiling

Ceiling at combat weight, rate of climb 500 ft/min. with maximum thrust at optimum Mach number (1.8 M) A/B lit	ft.	59,500

Rate of Climb

Steady state rate of climb at combat weight		
Sea Level (i) Maximum thrust, A/B lit, at o.92 M	ft/min.	42,500
(ii) Maximum thrust, A/B unlit at 527 kts. TAS	ft/min.	19,400
50,000 ft.(i) Maximum Thrust, A/B lit at 1.80 M	ft/min.	9,740

† Maximum gross take-off weight (Combat mission) less 1728 lb. missiles.

Time to Height

Time to reach 50,000 ft. and 1.5 M from engine start at gross take-off weight, maximum thrust A/B lit	min.	5.4

Manoeuvrability

Load factor at combat weight

1) Maximum thrust A/B lit 1.5 M at 50,000 ft.	1.50
2) Maximum thrust A/B lit 1.8 M at 50,000 ft.	1.60

Take-off Distance

Take-off distance over 50 ft. obstacle at sea level at gross take-off weight

1) Maximum thrust A/B lit, standard day	ft.	3,850
2) Maximum thrust A/B unlit, standard day	ft.	4,750
3) Maximum thrust A/B lit, hot day	ft.	4,640

Landing Distance

Landing distance over 50 ft. obstacle at sea level at normal design landing gross weight	ft.	4,800

Stalling Speed

True stalling speed in landing configuration at combat weight at sea level	kts.	117

Missions

Combat radius of action, see mission profile for detail breakdown

1) Subsonic high altitude mission - subsonic combat	n.m.	442
2) Subsonic high altitude mission - supersonic combat	n.m.	347
3) Supersonic high altitude mission- supersonic combat	n.m.	238
4) Combat air patrol - supersonic combat	n.m.	467
5) Subsonic low level mission (10,000 ft.) - subsonic combat	n.m.	349
6) Ferry Mission (no armament)		
a) ventral tank carried throughout	Range n.m.	1,306
b) ventral tank jettisoned when empty	Range n.m.	1,357

72/PERF/24.

ARROW 2.

MAX LEVEL SPEED AT COMBAT WEIGHT (56,372 LB)

IROQUOIS SERIES 2 ENGINES.

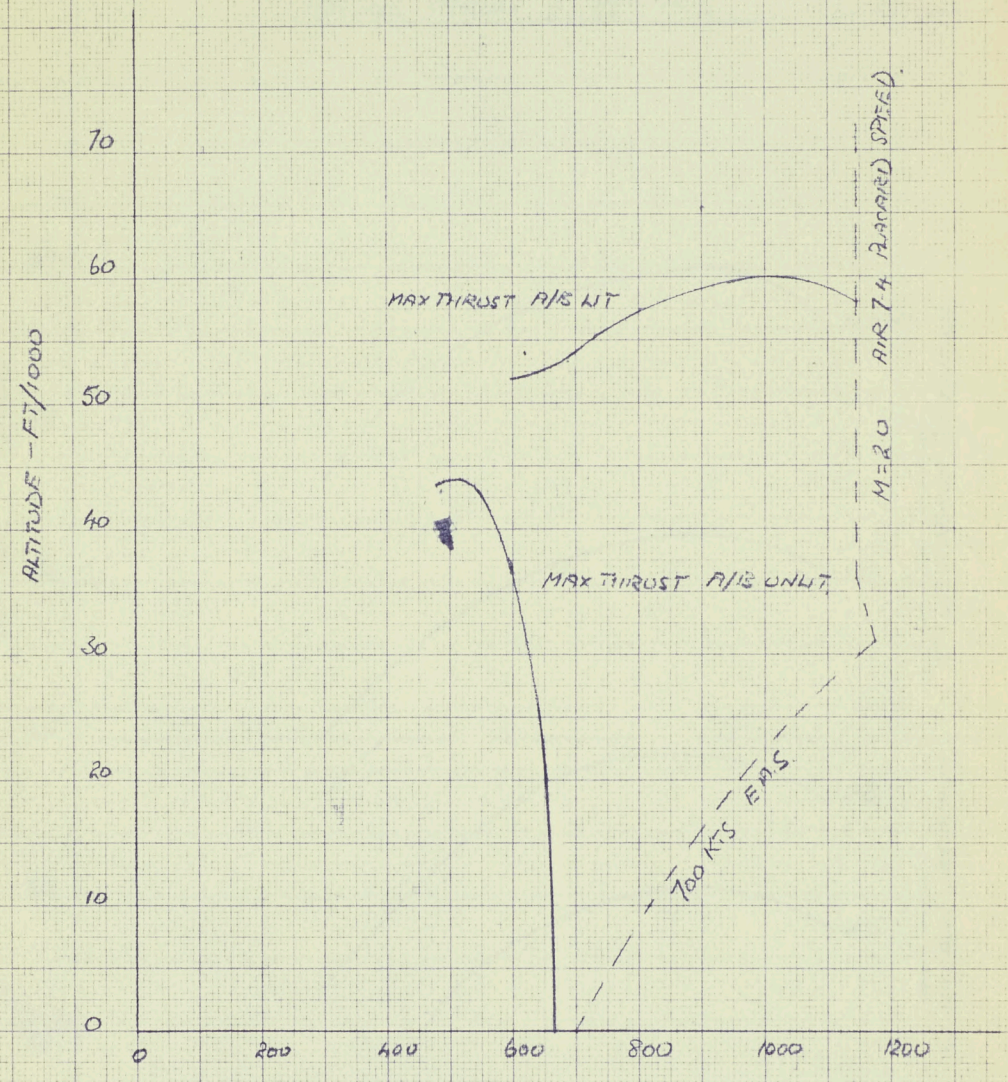


FIG. 1

ARROW 2.

MANOEUVRABILITY - STEADY G'S AVAILABLE

AT COMBAT WEIGHT MAX THRUST A/B LIT.

COMBAT WEIGHT = 56,378 LB.

