412TW-PA-19223

Preliminary Reports of the X-24B Flight Records (Flights 18-28)

AF/NASA X-24B Project Team

AIR FORCE TEST CENTER
EDWARDS AFB, CA

A
F
T
C

23 Sep 1970 - 28 May 1971

AIR FORCE TEST CENTER
EDWARDS AIR FORCE BASE, CALIFORNIA
AIR FORCE MATERIEL COMMAND
UNITED STATES AIR FORCE

X-24B Flts B-9-16 - B-15-26

FLIGHT 9

PRELIMINARY RESULTS OF X-24B

FLIGHT B-9-16

5 MARCH 1974

BY

USAF/NASA X-24B PROJECT TEAM

X-24B Flight Request

26 February 1974

Flight NO: B-9-16

Scheduled Date: 5 March 1974

Pilot: John Manke

Purpose:
1. Envelope Expansion to 1.1 Mach Number
2. Stability and Control at Mach Number > 1.0
3. Performance and Longitudinal Trim at .9 and .8 Mach Number
4. Fin and Rudder Pressure Survey
5. Boundary layer noise and vibration experiment (RED PLUG)

Launch: Cuddeback, Mag Heading 209° + Crosswind Correction Angle. 45,000 feet, 190 KIAS. Flap Bias "Manual", Upper Flaps = -40°, Lower Flaps = 27°, Rudder Bias Mode "AUTO", Rudder Bias = 0°. Rudder Trim = 1° Left. Aileron Bias = -7°, SAS Gains 6, 5, 3. Mach Repeater "Manual" = 1.0, KRA "AUTO", Hydraulic Pumps 2 and 4 on.

Landing: Rogers Lakebed Runway 36

B-52 Track: X-24B Track #3 (R2502, R2524, SPIN AREA 1)

ITEM	TIME	ALT	A/S	α	M_T/M_i	EVENT
1	0	45	190	5	.71 (.70)	Launch, Light 4 Chambers, Trim to and Maintain 15° α
2	22	43	250	15	.87 (.85)	Max Mach during rotation.
3	34	44	230	15	.84 (.82)	θ = 30° Maintain θ = 30° (cross check α)
4	78	54	190	14	.87 (.85)	At 54K Pushover to 10° α.
5	84	56	195	10	.90 (.87)	Observe vehicle's handling qualities.

ITEM	TIME	ALT	A/S	α	M_T/M_i	EVENT
6	102	58	220	10	1.05 (1.05)	At 1.05 $Mach_T$ shutdown chamber #1, perform rudder and aileron doublet, evaluate handling qualities.
7	118	58	230	10	1.10 (1.10)	At 1.10 $Mach_T$ shutdown engine. Perform rudder and aileron doublet, maintain 10^o α during decel to .9 $Mach_T$.
8	135	56	195	10	.92 (.89)	Perform pushover-pullup 5^o to 16^o to 10^o α, retrim to 13^o α.
9	167	46	220	13	.82 (.80)	Perform pushover-pullup 5^o to 16^o to 10^o α, retrim to 12^o α. Maintain steady conditions to .7 $Mach_T$.
10	196	40	200	12	.65 (.64)	Rudder bias to "Manual" toe rudders in to -10^o and return to 0^o while maintaining constant α. Rudder bias to "Auto".
11	216	33	200	12	.64 (.63)	Highway 58, turn to 184^o heading. Set SAS Gains 4, 3, 2.
12	237	31	210	12	.58 (.57)	Change configuration to -20^o upper flaps.
13	250	29	220	10	.56 (55)	Jettison remaining propellants approx 10 sec. (670 lbs lox, 630 lbs WALC) vector to low key.
14	295	22	220	10	.52 (.51)	Low key, rocket check, #1 and #3 hydraulic pumps on.
15						Set Mach repeater to .3 during final.

NOTES:

1. Nose Ballast = 220 lbs (+ 100 AMP HR Equp Batt)

2.

	Weight-lbs	cg-%
Launch	13457	65.9
Shutdown	9550	64.1
Landing	8394	64.0 (gear down)

3. Engine S/N 8, Pump S/N 8A

   Thrust = 2,100 lbs/chamber
   LOX Flow Rate = 4.51 lb/sec/chamber
   WALC Flow Rate = 4.05 lb/sec/chamber

4. Power on Base Drag Reduction C_C = -.005

5. Pitch Attitude Null at 30^{o}

Ground Rules for NO LAUNCH:

1. Radio, radar, PCM failure
2. Electrical or SAS malfunction
3. A/S, altitude, Machmeter failure
4. Angle of attack or sideslip malfunction
5. Any control system malfunction
6. Loss of cabin pressure
7. Turbulence below 10K in excess of moderate
8. Surface winds greater than 20 kts or crosswind greater than 10 kts
9. Failure of engine control box heater
10. Failure of stick shaker
11. Must have 3 good igniters to launch

(In addition to standard ground rules published in Lift Body Joint Operations Plan)

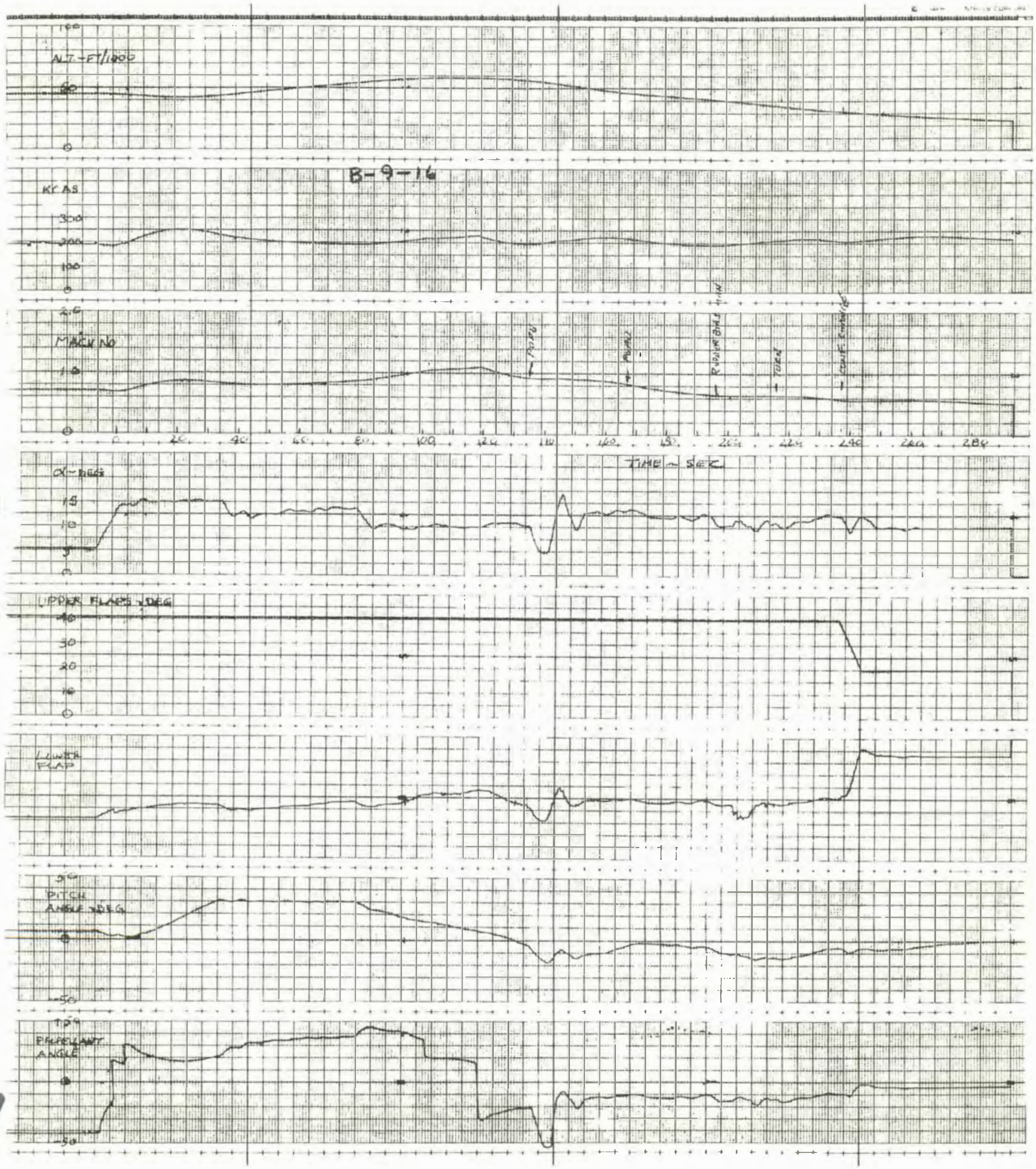
Alternate Situations After Launch:

Failure	Action
1. Radio, radar, PCM	Proceed as planned.
2. Only One Chambers Operates	Vector for RW 01 Cuddeback, shutdown chamber, jettison, change configuration.

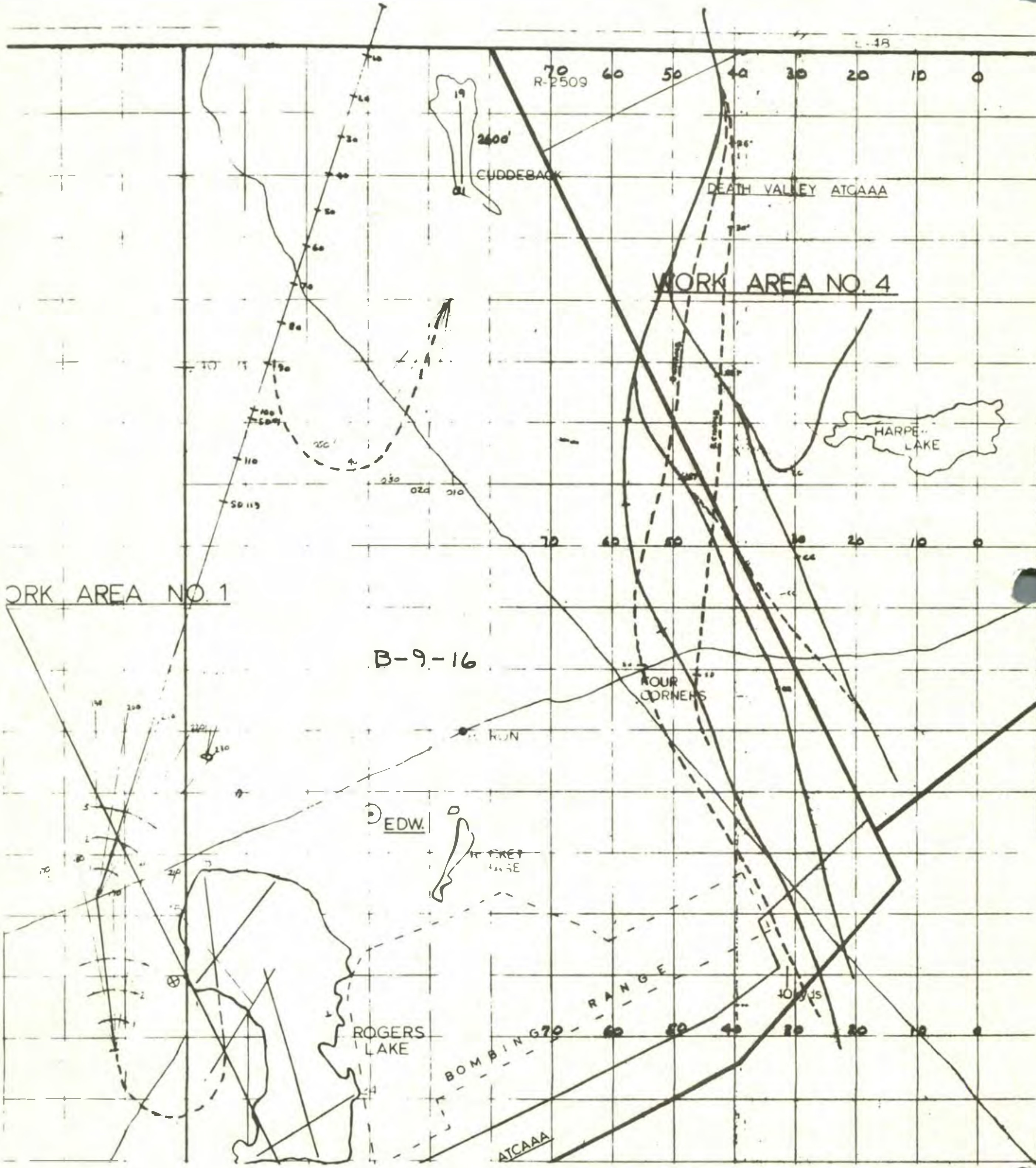
Failure	Action
3. Only Two Chambers Operate	Maintain 15^{o} α, Change configuration to 30^{o} upper flap at .7 Mach No. Shutdown on NASA I call ($\approx$ 200 sec). Evaluate dampers off handling qualities at pilot's discretion.
4. Only Three Chambers Operate	Maintain 15^{o} α. At 55K pushover to 8$^{o}\alpha$. Engine burnout at $\approx$ 1.05 $Mach_T$ (172 sec) Perform planned data maneuvers.
5. Delayed Engine Light	Proceed as planned. Use 35θ (15^{o} α Max)
6. Total damper failure - any axis	Fly 3 Chamber profile, limit M_T to .9. (For pitch damper failure rotate at 13^{o} α). Data maneuvers at pilot's discretion. If control is marginal go to two chambers. ROLL DAMPER FAILURE - MACH REP. TO .3
7. KRA "AUTO" Failure	Set to manual 10% and proceed as planned. If "MANUAL" mode inoperative-switch to "EMER" position and set to above value.
8. Angle of Attack (Indicator Only)	Proceed as planned using backup angle of attack gage. KRA "MANUAL" 10%, stick shaker off.
9. Total Angle of Attack	Fly Two Chamber profile, use 200 KTS instead of 15^{o} α. To rotate fly 1.0g to 230 KCAS then fly 1.2g to 200 KCAS. (KRA Manual 10%, stick shaker off)
10. A/S, altitude, Mach	Proceed as planned using α, θ and time for profile control.
11. Attitude System	Proceed as planned using backup attitude indicator.
12. Premature Engine Shutdown 0 - 60 sec RW 01 Cuddeback 60 - 85 sec RW 18 Rogers 85 - up sec RW 36 Rogers	

ROBERT G. HOEY

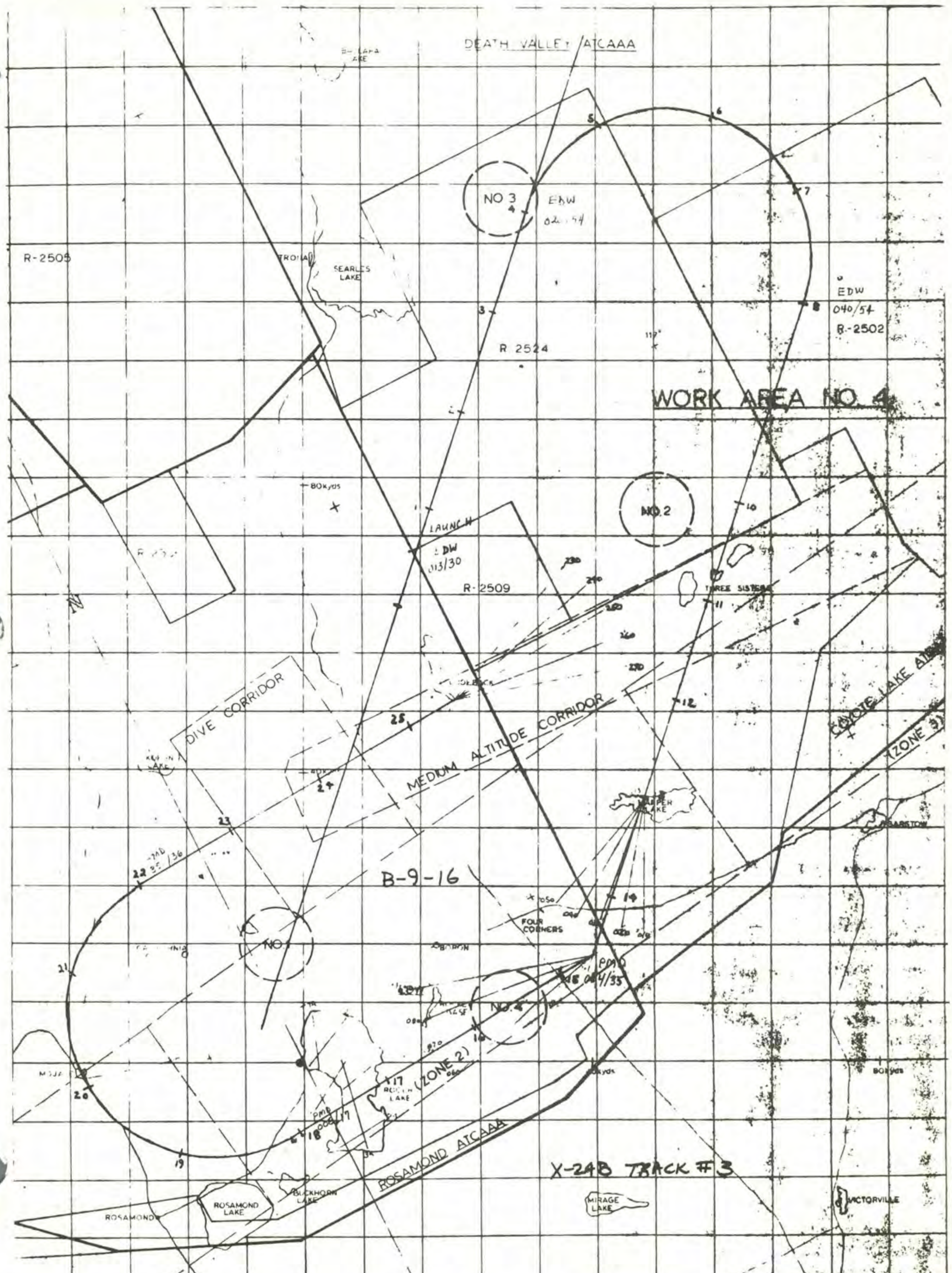
JACK L. KOLF



B-9-16
ALT-FT/1000
KCAS
MACH NO
α~DEG
UPPER FLAPS ~DEG
LOWER FLAP
PITCH ANGLE ~DEG
PROPELLANT ANGLE
TIME ~ SEC



R-2509
CUDDEBACK
2600'
DEATH VALLEY ATCAAA
WORK AREA NO. 4
HARPER LAKE
WORK AREA NO. 1
B-9-16
FOUR CORNERS
EDW.
ROGERS LAKE
BOMBING RANGE
ATCAAA


DEATH VALLEY ATCAAA
R-2505
TRONA
SEARLES LAKE
NO 3
EDW
R 2524
EDW
040/54
R-2502
WORK AREA NO. 4
NO.2
LAUNCH
EDW
013/30
R-2509
THREE SISTERS
DIVE CORRIDOR
MEDIUM ALTITUDE CORRIDOR
COYOTE LAKE
(ZONE 3)
B-9-16
FOUR CORNERS
NO 1
PMD
NO.4
(ZONE 2)
ROSAMOND ATCAAA
X-24B TRACK #3
ROSAMOND LAKE
ROSAMOND
BUCKHORN LAKE
MIRAGE LAKE
VICTORVILLE
BARSTOW

X-24B FLT B-9-16

TOD	MACH	ALT	KCAS	EVENTS
11:45:11.3	.678	44613.	182.	ENG MASTER ON
:45:19.4	.682	44604.	183.	LOX PRIME
:45:44.7	.682	44604.	183.	IGNITER TEST
:45:56.7	.684	44506.	184.	LAUNCH
:45:59.0	.664	44327.	179.	#2 & 4 CHAMBER PRESSURE STARTS UP
11:46:00.6	.666	44308.	179.	AX STARTS INCREASE
:46:02.1	.671	44177.	181.	AX LEVEL (2 CHAMBERS)
:46.02.9	.677	44070.	184.	#2 @ 100 %
:46:03.4	.683	44017.	185.	#4 @ 100 %
:46:04.4	.691	43889.	188.	#1 AND 3 CHAMBER PRESSURE STARTS UP
:46:05.5	.696	43737.	191.	AX STARTS 2ND INCREASE
:46:06.5	.705	43575.	194.	AX LEVEL (4 CHAMBERS)
:46:07.8	.722	43378.	200.	#1 @ 100 %
:46:09.2	.780	43212.	219.	#3 @ 100 %
46:14.5	.807	42378.	232.	START LEFT HEADING CORRECTION (MAX $\phi = 20^\circ$)
:46:19.7	.859	41849.	252.	LH FIN PRESS #72 & #372 STARTS DECREASING
:46:21.8	.870	41739.	256.	LH LOWER RUDDER HM - START BUFFET
:46:24.2	.871	41687.	257.	MAX MACH DURING ROTATION
:46:27.0	.866	41786.	255.	LH LOWER RUDDER HM - END BUFFET
:46:28.0	.854	41826.	250.	END LEFT HEADING CORRECTION
:46:30.5	.848	42114.	247.	LH FIN PRESS #72 & #372 RECOVERED
:46:34.8	.822	42825.	234.	$\theta = 29^\circ$
46:43.5	.828	44976.	225.	START RIGHT HEADING CORRECTION (MAX $\phi = 6^\circ$)
:46:48.0	.821	46173.	216.	END RIGHT HEADING CORRECTION
11:47:08.0	.864	51325	204.	START RIGHT HEADING CORRECTION (MAX $\phi = 10^\circ$)
47:10.2	.881	51886.	205.	SUDDEN FIN PRESS JUMP (START OSCILATING)
:47:18.4	.895	53990.	199.	PUSHOVER
:47:20.4	.894	54530.	196.	BETA STARTS OUT (NOSE RIGHT)

X-24B FLT B-9-16 (CONT)

TOD	MACH	ALT	KCAS	EVENTS
11 47:20.5	.894	54561.	196.	RH FIN PRESS #372 STARTS TO ZERO (LH DID NOT)
:47:20.5	.894	54561.	196.	RH LOWER RUDDER HM CHANGES SIGN
:47:21.3	.896	54788.	196.	END RIGHT HEADING CORRECTION
:47:25.0	.924	55823.	198.	APPROX TIME WHEN PRESSURES BECAME STEADY
:47:39.7	.988	58268.	203.	START MACH JUMP M_i = .9596
:47:41.3	1.026	59455.	206.	END MACH JUMP M_i 1.017
:47:43.1	1.037	59707.	208.	AX DECREASE (#1 OFF)
:47:45.0	1.045	59876.	209.	#1 CHAMBER PRESSURE STARTS DOWN
:47:47.1	1.046	60111.	208.	RUDDER DOUBLET $\alpha = 10°$
:47:50.7	1.053	60385.	208.	AILERON DOUBLET $\alpha = 10°$
:47:57.3	1.086	60609.	215.	#2 & 4 CHAMBER PRESSURE STARTS DOWN
:47:57.3	1.086	60609.	215.	AX DECREASE (SHUT DOWN)
:47:57.9	1.079	60609.	214.	#3 CHAMBER PRESSURE STARTS DOWN
:47:58.0	1.078	60609.	213.	RUDDER DOUBLET $\alpha = 9.5°$
11 :48:01.8	1.034	60665.	202.	AILERON DOUBLET $\alpha = 9.5°$
:48:03.1	1.016	60670.	198.	START MACH JUMP M_i = 1.0111
:48:04.6	.975	59764.	192.	END MACH JUMP M_i = .9491
:48:20.	.904	57539.	185.	APPROX TIME WHERE PRESS BECAME OSCILLATORY AGAIN
:48:21.0	.896	57293.	184.	START POPU $\alpha = 13°$
:48:27.0	.911	55564.	196.	AT MIN $\alpha = 5°$
:48:33.0	.924	53496.	209.	AT MAX $\alpha = 17°$
:48:34.7	.841	52149.	207.	RETURN TO $\alpha = 10°$
:48:57.0	.784	46334.	205.	START POPU $\alpha = 14.5°$
11 :49:04.0	.750	44659.	203.	AT MIN $\alpha = 5°$
:49:13.2	.755	41793.	218.	AT MAX $\alpha = 17°$
:49:15.5	.736	41132.	216.	RETURN TO $\alpha = 11°$
:49:18.	.739	40458.	220.	START STEADY FLIGHT $\alpha = 12°$ CONSTANT
:49:30.6	.676	37538.	214.	SUDDEN LARGE PRESS CHANGE DURING STEADY FLT
:49:37.5	.647	36200.	210.	START TURN TO DOWNWIND ($\phi = 21°$ MAX)

X-24B FLT B-9-16 CONT

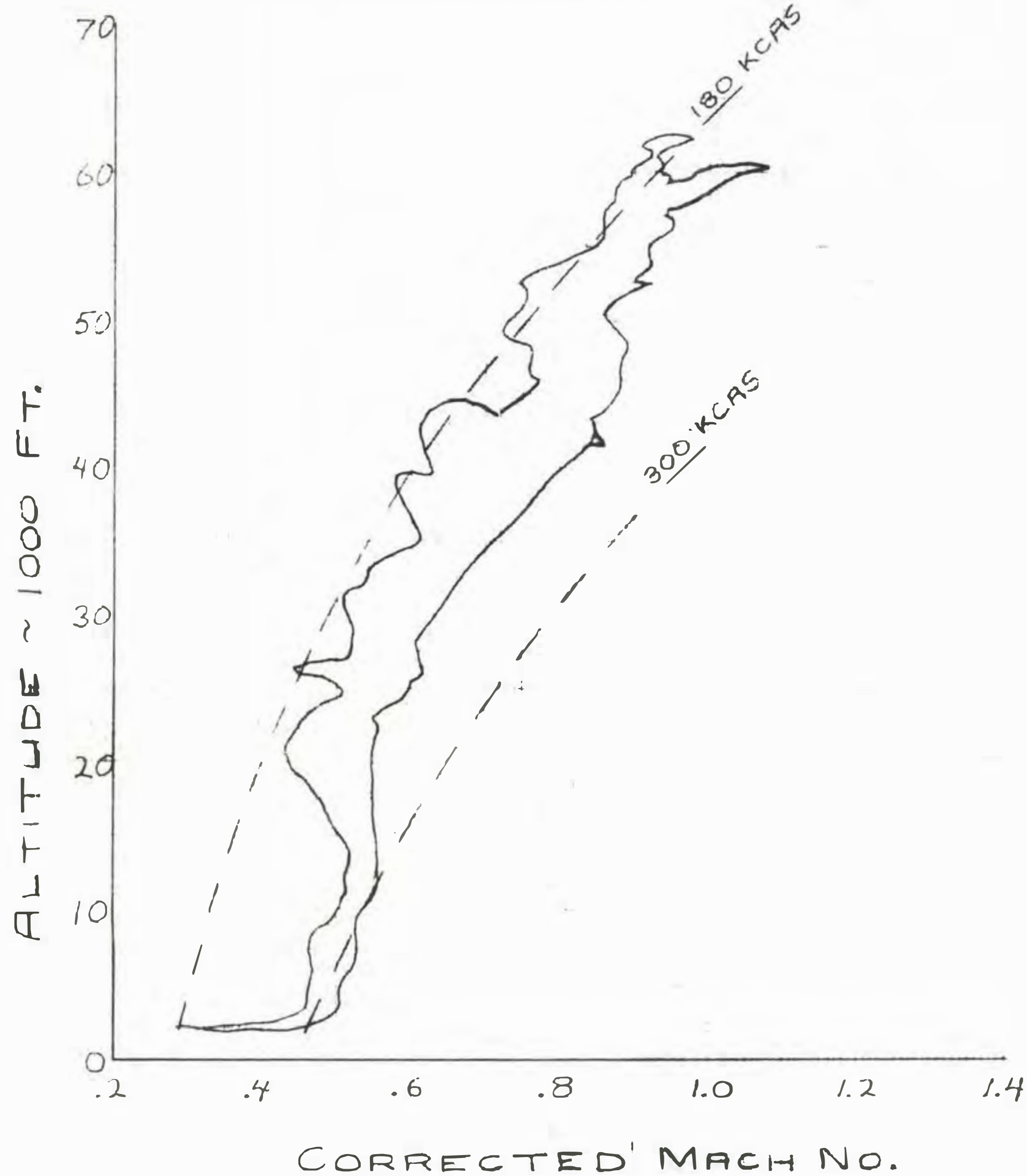
TOD	MACH	ALT	KCAS	EVENTS
49:42.	.637	35381.	210.	END STEADY FLIGHT
49:51.0	.617	33887.	211.	END TURN TO DOWNWIND
49:53.0	.606	33564.	208.	START RUDDER BIAS TOE IN
49:56.0	.589	33030.	204.	RUDDERS STOP AT -10°
49:58.4	.583	32587.	204.	START RUDDER BIAS TOE OUT
11:50:01.3	.579	32023.	205.	RUDDERS STOP AT 0°
50:03.8	.580	31527.	208.	PITCH GAIN TO 4
50:04.8	.578	31328.	208.	ROLL GAIN TO 3
50:06.1	.575	31085.	208.	YAW GAIN TO 2
50:14.5	.556	29604.	208.	START CONFIGURATION CHANGE
50:22.0	.558	28307.	214.	END CONFIGURATION CHANGE
50:26	.563	27649.	220.	START LOX JETTISON
50:26.5	.563	27562	220.	START WALC JETTISON
50:34.0	.564	26386.	226.	END LOX JETTISON
50:35.5	.563	26177.	227.	END WALC JETTISON
50:52.2	.544	24018.	229.	ROCKET CHECK
50:56.6	.546	23458.	233.	#1 & 3 HYDRAULIC PUMPS ON
11:51:07.8	.535	21950.	235.	LOW KEY START TURN
51:50.8	.516	14895.	261.	MACH REPEATER TO .3
11:52:19.2	.544	8814.	309.	UPPER FLAPS START OUT (SPEEDBRAKES) (28° MAX)
52:21.0	.539	8395.	308.	LEVEL ON FINAL
52:36.2	.491	5242.	296.	UPPER FLAPS RETURN TO 20°
52:41.2	.486	4319.	298.	FLARE (APPROX)
11:53:06.1	.364	2116.	232.	GEAR DOWN
53:13.9	.291	2074.	185.	MAIN GEAR TOUCHDOWN $\alpha = 11°$
53:15.4	.276	2066.	176.	NOSE GEAR TOUCHDOWN

BURN TIME 116SEC

FLT. TIME 7:17.2

X-24B

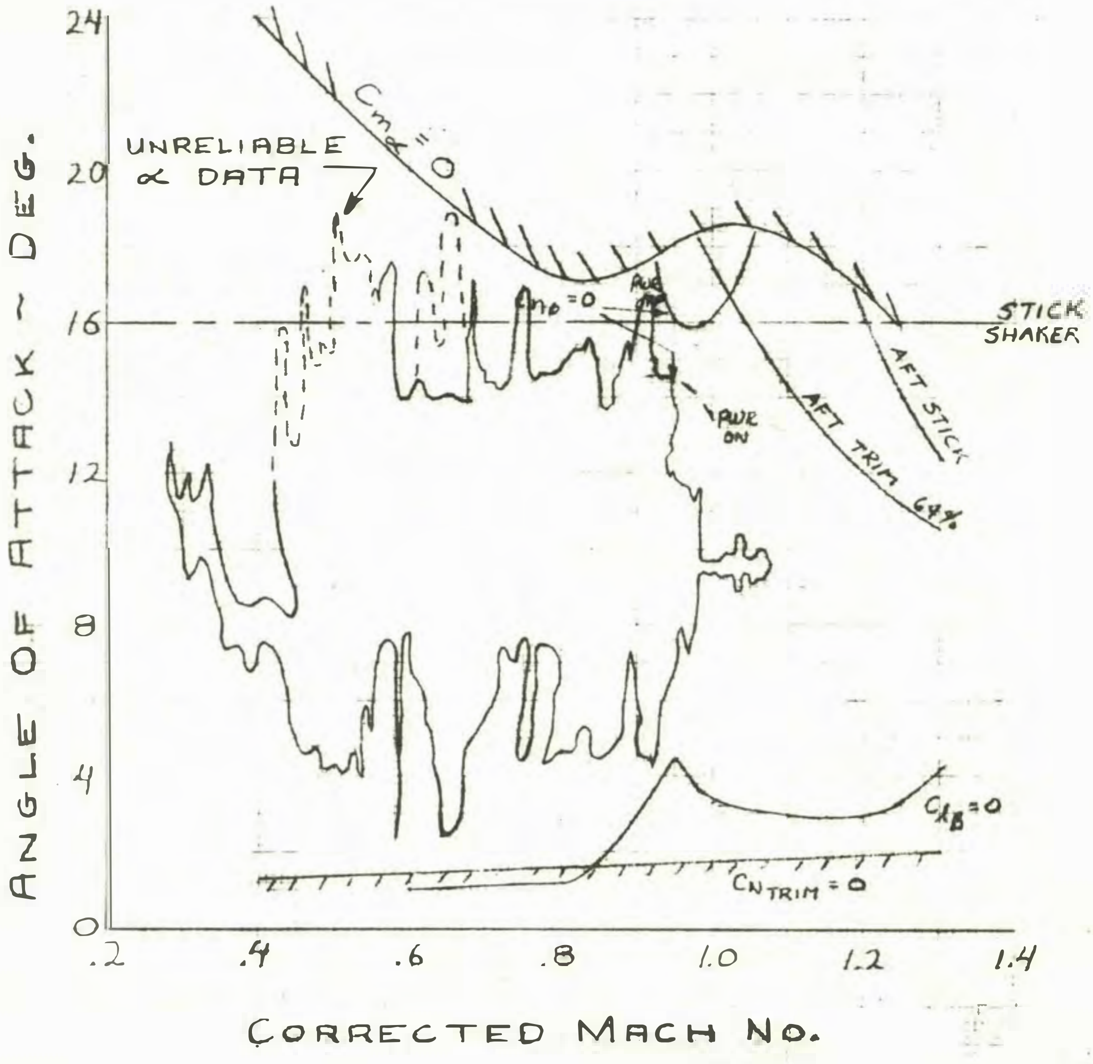
MACH NO. VS ALTITUDE ENVELOPE FLIGHTS 1 THRU 9



X-24B

MACH NO. VS ANGLE OF ATTACK ENVELOPE

FLIGHTS 1 THRU 9



Flight B-9-16 Flight Profile

Overall the profile control parameters (α, pushover conditions, engine shutdown time) were very close to the planned events for this flight(see table). However, the vehicle exceeded the planned max altitude by 2,600 feet. This amount of altitude deviation had no detrimental effects on the planned objectives of the flight. A comparison of the planned and actual profile (alt vs downrange) from the real time radar plot indicates an apparent difference in climb angle. It should be pointed out that winds different from planned can significantly effect the actual downrange track, resulting in false conclusions about climb angle. However, a comparison of flight path angle (γ) between actual and the preflight simulator run does in fact indicate that the actual γ was higher after 50 seconds. It is interesting to note that γ from radar and internal data agreed reasonable well on this flight (see figure). Previous flights had indicated that γ from internal data was 2 to 3^{o} lower than radar giving rise to doubts on the accuracy of the pitch angle from the platform. The platform in the vehicle was changed between flights 7 and 8. Also, shown is a comparison of true Mach number versus altitude between the actual and the preplanned. The comparison is considered quite good and gives some confidence to the overall validity of the simulation.

Flight B-9-16

Comparison Of Planned And Actual

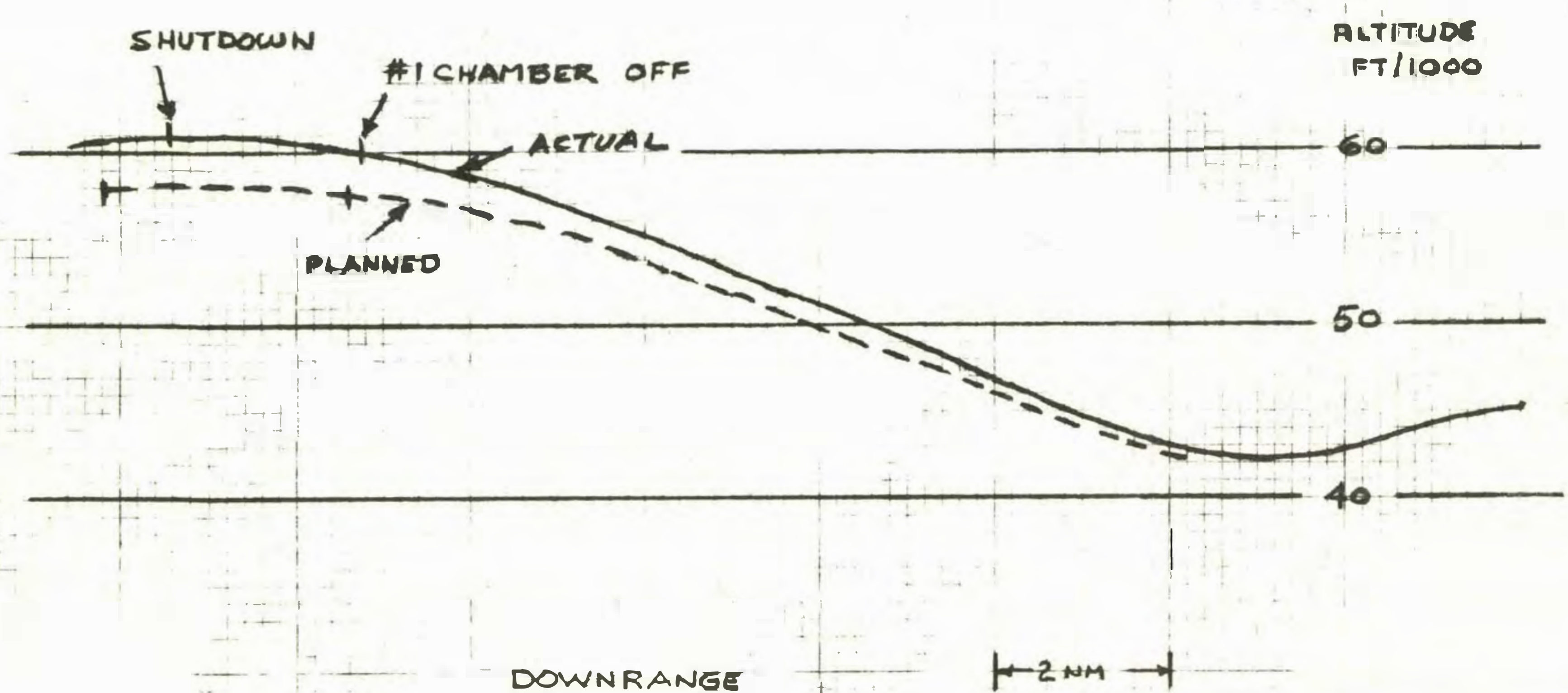
Profile Control Events During Boost

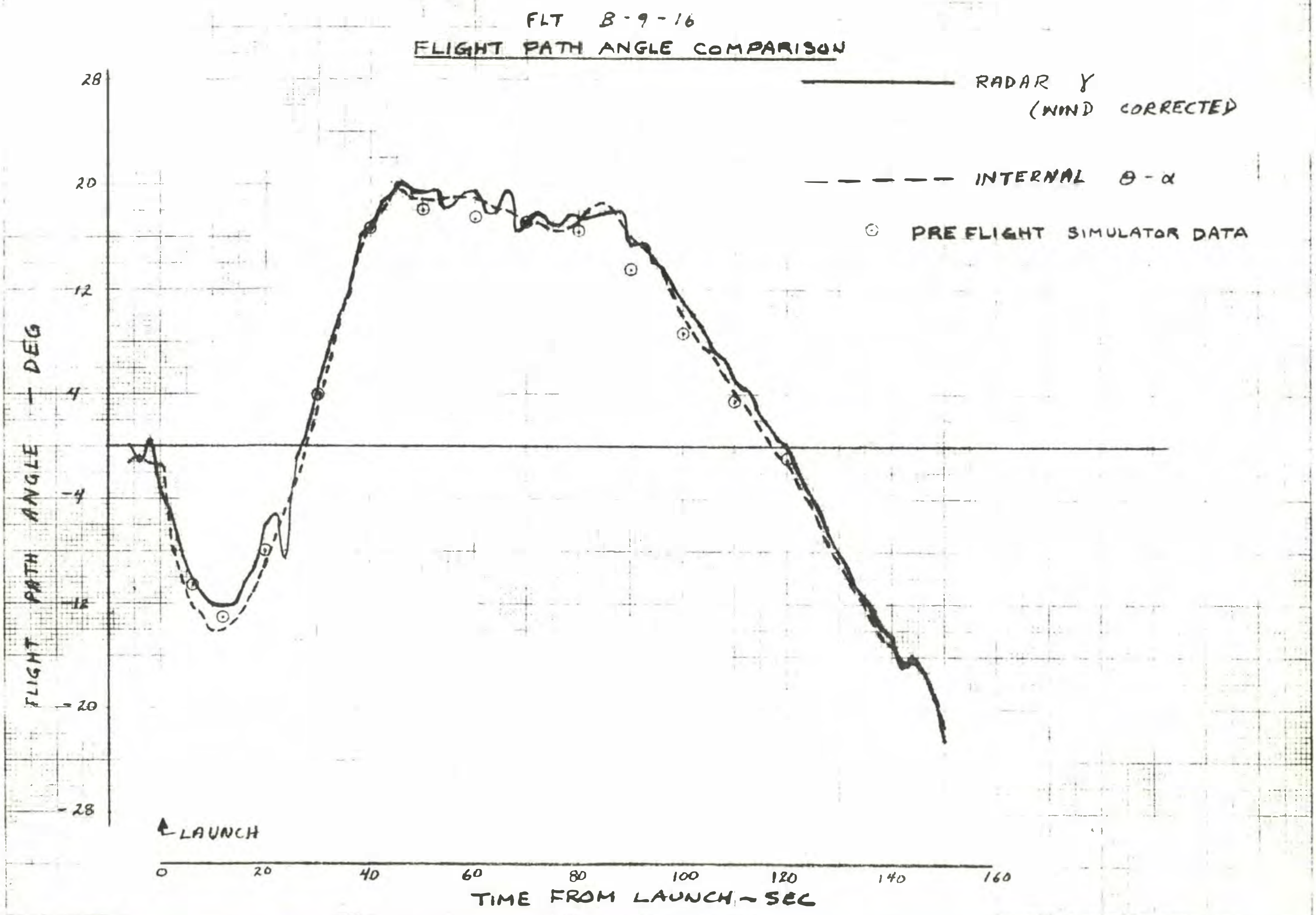
	TIME	ALT	KCAS	$MACH_T$	EVENT
Planned	22	42000	250	.87	Max Mach during rotation
Actual	22.8	41687	257	.871	
Planned	34	44000	230	.84	$\theta = 30^{o}$
Actual	33.4	42820	234	.822	$\theta = 29^{o}$
Planned	78	54000	190	.87	Pushover
Actual	77.0	53990	199	.895	
Planned	97	58000	210	1.0	M=1.0
Actual	98.3	58260	203	jump	
Planned	102	58000	220	1.05	Shutdown Chamber # 1
Actual	101.7	59700	208	1.037	
Planned	118	58000	230	1.10	Shutdown
Actual	115.9	60600	215	1.086	

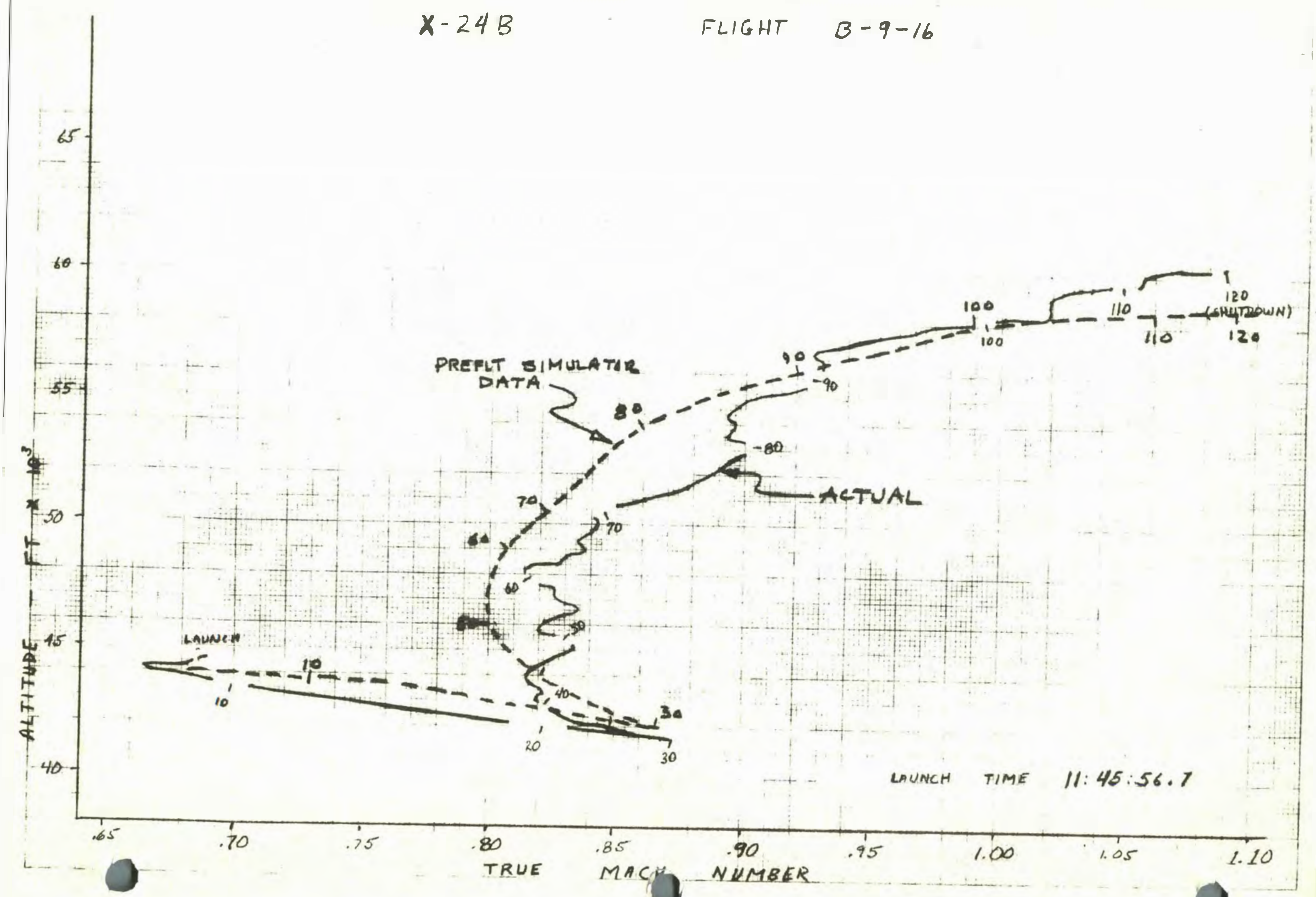
Time shown is from engine start

FLIGHT B-9-16

PROFILE COMPARISON FROM REAL TIME RADAR PLOT




FLT B-9-16
FLIGHT PATH ANGLE COMPARISON
RADAR γ
(WIND CORRECTED)
INTERNAL θ - α
PRE FLIGHT SIMULATOR DATA
FLIGHT PATH ANGLE — DEG
28
20
12
4
-4
-12
-20
-28
LAUNCH
0
20
40
60
80
100
120
140
160
TIME FROM LAUNCH ~ SEC


X-24B
FLIGHT B-9-16
PREFLT SIMULATOR DATA
ACTUAL
LAUNCH
(SHUTDOWN)
LAUNCH TIME 11:45:56.7
ALTITUDE — FT × 10³
TRUE MACH NUMBER
.65
.70
.75
.80
.85
.90
.95
1.00
1.05
1.10
40
45
50
55
60
65

X-24B Derivatives

From flight 9, the first two sets of lateral-directional derivatives above Mach one were obtained. One of the maneuvers was power-off, and the other was power on. Both sets of derivatives were near 1.05 Mach number with an angle-of-attack between 9 and 10 degrees. These data are presented in figure 1 along with power-off wind tunnel predictions. Additional subsonic data were also obtained and add to the base of previous flight data.

From figure 1, C_{ℓ_β} and C_{Y_β} were near wind tunnel predictions. Overall, C_{n_β} was at or above predictions and showing a possible power effect. $C_{\ell_{\delta_a}}$ is slightly higher than predicted, while $C_{n_{\delta_a}}$ is lower thus indicating better flight handling qualities due to aileron. Likewise, rudder characteristics are better than predicted. Damping characteristics have their normal scatter but are generally well behaved. In summary, these flight data generally indicate a better flying vehicle in the high transonic region.

Both Newton-Raphson and Hybrid matching results are shown in the figures. Agreement between the two programs is outstanding for the two maneuvers analyzed.

FIGURE 1,

X-24B DERIVATIVES

$\delta u_B = -40°, \ \delta r_B = 0°, \ cg = .65 \bar{c}$

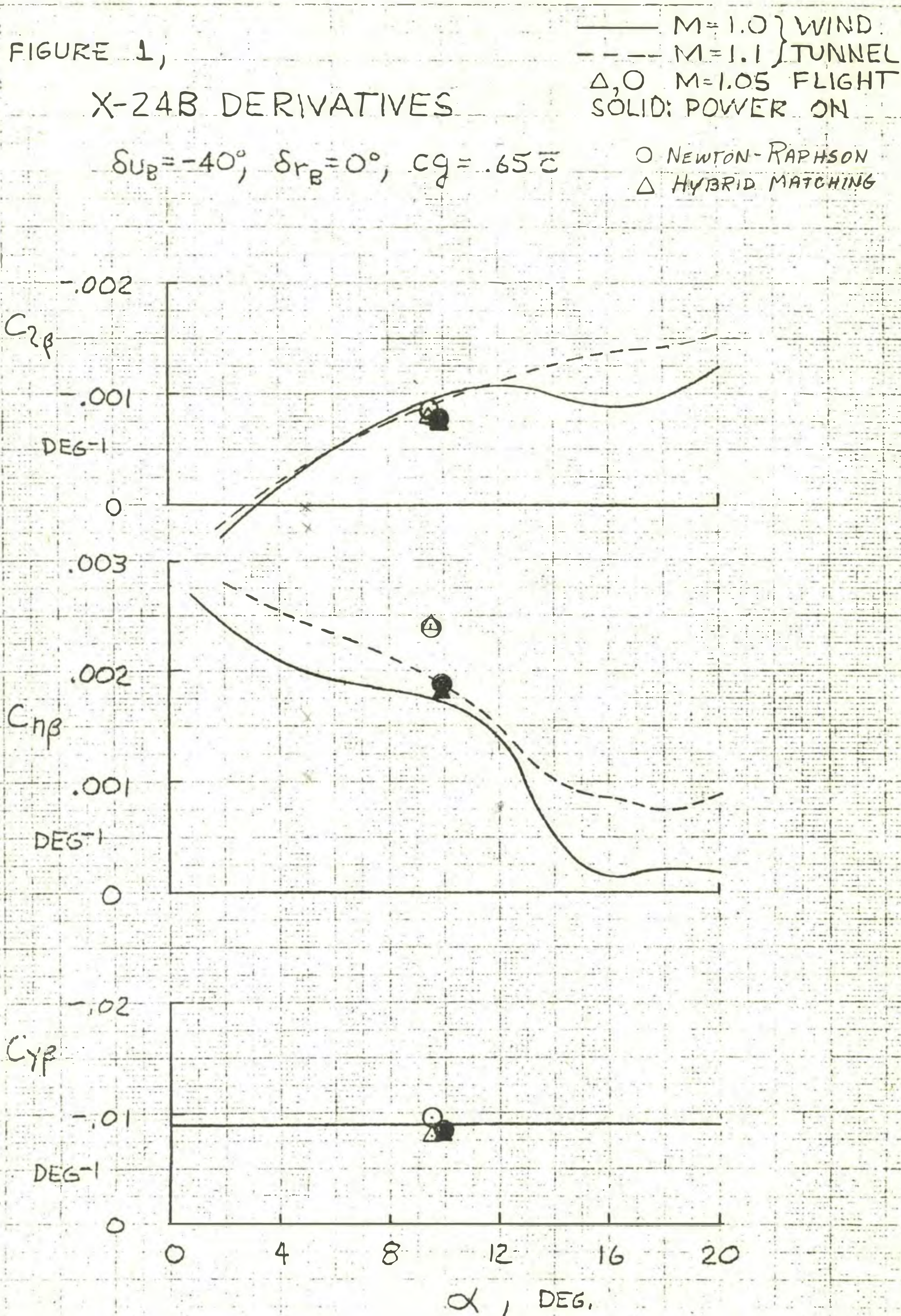


FIGURE 1, CONT.

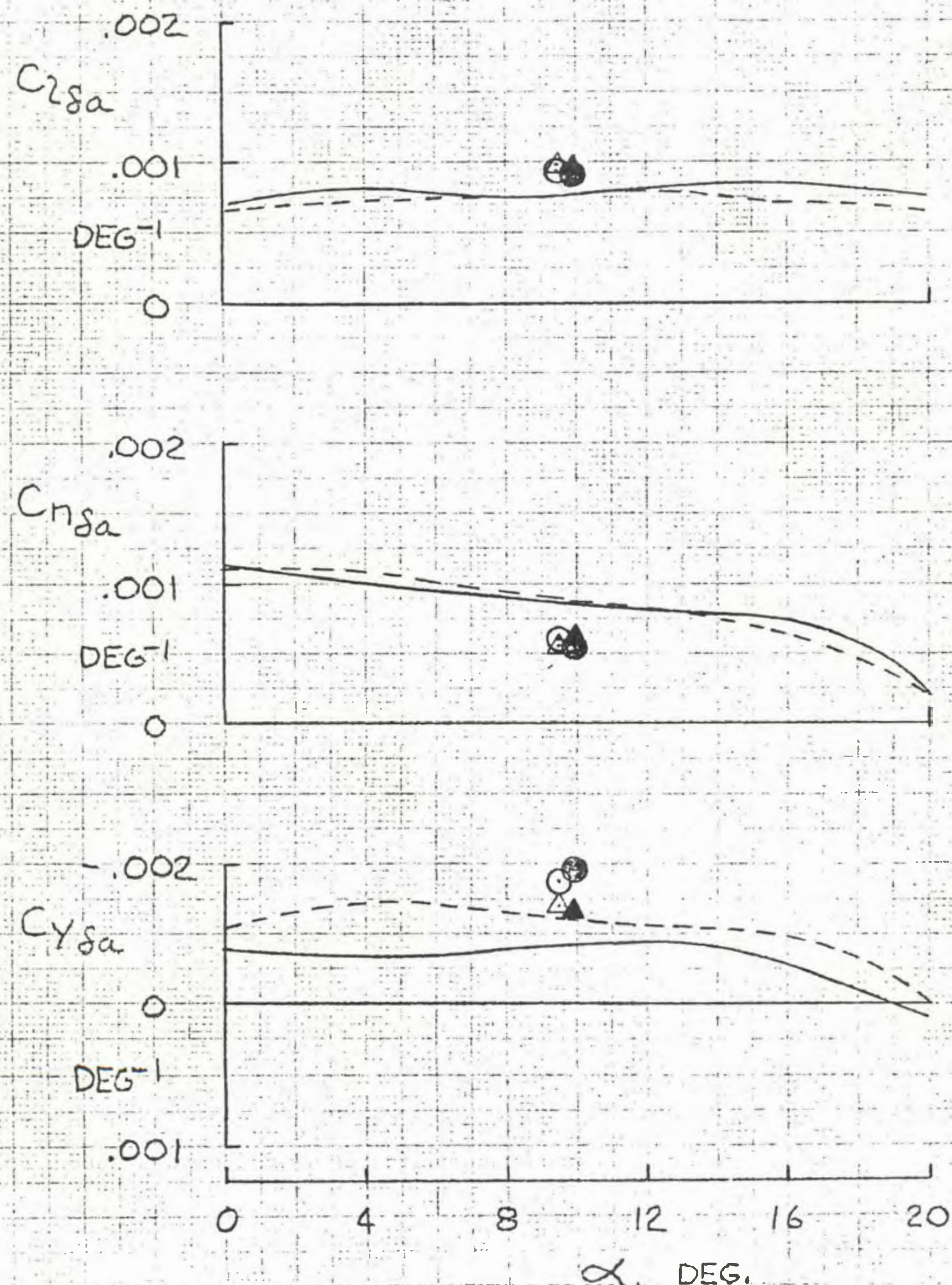
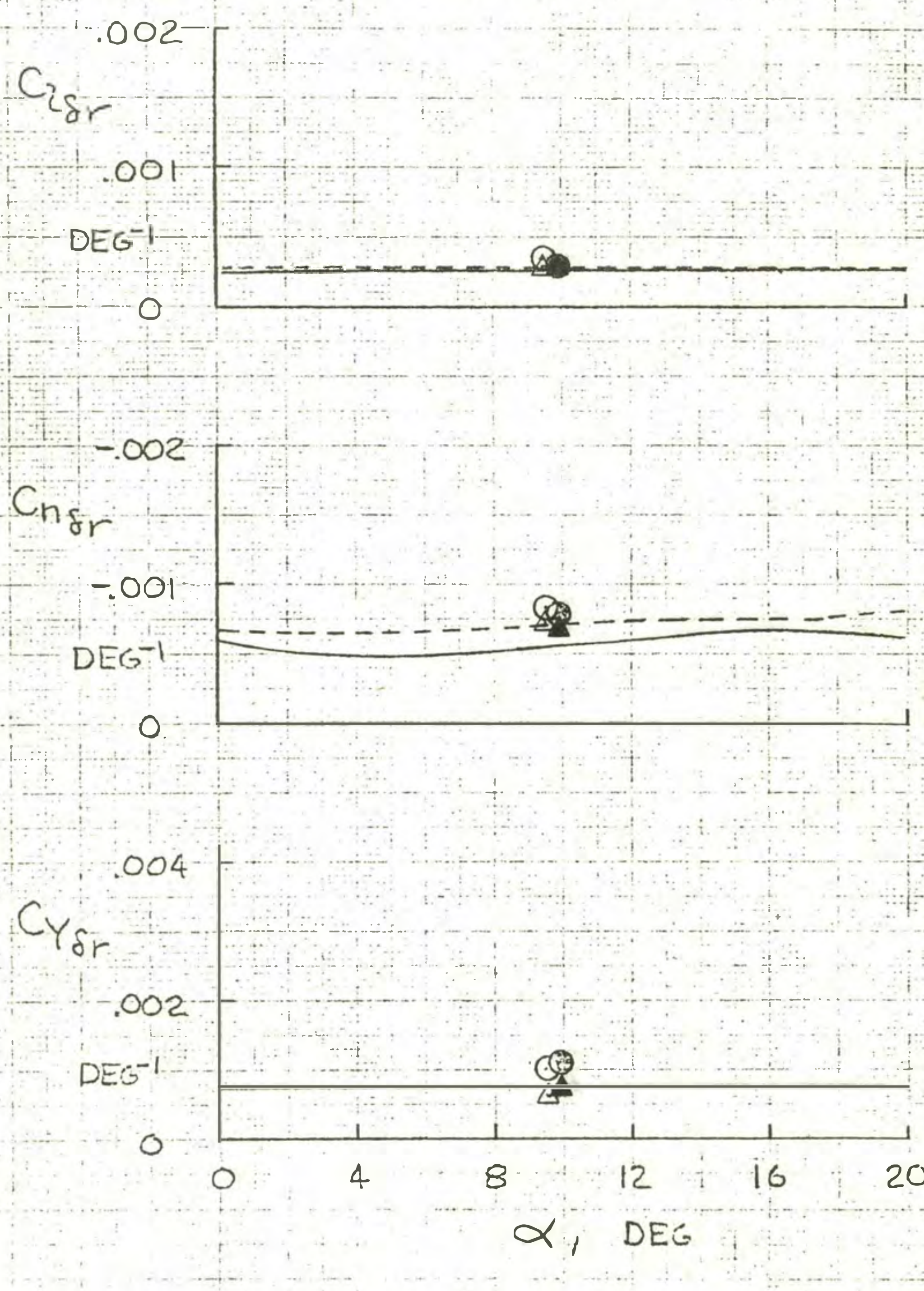
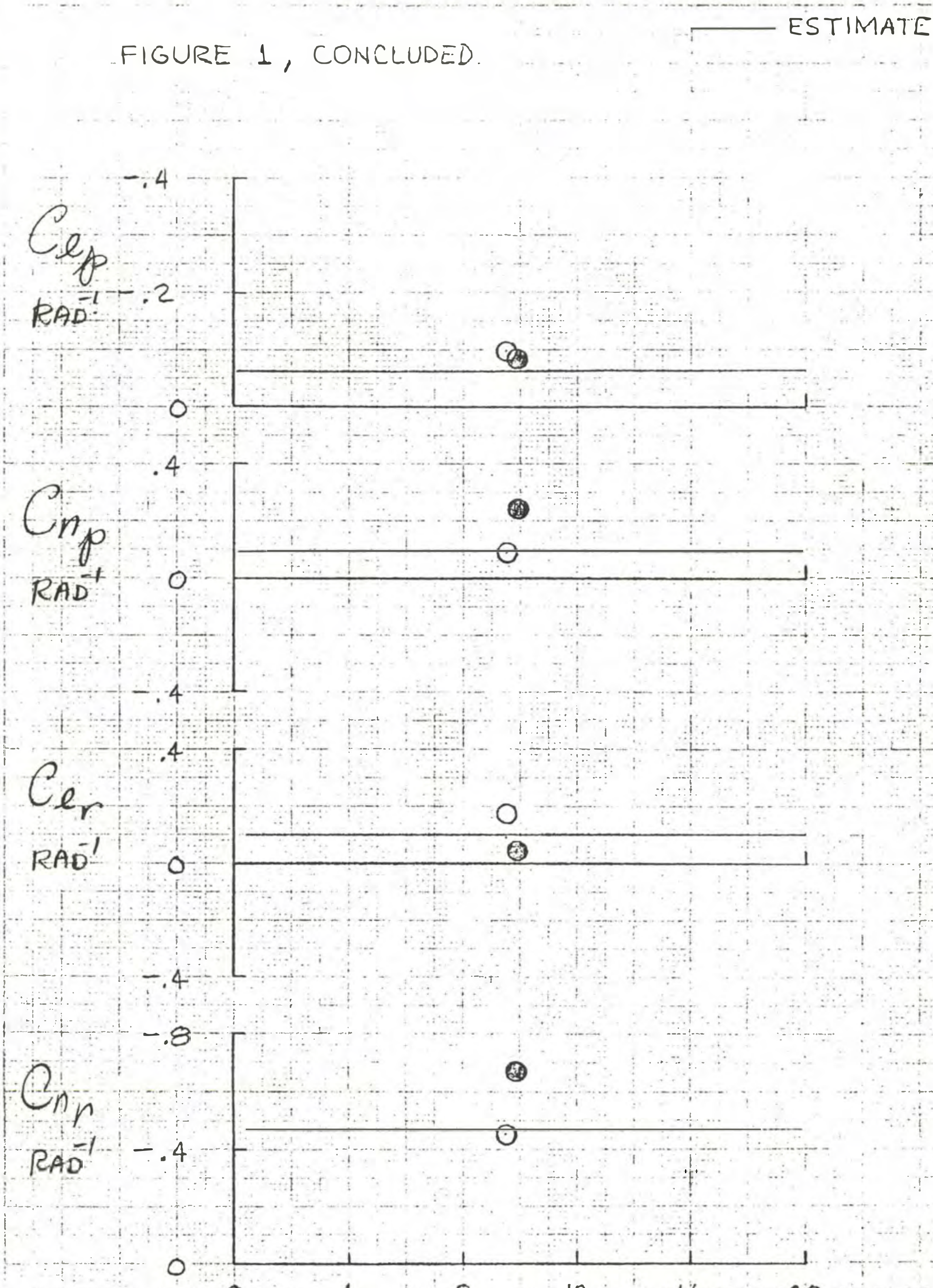


FIGURE 1, CONT.





ESTIMATE
FIGURE 1, CONCLUDED.
Clp
RAD-1
-.4
-.2
0
Cnp
RAD-1
.4
0
-.4
Clr
RAD-1
.4
0
-.4
Cnr
RAD-1
-.8
-.4
0
0
4
8
12
16
20
α, DEG.

Performance and longitudinal Trim
By
D. Richardson

During flight nine, the pilot accomplished two planned pushover-pullup maneuvers in the transonic configuration at 0.9 and 0.76 Mach number. The performance data from these two maneuvers were corrected to the standard c.g. location and are shown in figures 1 to 6. The normal force data compares well with the wind tunnel predicted data, however, the chord force is slightly higher than the wind tunnel data at the higher angles of attack.

Figure 7 is a comparison between the X-24B simulator predicted transonic trim change and the actual transonic trim change. This trim change was accurately predicted by the simulator although the X-24B simulator does trim with one degree less elevator than the flight vehicle. Note that the data in this figure is corrected for the engine misalignment, however, the X-24B simulator does accurately simulate the effect of engine misalignment.

Figures 8 and 9 are the longitudinal trim data from the two pushover-pullup maneuvers. This data is consistent with all previous flight data in that it shows a reduction in static margin when compared with wind tunnel predictions.