IROQUOIS SERIES 2 ENGINES

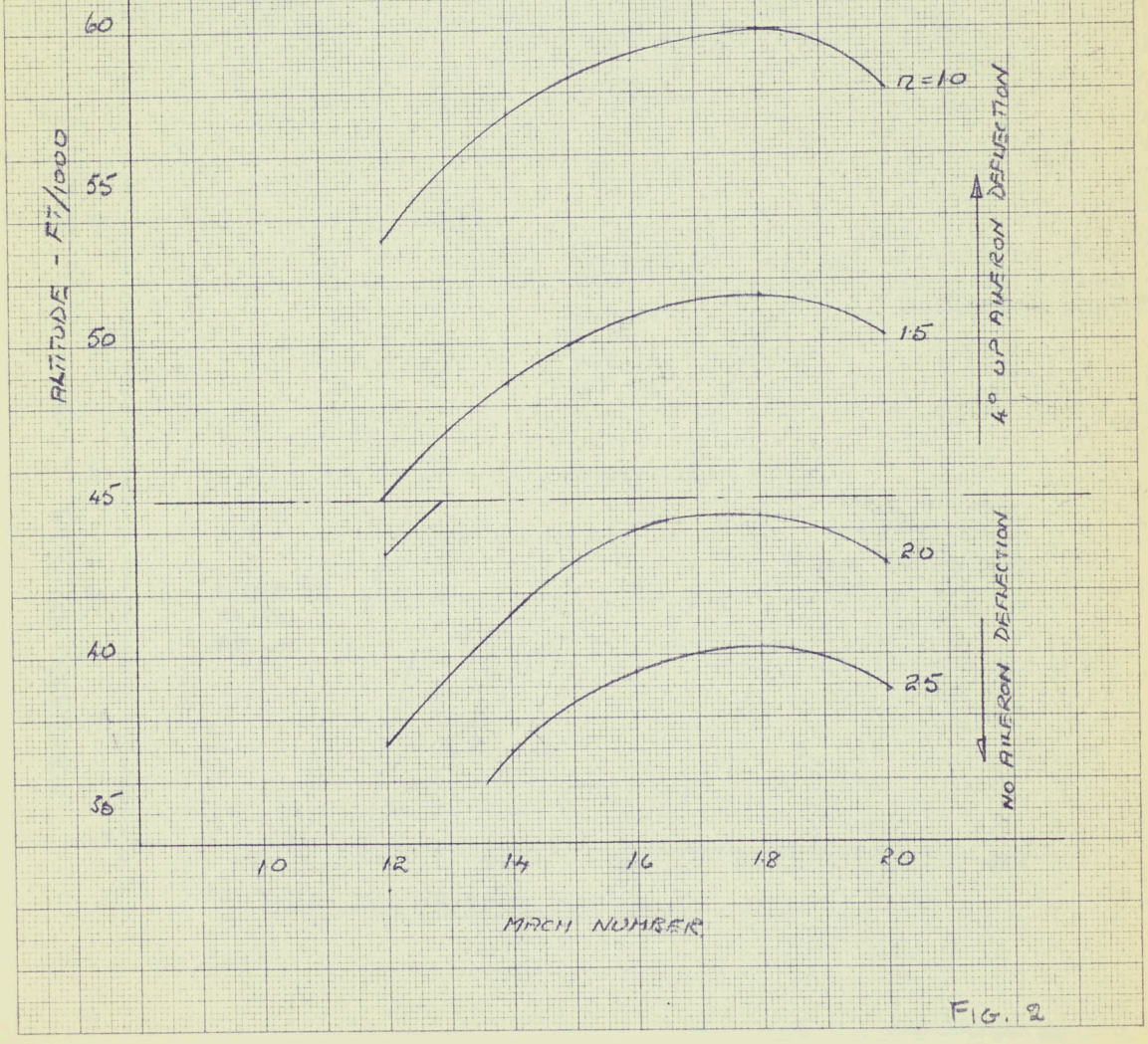


FIG. 2

SECRET

42/PERF/26

ARROW 2 - IROQUOIS SERIES 2 ENGINES

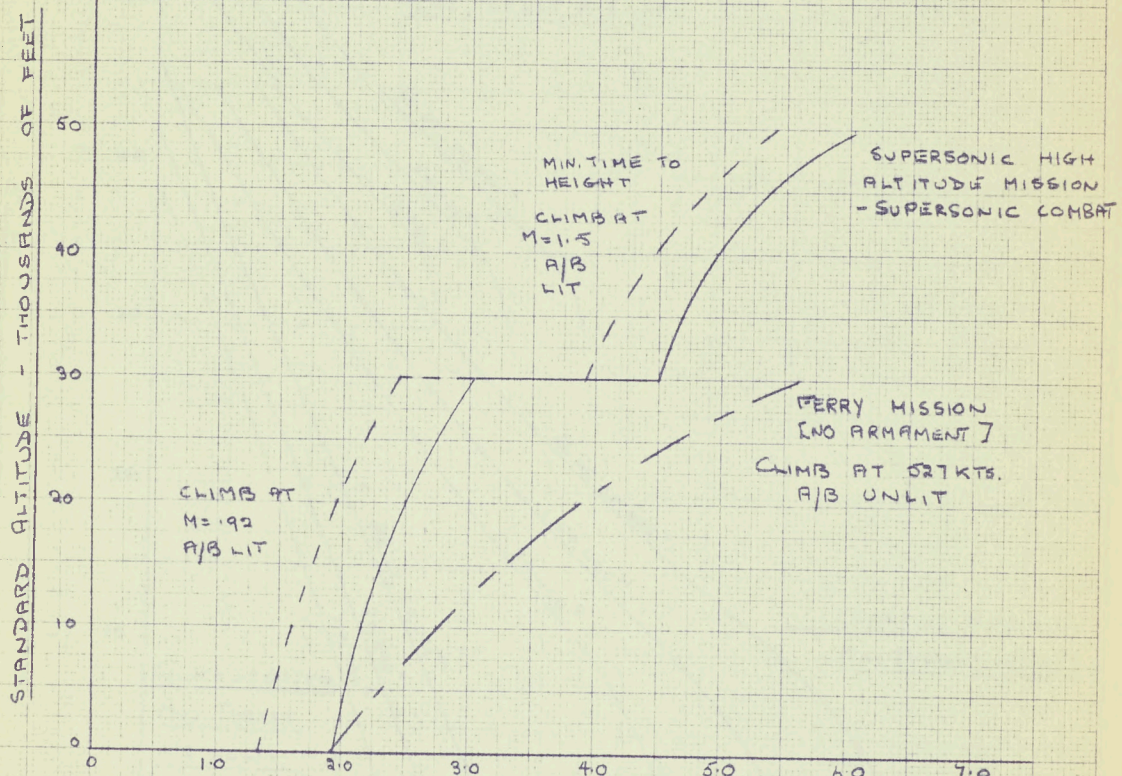
TIME TO HEIGHT

— — — MIN. TIME TO HEIGHT A/B LIT THROUGHOUT FLIGHT PLAN

——— SUPERSONIC HIGH ALTITUDE MISSION - SUPERSONIC COMBAT A/B LIT AT BEGINNING OF M=.92 CLIMB

— — — — FERRY MISSION - NO ARMAMENT A/B UNLIT THROUGHOUT FLIGHT PLAN

NOTE: ½ MIN. ALLOWED FROM ENGINE START TO MAX. THRUST



N.W. AUGUST '58

FIG. 3

72/PERF/24

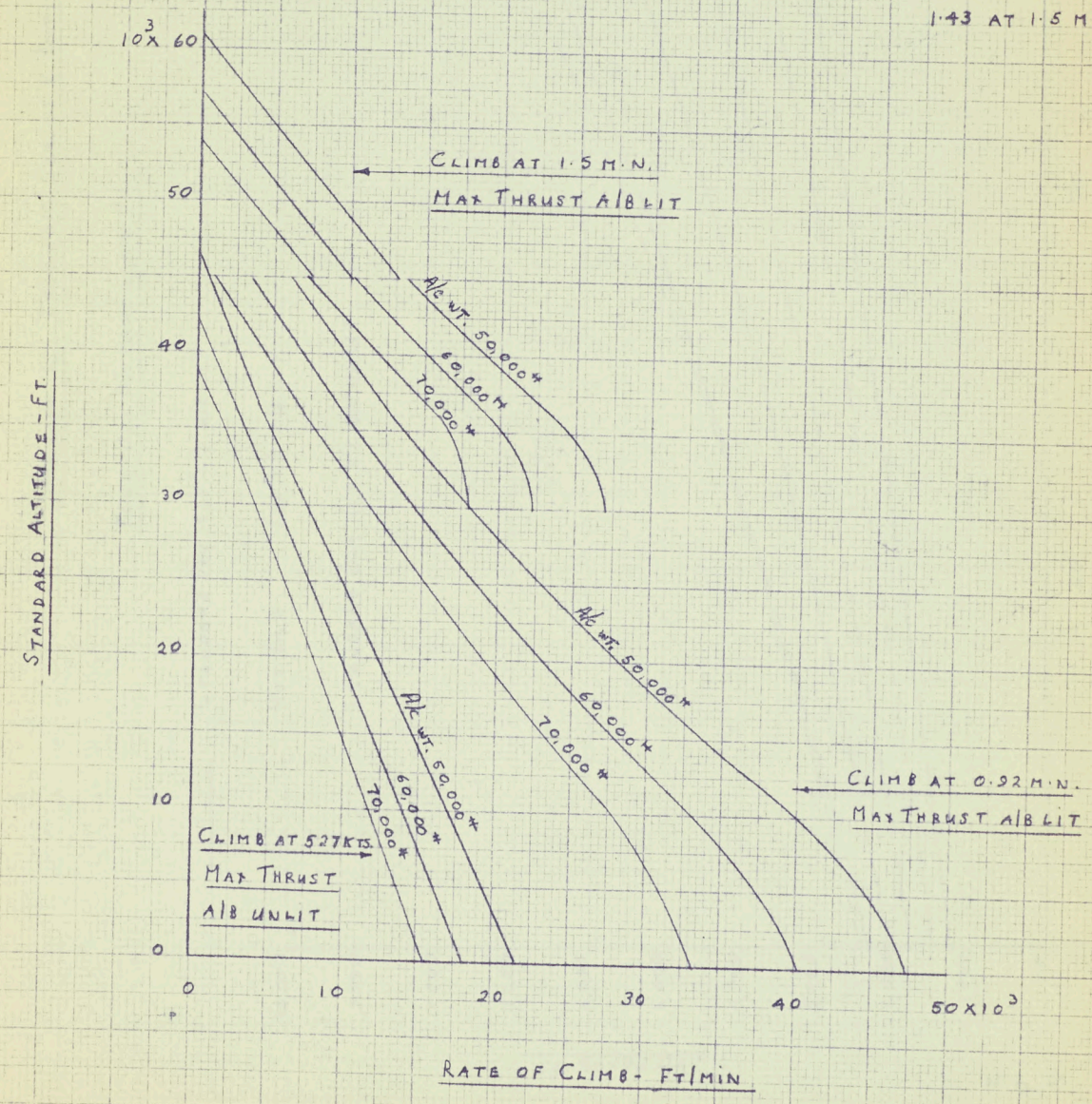
ARROW 2 IROQUOIS SERIES 2 ENGINE

STEADY STATE RATE OF CLIMB

FOR K.E. EFFECT INCREASE R/C

BELOW 36,089 FT BY 1.14 AT 0.92 M.N.

1.43 AT 1.5 M.N.



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721/PERF/24

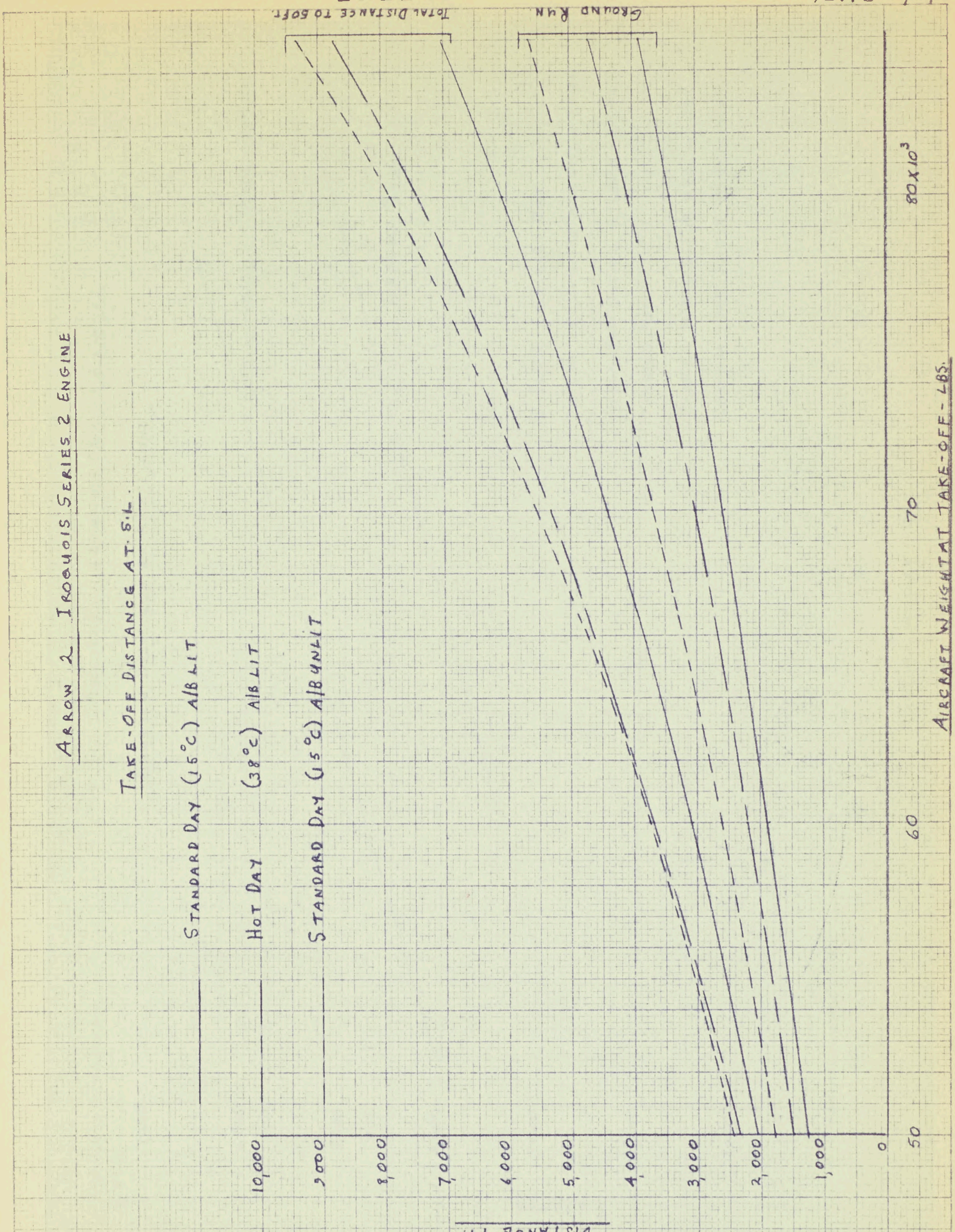
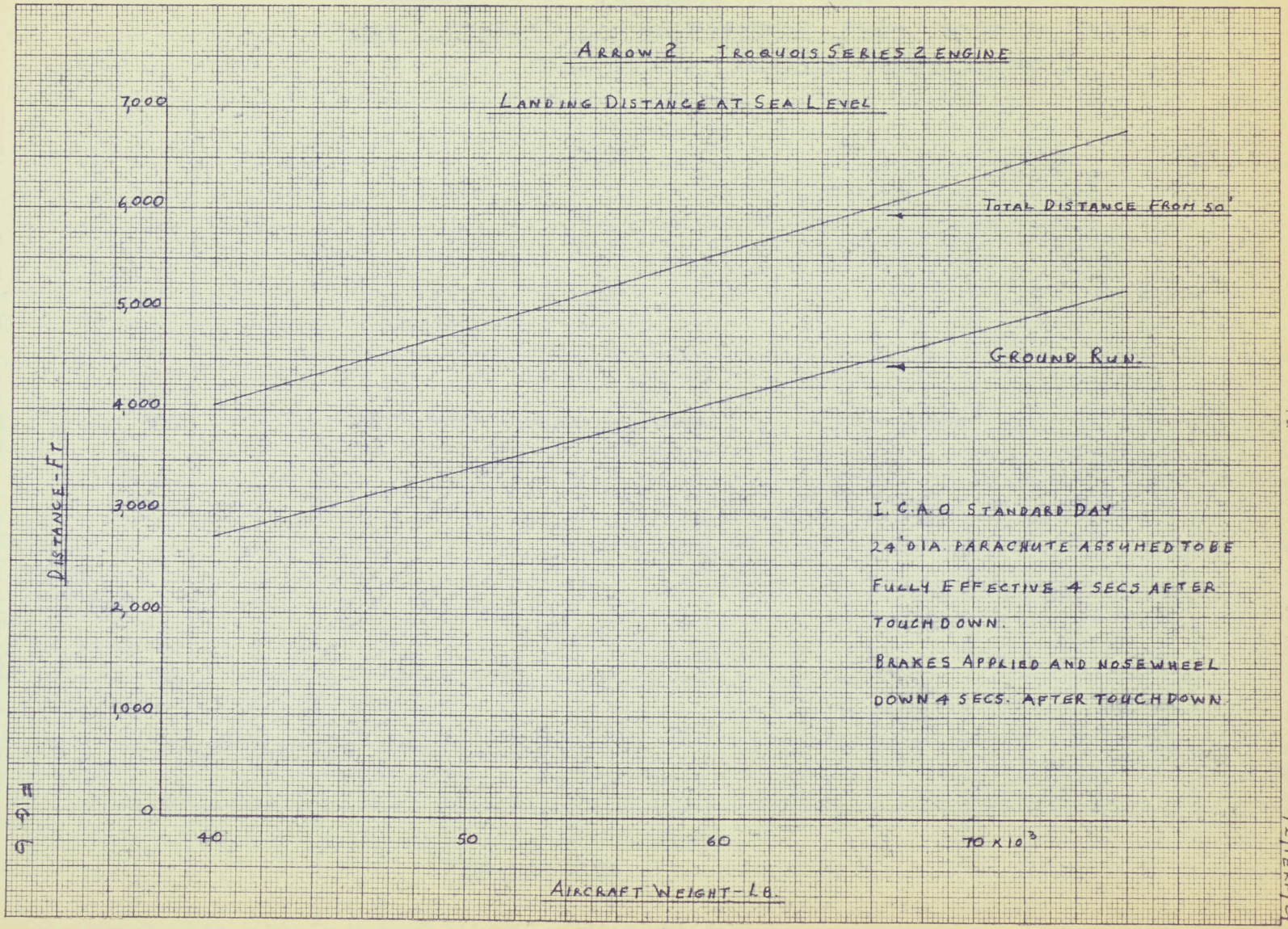