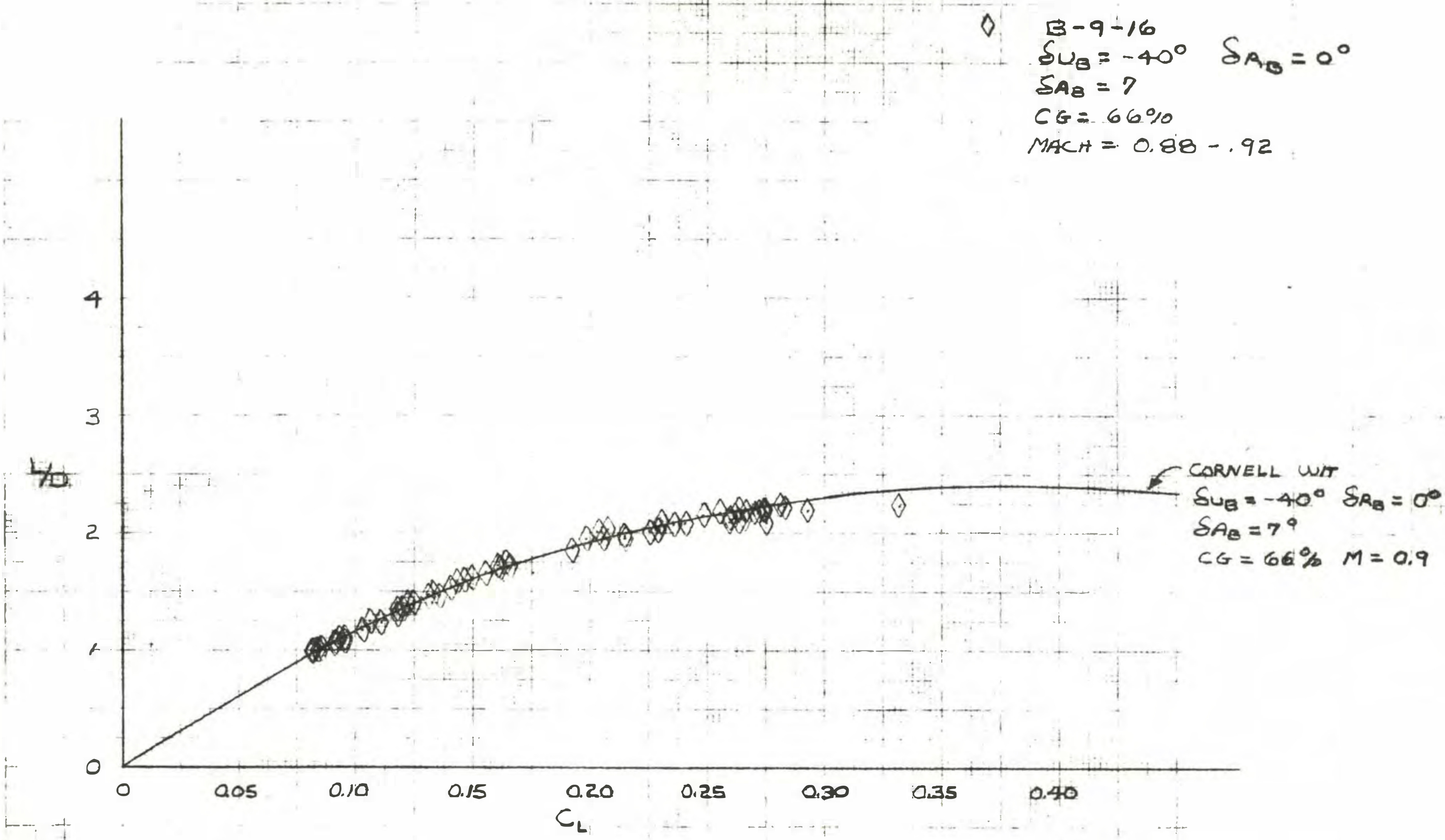
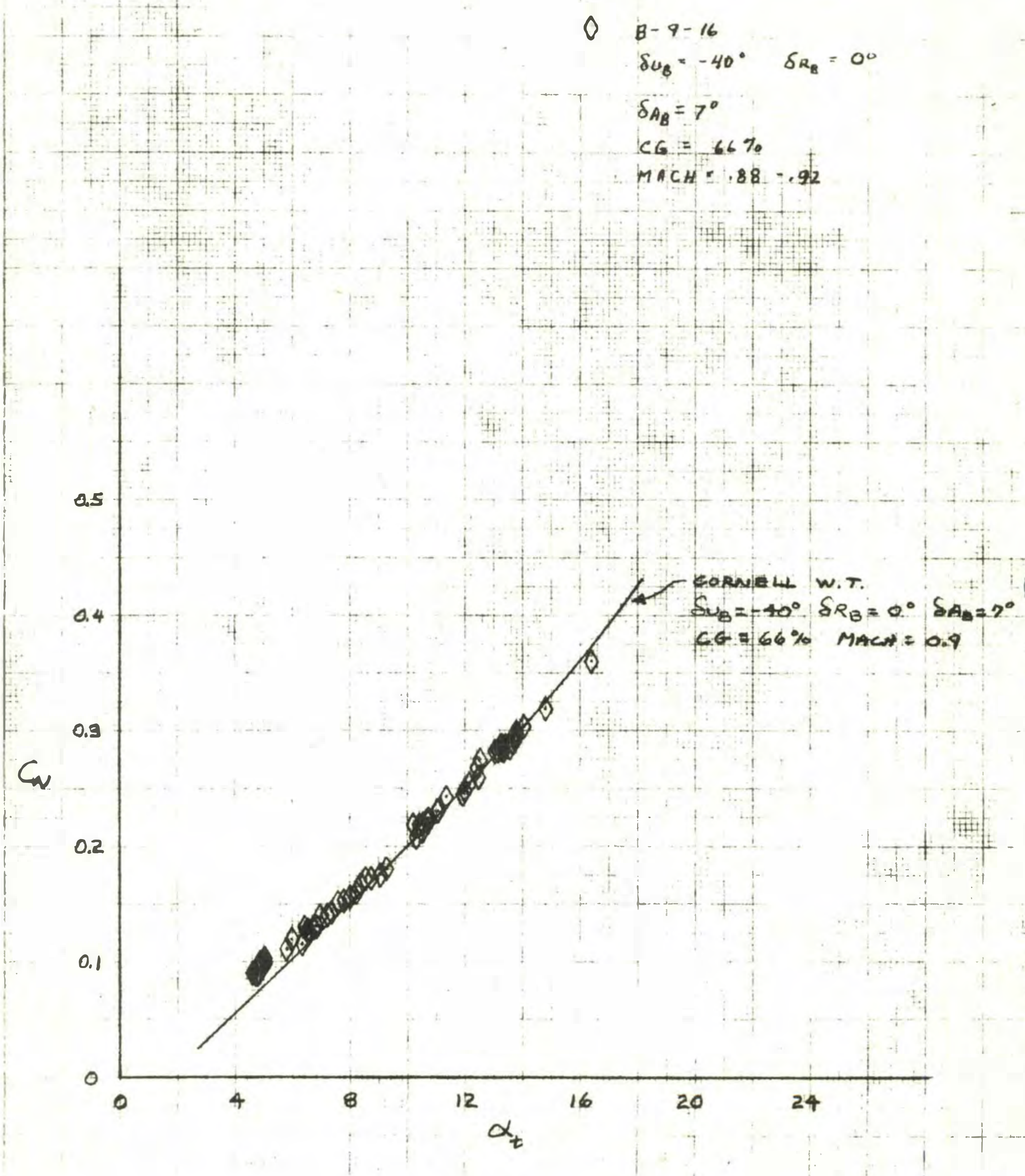
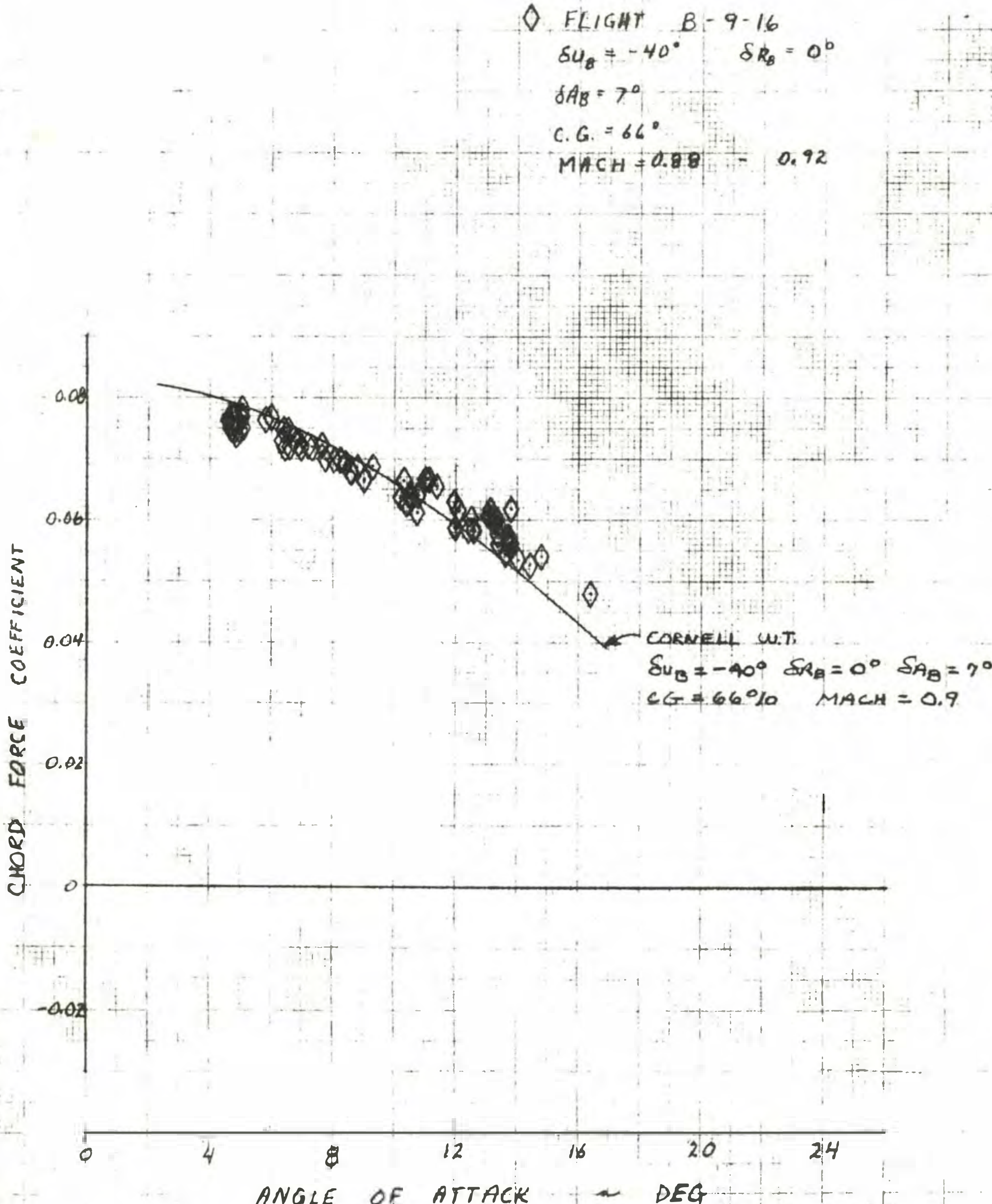

B-9-16
δU_B = -40° δA_B = 0°
δA_B = 7
CG = 66%
MACH = 0.88 - .92
CORNELL WIT
δU_B = -40° δR_B = 0°
δA_B = 7°
CG = 66% M = 0.9
L/D
4
3
2
1
0
0 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40
C_L

FIG 1



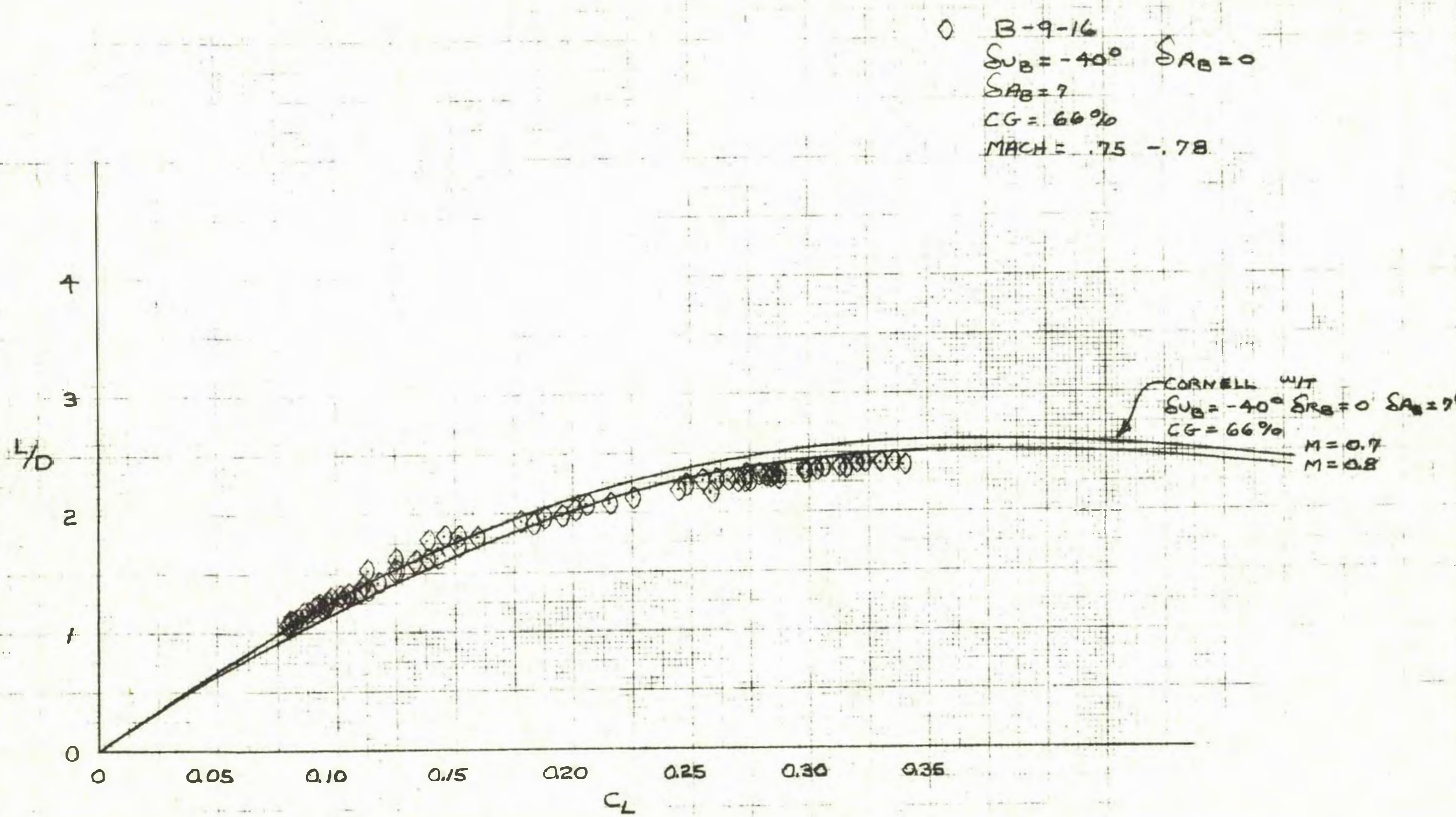
B-9-16
δU_B = -40° δR_B = 0°
δA_B = 7°
CG = 66%
MACH = .88 - .92
CORNELL W.T.
δU_B = -40° δR_B = 0.° δA_B = 7°
CG = 66% MACH = 0.9
0.5
0.4
0.3
0.2
0.1
0
C_N
0
4
8
12
16
20
24
α_t

FIG 2



◇ FLIGHT B-9-16
δU_B = -40° δR_B = 0°
δA_B = 7°
C.G. = 66°
MACH = 0.88 - 0.92
CORNELL W.T.
δU_B = -40° δR_B = 0° δA_B = 7°
CG = 66% MACH = 0.9
CHORD FORCE COEFFICIENT
0.08
0.06
0.04
0.02
0
-0.02
0
4
8
12
16
20
24
ANGLE OF ATTACK ~ DEG

FIG 3



O B-9-16
δUB = -40° δRB = 0
δAB = 7
CG = 66%
MACH = .75 -.78
CORNELL W/T
δUB = -40° δRB = 0 δAB = 7°
CG = 66%
M = 0.7
M = 0.8
L/D
4
3
2
1
0
0
0.05
0.10
0.15
0.20
0.25
0.30
0.35
CL

FIG 4

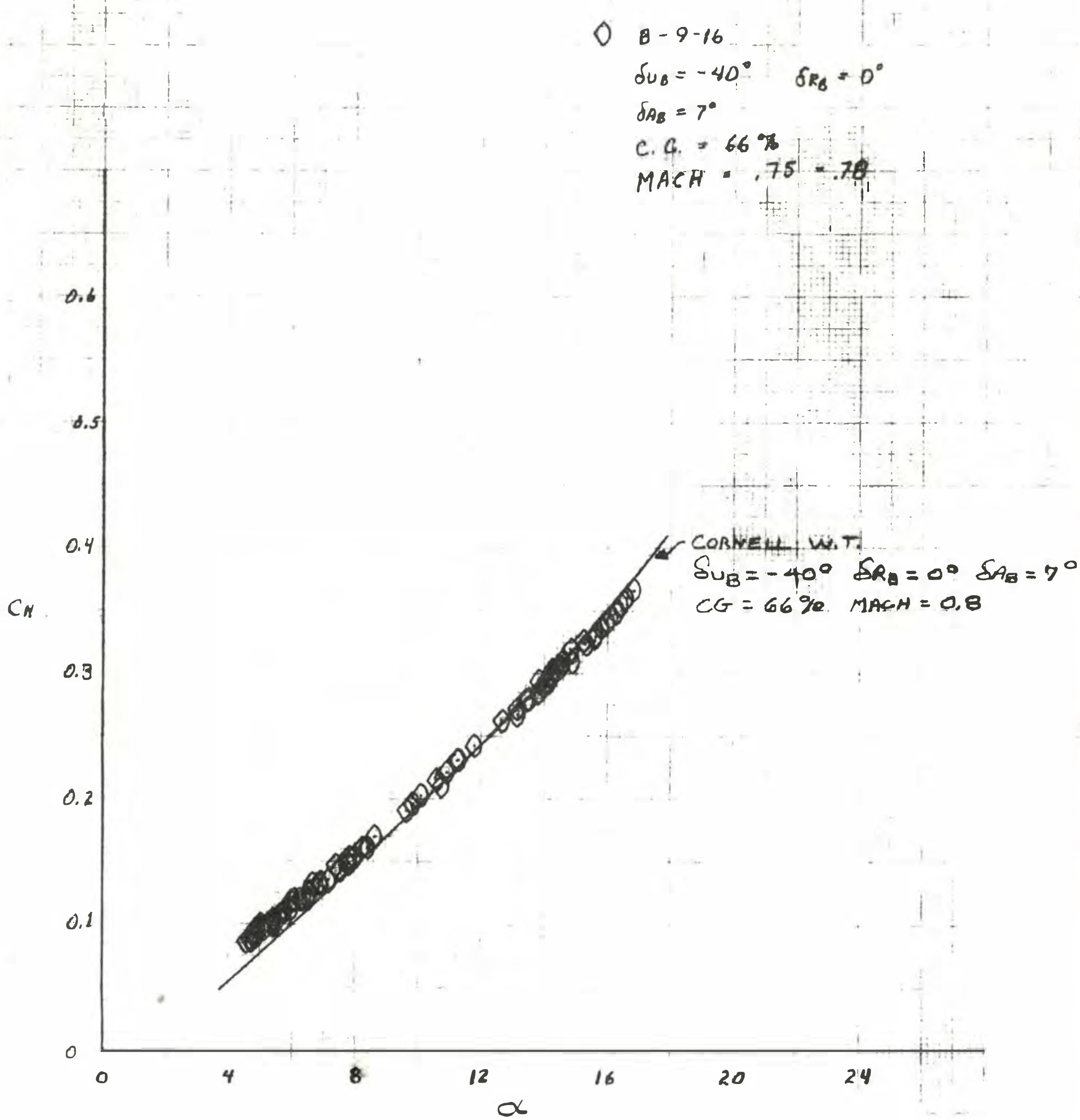
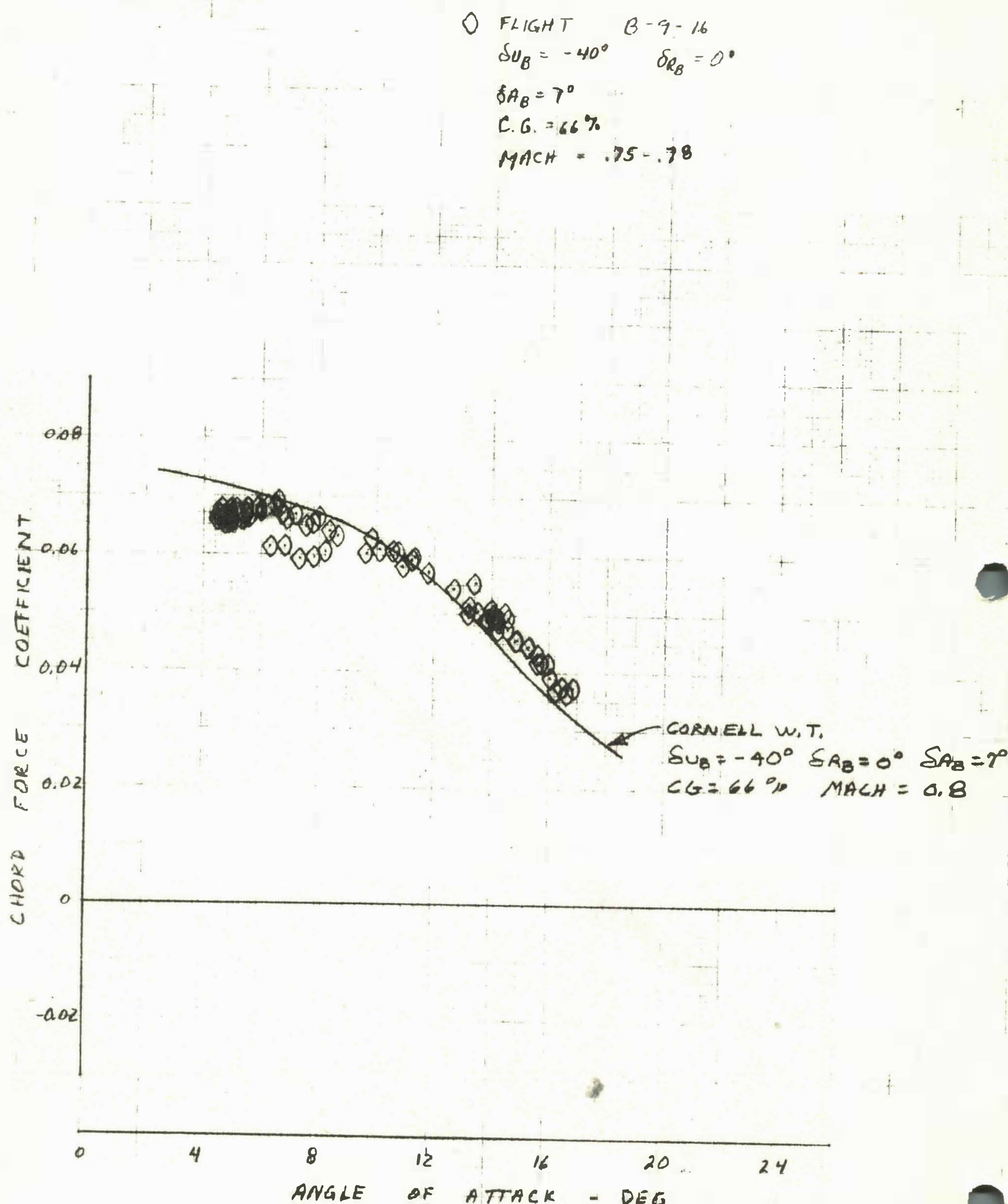
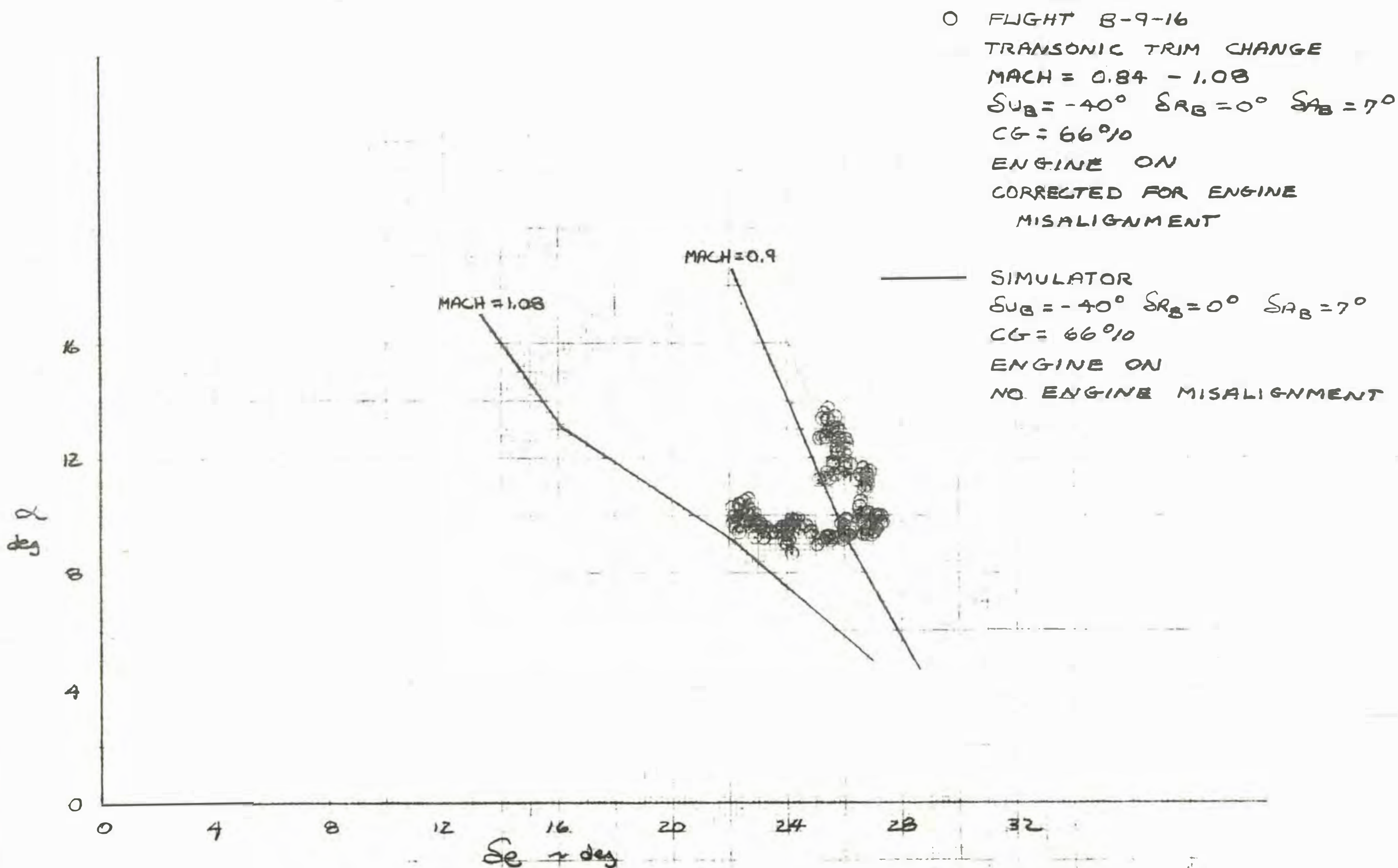

◇ B-9-16
δUB = -40° δRB = 0°
δAB = 7°
C.G. = 66%
MACH = .75 - .78
CORNELL W.T.
δUB = -40° δRB = 0° δAB = 7°
CG = 66% MACH = 0.8
0.6
0.5
0.4
0.3
0.2
0.1
0
CM
0
4
8
12
16
20
24
α

FIG 5



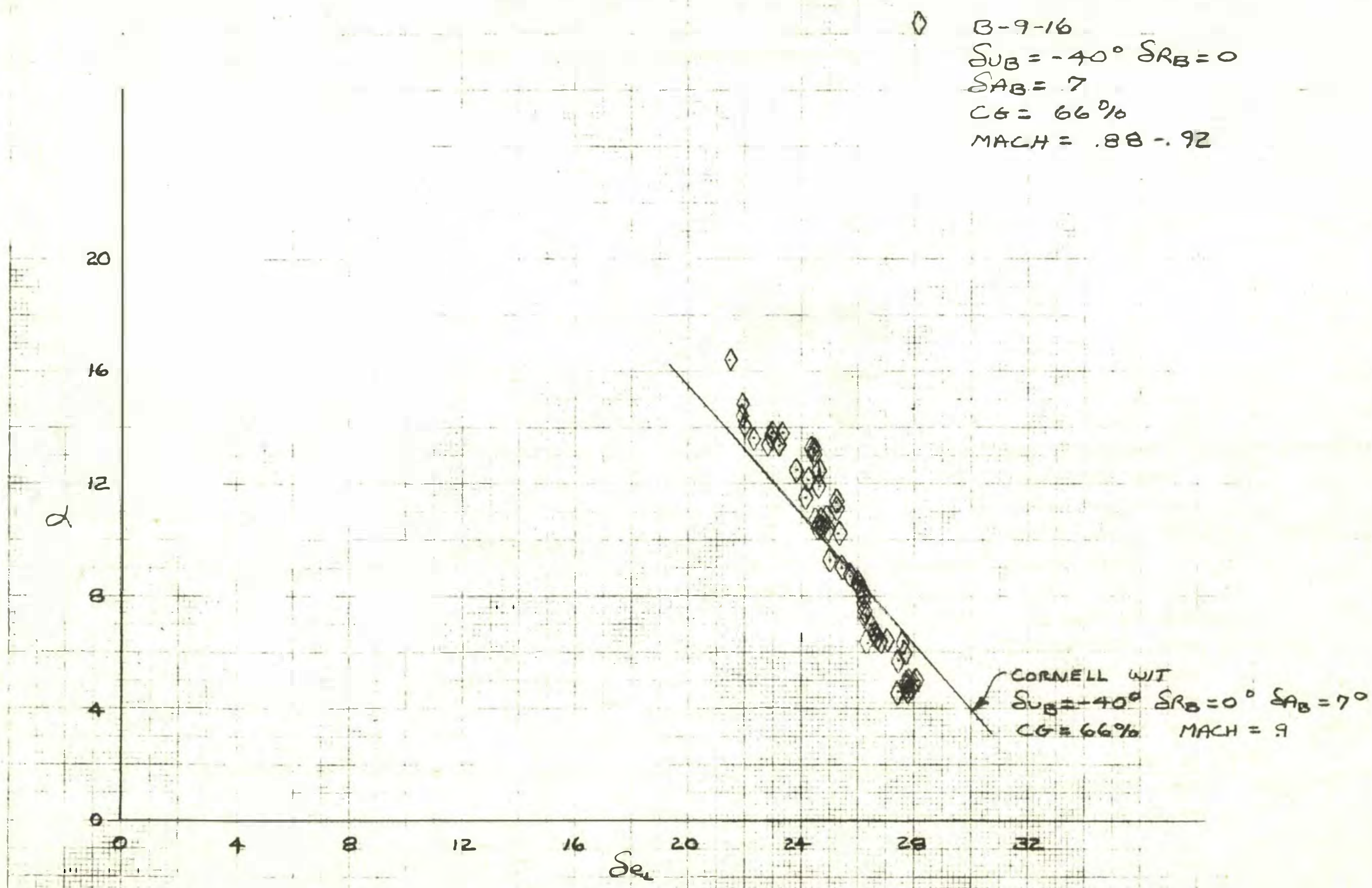
◇ FLIGHT B-9-16
$\delta U_B = -40°$ $\delta R_B = 0°$
$\delta A_B = 7°$
C.G. = 66%
MACH = .75 - .78
CORNELL W.T.
$\delta U_B = -40°$ $\delta R_B = 0°$ $\delta A_B = 7°$
CG = 66% MACH = 0.8
CHORD FORCE COEFFICIENT
0.08
0.06
0.04
0.02
0
-0.02
0
4
8
12
16
20
24
ANGLE OF ATTACK - DEG

FIG 6



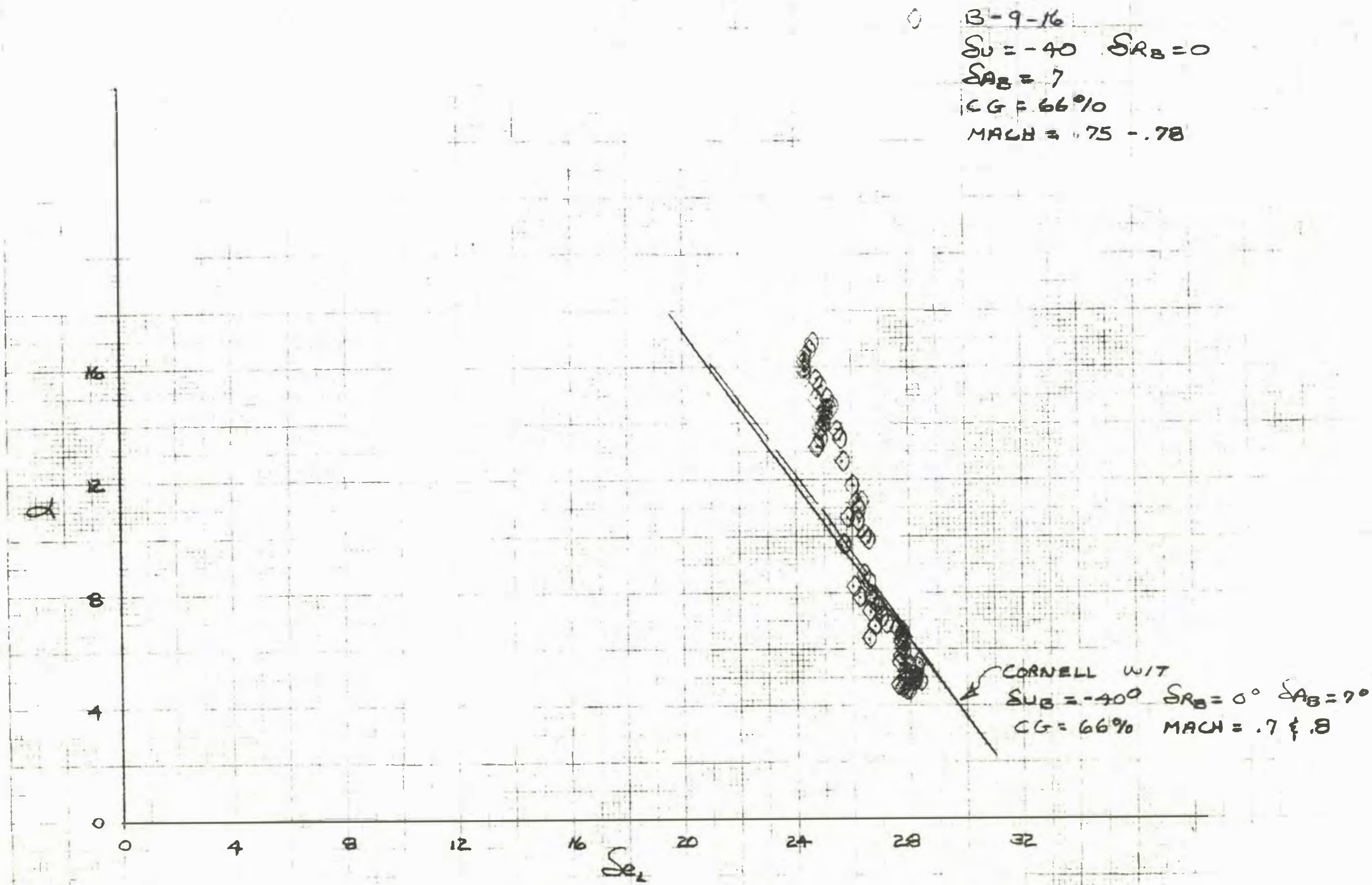
O FLIGHT 8-9-16
TRANSONIC TRIM CHANGE
MACH = 0.84 - 1.08
δUB = -40° δRB = 0° δAB = 7°
CG = 66%
ENGINE ON
CORRECTED FOR ENGINE MISALIGNMENT
SIMULATOR
δUB = -40° δRB = 0° δAB = 7°
CG = 66%
ENGINE ON
NO ENGINE MISALIGNMENT
MACH = 0.9
MACH = 1.08
α deg
δe ~ deg
0
4
8
12
16
20
24
28
32

FIG 7



B-9-16
$\delta_{UB} = -40°$ $\delta_{RB} = 0$
$\delta_{AB} = 7$
CG = 66%
MACH = .88 - .92
CORNELL WIT
$\delta_{UB} = -40°$ $\delta_{RB} = 0°$ $\delta_{AB} = 7°$
CG = 66% MACH = .9
α
20
16
12
8
4
0
0
4
8
12
16
20
24
28
32
δ_{e_L}

FIG 8



B-9-16
δU = -40 δRB = 0
δAB = 7
CG = 66%
MACH = .75 - .78
CORNELL W/T
δUB = -40° δRB = 0° δAB = 7°
CG = 66% MACH = .7 & .8
α
16
12
8
4
0
0
4
8
12
16
20
24
28
32
δeL

FIG 9

Outboard Fin Pressure Anomalies

By

D. Richardson

Two pressure orifices were installed on the inboard surface of the righthand fin prior to flight nine in order to aid with the continuing study of the fin pressure anomalies. These orifices are in the same location as lefthand fin orifices 48 and 72.

It was interesting to note that the abrupt pressure changes were often asymmetric in nature. Also, in many cases the righthand fin pressures lagged behind the lefthand fin pressures. The rudder hinge moments, as measured by strain gages, responded to these pressure changes as would be expected.

A plot of the angle of attack and Mach number conditions where these abrupt pressure changes occured is consistent with previous flight data (figure 1). It was observed that above a Mach number of 0.9 to 0.92 the fin pressures were steady. It is believed that this signifies that the air flow over the fins has gone supersonic.

These are the conditions at which an instantaneous change in pressure occured at several orifices on the inboard sides of the fins.

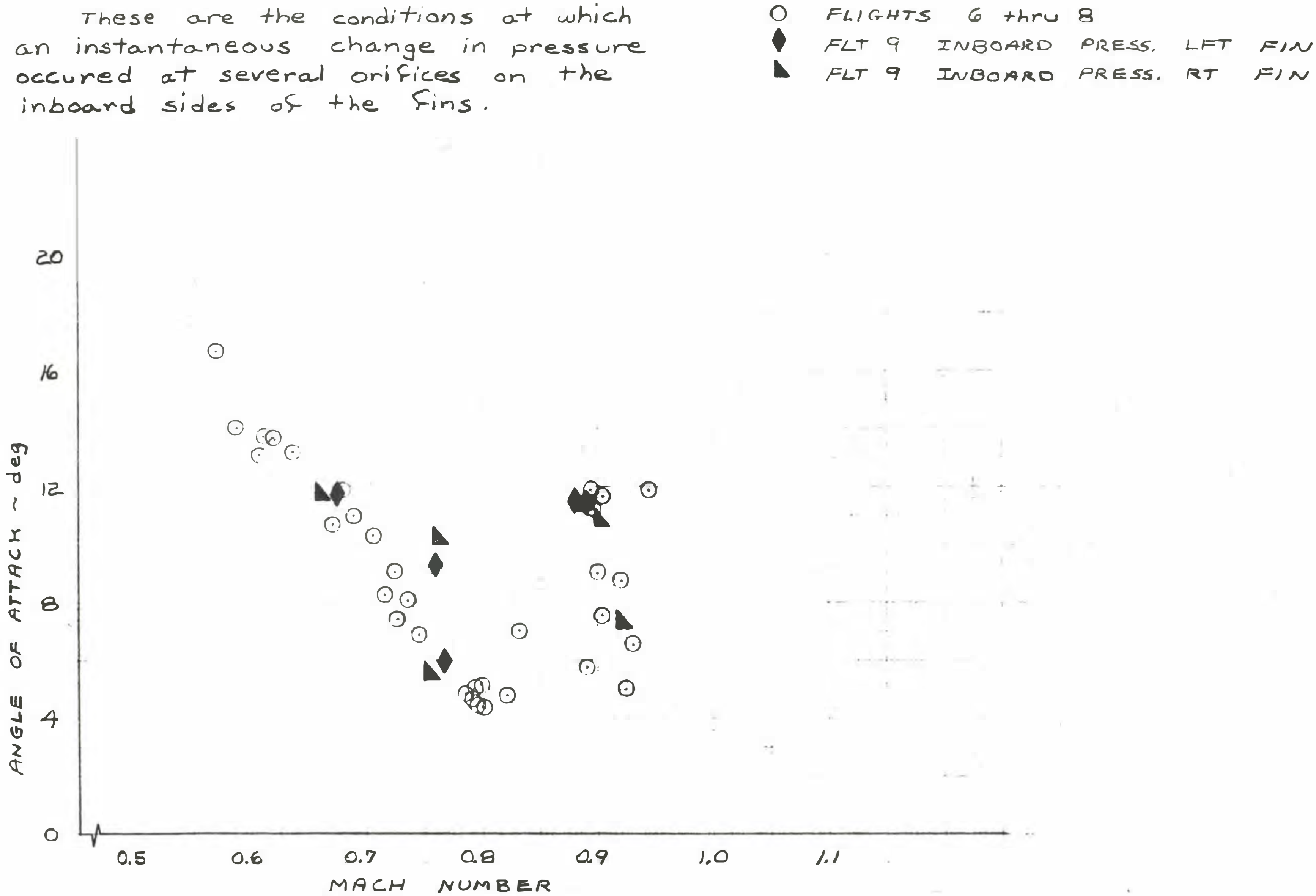


FIG 1

Flight B-9-16 Sideslip/Wind Investigation

By

Dennis J. Penka, Captain

The investigation of wind induced sideslip excursions begun as a result of Flight B-7-14 was continued to include Flight B-9-16. Once again, Sidewind vs Altitude Profiles were computed based on flight measured parameters and compared with the same profile computed from weather station winds. Results were similar to those obtained for other flights-computed ascent and descent profiles compared well, showing several abrupt wind shifts with altitude, while correlation with weather station winds was poor (figure 1). Again, the wind profile obtained by weather balloon showed none of the abrupt wind changes found in the computed profiles.

In an attempt to obtain another wind profile by independent means, the contrail left by the vehicle during the powered boost was filmed by a fixed ground based camera. The wind profile extracted by this method showed abrupt changes with altitude and compared remarkably well with the computed wind profiles (figures 2).

The weather station wind profiles used are normally obtained with the Rawinsonde GMD-5 system. The wind values obtained are mean values over some altitude increment and it is felt that this system may not be sufficiently sensitive to discern the wind changes shown in the computed wind profiles. In an effort to obtain a more accurate wind profile, a Jim sphere balloon tracked by FPS-16 Radar is planned for the next flight. This system is said to be capable of determining the mean wind value in an altitude increment of 25-150 meters to within ± 1.5 kts.

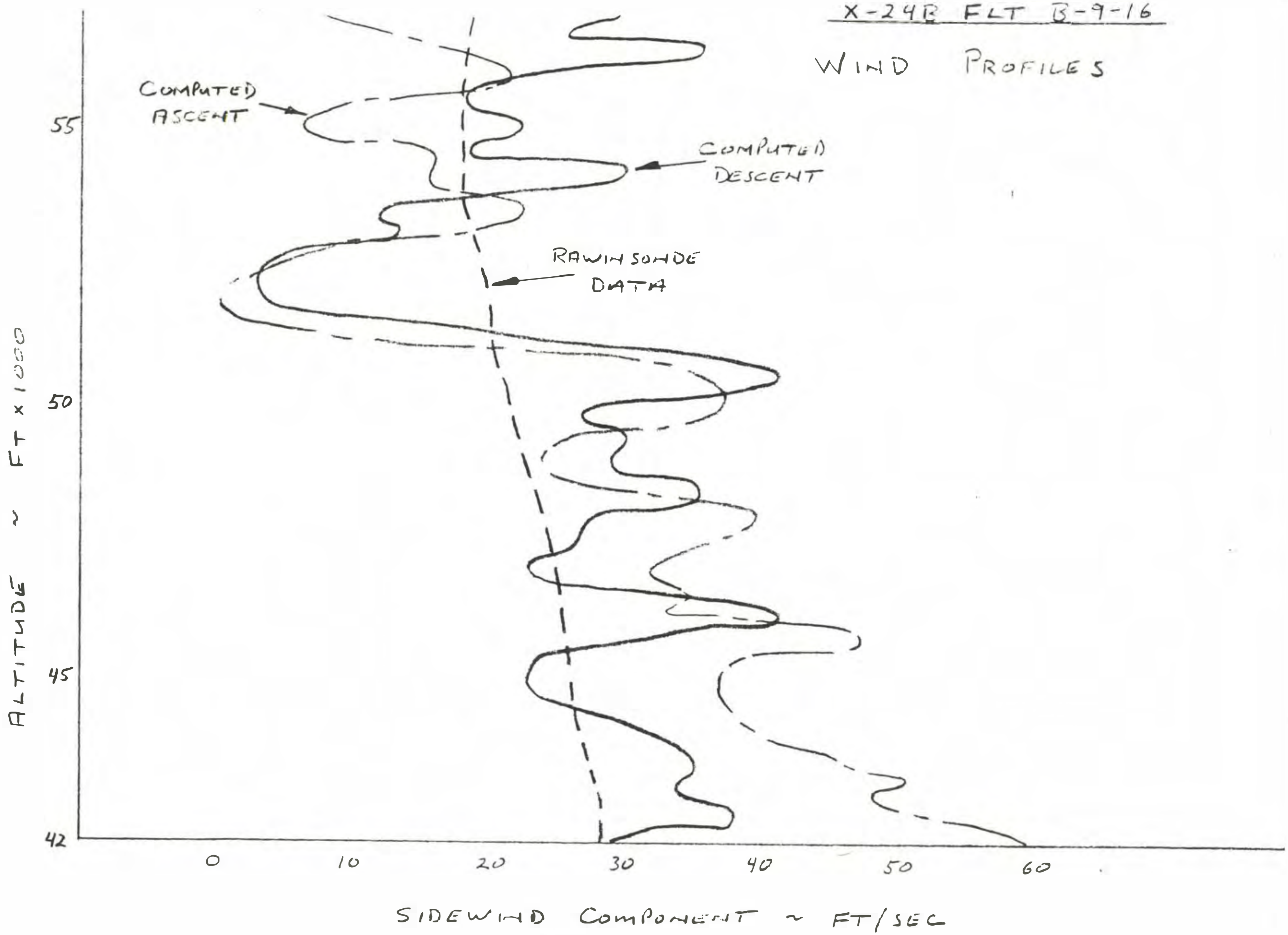

X-24B FLT B-9-16
WIND PROFILES
COMPUTED ASCENT
COMPUTED DESCENT
RAWINSONDE DATA
ALTITUDE ~ FT x 1000
55
50
45
42
0
10
20
30
40
50
60
SIDEWIND COMPONENT ~ FT/SEC

FIG 1

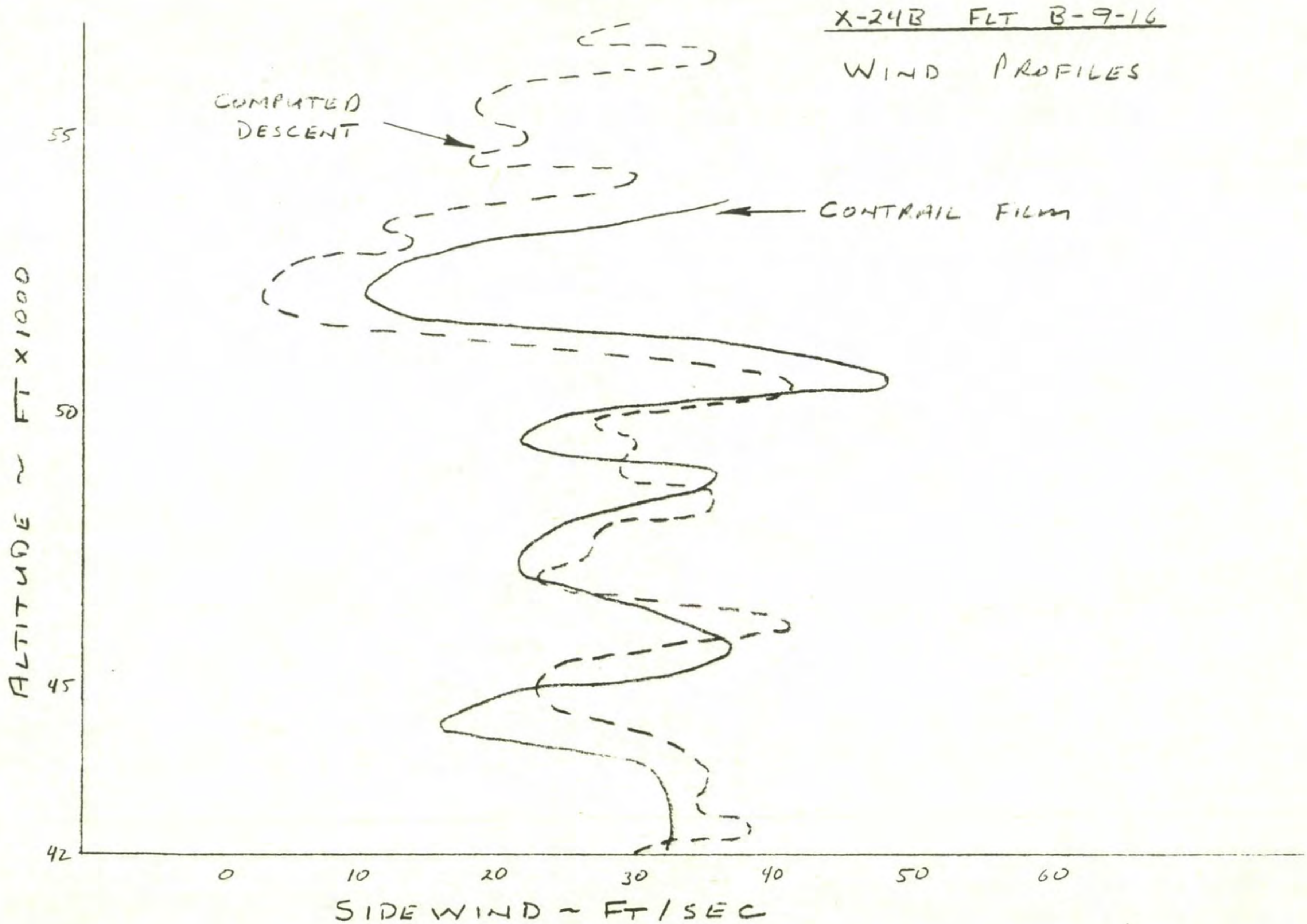

X-24B FLT B-9-16
WIND PROFILES
COMPUTED DESCENT
CONTRAIL FILM
ALTITUDE ~ FT x 1000
55
50
45
42
0
10
20
30
40
50
60
SIDEWIND ~ FT/SEC

FIG 2

HANDLING QUALITIES COMMENTS

BY

Johnny Armstrong

This flight was the first powered flight that included a four chamber rotation from 45,000 feet. The maximum Mach number during the rotation was as predicted - .87 Mach number. The handling qualities during the rotation ($\alpha=15^{o}$) were considered to be good, receiving pilot ratings of 3.5 in pitch and 2 to 2.5 in roll/yaw. The left hand lower rudder hinge moment did indicate a brief period of buffet (flow change) near peak $\bar{q}$, however, the magnitude was not sufficient to be felt by the pilot. The simulator was programed to include the lateral offset cg to the left of approximately three-quarters of an inch - causing the vehicle to have an annoying left rolling moment and a slight nose right side slip. Previous flight records indicated that the vehicle tended to fly in about a one degree nose right side slip. For this flight a 1^{o} left rudder trim was set in for launch to reduce this steady side slip. In addition the pilot developed a technique in the simulator to use his left hand to counter the left roll tendency and thereby allowing him to use his right hand primarily to control the pitch axis. This technique was utilized during the flight and was, the pilot felt, beneficial in improving his ability to maintain precise control during the rotation.

At approximately .9 Mach number on the previous powered flight (B-7-14) the pilot observed a side slip anomaly of 2 to 3 degrees that caused him to be concerned with the static stability of the vehicle and resulted in a pilot rating of 6. Post flight analysis of the maneuver indicated that the stability was still positive although degraded from power off predictions. On flight nine a similiar side slip anomaly occurred of lower amplitude and shorter duration. This occurrence was observed by the pilot, however, it did not concern him as much as it had on flight 7. A pilot rating of 3.5 was given for the lateral-directional axis for this flight condition. However, it is interesting to note that both side slip anomalies occurred at near identical conditions of Mach number and α as shown in the accompanying table. At the start of both conditions, surface pressures on the left and right (only 2 pressures) indicated an unsteady flow condition giving rise to the thought that asymmetric vortex impingment on the fins may be the source of the forcing function that causes this anomaly.

The longitudinal trim change between .9 and 1.1 Mach number was close to that predicted by the simulator using the wind tunnel data. The pilot had no difficulty maintaining the desired α during the trim change. The handling qualities above Mach 1.0 were quite obviously better than that observed in the .9 area. The pilot rated the handling qualities in both pitch and lateral-directional at 2.5

FLIGHT 7

TIME OF DAY	M	α	β	EVENT
11:17:00.0	.884	11.5	0	β starts out (nose right)
11:17:02.7	.890	12.5	-1.0	Divergence rate increases
11:17:04.0	.896	12.7	-2.0	β stops moving out
11:17:04.8	.900	12.4	-2.0	β starts back
11:17:05.4	.903	12.8	-1.8	Pilot put in recovery rudder
11:17:06.6	.910	12.4	0	β thru zero & over shoots (nose left)

FLIGHT 9

11:47:20.5	.892	12	- .6	β starts out (nose right)
11:47:21.8	.895	10.2	-2.6	β stops moving out
11:47:22.4	.903	9.6	-2.8	β starts back
11:47:26.2	.929	9.7	- .4	β back at starting value

FLT. B-9-16

HANDLING QUALITIES SUMMARY

PITCH AXIS HANDLING QUALITIES DURING ROTATION	3.5
ROLL AND YAW AXES HANDLING QUALITIES DURING ROTATION	2.0 TO 2.5
TASK TO MAINTAIN 30° θ DURING BOOST	3.0 TO 3.5
PITCH AXIS HANDLING QUALITIES ABOVE .9 MACH WITH POWER ON	2.5 TO 3.0
ROLL AND YAW AXES HANDLING QUALITIES ABOVE .9 MACH WITH POWER ON	3.5
HANDLING QUALITIES ABOVE 1.0 MACH WITH POWER ON (ALL AXES)	2.5
PITCH AXIS HANDLING QUALITIES DECERATING FROM 1.1 TO .9 MACH (POWER OFF)	2.5

Flight B-9-16   Technical Debriefing

PILOT: John Manke

1. Describe the launch transient (190KIAS)

Answer:

We actually launched at 184 kts (due to B-52 Performance) and it was very mild transient, I didn't notice any difference between this and the last flight. It looked like the airplane would have trimmed at 10° α, I was really pleased with our launch trim setting.

2. Discuss the engine light sequence and any associated trim changes.

Answer:

Light sequence was to get chambers 2 and 4 first, and once I got the orange lights to come on, then 1 and 3. I hit the switches just as quickly after I hit the launch switch as I could. I went from launch switch right on down and I'm a little more careful now because we've got the over ride switch down there also, so I look down to make sure I have the correct switch before I throw it, so I'm probably losing a good second. The one thing I did notice was I could hear the pumps start up and I could feel the engines starting, and before it got up to full speed, I felt three distinct chugs in the longitudinal axis in the engines, three distinct changes in longitudinal "g". This all occurred right before the lights came on, so maybe the last one occurred after they came on and then I hit the other two switches and the second two chambers seemed to come up normally. They came up very quickly and it was a good light from that point on.

3. Discuss the handling qualities during the rotation. Rate pitch, roll and yaw.

Answer:

I didn't notice any specific trim changes during the light but it's very much like the simulator, once you come up to 10 and hold it and then hit the chambers the airplane tends to increase in α, pretty much by itself. It doesn't take much back stick to get it on up to 15, and a guy has to watch it closely because each time you get up towards 15 you have to definitely stop it there and put in some forward stick to stop it. Then start trimming around 15 to find out where its going to be comfortable.

I like the airplane more this time because we had put in the extra half degree of rudder trim. I looked down at sideslip and I can't tell you what the number was but after seeing it I was satisfied it wasn't going to be a problem.

I went to the two-hand technique on the stick, I put my left thumb on the stick to put just a little right aileron in to keep the wings level and I used my right hand for just pitch control alone. I was able to trim the airplane back and I was satisfied that I was flying between 14° and 15° alpha. Alpha bobbed a little bit between 14° and 15° but I felt very pleased with the alpha control in this portion of the flight. It still isn't real solid, you can't just come up and lock it in on a given α, I felt that using the two-hand technique and not having to worry about Beta, I controlled it as well as it could be controlled.

I rate the pitch in this area of rotation at 3 1/2 and the roll and yaw, I didn't have to pay much attention to these two axis, so I guess from that fact I'd rate them from 2 to 2 1/2.

4. (a) Discuss the task to maintain 30° θ and rate.
(b) How did α to maintain θ compare with the simulator?

ANSWER:

(a) It requires a bit of attention to hold a very constant θ. I did let θ drag a little and, because of the high calls I got, I didn't worry about getting it back right after 30° θ. But if a guy was to fly a good solid θ task and not have to make heading changes and things like that it would still present a bit of a task because we are still getting trim changes. Since we changed Mach number in this area, I'd rate that at 3 to 3 1/2.

(b) I thought that it was about one degree less in the airplane than in the simulator.

5. Discuss the handling qualities above .9 Mach Number with power on. Rate.

Answer:

This is the area that we were concerned with last time. On this flight it seemed less troublesome, only one time did I see Beta start out to the left. It caught my attention but before I could do anything it started back towards the center again.

So from that stand point not being worried about it, it was a lot better than the last time. I think that if we fly it through here a few times, our confidence will go to the point whereas we won't worry about it. Bear in mind that we went through here faster this time than before so I spent less time looking at it. Limit handling quality to this rating as lateral-directional at 3 1/2. At this time I was 10° alpha and I found no difficulty in holding the airplane at 10° alpha, I'm going to rate this at 2 1/2 to 3 in pitch.

6. (a) Discuss the handling qualities above 1.0 Mach Number with power on. Rate.
(b) Compare the vehicles response to the doublet set with the simulator.

Answer:

(a) The airplane has better handling qualities above Mach 1 than it does in the area of .9 to 1.0 area. You can tell the defference in control sensitivity, sensitivity decreases both in pitch and in roll. In this area I rate these at 2 1/2 - that's pitch and lateral-directional.

(b) As I mentioned in the other debriefing I thought that the airplane was just a little bit better damped than the simulator. I can't pick out the damping very well on an aileron pulse, because I don't get enough airplane motion on aileron pulse to be able to tell but on rudder pulse it seemed like the airplane was better damped than the simulator; response wise they are about the same.

7. (a) Discuss the performance aspects of the boost.
(b) Describe the Mach jump and engine shutdown sequence.

Answer:

(a) Most of my key parameters during the boost occurred two to three seconds early so I got the impression we had a little more thrust than we'd planned on the simulator. Also I was lead to believe so with Mikes' calls indicating that I was high all the way along. But my pushover and my time to θ, I had a 60 second check and they all came on about two to three seconds early. Shut down occurred about six seconds early.

7. (b) I didn't see the Mach [redacted] jump on the Mach meter but I did see the Mach jump on the altimeter. I would think that the simulation that Dennis has, is very close to what I saw on the airplane.

Chamber number one came off about 1.05 Mach Number and the rest of them were shutdown about 1.1 with the engine master switch.

8. Comment on the handling qualities after shutdown, decelerating from 1.1 Mach to .92. If possible rate.

Answer:

I found no problem at all holding 10° alpha in this area. At shutdown I did feel the deceleration. It pushed me up into the straps a little and I probably bobbed the nose just a bit. I did the rudder doublet and the aileron pulse as rapidly as I could, so there's no qualitative data here, it was strictly a mechanical maneuver.

From that stand point I can't really evaluate or rate the lateral-directional data but I would give the pitch a rating of about 2 1/2. There seemed to be less of a trim change in the airplane than in the simulator.

9. Discuss the longitudinal trim change between 1.1 and .9 Mach number.

Answer:

Longitudinal trim change between 1.1 and .9 Mach Number, there was absolutely no problem in holding 10° Alpha and the trim change appears to be less in the airplane than in the simulator.

10. Discuss the push-over-pullup maneuvers at .9 and .8 Mach Number.

Answer:

They went like I hoped and planned they would but the difference was I had to wait a bit longer than we did in the simulator to decelerate to these particular Mach Numbers. I went from one degree and sometimes two degrees higher than planned during this deceleration period. To speed up the deceleration from the maneuver itself they both went down to 5° alpha and I held 5° alpha until the Mach Number stabilized. I pulled back up to 17 and through the stick shaker to 17 then back down to 10 then on up to some alpha. As I mentioned before it was 14° between .9 and .8 and about 13° after .8 so they were "super maneuvers."

11. Comment on steady flight between .75 and .7 Mach number. Did you note any changes in the vehicle.

Answer:

I felt that I held the airplane steady between .75 and .7. I held a little right aileron with my left thumb and the right hand was essentially off the stick.

I thought I was holding 11° alpha as indicated in the cockpit but the data shows I was holding 12° alpha. I didn't note any changes in the vehicle.

I did notice a little bit of roll change somewhere in this time period. I had the airplane pretty well steady on 0° bank angle and half way through it started rolling a bit to the left.

12. Describe the α control during the rudder bias sweep maneuver.

Answer:

My alpha varied a bit during the maneuver. It went from 10° alpha up to 11° alpha but as I brought the rudder back I think it got back down to 10° alpha and I held it probably within 1/4 to 1/2 degree as I swept the rudder back to 0° bank angle, so that's probably the best portion to analyze.

13. Describe the flight from highway 58 to low key.

Answer:

It was just the way as planned in the simulator. I don't remember when I reconfigured, I guess somewhere in the turn or maybe shortly after the turn. We went into jettison and after jettison I looked up to get my position. It looked like I was where I wanted to be and it was a routine flight from that point on.

14. Discuss the pattern.

Answer:

The pattern was the best pattern I've flown, I thought that if there had not been a change in wind at low altitudes I wouldn't have had to use the speed brakes at all, it was a perfect pattern.

I had it wired and flew the longest time at 300 knots, right on that slope. My aim point didn't change one foot. Then as it happened this morning on my F-104 flight we got down to around 8,000 feet the airplane started to hump over. It looked like I had a little bit of a tail wind. Rather than run the F-104 up on their gear speed (the F-104 has a 300 knots limit), I came out with a little bit of speed brake at that altitude and held my aim point.

The speed got up to 305 knots and right before the flare I pulled the brakes in and flared, it was a great pattern.

15. Discuss the landing and roll out.

Answer:

Landing was pretty routine. I tried to look down at my airspeed but as I tried I felt the airplane settle a bit and I honked back on the stick. I got a little bit of a balloon and I would guess my touch down vertical velocity was in the neighborhood of 3 to 4 instead of 1 to 2. This may account for the nose down (pitch at touchdown).

On the roll out it was rolling as straight as a string at about 150, I think, at 140 I armed the nose gear steering and started using those gear steering from about 130 on down, I felt at these high speeds I wouldn't want it much more sensitive because as I put some in and it started it going I could feel the airplane rock. It rocks as a tricycle with a high "cg" and when you put a little steering in, it'll rock one way or the other. It was no problem, I could have gone from one side of the runway to the other easily.

At least at these higher speeds our gearing is just fine. As you get a little slower you could handle some more but I don't think its going to cause any trouble. I think we're going to have superb control of the craft on the runway. We aren't going to be able to do a 180 on the runway or anything like that but we won't be able to turn off the runway.

But its adequate for at least this zero crosswind type landing.

APPROACH & LANDING

by

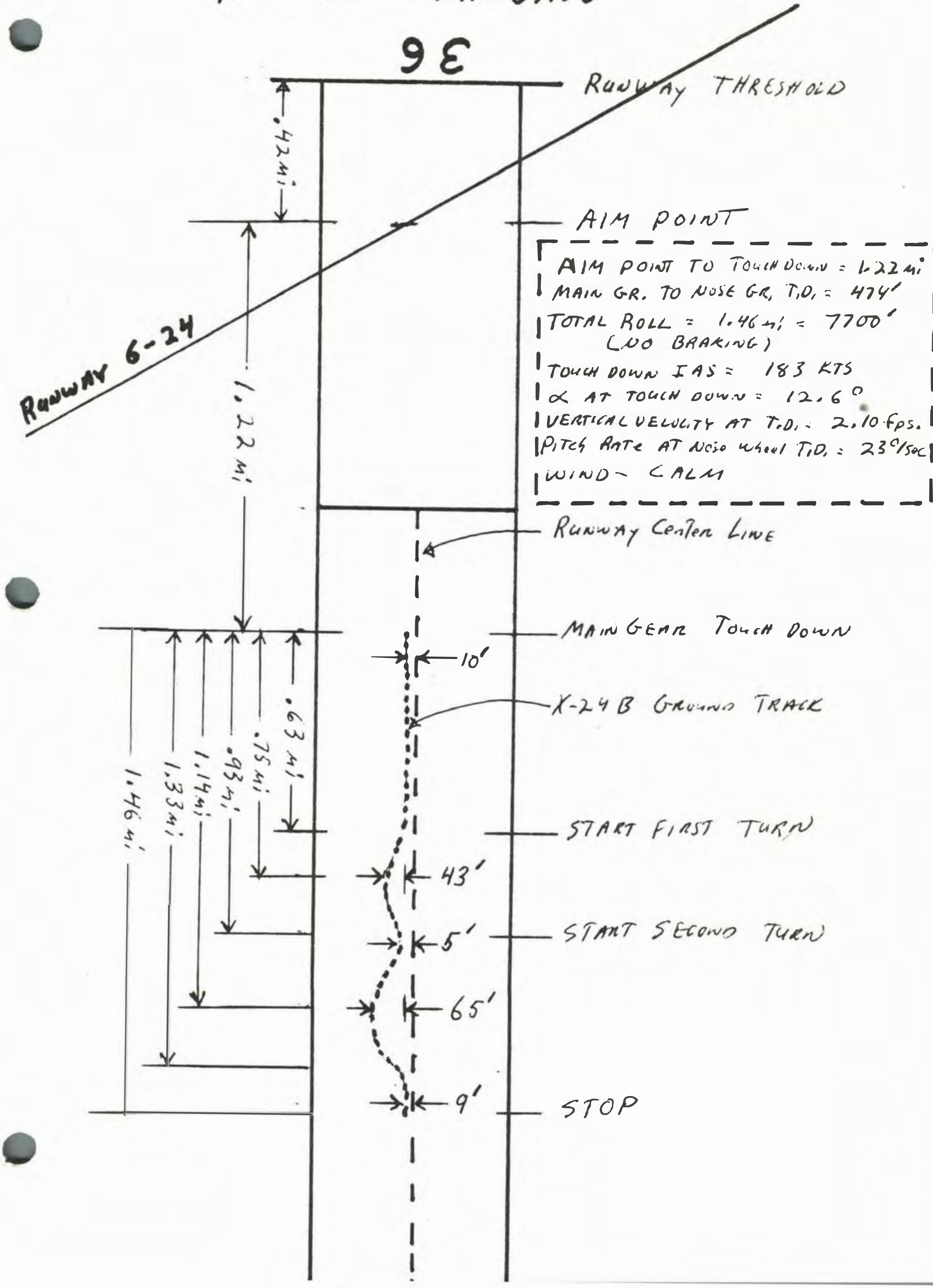
John Manke, Pilot

The following data is submitted to document what I considered an ideal approach, touchdown, and rollout. The pattern was the best I've flown to date with the X-24B. A 300 KIAS glide slope was flown utilizing the aim point shown on the attached diagram. The aim point remained constant throughout the final approach. (Aim point is defined as the point where the final approach glide slope intersects the landing runway.)

During the landing rollout, the nose wheel steering was engaged at approximately 130 KIAS and was kept engaged for the remainder of the rollout. Two lateral excursions, as indicated on the diagram, were performed to evaluate nose wheel steering response and authority. I was very pleased with both.

Braking was not utilized until the last few feet, therefore the total runout distance is representative of a zero-braking landing rollout.

APPROACH & LANDING



B-9-16 Position Error

By

Dennis J. Penka, Captain

Flight B-9-16 provided the first transonic position error data for the X-24B and has lead to an update of the position error curve (figure 1) which will be incorporated for flight B-10-17 data reduction. This updated curve is in general agreement with position error curves for similar type nose boom installations (figure 2). The transonic data for flight B-9-16 shows two distinct curves for acceleration and deceleration points. This is a phenomenon which has been noted in data for other nose boom installations, including the X-24A, and it is attributed partially to pressure lag effects (which tend to shift the acceleration curve down and the deceleration curve up) and to differences in the transonic flow change dependent on whether the aircraft is accelerating or decelerating through the region. At lower Mach numbers, data from flight B-9-16 compares well with data from previous flights (figure 3).

It should be noted that an error was found in the data reduction procedure used for flight B-7-14 position error data presented previously in the B-7-14 flight report (12 Dec 73). This data has been corrected (figure 3) and is now in agreement with data from other flights.

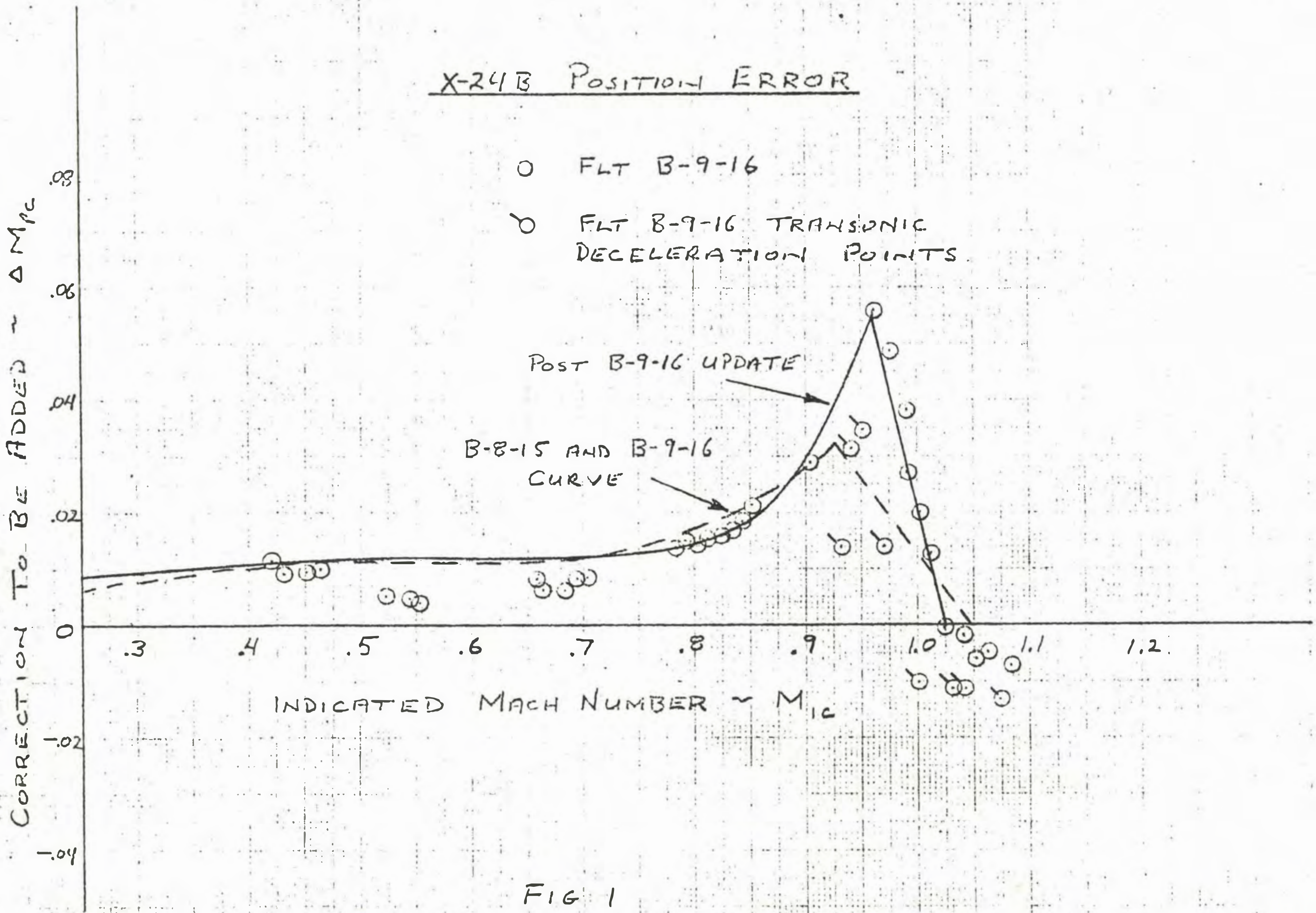


FIG 1

DJP 29 MAR 74

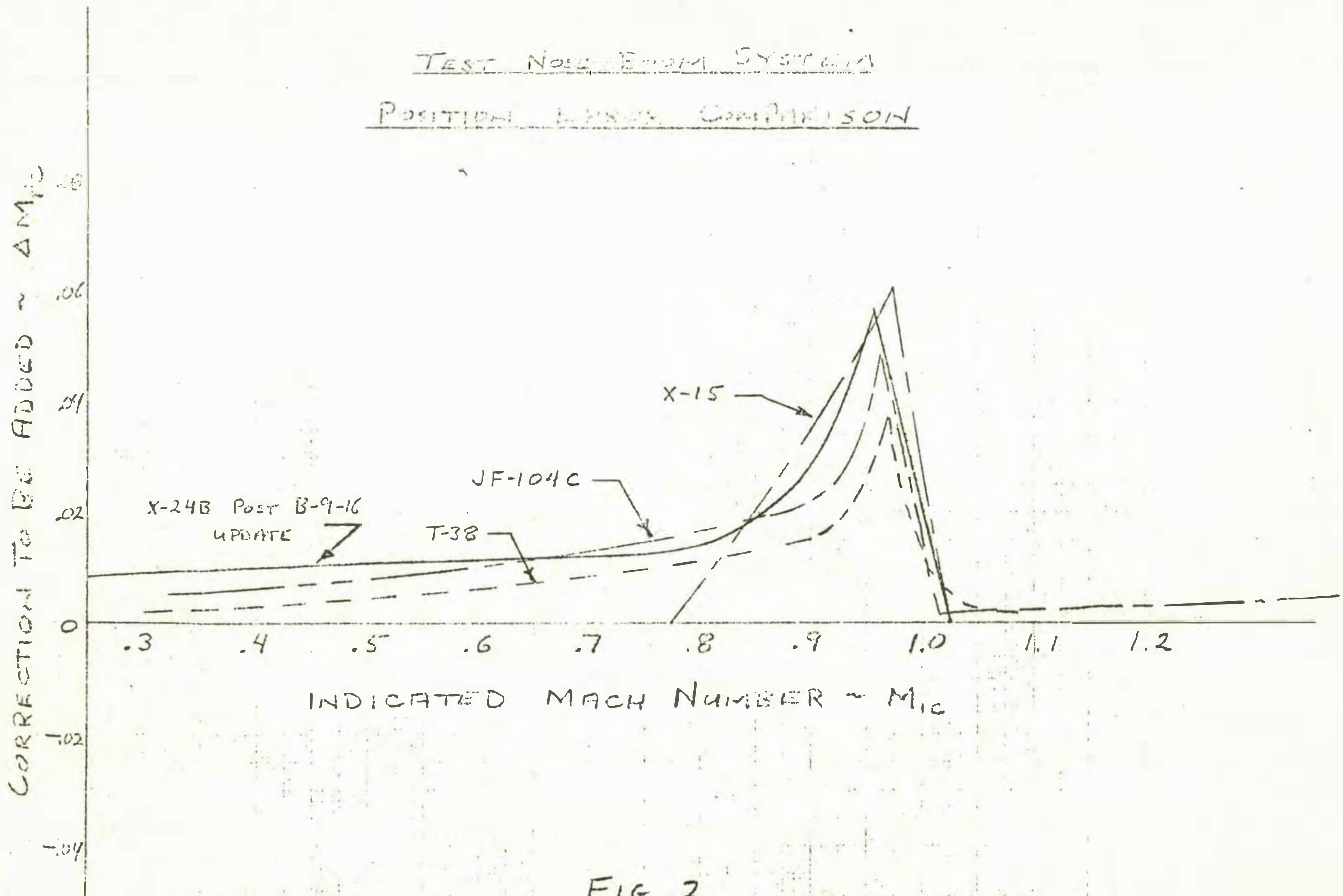


FIG 2

DJP 29 MAR 74

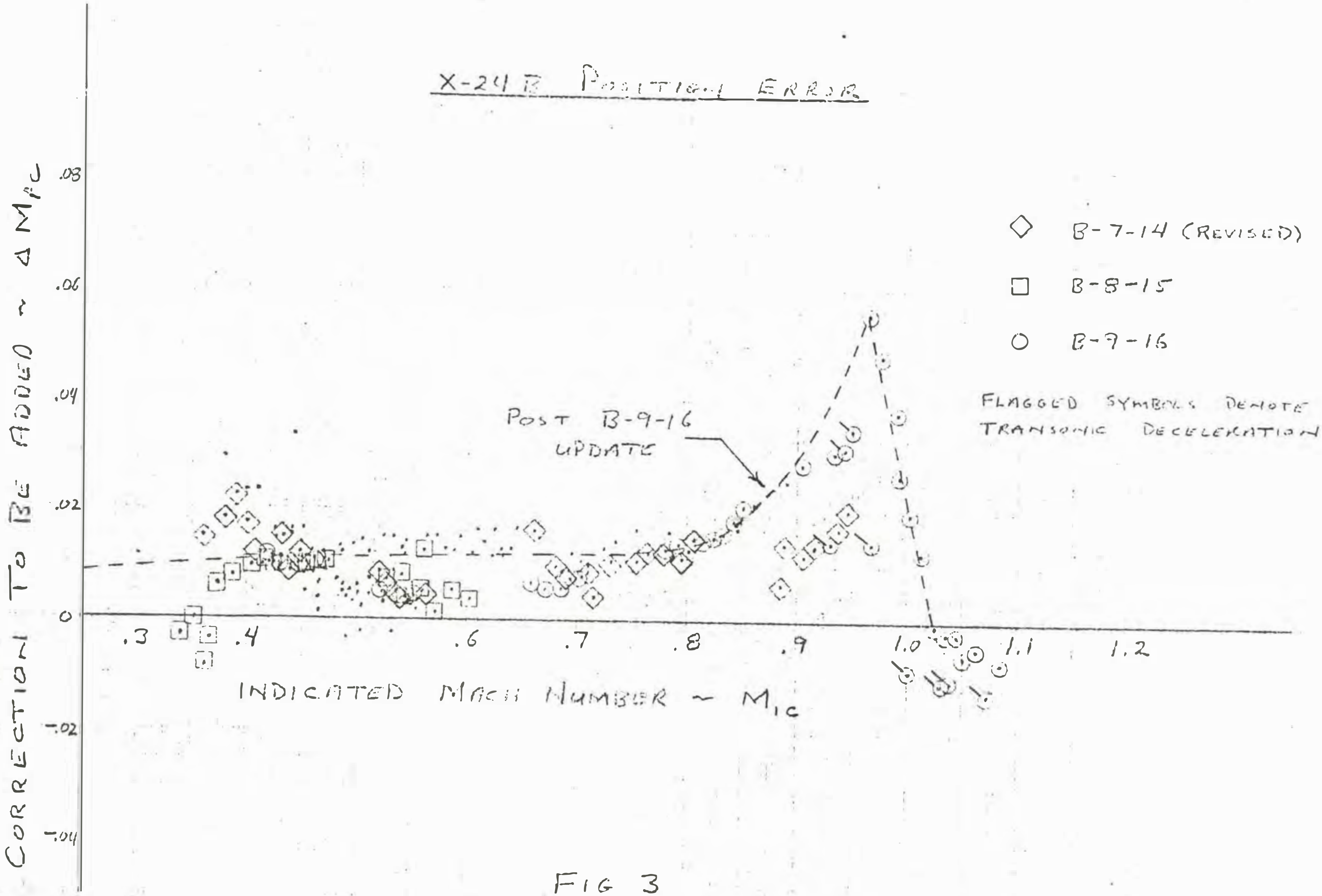
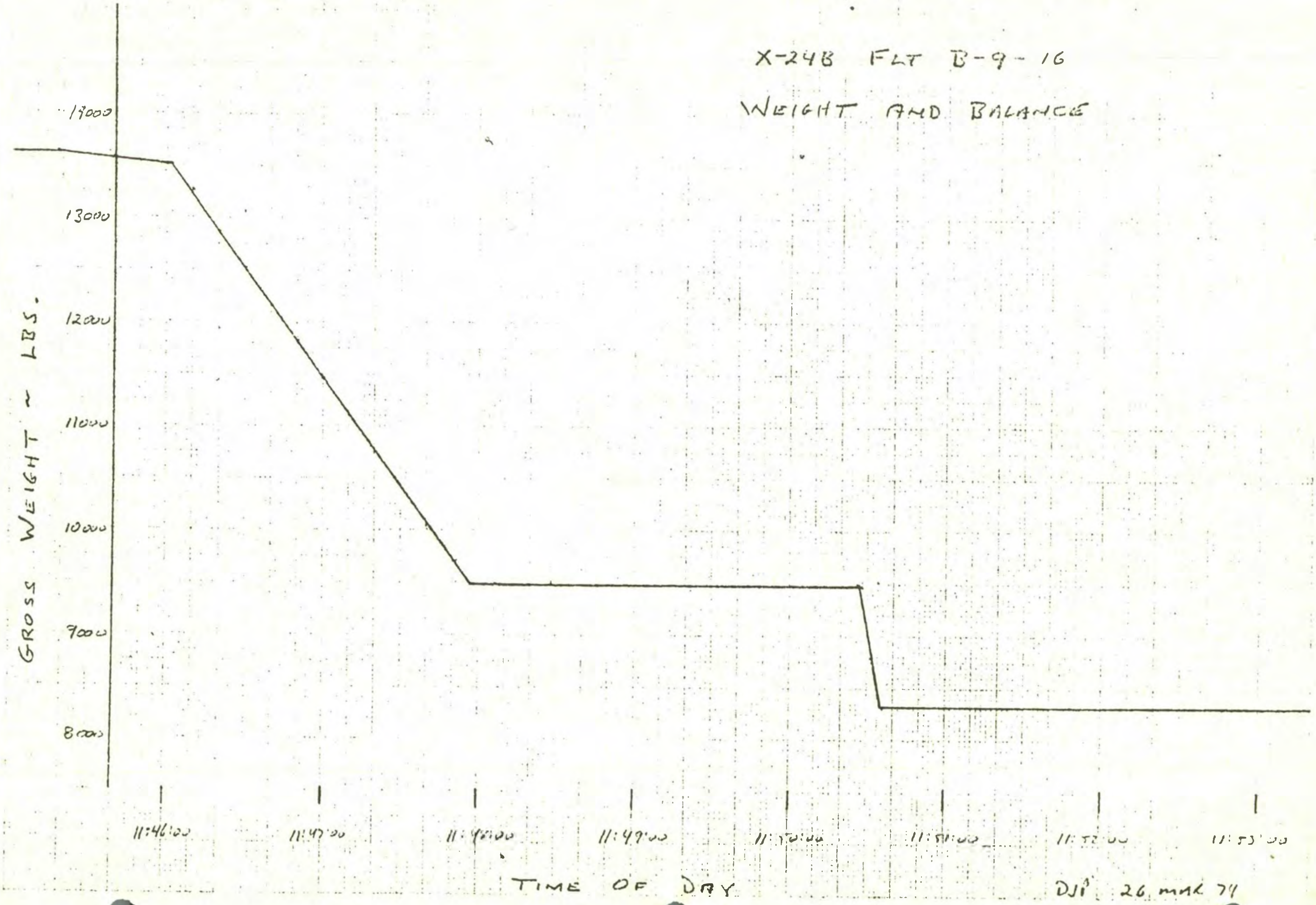
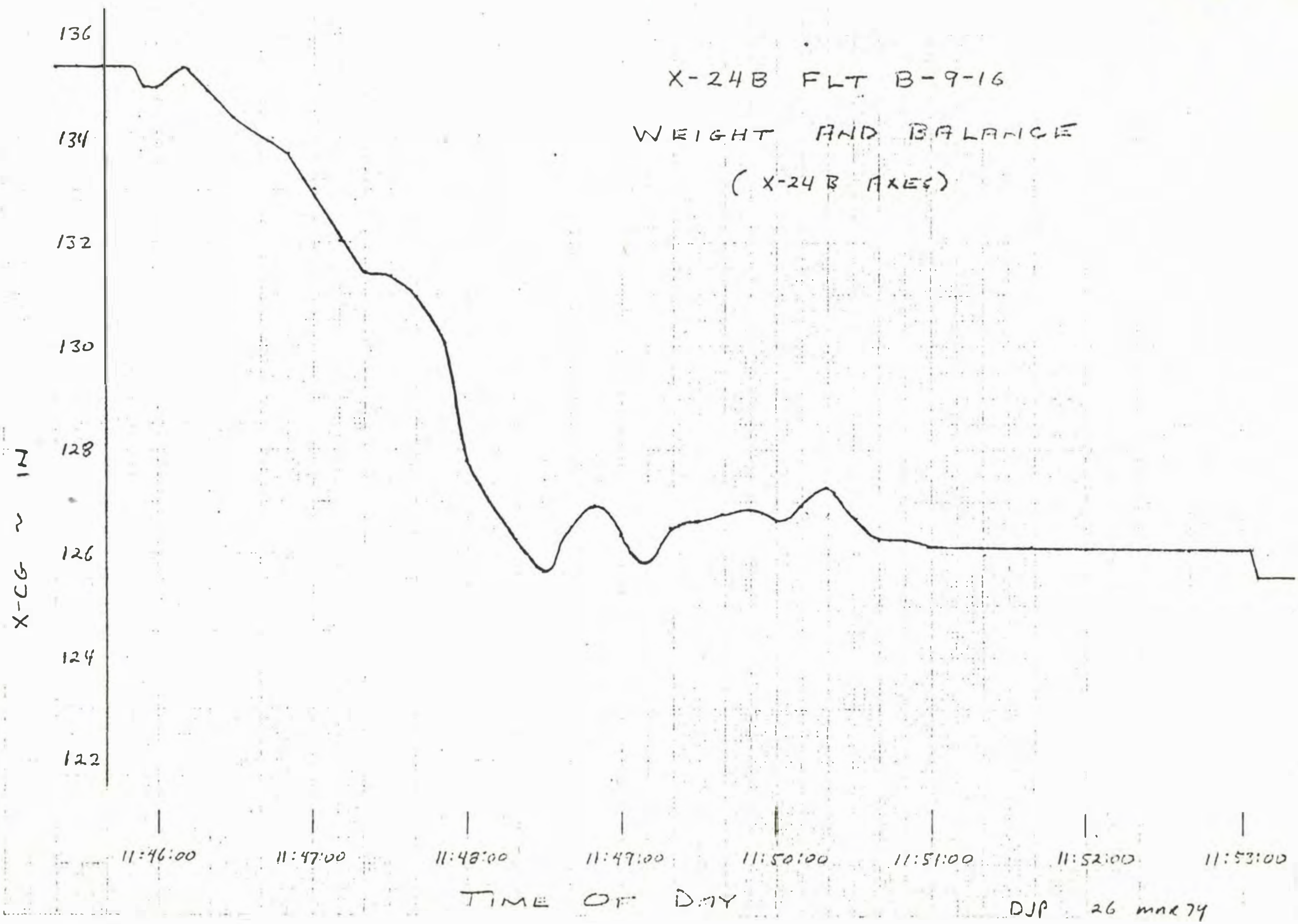


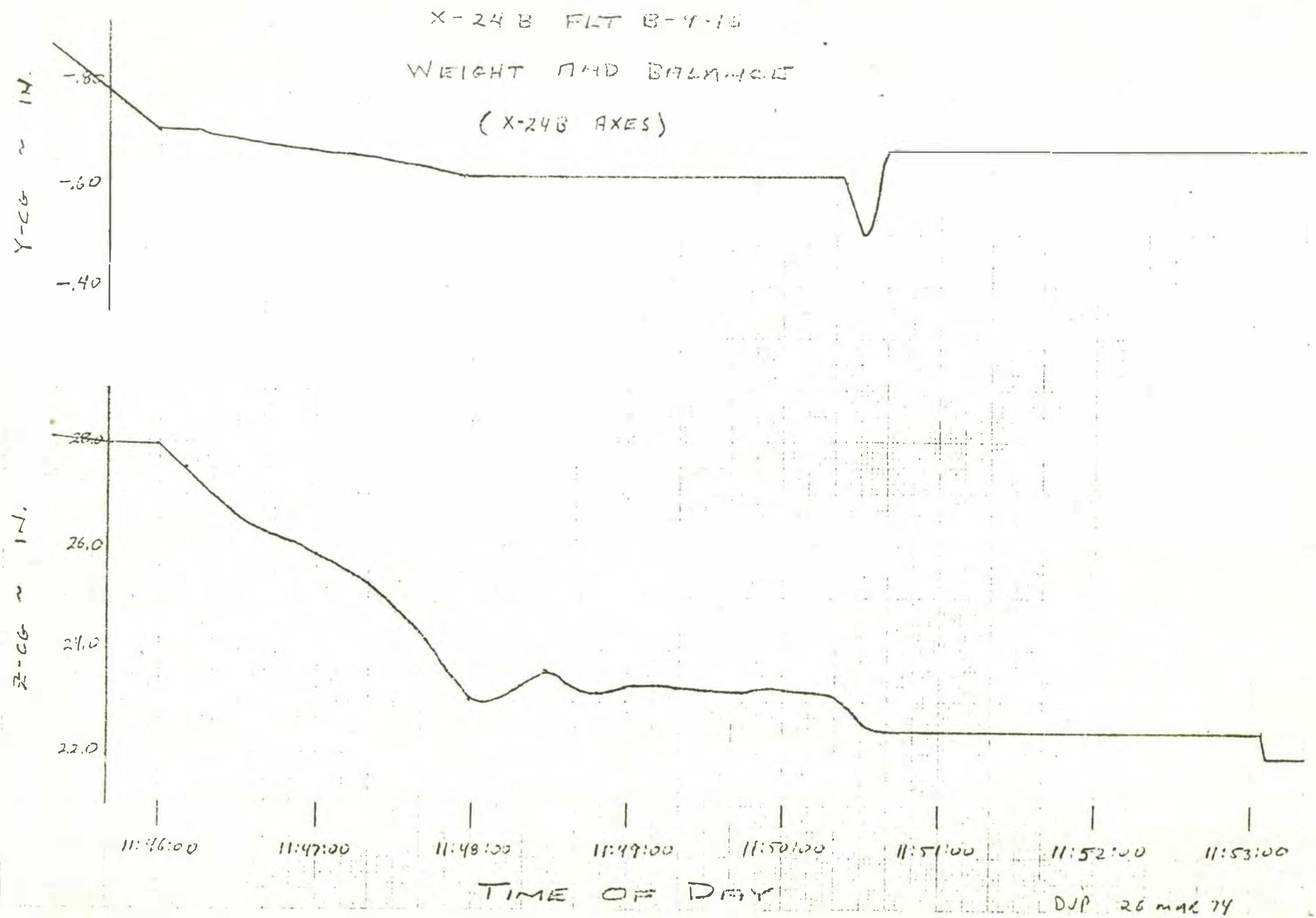
FIG 3

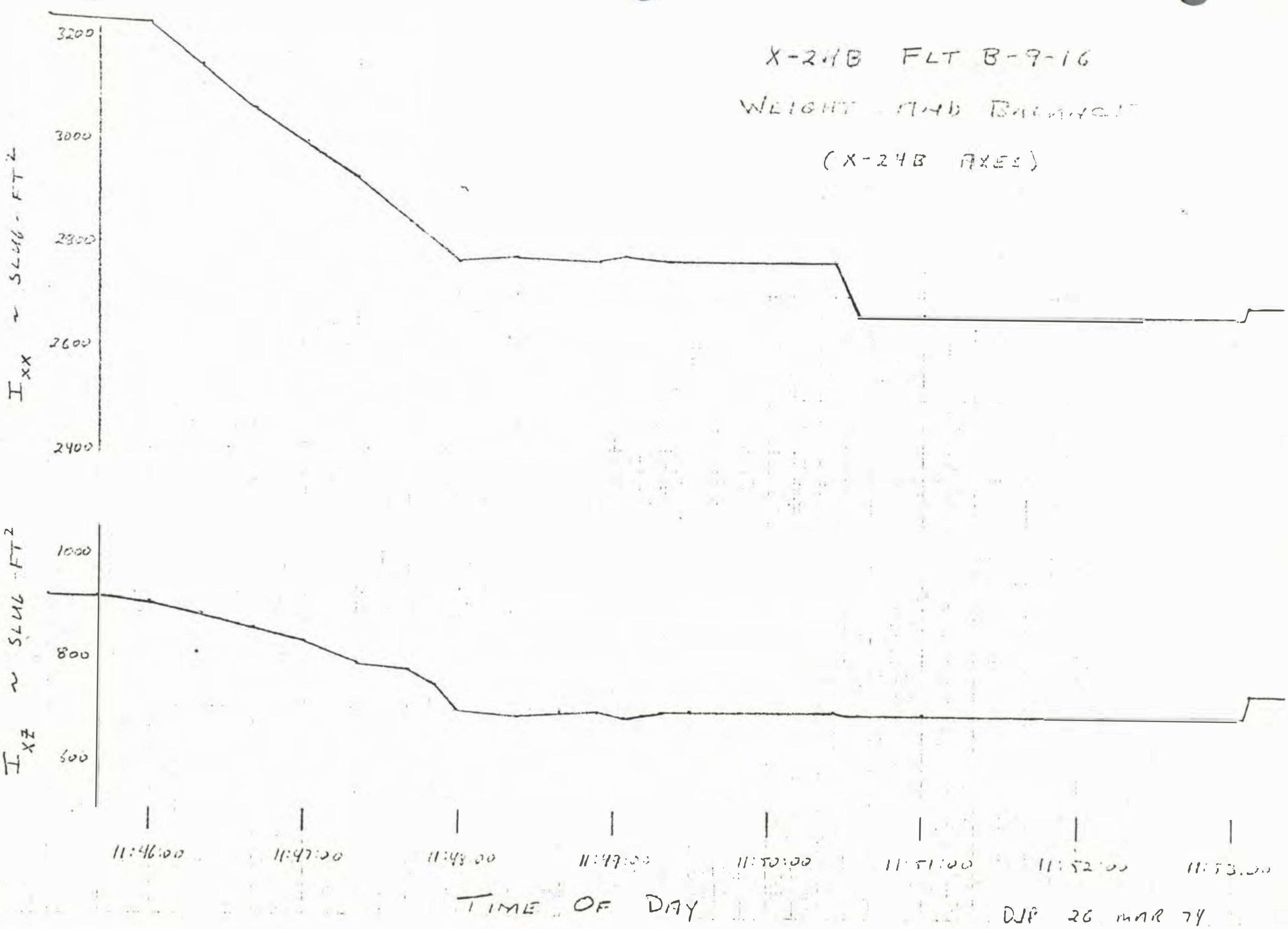
DJP 29 MAR 74

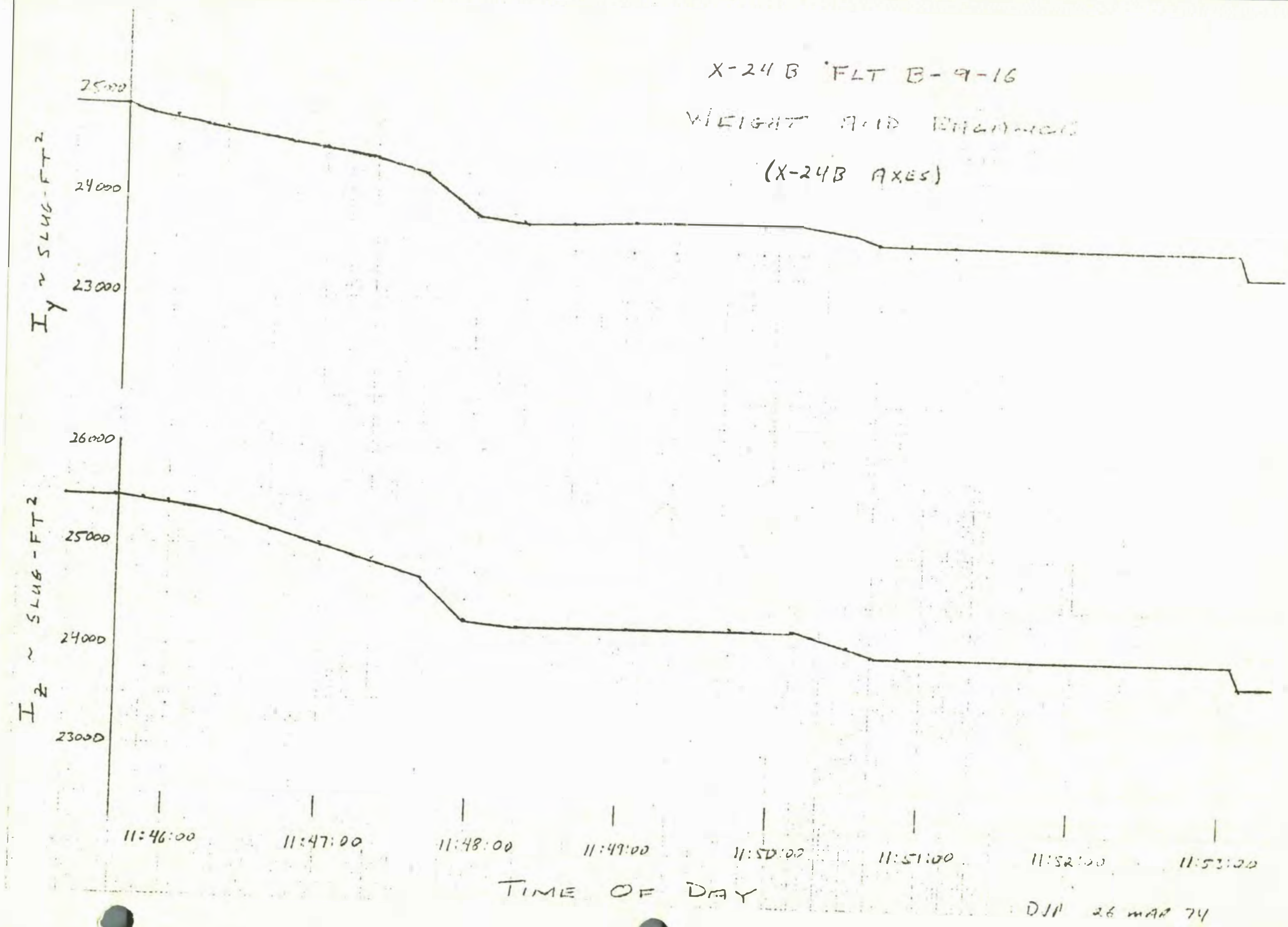


X-24B FLT B-9-16
WEIGHT AND BALANCE
GROSS WEIGHT ~ LBS.
14000
13000
12000
11000
10000
9000
8000
11:46:00
11:47:00
11:48:00
11:49:00
11:50:00
11:51:00
11:52:00
11:53:00
TIME OF DAY
DJI 26 MAR 74


X-24B FLT B-9-16
WEIGHT AND BALANCE
(X-24B AXES)
136
134
132
130
128
126
124
122
X-CG ~ IN
11:46:00
11:47:00
11:48:00
11:49:00
11:50:00
11:51:00
11:52:00
11:53:00
TIME OF DAY
DJP 26 MAR 74


X-24 B FLT B-4-16
WEIGHT AND BALANCE
(X-24B AXES)
Y-CG ~ IN.
-.80
-.60
-.40
Z-CG ~ IN.
28.0
26.0
24.0
22.0
11:46:00
11:47:00
11:48:00
11:49:00
11:50:00
11:51:00
11:52:00
11:53:00
TIME OF DAY
DJP 26 MAR 74


X-24B FLT B-9-16
WEIGHT AND BALANCE
(X-24B AXES)
I_{XX} ~ SLUG-FT^2
3200
3000
2800
2600
2400
I_{XZ} ~ SLUG-FT^2
1000
800
600
11:46:00
11:47:00
11:48:00
11:52:00
TIME OF DAY
DJP 26 MAR 74



X-24B FLT B-9-16
(X-24B AXES)
25000
24000
23000
I_Y ~ SLUG-FT^2
26000
25000
24000
23000
I_Z ~ SLUG-FT^2
11:46:00
11:47:00
11:48:00
11:49:00
11:50:00
11:51:00
11:52:00
11:53:00
TIME OF DAY
DJP 26 MAR 74

X-24B #551 POSTFLIGHT DATE: 3/5/74

PILOT: J. MANKE

OK, this was flight B-9-16 flown on the 5th of March. It was really a good flight. The only problem we had Mike, pre-launch, was that mic and I am almost convinced that it was my mic thatwas the problem. When it started busting up I went right over to B-52 radio and I could not get a good side-tone there and then it seemed to bother me all the way through the flight. My side-tone was changing once in a while. I bit on it some and ended up with the thing almost in my mouth, just as tight as I could against my lips. In fact, it was a little bit uncomfortable flying like that, but that was the only way it seemed to work reasonably good. It seemed like about 10 minutes on I got it positioned right and it worked OK from then on. Suit people know about that and they are going to take a look at it. Top-off, we got top-off in 7 minutes. That is fantastic. I can hardly believe that. OK, I can't think of any other cliches before launch. It was good. Tom had 45,000 pretty early. So whatever you used for the B-52 climb it seemed to be pretty good.

OK, I think this 1°; we put some more rudder trim in this time to take care of some of the sideslip problems we had during the last flight. That seemed to help considerably. I looked down at β shortly after launch and I never did see any more than $1/2^\circ$ and I decided then that I was not going to worry about it anymore during that portion of the flight. And that is a big relief if you can just kick that out of your mind. If you recall, on my last flight, I spent a lot of time worrying about β down in that area, and consequently my task of holding α and so forth wasn't quite like I'd like to have seen it.

Pulled up to 15° α and my α stayed pretty nice between 14 and 15. Probably it is going to average 14-1/2. I used two hands on the stick like I told some of you I was going to do. The second hand or left hand was just tohandle a little roll mis-trim that we have. The airplane wants to bank to the left because it is heavy on the left side. I used my left thumb just to hold the stick where I wanted to keep wings level, and that way I could just use my right hand for pitch control. I found that if I had to put in a constant roll input and then try to use the same hand for pitch control and trimming I did not do as good a job trimming, so if I used the left hand just to hold that stick in the lateral position I was able to do a much better job than just using my right hand for pitch control and that worked good. It sounds kind of stupid, say put two hands on the stick, but it is a real good technique and it works quite well. OK, a good 14-1/2° then was about my average α during rotation. I was pretty pleased with α because the airplane is a little squirlly in pitch at this c.g., and I think it held in real well. I don't recall seeing anymore than 1/2° of β after launch, at least during this portion of the rotation.

Theta came a little bit early. You guys were calling a little bit high and theta came maybe 2 seconds early. I was able to get on it and hold it quite well. At 50 seconds we were to get an α check there. The simulation was running about 12 - 12-1/2 there. I ran 11° on the airplane, so it just appeared that we had a little more thrust than we had been planning for. It was really nice. OK. I pushed over at 53-1/2 on my indicator. That came just a little bit early too. We are talking about maybe 2 seconds or so from the original simulation. Then during this accel, during this constant theta portion up to 53-1/2, my mach number seemed to be running just a little bit higher than I have seen in the simulator. Looked like we were pushing .9 by the time I got to the pushover. So it may have been .02 high or .03 high in that area. I guess that all adds up here with the burn time we had.

OK, the questionable area was this .95 area where we had the strange β during the last flight. I did not see anything that alarmed me at all this time. I looked down once and it looked like β had just started to move to the left and then it came back again. The airplane felt just a little more solid this time. I can't answer it, I don't know why. I don't think I saw any more than a degree at all in the left side slip this time, and probable less somewhere between a half and 1° left. During that time period I looked up once and it looked like it had just started out but it immediately came back in again. So we will have to look at this. I really felt good about it at that time and decided notto worry about it and press on, so it was 100% better this time than I remember it flying last time, and part of it is me getting used to it and not being afraid to have it move out just a little bit.

In this transonic region I can feel changes in the airplane. I can feel lit bits of buffet here and there and just some things going on in the airplane and I can't explain them, but they are there.

I want to back-up a minute, I forgot something. When I lit the engines, the first two chambers had about 3 good chugs to them as they came up. I have never felt it like that before. Chug, chug, chug, like that. I could feel the longitudinal acceleration and then they came up smoothly and the next two came up just like gangbusters.

OK, back to the .95. I did not see the Mach jump on the Mach gage. I think I was making heading corrections but I caught the altimeter jump so I could see the Mach jump and I am sure it showed up on the gage and your mechanization of the altitude is real good. Caught it out of the corner of my eye and I knew we had just gotten the jump. Looked up and we were probably 102 to 103 at that time. I waited a little bit and shut the one chamber down. Got a good rudder doublet followed by an aileron doublet and I would say that the airplane is a little better damped directionally than the simulator is at that point, on that rudder doublet.

Aileron doublet is just like any other aileron doublet. You don't see much motion in the airplane, so it is hard for the pilot to qualitatively evaluate it.

I shut the engine master off just little over 1.1, I guess 1.12 and then immediately got the rudder and aileron doublets and it seemed to decelerate a little bit slower than in the simulator. Maybe it was because I had a little bit higher Mach, but I am sure I got both doublets in before I got the Mach jump, so I should have gotten that aileron doublet in just barely supersonic. (a little higher altitude?) Yes, a little bit higher altitude. Then I noted this pattern all the way down. It did not decelerate quite like it did in the simulator so, in between all the maneuvers, the popu's and the other maneuvers, I went to a higher α than we planned to, just to get it to slow up quickly. So instead of 13 I went to 14 and instead of 12 I went back up to 14 again and that seemed to help it. That kept us just about right on the profile.

The first popu, push over pull up, was at .9. I pushed over and I had been practicing to push over to a -30 on theta and pull on up, and I'd do that to keep the Mach from bleeding off. The Mach started back up again and it might have gone to .92 indicated during that popu. Came off the popu then and it was down thru .9 and I went to a higher α again as I mentioned and got another popu at .8 and that should be good. That should be an .8 indicated popu. Both times I went thru 5 to about 17 on α. Went just beyond the stick shaker both times.

Johnny Armstrong's maneuver was a hands off thing from .75 down to .7. I had a good solid 11° α then. It won't show hands off on the cockpit film but I just was holding a little thumb pressure on it to keep the wings level. Ming Tang's maneuver, the rudder sweep, the rudder bias sweep at six five, I let α creep up about 3/4 of a degree on that thing, darn it. It started on 10 and then it crept up to 11. But

I think it held a little more constant as I swept back to zero. The trim change appeared to be very much like the simulator on that.

From there it was just getting into the pattern. I did not look out until we were about half way thru the downwind leg. Mike had indicated that I was outside the track a little bit. When I looked out, why it was just where I would have liked to have the airplane. Just perfect positioning. Configuration change, no problem, like we mentioned before. Jettision, I did not feel anything on jettison. Did we get any jettison. (yes.) OK. I had enough time to look down and saw the tank pressures coming down, so as they came thru about 25, then I stopped jettison.

The pattern was probably the nicest pattern I have had in the airplane so far. I don't know why it was any different than the other ones. I did not have to use speed brakes until I got down to about 8000' on final and then the speed started to creep up a little over 300 and I put brakes out and stopped it. My aim point stayed right where I started and right where I wanted it. It was a perfect traffic pattern. The best one so far. I even looked out once and saw Einar getting pictures. Looked like he was hanging ingood. Willie too. Flared at about 1000' and it was a very comfortable flare like I always mentioned before and there is plenty of time. A guy has to sit there and wait for 240 knots for the gear, and I guess maybe I was a little bit lower than I had been before when the gear came out. I knew that I had been but I had such a nice rate of descent going that I decided not to level it there but just keep her going. I had very good control of the airplane. It felt real good to me. When it came thru about 240 I popped the gear and then Bill started calling out my altitudes. I saw 200 before touchdown sometime, and I guess I touched down arould 180 or 175. Einar feels that I was a little bit slower than that. The nose came thru as fast as I have ever seen it come thru. It really barreled thru. Maybe I was some slower than I thought I was.

I armed the nose gear steering at about 150 and I guess I started nose gear steering at about 130. I wanted to start getting ready for some runway landings if we are ever to do that. I felt that it was as sensitive as I wanted it at that speed, Mike. You get a little bit of this rocking motion as you come in. Mike and I have been talking a little bit about the nose gear sensitivity, nose gear steering. I think we have ± 7° total throw, somewhere in that ballpark. It is very insensitive if you related it to other airplanes. But with this thing riding forward on the nose gear like it is, why I felt that it is quite adequate. Now, down in the area

50 or so a guy could handle quite a bit more. So far here I was pretty pleased with it, and the way it rocks over on you if you hit it at higher speeds, I would not want it a heck of a lot more. I thought it was quite good but I thought both of us would want to look at it a little more and will probably intentionally go ahead and engage it at fairly high speeds now and do some S-turns on the runway. OK. It was just a superduper flight and we will have to look at the records, but the airplane sure does handle nicely. It was good or better than I had hoped all the way thru.

FLIGHT: B-9-16
PILOT: J.A. Manke
NASA 1: M. Love

DATE: March 5, 1974
L/P: V. Horton

15 minutes to launch

Manke: 6-5-3
SAS servos are auto.
Set the lites.
Torque.
NASA 1: John we've still got a yaw lite.
Manke: Got it and a torque. No lites.
SAS mode switches are on.
NASA 1: Inside 15 John.
14 minutes.
Manke: Rog. OK, I've snapped.
Hydraulic pumps, pressures are 2750. Ready for a pitch and yaw pulse.
B-52: NASA 1, here comes pitch pulse.
NASA 1: Good pitch pulse.
B-52: OK, here come the yaw.
NASA 1: Good yaw pulse.
Manke: Looks good here.
Are we in a good enough heading for erect switch now Mike?
NASA 1: Standby.
OK, we're 13 minutes.
008 come 2° left and then you can get the erect switch on.
Manke: Roger.
B-52: Rog, coming left.
Manke: Erect, fast erect is on.
NASA 1: 12 minutes.
11 minutes.
Manke: Upper flaps 40°.
Lower flaps 10°, ailerons are zero.
Aileron bias is at 7.
Rudders 1° left.
Rudder bias is 0.
NASA 1: Roger.
B-52: Looks like you're getting an overboard flow now.
NASA 1: Roger we see that. 10 minutes.
Manke: 10 minutes
OK, #1 helium is 4000, #2 is 42
Control gas 500
Gov balance 465
Fuel tank is 5
Lox zero
Landing gear 3000
Ready for pump heater switch?

NASA 1: We're ready.
Manke: OK, here comes - off now.
NASA 1: Control back on.
Manke: Back on now.
NASA 1: Good check John.
Manke: Very good, thank you
What's your heading now?
B-52: 03
Tower: Recovery on RW 36?
NASA 1: Roger 36 Tower.
9 minutes.
Manke: Erect switch cutoff.
Fast erect off.
Both attitudes look good.
NASA 1: Roger
8 minutes, start left turn #008.
B-52: Roger.
Manke: OK, 8 minutes, here comes landing rocket test.
NASA 1: 2 good ones.
Manke: OK.
NASA 1: 7 minutes.
Manke: Rog, 7 minutes
X-24 radio
Back on primary - how do you read?
NASA 1: OK didn't read you on secondary or guard John.
Manke: As we come down the straight-away, I'll give you another check on that.
NASA 1: OK.
Manke: ....
NASA 1: Rog.
6 minutes.
Chase aircraft, you can check windshield heat again.
Chases: (All checked in.)
NASA 1: Shallow your turn #008.
B-52: Rog.
Manke: OK, Mike that's at 27, what do you read?
NASA 1: Little more forward.
That'g good.
5 minutes.
Manke: OK
On battery
Reset the lites.
On #2 and #4 hydraulics, lites are out, I got 3200 lbs.
#1 bus 120, #2 is 110, #3 110 and #4 about 40
SAS gains are 5-5-5
Here comes another old SMRD.
No lites.

B-52: Power is off and ammeters are zero.
NASA 1: Roll out 212°, #008.
B-52: Roger.
Manke: Torque, no lites.
#1's are off
Torque, #3 amber lites.
#2's are off, torque, 3 red lites.
Gains are 6-5-3
SAS servos are auto
SAS lites are punched out, and the torque, no lites.
NASA 1: OK John we're just inside 4 minutes.
Manke: Lets go secondary for a radio check.
I'm on standby.
NASA 1: 5 square.
7° right #008
3 minutes.
Manke: On X-24 oxygen
Cylinder is 1750
Regulator at 85
Going to X-24 air, reads about 25 lbs.
Cabin altitude 24,000
Canopy defog is heat
Forward canopy is on
Suit vent is low
#1 helium 3950
#2 helium 2100
Control gas 505
Gov balance about 465
Erect switch going to erect
Fast erect is on
Mike, trims look OK, looks like a little left aileron but that's OK.
NASA 1: Come 2 more right #008.
B-52: Roger.
NASA 1: 2 minutes
Manke: Precook, heater, off
Engine bleed is on
Prop supply is on
Tanks pressurized
B-52: Topoff complete beacon's off and alternate pressure good
Manke: OK, fuel is 46
LOX about 48
Release pressure low lite is out.
NASA 1: 2° left #008
B-52: Roger.
NASA 1: 70 seconds.
Manke: Roger, OK.

NASA 1: Standby for 1 minute.
1 minute, mark.
Manke: OK, got my clock.
Sources are good.
SAS lites are out.
α is 5, β is almost 2° needle left.
Engine master coming on.
Erect switch is cutoff.
Fast erect switch is off.
NASA 1: Systems are OK.
Manke: Release C/B is in.
Camera/recorder and fin camera are on.
Igniter test
NASA 1: 4 good ones.
Check your reset
Manke: 5 seconds
Launch
NASA 1: OK, check your α John.
We see 4 good ones.
Trim to 15 and go to two hands.
Turn left to 209
Rounding out on profile and that will be a good heading, 209.
Going little high on profile now, heading is good.
Standby for theta. Come back right 3°
Holding 1500 high.
Manke: 11 α at 50 seconds.
NASA 1: Rog
Manke: ...α
NASA 1: Standby for 15 now
Manke: OK, got it.
NASA 1: Come on 3 more right
Standby for pushover at 53.5 and 10 α
54
Good heading, you're holding 2000 high.
Check you Mach
Come on 2° right
About 3000 high
Standby for 1 chamber off.
Standby for doublets
We see the doublets, John.
OK, you can standby for engine master off and doublets.
Good heading.
Check your α and get a doublet.
You are 2000 high, right on track.
OK, standby for a .9 po-pu and 13 α
You're coming back down in profile, 1000 high, good track.
You're right on profile, good track.

	OK get prop supply
	Good track, good profile.
	You can standby for .8 po-pu and 12 α
Manke:	It's going good, Mike.
NASA 1:	OK, we see your po-pu, John.
Manke:	What's the energy looking like?
NASA 1:	Good energy, right on profile
	Heading is OK
	Out of that po-poo, check your Mach
	Hands off at 12
	OK you're about 1000 low.
	Come left 2° when you have time.
	Check your β
	OK when you start flying it again, you get rudder bias manual and turn 185
	Standby for .65 Mach and a rudder sweep.
Manke:	Give me a heading now.
NASA 1:	180 will be a good heading
	You're right on profile
	OK, we see your sweep, John.
	180 is a good heading, on profile.
	Get rudder bias auto
	SAS 432
	Come around to 175
Manke:	I got the runway now, Mike.
NASA 1:	Rog.
	Close up -when you get closed up you can go jettison
	175 good heading
Manke:	Coming clean
NASA 1:	Right on profile
Manke:	Jettison
NASA 1:	OK, we see your jettison
	About 1 mile outside track, right on profile
Manke:	OK
NASA 1:	You're at 3 miles, John.
Manke:	There go my tank pressures
NASA 1:	Roger
Manke:	Stop jettison
NASA 1:	Stop jettison, tanks and engine bleed
	2 miles
	Get your chamber switches
	You're right on profile.
	Get a rocket check at a mile
	Check #1 & #3 hydraulics
	Got 2 good chambers.
	Approaching turn point, right on profile, 1/2 mile wide.
Manke:	OK, going to .3 Mike.
NASA 1:	OK, John.

Chase: 15,000 at 268 and 89%
Manke: OK Willy, I had about 268 also.
Chase: You got a tuft watcher watching tufts.
Manke: OK, that's what we're paying him for.
Flaps
NASA 1: See your flaps
Chase: 305, 6000 feet
Manke: OK, flaps coming in.
NASA 1: Roger.
Chase: 1200 feet.
Manke: OK, Bill.
Little turbulence
Chase: 75 feet
20, 15, 10, 5, 3, 2, down.
How about that?
NASA 1: OK, John check your nose gear steering arm. 1230 debrief
Armstrong would like to know what you saw for max Mach.
Manke: I saw just a little bit over 1.1
?, 166 for burn
Throttle off
.... manual
Cameras off
Calibrate
NASA 1: We're ready - good calibrate.
Manke: I shut the recorder off before I calibrated, I'll
put the recorder back on for a calibrate.
Servos are off.
NASA 1: Check recorder off.
Manke: Off.
Defogs off
Erect switch on, fast erect off
#1 helium 1200
#2 helium 38
Cont gas ....
Landing gear 2600
Cabin air down to 600

X-24B OPERATIONS FLIGHT REPORT

FLIGHT: B-9-16

DATE OF REPORT: 3/27/74

PILOT: John Manke

DATE OF FLIGHT: 3/5/74

CARRIER AIRCRAFT: B-52 #008

LAUNCH LAKE: Cuddeback

PURPOSE OF FLIGHT:
(1) Envelope Expansion to 1.1 Mach Number.
(2) Stability and Control at Mach Number 1.0.
(3) Performance and Longitudinal Trim at .9 and .8 Mach Number.
(4) Fin and Rudder Pressure Survey.
(5) Boundary layer noise and vibration experiment (RED PLUG)

I. Discussion of Previous Operations

No evidence of the aileron lost motion was observed on flight B-8.

II. Vehicle Configuration Changes

A. The L.H. side of the vehicle from Sta. 65 to 175 was painted white to provide background for tuft photographic studies of local airflow. Photo coverage is from the L.H. tip fin and chase cameras.

B. The center fin camera was realigned to photograph the inboard surface of the R.H. fin.

C. Two surface pressure taps were installed on the inboard surface of the R.H. fin to aid in investigating possible flow asymmetry on the fins.

D. The governor balance pressure regulator was replumbed to eliminate outlet pressure droop during engine operation. The regulator inlet pressure had been connected to the engine control gas manifold at 490 psi. With the outlet requirement for 465 psi the pressure differential across the regulator so small that mechanical friction can introduce undesirable hysteresis.

To overcome this problem the regulator inlet was connected directly to the Helium source which operates as high as 4000 psi.

E. A heater was added to the window of the nose camera to prevent fogging during flight.

III. Instrumentation Changes

A. Changed "Dynamic Inst. System" PCM format recorded on on-board tape to Miller code.

B. Added two new pressure taps on R/H fin.

C. Added heater to nose window.

D. Changed frame rate on cockpit camera and L/H fin camera to 8 frame/sec.

E. Center fin camera re-positioned to look at R/H upper flap surface. New insulation blanket was added.

IV. Preflight Events

All preflight functionals were performed without incident.

V. Flight Events

A. Flight servicing was normal until the pilot could not transmit shortly after closing the canopy. The communication technician made a quick check and found nothing wrong, but the system started work satisfactorily and the flight proceeded as planned.

B. An igniter test was made prior to launch to increase confidence in the system following the recent modifications as reported in the flight report for flight B-7-14.

All four igniters functioned properly and engine operation during the flight was normal.

C. The vehicle was in good shape after the flight.

D. All cameras worked during the flight and the nose camera window did not fog.

Approved by: W P Albrecht
William P. Albrecht
Chief, Operations
Engineering Branch

Written by: WPA for
Norman E. DeMar
X-24B Project Engineer
Operations Engineering Branch

FLIGHT 10

PRELIMINARY RESULTS OF X-24B

FLIGHT B-10-21

30 April 1974

BY

USAF/NASA X-24B PROJECT TEAM

Flight Summary - Flight B-10-21

Flight B-10-21 was flown on 30 April 1974 by Major Love. This was Major Love's first powered flight and as such was a planned three chamber check out flight. As a result of engine malfunction on the first start attempt after launch; a preplanned delayed engine light profile was flown. The delayed light profile was flown as planned on the simulator, achieving close to the normal engine shut down conditions and also all planned data maneuvers. The significant flight conditions achieved were as follows:

Maximum Mach number = .876

Maximum Altitude = 52040 feet

Maximum True Airspeed = 502 KTS

Flight Time = 6 minutes 59.1 seconds

Burn Time = 139 seconds

Stability and Control derivatives determined were consistant with previous results. The left hand main gear strut bottomed shortly after touch down. No aileron dead band was experienced during the flight. Significant flow changes were observed on the tufts on the inside of the right tip fin and on the fuselage.

Flight operations between flight 9 and flight 10 included; one abort due to clouds, two aborted captive flight attempts and one captive flight. A summary of the factors causing the delay between flight nine and flight ten is presented in the accompaning table.

FLIGHT B-10-21 OPERATIONS SUMMARY

5 Mar 74	B-9-16 Flown
19 Mar 74	B-A-17 Aborted due to clouds, aileron dead band not acceptable.
21 Mar 74	Demated to install aileron instrumentation
25 Mar 74	Work Schedule meeting - Target date 10 April
8 Apr 74	B-52 #6 engine problem on F-15 RPRV flight.
10 Apr 74	B-52 engine run unsuccessful
15 Apr 74	Redoing functionals; NASA control room down all this week Scheduled B-4C-18 for 22 April.
22 Apr 74	Mated. Take off delayed due to B-52 #8 engine start problem (1400 Takeoff). B-4CA-18. Abort due to TV monitor fire in B-52.
23 Apr 74	B-4CA-19 abort due to B-52 LOX Top off system.
24 Apr 74	Cancelled due to "red X" on B-52 (Hyd Packs)
25 Apr 74	B-4C-20 Flown
26 Apr 74	B-10-21 cancelled due to Yaw SAS problem during torque check.
27 Apr 74	Flight rescheduled for Monday but cancelled and changed to Tuesday because SAS preflight had to be accomplished.
30 Apr 74	Flight B-10-21 Flown.

X-24B Flight Request
8 March 1974

Flight No: B-10-~~17~~ 21

Scheduled Date: 19 March 1974 FLOWN: 30 APRIL 74

Pilot: Major Love

Purpose:
1. Pilot's Powered Flight Checkout
2. Stability and Control at .8, .85 and .7 Mach Number
3. Fin and Rudder Pressure Survey
4. Boundary Layer Noise and Vibration Experiment (RED PLUG)
5. Fuselage Tuft Study

Launch: West of Rosamond, Mag Heading 060° + Crosswind correction Angle. 45,000 feet, 190 KIAS. Flap Bias "Manual", Upper Flaps =-40°, Lower Flaps = 27°, Rudder Bias Mode "AUTO", Rudder Bias = 0°. Rudder Trim = 1° Left. Aileron Bias = 7°, SAS Gains 6,5,3. Mach Reapeater "Manual" = 1.0, KRA "AUTO", Hydraulic Pumps 2 and 4 on.

Landing: Rogers Lakebed Runway 18

B-52 Track: X-24B Track #2 (R2515, Work Area I)

ITEM	TIME	ALT	A/S	α	MT/MI	EVENT
1	0	45	190	5	.71 (.70)	Launch, Lite Chambers #2 and #4 Then #1, Trim to and Maintain 14° α Until θ = 20°.
2	25	42	250	14	.85 (.83)	Max Mach During Rotation.
3	37	42	240	14	.82 (.80)	θ = 20°, Maintain θ = 20°, (Crosscheck α)
4	94	47	205	13	.80 (.78)	●, Perform Rudder and Aileron Doublets.
5	127	50	205	13	.85 (.83)	Perform Rudder and Aileron Doublets.
6	149	53	210	12	.90 (.88)	At .90 Mach (True) or Call From NASA I Based on Ground Position, Shutdown Engine with Engine Master. Pushover to 5° α

ITEM	TIME	ALT	A/S	α	MT/MI	EVENT
7	159	54	180	5	.80 (.78)	At .80 Mach (True) Perform Rudder and Aileron Doublets Trim to 14° α (θ= -20°)
8	174	50	195	14	.80 (.78)	Perform Pitch Pulse, Push over to 10° α
9	190	46	220	10	.80 (.78)	Perform Pitch Pulse, Trim to 13° α, Check ground Position.
10	218	38	230	11	.70 (.69)	Perform Rudder and Aileron DOUBLETS, Return to 13° α.
11	229	35	230	13	.67 (.66)	Intersection, Turn to Low Key Heading. Set SAS Gains 4,3,2. Jettison Propellants.
12	266	28	210	12	.54 (.53)	Change Configuration to -20° Upper Flaps.
13	306	21	220	10	.48 (.47)	Low Key, #1 & #3 Hydraulic Pumps on, Rocket Check, Set Mach Repeater to .3 During Final.

NOTES:

1. Nose Ballast = 220 lbs (+ 100 AMP HR Equip Batt)

2.

	Weight-lbs	cg-%
Launch	13457	65.9
Shutdown	9550	64.1
Landing	8394	64.0 (gear down)

3. Engine S/N 8, Pump S/N 8A

   Thrust = 2,100 lbs/chamber
   LOX Flow Rate = 4.51 lb/sec/chamber
   WALC Flow Rate = 4.05 lb/sec/chamber

4. Power on Base Drag Reduction C_C = -.005

5. Pitch Attitude Null at 20^o

Ground Rules for NO LAUNCH:

1. Radio, radar, PCM failure
2. Electrical or SAS malfunction
3. A/S, altitude, Machmeter failure
4. Angle of attack or sideslip malfunction
5. Any control system malfunction
6. Loss of cabin pressure
7. Turbulence below 10K in excess of moderate
8. Surface winds greater than 20 kts or crosswind greater than 10 kts
9. Failure of engine control box heater
10. Failure of stick shaker
11. Must have 3 good igniters to launch

(In addition to standard ground rules published in Lift Body Joint Operations Plan)

Alternate Situations After Launch:

Failure	Action
1. Radio, radar, PCM	Proceed as planned.
2. Only One Chambers Operates	Vector for RW 02 Rosamond, shutdown chamber, jettison, change configuration.

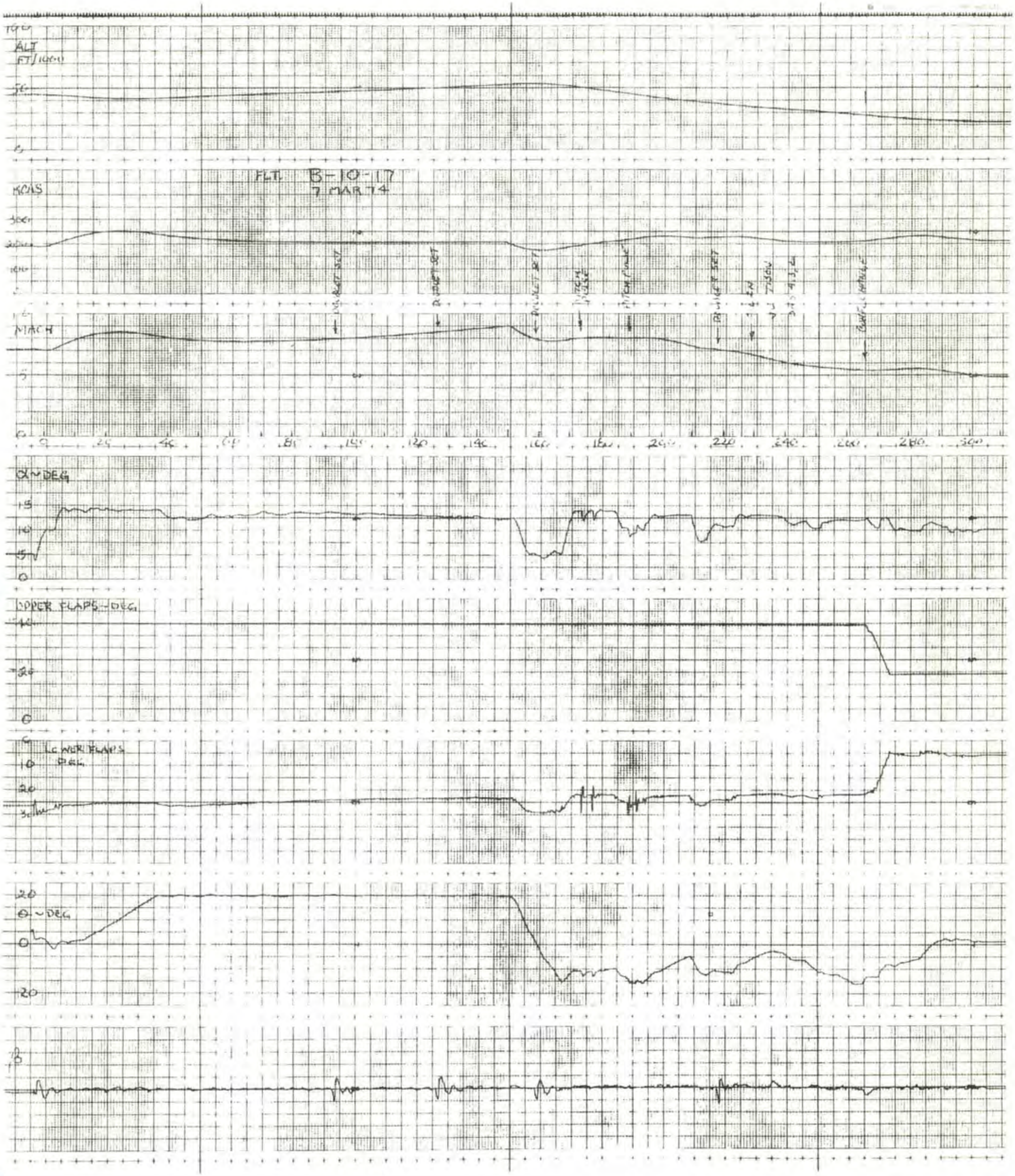
Failure	Action
3. Only Two Chambers Operate	Maintain 14° α, Change configuration to 30° upper flap at .7 Mach No. Shutdown on NASA I call (≈ 200 sec).
4. Delayed Engine Light	Proceed as planned. Use 250 (14° α Max) PUSH OVER TO 10°α AT EARLY SHUTDOWN LINE.
5. Total damper failure-any axis	Fly Planned profile, limit M_T to .9. Data maneuvers at pilot's discretion. If control is marginal go to two chambers. (For pitch damper failure rotate at 13° α). (For roll damper failure set Mach Repeator to .3)
6. KRA "AUTO" Failure	Set to manual 10% and proceed as planned. If "MANUAL" mode inoperative-switch to "EMER" position and set to above value.
7. Angle of Attack (Indicator Only)	Proceed as planned using backup angle of attack gage. KRA "MANUAL" 10%, stick shaker off.
8. Total Angle of Attack	Fly Two Chamber profile, use 200 kts instead of 14° α. To rotate fly 1.0g to 230 KCAS then fly 1.2g to 200 KCAS. (KRA Manual 10%, stick shaker off)
9. A/S, Altitude, Mach	Proceed as planned using α, θ and time for profile control.
10. Attitude System	Proceed as planned using backup indicator.

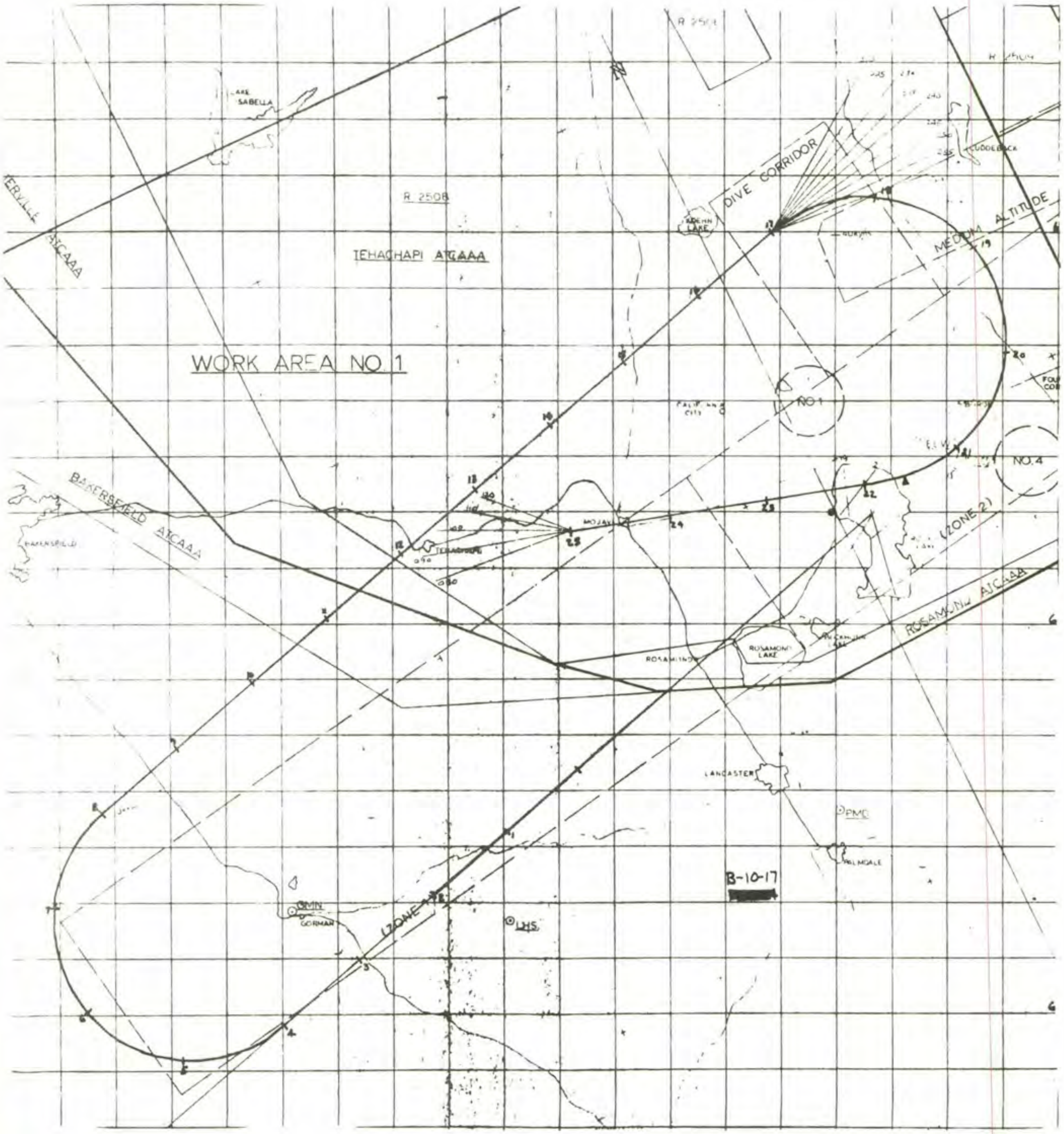
11. Premature Engine Shutdown

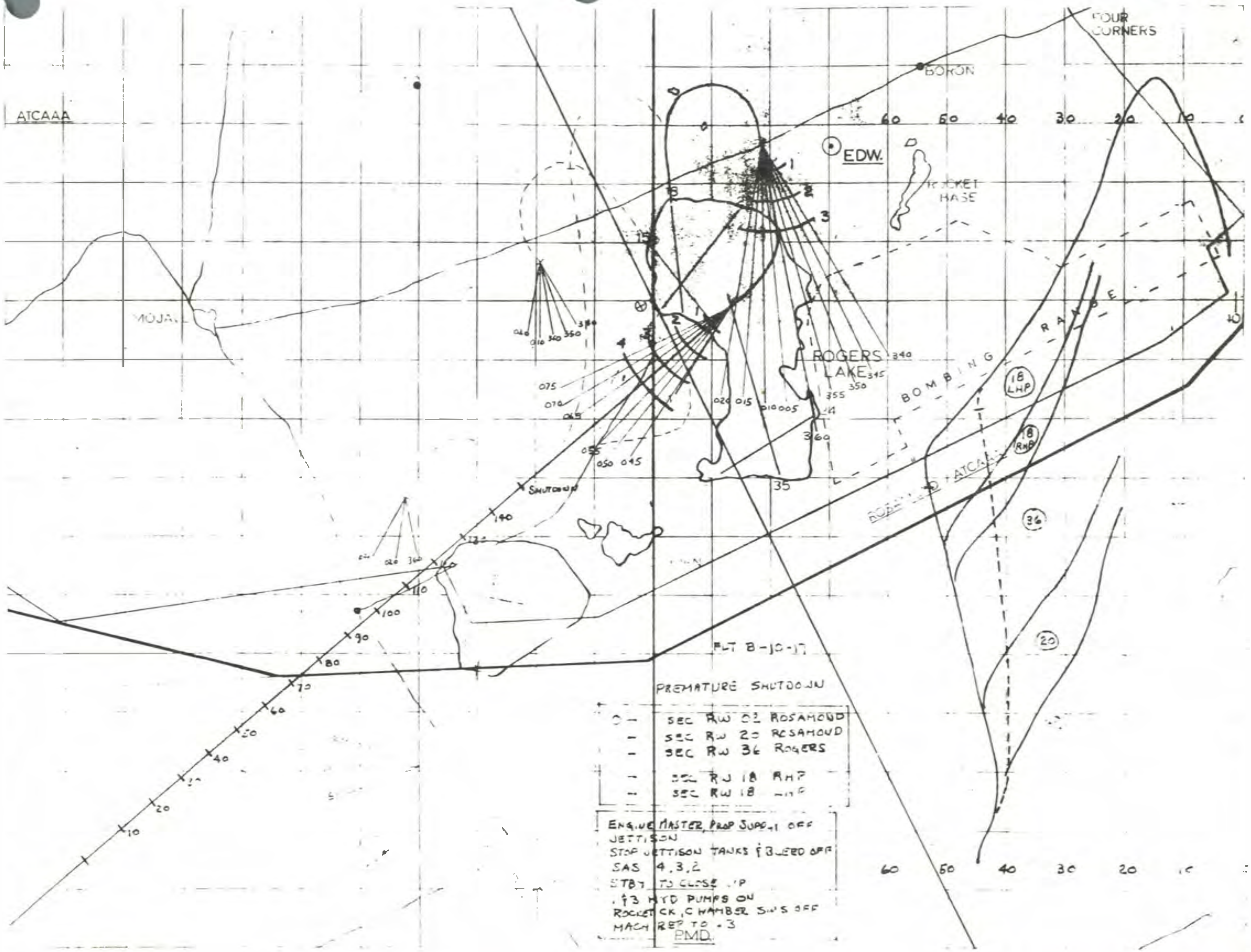
0-20	sec	RW	2	Rosamond
20-55	sec	RW	20	Rosamond
55-105	sec	RW	36	Rogers
105-120	sec	RW	18	(RHP) Rogers
120-up	sec	RW	18	(LHP) Rogers

Robert G. Hoey
ROBERT G. HOEY

Jack L Kolf
JACK L. KOLF


ALT FT/1000
FLT. B-10-17
7 MAR 74
KCAS
MACH
α ~ DEG
UPPER FLAPS ~ DEG
LOWER FLAPS DEG
θ ~ DEG
β


WORK AREA NO. 1
TEHACHAPI ATCAAA
R 2508
DIVE CORRIDOR
MEDIUM ALTITUDE
BAKERSFIELD ATCAAA
ROSAMOND ATCAAA
(ZONE 2)
(ZONE 1)
NO. 1
NO. 4
SABELLA
MOJAVE
ROSAMOND LAKE
LANCASTER
PMD
PALMDALE
GMN
GORMAN
LHS
B-10-17
[redacted]



FOUR CORNERS
BORON
ATCAAA
EDW.
ROCKET BASE
ROGERS LAKE
BOMBING RANGE
SHUTDOWN
FLT B-10-17
PREMATURE SHUTDOWN
SEC RW 02 ROSAMOND
SEC RW 20 ROSAMOND
SEC RW 36 ROGERS
SEC RW 18 RHP
SEC RW 18 LHP
ENGINE MASTER, PROP SUPPLY OFF
JETTISON
STOP JETTISON TANKS & BLEED OFF
SAS 4,3,2
STBY TO CLOSE UP
& 3 HYD PUMPS ON
ROCKET CK, CHAMBER SW'S OFF
MACH REP TO .3
PMD

X-24B Flight Request
28 March 1974

Flight No: B-4C-~~18~~

Scheduled Date: 9 April 1974

Pilot: Major Love

Purpose: 1. Aileron Dead Band Investigation in Captive Flight Environment
2, Aileron Actuator Compartment Temperature Survey

Simulated Launch: West of Rosamond, Mag Heading 060° + Crosswind correction Angle. 45,000 feet, ~~190~~ 188 KIAS. Flap Bias "Manual", Upper Flaps = 40°, Lower Flaps = 10°, Rudder Bias Mode "AUTO", Rudder Bias = 0°. Rudder Trim = 1° Left. Aileron Bias = 7°, SAS Gains 6,5,3. Mach Reapeater "Manual" = 1.0, KRA "AUTO", Hydraulic Pumps 2 and 4 on.