FIG. 5



ARROW 2 - IROQUOIS 2 - A/B LIT

TIME TAKEN TO ACCELERATE FROM M=·92 TO M=2·0

A/C WEIGHT = 56,372 lb [COMBAT WEIGHT]

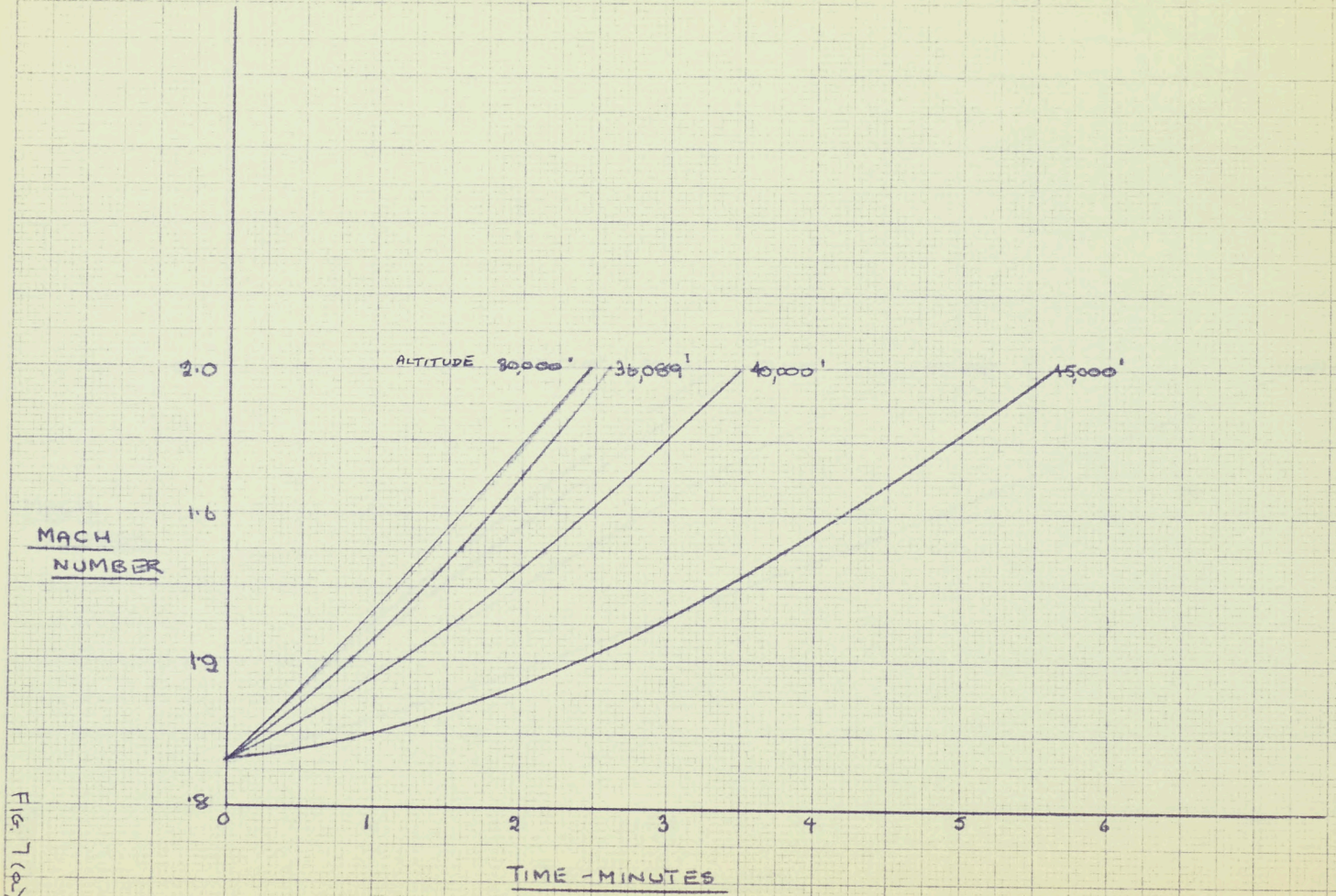


FIG. 7 (a)

M.W. AUGUST '58

ARROW 2 - IROQUOIS 2 - A/B LIT

DISTANCE TAKEN TO ACCELERATE FROM M = .92 TO M = 2.0

A/C WEIGHT = 56,372 lb [COMBAT WEIGHT]