B-52 Landing: Main Base Runway

B-52 Track: X-24B Track #2 (with extra turn) (R2515, Work Area I)

ITEM	EVENT
1	Takeoff and climb at 230 KIAS to 35,000 feet to initial point at Mojave, heading 100°. Complete checklist items to 25 minute point.
2	At the 25 minute point-proceed with checklist functions. B-52 will continue to climb to 45K at .74 to .76 Mach number.
3	At 18 minutes (before lox top off begins), X-24B will perform aileron activity cycle. Photo chase and B-52 aft camera will photograph all aileron activity cycles. Photo chase will also obtain close up movies of vapor/fluid flow from Lox vent line (lower left side) as final top off is reached.
4	At the initial 6 minute point, an 8 minute addition to the countdown will be announced. The initial 6 minute point will then become the new (14) minute point. (Updated countdown time will be denoted hereafter by a circle). The B-52 will continue the left turn to return to the initial 8 minute point location.
5	At the (12) minute point - perform aileron activity cycle.
6	At the (8) minute point - perform aileron activity cycle.
7	At the (4) minute point - perform aileron activity cycle.

ITEM	EVENT
8	At (45) to (15) sec perform pre-launch engine test.
9	At simulated launch point-X-24B pilot will begin aileron activity to simulate flight control inputs: B-52 pilot will maintain 45 K for 3 minutes then begin a descent (230 KIAS max). Chase and B-52 aft camera will photograph the aileron motion.
10	Seven minutes after the simulated launch point, the control system activity test will be terminated and the hydraulics turned off.
11	Proceed with the abort checklist.
12	If aileron dead band had been encountered, NASA I will request additional aileron activity cycles during descent and after landing.

NOTES:

1. Nose Ballast = 220 lbs (+ 100 AMP HR EQUIP BATT)

ALTERNATE SITUATIONS

1. Surface wind limit, 10 kts crosswind/20 kts max

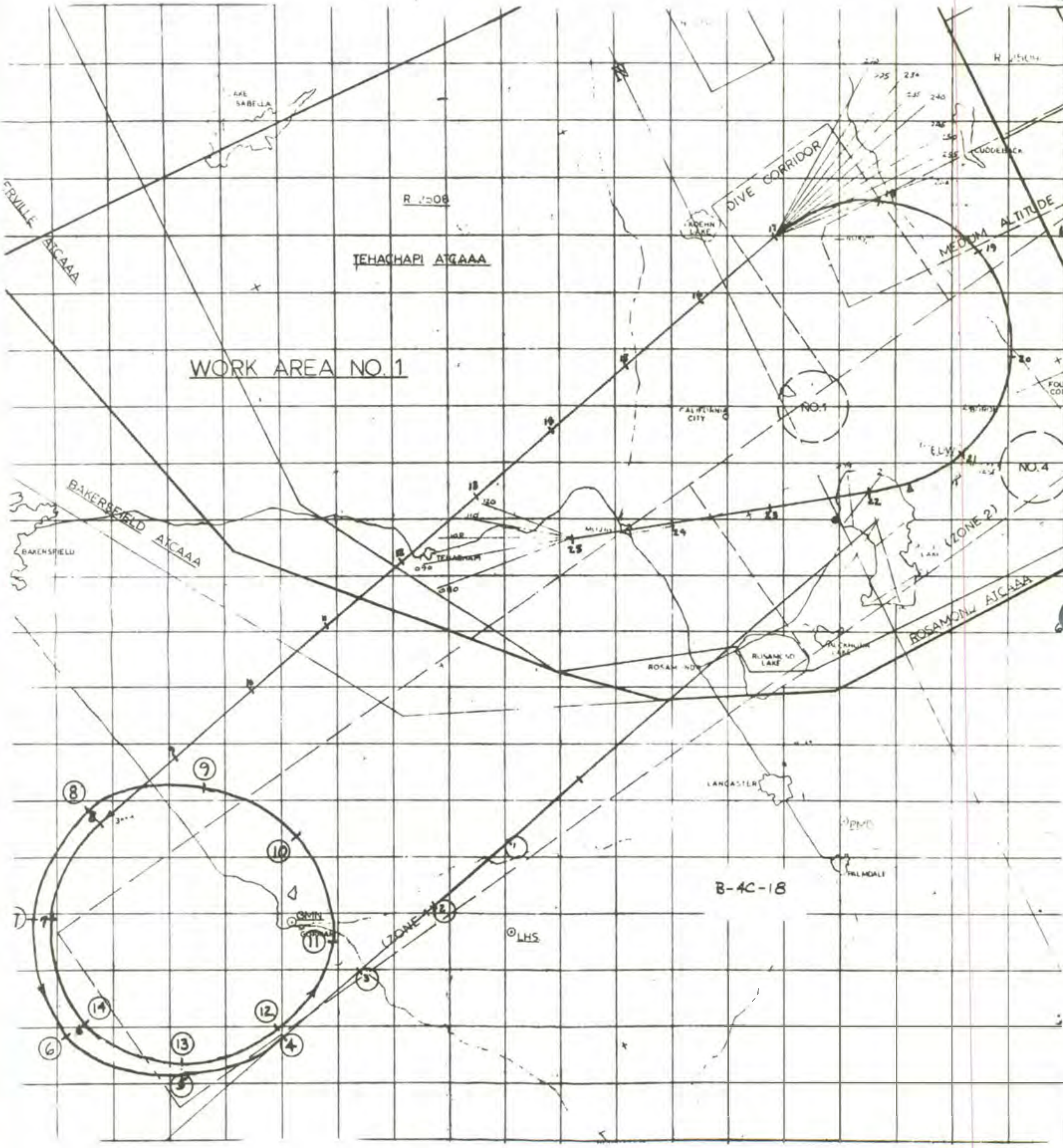
2. If systems check reveal X-24B to be in unflyable condition - abort mission.

Robert G. Hoey

ROBERT G. HOEY

Jack L. Kolf

JACK L. KOLF



WORK AREA NO.1
TEHACHAPI ATCAAA
R 2508
BAKERSFIELD ATCAAA
BAKERSFIELD
DIVE CORRIDOR
MEDIUM ALTITUDE
NO.1
NO.4
(ZONE 2)
ROSAMOND ATCAAA
ROSAMOND
ROSAMOND LAKE
LANCASTER
PALMDALE
PMD
LHS
GMN
ZONE
CALIFORNIA CITY
TEHACHAPI
B-4C-18

X-24B FLT B-10-21

TOD	MACH	ALT	KCAS	EVENTS
12:09:20.2	.7113	44817.	190.	LOX PRIME
:09:45.8	.7113	44817.	190.	IGNITER TEST
:09:58.7	.7121	44773.	191.	LAUNCH
12:10:02.5	.6974	44613.	188.	#2 & #4 CHAMBER PRESSURES START UP
:10:03.6	.6954	44522.	187.	WALC MANIFOLD PRESSURE DROP
:10:04	.6941	44489.	187.	FIN PRESSURE GLITCH
:10:04.8	.6928	44400.	187.	#2 & #4 CHAMBERS SHUT DOWN
:10:16.3	.6951	42638.	195.	#1 & #3 CHAMBER PRESSURES START UP
:10:17.6	.6927	42382.	196.	A_x STARTS INCREASE
:10:19.3	.7016	42030.	200.	A_x LEVEL (2 CHAMBERS)
:10:19.4	.7027	41998.	201.	#1 AT 100%
:10:19.7	.7092	41734.	203.	#3 AT 100%
:10:29.2	.7785	37852.	236.	#2 CHAMBER PRESSURE STARTS UP
:10:30.3	.7854	39615.	240.	A_x STARTS SECOND INCREASE
:10:31.5	.7925	39367.	244.	#2 AT 100%
:10:32.2	.7980	39228.	246.	A_x LEVEL (3 CHAMBERS)
:10:41.4	[illegible]	37934.	270.	MAX MACH DURING ROTATION
:10:57.0	.7601	[illegible]	237.	$\theta = 24°$
12:11:16.2	.6739	42021.	192.	FIN PRESSURE GLITCH
:11:26.0	.6601	43477.	183.	START LEFT HEADING CORRECTION (MAX $\phi = 12°$)
:11:49.2	.7056	46122.	183.	END LEFT HEADING CORRECTION
12:12:05.2	.7679	47656.	194.	RUDDER DOUBLET $\alpha = 13\frac{1}{2}°$
:12:07.3	.7746	47906.	195.	AILERON DOUBLET $\alpha = 13\frac{1}{2}°$
:12:22.2	.8145	49726.	197.	RUDDER DOUBLET $\alpha = 12°$
:12:24.5	.8149	50015.	196.	AILERON DOUBLET $\alpha = 12°$
:12:37.8	.8755	51527.	205.	ENGINE SHUTDOWN

B-10-21

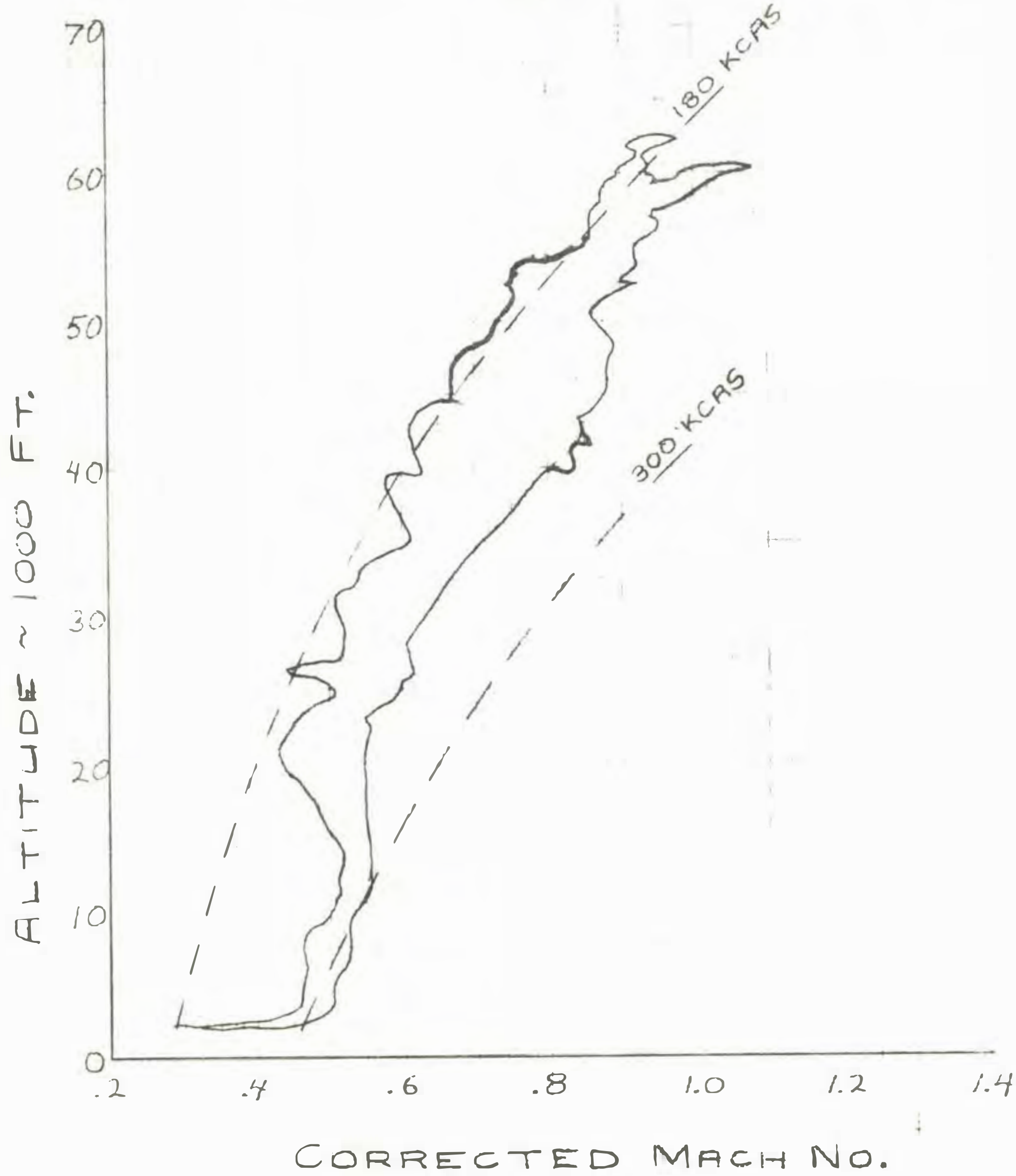
TOD	MACH	ALT	KCAS	EVENTS
12:12:37.8	.8755	515[illegible]	205.	AX DECREASE
:12:38.0	.8757	51601.	205.	MAX MACH
:12:39.3	.8659	51776.	203.	PUSHOVER TO 5° α
:12:42.0	.8374	51965.	193.	5° α
:12:44.9	.8272	52040.	185.	MAX ALTITUDE
:12:47.0	.7907	51993.	181.	RUDDER DOUBLET α = 5°
:12:49.5	.7731	51811.	177.	AILERON DOUBLET α = 5°
:12:50.0	.7684	51753.	176.	START RIGHT HEADING CORRECTION (MAX φ = 18°)
:12:55.3	.7603	50787.	178.	PULLUP TO 14° α
:12:56.7	.7684	50439.	182.	FIN PRESSURE GLITCH
:12:58.1	.7755	50052.	185.	14° α
12:13:00.1	[illegible]	49477.	190.	END RIGHT HEADING CORRECTION
:13:02.5	.775[illegible]	48783.	191.	PITCH PULSE (FWD)
:13:05.6	.7735	47883.	194.	PITCH PULSE (FWD)
:13:08.8	.7573	46952.	195.	PUSHOVER TO 10° α
:13:10.3	.[illegible]55	46507.	196.	START RIGHT HEADING CORRECTION (MAX φ = 25°)
:13:10.6	.7552	46418.	196	10° α
:13:11.2	.7574	[illegible]	198.	PITCH PULSE (FWD)
:13:13.5	.7617	[illegible]	[illegible]	PITCH PULSE (AFT)
:13:15.9	.7678	44767.	204.	PULLUP TO 13° α
:13:17.7	.7623	44204.	209.	13° α
:13:27.8	.7471	41305.	218.	END RIGHT HEADING CORRECTION
:13:28.5	.7485	41118.	220	START RIGHT HEADING CORRECTION (MAX φ = 18°)
:13:35.2	.7081	39675.	214.	END RIGHT HEADING CORRECTION
:13:36.6	.6937	39426.	210.	START PUSHOVER TO 9° α
13:37.6	.[illegible]879	39242.	210.	FIN PRESSURE GLITCH
:13:37.9	.6[illegible]	[illegible]	209.	9° α
:13:47.8	.6649	37960.	211.	RUDDER DOUBLET α = 10°
:13:50.7	.66[illegible]	[illegible]	213.	AILERON DOUBLET α = 10°

B-10-21

TOD	MACH	ALT	KCAS	EVENTS
12:13:54.2	.6525	35963.	213.	START TURN TO DOWNWIND (MAX ϕ = 48°)
:13:54.3	.6525	35941.	213.	START LOX JETTISON
:13:55.0	.6508	35819.	213.	START WALC JETTISON
				PITCH GAIN TO 4
:13:56.7	.6467	35464.	214.	ROLL GAIN TO 3
:13:57.1	.6453	35364.	214.	YAW GAIN TO 2
12:14:02.7	.6244	34254.	212.	END LOX JETTISON
:14:04.1	.6174	33964.	210.	END WALC JETTISON
:14:07.4	.6041	33253.	209.	MAX ϕ = 48°
:14:29.4	.5624	28029.	218.	END TURN TO DOWNWIND
:14:30.0	.5630	27919.	218.	START CONFIGURATION CHANGE
:14:37.6	.5654	26217.	228.	END CONFIGURATION CHANGE
:14:41.4	.5726	25396.	235.	START LEFT BANK (VISUAL POSITION CH - MAX ϕ = 30°)
:14:43.0	.5723	25077.	236.	ϕ = 30°
:14:46.0	.5750	24507.	240.	END LEFT BANK
12:15:04.1	.5366	22193.	235.	#1 & #3 HYDRAULICS ON
:15:05.7	.5355	21754.	236.	START ROCKET CHECK
:15:07.9	.5450	21628.	241.	END ROCKET CHECK
:15:14.9	.5442	20464.	247.	LOW KEY START TURN (MAX ϕ = 49°)
:15:32.1	.5550	16988.	270.	UPPER FLAPS START OUT (SPEEDBRAKES) (28½° MAX)
:15:50.0	.5345	12457.	283.	UPPER FLAPS INCREASE (31° MAX)
:15:56.8	.5141	10560.	282.	UPPER FLAPS START RETURN TO 20°
12:16:05.7	.5192	8182.	297.	UPPER FLAPS AT 20°
:16:09.1	.5027	7361.	304.	MACH REPEATER TO .3
:16:28.1	.4915	3556.	311.	LEVEL ON FINAL
:16:28.5	.4989	3479.	311.	START FLARE
:16:48.1	.3773	2150.	240.	GEAR DOWN
:16:57.8	.2844	2089.	181.	MAIN GEAR TOUCHDOWN α = 11½°
:16:58.4	.2836	2089.	181.	CROSSOVER TO UPPER FLAP
2 :17:01.1	.2567	2084.	164.	NOSEGEAR TOUCHDOWN
:17:07.1	.2079	2080.	132.	CROSSOVER TO LOWER FLAP

X-24B

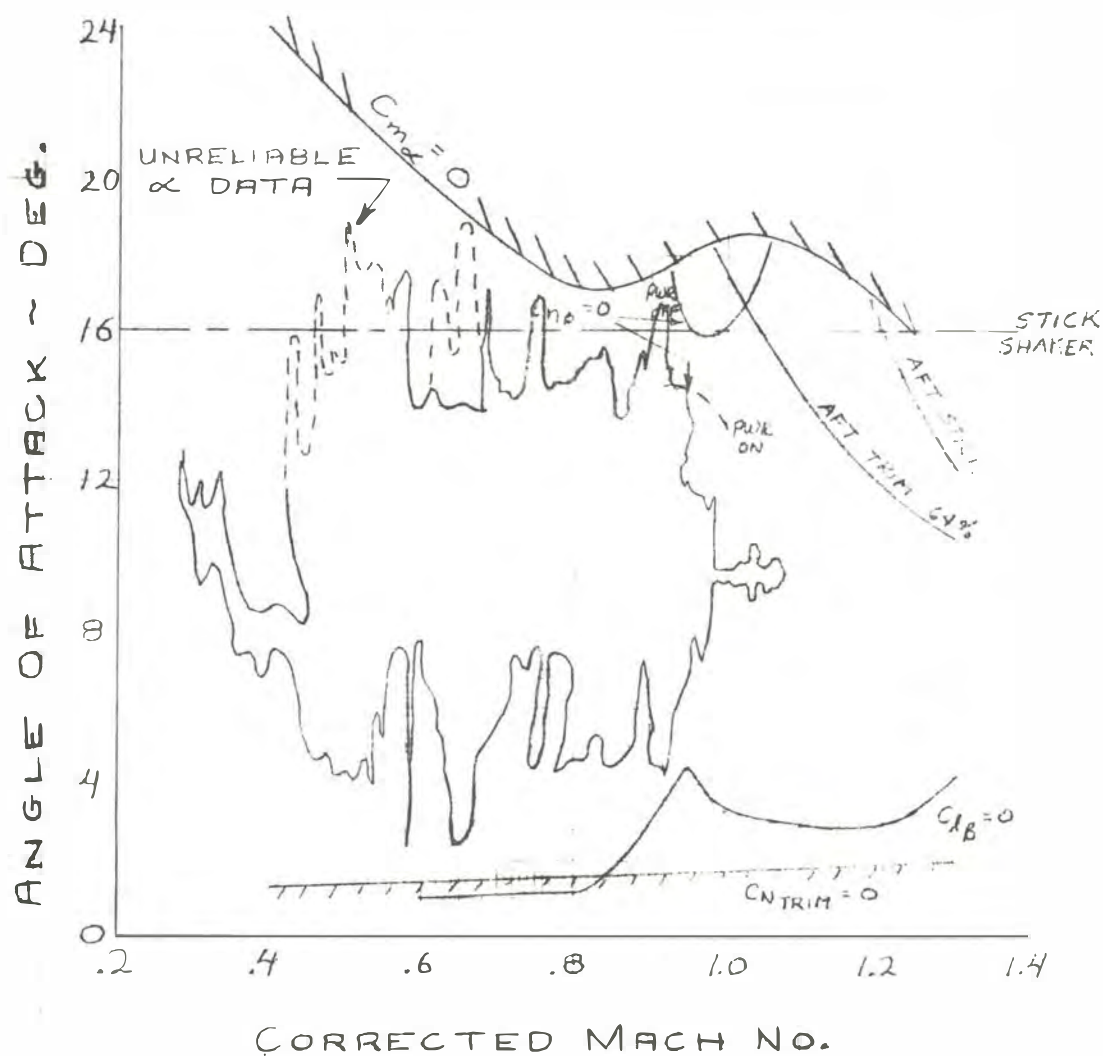
MACH NO. VS ALTITUDE ENVELOPE
FLIGHTS 1 THRU 10



X-24B

MACH NO. VS ANGLE OF ATTACK ENVELOPE

FLIGHTS 1 THRU 10



X-24B DERIVATIVES

Alex G. Sim

From flight 10, six sets of derivatives were obtained. Two of these were in the longitudinal mode while the other four were in the lateral-directional mode.

The two longitudinal sets of derivatives, shown in figure 1, were obtained power off at about Mach number 0.8. These were obtained from maneuvers consisting of two lower flap inputs which were separated by approximately two seconds of no pilot control input. This "double pulse" type of maneuver is considered to yield better results than the conventional "single pulse" type of maneuver.

Of the four sets of lateral-directional derivatives obtained, three were at about a Mach number of 0.8; while the other was at a Mach number of 0.7. The Mach 0.8 data are shown in figure 2. In this figure, data which were obtained using the Newton-Raphson digital technique (without flags) are presented with "confidence levels" which indicate the amount of information contained in a particular maneuver about each derivative. A wide confidence level or bound indicates a lack of information about a specific derivative. The flight 10 static stability derivatives have a lower confidence level than those previously obtained and tend to verify the line of static stability indicated by the wind tunnel predictions. Note that the power-on flight 7 derivatives were obtained from airplane oscillations resulting from beta-excursions rather than from intentional maneuvers for the purpose of derivative extraction. The Mach number 0.7 set of derivatives agree well with data previously obtained.

FIGURE 1

X-24B DERIVATIVES

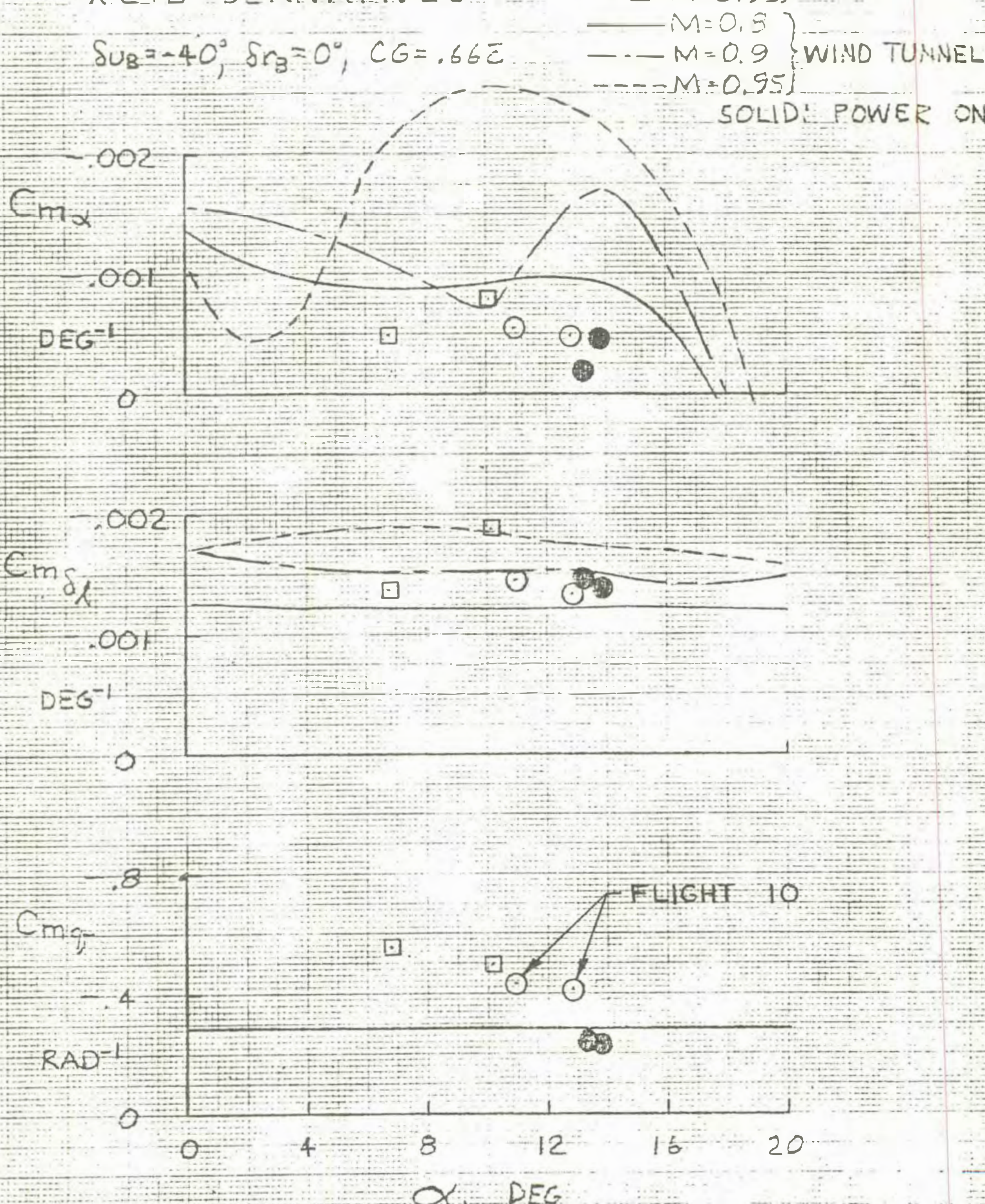


FIGURE 2 (a)

X-24B DERIVATIVES

$M=0.8$, $\delta u_B = -40°$, $\delta r_\beta = 0°$

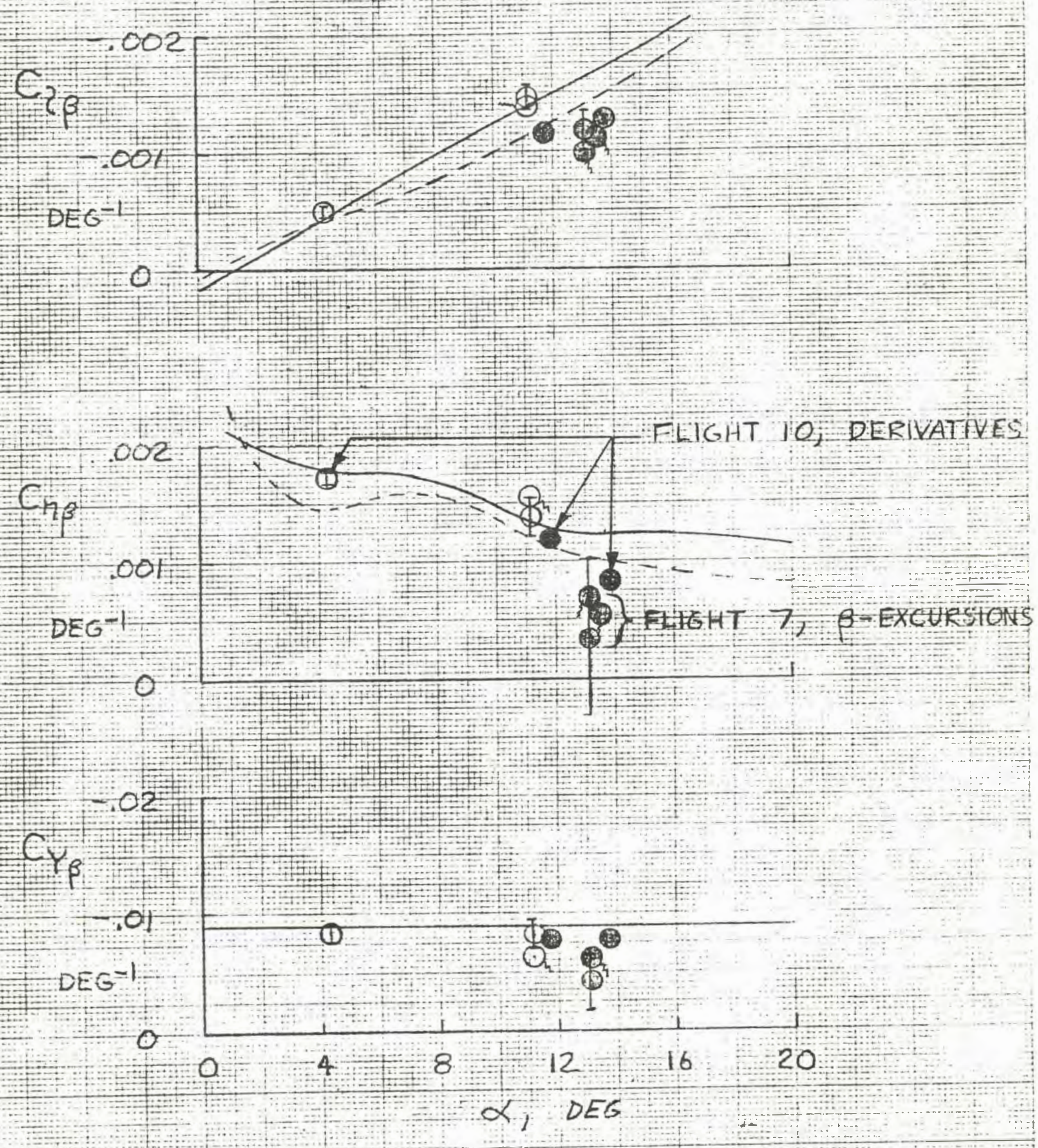


FIGURE 2 (b)

X-24B DERIVATIVES

$\delta v_B = -40°$, $\delta r_B = 0°$

○ M = 0.8, □ M = 0.9, △ M = 0.95 } FLIGHT

——— M = 0.8, — — — M = 0.9, ——— M = 0.95 } WIND TUNNEL

SOLID: POWER ON

FLAG: HYBRID

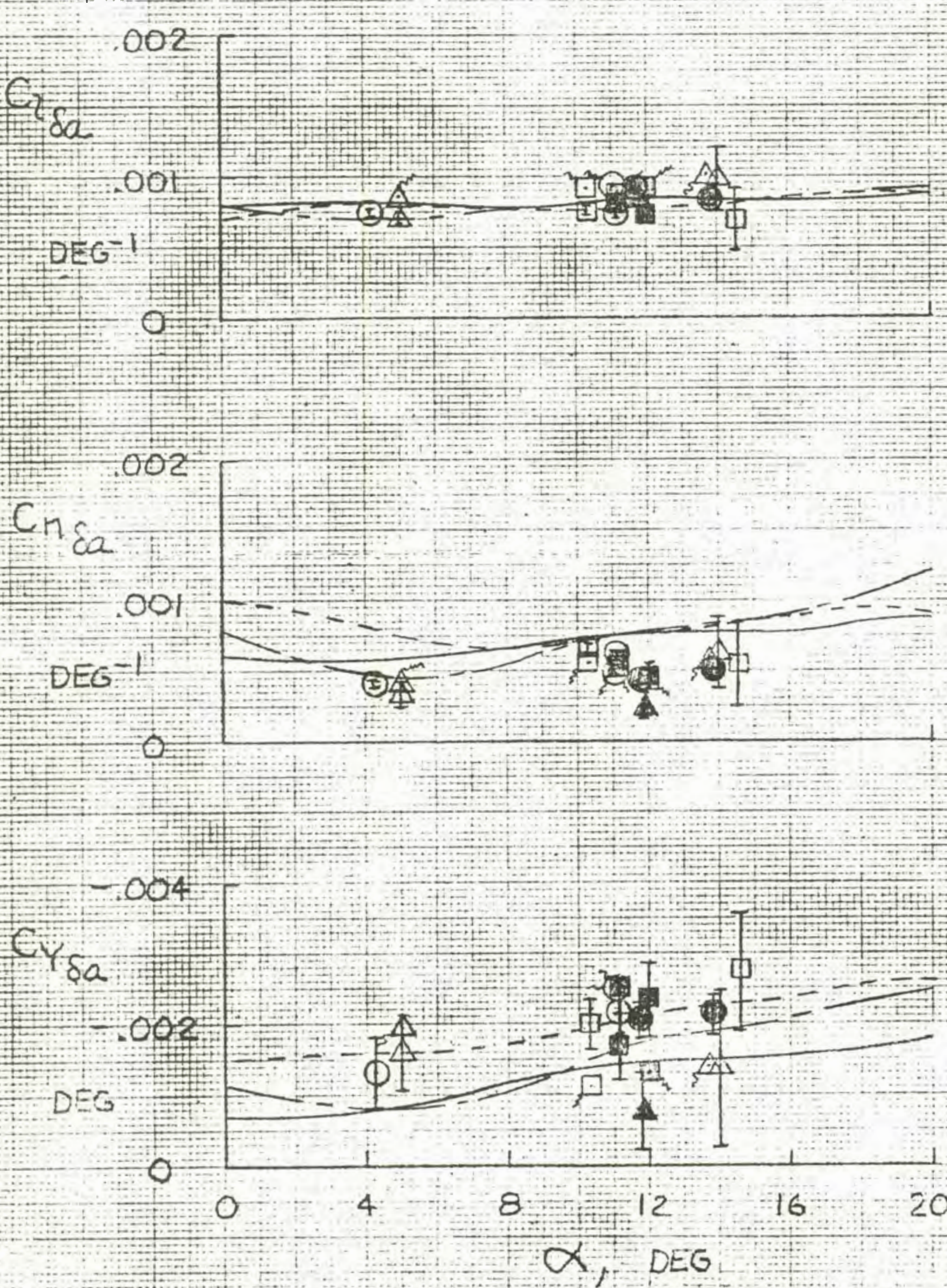


FIGURE 2 (c)

X-24B DERIVATIVES

$\delta_{u_B} = -40°, \quad \delta_{r_B} = 0°$

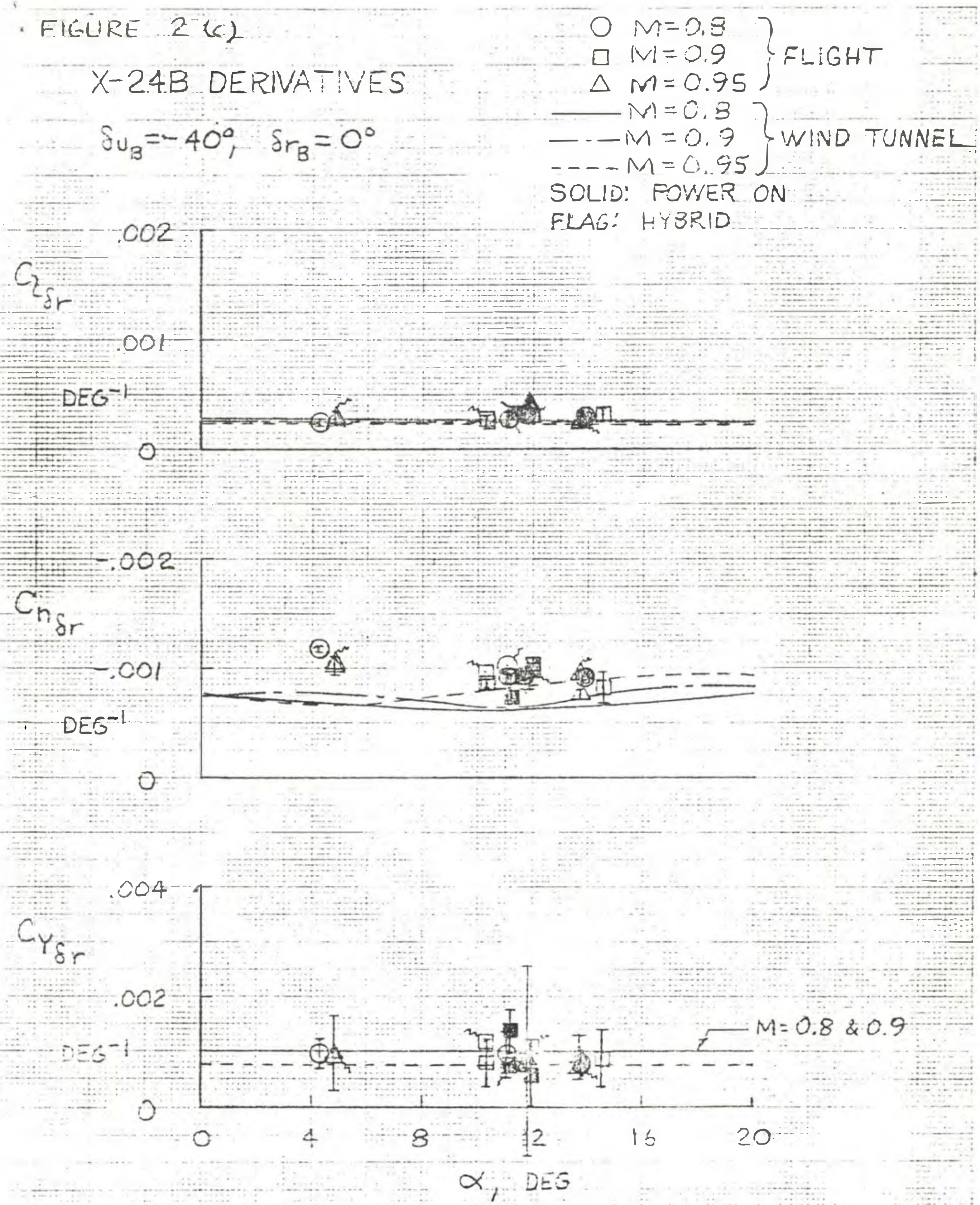
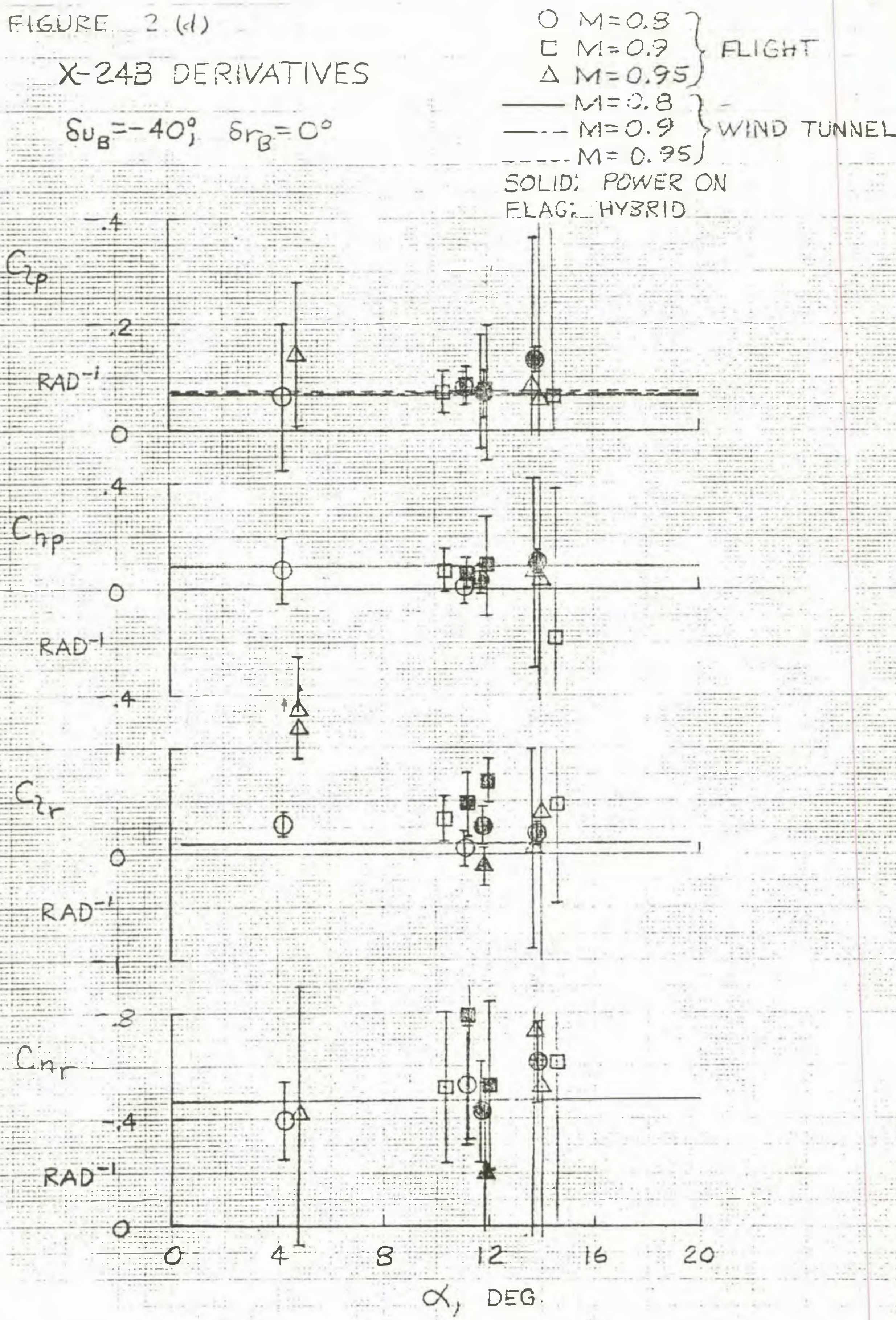


FIGURE 2 (d)

X-24B DERIVATIVES

$\delta u_B = -40°; \quad \delta r_B = 0°$



FLT. B-10-21

PILOT RATING SUMMARY

OVERALL RATING DURING ENGINE LITE (DELAYED)	2
OVERALL RATING DURING ROTATION	4
TASK TO MAINTAIN 25° θ	3
OVERALL RATING ABOVE .85 MACH - PWR ON	2
H.Q. AT 5° α ≈ .8 MACH - PWR OFF	2
OVERALL RATING @ .8 MACH / 10 TO 14° α	2

TECHNICAL DEBRIEFING

X-24B Flight B-10-21

Pilot: Major Love

1. Describe the launch transient (190KIAS)

Answer:

Launch transient was the same as I saw on the 2nd flight. I was strapped in tightly and I didn't rise up in the seat. I didn't look outside on this one, I looked directly at switches 2 and 4 and during the pitch down I was able to move my left hand right on those two switches. So I wouldn't say there was much to the launch transient. I looked up from getting my hand on those two switches to the alpha gauge and saw, I think 11^{o} and was not aware of any roll off. Very easy to control, no concern at all in controlling the airplane. I think that it would be impossible for me to note any difference between being empty and full during that 4 seconds lets say from hitting the switch to actually flying the airplane.

2. Discuss the engine light sequence and any associated trim changes.

Answer:

We had an abnormal engine light sequence. After I'd hit what I thought was 11^{o}, I pushed numbers 2 and 4 switches forward, got some noise and some twitching on the guages but no chamber light. I waited what I felt was an appropriate amount of time just to be sure I wasn't getting anything and things got pretty quite. Then I turned 2 and 4 off; hit reset; turned 1 and 3 on: got correct amount of noise; correct amount of gauge movement and two lights with some pulsing during the light sequence. Then tried chamber 4; the switch for 4 was off at the time. I moved it to on-got some noise and a little bit of movement on the gauges over in the chamber pressure gauges and then nothing. I turned 4 off, moved switch 2 on and in this case I got noise, again I noted a pointer moved through about 160 (psi) then looked up for the light and got the light by the time I was looking up there. I was busy enough during this light sequence that I didn't notice any trim changes. I was aware that I was probably moving back and forth between 10^{o} and 13^{o} of α, I was making no considered effort to trim and I was not aware of any big requirement for rudder or aileron. The airplane was pleasant to fly during this time because I could just leave it alone and look down at chamber switch and look at chamber gauges, look at lights and spend almost no time looking at the alpha gauge but at the same time being aware that the alpha was staying down well below 14^{o}.

Question: Rate the pilot's task of lighting the engine?

Answer:

With this light sequence that I described with the aim alpha not actually going to 14^{o} but being somewhere above 10^{o}, say 10^{o} and 13^{o}. The reason for this Johnny is that Manke had made it clear to me that I should just go ahead and stay in that regime while I was lighting the engine so without the task of trying to hold a high α and light the engine just let the airplane fly. I'd have to rate it at a pretty good rating, I would rate it at 2 for the tasks I flew today. Reason for this rating of 2 is possible, is that the pitch task was a very loose task all I had to do was fly the airplane in a controlled manner between 10^{o} and 13^{o}, I didn't have a very

FLT. B-10-21

PILOT RATING SUMMARY

OVERALL RATING DURING ENGINE LITE (DELAYED)	2
OVERALL RATING DURING ROTATION	4
TASK TO MAINTAIN 25° θ	3
OVERALL RATING ABOVE .85 MACH - PWR ON	2
H.Q. AT 5° α ≈ .8 MACH - PWR OFF	2
OVERALL RATING @ .8 MACH / 10 TO 14° α	2

TECHNICAL DEBRIEFING

X-24B Flight B-10-21

Pilot: Major Love

1. Describe the launch transient (190KIAS)

Answer:

Launch transient was the same as I saw on the 2nd flight. I was strapped in tightly and I didn't rise up in the seat. I didn't look outside on this one, I looked directly at switches 2 and 4 and during the pitch down I was able to move my left hand right on those two switches. So I wouldn't say there was much to the launch transient. I looked up from getting my hand on those two switches to the alpha gauge and saw, I think 11° and was not aware of any roll off. Very easy to control, no concern at all in controlling the airplane. I think that it would be impossible for me to note any difference between being empty and full during that 4 seconds lets say from hitting the switch to actually flying the airplane.

2. Discuss the engine light sequence and any associated trim changes.

Answer:

We had an abnormal engine light sequence. After I'd hit what I thought was 11°, I pushed numbers 2 and 4 switches forward, got some noise and some twitching on the guages but no chamber light. I waited what I felt was an appropriate amount of time just to be sure I wasn't getting anything and things got pretty quite. Then I turned 2 and 4 off; hit reset; turned 1 and 3 on: got correct amount of noise: correct amount of gauge movement and two lights with some pulsing during the light sequence. Then tried chamber 4; the switch for 4 was off at the time. I moved it to on-got some noise and a little bit of movement on the gauges over in the chamber pressure gauges and then nothing. I turned 4 off, moved switch 2 on and in this case I got noise, again I noted a pointer moved through about 160 (psi) then looked up for the light and got the light by the time I was looking up there. I was busy enough during this light sequence that I didn't notice any trim changes. I was aware that I was probably moving back and forth between 10° and 13° of α, I was making no considered effort to trim and I was not aware of any big requirement for rudder or aileron. The airplane was pleasant to fly during this time because I could just leave it alone and look down at chamber switch and look at chamber gauges, look at lights and spend almost no time looking at the alpha gauge but at the same time being aware that the alpha was staying down well below 14°.

Question: Rate the pilot's task of lighting the engine?

Answer:
With this light sequence that I described with the aim alpha not actually going to 14° but being somewhere above 10°, say 10° and 13°. The reason for this Johnny is that Manke had made it clear to me that I should just go ahead and stay in that regime while I was lighting the engine so without the task of trying to hold a high α and light the engine just let the airplane fly. I'd have to rate it at a pretty good rating, I would rate it at 2 for the tasks I flew today. Reason for this rating of 2 is possible, is that the pitch task was a very loose task all I had to do was fly the airplane in a controlled manner between 10° and 13°, I didn't have a very

precise pitch task; I think the rating would be lower if I had a very tightly defined pitch task at the same time I was having to move my head up and down and look at different gauges and had a wide cross check like that.

3. Discuss the handling qualities during the rotation.
   Rate Pitch, and lateral directional.

   Answer:

All right, when we got the engine started I saw somewhere between 260-270 (KIAS) I wasn't sure of the airspeed, I was very sure I had .85 indicated Mach. I thought, I will now go to 14^o α and I found it difficult to make myself trim to 14^o. I think the reason being that I sensed a pitch rate and the pitch rate concerned me, It's just something I hadn't seen before because the simulator doesn't give you a pitch rate. I'd hold about 13^o and try to trim to 14^o and then I'd watch the 8 ball and the outside and it just took me awhile to get it up to 14^o. I don't think that's an airplane problem. I was flying with two hands at this time so that I could control the roll off, go to 14^o and also trim out the tendency to roll off. I had a difficult time holding 14^o α to 25^o θ, (14^o plus or minus a 1/2). By the time I'd been at 25^o for awhile or hit 25^o it went down to 12^o α and holding 25^o θ wasn't a hard task. As the airspeed bled off then you could see the α creep back up and by this time I had 14^o and I was getting the roll trimed out and it felt good. I rate the pitch task and lateral-directional as a total pilot task because you have to use two hands, I'd have to rate it at _____(even though I feel that part of the problem of getting to 14^o was my hesitation; its still a difficult thing to do) I have to rate it a 4, I'll give you the reasons I rate it a 4 is the same reason I rate the simulator a 4. Thats a controlled stick and it shouldn't take two hands to do a pitch task and a roll task. Shouldn't be that difficult to fly; shouldn't have to go two hands to hold to 14^o and control that roll and that's why I go to a 4 because I say that warrants improvement if you got an airplane like that.

4.a. Discuss the task to maintain 25^o θ and rate.

   Answer:

I can rate both of those Johnny because we flew enough simulated delayed engine lights so that I can tell you. Once I got to 25^o θ, I got to a point where I could take my hands off the stick. I hope the cockpit film shows that because I could just leave it alone and it just set there. I was happy then and I could hold 25^o θ pretty easily and of course on a delay engine light you get to 14^o α and right then the rating goes from a 4 to 3, In my opinion. It becomes a reasonable thing to do, getting it trimmed up is not a reasonable thing its irritable, an irritation, I don't know what word to use.

b. How did α to maintain θ compare with the simulator?

   Answer:

4. b. continue

When I got at 25^{o} θ alpha was down to 12^{o} John called; we probably had better performance but I think that was just the more airspeed you get when you have a delayed engine light. Then the α moved to 14^{o} just as advertised. At 14^{o} the θ dropped off to 20^{o} and thats the last time I looked at it. Now whether it went down to 18^{o} like it does in the simulator well I don't know. But that looked just exactly like the simulator. I thought that the delayed engine lights we did in the simulator were just duplicated by what we did in the airplane.

5. Discuss the handling qualities above .85 Mach number with power on. Rate.

   Answer:

I was above .85 Mach number for such a short time that I don't know or I wasn't aware of anything. I just waited till I went to .87 and was listening to John's call and shut it down. The .85 indicated during rotation wasn't bad, it felt good. I felt good at, and above,.85 Mach. I rate it, since it feels good,at 2.

6. Compare the vehicle's response to the .8 & .85 doublets (power on) with the simulator.

   Answer:

I thought the response to the rudder doublet at both .8 and .85 was the same. I felt that there was even less response to the aileron at .8 than there is in the simulator. I mean virtually zero; as I said before its almost like the stick isn't hooked to the airplane. At .85 I could feel some response to the aileron doublet.

7. Discuss the trim changes at engine shutdown.

   Answer:

As I hit the engine master switch I was aware that I didn't want to put any stick inputs in. I got no trim changes, the nose just falls thru and I felt no pitch up or pitch down at all; very, very pleasant. Made it necessary of course to push the stick forward to go down 5^{o} α.

8. Discuss the rudder doublet at 5^{o} α after engine shutdown. If possible rate the handling qualities.

   Answer:

I think that you need to discuss getting to 5^{o} α. I find it a little difficult in the simulator to get to 5^{o} α and I had kind of come up with mechanical ways to trim and come out at 5^{o} α. Now I think I hit 5^{o} α plus or minus 1/2 and I hit it very easily in the airplane, it was easier than in the simulator to push over to 5^{o} α. Flying at 5^{o} α was extremely pleasant. The most pleasant part of the flight except for the final portions of the landing pattern which are about the same. (b) No tendency to roll off like the simulator does. No Yawing. Easy to stay at 5^{o} α. One of the things that surprised me, we usually talk of time compression where the flight goes fast; faster than the simulator. It seemed to take quite a bit longer to slow down to .78 Mach than the simulator. So it was easier to shut down, go to 5^{o} α, trim and feel what the airplane felt like, and look up still not have .78 and then just really nail it right on .78 Mach when we got there. I'd have to rate the handling qualities there very good at 2.

9. Discuss the pitch pulses at .8 Mach number at 14° and 10° α with respect to Mach number control and vehicle response to pulse compared to simulator.

Answer:

This whole maneuver starts in the letting the nose down and letting the Mach coming back up to .78 and pull the nose up and stop the Mach. I wasn't aware of going to $-20^{\circ}(\theta)$ I was just letting the airplane nose go down watching the Mach indicator and then pulling the nose up to 14° α and its easier to get it up to 14° α than it is in the simulator. I think its easier to trim to 14° α and I think I hit 14° α well; right at .78. Did a pitch pulse and forward and got about 3° change just like the simulator. Back up another one, the Mach held at .78 trim over to 10° α. That was easy to hold ten; a pitched pulse forward and got about 3° and I was intending to put in a pretty good aft pitch pulse in all preparation for this flight. But, I didn't intend to put in as much as I did. I put in about 6° on that pulse, I intend to get about 14° or 15° α. I got the stick shaker on that one and thats because I just pulled too hard. Harder than I had been in the simulator. So overall I'd say that, that was an excellent training maneuver if you were going to check a guy out. That was just super and if it got us some good data that's also fine. It was as easy or easier in the airplane to do that task than in simulator and it looked just like the simulator. I want to see the data but one of the things I was super happy with, was hitting the Mach number and I think I did. For a minute I thought I was going to have .8 indicated at 14 and I was going to sit there for a moment but it looked like .78 to me. I was really happy to be able to do that. I don't see any place to rate the airplane there but I'd like to put a rating on there because I thought that was a pretty good task to do. I rate it a 2. The overall airplane at 2 because even though I had to trim a bunch of aileron in, as we climbed out, I wasn't aware of trimming it out. If I did trim it out I wasn't aware of a lot of rolling off or problems in any other axis it was a very straight forward task of flying the airplane.

10. Discuss the doublet set at .7 Mach and 11° α.

Answer:

I had another surprise in this area. I went to 13° α and prop supply off and expected the Mach to bleed off and the Mach didn't bleed off like in the simulator. This seems to take longer. I went down and waited until about .72 down to 9° α back to 11° α and hit .68. It just didn't seem to move towards that .68 like the simulator does. The response to the doublet at .68 was like the simulator, you get a little sharper response and I don't quite understand that in the airplane but its about like if you put a rudder doublet in some airplanes at high altitudes doublet you get a kind of a sloppy slow response. At .68 in simulator shows a much sharper more well pronounced response and airplane looks the same as the simulator.

11. Discuss the energy management from the "intersection to low key'.

Answer:

That was a very easy thing to do,John said; "we were about on profile; about 2000 low and we were moving outside", so I was looking outside, roll into a turn went jettison on my own and SAS switch change, and turned the chamber switches off and based on his calls, altitude looked just like T-38 when I do it. They looked just like the simulator. Closed right up at 28000; couldn't have been more like the simulator this morning. Was able to tell Bill Dana, what my airspeed was going to be at low key in case he was not in and he was already in but we're going to have 250 KIAS at the highway and we did. We had 250 and just a little bit low, but thats because I decided to hold 250 there.

12. Discuss the pattern.

13. Discuss the landing and roll out.

Answer:

Pattern was a high energy pattern but easy to fly. I made a decision to put the flaps out early. I intended to get them to 30° but I don't think they went to 30°, I think I put them out probably at 25° or 26° just prior to the 90° point. Still wasn't gaining enough sink rate so I went to 30° and rolled out on final with a then out at 30° and then got them in. Just a easy pattern to fly; had a lot of bank angle in it and the airplane was very comfortable. Got the flaps in when I felt I had my aim point. I could have left them out a little longer cause as I got them in, the airspeed went from 300 to 310 and Bill called that, but the aim point stayed there but it was just a little bit fat. Started to flare at 1200 feet and come thru; got a 100 foot call was about 260 and then held it. At 50 foot waited for 240. Got the gear down and then I became very much aware that I wasn't in a T-38. Because I became aware of the nose rotation thats necessary; I just happen to get thru to my consciousness that you do have to raise the nose more on this but it was no problem. As I hit 240 it popped the gear out, had a sink rate still going; I wasn't level. I got a little bit of nose down transient as I got the gear out. Just enough to say I could see the nose bobble. Bill called three good ones and I still was waiting, I had about 210 and I could have touched down. So I determined to hold it off and try to hold my airspeed. Shot for 180 and feel that I came pretty close to a 180 touch down with the smoothest roll on that I felt. I think that may have something to do with the fact that the nose stayed up after it got on the ground. I got what people call a wheel roller I really went on with a low sink rate so the nose stayed up until the last 20 - 25% of the pitch down and then it started to accelerate pretty good then it hit the ground with a pretty good rate. In the roll out I armed the nose gear steering and was making steering inputs by 130 kts and I made a large one at 130. I didn't get the full rudder before I knew I had all I wanted. In other words, you've got pretty good authority at 130. I used just a little bit of braking to get it stopped didn't need it but I did.

14. What was your biggest surprise on this first powered flight?

Answer:

I'd say the biggest surprise was a very inconsequential thing, was the way the thing held its Mach coming down the back side. That surprised me. That was really nice because it made a lot easier task. I didn't seemed rushed.

FIN LOAD & CONTROL-SURFACE HINGE MOMENTS

BY

Ming H. Tang

The left-fin shear, C_y; bending-moment, C_B; and torque, C_T coefficients' variation with change in angle of attack at Mach numbers .75 and .92 are shown in figures 1(a) and 1(b). Both the flight strain-gage data and the pressure data show a higher load level than the wind tunnel values, particularly at angles of attack less than 10 degrees. It is interesting to note that at these Mach numbers the two independent data acquisition systems, strain gages and pressures indicated good correlation for C_y C_B and C_T.

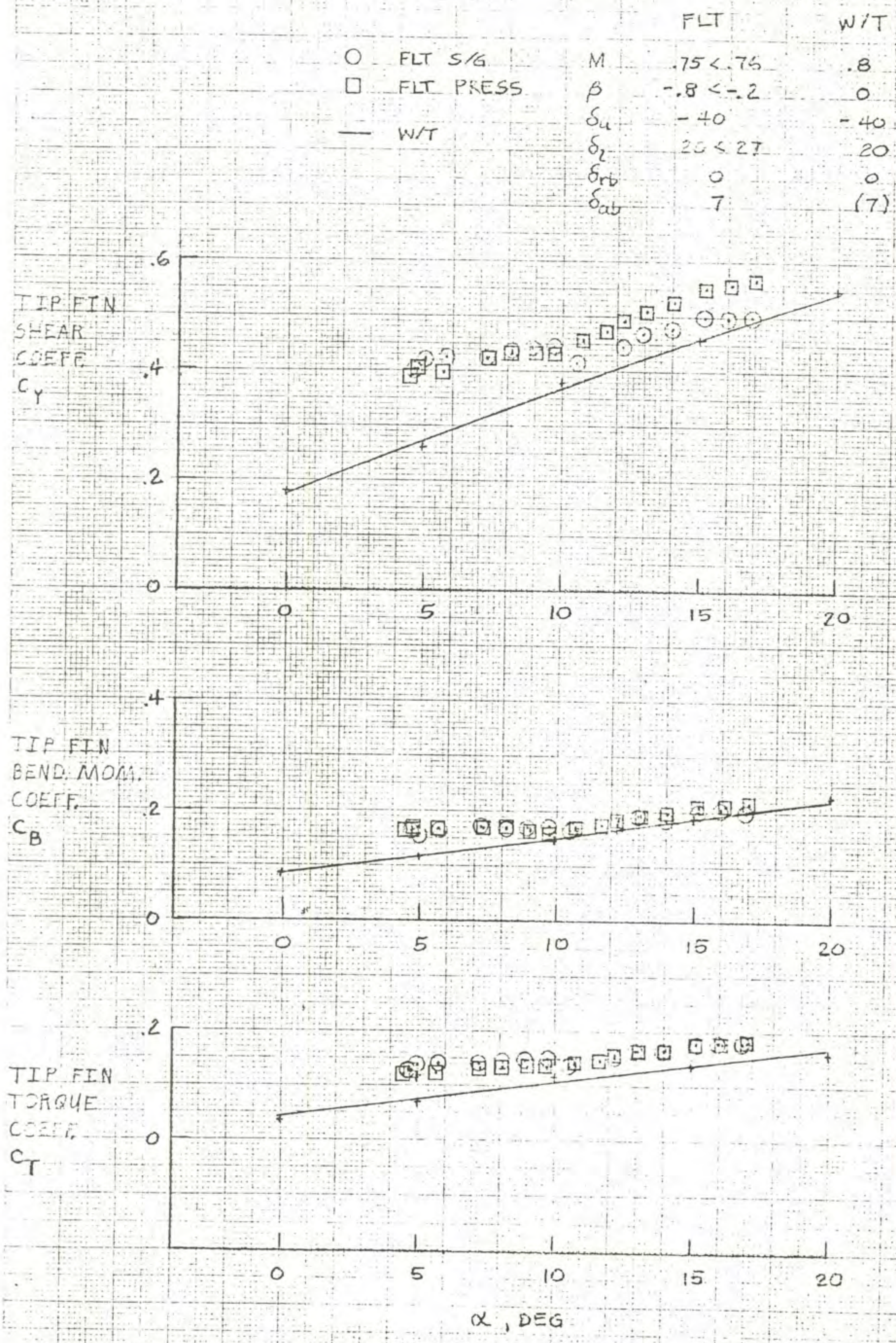
C_y, C_B and C_T variation with change in sideslip angle during a rudder doublet at Mach 1.0 is shown in figure 1(c). As might be expected during a doublet maneuver the strain-gage and pressure values show a wider scatter band due to the rudder motion. Similar to the Mach .75 and .92 conditions, the flight C_y C_B and C_T at Mach 1.0 are higher than the wind tunnel predictions. Agreement between the strain gage and pressure values is good.

The left upper and lower rudder hinge-moment coefficients' variation with angle of attack & angle of sideslip at Mach Numbers .75, .92 and 1.0 is shown in figures 2(a) through 2(c). As with the fin loads, the flight upper-rudder hinge-moments values are greater than the wind tunnel predictions. The lower rudder coefficients are virtually at zero hinge-moment level for both the flight and the wind tunnel values and show good correlation at all three Mach Numbers. The scatter in $C_{h_{ru}}$ in figure 2(c) is due to the rudder movement during the doublet.

The left upper flap, lower flap and aileron hinge-moment coefficients' variation with changes in angle of attack and angle of sideslip at .75, .92 and 1.0 Mach Number are shown in figures 3(a) through 3(c). No flight pressure values for the flaps and ailerons are available at this time.

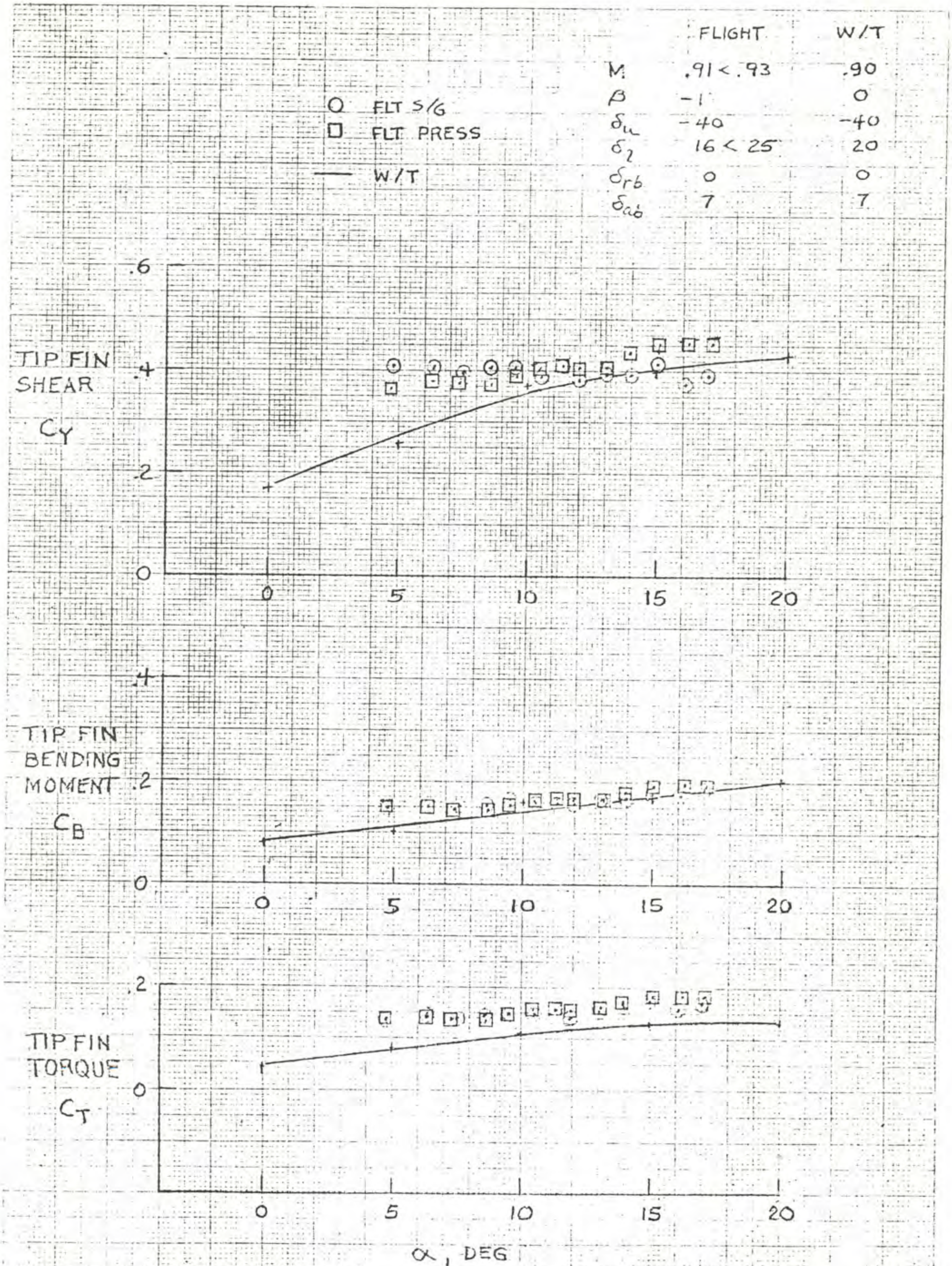
The upper flap and aileron hinge-moment coefficients show excellent agreement between the flight strain gage values and the wind tunnel predictions. The difference in slope in the lower flap hinge-moment coefficient due to change in angle of attack is due to not having corrected the flight hinge moments for lower flap position in figures 3(a) & 3(b). In figure 3(c) where the lower flap position was constant, the flight and wind tunnel lower flap hinge moments show excellent agreement.

The wind tunnel predicted variation of the shear force due to sideslip on the left fin versus Mach Number at 10 and 15 degrees angle of attack is shown in figure 4. The magnitude of C_{y_β} decreases with increasing Mach Number until Mach 1.0 after which C_{y_β} increases. (Exception is the single point for $10^\circ \alpha$ and Mach 1.0 where C_{y_β} increases in magnitude.) Since there is relatively small restoring force on the left fin at Mach Numbers greater than .9. Any assymetry on the vehicle due to flow separating off the fins or wind shear could result in the sideslip drifting out, as experienced in flight B-7-14 at .9 Mach and 12° angle of attack.



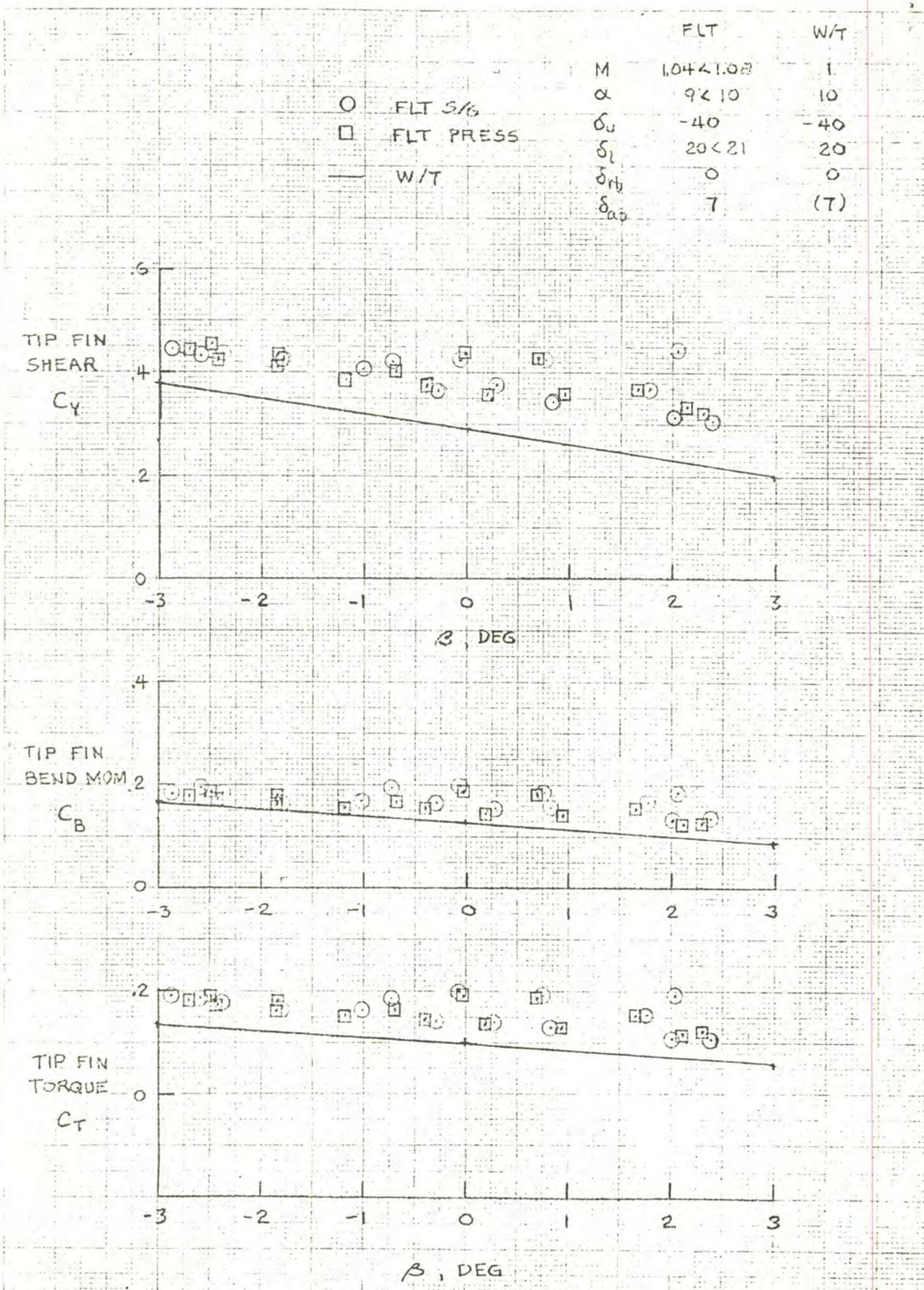
11-49-05-790 to 11-49-12-990
FLIGHT 8-9-16

FIG 1 (a)



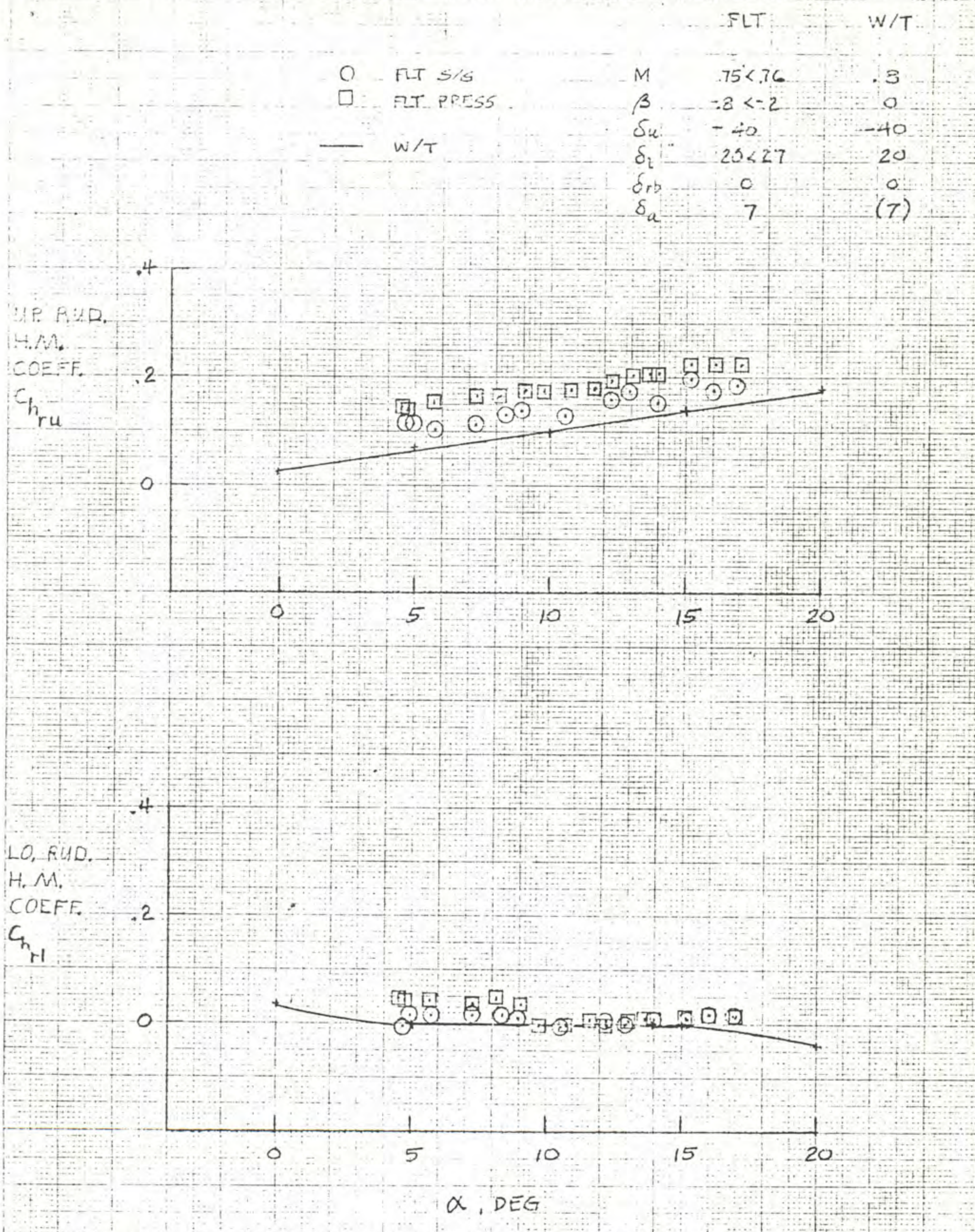
11:48:28.591
8-9-16

FIG 1 (b)



11:47:58.192
8-9-16

FIG 1(c)

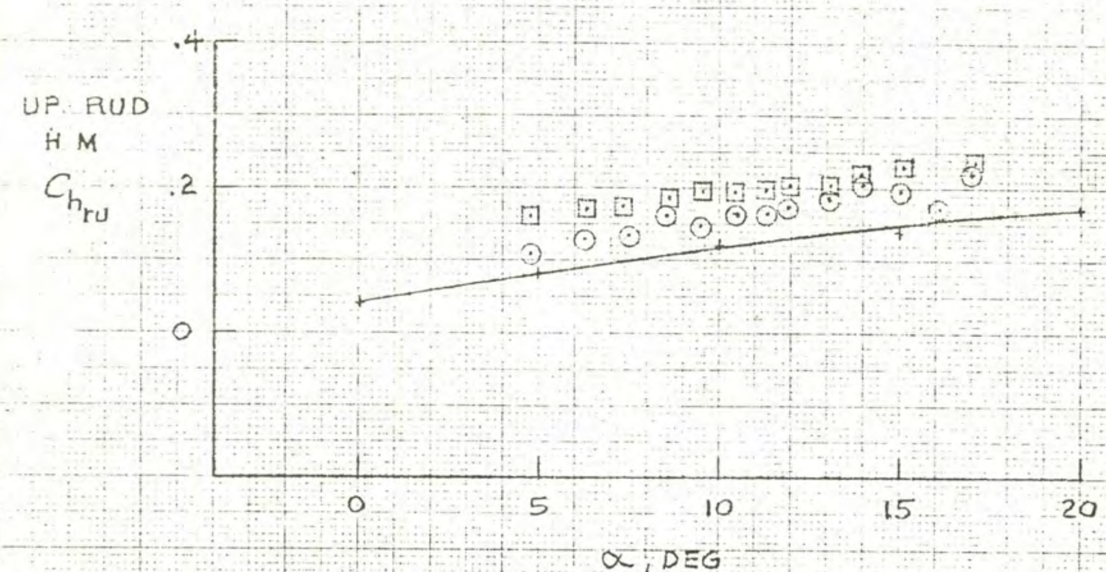


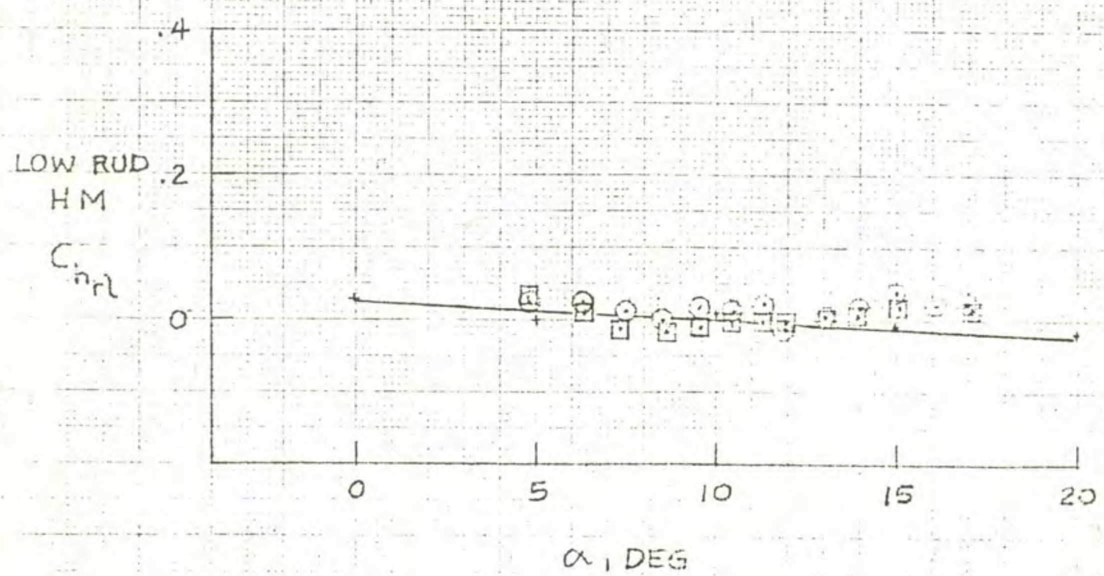
11-49-05-??? To 11-43-12-???
FLIGHT 8-9-10

FIG 2 (a)

- ○ FLT S/G
- □ FLT PRESS
- — W/T

	FLIGHT	W/T
M	.91 < .93	.90
β	−1	0
δ_u	−40	−40
δ_l	16 < 25	20
δ_{rb}	0	0
δ_{at}	7	7



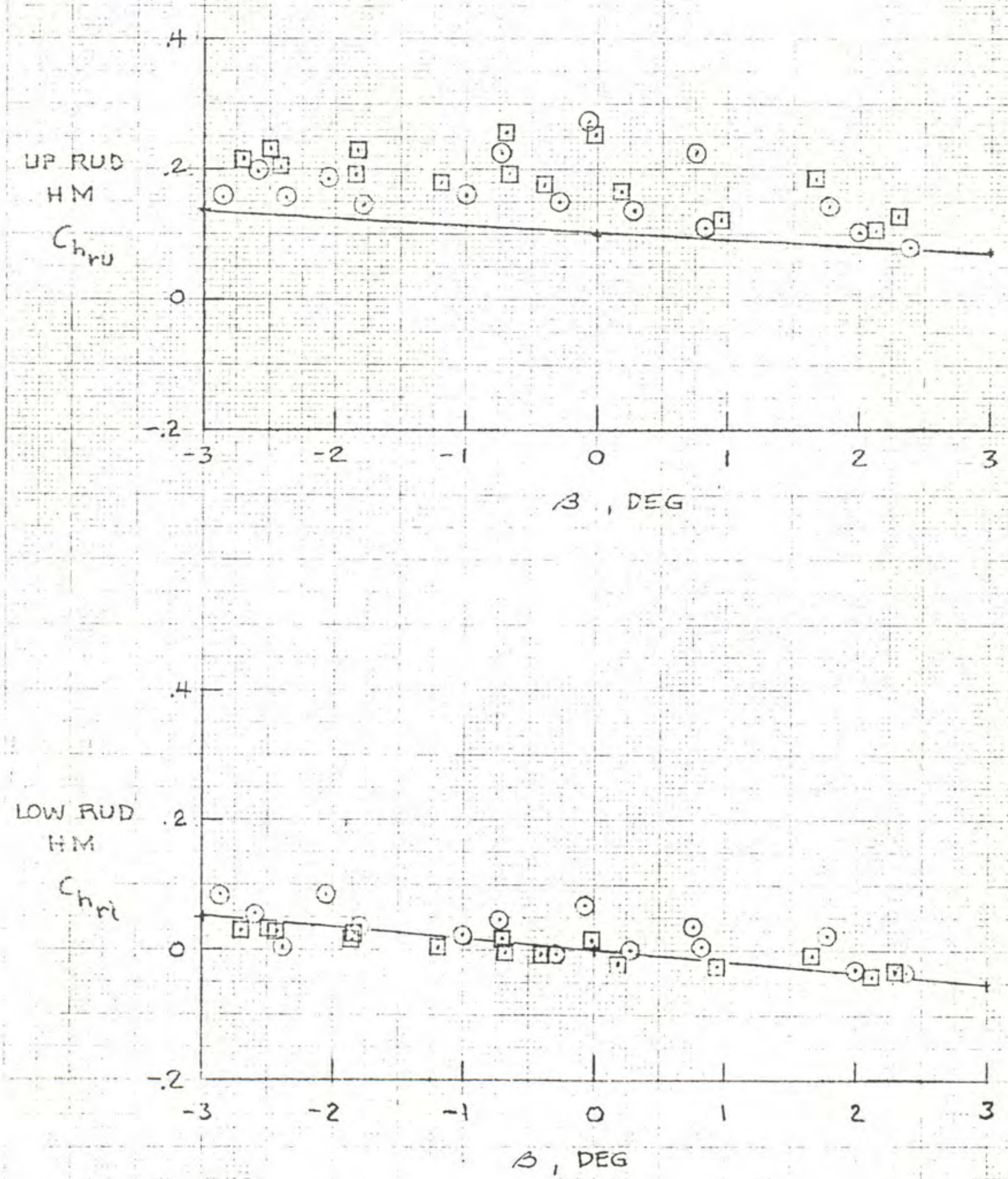


11:48:28.591
B-9-16

FIG (a)

	FLT	W/T
M	1.04 < 1.08	1.0
α	9 < 10	10
δ_u	-40	-40
δ_l	20 < 21	20
δ_{rb}	0	0
δ_{ab}	7	(7)

○ FLT S/G
□ FLT PRESS
— W/T



11:47:58.192
8-9-16

FIG 2(c)

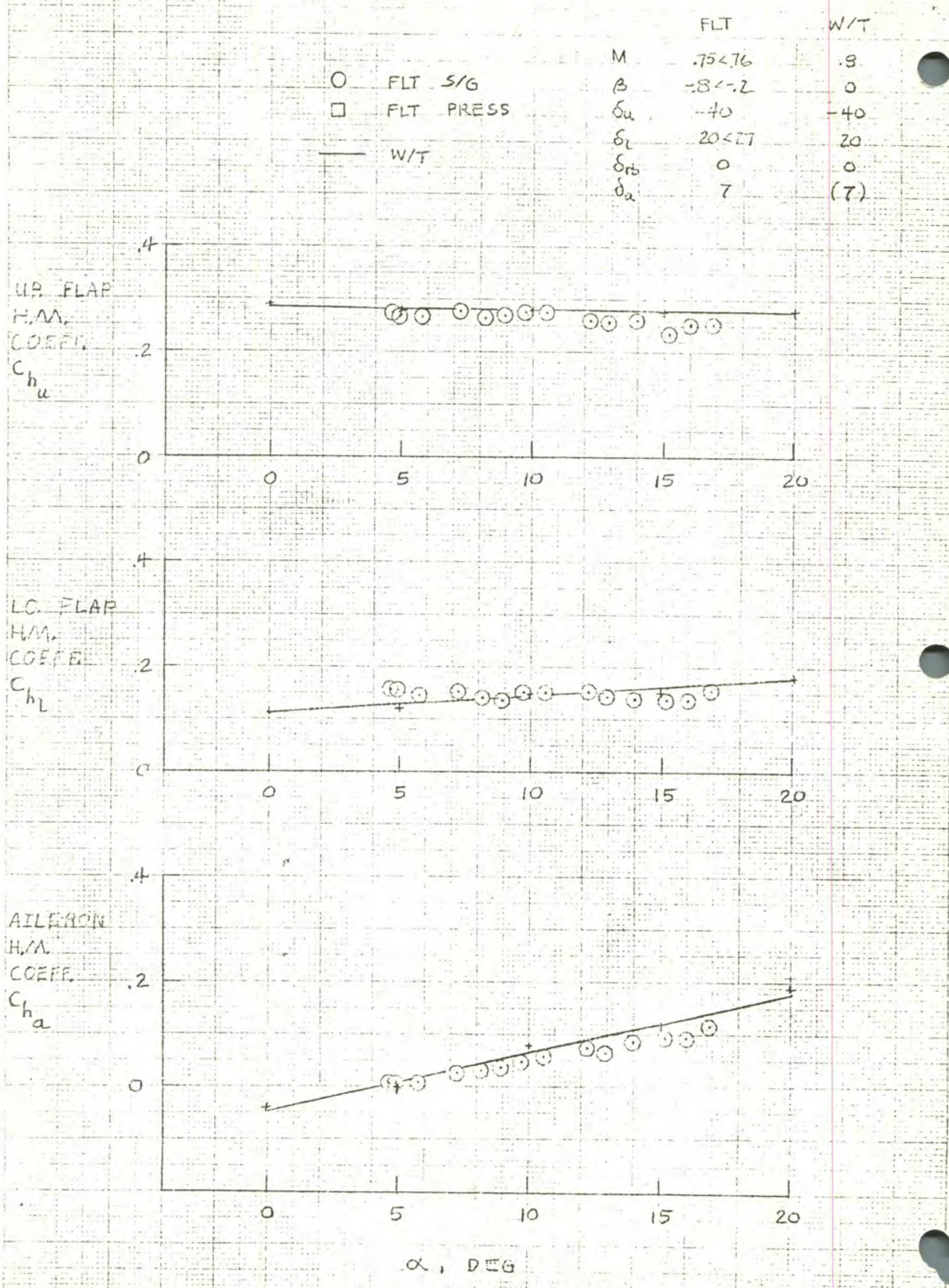
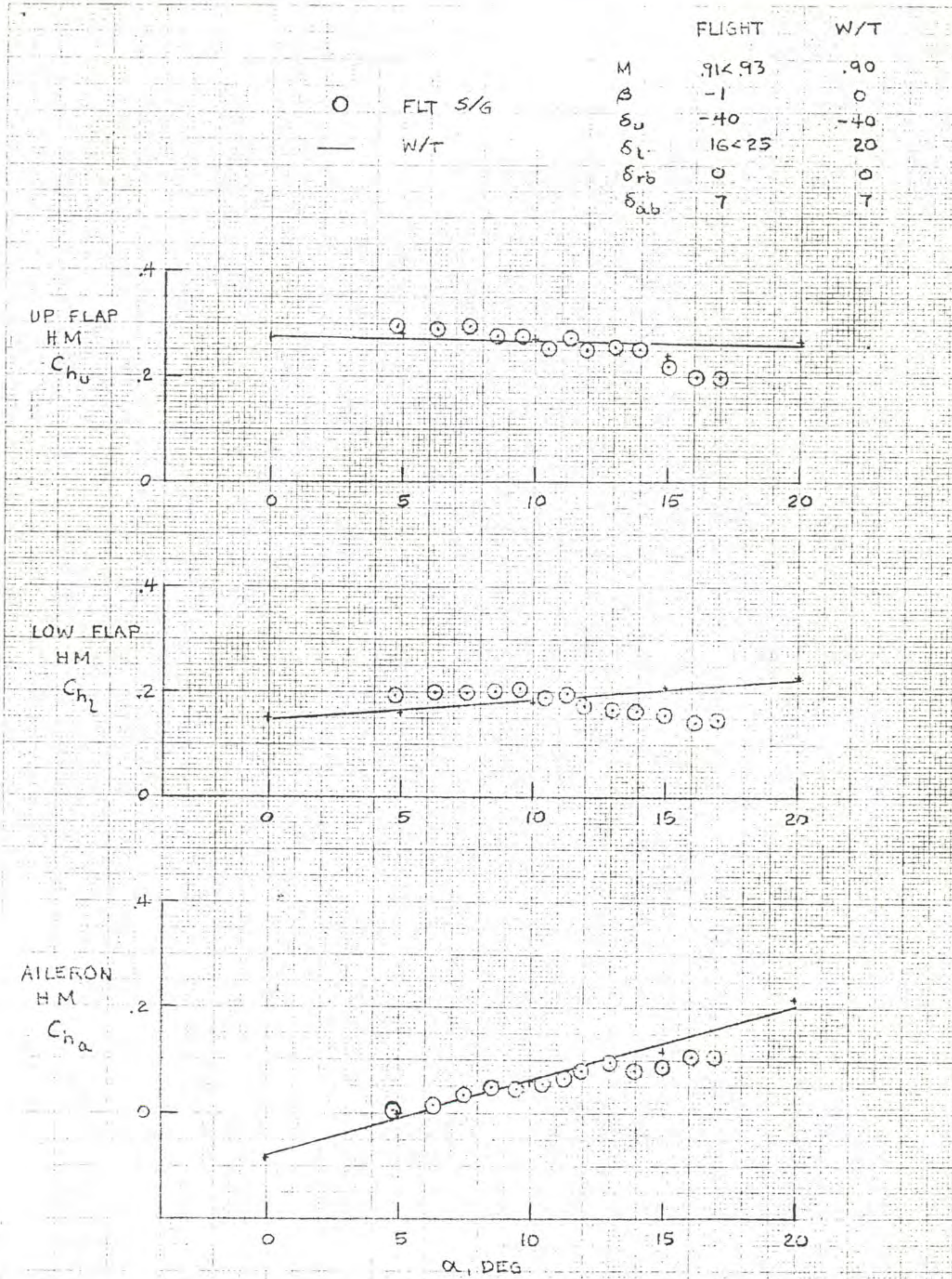

FLT
W/T
M .75<.76 .9
β -.8<-.2 0
δ_u -40 -40
δ_l 20<27 20
δ_{rb} 0 0
δ_a 7 (7)
○ FLT S/G
□ FLT PRESS
W/T
UP. FLAP
H.M.
COEFF.
C_{h_u}
LO. FLAP
H.M.
COEFF.
C_{h_l}
AILERON
H.M.
COEFF.
C_{h_a}
.4
.2
0
0
5
10
15
20
α, DEG

FIG 3 (a)



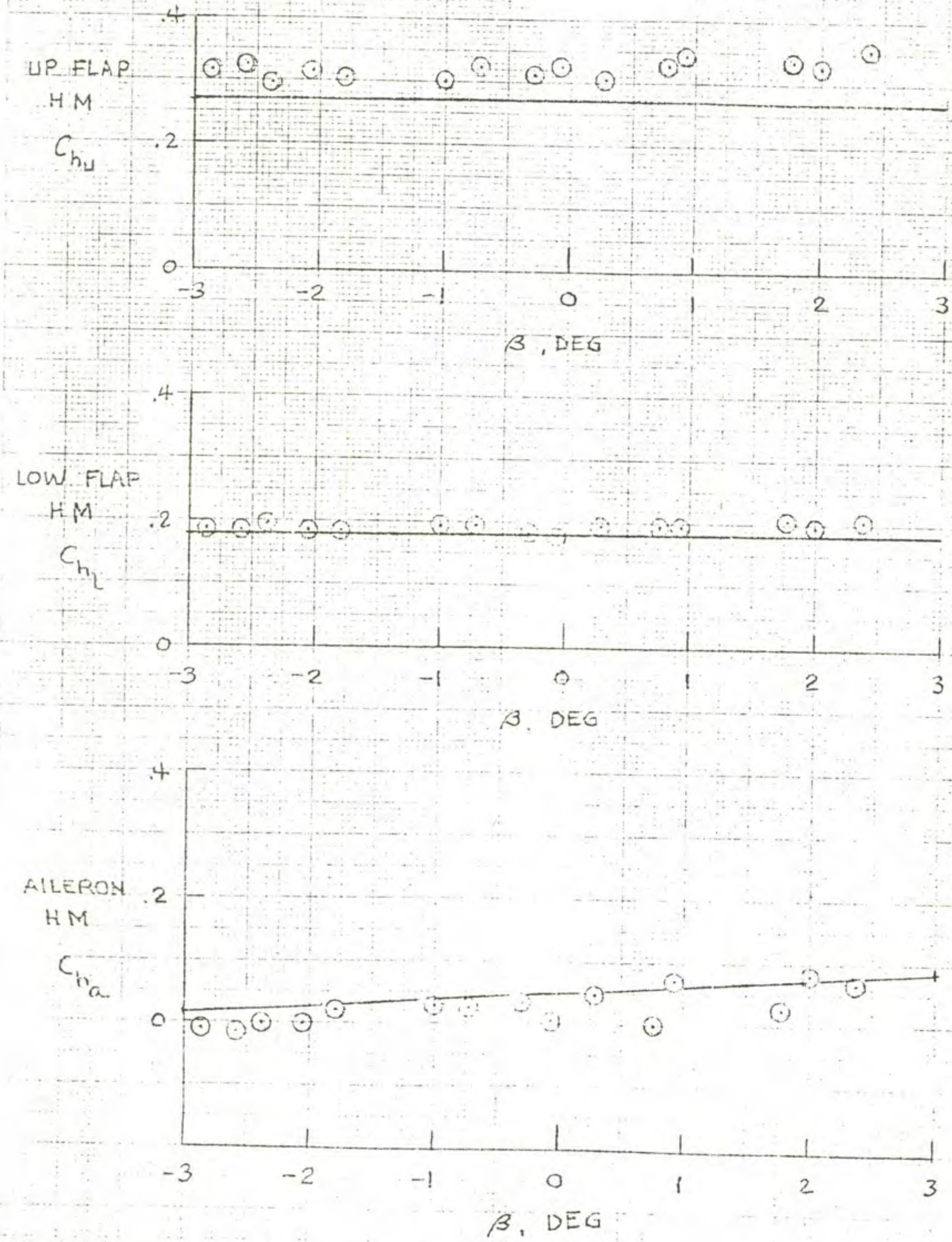
11:48:28.591
8-9-16

FIG 3(b)

○ FLT S/G

—— W/T

	FLT	W/T
M	1.04<T.08	1.0
α	9<10	10
δ_u	-40	-40
δ_l	20<21	20
δ_{rb}	0	0
δ_{ab}	7	(7)



11:47:58.192
B-9-16

FIG 3 (C)

WIND TUNNEL L/H FIN SIDEFORCE COEFFICIENT VARIATION WITH SIDESLIP AND MACH NUMBER

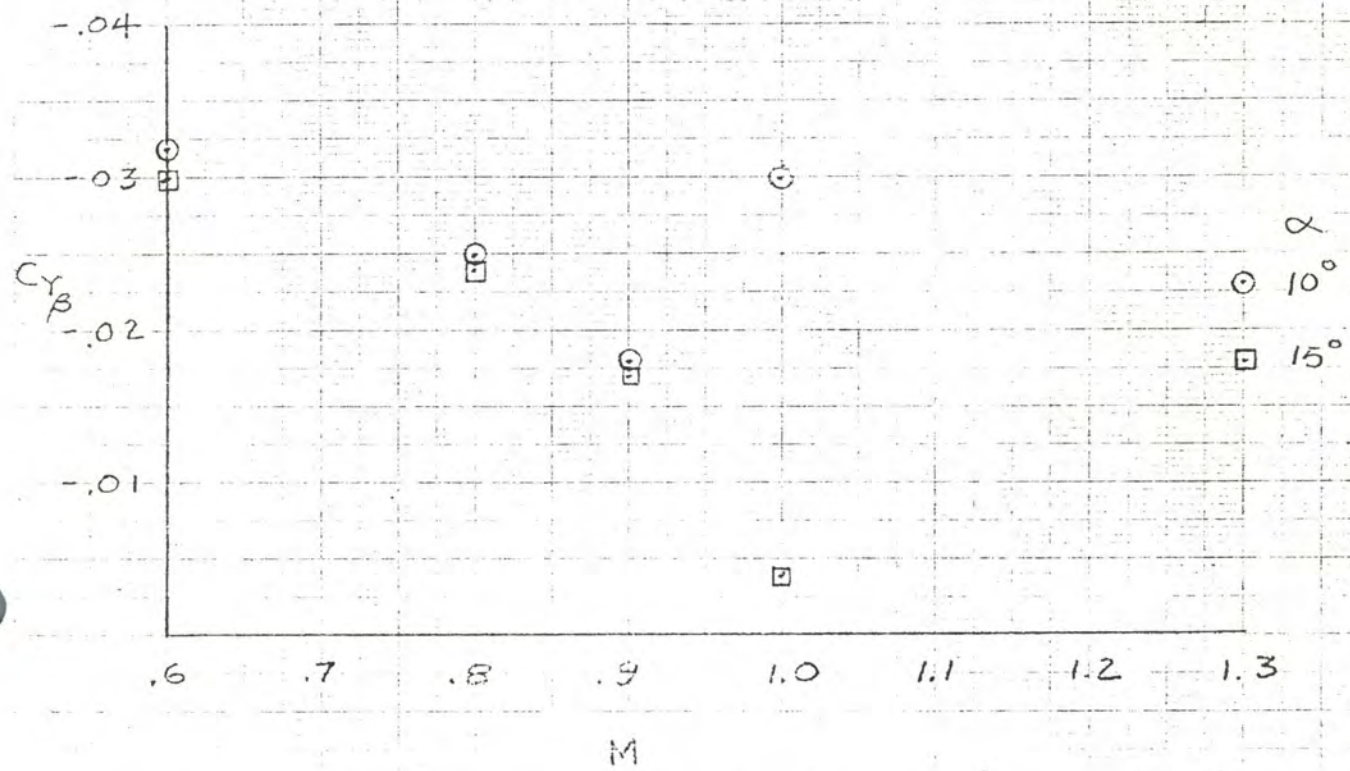


FIG 4

Right Hand Fin Tuft Study

BY

Johnny Armstrong

For flight 10, three tufts were placed on the inside surface of the right hand tip fin. These tufts were located in areas experiencing significant sudden changes in surface pressure as determined from pressure data on the left and right hand fin from previous flights. The tufts were photographed from the camera mounted on the center fin. The film rate of the camera was established to be 4.16 frames per second by determining the number of frames between known events i.e., launch and configuration change. The accompaning figure depicts the location and general flow direction of the tufts. In this discussion the tufts will be referred to as: forward (leading edge), middle, and aft (on lower rudder).

In general the flow direction of the forward and middle tuft is span wise during the powered phase of the flight (M>.7). Of special interest is a significant change in flow as the vehicle decelerated through .69 Mach number at 12:13:37.6 hours. This time corresponds exactly to the sudden change in surface pressures on the inside of the fin on this flight. This then is a visual representation of the flow that corresponds to the ".7 Mach pressure glitch" referred to in previous flight reports.

The flow direction and characteristic before and after the ".7 Mach pressure glitch" is summerized in table I and figure 1. Similar flow change of the tufts were also observed during the rudder doublet at 5^{o} α at .8 Mach number after engine shutdown.

At the risk of oversimplification, the existence of a tip fin flow boundary will be postulated as shown in figure 2. The previously observed sudden pressure changes form the basis of the flow change boundary as a function of α and Mach number. Note the conditions shown for the observed changes in tuft flow on flight 10. It is therefore, generalized that at conditions above the boundary the flow is chiefly span wise and quite unsteady near the leading edge. At conditions below the boundary the flow tends to be more steady and chord wise.

With the existing data gathering devices and future planned smoke visualization tests; the X-24B presents the researcher with the opportunity to understand and document the aerodynamic flow on a unique configuration better than any of the lifting body configurations. A detailed analysis of the flow characteristics will be documented by the AFFDL.

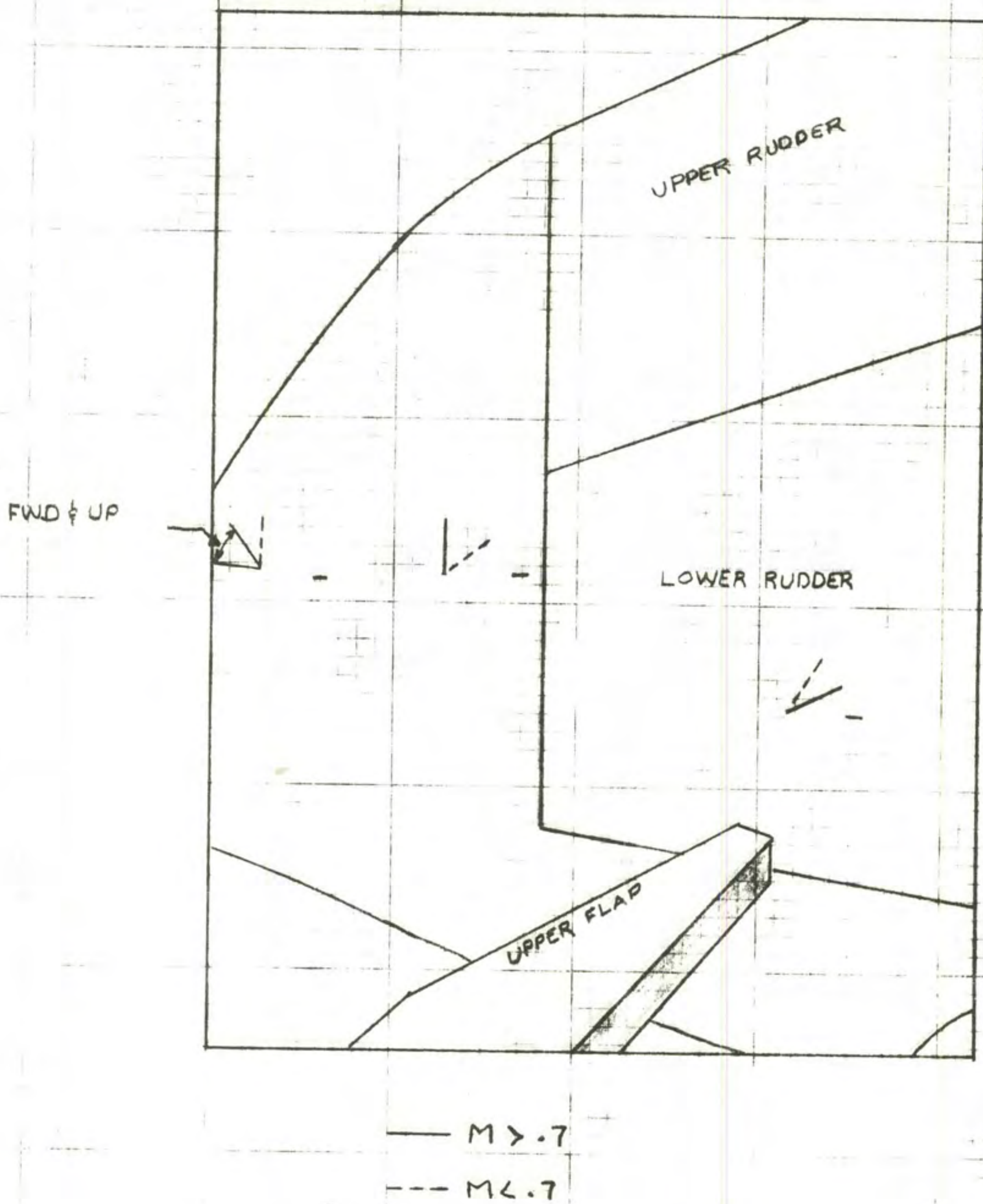
TABLE I. FLIGHT 10 TUFT FLOW

TUFT	FLOW DIRECTION	
	Mach number >.7	Mach number <.7
Forward	Unsteady flow forward toward the leading edge and upward away from the surface.	Flow more steady and span wise.
Middle	Span wise flow	Flow change toward more chord wise flow. approximate 45° angle change.
Aft	Mainly chord wise flow	Changed to more span wise

FIGURE NO. 1

RIGHT TIP FIN TUFT FLOW (INSIDE)

FLT. 10



These are the conditions at which an instantaneous change in pressure occured at several orifices on the inboard sides of the fins.

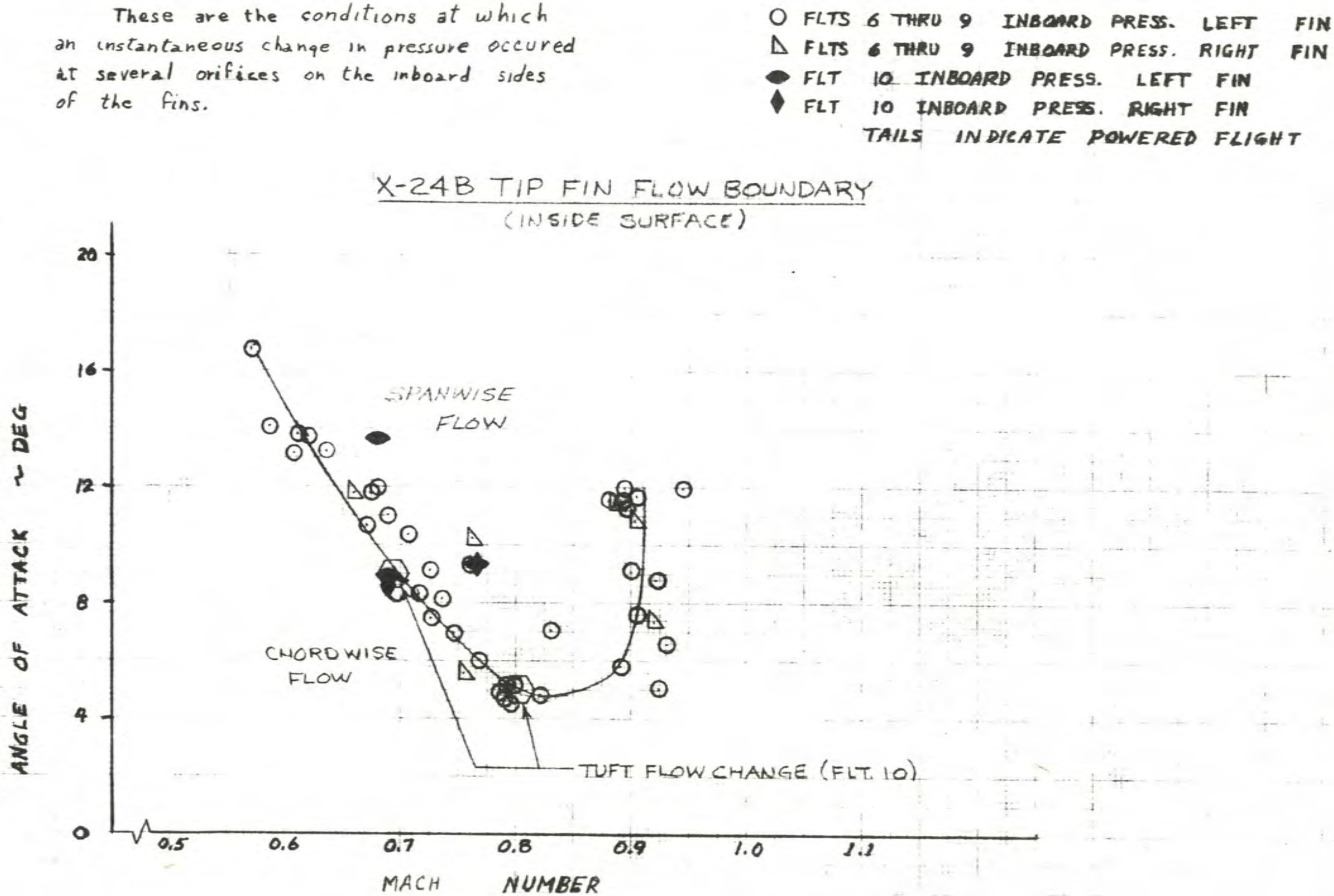


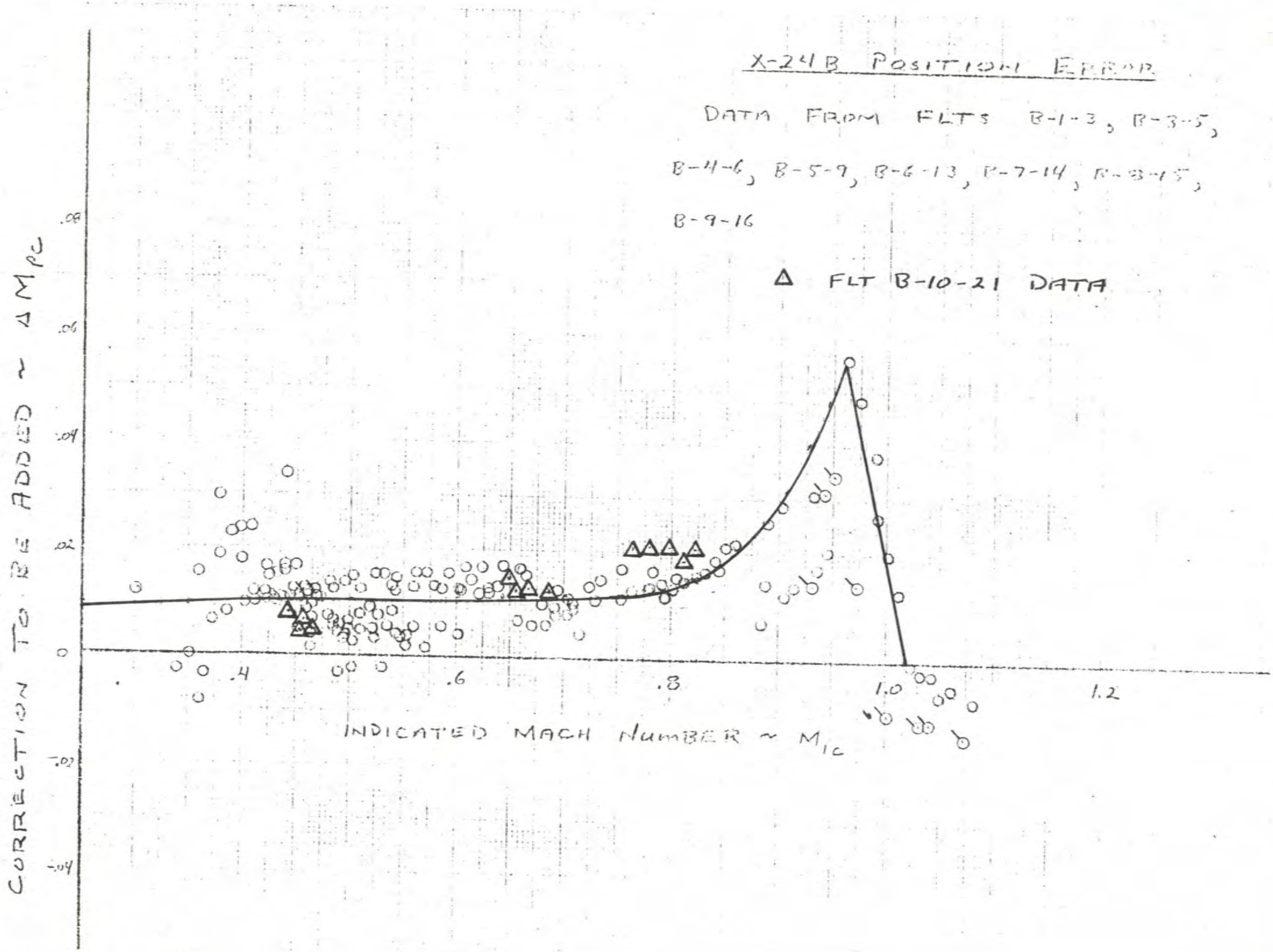
FIGURE NO. 2

B-10-21 Position Error

BY

Dennis J. Penka, Capt

Position Error Data from Flight B-10-21 was in good agreement with data from previous flights and with the Position Error Curve now in use (figure 1). No changes were made to the Position Error Curve used for Data Reduction as a result of this flight.



X-24B POSITION ERROR
DATA FROM FLTS B-1-3, B-3-5, B-4-6, B-5-9, B-6-13, B-7-14, B-8-15, B-9-16
Δ FLT B-10-21 DATA
CORRECTION TO BE ADDED ~ ΔMpc
.08
.06
.04
.02
0
-.02
-.04
.4
.6
.8
1.0
1.2
INDICATED MACH NUMBER ~ Mic

Flight B-10-21 Sideslip/Wind Investigation

BY

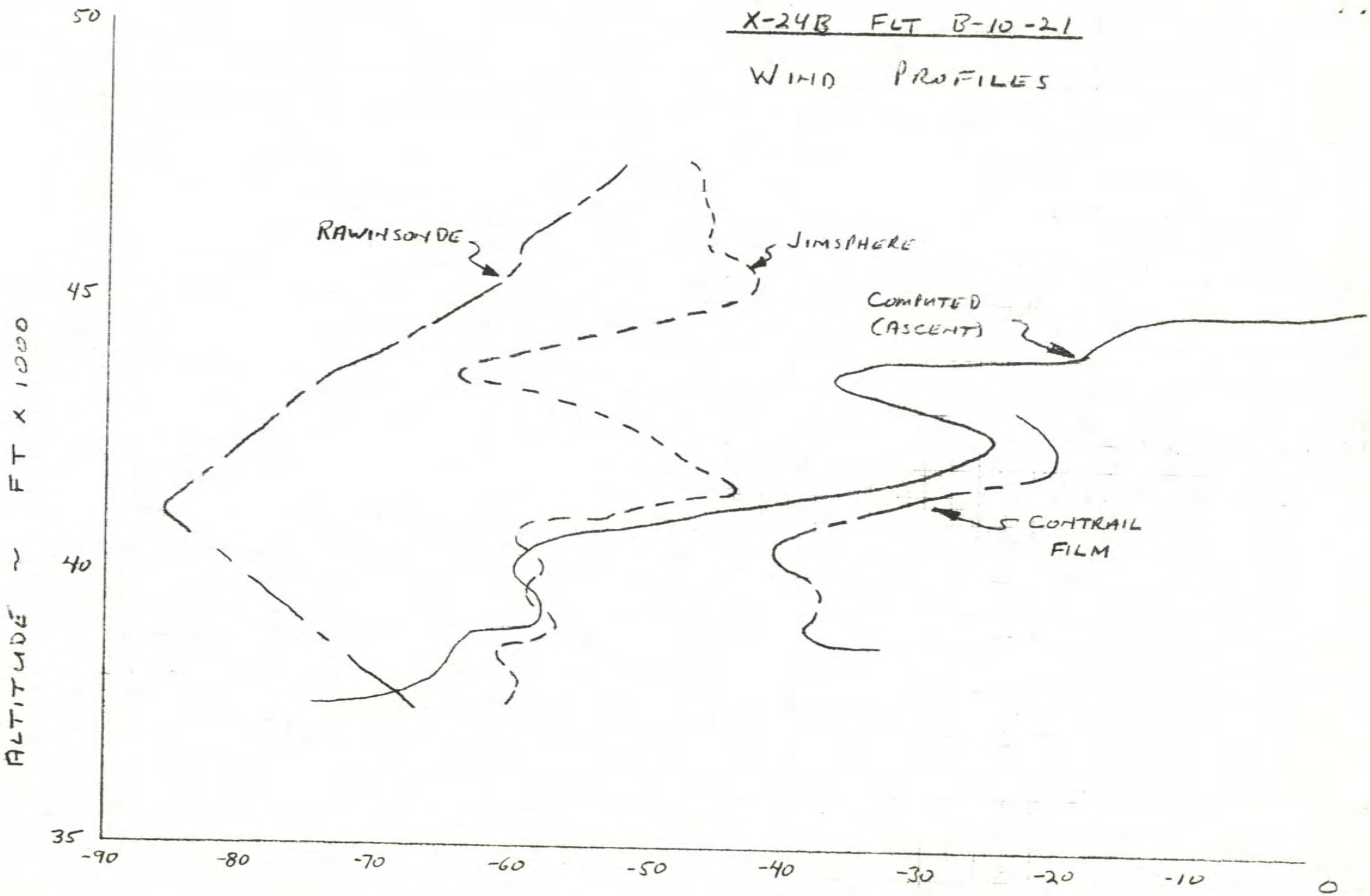
Dennis J. Penka, Captain

The investigation of wind induced sideslip excursions begun as a result of flight B-7-14 was continued to include flight B-10-21. For the first time a wind profile obtained from a Radar Tracked Jimsphere Balloon was available in addition to the Rawinsonde Profile used on other flights. The Jimsphere Data was smoothed over 200 foot altitude bands, then used like the Rawinsonde Data to provide a sideslip-producing wind component during the aircraft's climb and descent.

Agreement between the computed ascent and descent sidewind profiles was poor. The ascent profile had a tendency to "wander" excessively during wind shifts (figure 1). This type of response has been noted on previous flights as the aircraft's rate of climb decreased near maximum altitude. The ascent profile wandering is attributed to the relatively low rate of climb during this flight and, therefore, the descent profile will be used as the representative computed wind profile for this flight.

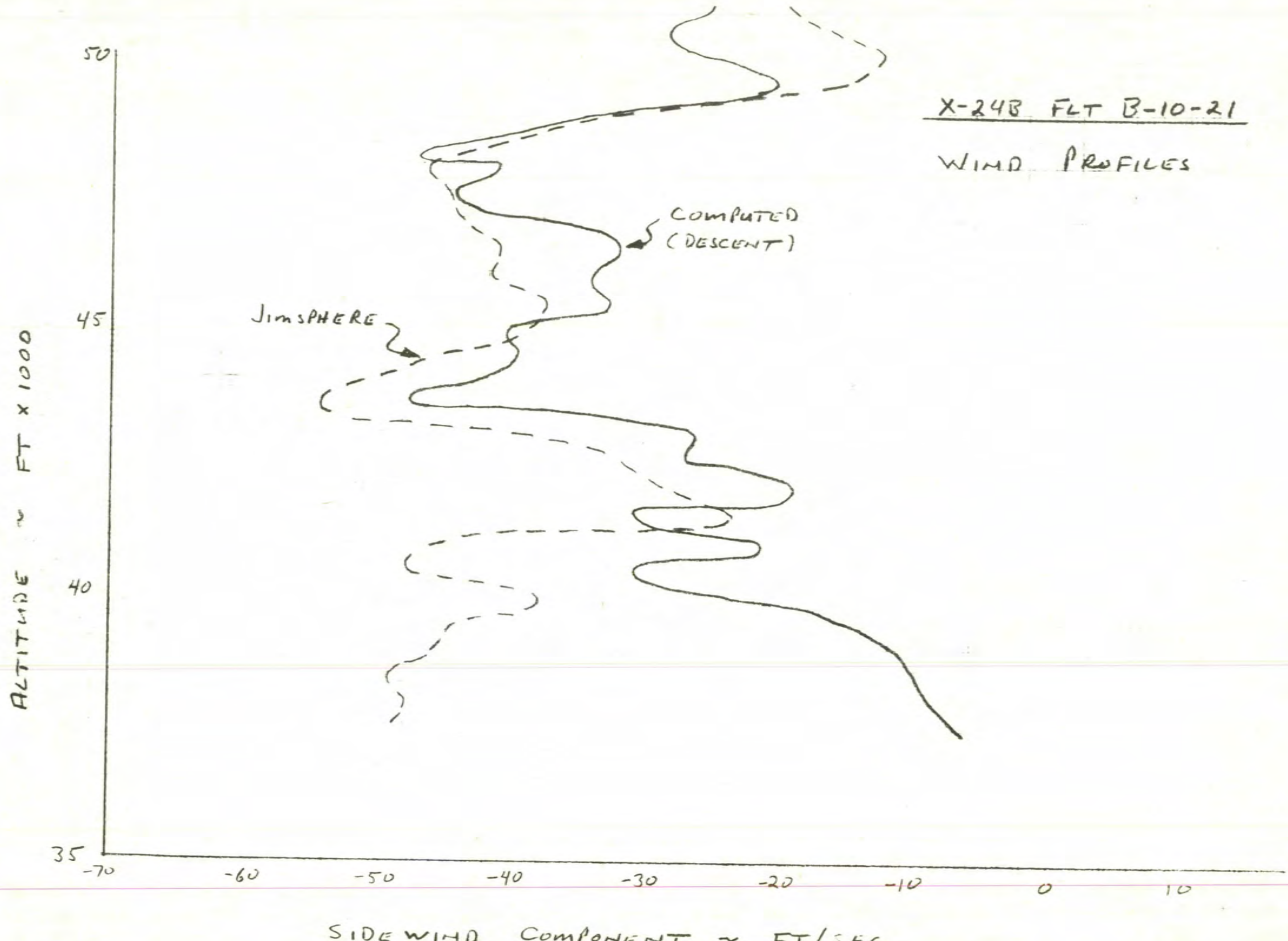
As seen previously, comparison of the Rawinsonde wind profile and the computed profile was poor with the Rawinsonde winds showing almost none of the abrupt wind shifts seen on the computed profile. However, agreement between the computed winds and the Jimsphere profile was good (figure 2) with both showing abrupt wind shifts with altitude. This supports the contention that the computed wind profiles have been presenting a truer picture of the actual flight winds (as far as abrupt wind shifts with altitude) then do the Rawinsonde wind profiles.

The contrail left by the vehicle during the powered boost was filmed by a fixed, ground-based camera and a wind profile was extracted from the contrail motion, as was done on the last flight. The field of view of the camera only provided data up to 43,000 feet, however, the shape of this limited profile agreed with that of the Jimsphere and computed (ascent) profiles (figure 1).



X-24B FLT B-10-21
WIND PROFILES
RAWINSONDE
JIMSPHERE
COMPUTED (ASCENT)
CONTRAIL FILM
ALTITUDE ~ FT x 1000
50
45
40
35
-90
-80
-70
-60
-50
-40
-30
-20
-10
0
SIDEWIND COMPONENT ~ FT/SEC

(FIGURE 1)



X-24B FLT B-10-21
WIND PROFILES
COMPUTED (DESCENT)
JIMSPHERE
ALTITUDE ~ FT x 1000
50
45
40
35
-70
-60
-50
-40
-30
-20
-10
0
10
SIDEWIND COMPONENT ~ FT/SEC

(FIGURE 2)

X-24B Aileron Deadband

BY

John Stuart, Captain

Dennis J. Penka, Captain

During the captive portion of flight B-A-17 (19 Mar 74), which air aborted due to cloud cover, a deadband developed in the left aileron. The deadband was first observed approximately 57 minutes after take-off, reached a maximum of one degree peak-to-peak 76 minutes into the flight and returned to normal motion after the B-52 landed. A deadband of .6 degrees peak-to-peak had been observed in the left aileron at 15 seconds after launch on flight B-6-13 and again late in the flight of B-9-16 Subsequent to both of these flights, the aileron control system was completely checked, rigging tightened and some components (bushings, rod end bearings, input rod) replaced in an attempt to eliminate the problem.

Since the deadband continued to occur during flights in spite of the above efforts and because it seemed to develop during the mission, then returned to normal after landing, it was felt that the problem may be temperature dependent. It was noted that the LOX vent line is forward of the left aileron mechanism and that the number 1 and number 2 pressure and return hydraulic lines were routed close to the lower door panel, just aft of the LOX vent. It was thought that with LOX venting overboard, the left hand aileron compartment could become significantly colder than the right side, thus cold-soaking some components in the left aileron system causing the deadband to appear. In order to confirm this as a possible cause for the problem, a lab test was performed on a spare hydraulic actuator by routing one pair of pressure and return lines through a LN_2 locker. With the lines frozen, an input arm motion normally requiring 14 oz. of force and resulting in a surface output of .34 degrees peak-to-peak required 12 lbs input force and produced no output. As the fluid warmed, the input force remained constant until the output magnitude stabilized, then the input force required began to decrease while the output amplitude remained constant. The viscosity of the hydraulic fluid used begins to increase sharply between -40^{o} and -60^{o} F.

Since it appeared that the aileron deadband problem may indeed be temperature related, modifications were made in the left hand aileron compartment to minimize temperature effects in the components. The actuator hydraulic lines were re-routed away from the compartment door and wrapped with thermal insulation. In addition, the aileron compartment access panel was insulated with a 1 inch thick polyurethane blanket. A captive flight was planned to insure that the above modifications were adequate to prevent the aileron deadband from becoming significant enough to effect vehicle handling qualities.

Supplemental instrumentation was installed to permit real-time monitoring of the aileron control system. CPT's were used to detect the positions of the following aileron linkage components: LH Aileron Multiplier, LH Aileron Preload Spring, LH Aileron Actuator ~~Actuator~~ Control Rod, RH Aileron Multiplier, RH Aileron Preload Spring, RH Aileron Actuator Control Rod. Temperature sensors were used to monitor the LH Aileron Compartment Skin Temperature, LH Aileron Compartment Ambient Air Temperature, RH Aileron Compartment Skin Temperature, and RH Aileron Compartment Ambient Air Temperature.

An "end-to-end" check was performed to verify the accuracy of the calibrations and the proper operation of an additional PCM data transmitter, and to make known to the pilot (Major Love) the amplitude and frequency of the aileron inputs which would be desired during the proposed captive flight. All systems operated satisfactorily.

After two air aborts (due to B-52 system malfunctions), the captive flight was flown on 25 April 1974 as outlined in the Flight Request.

Figure 1 shows a plot of the four temperatures versus time; also shown are the flight activities and events of interest which occurred during this captive flight. Two conclusions can be drawn from the information depicted in figure 1. First, the left side of the vehicle had been cold-soaked prior to takeoff through conduction and radiation from the X-24B LOX tank and through radiation from the LOX topoff tanks onboard the B-52. This is indicated by the fact that (within the range of the temperature sensors) the left hand temperatures are 8 to 10 degrees below the corresponding right hand temperatures. Second, flow from the LOX vent lines does cause the LH Skin Temperature, and eventually the LH Air Temperature, to decrease considerably. This conclusion is supported by the sudden increase in LH Skin Temperature when the LOX topoff stopped at 11 1/2 minutes before simulated launch and the immediate decrease when topoff was restarted at 10 minutes before simulated launch. No corresponding changes occurred on the right side.

Those aileron activity cycles during which some loss of motion was detected in the left aileron are indicated by an asterisk in figure 1. The first loss was detected approximately 5 minutes after the simulated launch. A corresponding loss was not indicated at the multiplier or the preload spring, so it must have occurred in the actuator control rod linkage, in the actuator linkage, or in the actuator itself as a result of temperature related viscosity effects. The second and third losses, which occurred 17 1/2 and 19 minutes after the simulated launch, appear to have occurred between the multiplier and the preload spring, possibly as a result of cold-soaking the linkage or the spring.

The magnitude of the losses detected on the captive flight was less than 0.2 degree of left aileron deflection at all times, considerably less than the losses encountered on the aborted flight of 19 March 1974. It was determined that the effect of this 0.2 degree loss on flight safety, vehicle handling qualities, and data acquisition would be negligible. The aircraft was cleared to perform the scheduled powered flight.

The supplemental instrumentation was used during flight 10 to again monitor the aileron compartment temperatures and linkage positions. Figure 2 shows that the temperatures followed the same general pattern observed during the captive flight. No observable loss of aileron motion occurred.

It was concluded that the relocation and insulation of the hydraulic lines and components reduced the losses to an acceptable level.

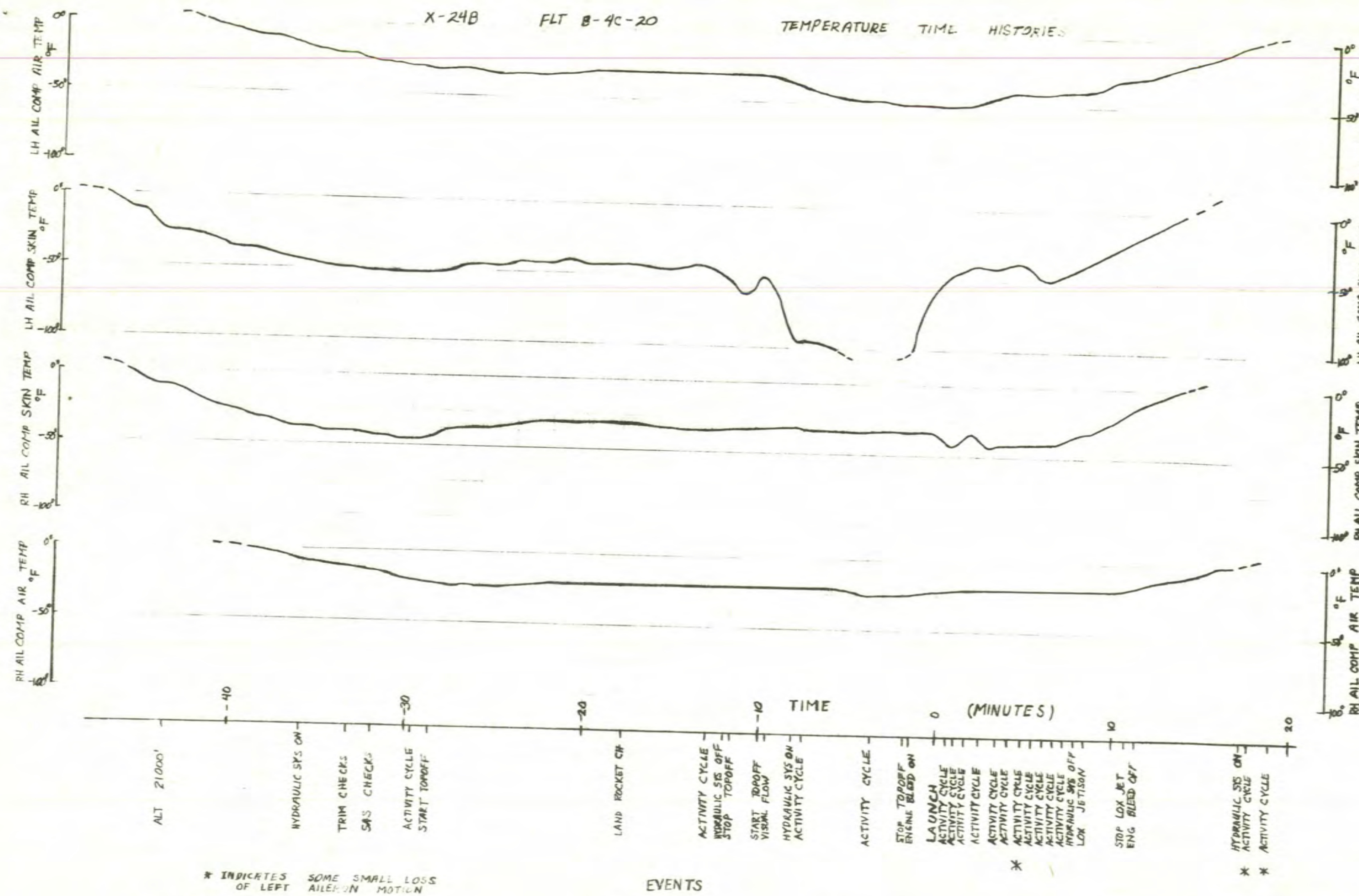


FIGURE 1

FIGURE 1 (CONCLUDED)

X-24B FLT B-10-21 TEMPERATURE TIME HISTORIES

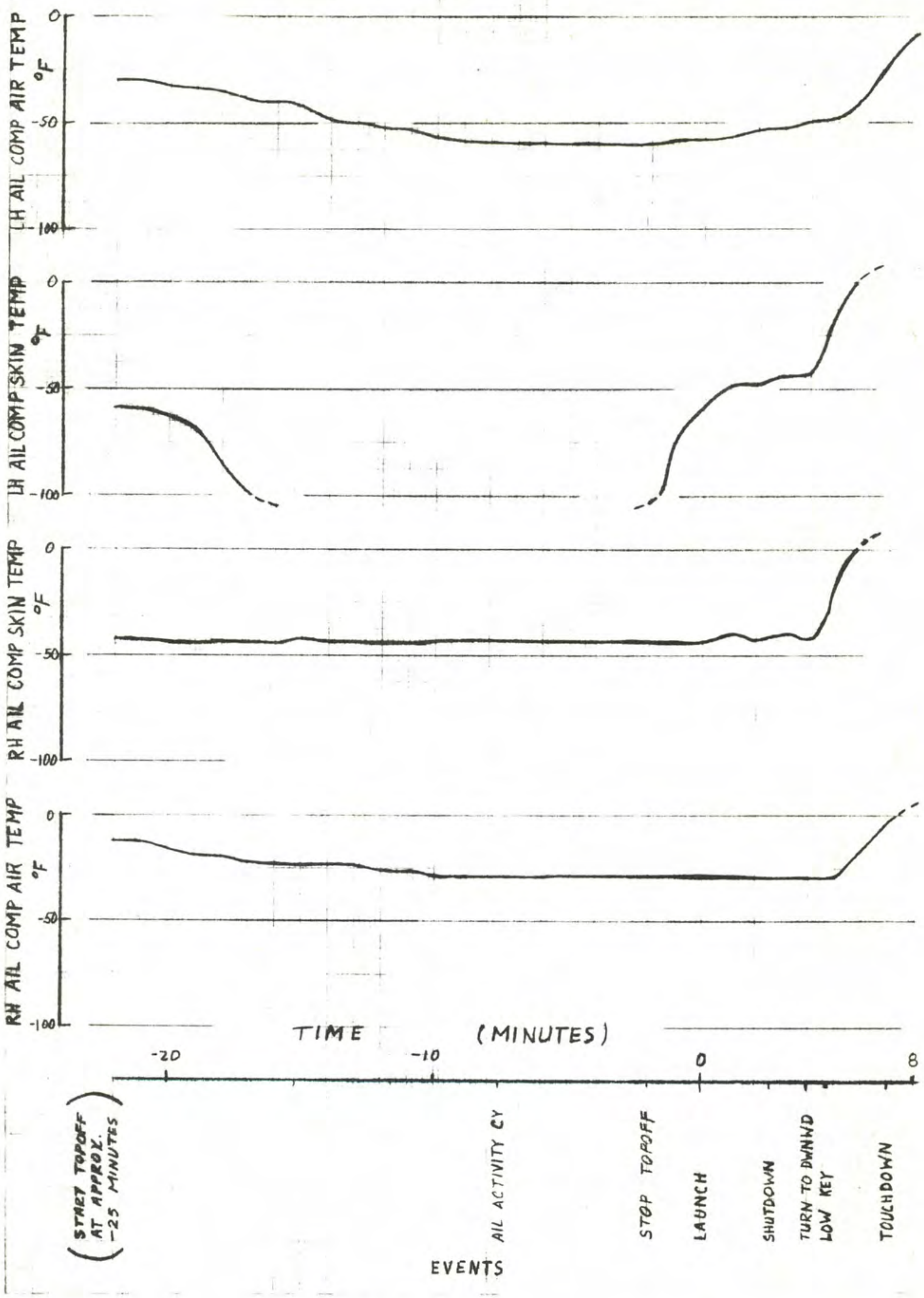


FIGURE 2.