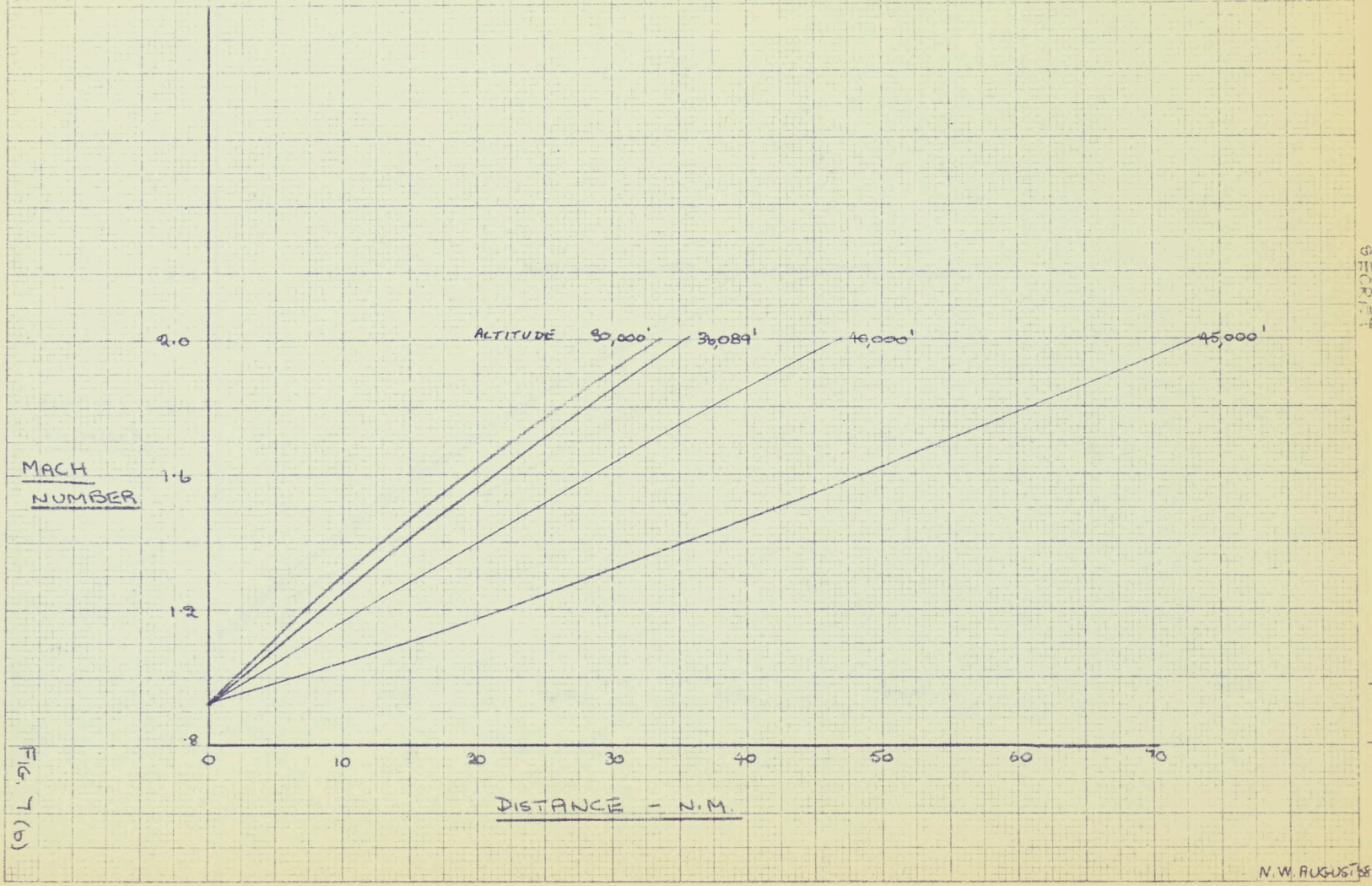


FIG. 7 (a)

N. W. AUGUST '58

ARROW 2 -IROQUOIS 2 - A/B LIT

FUEL TAKEN TO ACCELERATE FROM M=.92 TO M=2.0

A/C WEIGHT = 56,372 lb [COMBAT WEIGHT]

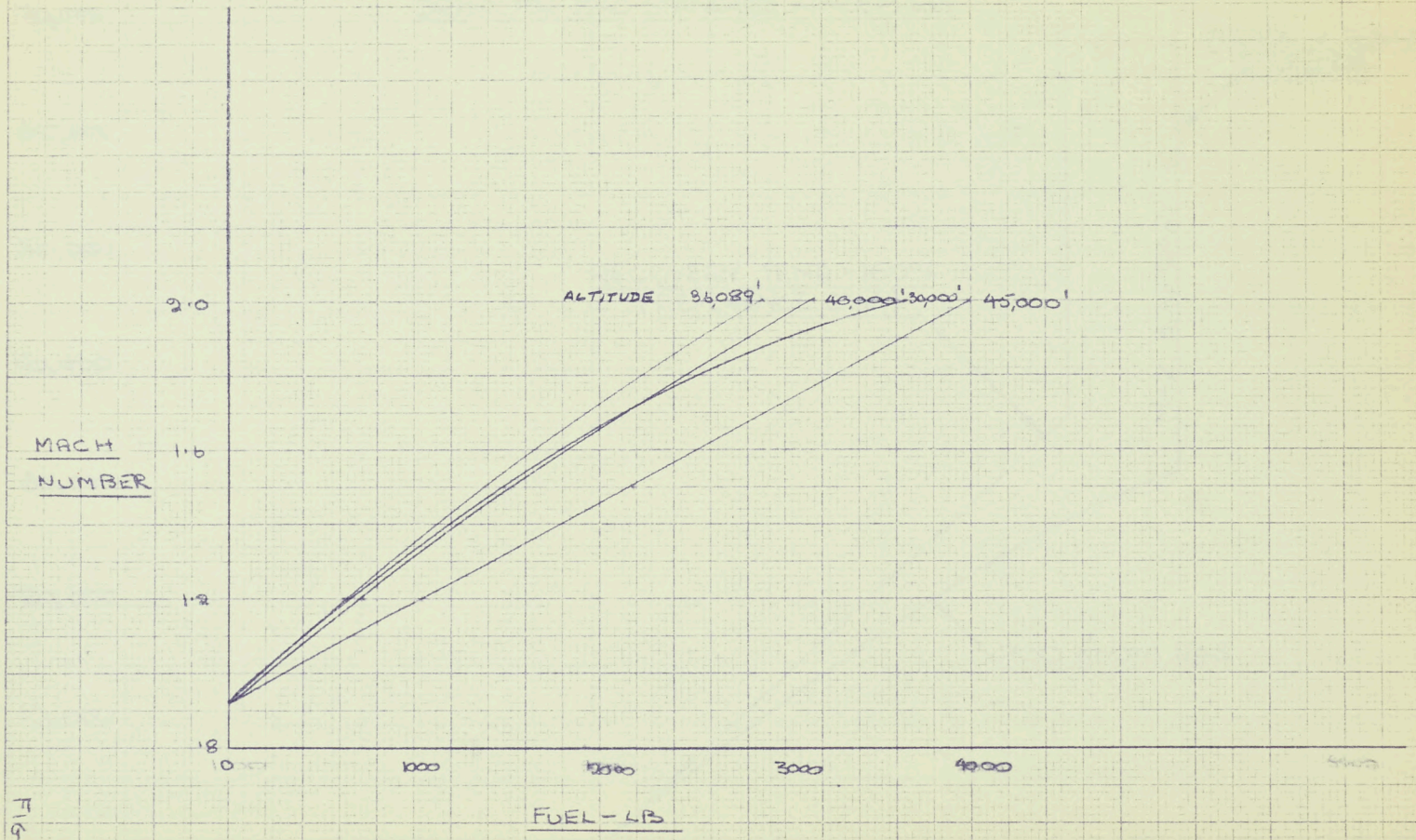


Fig. 7 (c)