Left Main Landing Gear Strut Bottoming

BY

Captain John L. Stuart

Post flight computer plotted time histories of the landing gear positions indicated that the left main gear attained the fully compressed or "bottomed" position during the landings on flights 9 and 10. Visual inspection did not reveal any external physical contact of the strut components. The time histories indicate that the strut did not bottom on initial compression (touchdown), but that it did bottom as the nose gear contacted the runway, and it remained at or near the fully compressed position for a short time during the landing rollout.

It appears that the air loads on the vehicle contributed significantly to the problem because the strut finally extended somewhat as the airspeed, and hence the air loads, decreased. On flight 9, the strut extended after approximately 14 seconds as the aircraft decelerated through 108 KCAS. On flight 10, the strut extended after 9 seconds as the aircraft decelerated through 120 KCAS. The landing dynamics analyst at the Flight Dynamics Laboratory, Wright-Patterson AFB, Ohio, has indicated that the landing gear loads encountered on flight 9 were not significantly different from those of other flights.

Figure 1 shows traces of the computer plotted time histories of the left main landing gear strut position for flights 3, 6, 7, 9, and 10. Flights 6, 7, 9, and 10 were powered flights and the touchdown gross weights and c.g.'s averaged approximately 8350 lbs and 64%, respectively. Flight 3 was unpowered with touchdown gross weight and c.g. of 8158 lbs and 65%, respectively. The flight 3 trace was included for comparison.

After flight 9, the strut CPT calibration was checked. It was determined at that time that the information used by the computer to produce the flight 9 time history plot had not been updated to reflect the most recent calibration. However, this error was easily corrected by shifting the position scale 0.45 inches. (The flight 9 time history shown in figure 1 reflects this correction.) The strut was reserviced to 100 psi air pressure, and the correct calibration information was entered in the computer.

When the problem recurred on flight 10, both the strut pressure and the CPT calibration were rechecked and found to be correct. Further investigation showed, however, that the hydraulic fluid quantity in both main gear struts had diminished somewhat; 55 cc of fluid were added to the left strut, 20 cc were added to the right strut, and both were reserviced to 100 psi air pressure.

At this time it is concluded that the bottoming of the left main gear strut was due to insufficient hydraulic fluid.

COMPUTER PLOTTED TIME HISTORIES

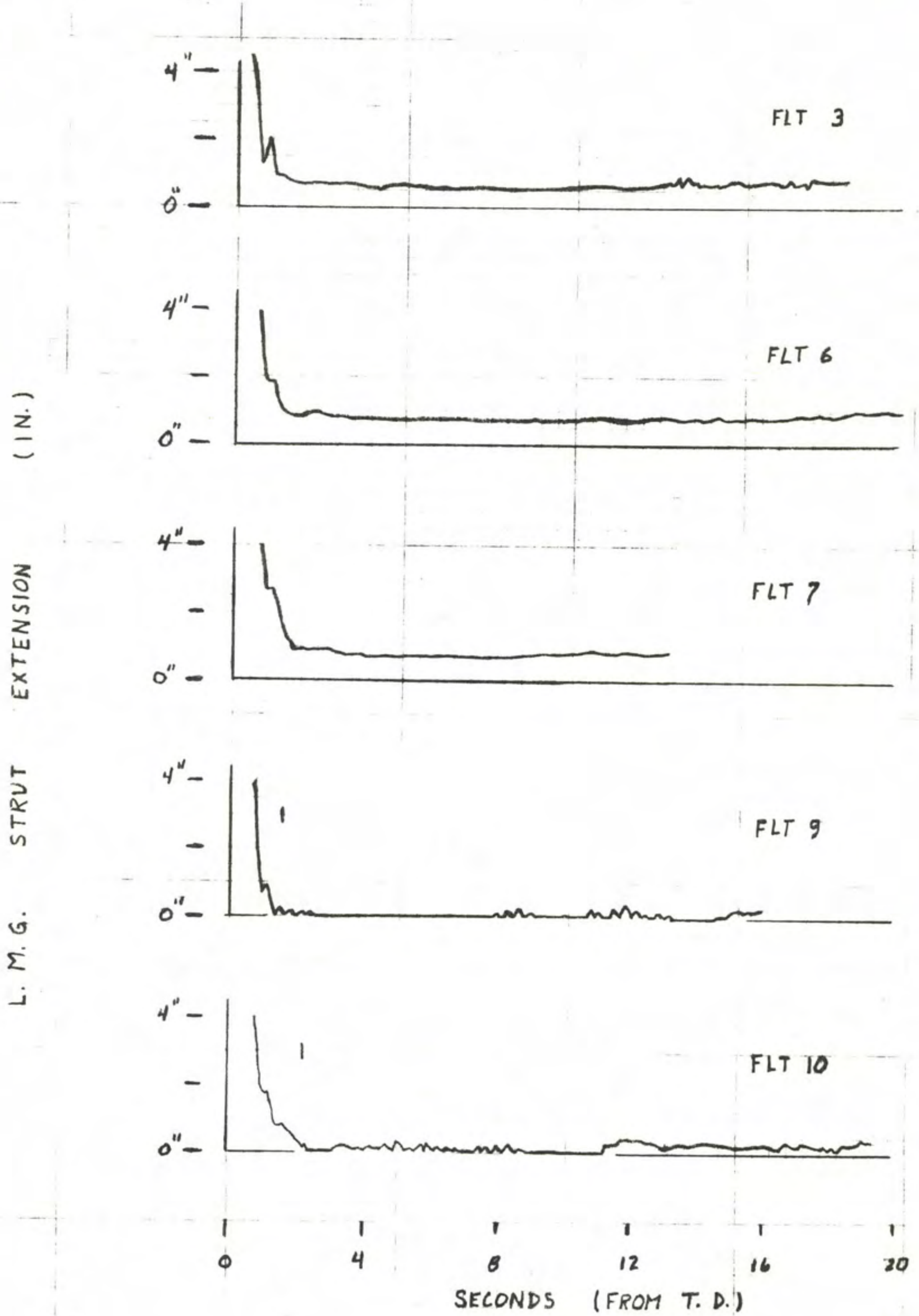


FIGURE 1

May 13, 1974

TO: DOEER

FROM: W.B. Arnold - THIOKOL

SUBJECT: Flight B-10-21

SUMMARY OF ENGINE OPERATION

1. Prelaunch igniter test was satisfactory.
2. Post launch attempt to start chambers #2and #4 resulted in a engine shutdown due to a fuel pump cavitation.
3. The engine malfunction was reset and a satisfactory start of chambers #1 and #3 was accomplished.
4. A second start attempt of the #4 chamber was unsuccessful due to trapped pressure in the #4 chamber pressure sensing system due to freezing.
5. A start of the #2 chamber was accomplished however this start required approximately 5.2 seconds due to a restriction of the #2 chamber pressure sensing system as a result of freezing.
6. Engine operation was satisfactory for the remainder of the flight. Data review indicated that the #1,2 and 3 chamber pressure sensing lines were all frozen preventing accurate chamber pressure readings.

DISCUSSION

The post launch shutdown was the result of a fuel pump cavitation. The fuel manifold pressure during this shutdown was compared to two other fuel pump cavitations encountered in the PSTS early in the X24A propulsion system tests and found to be almost identical(see Fig.1). The fuel pump cavitations encountered in the PSTS were found to be the result of a gas trap in the fuel tank outlet line. This gas trap will remain in the line during igniter tests indicating satisfactory operation. Engine operation will appear normal until the chamber prop valves start to open. The increased flow demand would then accelerate the fluid column in the tank outlet line moving the gas trap into the fuel pump causing a momentary cavitation and subsequent pump over-speed shutdown. This problem was eliminated by the incorporation of a bleed hole in the trap area of the fuel tank outlet line. (See fig.2)

Since this was the first fuel pump cavitation encountered since incorporation of the bleed hole, it was assumed that the hole in the aircraft tank was not functioning due to restriction or plugging. Attempts to perform a visual inspection of the hole were unsuccessful due to accessibility. The hole was then probed with a .032 in. wire. No restriction was obvious however, a small amount of fuel "jelly" was observed on the probe indicating a possible restriction of the hole by this substance. No other reason for the fuel cavitation could be found consequently it was assumed that the hole was restricted to a point where surface tension prevented displacement of the gas in the trap area.

DISCUSSION continued:

The problem of chamber pressure line freezing was found to be the result of low chamber pressure line bleed flow. The required flowrate of these orifice is 4500 - 5000 cc/m helium. The flowrate of the orifice in the engine were #1-1200, #2- 1200, #3-2800 and #4- zero. The configuration of this system is shown in figure 3.

The chamber pressure freezing is the result of moisture accumulation from combustion products and the inability of Pch bleed flow to keep the line clear. This freezing occurs somewhere between the igniter and the chamber pressure switches during a igniter or chamber start. This freezing can prevent or delay a chamber start.

The restriction of the Pch bleed orifice is the result of contamination by microscopic particles from the helium supply system. The Pch bleed orifice are made of a sintered metal which resembles and acts like a filter and the flowrate will reduce over a period of time.

CORRECTIVE ACTION

1. Determine that fuel tank outlet line bleed hole is clear and replace fuel prime valve as a secondary measure.
2. Allow fuel tank to remain in vent condition during climb to altitude to create a pressure differential across the fuel line bleed hole. This should increase the transfer of trapped gas from the outlet line. Lab tests indicate that the fuel does not boil at an altitude of 50K.
3. Replace defective Pch bleed orifice with correct flowrate.
4. Investigate the possibility of increasing Pch line bleed flows to reduce possibility of plugging and subsequent line freezing. This increase in bleed flowrate appears to be feasable with the new surface gap ignition system but will require altitude qualification.

W. B. Arnold

cc: N. DeMar
J. Kolf
TC-Elk.

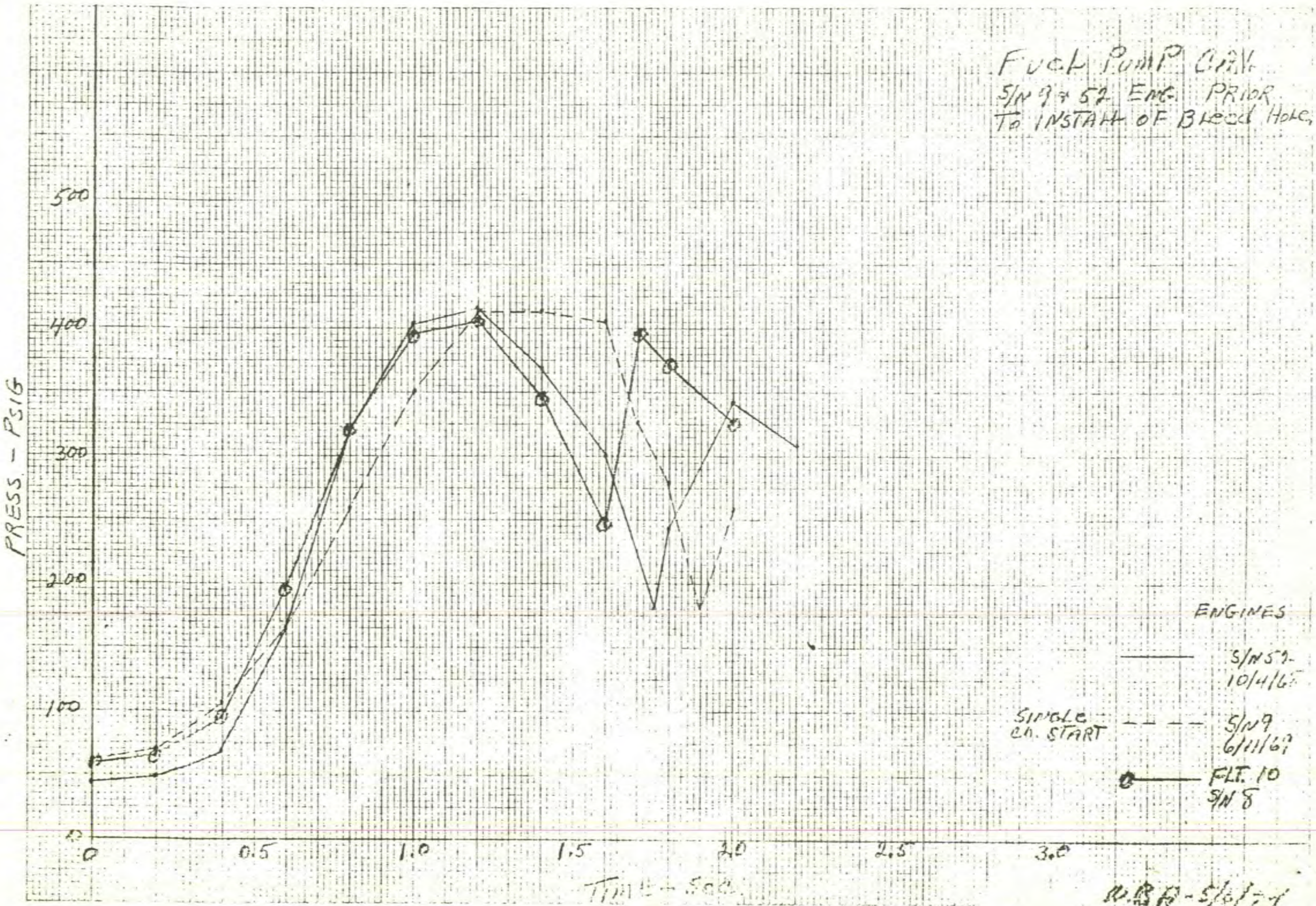
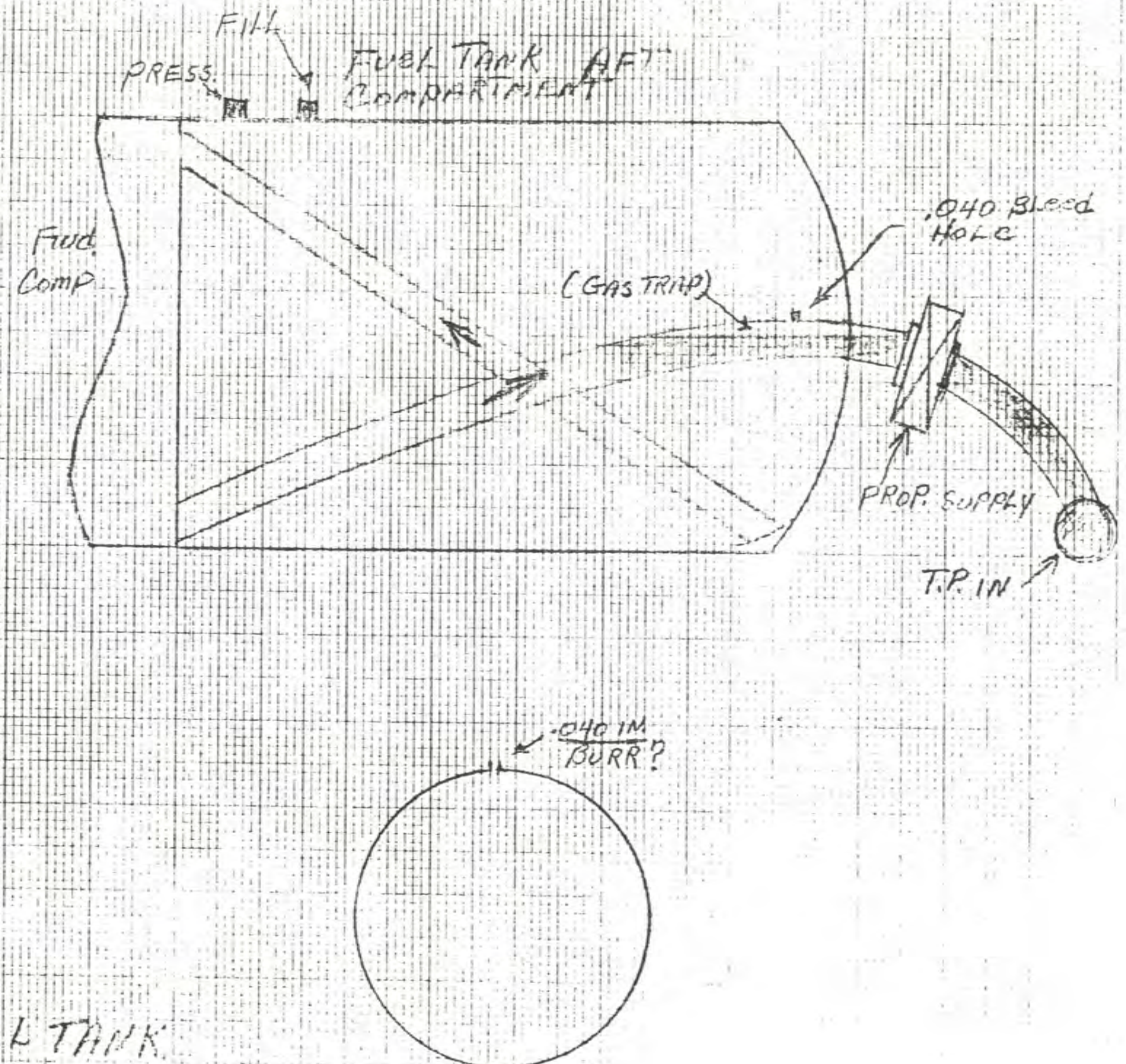

Fuel Pump CAV.
S/N 9 + 52 ENG. PRIOR
To INSTALL OF Bleed Hole.
PRESS. - PSIG
500
400
300
200
100
0
0
0.5
1.0
1.5
2.0
2.5
3.0
TIME - SEC.
ENGINES
S/N 52 10/4/65
SINGLE CH. START
S/N 9 6/11/67
FLT. 10 S/N 8
W.B.A - 5/6/77

FIG. 1



X 24 - FUEL TANK

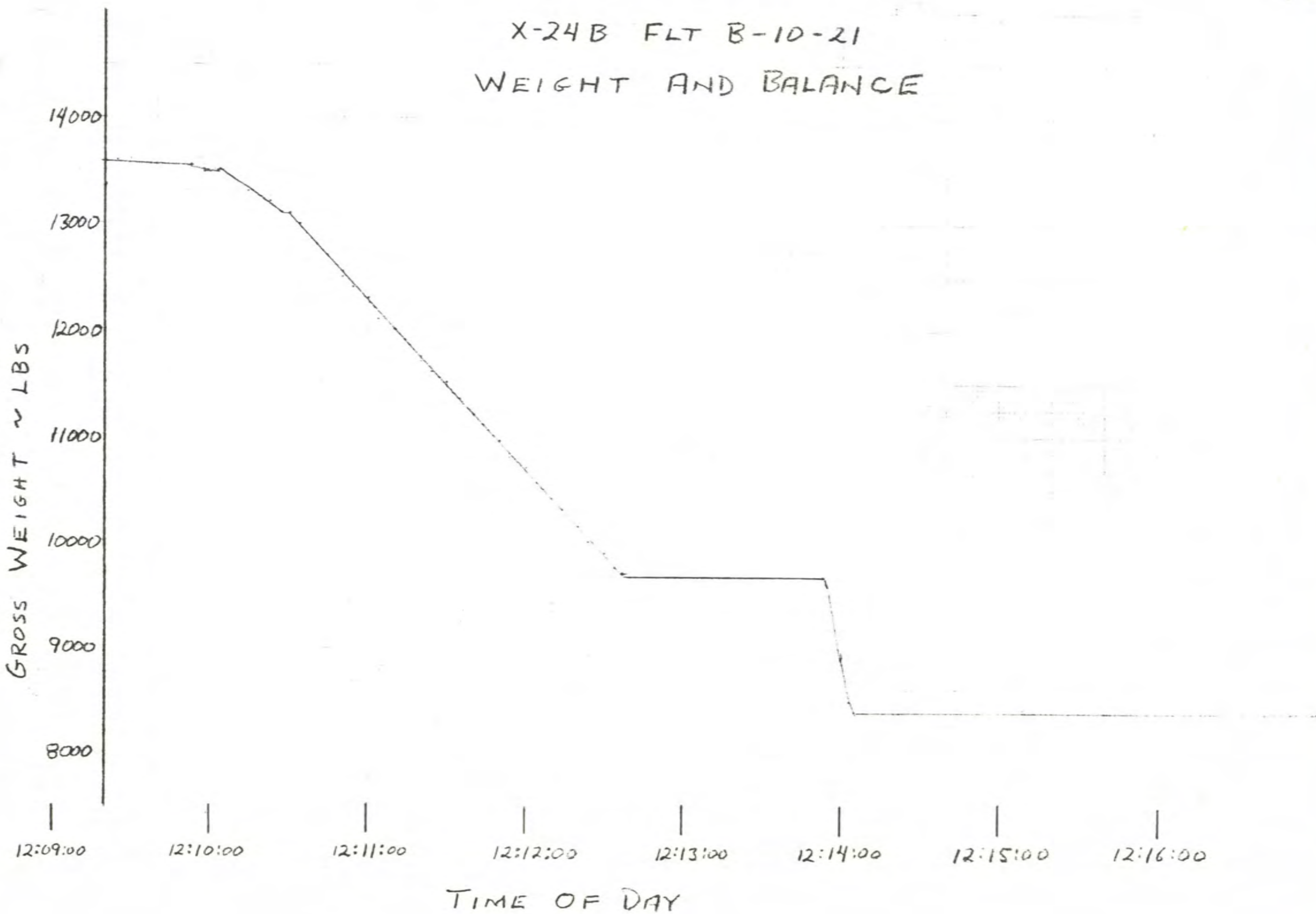
FIG. 2

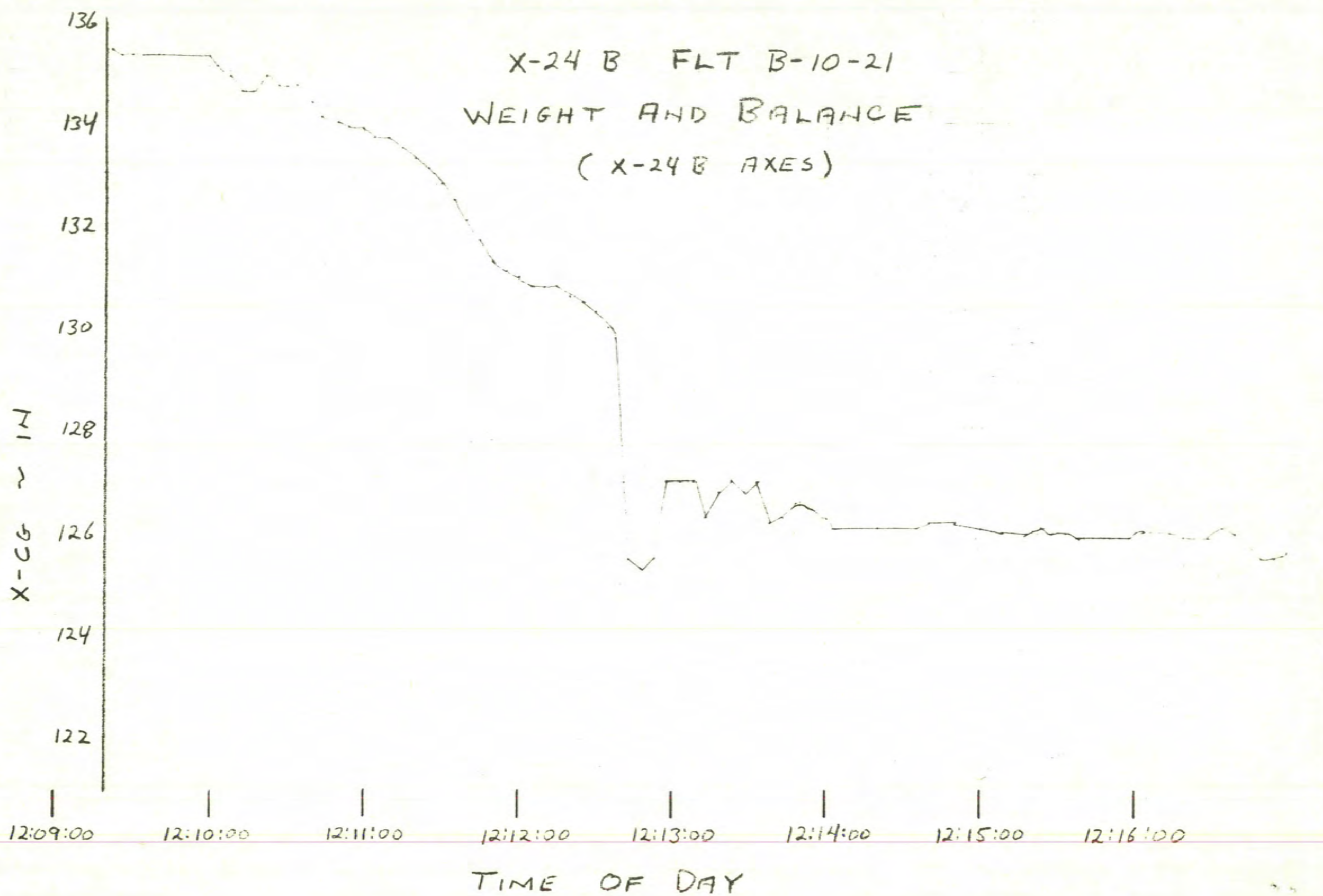
Pch Bleed Flow = 4500 – 5000 cc/m

Removed AFTER FLT. 10
#1 1200
#2 1200
#3 2800
#4 0

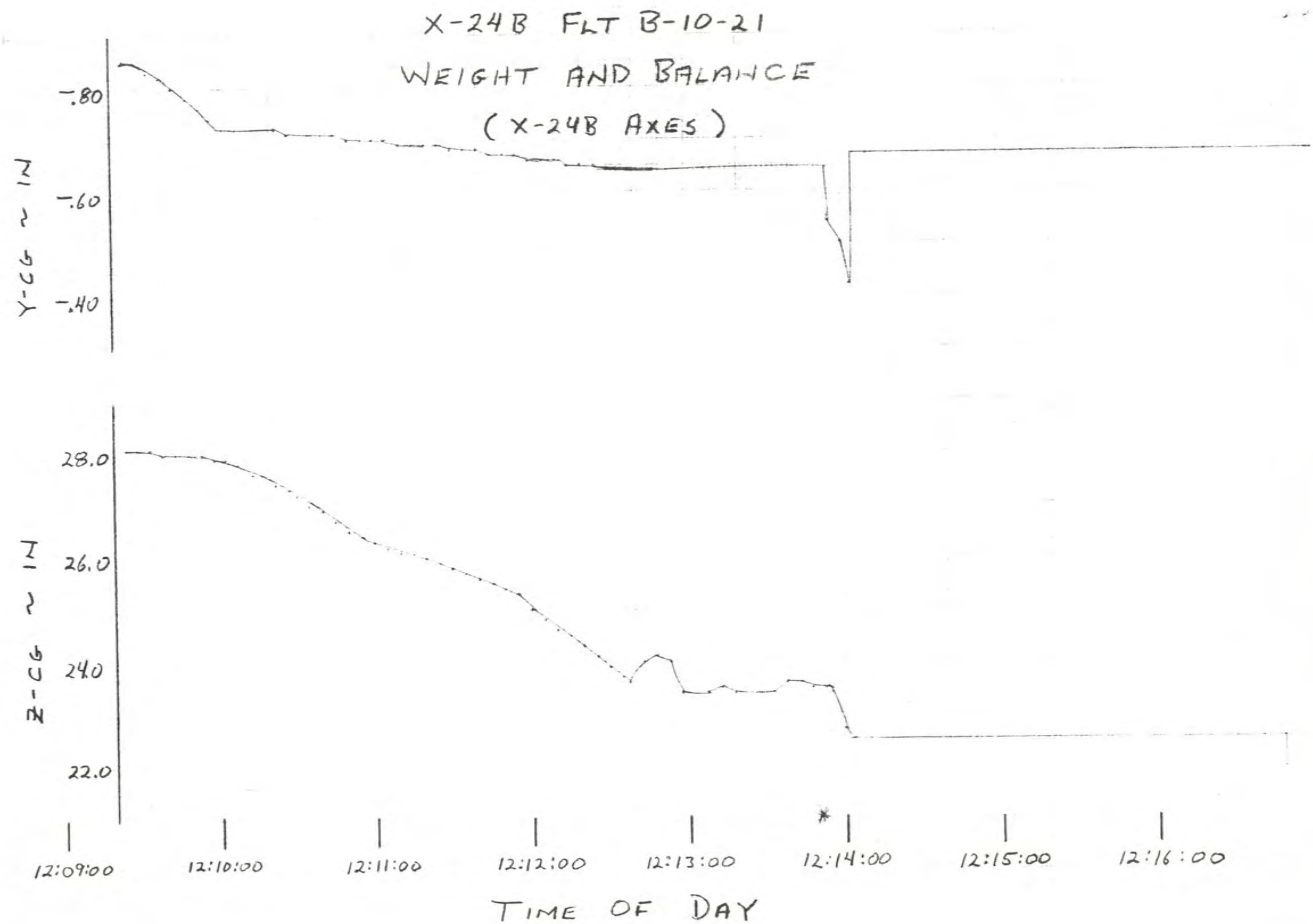
XLR11 Pch SENSING SYSTEM

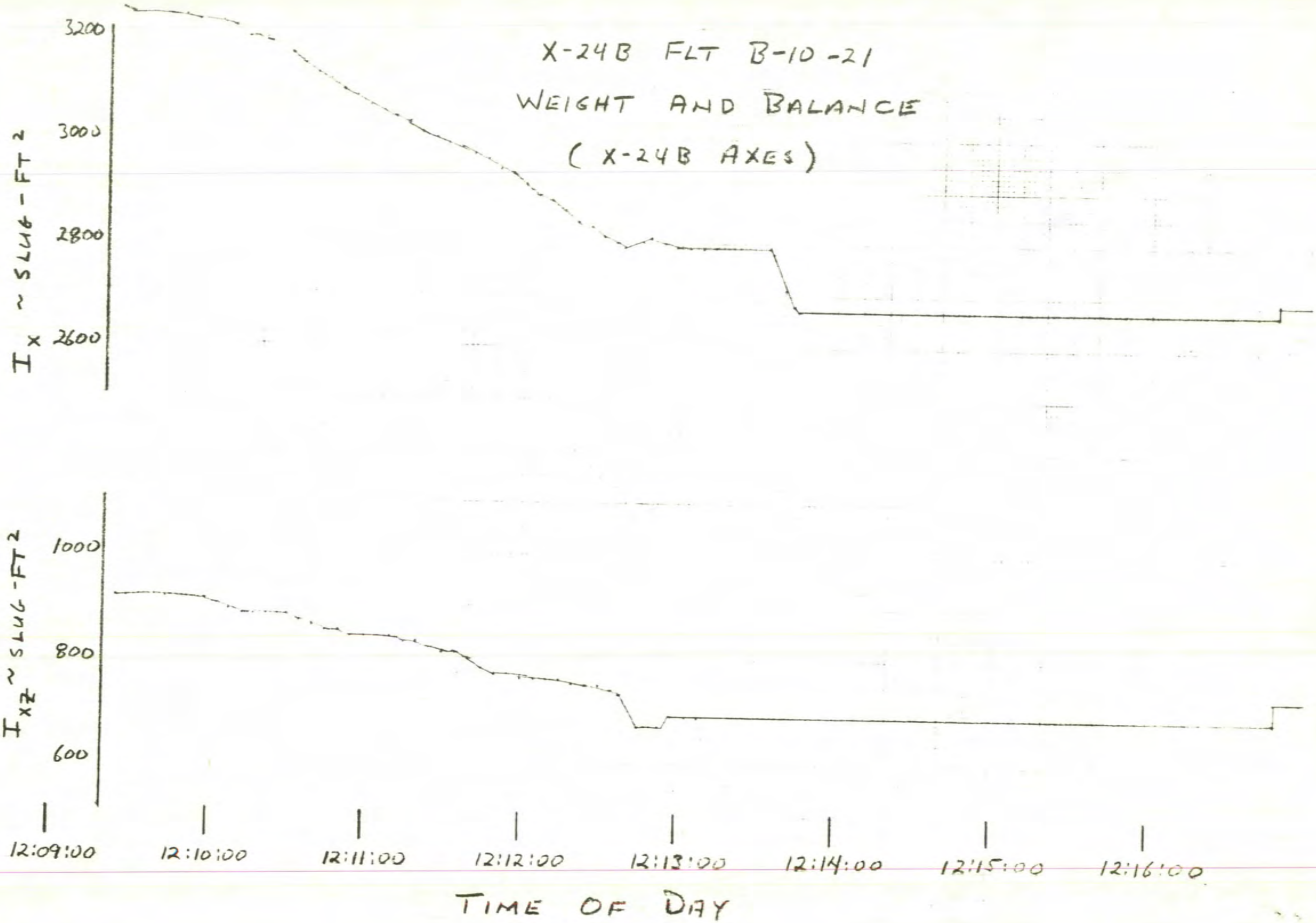
FIG-3


X-24B FLT B-10-21
WEIGHT AND BALANCE
GROSS WEIGHT ~ LBS
14000
13000
12000
11000
10000
9000
8000
12:09:00
12:10:00
12:11:00
12:12:00
12:13:00
12:14:00
12:15:00
12:16:00
TIME OF DAY

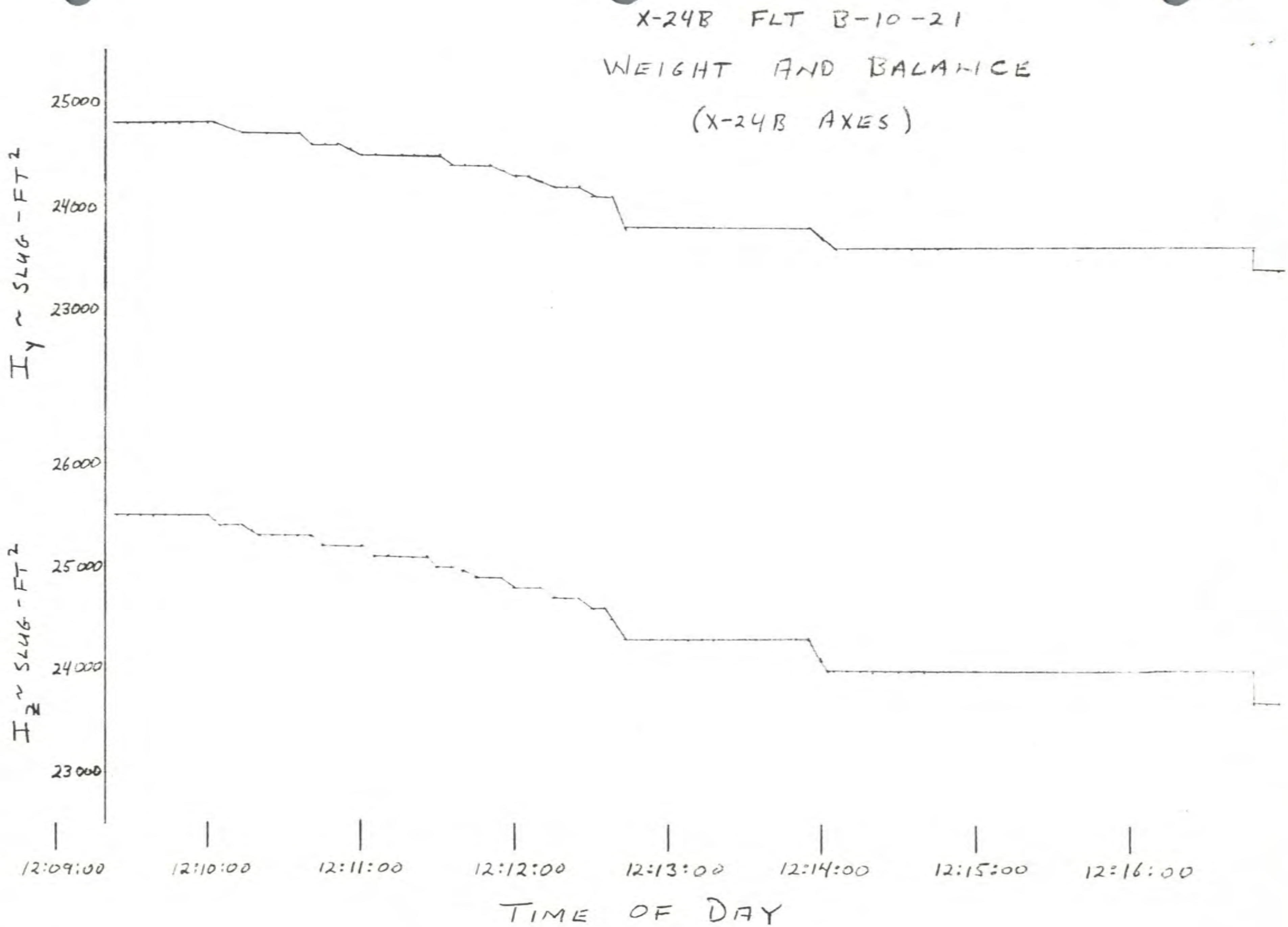


X-24 B FLT B-10-21
WEIGHT AND BALANCE
(X-24 B AXES)
136
134
132
130
128
126
124
122
X-CG ~ IN
12:09:00
12:10:00
12:11:00
12:12:00
12:13:00
12:14:00
12:15:00
12:16:00
TIME OF DAY


X-24B FLT B-10-21
WEIGHT AND BALANCE
(X-24B AXES)
-.80
-.60
-.40
Y-CG ~ IN
28.0
26.0
24.0
22.0
Z-CG ~ IN
*
12:09:00
12:10:00
12:11:00
12:12:00
12:13:00
12:14:00
12:15:00
12:16:00
TIME OF DAY



X-24B FLT B-10-21
WEIGHT AND BALANCE
(X-24B AXES)
I_X ~ SLUG - FT^2
3200
3000
2800
2600
I_{XZ} ~ SLUG - FT^2
1000
800
600
12:09:00
12:10:00
12:11:00
12:12:00
12:13:00
12:14:00
12:15:00
12:16:00
TIME OF DAY



X-24B FLT B-10-21
WEIGHT AND BALANCE
(X-24B AXES)
25000
24000
23000
I_Y ~ SLUG - FT²
26000
25000
24000
23000
I_Z ~ SLUG - FT²
12:09:00
12:10:00
12:11:00
12:12:00
12:13:00
12:14:00
12:15:00
12:16:00
TIME OF DAY

X-24B OPERATIONS FLIGHT REPORT

FLIGHT: B-10-21 DATE OF REPORT: 5-21-74

PILOT: Major Love DATE OF FLIGHT: 4-30-74

CARRIER AIRCRAFT: B-52 #008 LAUNCH LAKE: Rosamond

PURPOSE OF FLIGHT: (1) Pilot's Powered Flight Checkout

(2) Stability and Control at .8, .85, and .7 Mach Number

(3) Fin and Rudder Pressure Survey

(4) Boundary Layer Noise and Vibration Experiment (RED PLUG)

(5) Fuselage Tuft Study

I. Discussion of Previous Operations

Flight B-9-16 was made on 3-5-74 with no vehicle problems.

The first attempt at flight 10 was aborted for cloud coverage. Following the abort the ailerons were cycled to determine if the deadband had been eliminated. The deadband was still present at the previous level.

Based on this test it was decided to slip flight 10 until a positive fix could be made and demonstrated on a captive flight.

Examination of the deadband data revealed that the only flights on which the problem was present were powered flights. The difference between glide and powered is that lox tank topoff flow exits the vehicle just forward of the left hand aileron actuator bay.

Inspection of the actuator bays revealed that the hydraulic lines to the left hand actuator were routed so that they were either resting on the access door or running very close to it.

An attempt was made to ground simulate the chilling effect by directing liquid nitrogen over the aileron area with the vehicle mated to the B-52. No deadband was caused by this chilling because the flight conditions could not be adequately simulated.

The vehicle was demated for rework of the left hand aileron actuator area.

The spare aileron actuator was set up in the hydraulic lab with the supply hoses subjected to liquid nitrogen to demonstrate the effect of cold hydraulic fluid. As the lines were chilled deadband approaching the flight was experienced.

With this information, the decision was made to:

1. Reroute and wrap the hydraulic lines to the left hand aileron actuator.

2. Insulate the aileron actuator access panel with 1" thick polyurethane blanket.

3. Install CPT's on the right hand and left hand aileron drive system at three locations to determine where the deadband was if it repeated with the above two "fixes."

4. Temperature sensors were installed on the inside surface of both left and right aileron actuator access panels and in the compartment to measure air temperature surrounding the actuators.

5. Items 3 and 4 were to be telemetered to NASA-1 during captive flight for in-flight monitoring.

II. Vehicle Configuration Changes

A. Installed T/M transducer to monitor governor balance "overdrive" pressure in NASA-1.

B. Relocated dynamics system power supply C/B from equipment to instrumentation buss.

III. Instrumentation Changes

A. Added three CPT's to both left hand and right hand aileron systems.

B. Added two temperatures measurements on each side, compartment air and compartment door. (aileron actuator)

C. Added new pressure measurement, "Overdrive Pressure" to SO SPS sub-com. To make room for it, "SAS Inverter Voltage" measurement was moved to No. 2 PCM main com.

D. Installed a second TM Transmitter (1480.5 MH_z) and a multicoupler to enable transmission of both frequencies over same antenna.

E. Installed a charging circuit for the Time Code Generator.

F. Changed instrumentation DC circuit breaker from 25 amps to 35 amps. Revised hook-up of "Dynamic Instrumentation System" circuit breaker.

IV. Preflight Events

All preflight functionals were performed without incident.

V. Flight Events

1a. The vehicle was serviced for captive flight on 4-22-74 with no problems but the B-52 #8 engine starter failed causing a two hour delay in take-off.

b. Shortly after take-off the TV monitor in the B-52 caught fire and the mission was aborted. Could not attain altitude or flight elevation to test ailerons for deadband.

c. The pilot's overboard suit vent malfunctioned causing suit pressurization.

d. The lox jettison was slow in opening during propellant jettisoning.

2b. The TV system was deactivated for the next flight and work began on installation of the new cameras and receivers.

c. A new suit vent valve was installed. Suspect moisture in valve.

d. A new lox jettison valve pilot valve was installed to replace one from flight which had a failed heater theromO-stat switch.

3a. The captive flight was attempted again on 4-23-74, but again aborted because of loss of helium topoff source in the B-52.

4a. The lox topoff system was ground checked O.K., then purged to remove suspected moisture in system.

5a. The captive flight was successfully flown on 4-25-74. Both B-52 lox tanks, cruise and climb, were serviced to provide backup topoff capability. The climb tank failed to pressurize prior to B-52 taxi and the cruise tank was pressurized and utilized for the flight.

The aileron system worked satisfactorily and the vehicle was okayed for flight B-10 on 4-26-74.

6a. Flight B-10 was cancelled for Yaw SAS system failure to pass controls check tests.

b. The SMRD and Torque test box was changed to correct a low torquing signal and the system checked out satisfactorily.

7a. The vehicle was serviced for flight on 4-30-74 and again the SAS Yaw amber lite came on during controls checks. After repeated tests it was determined that the system worked with the high pressure pumps, 2 & 4 and intermittently with the low pressure pumps, 1 & 3. This caused the experts to suspect trapped air in the hydraulic system caused by operation with only one pump on during checkout and captive flight.

B-52 take-off was delayed approximately two and one half hours.

The captive part of the operation proceeded with no problems and the vehicle was launched on schedule.

The engine shutdown from a fuel pump cavitation but restarted satisfactorily and operated for the duration of the flight.

The vehicle was in good shape following the flights.

Approved by: William P. Albrecht
Chief, Operations
Engineering Branch

Written by: Norman E. DeMar
X-24B Project Engineer
Operations Engineering
Branch

POSTFLIGHT : B-10-21
DATE: April 30, 1974
PILOT: Mike Love

This is flight B-10-21, 30 April, 1974, Mike Love.

We went down the checklist accomplishments. No comments. Real smooth all the way to launch. We have one addition to the checklist and that is to add another hydraulic pump taxiing out next time.

The first thing to comment on as far as I am concerned was the launch. The launch transients were the same as the last two times, and I feel the aircraft just takes care of itself. I had no intention of worrying about it. I launched, looked down at 2 and 4 switches and then glanced up and I had about 11° α. Did not even notice any roll-off, if there was any. I was just flying without regard to having to do it. I think I held somewhere probably between 10 and 13 during the time period that I was trying to sort the engine out. Concern was going to 02 Rosamond.

I think the important thing to cover is the sequence that I went thru with the engine, starting with igniter test. Now in igniter test, looked down and pushed the button and said reset. Now I don't know if we can tell that I reset by the data, but Maybe I did not push the button hard enough. Don't know. After launch, when I knew the airplane was nice and stable, I went 2 and 4 on. Then I got the noise, glanced down, got some twitching on the gages, but I never got any lites. Then the noise and twitching stopped, and I think the gages were sitting around 100, but there wasn't any movement. Got 2 and 4 off. Punched reset and went 1 and 3 and I got noise and gage movement and lites just like we saw in the ground runs. As far as I was concerned and just as I expect it to build up. This includes some chugging like John described last time. So I said, alright, I'll try 4. At that time 4 was off and I hit #4. Did get a noise of some kind. This kind of surprised me. I knew the pumps already running. Why should I hear this noise again. It must be the chamber I was hearing. I know I got some gage twitching, but then all that stopped and I did not get a lite. So I turned #4 off, hit #2 and it came up just like 1 and 3 did that time. Again you could hear the noise when it started and I was really surprised that you could hear that. Don't know how many times it chugged. I know #2 gave me a couple of kicks while it was starting. Last time I looked at the gage on #2 it was going thru about 160, and I knew that when I looked up that I would get a lite. Then I started communication problems with John, and I said OK, I'll go with2. Yes, I had 3 going and John said OK, we will go with 2, and I thought now John, I really mean I got 3, but I got chamber 2 running finally. I should not have said that. I just sort of ran off at the mouth there. I had tried to get #4 going, so when it would not go that's when I got 2 going and that's when I made the comment. (?) In fact, I thought that I got some noise and gage twist like before.

It was my impression any, whatever the data shows.

OK, I looked down, I think I had 260 or more, Johnny, and .85 and I knew that that was not a good idea, so I said I'll trim to 14 now. Had a lot more cues than the simulator, so the nose started up immediately and I said the simulator does not do that. Then I felt the nose coming up and I tried to make myself trim to 14, and I just kept pushing the stick forward. I had a hard time making myself trim to 14. The airplane, I don't think was hard to trim. I just had a hard time making myself do it. I was using two hands at that time and I was trying to trim out both the pitch and the roll. The only thing I can say is that I finally decided I really was going to go to 25 theta. It started to slow down and I found I could trim to 14. I don't know if I talked myself into it and finally I just got it so I just let myself go into it. So overall, there may be some inexperience there. Also some problems in making it go to 14 theta. Certainly not as easy as the simulator after several hundred runs.

OK, got to 14 and started calling off the Mach and let John know where I was. Had .825 and it went down to about 12 and said that I had a little extra thrust, but I think that was just airspeed because pretty soon it came back to 14 and finally we were down to 20. Just about like the simulator, and at that time I felt pretty good in it and had the roll trimmed out. I don't know, we said can you hold $\alpha \pm 1/2°$. I sure could not hold $\alpha \pm 1/2°$ during the boost portion. I think I can on later flights when I have more time in the airplane. OK, we got .77 I think about 100 seconds. I was not paying much attention to the time after I found I was going to be late. Did a doublet and got what I expected out of the rudder portion and then the aileron portion it just - you wonder why you do that because it is - just does not do anything. Evidently good for the data, but I just felt like the stick was not hooked to the airplane.

OK, at that time I started pushover to 12 to accelerate just like the simulator, and it started coming up good. Got a .82 doublet, got a little more response out of the airplane and held 12 to shutdown. Got the early shutdown call, and shutdown now call, that was really a help because I had .87 right there and it worked out. Shut her down and tried to be aware of not putting in any stick inputs to see how it pitches over and it doesn't. It doesn't pitch at all. You can feel it decelerating in the X-axis and it is just pleasant. You shut it down and go over to 5 α. In fact, going over to 5 α and being at 5 α was the most pleasant part of the flight. I would say that the airplane was the most pleasant to fly at that part of the profile except perhaps on final and during the flare, the landing. I was surprised to see how long it took to decelerate to .78. It seemed like it was longer than the simulator, but I think I got the doublet at .78 and that doublet looked a lot like the simulator doublet. Kind of a snake motion. Pulled out and got 14 α at .78 and was happy with that pitch pulse. Looked like the simulator, easy to do. Down to 10, still had .78, for the pitch pulse and got about 3° change in α and then a little adreinalin took over and I really rapped it back and went to about at least 16-1/2 and got a stick shaker. I did not mean to do that, but I did it anyway. OK, it took a long time to decelerate again. I went to 13, prop supply off and just sat there and waited for it to decelerate again. It seemed longer than the simulator. Down to doublet at .68. A sharper response. That shows up in the simulator also, more than the other doublets.

By that time I had a 075° heading. I was quite startled at that. John seemed to be happy with it so I pressed on. He called turn, I went to jettison, 4, 3, 2, on the chamber switches right there and then I just enjoyed myself to the landing. The rest of the flight I did not do anything with the airplane but fly it around the pattern and land it. It was the same as the two glide flights and a very nice airplane to fly. Had about 30° of flaps from even before the 90° point, because I knew I was pretty high on energy. Then made a decision to put them in and then decided I just would not put them out again, so I left the air speed build to 310 or 315 but I figured that was OK. That's about it.

OK, the landing was a little different than the other two in the sense that I could hold the nose off. The nose did not fall through initially like it has before, and until about the last 25%, then it goes down fast. But it did hesitate a good bit and lower itself down slowly and I had the stick back. I put --- on the nose gear steering and put a couple of good inputs in at 130 and yes, agree with John, it is all we want at 130. You could probably roll the airplane if you worked at it.

FLIGHT:	B10-21	PILOT ENTRY:	1040
PILOT:	Maj. M. Love	ENGINE START:	1055
B-52:	008	TAXI:	1105
NASA 1:	J. Manke	TAKEOFF:	1120
Lnch Panel:	V. Horton	LAUNCH:	1210
DATE:	April 30, 1974	LAND:	1217

24 Minutes:

LOVE: SAS gains are 6, 5, 3.
Ready for a calibrate?
NASA 1: We are ready.
Good calibrate
LOVE: OK, cabin pressure altitude 21,000
X-24 air 3200
Pylon 6
NASA 1: Left to 090 noew, 008
008: Rog
LOVE: 3 SAS mode switches are on
All circuit breakers are in except vehicle release and brake
NASA 1: Roger, Mike
LOVE: Mach repeater auto
NASA 1: Roger
LOVE α reads 2
Airspeed is 234
Altitude 38.3
Indicated Mach is .76
And Mach repeater .76
NASA 1: Roger
008: For what it is worth the Mothership has .73 Mach
NASA 1: Alright
LOVE: Mach repeater is manual at 1.0
NASA 1: Roger, and 008 you can start your left turn and use about 10° bank angle
008: 008
LOVE: OK, trim to 1° on the lower and cycle
Emergency flaps
20 30 25
NASA 1: Roger, Mike
LOVE: Flap bias open 40, zero
Rudders started at 30
CHASE: Good
LOVE: Closed to 20 and -10
40 and zero again
NASA 1: 008 you can resume your normal turn rate now
008: 008
LOVE: Rudder mode manual
Toed in to -10 then to -7 back auto, going to zero
NASA 1: Roger, Mike

LOVE: Aileron made is back-up
NASA 1: Roger
LOVE: Cycle 5 down to 9
NASA 1: 008 you can steepen your turn a little bit now please.
008: 008
LOVE: OK, aileron mode in normal
Cycle 9 to 5 and back to 7
Stick full aft
Forward trim
Aft trim
Set 10°
NASA 1: OK, Mike
LOVE : Right and left aileron trim, set zero
NASA 1: OK, Mike
LOVE: Right and left rudder
NASA 1: 008, roll your wings level for just about one minute please
008: 008
LOVE: Right and left yaw trim, set 1° left
KRA 50
Right and left stick and rudder moved
CHASE: OK roger that
LOVE: KRA zero
Right and left stick and rudder did not move
NASA 1: Roger, Mike
LOVE: KRA emergency
Set 50
Right and left stick
The rudder moved
KRA TO auto
NASA 1: Roger, Mike
LOVE: Stick shaker test is good and its on
Mach repeater is 1.0
Flap mode manual
Rudder mode auto
NASA 1: OK, Mike
CHASE: All looks good
NASA 1: Mike Love, precool off, please
LOVE: Precool off
OK SAS servos are auto
Set 5, 5, 5, and the old SMRD
008: Don't you want some more left on the Mothership?
No lites
NASA 1: We will call you when to start the turn 008
LOVE: Torque
No lites
NASA 1: Very good
OK, you can start your turn again, 008
Normal turn rate
NASA 1: Alright

008: 008, left turn
LOVE: 3 red
NASA 1: Mike, looking real good
LOVE: 6, 5, 3,
Servos are auto
Lites reset
Torque
No lites
NASA 1: How about that
LOVE: SAS mode switches are on
NASA 1: OK, we are doing real good timewise
We are 19 minutes

<u>19 Minutes</u>

LOVE: Roger
I will hold here
NASA 1: OK Mike, we would like a little bit of left roll and a little bit of left rudder
A little bit more roll
OK, they are both good
LOVE: Roger
NASA 1: 008, your roll out heading is 250
008: 250
NASA 1: OK roll out that heading, 008
008: 008
NASA 1: 008, we got you a little bit too far left of track
Could you go about 10° right for us please
008: Roger, 10 right

<u>17 Minutes</u>

NASA 1: 17 minutes
LOVE: 17
NASA 1: 008 what heading do you read now?
008: 260
NASA 1: Thank you
oo8 would you come 8° left, please
008: 008, 8 left
NASA 1: 008, we dould like 4 more degrees left, please
008: OK, 4 left
NASA 1: And now 2 more degrees left, 008
008: 008
NASA 1: We are controlling you with such precision you would not believe it
And Mike we just past 14 minutes

<u>14 Minutes</u>

LOVE: OK, 14 John
Hydraulics are swapped
Pressure 2700
NASA 1: Roger, and 008 we are ready for the pitch and yaw pulses, please

008: Roger, pitch
NASA 1: That was a good one
008: Yaw
NASA 1: OK, that was a good yaw pulse
Mike Love you can go erect switch erect
Fast erect on
LOVE: OK
NASA 1: We are just pas 13 minutes, Mike

13 Minutes

LOVE: Roger, 13
NASA 1: 008 say your heading
008: --- 244/246

11 Minutes

NASA 1: OK, Mike Love, 11 minutes, 11
LOVE: OK, 11 minutes John
I got the uppers 40
Lowers 10
Aileron 0
Aileron bias 7
Rudder is left 1
Rudder bias is 0
NASA 1: OK Mike, we concur
CHASE: Looks good here Mike
NASA 1: Have you seen any top-off?
CHASE 1: I called it about 5 minutes ago
It started, now its kind of pulsating
NASA 1: OK, thank you

10 Minutes

NASA 1: OK Mike Love, 10 minutes, 10
LOVE: 10 Minutes, John
#1 4000
#2 4100
Control gas 500
Governor balance 460
Fuel tank is 8
LOX is 2
Landing gear 3100
And ready for the pump heater check
NASA 1: I reckon we are ready
LOVE: Pump heater is off
NASA 1: OK
Now back on, Mike
LOVE: Pump heater is on
NASA 1: Good check
LOVE: Roger
NASA 1: OK Mike Love, 9 minutes, 9

9 Minutes

LOVE: Roger
Erect switch is cutoff
Fast erect is off
Both attitude indicators are good
NASA 1: OK Mike

8 Minutes

NASA 1: OK, there is 8 minutes
008 you can start your left turn
008: 008
LOVE: Here comes the throttle, John
NASA 1: Roger
LOVE: Standby for a δa, John
NASA 1: OK Mike, we are ready
OK Mike, that is good
LOVE: OK have you got 2 good chambers
NASA 1: OK, we got two good ones
LOVE: OK
NASA 1: Vic Horton it looks like a good indication of top off down here on our temperature
HORTON: Rog, John, thank you

7 Minutes

NASA 1: We are showing 7 minutes now Mike, 7 minutes
LOVE: OK, 7 minutes John, lets go secondary
NASA 1: Alright
Loud and clear, good radio check
008, will you shallow your turn now, please
008: 008

6 Minutes

NASA 1: OK Mike, 6 minutes, 6 minutes
Chase aircraft check your windshield heat
CHASE: 1, 2, 2 alpha
LOVE: OK, there is 27 John
NASA 1: OK Mike, we like that

5 Minutes

NASA 1: OK Mike there is 5 minutes, 5 minutes
LOVE: Roger, 5 minutes
I'm on battery power
Emergency battery lite is reset
Hydraulics are swapped and pressures are 3200
NASA 1: OK Mike
LOVE: I got 110, 105, 100 and 35
NASA 1: Looks good Mike
LOVE: 5, 5, 5, set and an old SMRD
No lite
Torque
And no lite
NASA 1: Good show
LOVE: #1's off
NASA 1: Roger

NASA 1: 008 tighten your turn
LOVE: 3 yellow
3 red
NASA 1: Alright
Roll out 053, 008
008: 053
LOVE: OK, I have got them on
I've set 6, 5, 3,
SAS lites are reset
Torque
No lites
NASA 1: OK Mike, good show
Standby for 3 minutes
LOVE: Yes, we passed the 4 minutes here in good shape
HORTON: Adapter power switch is off
Ammeters zero
NASA 1: Thank you, Vic
We are about 3 1/2 minutes Mike
LOVE: Roger
NASA 1: Really good show
008, 2 more degrees left please, 2 left
008: 008

3 Minutes

NASA 1: OK Mike there is 3 minutes, 3 minutes
LOVE: Roger
NASA 1: 2 more degrees left, 008
008: 2 left
LOVE: I'm on X-24 oxygen
1700 and regulated is 85
NASA 1: Roger, Mike
LOVE: I am on X-24 air and I have got 3000
NASA 1: Roger
LOVE: Cabin altitude 24,000
NASA 1: Roger
LOVE: Canopy forward defog on and I'm in heat
Suit vent is going low
#1 is 4000
#2 is 4100
Control gas is 500 and governor balance 465
NASA 1: Roger Mike
LOVE: Erect switch erect
Fast erect is on and my trim looks good.
NASA 1: Looks good here Mike
LOVE: Roger

2 Minutes

NASA 1: OK Mike, 2 minutes now, 2 minutes
LOVE: 2 minutes
Precool is off

LOVE: Engine bleed on
Prop su;;y on
Fuel and LOX tanks pressurized
NASA 1: Roger, and we will watch your tanks
LOVE: Release pressure low lite out
NASA 1: Roger, and your tank pressures are good, Mike
LOVE: OK
NASA 1: 008, 2° right, now
008: 2 right
HORTON: Topoff is off
Beacon off and alternate pressure's good, John
NASA 1: Thank you, Victor, and 2 more degree right 008
008: 008
NASA 1: 70 seconds now, Mike
LOVE: 70 seconds

1 Minute

NASA 1: OK Mike, one minute, mark
LOVE: OK, cloc's running
#1 is 38
#2 41
SAS lites are out
052 heading
alpha 4
beta zero
NASA 1: Roger
LOVE: Engine master
NASA 1: Roger, Mike
LOVE: Erect switch cutoff
Fast erect off
NASA 1: Roger
OK Mike, systems OK at NASA 1
LOVE: OK
Circuit breaker's
Camera, recorder and fin camera are on
NASA 1: Roger, Mike
LOVE: Igniter test
1 got 4 good ones
NASA 1: We got 4 good ones too, Mike
Good show
LOVE: Reset
NASA 1: Very good
LOVE: 5 seconds

LAUNCH

NASA 1: OK, Mike watch your α 14°
LOVE: OK, John
NASA 1: You just keep try them Mike
LOVE: Got two good ones

NASA 1: OK
LOVE: Going with 4
NASA 1: Roger
LOVE: I will take 2
NASA 1: OK, 2 chamber profile Mike
14° α
LOVE: 14
NASA 1: OK, good show
LOVE: 3 chamber, John
I got 1, 3 and 2
NASA 1: OK
I got delayed engine lite
Let's go up to 25 θ
LOVE: Roger, 25, on θ
NASA 1: OK, you are coming up good, Mike
Looking real good
25 theta and watch your α 14
LOVE: Rog, holding about 12
NASA 1: OK, that's good ---
We got you converging pretty nicely on the profile
LOVE: Good, going through .68 Mach
NASA 1: OK, your track is great
Got a very nice heading
LOVE: OK
NASA 1: Everything is back to normal now
Check your α/β
LOVE: 14 now, John
Beta isjust a little, its on zero
NASA 1: OK, and you can shade to the left a bit, maybe 3 to 4°
LOVE: Little bit left
NASA 1: OK you can check your Mach and standby for your .77 doublet
LOVE: I got .68 John
NASA 1: You got a good track
You are right on the track, Mike
LOVE: OK, going 14
NASA 1: And we see your doublets, Mike
LOVE: Roger
NASA 1: That looked real good
We got you about 2000' below profile and we are going to have to do the normal thing on the pushover here
LOVE: There is 12 now
NASA 1: OK, you are at the early shutdown line now and Mike, standby for your .82 doublet
LOVE: There is your doublet
NASA 1: Very good
Doing a nice job, Mike
Standby for shutdown and 5α
LOVE: Roger
NASA 1: You are at your normal shutdown line now and we are about 2000' low

NASA 1: OK, we got the shutdown, Mike
Go to the 5 α doublet
Your peak altitude is about 51.5
Shade a bit right when you get a chance
Check your Mach, theta and check you 14 α
LOVE: Roger
NASA 1: OK, we see your pitch pulse
Go to 10° α and 2 more degrees right
We got you running about 2000' high
No sweat
You are 4 miles now
Come a little more right Mike
LOVE: I'm at 13
Prop supply is off
NASA 1: A good show
Bring it a little more right, Mike
OK, that's good right there
That is a good heading
You are coming up on 2 miles
Standby for .68 and 11° α doublet
LOVE: Roger
NASA 1: One mile
We see the doublet
Start the left turn now and go to jettison
Look out and see where you are going
LOVE: --- I got jettison and the SAS 4, 3, 2
NASA 1: Alright, good turn
Got a nice turn going
You are right on your profile right now
LOVE: OK, just like the simulator
NASA 1: OK great
It looks like 0, 0, 0, for a heading
Stop jettison, Mike
Tanks and bleed off
LOVE: Roger
NASA 1: And north looks like a good heading
Standby to close it up
LOVE: I will have 250 Willie
CHASE: OK Mike, that's what I got
NASA 1: 3 miles and got you about 500 below
You got a great profile
2 miles, Mike
LOVE: Roger
NASA 1: That looks like a dandy heading
This is taking us right into the low key point
LOVE: OK, John
NASA 1: Perfect energy
Why don't you get your ---
1 and 3 hydraulics on and give us a rocket check
CHASE: That's a good check

NASA 1: Yes, we saw it here
You are coming up on the turn point now, Mike
Crossing the highway, now
LOVE: Roger, starting my turn
NASA 1: It is just like a glide flight now
LOVE: Roger
CHASE: 282
Altitude 15.5
RPM is 86, Mike
LOVE: Roger
NASA 1: And we show you with speed brakes out, Mike
LOVE: Speed brakes coming in
NASA 1: OK, Mach repeater to three-tenths
LOVE: Three-tenths
CHASE: 310 knots, 5700' and RPM is 92
LOVE: Roger
CHASE: 1200'
LOVE: Starting the flare
CHASE: There is 100, 50, 3 good ones, Mike
20', 10, 5, 3, 2, 1
How about that?
LOVE: Nice one
NASA 1: OK Mike, nose gear steering arm when you feel like it
LOVE: Roger
CHASE: Chase 1 are you going to fly-by?
CHASE: --- on your right
NASA 1: Debrief 1300
OK Mike, that was a beauty
Real good flight
LOVE: Thank you, John
NASA 1: We are on page 20
LOVE: Alright
Engine master off
That's the wrong page
NASA 1: OK, lets go to 21
LOVE: KRA is manual
Throttle is already off
Camera off
Ready for a calibrate
NASA 1: Ready
Good calibrate
NASA 1: OK, we want the recorder off
LOVE: Roger, it is off
SAS servos going off
Hydraulics going off
NASA 1: Roger
LOVE: Defog off
OK, erect switch erect, fast erect is on

LOVE: #1 helium 1300
#2 is 3800
Control gas 510
Governor balance 460
Landing gear is down to 2600
Oxygen is 1000
Cabin air 800
SAS system switches are coming off
I want to open up and get oxygen off and cabin air off

NASA 1: OK, and see you back here

FLIGHT 11

Preliminary Results of X-24B

Flight B-11-22

24 May 1974

BY

USAF/NASA X-24B Project Team

Flight Summary - Flight B-11-22

Flight B-11-22 was flown on 24 May 1974, by John Manke. The number one chamber of the XLR-11 engine failed to start, resulting in a preplanned three chamber alternate profile. However, the envelope was expanded to 1.14 Mach number and the alternate data maneuvers were performed. The significant flight conditions achieved were as follows:

Maximum Mach Number = 1.14
Maximum Altitude = 55979 feet
Maximum True Airspeed = 654 kts
Flight Time = 7 minutes 28.9 seconds
Burn Time = 156 seconds (Burnout)

A summary of the key data maneuvers performed on the flight is listed below.

Mach	α	Maneuver
1.05 - 1.08	7^{o}	Rudder/aileron doublet (power on)
1.02 - .97	5^{o}	Rudder/aileron doublet
.93 - .90	10^{o}	Pitch pulses (2)
.79 - .66	5^{o} to 12^{o}	Yaw Damper off HQ (30 sec)
.63 - .59	12^{o}	Buffet Study (20^{o} upper flap)

The increased thrust level system (overdrive) was successfully checked out during the flight. Engine shut down was caused by LOX starvation due to unporting of the LOX outlet feed line. The observed burn time of 156 seconds does not represent the total capability of the propulsion system because of the non optimum propellant angle at these flight conditions.

Post flight inspection revealed a hydraulic oil leak in the left main gear strut. However, the data indicates that the strut did not bottom on landing as had been observed on previous flights.