N.W. AUGUST '56

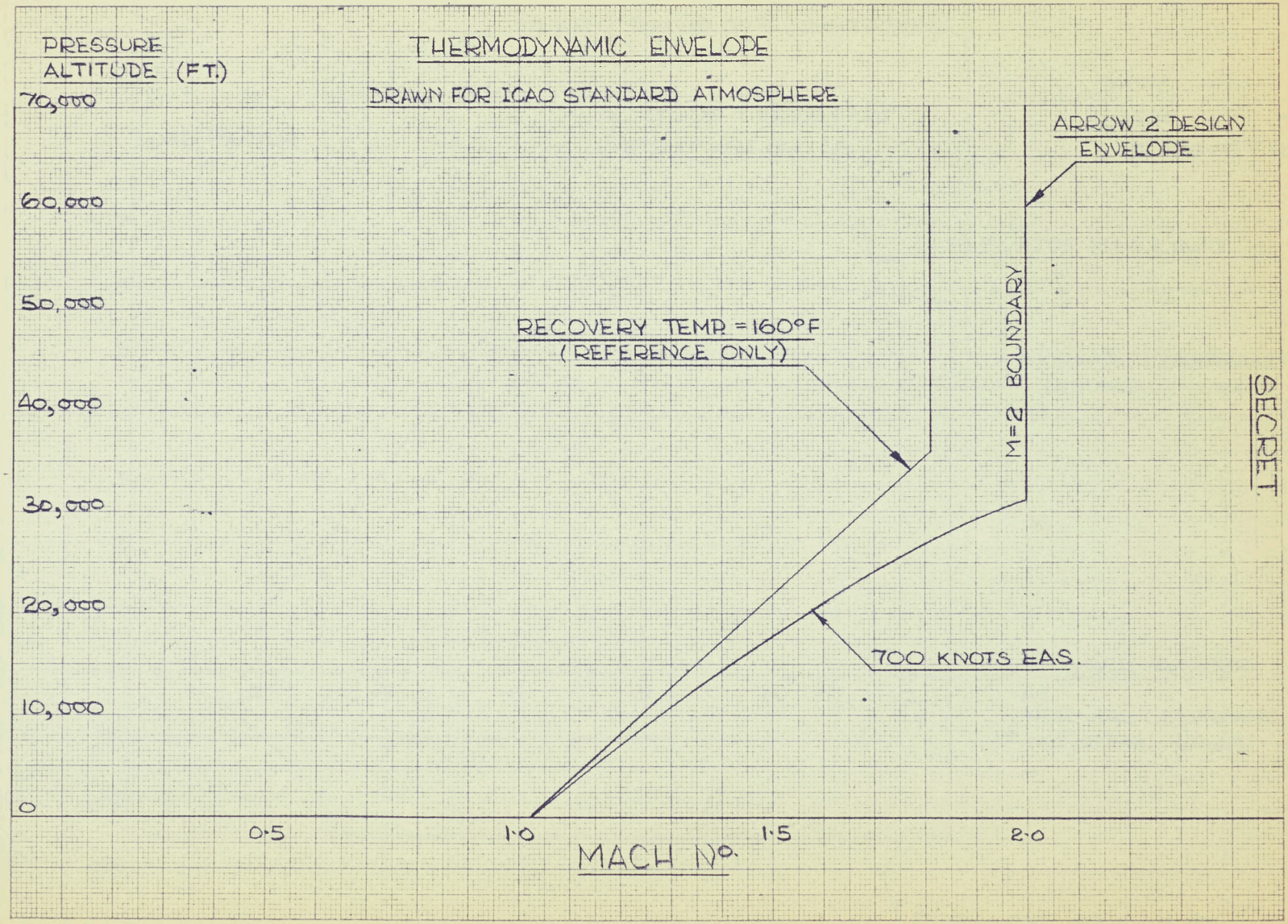


FIG 8

AT/SB 25-8-1958

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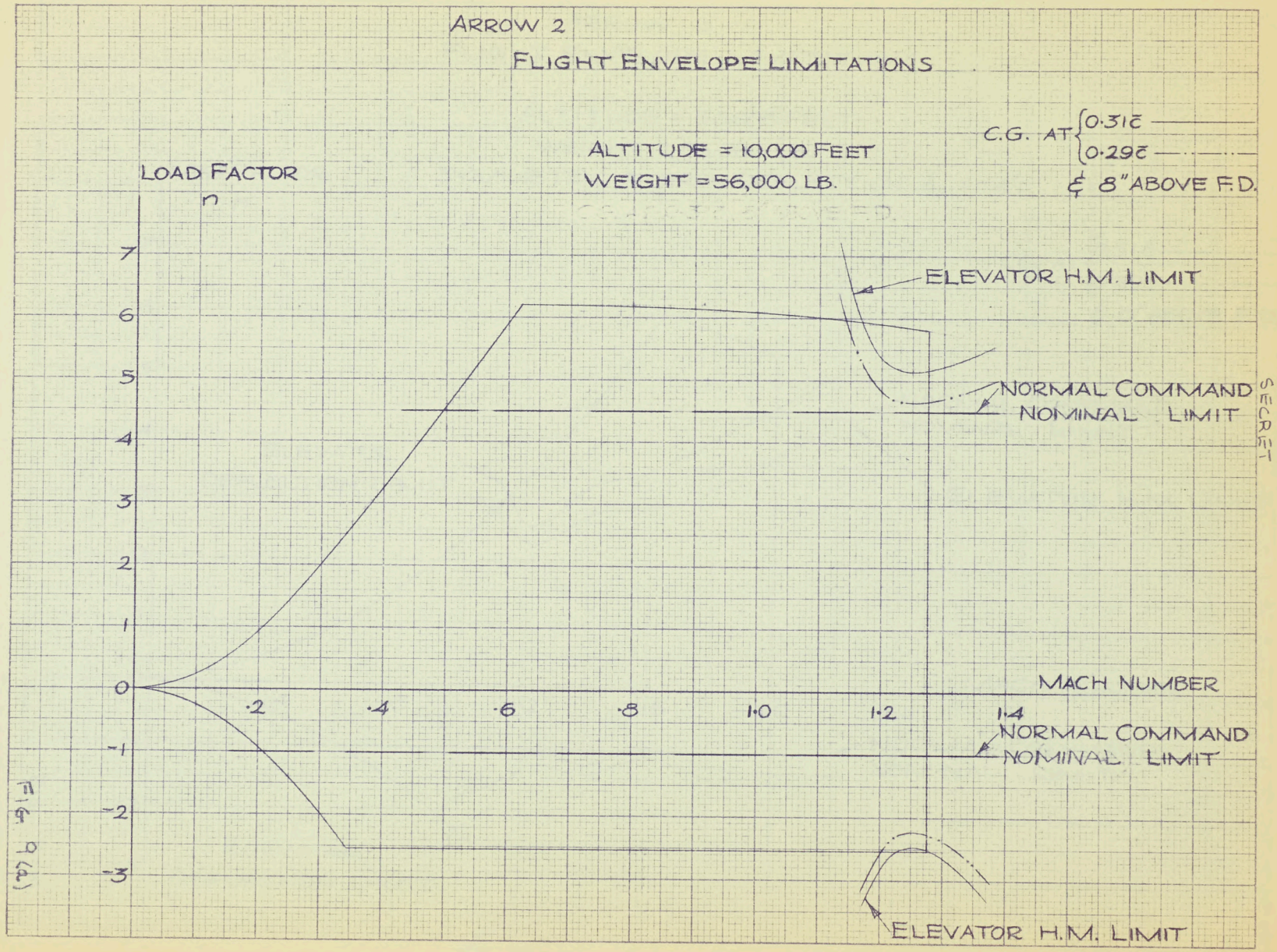

ARROW 2
FLIGHT ENVELOPE LIMITATIONS

ALTITUDE = 50,000 FEET
WEIGHT = 56,000 LB.
SYMMETRIC AILERON DEFLECTION $\delta_a = -4°$

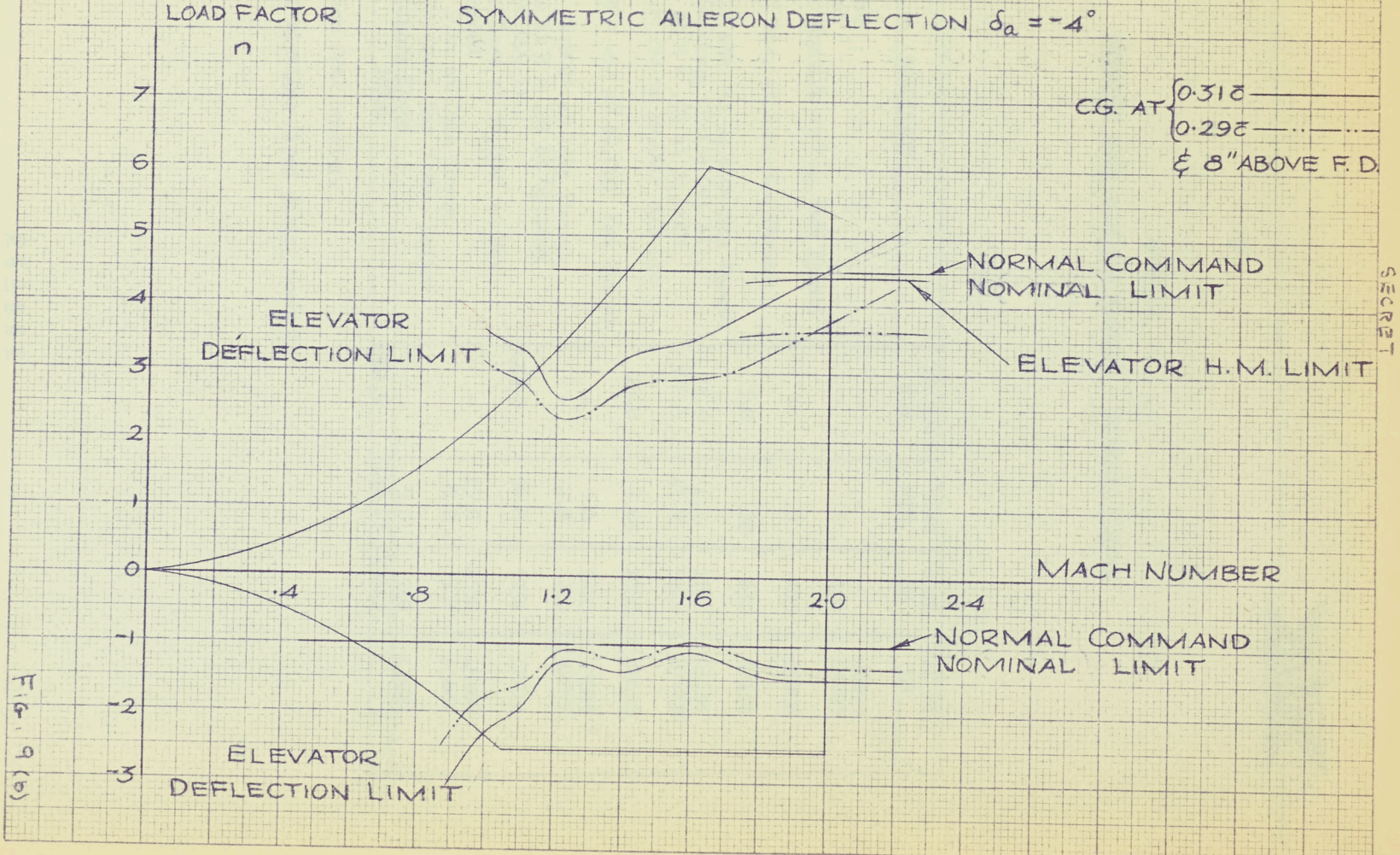

Fig. 9 (a)

ARROW 2

TABLE 2 SUBSONIC HIGH ALTITUDE MISSION - SUBSONIC COMBAT

CONDITION	DISTANCE N.M.	TIME MIN.	FUEL LB.	A/C WT. LB.
Start Weight	-	-	-	66093
Engine Start	-	.5	100	65993
Take-off to Unstick at S.L. Max Thrust A/B Unlit	-	.3	185	65808
Acc. to 527 kts. at S.L. Max Thrust A/B Unlit	5.0	.88	634	65174
Climb at 527 kts. to 34,000' Max Thrust A/B Unlit (Optimum Cruise Out Alt.)	35.5	4.1	1765	63409
Cruise Out at M = .91 at 34,000'	378.5	42.9	5646	57763
Climb at M = .92 to 50,000' A/B Lit Max Thrust	23.0	2.65	1330	56433
Combat at M = .92 at 50,000' Max Thrust A/B Lit	-	5.0	1620	53085 *
Descend to 36,000' at Idle Thrust	-	2.8	210	52875
Cruise Back at M = .91 at Optimum Altitude (36,000 ft.)	442.0	50.8	5359	47516
Loiter Over Base at 36,000' at Max Endurance speed	-	15.0	1530	45986
Descend to S.L. at Idle Thrust		6.2	324	45662
Land with Reserves for 5 min. Loiter at Max Endurance Speed		5.0	740	44922
TOTAL	884.0	136.13	19443	

7.8 lb/gallon fuel density.

*1728 lb. of missiles fired during combat.

TABLE 3 - ARROW 2 WITH IROQUOIS SERIES 2 ENGINES

SUBSONIC HIGH ALTITUDE MISSION - SUPERSONIC COMBAT

CONDITION	DISTANCE N.M.	TIME MIN.	FUEL LB.	A/C WT. LB.
Start Weight	-	-	-	66093
Engine Start	-	.5	100	65993
Take-off to Unstick at S.L. Max Thrust A/B Unlit	-	.3	185	65808
Acc. to 527 kts. at S.L. Max Thrust A/B Unlit	5.0	.88	634	65174
Climb at 527 kts. to 34,000' Max Thrust A/B Unlit (Optimum Cruise Out Alt.)	35.5	4.1	1765	63409
Cruise Out at M = .91 at 34,000'	269.5	30.68	4055	59354
Acc. to M = 1.5 at 34,000' Max Thrust A/B Lit	19.0	1.65	1560	57794
Climb to 50,000' at M = 1.5 Max Thrust A/B Lit	18.0	1.25	1080	56714
Combat at M = 1.5 at 50,000' Max Thrust A/B Lit	-	5.0	3042	51944 *
Descend to 36,000' at Idle Thrust	-	2.8	210	51734
Cruise Back at M = .91 at Optimum Altitude (36,000 ft.)	347.0	39.62	4218	47516
Loiter Over Base at 36,000' at Max Endurance Speed	-	15.0	1530	45986
Descend to S.L. at Idle Thrust	-	6.2	324	45662
Land with Reserves for 5 min. Loiter at S.L. at Max Endurance Speed	-	5.0	740	44922
TOTAL	694.0	112.98	19443	

Fuel density 7.8 lb/gallon.