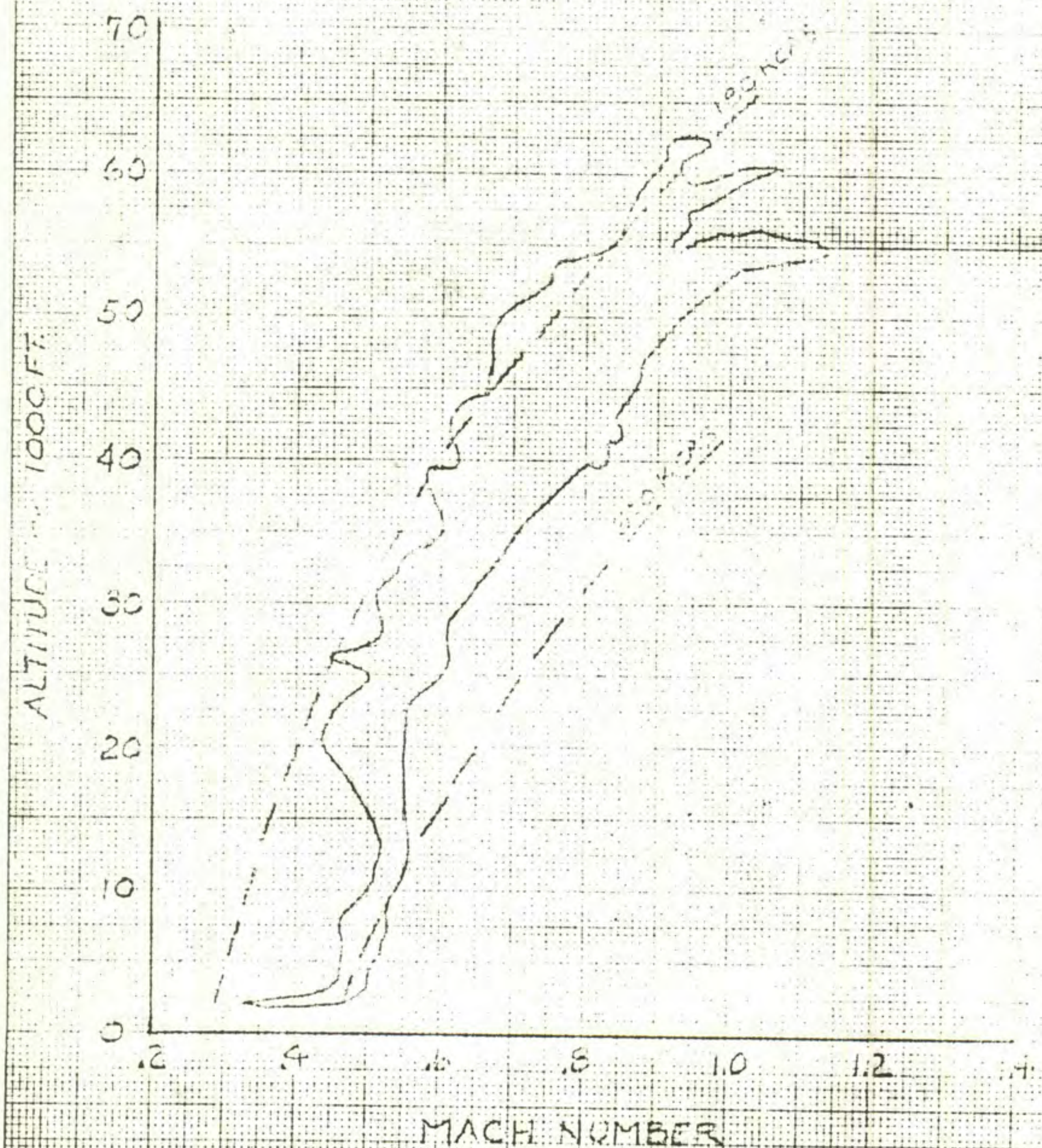
Only a very small aileron deadband was observed in the left hand aileron during the flight. However, the left hand aileron input rod position was observed to be erratic before launch and during flight. It has been concluded that this was not a real mechanical problem with the aileron linkage but rather a resulting temperature effect on the position measuring transducer itself. Lab tests are planned to confirm the characteristics of these transducers at cold temperatures.

X-24 B

[illegible] ALTITUDE

ENVELOPE

FLIGHTS 1 THRU 11

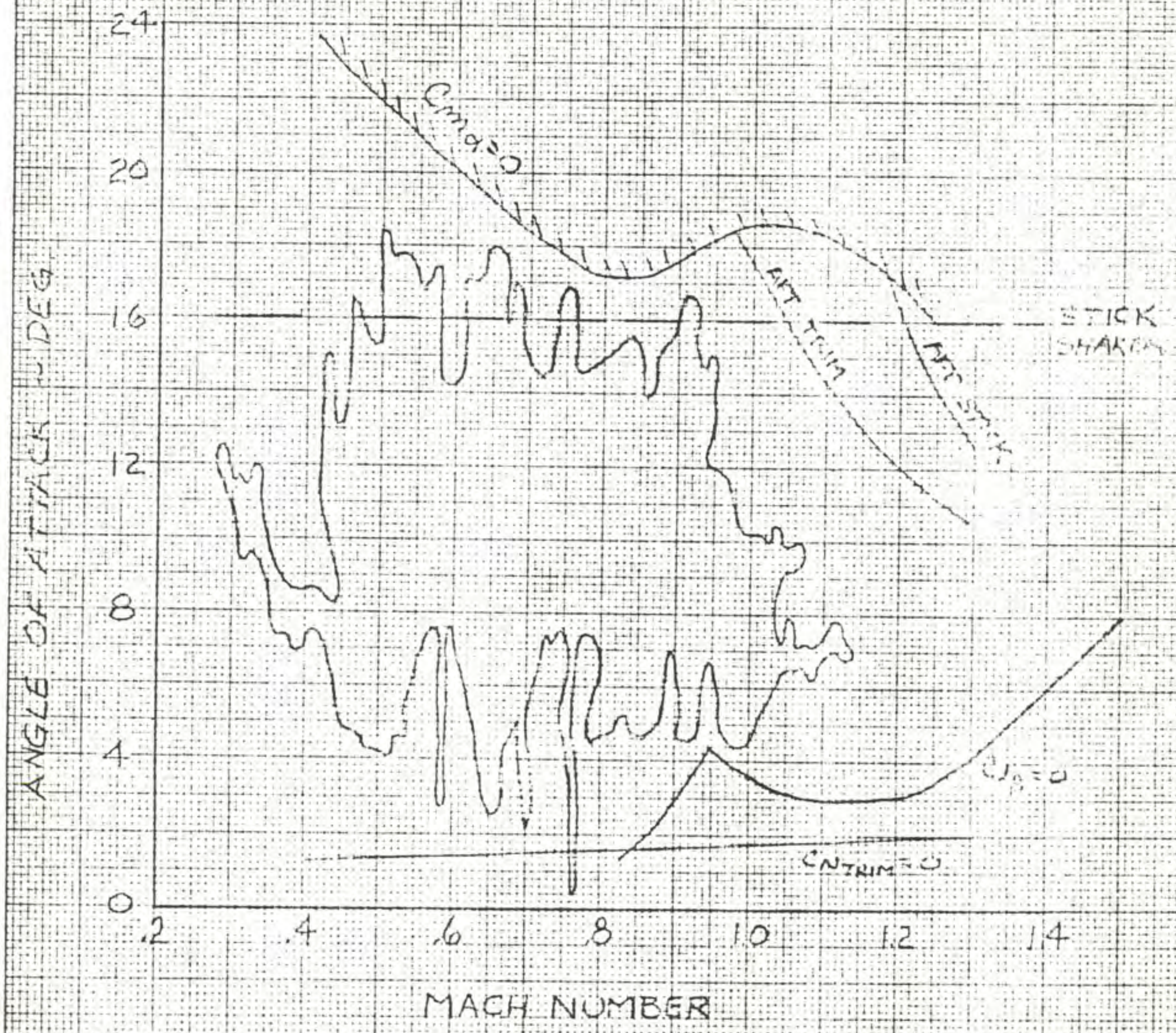


X-24 B

MACH NO. VS ANGLE OF ATTACK

ENVELOPE

FLIGHTS 1 THRU 11



X-24B Flight Request

3 May 1974

Flight No: B-11-22

Scheduled Date: 14 May 1974 FLOWN 24 MAY 74

Pilot: John Manke

Purpose:
1. Envelope Expansion to 1.25 Mach Number
2. Stability and Control at Mach Number> 1.0
3. Buffet Investigation at .65 Mach Number with 20^o Upper Flaps
4. Engine Checkout at 300 psi Chamber Pressure (overdrive)
5. Fin and Rudder Pressure Survey
6. Boundary layer noise and vibration experiment (RED PLUG)

Launch: West of Rosamond, Mag Heading 060^o + Cross wind Correction Angle. 45,000 feet, 190 KIAS. Flap Bias "Manual", Upper Flaps = -40^o, Lower Flaps = 27^o, Rudder Bias Mode "AUTO", Rudder Bias = 0^o. Rudder Trim = 1^o Left. Aileron Bias = +7^o, SAS Gains 6, 5, 3. Mach Repeater "Manual" = 1.0, KRA "AUTO", Hydraulic Pumps 2 and 4 on.

Landing: Rogers Lakebed Runway 18

B-52 Track: X-24B Track #2 (R2515, Work Area I)

ITEM	TIME	ALT	A/S	α	M_T/M_i	EVENT
1	0	45	190	5	.71 (.70)	Launch, Light 4 (1 & 3 FIRST) Chambers, Trim to and Maintain 15^o α
2	30	44	245	15	.84 (.82)	At 30 sec. Turn "overdrive" on.
3	38	45	225	15	.80 (.79)	θ = 35^o Maintain θ = 35^o (cross check α)
4	70	54	190	13	.85 (.83)	At 54K (.85 $Mach_T$) Pushover to 12^o α.
5	99	62	200	12	1.05 (1.05)	At 1.05 $Mach_T$, overdrive off, pushover to 7^o α.
6	110	64	215	7	1.15 (1.15)	Perform rudder and aileron doublets

ITEM	TIME	ALT	A/S	α	M_T/M_i	EVENT
7	117	64	240	7	1.25 (1.25)	At 1.25 $Mach_T$ shutdown engine. Perform rudder and aileron doublets.
8	128	63	220	7	1.12 (1.12)	Pushover to 5^o α, perform rudder and aileron doublets.
9	141	58	230	5	1.05 (1.05)	Pull up to 10^o α, perform two pitch pulses, then pull up to 12^o α and evaluate handling qualities to .85 M_T; at .85 M_T Yaw damper to "zero gain"
10	172	45	240	12	.84 (.82)	Pushover to 6^o α, pitch damper to "zero gain", perform ~~two~~ pitch pulse~~s~~, pitch damper to "ON" Return to 13^o α.
11	200	35	250	12	.72 (.71)	Intersection, Yaw damper to "on", Turn to low key heading. Jettison propellants. (400 lbs Lox, 460 lbs WALC)
12	220	32	220	8	.58 (.57)	Change configuration to -20^o upper flaps. increase $Mach_T$ to .65.
13	228	29	250	8	.65 (.64)	Pull up to ~~18~~ 12° α, observe buffet, return to ≈ 10^o α, vector to low key; set SAS gains to 4,3,2.
14	280	21	240	10	.55 (.54)	Low key, rocket check, #1 and #3 hydraulic pumps on.
15						Set Mach repeater to .3 during final.

NOTES:

1. Nose Ballast = 220 lbs (+ 100 AMP HR Equp Batt)

2.

	Weight-lbs	cg-%
Launch	13457	65.9
Shutdown	9130	64.1
Landing	8394	64.0 (gear down)

3. Engine S/N 8, Pump S/N 8A

	Normal	Overdrive
Thrust - lbs/chamber	2100	2350
LOX Flow Rate - lb/sec/chamber	4.51	5.045
WALC Flow Rate - lb/sec/chamber	4.05	4.53

4. Power on Base Drag Reduction C_C = -.005

5. Pitch Attitude Null at 35°

Ground Rules for NO LAUNCH:

1. Radio, radar, PCM failure
2. Electrical or SAS malfunction
3. A/S, Altitude, Machmeter failure
4. Angle of attack or sideslip malfunction
5. Any control system malfunction
6. Loss of cabin pressure
7. Turbulence below 10K in excess of moderate
8. Surface winds greater than 20 kts or crosswind greater than 10 kts
9. Failure of engine control box heater
10. Failure of stick shaker

(In addition to standard ground rules published in Lift Body Joint Operations Plan)

NOTE: NO IGNITER TEST

Alternate Situations After Launch:

Failure	Action
1. Radio, radar, PCM	Proceed as planned.
2. Only One Chamber Operates	Vector for RW 02 Rosamond, shutdown chamber, jettison, change configuratio

Failure	Action
3. Only Two Chambers Operate	Maintain 15^{o} α, overdrive on at ~~30 sec~~ RW 36 ENERGY, Change configuration to 35^{o} upper flap at .7 Mach No. Shutdown on NASA I call ($\approx$ 196 sec). Evaluate dampers off handling qualities at pilot's discretion.
4. Only Three Chambers Operate	Maintain 15^{o} α. Overdrive on at 30 sec. at 53K ($.85M_T$) pushover to 10^{o} α. At $1.05M_T$ pushover to 7^{o} α (overdrive stays on). Burn out approximately $1.1M_T$ (147 sec). Perform $1.05M_T/5^{o}$ α doublet set and proceed as planned.
5. Delayed Engine Light	Proceed as planned. Use $40^{o}\theta$ (15^{o} α Max). At 54 K pushover to 11^{o} α.
6. Overdrive Failure	Proceed as planned. Limit α to 15^{o}. (129 sec Burn Time)
7. Total damper failure - any axis	Fly 3 chamber profile, maintain 13^{o} α, limit M_T to .9. Overdrive checkout at pilot's discretion. Shutdown on NASA one call. If control is marginal go to two chambers. FOR ROLL or YAW FAILURE SET MACH REP TO .3
8. KRA "AUTO" Failure	Set to manual 10% and proceed as planned. If "MANUAL" mode inoperative-switch to "EMER" position and set to above value.
9. Angle of Attack (Indicator Only)	Proceed as planned using backup angle of attack gage. KRA "MANUAL" 10%, stick shaker off.
10. Total Angle of Attack	Fly Two Chamber profile, use 200 KTS instead of 15^{o} α. To rotate fly 1.0g to 230 KCAS then fly 1.2g to 200 KCAS. (KRA Manual 10%, stick shaker off)
11. A/S, altitude, Mach	Proceed as planned using α, θ and time for profile control.
12. Attitude System	Proceed as planned using backup attitude indicator.

Failure	Action

13. Premature Engine Shutdown

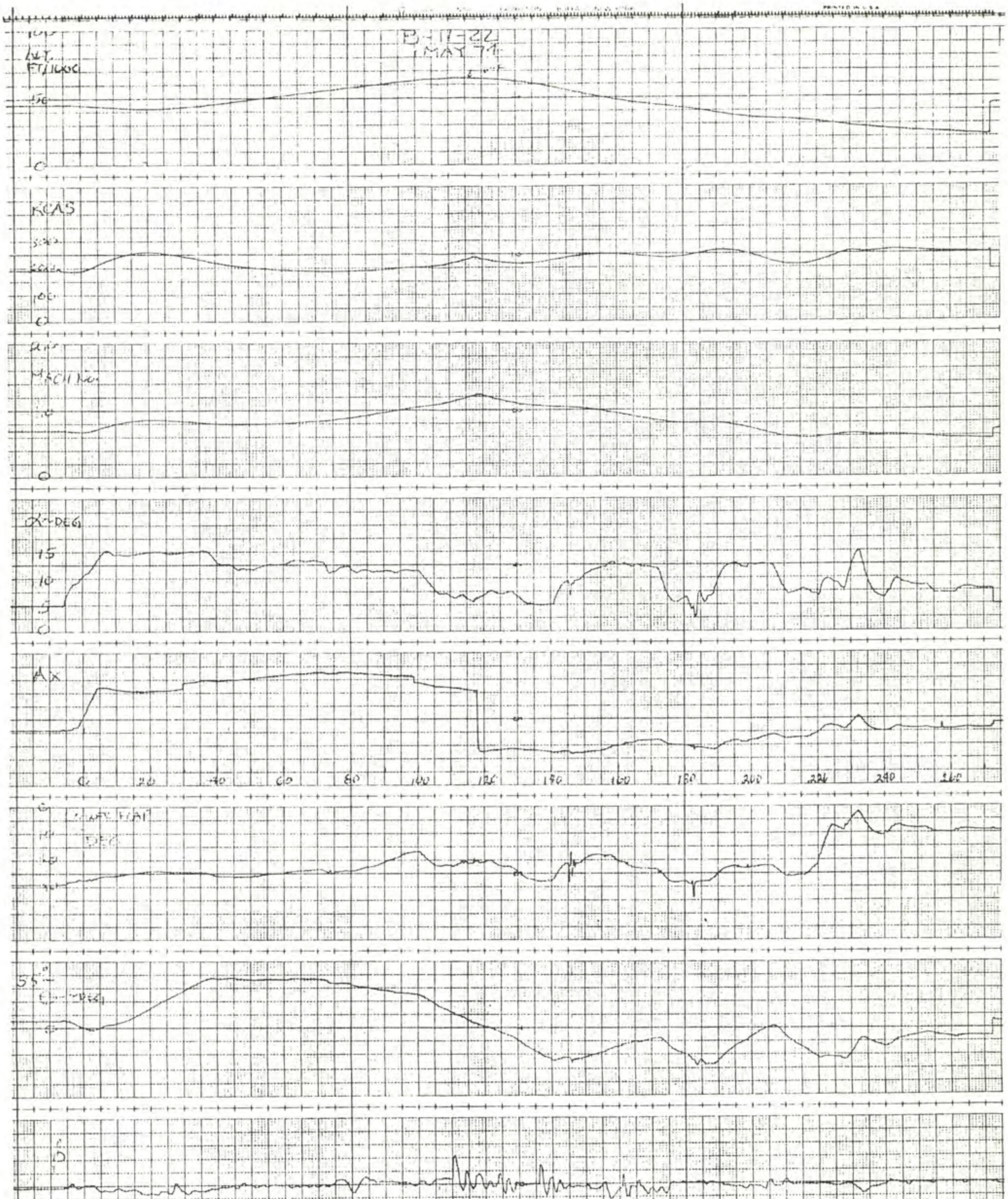
0 - 20 Sec RW 02 Rosamond
20 - 40 Sec RW 20 Rosamond
40 - 72 Sec RW 36 Rogers
72 - 80 Sec RW 18 (RHP) Rogers
80 - up Sec RW 18 (LHP) Rogers

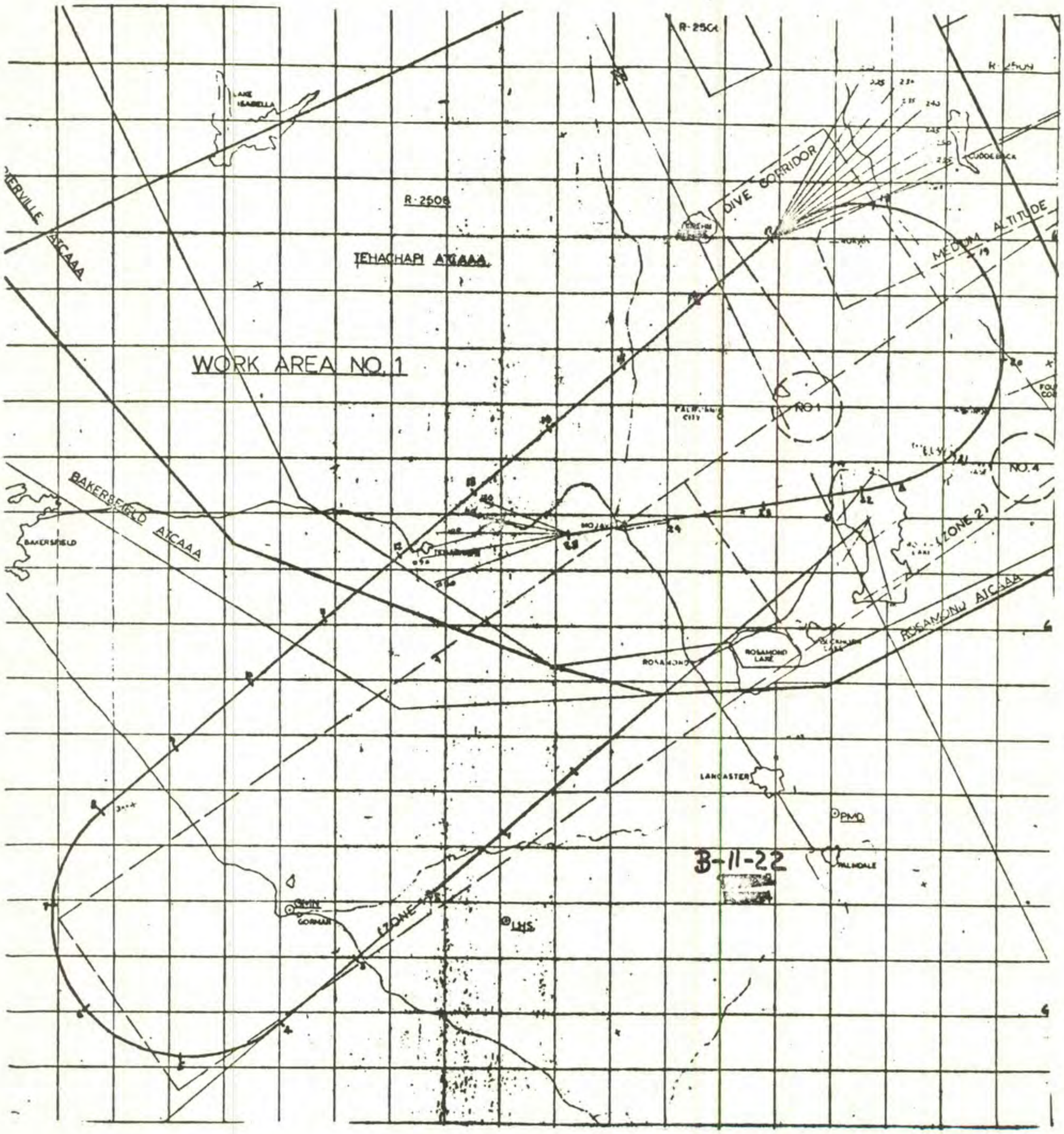
Robert G. Hoey

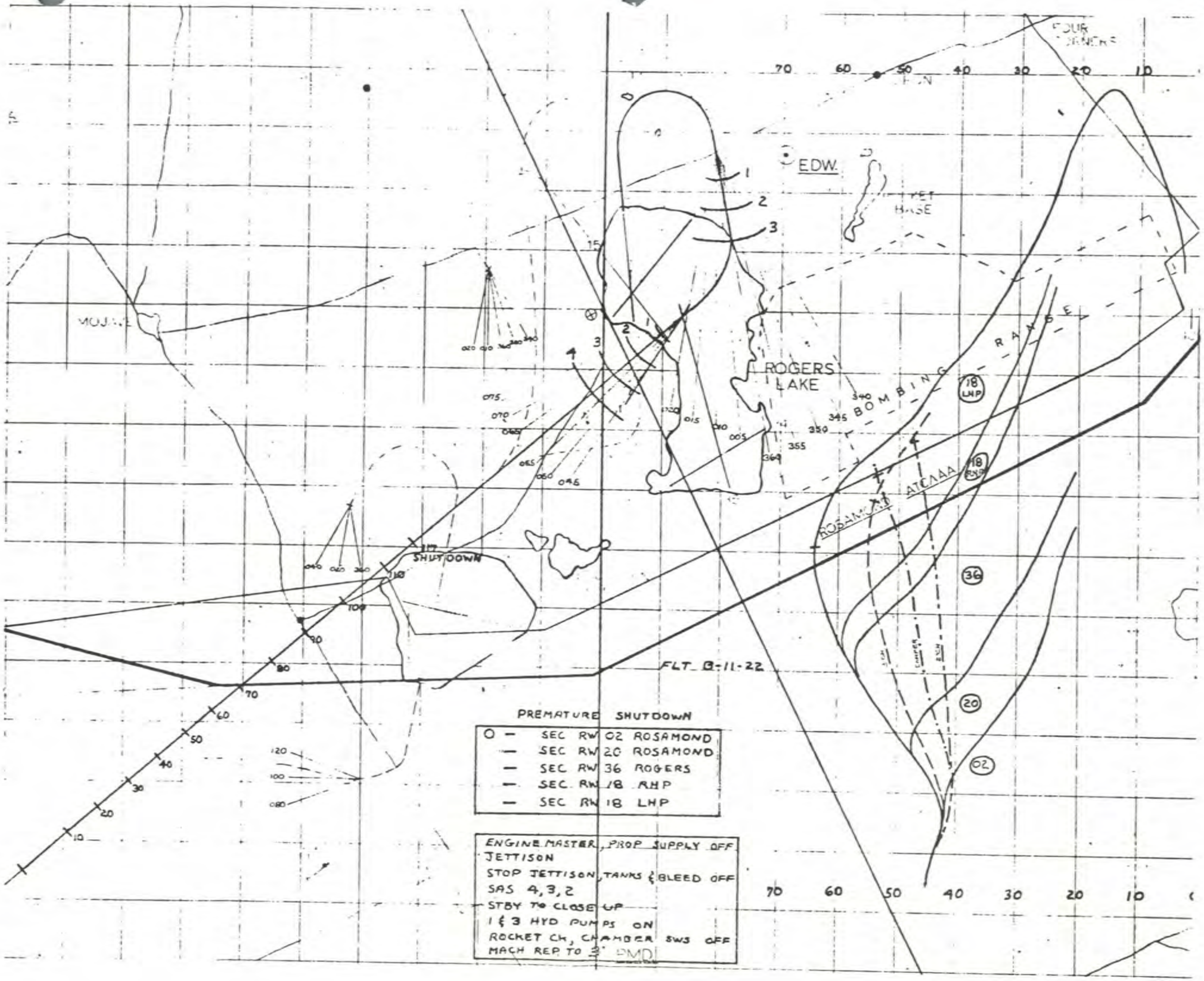
ROBERT G. HOEY

Jack L. Kolf

JACK L. KOLF


B-17-22
1 MAY 71
ALT.
FT/1000
KCAS
MACH No.
α~DEG
Ax
0
20
40
60
80
100
120
140
160
180
200
220
240
260


R-2508
TEHACHAPI ATCAAA
WORK AREA NO. 1
DIVE CORRIDOR
MEDIUM ALTITUDE
BAKERSFIELD ATCAAA
BAKERSFIELD
ROSAMOND ATCAAA
(ZONE 2)
NO.1
NO.4
LAKE ISABELLA
ROSAMOND LAKE
LANCASTER
PALMDALE
PMD
LHS
GORMAN
3-11-22



FOUR CORNERS
EDW.
ROGERS LAKE
MOJAVE
BOMBING RANGE
ROSAMOND ATCAAA
SHUTDOWN
FLT B-11-22
18 LHP
18 RHP
36
20
02
PREMATURE SHUTDOWN
O — SEC RW 02 ROSAMOND
— SEC RW 20 ROSAMOND
— SEC RW 36 ROGERS
— SEC RW 18 RHP
— SEC RW 18 LHP
ENGINE MASTER, PROP SUPPLY OFF
JETTISON
STOP JETTISON, TANKS & BLEED OFF
SAS 4,3,2
STBY TO CLOSE UP
1 & 3 HYD PUMPS ON
ROCKET CH, CHAMBER SWS OFF
MACH REP TO 3° PMD
70
60
50
40
30
20
10

X-24B EVENT SHEET

FLT B-11-22

TIME	MACH	ALT	KCAS	α	EVENTS
10:01:43.0					ENGINE MASTER ON
:01:50.6					GOX PRIME
10:02:05.0					LOX PRIME
:02:10.4					CENTER FIN CAMERA ON
:02:27.3	.7053	44703.	189	3.148	LAUNCH
:02:31.2	.6930	44544.	186	9.495	#1 & #3 CHAMBER PRESSURES START UP
:02:32.3	.6926	44466.	186	10.931	#1 LEVEL AT 90 PSIA (NO LIGHT)
:02:32.3	.6926	44466.	186	10.931	A_x STARTS INCREASE
:02:33.8	.6963	44301.	188	13.001	A_x LEVEL (1 CHAMBER)
:02:33.8	.6963	44301.	188	13.001	RH FIN PRESSURE GLITCH
:02:34.0	.6974	44268.	189	13.165	#3 AT 100%
:02:34.7	.7001	44181.	190	13.373	LH FIN PRESSURE GLITCH
:02:35.7	.7001	44059.	190	13.862	#1 OFF
:02:36.4	.6987	43969.	190	14.419	#2 & #4 CHAMBER PRESSURES START UP
:02:37.7	.6958	43791.	190	14.982	A_x STARTS SECOND INCREASE
:02:39.3	.7029	43539.	194	16.300	A_x LEVEL (3 CHAMBERS)
:02:39.5	.7041	43506.	194	16.535	#4 AT 100%
:02:40.0	.7068	43429.	195	14.739	#2 AT 100%
:02:41.3	.7181	43223.	200	14.283	#1 CHAMBER PRESSURE STARTS UP
:02:42.1	.7234	43092.	202	13.972	#1 LEVEL AT 90 PSIA (NO LIGHT)
:02:45.5	.7646	42510.	218	14.591	#1 OFF
:02:55.6	.8135	41322.	240	14.364	MAX MACH DURING ROTATION
10:03:03.9	.7942	413.71.	233	14.532	OVERDRIVE ON
:03:03.9	.7942	41371.	233	14.532	A_x STARTS INCREASE FROM 0.30g (A_z CONSTANT 1.30g)
:03:04.2	.7938	41382.	233	14.533	A_x LEVEL AT 0.36g (3 CHAMBERS, OVERDRIVE)
:03:30.7	.6868	46160.	178	15.908	$\theta = 34°$
:03:36.5	.6662	47427.	167	15.120	LH FIN PRESSURE GLITCH

TOD	MACH	ALT	KCAS	α	EVENTS
10:04:23.4	.8751	54263.	193.	12.199	PUSHOVER TO 10°α
:04:23.6	.8768	54286.	193.	11.958	LH FIN PRESSURE GLITCH
:04:24.5	.8859	54401.	195.	11.012	RH FIN PRESSURE GLITCH
:04:25.7	.8972	54547.	197.	10.197	LH FIN PRESSURE GLITCH
:04:25.9	.8984	54563.	197.	10.278	10° α
:04:26.5	.9048	54646.	199.	10.825	STEP CHANGE IN RH LOWER RUDDER HINGE MOMENT (MORE NEGATIVE)
:04:26.9	.9082	54693.	199.	11.044	RH FIN PRESSURE GLITCH
:04:33.8	.9553	55403.	208.	10.080	INCREASE IN RUDDER HINGE MOMENT NOISE LEVEL
:04:48.3	1.0133	55794.	221.	10.161	START MACH JUMP
:04:50.0	1.0249	55939.	224.	10.274	END MACH JUMP
:04:50.5	1.0278	55963.	224.	10.073	PUSHOVER TO 7°α
:04 52.0	1.0349	55979.	226.	8.620	MAX ALTITUDE
:04:53.4	1.0414	55957.	228.	7.245	7° α
:04:54.4	1.0482	55924.	230.	7.142	RUDDER DOUBLET α = 7°
:04:56.2	1.0763	55725.	238.	6.762	AILERON DOUBLET α = 7°
10:05:08.0	1.1398	54424.	263.	6.849	MAX MACH (TAS = ---)
:05:08.1	1.1396	54413.	263.	6.710	ENGINE SHUTDOWN
:05:12.5	1.0429	53540.	241.	6.467	PUSHOVER TO 5°α
:05:13.8	1.0240	53381.	237.	5.060	5° α
:05:14.2	1.0234	53362.	237.	4.925	START MACH JUMP
:05:14.2	1.0234	53362.	237.	4.925	RUDDER DOUBLET α = 5°
:05:16.0	.9981	52700.	233.	4.290	END MACH JUMP
:05:18.7	.9763	52035.	231.	4.146	AILERON DOUBLET α = 5°
:05:21.4	.9625	51192.	232.	5.213	PULLUP TO 10° α
:05:24.3	.9361	50124.	230.	9.786	10° α
:05:25.8	.9295	49561.	231.	9.713	PITCH PULSE α = 10°
:05:28.4	.9033	48570.	230.	9.177	RH FIN PRESSURE GLITCH
:05:28.8	.9069	48431.	230.	9.311	PITCH PULSE

TOD	MACH	ALT	KCAS	α	EVENTS
10:05:29.1	.9040	48353.	230.	6.825	LH FIN PRESSURE GLITCH
:05:29.2	.9026	48280.	230.	5.856	RH FIN PRESSURE GLITCH
:05:30.2	.9034	47917.	232.	7.565	RH FIN PRESSURE GLITCH
:05:30.7	.8951	47717.	231.	8.257	RH FIN PRESSURE GLITCH
:05:31.6	.8861	47369.	230.	9.462	PULLUP TO 12° α
:05:32.5	.8902	47064.	233.	10.531	RH FIN PRESSURE GLITCH
:05:33.6	.8843	46662.	233.	11.163	RH FIN PRESSURE GLITCH
:05:35.4	.8614	45984.	230.	11.695	12° α
:05:39.7	.8360	44607.	229.	11.518	START LEFT HEADING CORRECTION (MAX ϕ = 17°)
:05:42.3	.8212	43887.	228.	11.867	ϕ = 17°
:05:43.4	.8126	43593.	227.	11.258	PUSHOVER TO 6° α
:05:45.2	.7880	43150.	222.	9.320	YAW SAS TO "ZERO GAIN"
:05:45.3	.7870	43127.	222.	9.192	START LATERAL OSC.
:05:46.6	.7758	42796.	220.	9.726	END LEFT HEADING CORRECTION
:05:49.0	.7696	42182.	221.	6.223	6° α
:05:52.4	.7689	41228.	226.	5.689	PITCH SAS TO "ZERO GAIN"
:05:52.6	.7680	41172.	226.	5.473	LH FIN PRESSURE GLITCH
:05:53.0	.7677	41050.	226.	4.987	PITCH PULSE
:05:53.5	.7674	40883.	227.	-.144	RH FIN PRESSURE GLITCH
:05:53.7	.7680	40817.	228.	.223	LH FIN PRESSURE GLITCH
:05:54.2	.7663	40661.	228.	5.292	LH FIN PRESSURE GLITCH
:05:54.5	.7662	40572.	228.	7.891	RH FIN PRESSURE GLITCH
:05:55.9	.7602	40114.	229.	4.557	LH FIN PRESSURE GLITCH
:05:56.0	.7604	40081.	229.	4.437	RH FIN PRESSURE GLITCH
:05:58.8	.7585	39096.	234.	5.241	PITCH SAS GAIN TO 6
:05:59.6	.7533	38798.	235.	6.175	PULLUP TO 12° α
10:06:04.8	.7343	36291.	241.	12.110	12° α
:06:08.5	.7237	35813.	239.	11.362	START LOX JETISON
:06:10.0	.7143	35401.	238.	12.460	START WALC JETISON

TOD	MACH	ALT	KCAS	α	EVENTS
10:06:11.1	.7069	35134.	237.	12.698	STOP LATERAL OSC.
:06:13.0	.6877	34730.	232.	12.383	STOP WALC JETISON
:06:14.2	.6765	34516.	229.	12.324	LH FIN PRESSURE GLITCH
:06:15.3	.6674	34325.	227.	12.271	STOP LOX JETISON
:06:15.4	.6658	34313.	226.	12.341	YAW SAS GAIN TO 3
:06:17.2	.6474	34064.	221.	12.428	STEP CHANGE IN RH LOWER RUDDER HINGE MOMENT (MORE POSITIVE)
:06:17.5	.6445	34019.	220.	12.488	RH FIN PRESSURE GLITCH
:06:31.3	.5512	32737.	192.	8.492	START CONFIGURATION CHANGE
:06:31.7	.5502	32682.	192.	8.407	START TURN TO DOWNWIND (MAX φ = 39°)
:06:42.3	.5752	30695.	210.	6.889	END CONFIGURATION CHANGE
:06:44.0	.5852	30280.	216.	5.711	#1 BATTERY VOLTAGE START DECREASE FROM 26 V, #2 BATTERY VOLTAGE STEADY AT 27 V.
:06:50.5	.6230	28393.	241.	7.735	RH FIN PRESSURE GLITCH
:06:51.2	.6289	28165.	244.	8.819	LH FIN PRESSURE GLITCH
:06:51.6	.6316	28045.	246.	9.429	START RH RUDDER HINGE MOMENT BUFFET
:06:59.4	.6221	26053.	253.	12.469	LH FIN PRESSURE GLITCH
10:07:04.2	.5901	25480.	242.	11.731	RH FIN PRESSURE GLITCH
:07:04.4	.5893	25468.	242.	11.790	END RH RUDDER HINGE MOMENT BUFFET
:07:09.3	.5518	25179.	227.	11.434	φ = 39°
:07:14.6	.5164	24956.	213.	11.047	PITCH GAIN TO 4
:07:15.8	.5094	24920.	210.	10.833	ROLL GAIN TO 3
:07:16.2	.5069	24908.	209.	10.879	YAW GAIN TO 2
:07:27.7	.4698	24235.	196.	10.564	START ROCKET CHECK
:07:28.6	.4710	24158.	197.	10.233	END ROCKET CHECK
:07:30.3	.4698	24026.	197.	10.205	#1 HYDRAULIC PUMP ON
:07:30.3	.4698	24026.	197.	10.205	#1 BATTERY VOLTAGE AT 24 V (STARTS FASTER DECREASE) #1 BATTERY CURRENT SHOWS NORMAL INCREASE

TOD	MACH	ALT	KCAS	α	EVENTS
10:07:30.9	.4690	23971.	197.	9.911	END TURN TO DOWNWIND
:07:31.2	.4688	23949.	197.	10.007	#3 HYDRAULIC PUMP ON
:07:31.2	.4688	23949.	197.	10.007	#2 BATTERY VOLTAGE DECREASE TO 25.5 V (AVERAGE), #2 BATTERY CURRENT SHOWS NORMAL INCREASE
:07:34.7	.4653	23651.	196.	9.319	START RIGHT HEADING CORRECTION
:07:48.3	.4843	21933.	212.	9.284	#1 BATTERY VOLTAGE AT 20V
:07:56.0	.4724	20816.	221.	9.551	END RIGHT HEADING CORRECTION
:07:57.3	.4913	20651.	221.	8.952	#1 BATTERY VOLTAGE STEADY AT 19 TO 20 V
10:08:00.8	.4928	20179.	224.	6.901	LOW KEY START TURN (MAX φ > 50°)
:08:44.4	.5186	12127.	276.	5.732	UPPER FLAPS START OUT (SPEEDBRAKES)
:08:49.3	.5155	10956.	281.	6.375	UPPER FLAPS AT 32° (SPEEDBRAKES)
:08:49.3	.5155	10956.	281.	6.375	#1 BATTERY VOLTAGE INCREASES FROM 20V
10:09:07.7	.4771	6408.	282.	7.274	UPPER FLAPS START IN
:09:09.2	.4734	6089.	281.	6.633	#1 BATTERY VOLTAGE STEADY AT 22 TO 23 V #1 BATTERY CURRENT NORMAL
:09:12.2	.4680	5505.	281.	5.973	LEVEL ON FINAL
:09:12.8	.4680	5384.	282.	5.529	UPPER FLAPS AT 20°
:09:15.8	.4704	4845.	286.	5.950	MACH REPEATER TO .3
:09:32.5	.4430	2708.	279.	6.119	START FLARE
:09:45.6	.3612	2207.	229.	7.807	GEAR DOWN
:09:48.8	.3317	2193.	211.	10.781	IN CROSSOVER REGION
:09:56.2	.2691	2168.	171.	12.541	MAINGEAR TOUCHDOWN α = 12½°
:09:56.4	.2671	2166.	170.	11.393	ON UPPER FLAP
:09:58.3	.2503	2157.	159.	-5.481	NOSEGEAR TOUCHDOWN
:09:58.3	.2503	2157.	159.	-5.481	CROSSOVER TO LOWER FLAP
10:11:11.2					CENTER FIN CAMERA OFF

10 5C41

X-24B DERIVATIVES

Alex G. Sim

On flight 11, five maneuvers were analyzed to obtain derivatives.

Two sets of lateral-directional derivatives were obtained from maneuvers near Mach number 1.0 and 1.05 at low angles of attack. These derivatives along with previously obtained derivatives are shown in figure 1. Of particular significance is the level of the effective dihedral parameter, C_{l_β}, at low angles of attack. Note that the flight generally verifies the wind-tunnel predictions for this parameter. Other significant parameters, the weathercock stability derivative, C_{n_β}, the aileron control effectiveness derivative, $C_{l_{\delta a}}$, and the rudder control effectiveness, $C_{n_{\delta_r}}$, is generally at the same or higher than wind-tunnel predictions. This is true both power-on and power-off; although, C_{n_β} is at a lower level power-on. The result of these characteristics is a better flying airplane in the lateral-directional mode.

Of the three longitudinal sets of derivatives obtained on flight 11, one was at an angle of attack of 5.2° at 0.76 Mach number. The other two were at angles of attack of 7.5°

and 9.0° at a little over 0.9 Mach number. These last two sets of derivatives were performed as one maneuver; however, nonlinearities with respect to Mach number and angle of attack necessitated splitting the maneuver into two parts. The flight 11 data, along with previously obtained data at similar Mach numbers, is presented in figures 2 and 3. Figure 2 presents the data as a function of angle of attack. Trends of the data indicate a lower level of longitudinal static stability, C_{m_α}, than predicted by wind-tunnel data. Longitudinal control effectiveness, $C_{m_{\delta_\ell}}$, and pitch damping, C_{m_q}, are generally at or above predictions. Figure 3 presents the longitudinal static stability as a function of Mach number which illustrates the increasing stability due to the aerodynamic center moving aft with increasing Mach number.

FIGURE 1

X-24B DERIVATIVES

$\delta_{U_B} = -40°$; $\delta_{r_B} = 0°$, $cg = .65\bar{c}$

— · — M = 1.2 WIND TUNNEL
——— M = 1.0 WIND TUNNEL
– – – M = 1.1 WIND TUNNEL
○ M = 1.05 FLIGHT
□ M = 1.0 FLIGHT
△ M = 1.17 FLIGHT
SOLID ~ POWER ON
FLAG ~ HYBRID

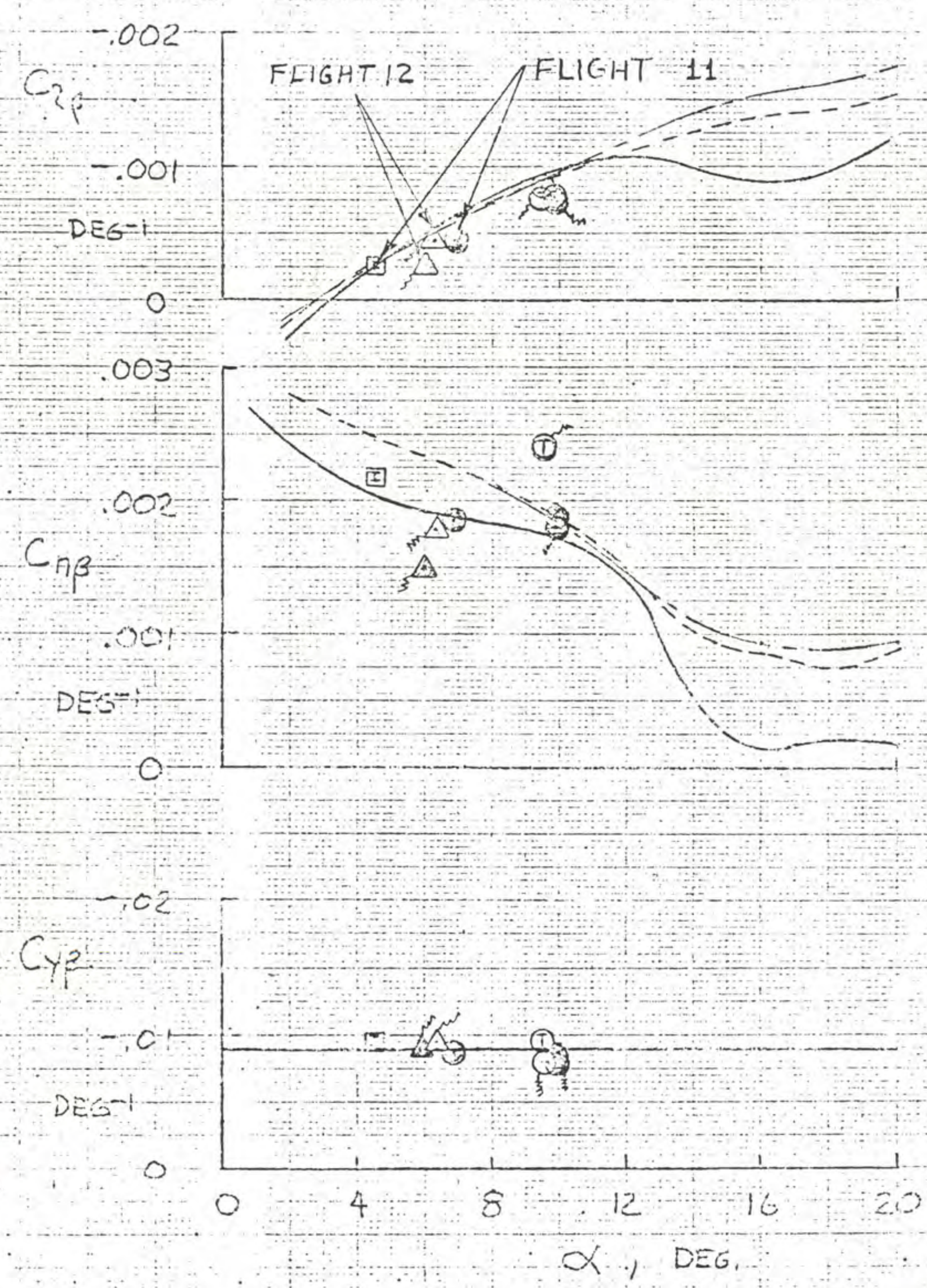


FIGURE 1, CONTINUED

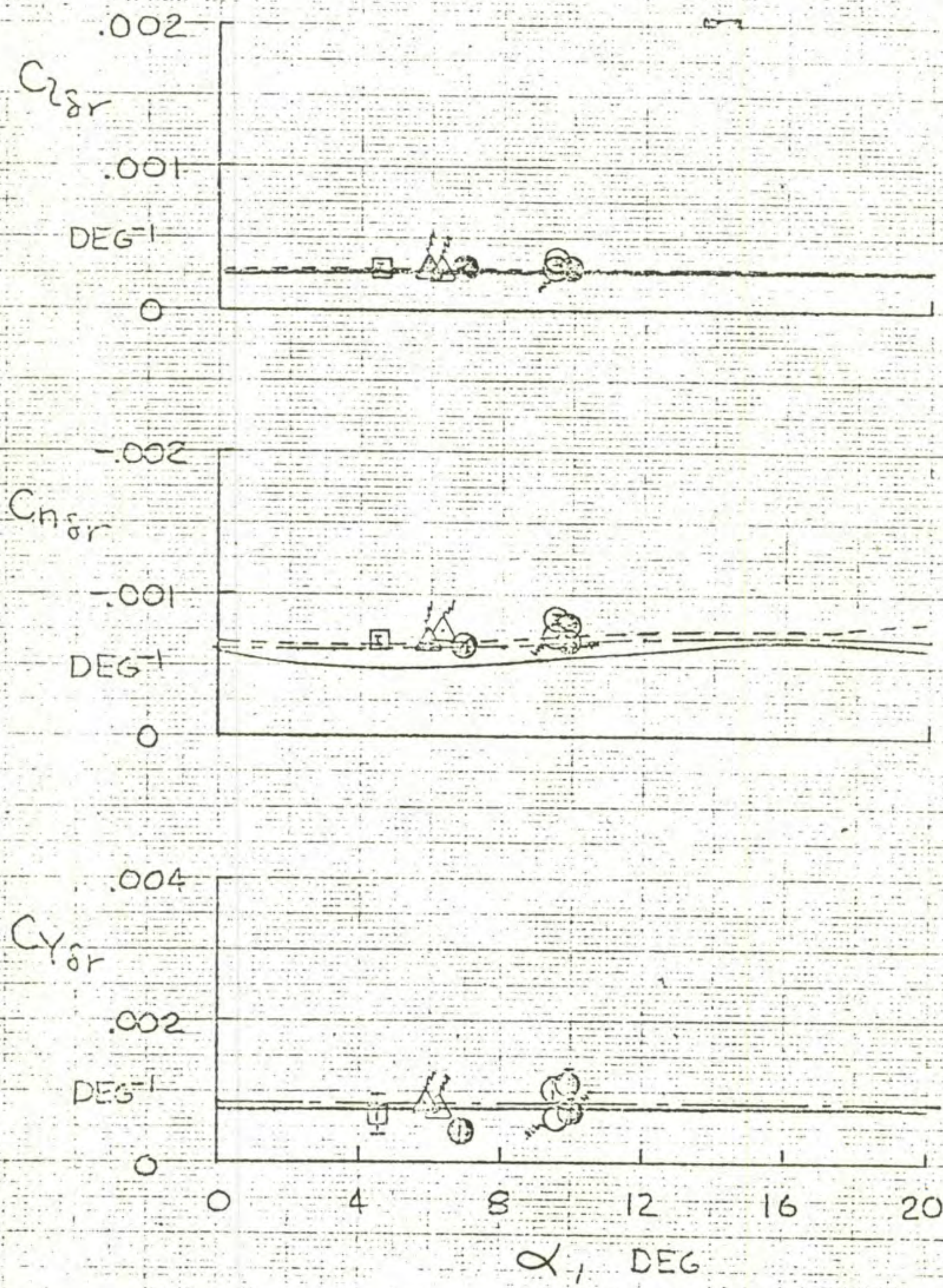
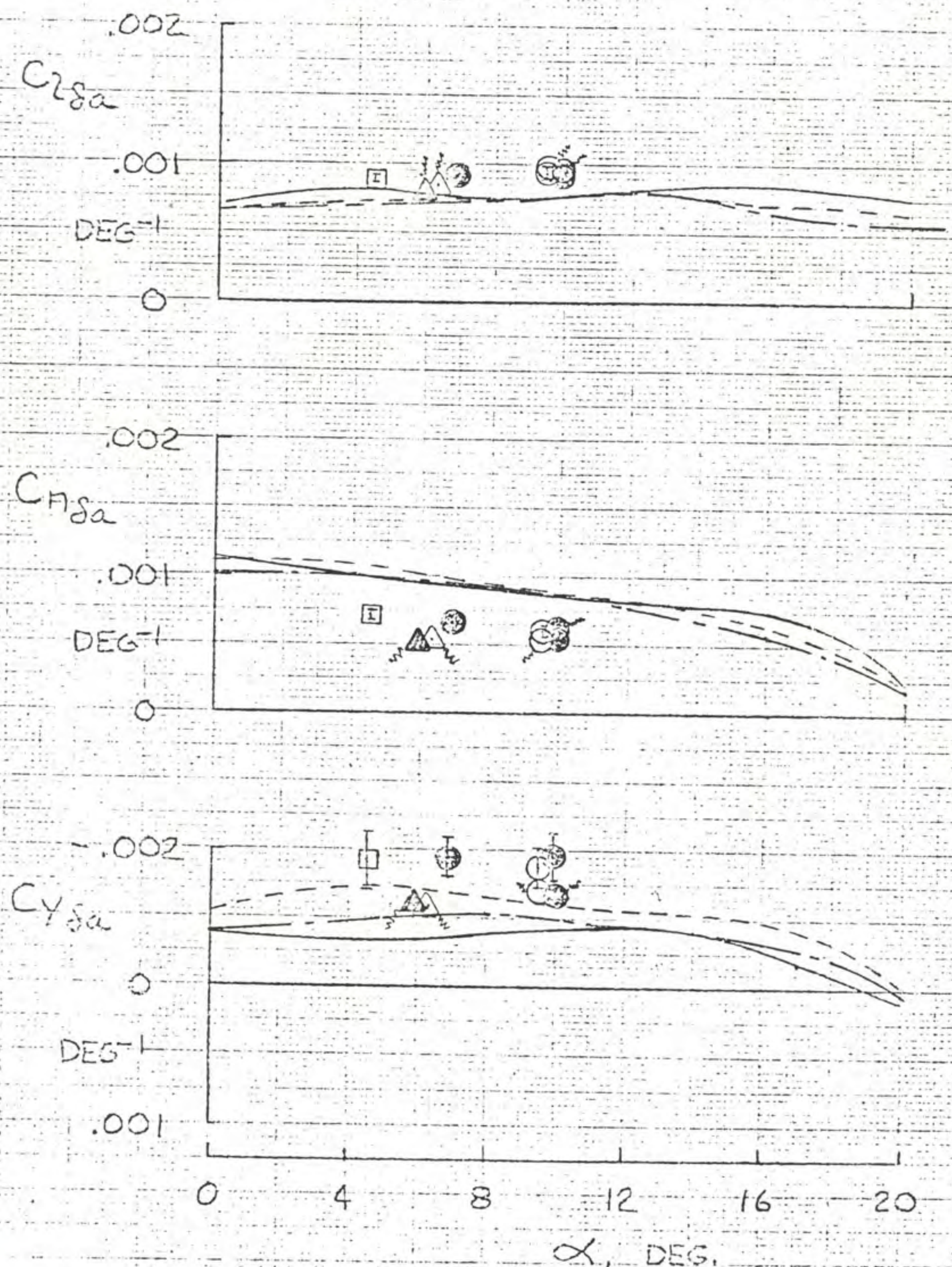


FIGURE 1, CONTINUED



—— ESTIMATE

FIGURE 1, CONCLUDED

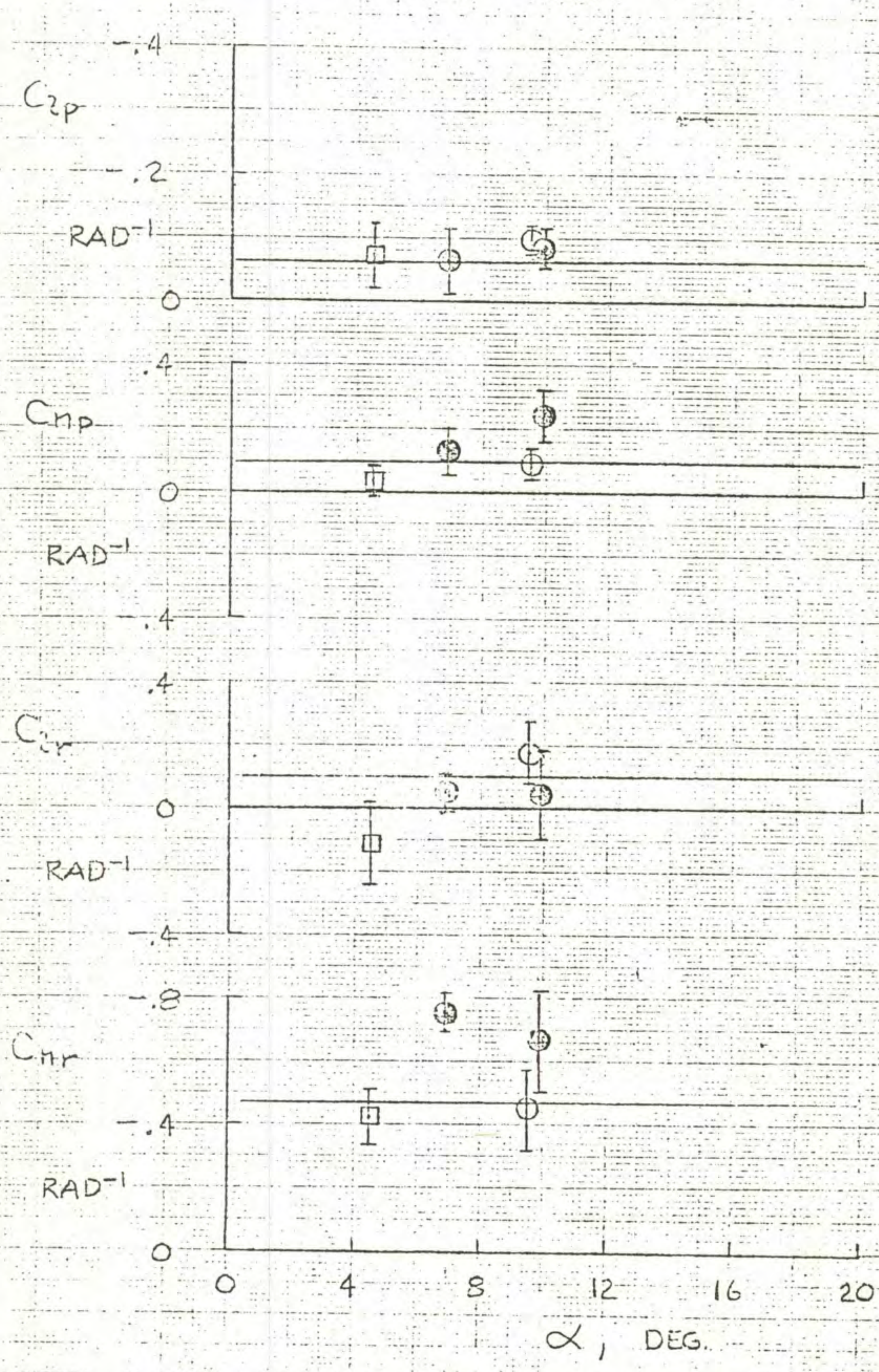


FIGURE 2

X-24B DERIVATIVES

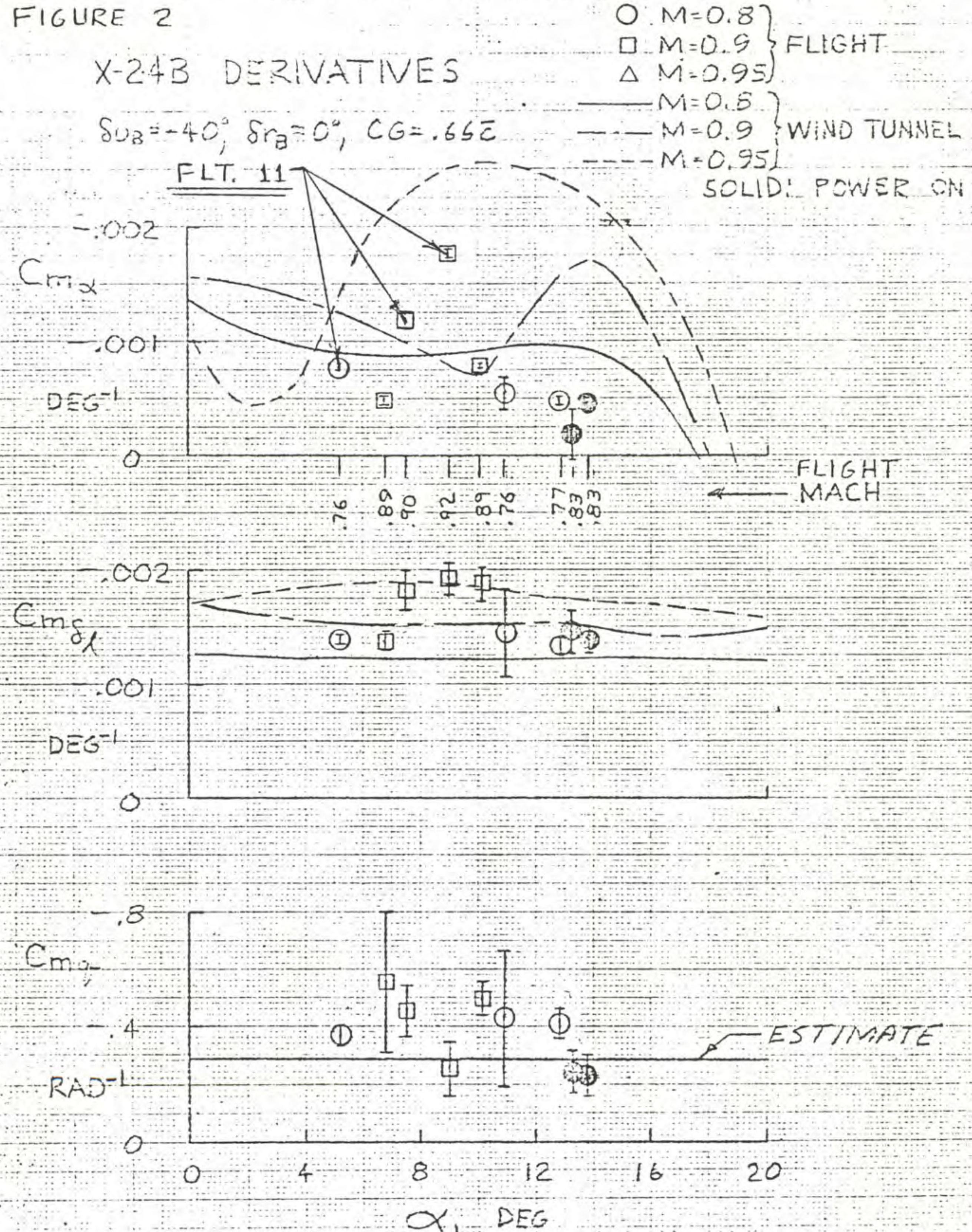
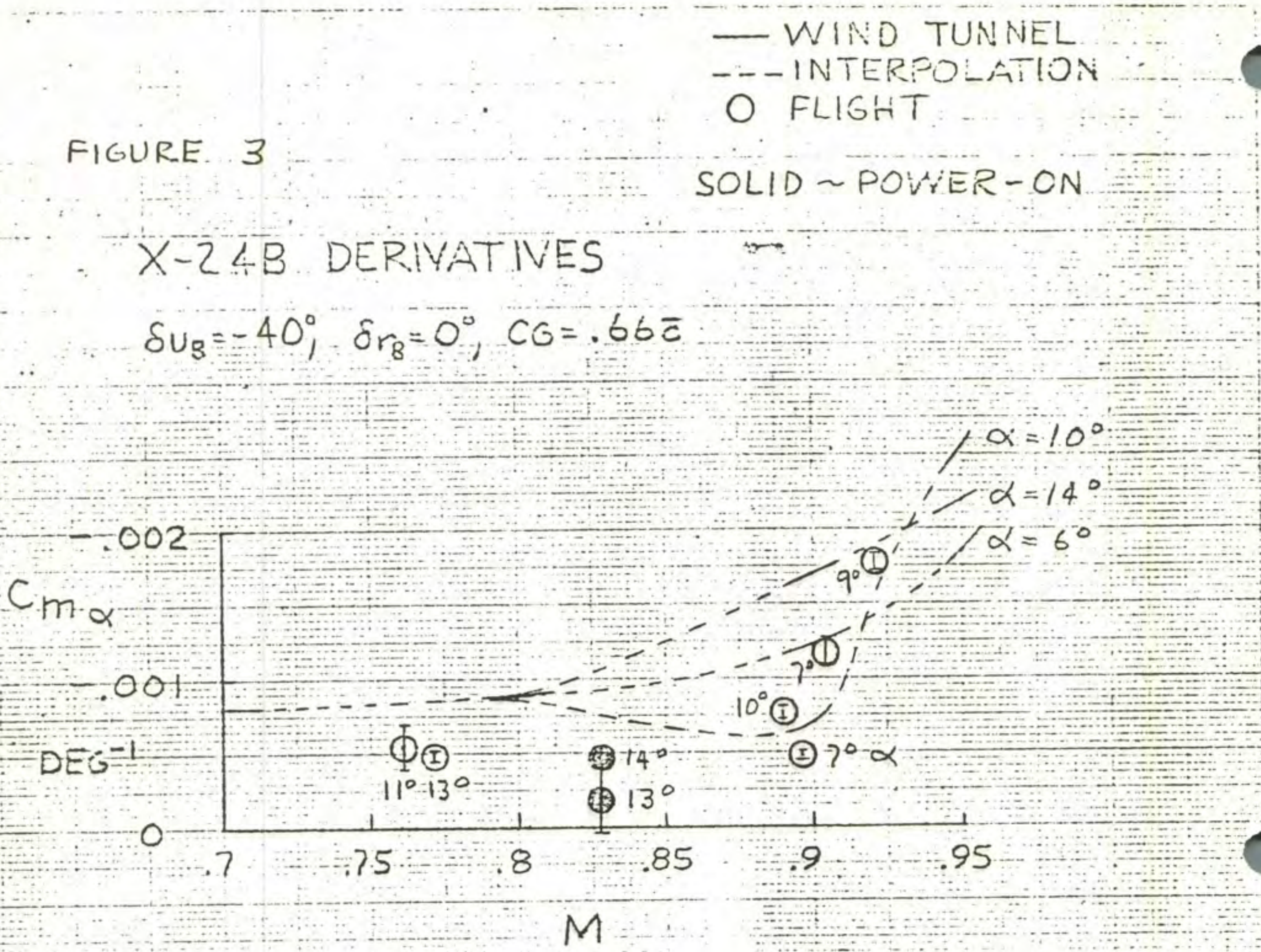


FIGURE 3

X-24B DERIVATIVES

$\delta u_B = -40°,\ \delta r_B = 0°,\ CG = .66\bar{c}$



VERIFICATION OF Ixz

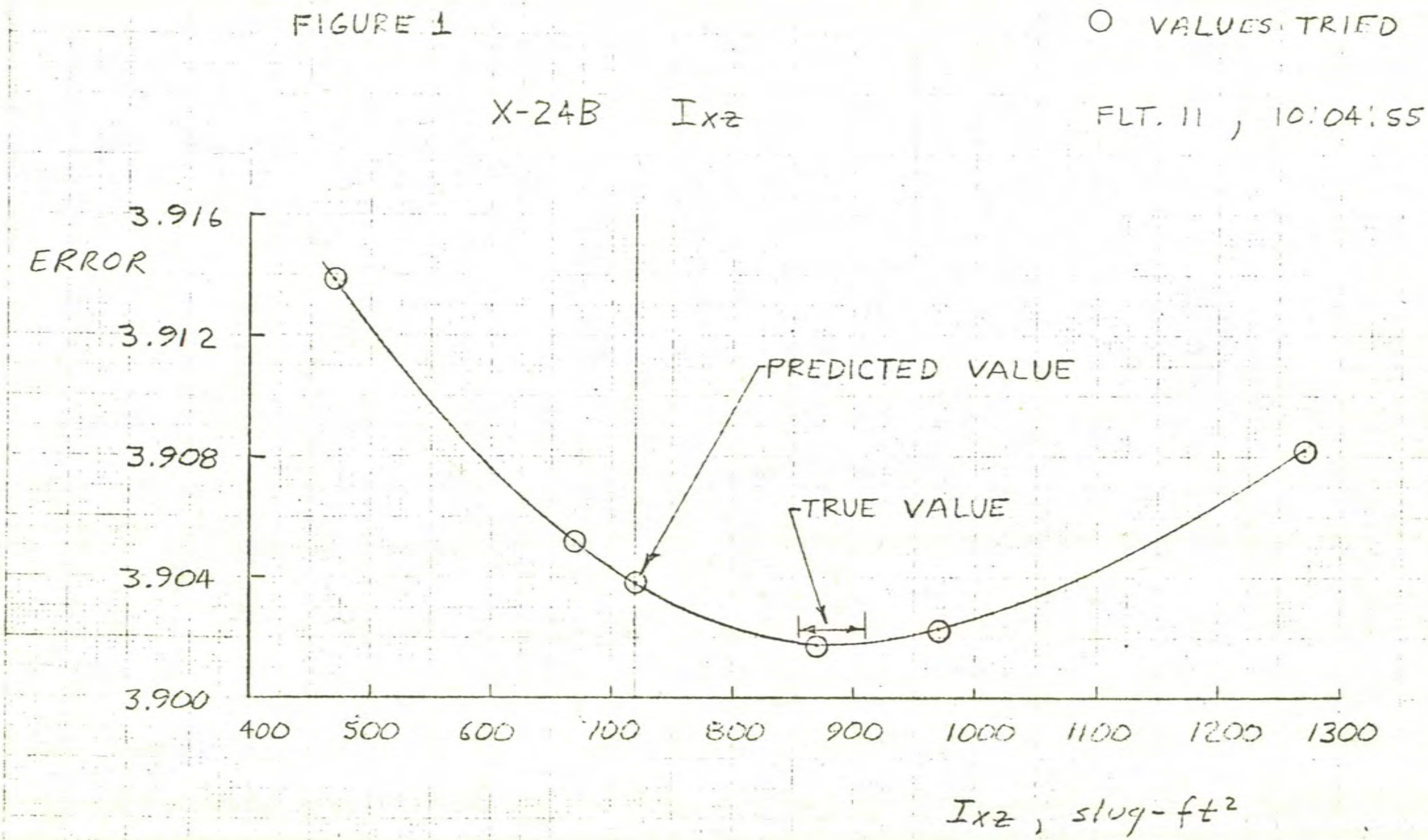
by Alex G. Sim

The digital program used to extract derivatives from flight data, now called "Modified Maximum Likelihood Estimator," can be used to determine the cross product of inertia, Ixz. Since the program's normal mode of operation is to initially convert derivatives and angular rates from vehicle body axis to principal axis, the least error between the flight and the computed time histories will occur when the true value of Ixz is used. This means the value of Ixz can be found by varying the value of Ixz used for a particular maneuver and plotting it verses the resulting error. The results obtained for the power-on maneuver from flight 11 are shown in figure 1. They indicate the true value of Ixz is approximately 870 slug-ft^2.

Assumptions:

1. Ix and Iz are correct.
2. Roll and yaw gyros are aligned exactly with the X-24B body axis.

FIGURE 1


○ VALUES TRIED
X-24B Ixz
FLT. 11 , 10:04:55
ERROR
3.916
3.912
3.908
3.904
3.900
PREDICTED VALUE
TRUE VALUE
400
500
600
700
800
900
1000
1100
1200
1300
Ixz , slug-ft²

FLT B-11-22

HANDLING QUALITIES SUMMARY

PITCH AXIS DURING ROTATION	3
ROLL AXIS DURING ROTATION	2
ABOVE .85 MACH - POWER ON	2.5
ABOVE 1.0 MACH - POWER ON	2.5
DURING DECEL FROM 1.0 TO .85 MACH - POWER OFF	2 TO 2.5

Technical Debriefing

3-11-22

Pilot: John Manke

1. Describe the launch transient (190 KIAS)

Answer:

Very Mild, just like any of the other heavy weight launches. This the mildest launching airplane that I've flown so far.