* 1728 lb. of missiles fired during combat.

TABLE 4 - ARROW 2 WITH IROQUOIS SERIES 2 ENGINES

SUPERSONIC HIGH ALTITUDE MISSION - SUPERSONIC COMBAT

CONDITION	DISTANCE N.M.	TIME MIN.	FUEL LB.	A/C Wt. Lb.
Start Weight	-	-	-	66093
Engine Start	-	.5	100	65993
Take-off to unstick at S.L. Max Thrust A/B Unlit	-	.3	185	65808
Acc. to M = .92 at S.L. Max Thrust A/B Unlit	7.0	1.1	810	64998
Climb at M = .92 to 30,000' Max Thrust A/B lit	9.4	1.12	1560	63438
Acc. to M = 1.5 at 30,000' max Thrust A/B Lit	17.8	1.48	1680	61758
Climb at M = 1.5 to 50,000' Max Thrust A/B Lit (Optimum Cruise Out Alt.)	21.5	1.53	1360	60398
Cruise out at M = 1.5 at 50,000'	182.15	12.67	5068	55330
Combat at M = 1.5 at 50,000' Max Thrust A/B Lit	-	5.0	3042	50560 *
Descend to 36,000' at idle thrust		2.8	210	50350
Cruise back at M = .91 at optimum Alt. (36,000 ft.)	237.85	27.2	2834	47516
Loiter over Base at 36,000' at Max Endurance Speed		15.0	1530	45986
Descend to S.L. at Idle Thrust		6.2	324	45662
Land with reserves for 5 min Loiter at Max Endurance Speed		5.0	740	44922
TOTAL	475.7	79.9	19443	

* 1728 lb of Missiles fired during combat

Fuel Density 7.8 lb/gal.

ARROW 2

TABLE 5 - COMBAT AIR PATROL - SUPERSONIC COMBAT

WITH VENTRAL TANK - JETTISONED AT FUEL EXHAUSTION

CONDITION	DISTANCE N.M.	TIME MIN.	FUEL LB.	A/C WT. LB.
Start Weight	-	-	-	70335
Engine Start	-	.5	100	70235
Take-off to Unstick at S.L. Max Thrust A/B Unlit	-	.33	200	70035
Acc. to 527 kts. at S.L. Max Thrust A/B Unlit	5.4	.93	680	69355
Climb at 527 kts. to 32,000' Max Thrust A/B Unlit (Optimum Cruise Out Alt.)	34.0	3.9	1820	67535
Cruise Out at M = .91 at 32,000'	390.0	44.1	6194	60999
Acc. to M = 1.5 at 32,000' Max Thrust A/B Lit	18.0	1.5	1610	59389
Climb to 50,000' at M = 1.5 Max Thrust A/B Lit	19.5	1.38	1210	58179
Combat at M = 1.5 at 50,000' Max Thrust A/B Lit	-	5.0	3042	53049 *
Descend to 36,000' at Idle Thrust	-	2.8	210	53199
Cruise Back at M = .91 at Optimum Altitude (36,000 ft.)	466.9	53.8	5683	47516
Loiter Over Base at 36,000' at Max Endurance Speed	-	15.0	1530	45986
Descend to S.L. at Idle Thrust	-	6.2	324	45662
Land with Reserves for 5 min. Loiter at S.L. at Max Endurance Speed	-	5.0	740	44922
TOTAL	933.8	140.44	23343	

*1728 lb. missiles fired during combat

Fuel density 7.8 lb/gallon.

ARROW 2

TABLE 6 - SUBSONIC LOW LEVEL MISSION (10,000') - SUBSONIC COMBAT

CONDITION	DISTANCE N.M.	TIME MIN.	FUEL LB.	A/C WT. LB.
Start Weight	-	-	-	66093
Engine Start	-	.5	100	65993
Take-off to Unstick at S.L. Max Thrust A/B Unlit	-	.3	185	65808
Acc. to 527 kts. at S.L. Max Thrust A/B Unlit	5.0	.88	634	65174
Climb to 10,000' at 527 kts. Max Thrust A/B Unlit	5.7	.7	480	64694
Cruise at M = .6 at 10,000'(Opt.Cruise Speed)	335.3	52.6	7050	57644
Acc. to M = .92 at 10,000' A/B Unlit	3.1	.39	220	57424
Combat at M = .92 at 10,000' Max Thrust A/B Unlit	-	5.0	3220	52476 *
Climb to 36,000' at 527 kts. A/B Unlit	24.5	2.8	1010	51466
Cruise Back at M = .91 at Optimum Altitude (36,000 ft.)	324.6	37.3	3950	47516
Loiter Over Base at 36,000' at Max Endurance Speed	-	15.0	1530	45986
Descend to S.L. at Idle Thrust	-	6.2	324	45662
Land with Reserves for 5 min. Loiter at S.L. at Max Endurance Speed	-	5.0	740	44922
TOTAL	698.2	126.7	19443	

* 1728 lb. missiles fired during combat

Fuel density 7.8 lb/gallon.

ARROW 2 - IROQUOIS SERIES 2 ENGINES

TABLE 7 - FERRY MISSION (NO ARMAMENT)

VENTRAL TANK CARRIED THROUGHOUT

CONDITION	DISTANCE N.M.	TIME MIN.	FUEL LB.	A/C WT. LB.
Start Weight	-	-	-	68,607
Engine Start	-	.50	100	68,507
Take-off to Unstick Max Thrust A/B Unlit	-	.33	198	68,309
Accelerate to 527 kts. at S.L. A/B Unlit	5.2	.92	662	67,647
Climb to 30,000' Max Thrust A/B Unlit at 527 kts. TAS	29.0	3.37	1640	66,007
Cruise Climb to 36,000' at M = .91	1271.8	145.5	18129	47,878
Loiter Over Base 15 mins. at 36,000'	-	15.0	1530	46,348
Descend to S.L. at Idle Thrust	-	6.2	324	46,024
Land with Reserves for 5 mins. Loiter at S.L. at Max Endurance Speed	-	5.0	760	45,264
TOTAL	1306.0	176.82	23343	

Fuel density 7.8 lb/gallon.

ARROW 2 - IROQUOIS SERIES 2 ENGINES

TABLE 8 - FERRY MISSION (NO ARMAMENT)

VENTRAL TANK JETTISONED WHEN EMPTY

CONDITION	DISTANCE N.M.	TIME MIN.	FUEL LB.	A/C WT. LB.
Start Weight	-	-	-	68,607
Engine Start	-	.50	100	68,507
Take-off to Unstick Max Thrust A/B Unlit	-	.33	198	68,309
Accelerate to 527 kts. A/B Unlit at S.L.	5.2	.92	662	67,647
Climb to 30,000' Max Thrust A/B Unlit 527 kts. TAS	29.0	3.37	1640	66,007
Cruise Climb to 36,000' at M = .91	1322.6	151.13	18129	47,536
Loiter Over Base 15 mins. at 36,000'	-	15.0	1530	46,006
Descend to S.L. at Idle Thrust	-	6.2	324	45,682
Land with Reserves for 5 mins. Loiter at S.L. at Max Endurance Speed	-	5.0	760	44,922
TOTAL	1356.8	182.4	23343	

Fuel density 7.8 lb/gallon.