2. Discuss the engine light sequence and any associated trim changes.

Answer:

The sequence was one and three and one didn't work then two and four and back a second try at one, it still didn't work: so it was a three chamber flight. Using two, three, and four. I didn't notice any trim changes.

3. Discuss the handling qualities during the rotation. Rate Pitch and lateral directional.-

Answer:

O.k. its pretty much as before, I don't feel I do as good of job in pitch in the airplane as I do in the simulator. I don't know whether its the fact that I'm not able to give as much attention to the alpha gauge or whether its just a little looser in pitch. I got the feeling its just a little looser in pitch in the airplane than in the simulator. I'd rate pitch about three, lateral-directional doesn't seem to be any problem. Somewhere along the line it felt that I had maybe a one cycle PIO thing or something like that, but as I thought about it a little bit I kind of determined it was probable a clurd in that particular area that upset it a little bit in roll. Roll is not any problem I think we do all the roll visualization from our peripheral vision rather than use the three axis ball. I rate roll a two.

4. (a) Discuss the task to maintain 35° θ and rate.

(b) How did α to maintain θ compare with the simulator?

Answer:

Deleted no maneuvers done.

5. Discuss the handling qualities above .85 Mach number with power on. RATE.

Answer:

As I mentioned before we had more of the clurds or upsets due to wind sheer today than I had on any previous flight at least with this airplane. So any of the handling qualities that I was aware of occurred because of these atmospheric inputs and they manisfested themselves as little beta excursions, then along with that just a little roll activity. I didn't have any handling qualities problems per say, at one time in the flight I noticed we were flying with a steady one degree left needle side slip it seemed to be solid over there so I didn't concern myself anymore with it

8. Discuss the engine overdrive operation.

Answer:

Mike's call on the overdrive was superb if he hadn't called me I would not have gotten it on in thirty seconds, the first thirty seconds went by so fast I couldn't believe it. I guess with the associated engine problem and resolving that we were going to fly a different profile than we'd planned. When I did hit the switch I could feel the delta thrust and it was very similar to what we feel on downwind leg when we hit the landing rockets.

9. Compare the vehicle's response to the doublets at 7^o α after engine shutdown with the "power on" doublets. Compare to simulator and rate the handling qualities if possible.

Answer:

Wasn't performed so delete it.

10. Discuss the doublets at 5^o α after engine shutdown. If possible rate the handling qualities.

Answer:

The doublets at 5^o α after engine shutdown were very much like the simulator particularly on the simulator when we're coming trans-sonic during the pulse. Here again I got more slideslip than I had expected and I attributed that to a little higher rudder authority on the airplane than on the simulator but the subsequent damping looked very much like the simulation I think it compares extremely well.

11. Discuss the pitch pulses at 1.05 Mach number at 10^o α with respect to the vehicle response to pulse as compared to simulator.

Answer:

Pitch pulses at 10^o α occurred sub-sonic and they probably occurred at around .9 or a little bit higher Mach number -.9 or .92 Mach number. The airplane is extremely well damped at 10^o α, we tried the combination of the two pitch pulses in a row. After the first pitch pulse it was nose down pitch pulse the nose of the airplane came down and sort of stayed down. I couldn't detect any oscillation at all, no oscillation it went down to 6 or 7 degrees then gradually came up to eight or nine. I had to help it up again and then I punched it again and it did the same thing again. Just absolutely dead-beat. The simulation does show just a slight oscillation and it does return to 10^o α so I think if this pitch gain is six the airplane is better damped in pitch than in the simulator.

12. Discuss the handling qualities while decelerating from Mach 1.0 to .85. Longitudinal trim change. If possible rate.

Answer:

The handling qualities while decelerating from Mach one to .85. I didn't get to this 12^o α until we were down to less than .9 so I really didn't get a very good look at that. What I did see at 12^o α looked very so the rating on the handling qualities above .85 about a 2 1/2.

6. a) Discuss the handling qualities above 1.0 Mach number with power on. Rate.

Answer:

a) As we noticed before the δe alpa or the amount of pitch change per degree of elevator decreases considerable once we get supersonic. Thats not any problem at all its kind of a nifty thing. Didn't have any handling problems so again I rate that at 2.5.

b) Compare the vehicle's response to the 1.15 doublets (power on) at 7^o α with the simulator.

Answer:

b) The doublets in this case occurred a little bit less than 1.1 Mach number with power on at 7^o α. Comparing with simulator I thought it was an extremely good comparison it looked just about how I expected it to look. As I mentioned before it seemed like I had a little more rudder power and I got a little more beta than I had expected to get during the rudder kick but it sure damped well and wasn't any problem.

7. a) Discuss the performance aspects of the boost.

Answer:

a) O.K. our simulation is quite good except that flying a constant 15^o α profile we seem to climb a little bit steeper this resulted in slower increase in Mach number as we went up hill and because of that I did decrease my α down to 13 or 14^o a few seconds prior to our push over to ten degrees α and this seemed to take care of the problem. We did hit .85 at just a little over 53,000 on my indicator.

b) Discuss the trim changes at engine shutdown.

Answer:

b) Didn't notice any trim changes at engine shut down but here again I was primed to pushover right after that for five degrees alpha so I may have missed the trim change.

c) If not previously covered, discuss the roll task during the boost with respect to two hands, roll trim, resulting sideslip, compare to simulator.

Answer:

c) I did use two hands, did not require a heck of a lot of force with the left hand but it did take a little bit of right roll steady input with my left hand very easy thing to do and I still prefer that to trimming in this case. After burn out I didn't notice any roll mistrim at all. The slideslip was continually one degree or so needle left which does not compare to or with the simulator. The simulator shows in this area about a zero or a quarter of a degree needle right.

much like the simulator the airplane, flies like a champ in that area. When you do put an aileron input you can see the beta swing out and it swings out about a degree or a degree and a half but it does that in the simulator and comes right back again and its a beautiful airplane to fly. I rate it at 2 or 2 1/2 in that area.

13. Discuss the pitch pulse at .84 Mach number at 6° α. Compare to the simulator.

Answer:

The pitch pulse at about .82 Mach number at 6° α I thought compared very well with the simulator in fact the airplane is probably better damped than the simulator. You'd probably get one to two cycles more in the simulator than we got in the airplane on that pitch pulse. I was impressed at the amount of push I gave compared to the simulator, give me just about the same alpha excursion so the elevator effectiveness was just about what I expected and it looked very much like the simulator, again one heck of a good representation in our simulation.

14. Discuss handling qualities with the Yaw damper at "zero gain". Rate.

Answer:

Frankly I didn't notice any difference in the airplane when I went from a Yaw gain of 3 down to a Yaw gain of 0. So I don't know how I'd rate that because I didn't do any particular task or didn't even look at the thing in the Yaw axis, so I'll decline to rate there other than to say it must be damned good with the Yaw damper off because I didn't notice anything usual although the task at the time was not a lateral-directional task it was more of a pitch task.

15. Comment on any buffet encountered at .65 Mach number with the upper flaps at 20 degrees. Any handling problems?

Answer:

O.K., this evaluation went real well. I got the .65 Mach number by pushing the nose down to 5 or 6 alpha and came back up at 10° α I got the onset of buffet. I pulled it up to 12 and as I mentioned at the debriefing it is very reminiscent of an F-104 with the flaps in the up position at 300 knots when you pull it up into the buffet, It's a light buffet but about the same frequency that you get in a 104 and as I pulled it up above 1.2 at one area got just a slight wing rock that I called out in the air. I'm not so sure the wing rock was a result of turbulence or whether it was actually a result of buffet like you get in the F-104. I held 11 or 12 in that area until we got out of buffet. I didn't look at the Mach number when the buffet quit so we'll have to get that off the records but I guess that it was down to .6 or .61 somewhere in that ball park. I didn't have any handling problems there. During this whole time, that we were in the buffet why we were turning and going to a heading that Mike had given me.

16. Discuss the energy management from the "intersection to low key".

Answer:

Energy management from the intersection to low key was all done on NASA one's calls. I didn't look out of the cockpit until Mike called one mile from low key. Was absolutely no problem at all. Here again I attribute this to the simulator work we did this morning, that just shows the value of the morning of this flight if you can go to the simulator and put the winds in there and see what your problems are. As you know we swung wide in the intersection but we had done that this morning in the simulator and we all realize that there would be no problem and that was the way the flight was going to go and it worked out like it was a piece of cake.

17. Discuss the pattern.

Answer:

The pattern was like the one I'd seen in the F-104 this morning with a north-northeast wind the pattern appeared normal until the 90° position it was time we went high and I ended up using about 30° speed brakes. Then as I'd done so many times before. I think I started pulling the brakes in at about the right time but they come in so darned slow that by the time I got them back to 20, I had dropped a little bit low and my in point slid back a quarter to a half a mile.

18. Discuss the landing and roll out.

Answer:

It was about a 300 knot final. Flare was done mostly on eyeball. I got Dana's call at 1200 but the airplane was such an easy one to fly that you can look out and do the flare, gear came down at about 50 feet a little less than 240 knots and I guess the touch down was somewhere around a 170 or 175. I did get one good bit of turbulence just a little above the runway. I got a pretty good upset of maybe 5 or 10 degrees. And there was some light turbulence most of the way down on final approach. The roll out was a piece of cake without any crosswind why it rolled real straight all by itself and I didn't use any nose gear steering until very low airspeed. I did use moderate braking below about 80 or 90 knots that's all there was to it.

X-24B Buffet Study

BY

Captain John L. Stuart

A vertical fin stall boundary was defined from rudder hinge moment data acquired during the X-24A program (reference FTC-TO-71-8). Figure 1 shows the Mach number and angle of attack conditions at which the rudder hinge moment data indicated that a stall buffet either started or stopped. Also shown is the stall boundary predicted from nonlinearities in certain wind tunnel derivatives.

To verify that this stall boundary is applicable to the X-24B, a special maneuver was performed on flight B-11-22. With -20^{o} upper flap and 10^{o} rudder bias, the aircraft was maneuvered to the Mach number and angle of attack range of interest, and the angle of attack was increased above that required for buffet and then held constant until buffet stopped. Figure 2 shows a reproduction of real-time data traces of sideslip angle β, angle of attack α, Mach number, right hand fin pressure, and right hand lower rudder hinge moment versus time. Figure 2 indicates that there are large pressure changes which correspond to the start and stop of the hinge moment buffet indications.

The Mach number and angle of attack conditions at which the buffet started and stopped are shown in figure 1. Correlation with the X-24A data is sufficiently strong to conclude that the X-24B fin stall boundary is similar to that of the X-24A. Fin pressures can be used in conjunction with rudder hinge moments to further define this boundary.

The corresponding hinge moment buffet and pressure changes on the left hand fin (not shown) are of considerably smaller magnitude and shorter duration than those on the right hand fin. This asymmetric pressure condition caused a negative (nose left) yawing moment as shown in the β trace.

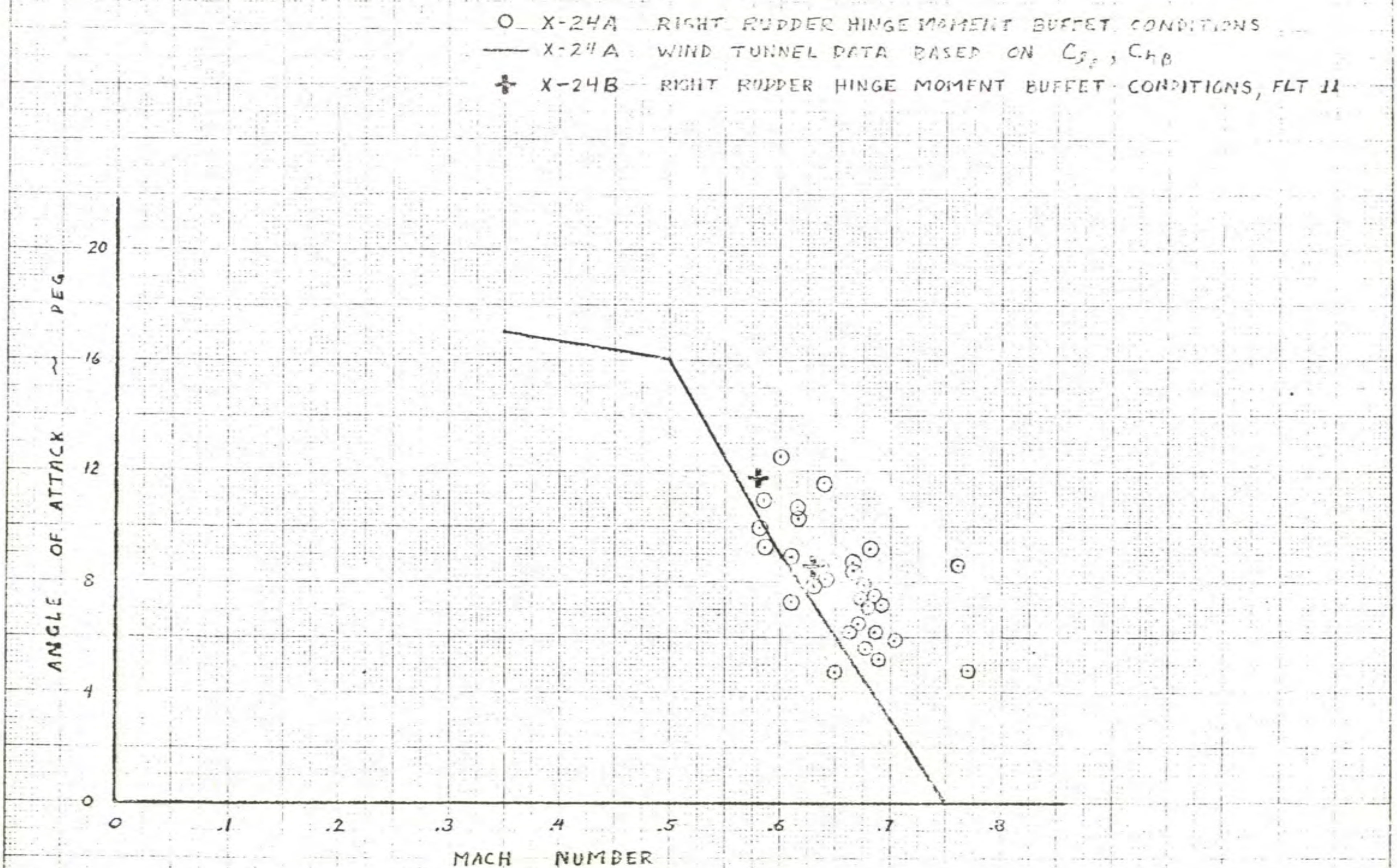
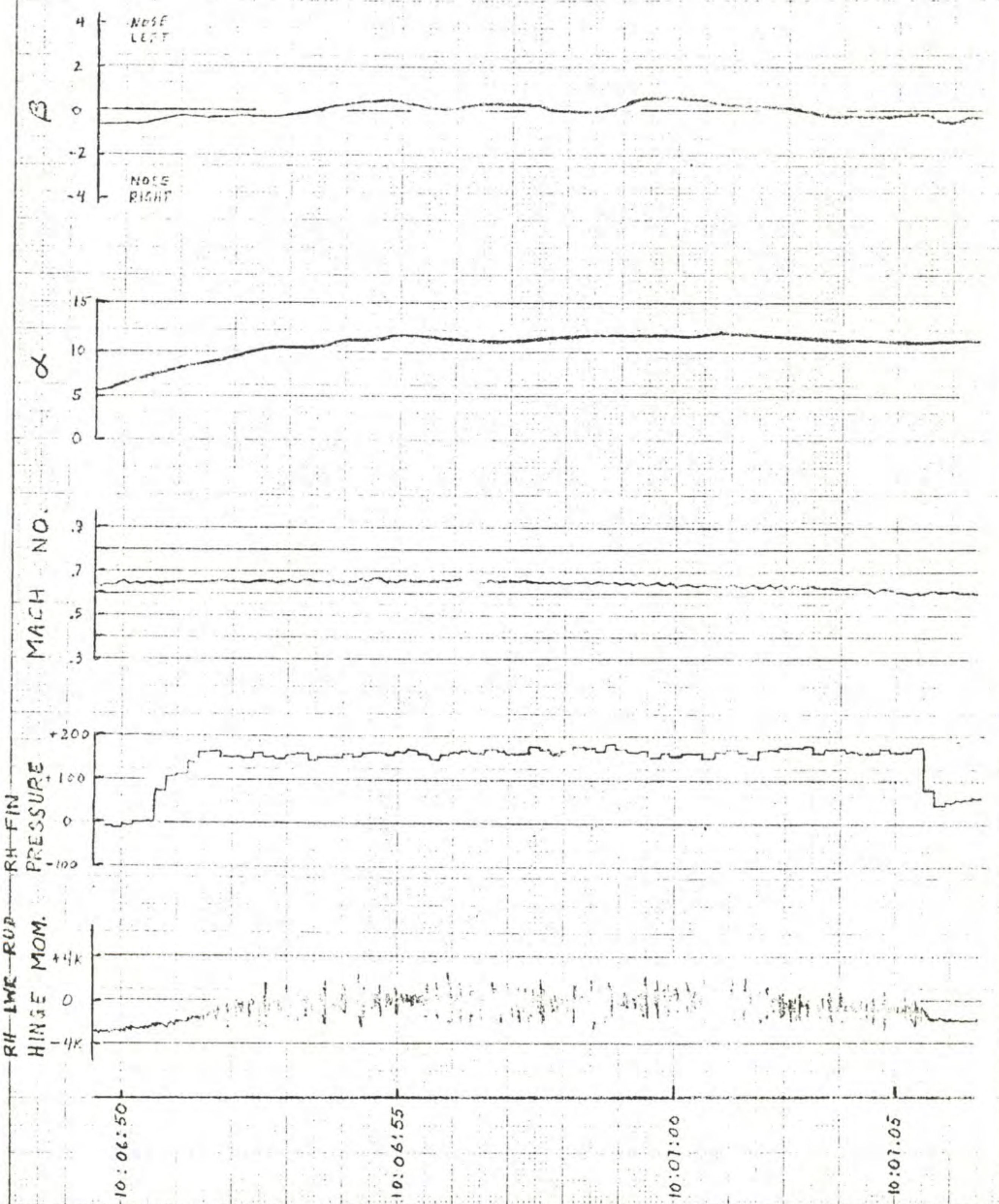


FIGURE 1. X-24 FIN STALL BOUNDARY

FIGURE 2. SELECTED TIME HISTORIES

X-24B FLT B-11-22 BUFFET STUDY



10 X 10 TO THE CENTIMETER 46 1516

Flap Crossover During Landing

BY

Captain Dennis J. Penka

Review of the Sanborn records for flight B-11-22 showed that the pilot was operating in the crossover region between the upper and lower flaps during the landing flare. Records from previous flights were reviewed and it was found that the pilot had crossed over to the upper flaps during the landing for flight B-7-14 and B-9-16, also. Figure 1 shows the traces for upper and lower flap positions, longitudinal stick position and angle of attack for flight B-11-22 in the period between gear extension and touchdown during which crossover occurred. As can be seen from the traces, the amplitude of the pilot's longitudinal stick input increased slightly when traversing the deadband region. The pilot was unaware that he was operating in the crossover region and did not notice the increase in control stick deflection. Figure 2 shows the same time period for flight B-10-21, which did not have flap crossover.

Operation in the crossover region during landing has presented no problems from a control and handling qualities standpoint. In fact, the pilots have been unaware that they were in the crossover area. In view of this, no changes are currently planned to the aircraft control system or landing configuration to eliminate operation in the crossover region during the landing phase.

X-29A F[illegible] [illegible]

FLAP [illegible]

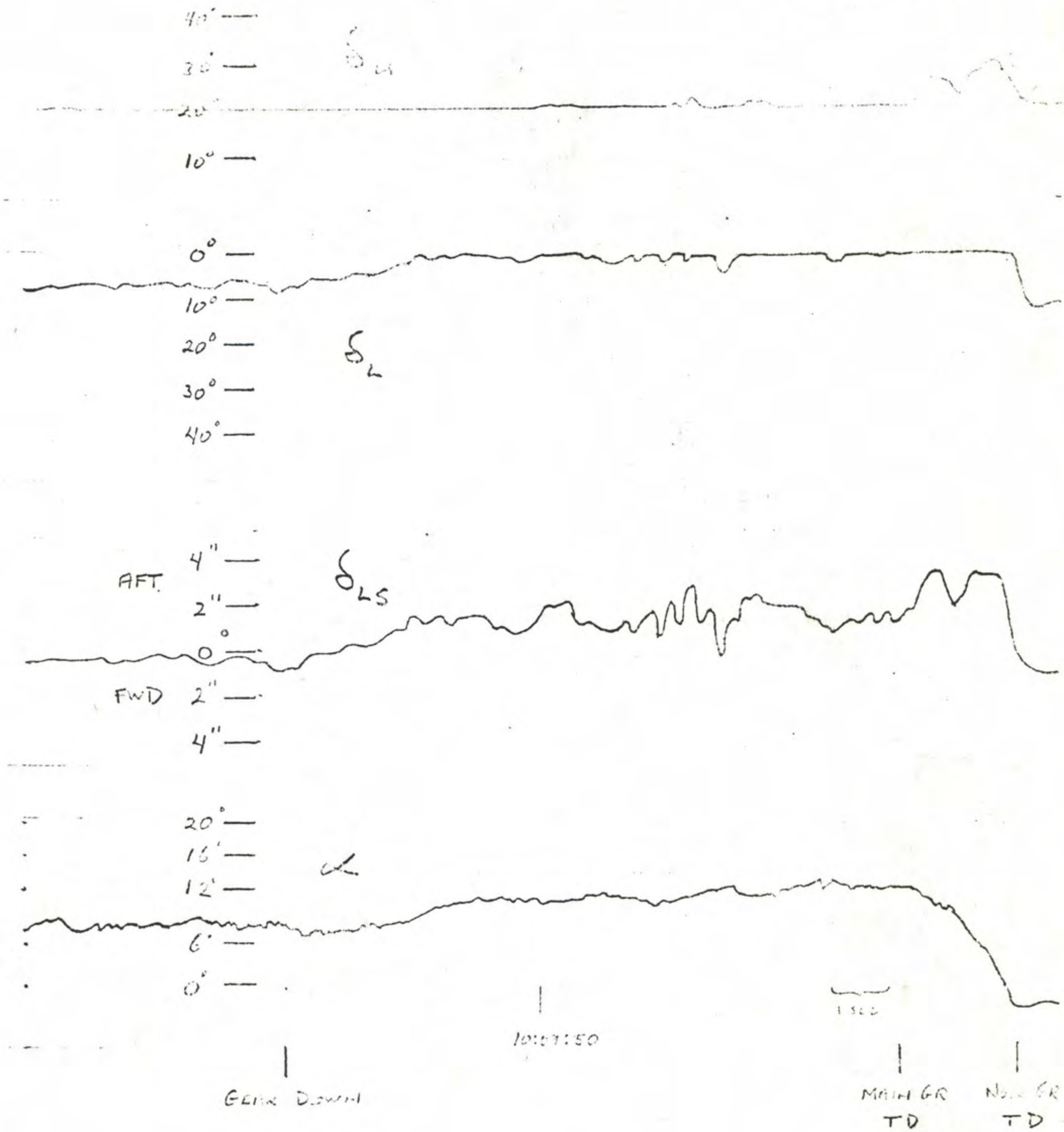


FIGURE 1

X-24B FLT B-10-21

FLAP CROSSOVER

MAJ LOVE
P369 #
$\bar{X}$ = 53.37 %

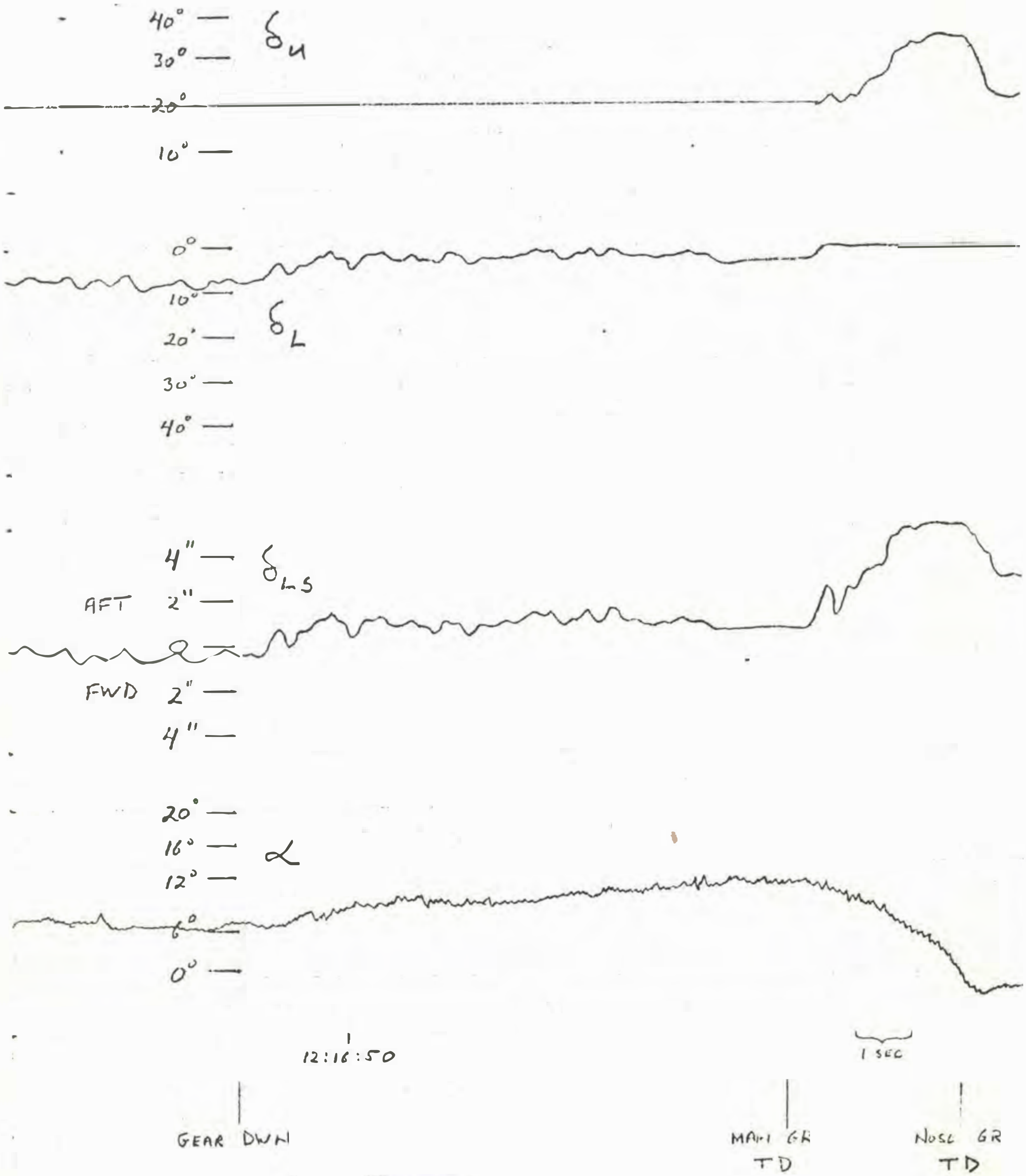


FIGURE 2

Flight B-11-22 Sideslip/Wind Investigation

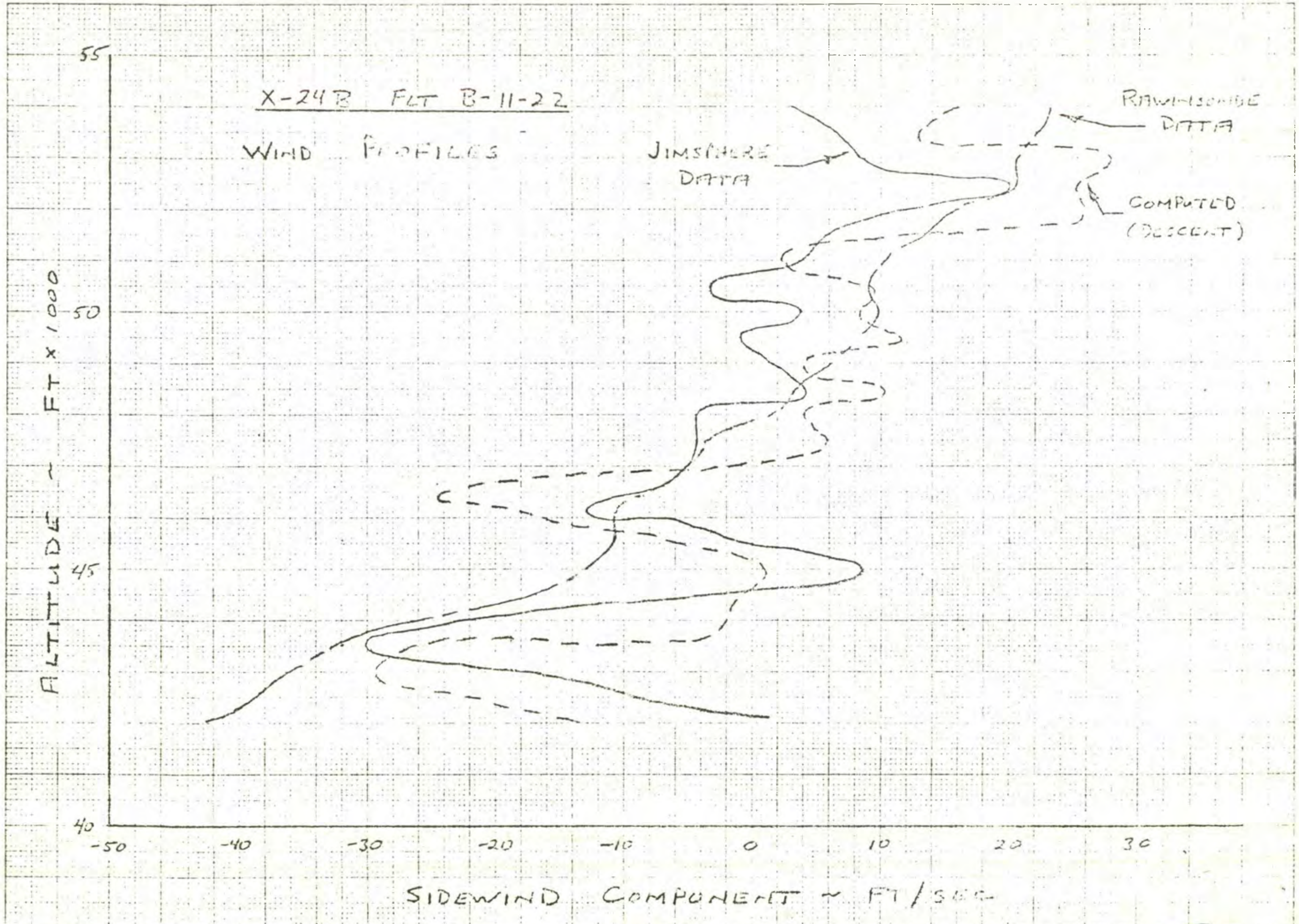
BY

Captain Dennis J. Penka

The investigation of wind-induced sideslip excursions was continued for flight B-11-22. As with the last flight, radar tracked Jimsphere Balloon wind data were available in addition to the usual Rawinsonde data. It should be noted, however, that the Rawinsonde data for this flight were obtained from a balloon released at 2:15 AM. Normally data from the balloon released at B-52 takeoff time (9:00 AM) are used since significant atmospheric changes have been shown to take place between the normal daily balloon launch time (2:00 AM) and X-24 flight time. An instrumentation problem resulted in the loss of all Rawinsonde data from the later launch for this flight.

This flight was significant in that large wind shifts with altitude were shown in both the computed and Jimsphere Profiles and that the pilot commented on "clurds" (sideslip excursions) during the boost. This comment came at approximately 47,000 feet, which would have been just after the aircraft had flown through the large wind changes shown on the profiles between 41 and 45,000 feet. In addition, films were again made of the contrail during the boost phase which clearly showed the large wind shifts at the start of the boost and several smaller magnitude shifts throughout the climb.

This investigation indicates that the "clurds", or sideslip excursions, noted during the powered boost on flights since B-7-14 are, in fact, caused by abrupt wind changes (either in magnitude or heading) with altitude. Rawinsonde wind data do not show these abrupt changes since the Rawinsonde system, by its nature, tends to average the winds over a large altitude band. In addition, it appears to be possible to extract a sidewind profile from parameters measured on-board the aircraft which shows the wind shifts with altitude.


X-24B FLT B-11-22
WIND PROFILES
JIMSPHERE DATA
RAWINSONDE DATA
COMPUTED (DESCENT)
ALTITUDE ~ FT x 1,000
55
50
45
40
-50
-40
-30
-20
-10
0
10
20
30
SIDEWIND COMPONENT ~ FT/SEC

June 5, 1974

TO: DOEER

FROM: W.B. Arnold - THIOKOL

SUBJECT: Propulsion System Operation Flight B-11-22

SUMMARY OF ENGINE OPERATION

1. The prelaunch igniter test was eliminated for this flight.
2. The post launch attempt to start chambers #land #3 resulted in a satisfactory start of chamber #3 and igniter operation only in chamber #1.
3. The #1 fire switch was deactuated and chambers #2 and #4 were started satisfactorilly.
4. A second attempt to start chamber #1 again resulted in igniter operation only.
5. The engine was placed in overdrive (high Pc) approximately 30 seconds after chamber #3 had stabilized.
6. During the advance to the overdrive condition the fuel manifold and chamber pressures responded as predicted. The lox manifold pressure entered an excursion cycle 0.3 seconds after the advance was started. This excursion reached a low point of 299 psi and did not stabilize again for 9.0 sec.
7. Fuel and lox tank pressures were lower than on previous flights but were well within operating limits.
8. Engine shutdown was caused by liquid oxygen exhaustion after approximately 155 seconds of engine run time.

DISCUSSION

The engine was removed from the aircraft and returned to the maintenance shop for investigation of the failure of the #1 chamber to start. Final Flight data was not available for analysis so it was assumed that the 65# chamber pressure switch was defective. It was suspected that the switch actuating piston "O" ring had lost sealing ability similar to failures experienced in the past. The #1 65# chamber pressure switch was removed from the control box and cold soaked at $0^{o}F$ for 20 minutes.The actuation pressure was determined to be 109 psia and no vent port leakage was detected which indicated that the piston seal was satisfactory. The switch was disassembled and a considerable amount of moisture was found in the piston area. This moisture when frozen can change the actuation pressure.

DISCUSSION continued:

The components were dried and reassembled and the cold soak was repeated. The switch actuation pressure returned to normal. This test indicated that the failure mode was due to moisture rather than piston seal failure. The moisture accumulation was probably the result of the low chamber pressure line bleed flows which were found after Flight B-10. All of the pressure switches in the control box were disassembled, cleaned and rebuilt with new "O" rings as a precautionary measure. A procedure to detect reduced flowrates of the Pch line bleed orifice will be established.

The pressure excursion which occurred in the lox manifold pressure cannot be explained from the preliminary data. The transfer into overdrive appeared to be normal as indicated by the fuel manifold and chamber pressures. The #4 chamber pressure appears to b e slightly damped and lags the #2 and #3 pressures. Figure 1 is a copy of the data showing the transfer and excursion. The low point of lox manifold pressure was 299 psi which is approximately 41 psi above the cutoff level. The shape and duration of the excursion provides some doubt of validity of the data. This doubt is further warranted by the fact that there was no indication in fuel manifold and chamber pressures that the excursion was occurring in the lox manifold. Normally the chamber pressures are greatly affected by lox manifold pressures. The fuel manifold will also respond as a result of lower turbopump power requirements due to reduced or changing lox flowrates.

Figure 2 is a data copy of the shutdown transient showing manifold pressures and the #2 chamber pressure. It must be remembered that the liquid oxygen manifold pressure reading is delayed by 0.15 seconds due to accumulator damping. At time marked O the first indication of a change in lox manifold pressure occurs. This is reflected 0.1 sec later in the #2 chamber pressure. The shutdown was signalled at about 1.2 sec. The decrease in fuel manifold pressure indicated that the fuel was probably almost exhausted at this time. The affect lox manifold pressure has on chamber pressure is shown in this shutdown sequence where instantaneous lox exhaustion is not encountered. This data also indicates that the lox pressure excursion indicated during the overdrive initiation should have provided a significant change in chamber pressures.

W. B. ARNOLD

cc: M. DeMar
J. Kolf
TC-Elk.

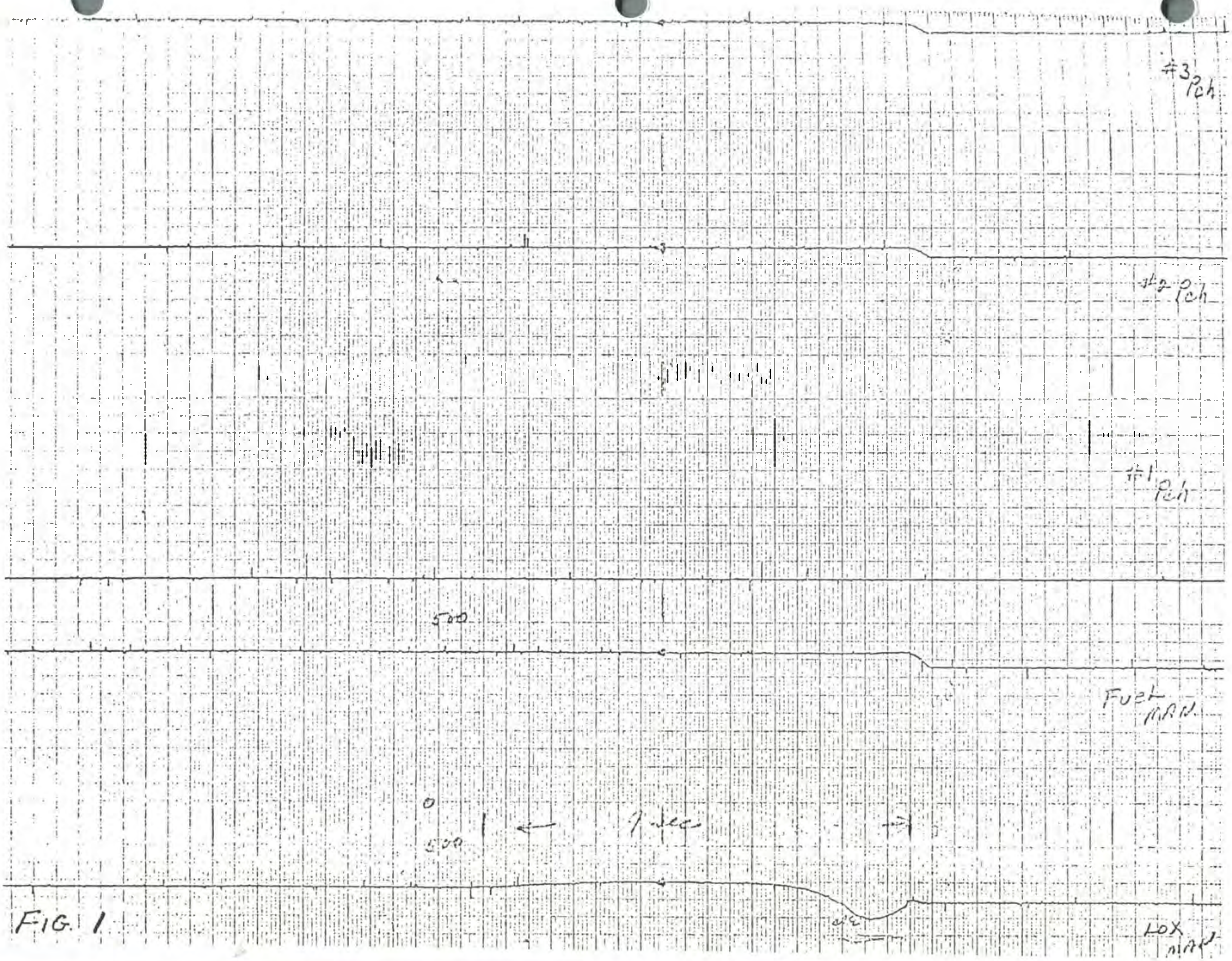


FIG. 1

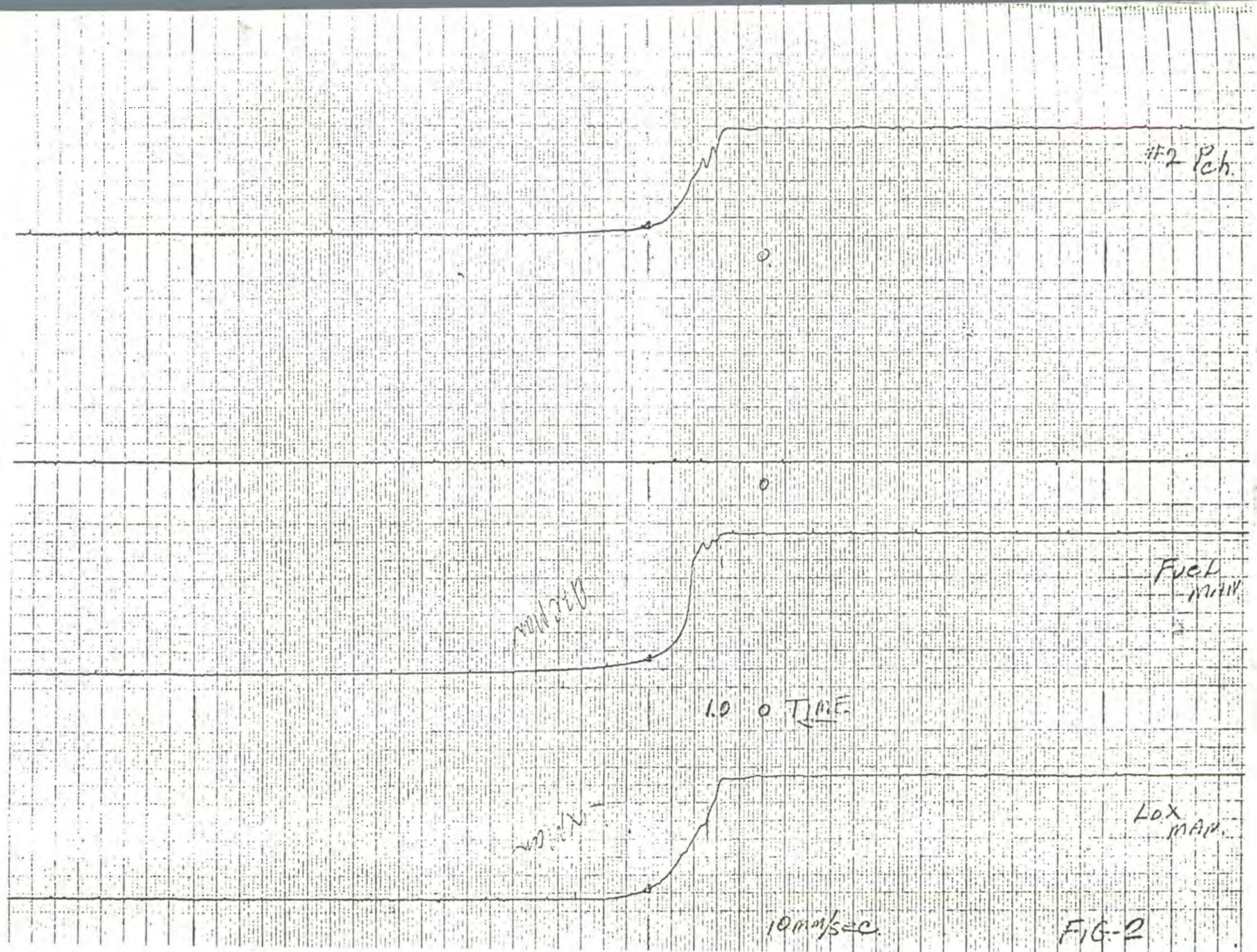
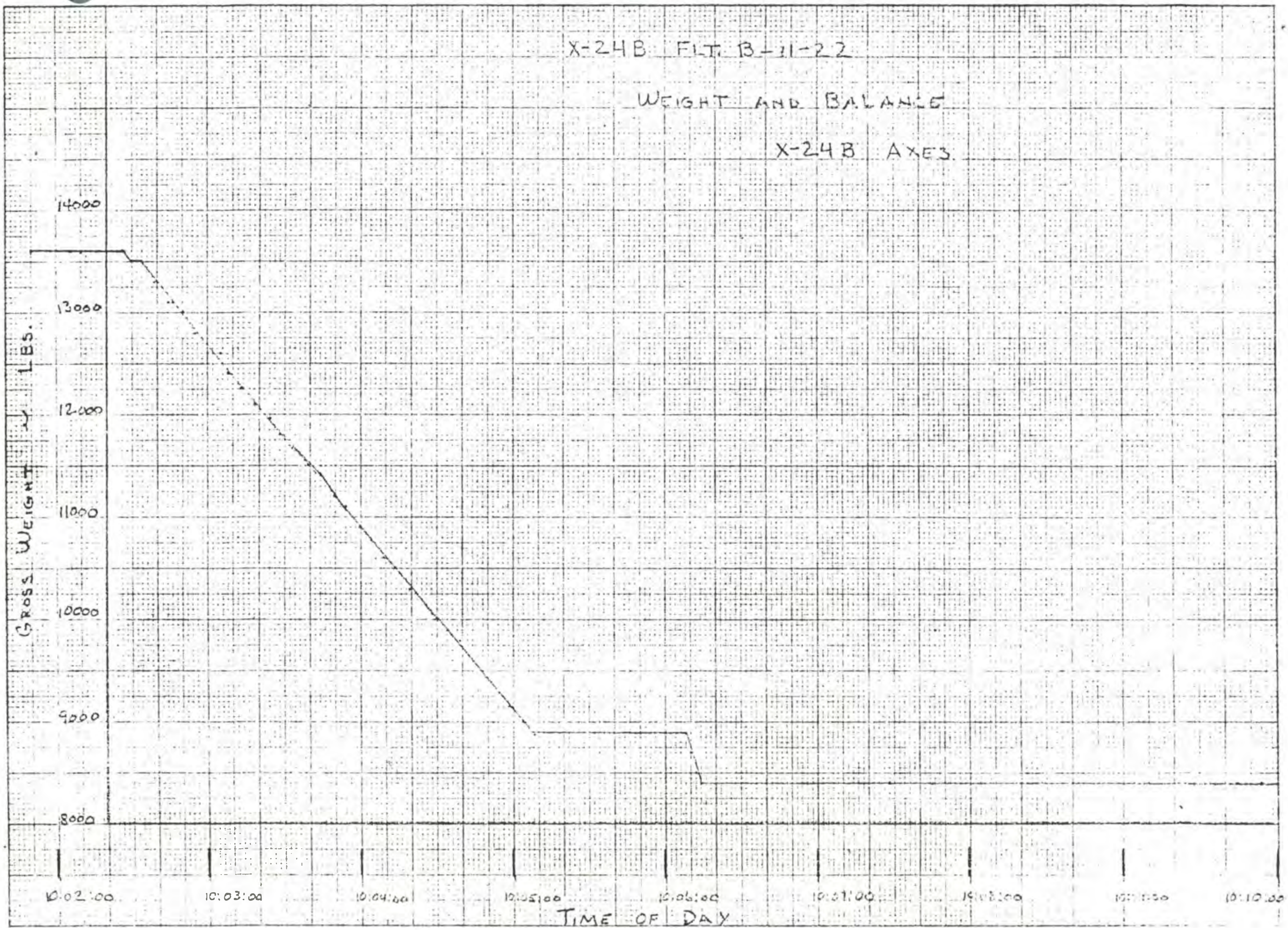
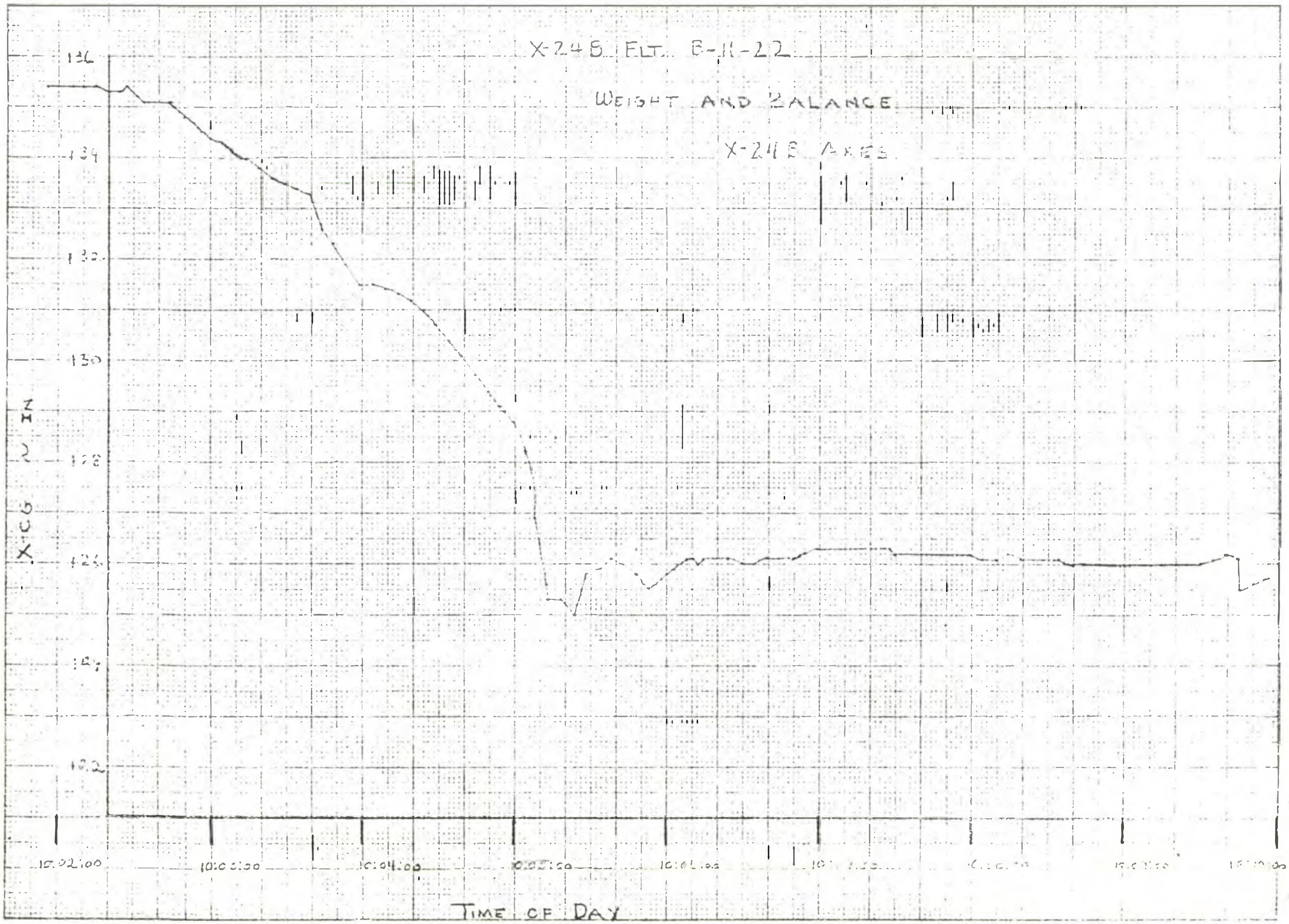
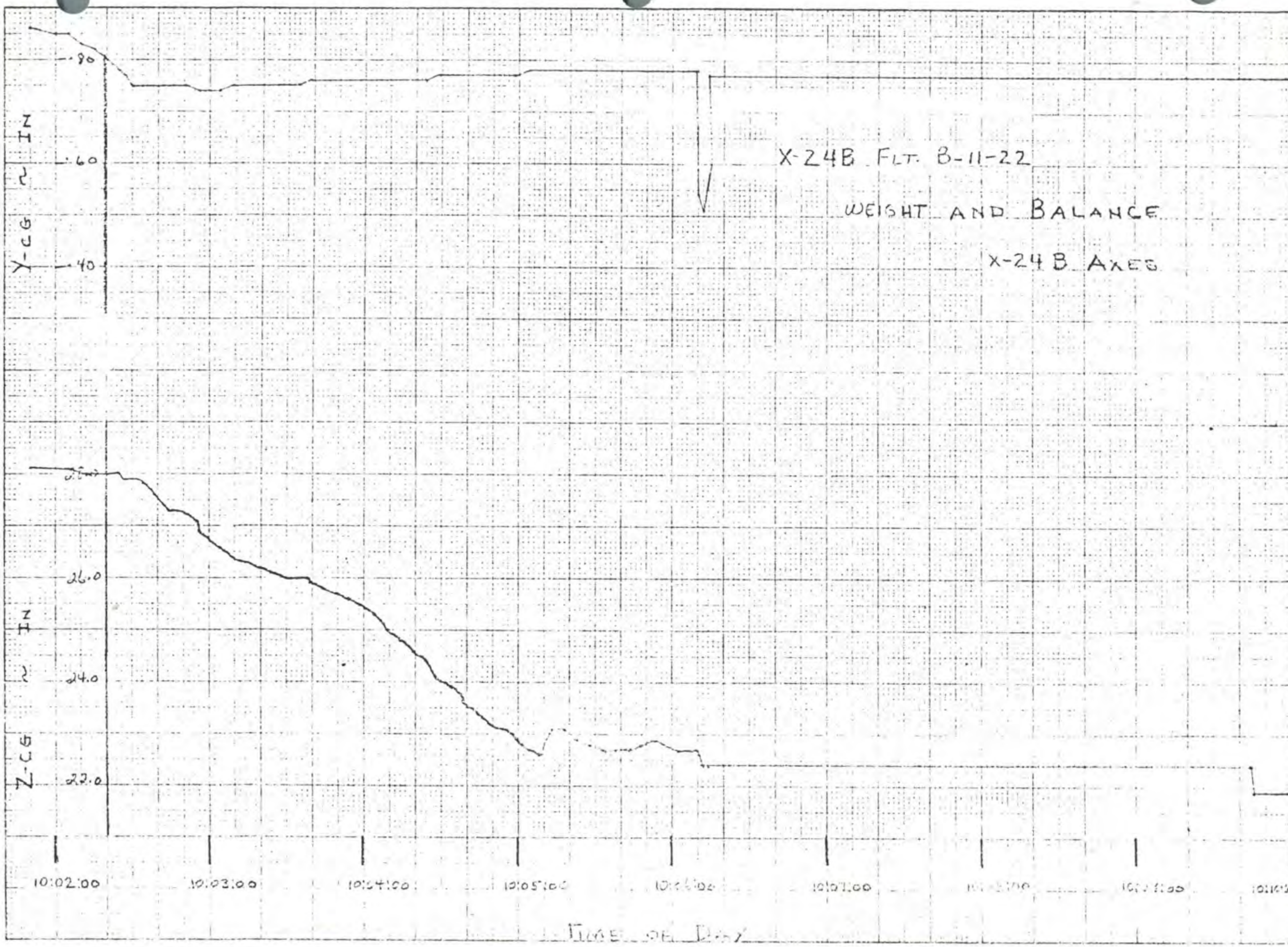


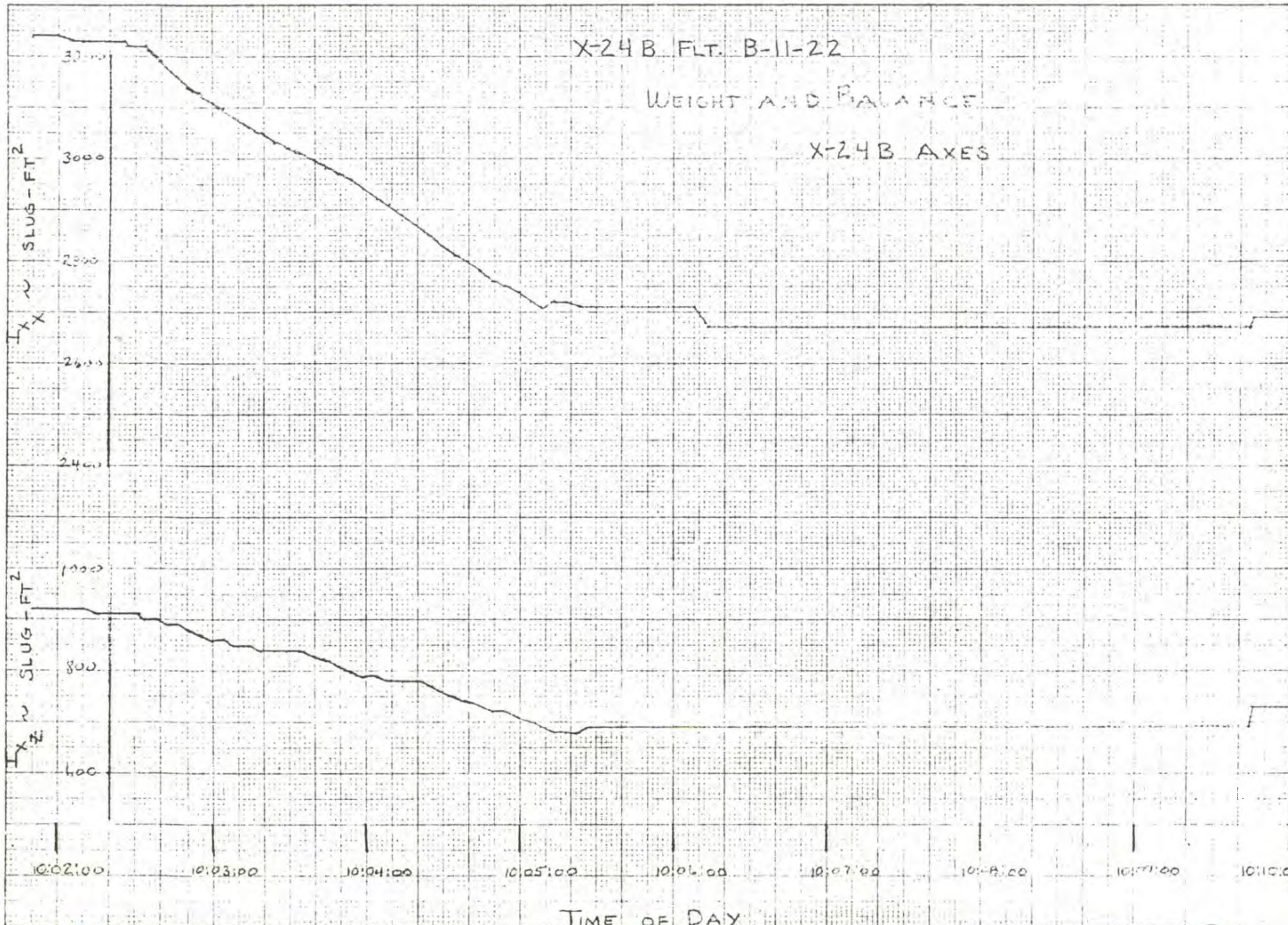
FIG-2

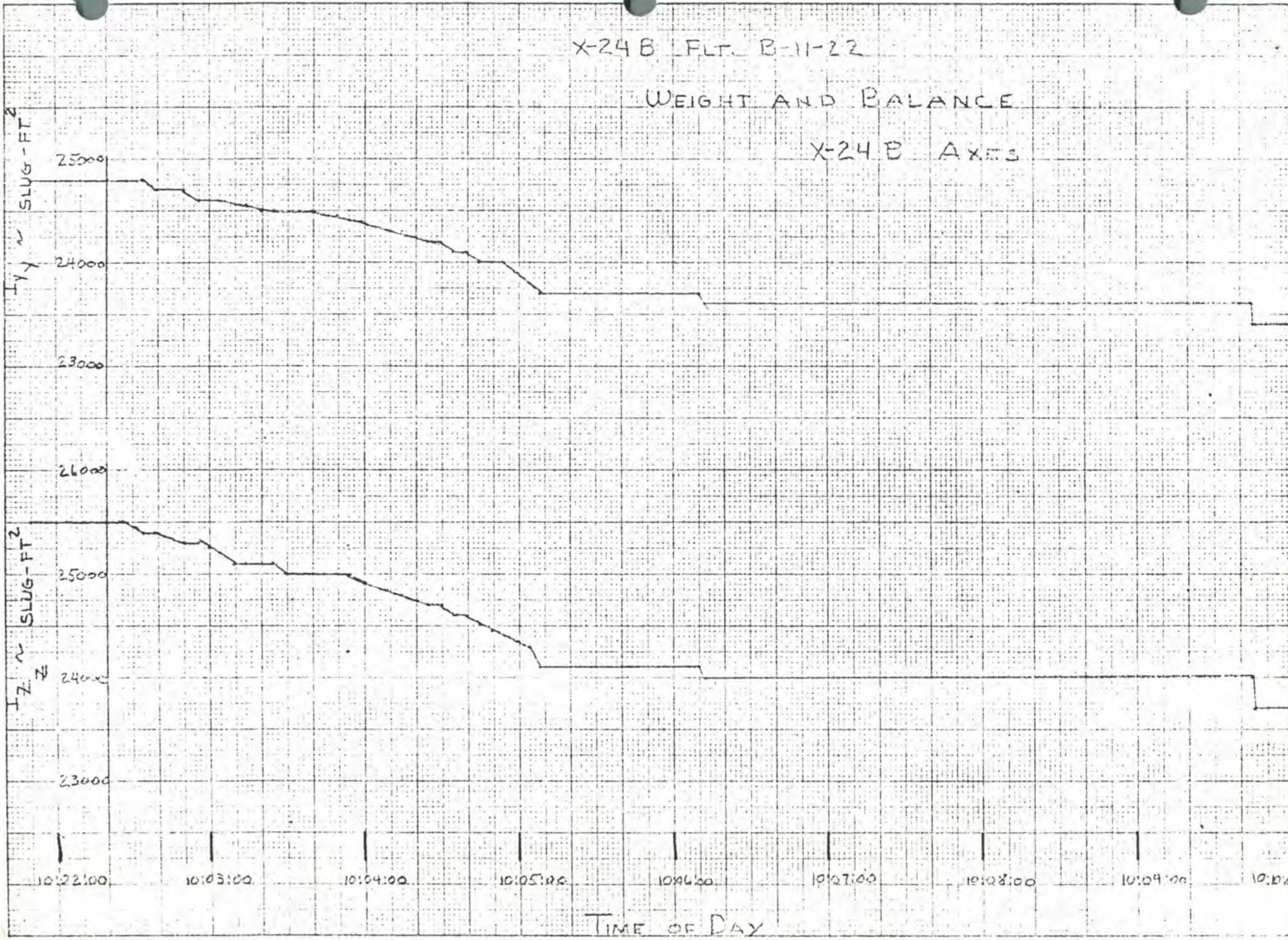

X-24B FLT. B-11-22
WEIGHT AND BALANCE
X-24B AXES
14000
13000
12000
11000
10000
9000
8000
GROSS WEIGHT ~ LBS.
10:02:00
10:03:00
10:04:00
10:05:00
10:06:00
10:07:00
10:08:00
10:10:00
TIME OF DAY



X-24B FLT. B-11-22
WEIGHT AND BALANCE
X-24B AXES
X-CG ~ IN
136
134
132
130
128
126
10:02:00
10:03:00
10:04:00
10:05:00
TIME OF DAY


X-24B FLT. B-11-22
WEIGHT AND BALANCE
X-24B AXES
Y-CG ~ IN
.80
.60
.40
Z-CG ~ IN
26.0
24.0
22.0
10:02:00
10:03:00
10:04:00
10:05:00
10:07:00
TIME OF DAY


X-24B FLT. B-11-22
WEIGHT AND BALANCE
X-24B AXES
I_{XX} ~ SLUG - FT^2
I_{XZ} ~ SLUG - FT^2
3000
2400
800
400
10:02:00
10:03:00
10:04:00
10:05:00
10:10:00
TIME OF DAY


X-24B FLT. B-11-22
WEIGHT AND BALANCE
X-24B AXES
I_{YY} ~ SLUG-FT^2
25000
24000
23000
I_{ZZ} ~ SLUG-FT^2
26000
25000
24000
23000
10:02:00
10:03:00
10:04:00
10:05:00
10:06:00
10:07:00
10:08:00
10:09:00
10:10:00
TIME OF DAY

X-24B OPERATIONS FLIGHT REPORT

FLIGHT: B-11-22

DATE OF REPORT: 7/11/74

PILOT: J. Manke

DATE OF FLIGHT: 5/23/74

CARRIER AIRCRAFT: B-52 #008

LAUNCH LAKE: Rogers Lakebed

PURPOSE OF FLIGHT:
(1) Envelope Expansion to 1.25 Mach Number
(2) Stability and Control at Mach Number > 1.0
(3) Buffet Investigation at .65 Mach Number with 20° Upper Flaps
(4) Engine Checkout at 300 psi Chamber Pressure (overdrive)
(5) Fin and Rudder Pressure Survey
(6) Boundary Layer Noise and Vibration Experiment (RED PLUG)

I. Discussion of Previous Operations

Utilization of the B-52 cruise tank for lox topoff appeared to alleviate the temperature problem with the L.H. aileron. This is because there is an orifice in the feed line from the cruise to reduce the lox flowrate during topoff. This reduced flowrate results in acceptable topoff rate with very little overflow of liquid from the X-24B lox vent line.

The plan now is to install an orifice in the climb tank feed line so that either tank may be used for topoff. With this capability we will revert to the original procedure of leaving the B-52 tanks in vent during the initial climbout to allow the lox to cool.

II. Vehicle Configuration Changes

A. Reworked SAS system per attached memo.

B. Replaced attitude system gyro package with new "B" model.

C. Reworked pylon adapter forward camera mount to realign camera.

III. Instrumentation Changes

Changed dynamics system circuit breaker from 5 amp to 7 amp rating.

IV. Preflight Events

A. The engine igniter bleed orifices were flow checked to determine if they caused the freezing of the chamber sensing lines during flight 10. The #4 orifice was completely plugged and the other three were partially plugged. New orifices were installed and a new inspection requirement for flow checking the orifices following engine operation were instituted.

B. The alcohol manifold pressure dip during engine start on flight 10 was very similar to dips experienced on the PSTS prior to incorporation of a bleed hole in the fuel feed line. Mr. Arnold felt that the bleed hole in the vehicle had become plugged so the feed valve was removed and visual inspection of the hole was attempted. The location made positive determination of the condition of the hole inconclusive.

C. The nose gear steering circuit breaker was replaced because of excessive force required to reset.

D. The cabin air cooling system on the pylon adapter was reactivated for hot weather operation.

E. Replaced lox/alcohol tank pressure regulator for low setting.

V. Flight Events

A. Servicing was accomplished without incident.

B. The #1 chamber failed to lite after launch and a three chamber profile was flown with no further problems.

C. The T/M indication of the #1 hydraulic buss voltage dropped to 20 volts during the final approach. The current and hydraulic pressure indications were normal which would indicate that the problem was in the T/M system. Following the flight the #1 Hydraulic power and monitoring systems were checked with no discrepancies noted.

The vehicle was in good condition after the flight.

Approved by: William P. Albrecht
Chief, Operations
Engineering Branch

Written by: Norman E. DeMar
X-24B Project Engineer
Operations Engineering Branch

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FLIGHT RESEARCH CENTER
EDWARDS, CALIFORNIA 93523

REPLY TO
ATTN OF: FS-044-74

June 18, 1974

MEMORANDUM

TO: X-24B Project Manager

FROM: Flight Systems Engineering

SUBJECT: X-24B SAS Problems Between Flight B-10 and B-11

1. After flight B-10 the stability augmentation system was failing in the yaw axis. An investigation showed that the #5 comparitor was failing, further investigation showed that the three gyros in yaw had different damping characteristics which could give this type of failure presentation.

2. Installed the spare gyro packages in the roll/yaw systems.

2.1 This installation required rewiring the SMRD and torque test box because of the differences in the number of test coils between the flight system and the spare system. The flight system used one coil for both SMRD and torque tests where as the spare system uses two coils one for SMRD and one for torque.

2.2 Discovered that during the rework the 28VDC pin was misplaced in the plug. Spent half a day troubleshooting the system before the error was discovered.

2.3 Calibrated gyros and found yaw S/N 10 gyro was 25% lower in output than the other two gyros.

2.4 Installed a roll/yaw gyro package S/N 1 from the removed flight system in S/N 10's place.

2.4.1 Rewired SMRD and torque test box to make S/N 1 compatible for gyro test purposes.

2.4.2 Rewired X-24B vehicle for S/N 1 due to torque reversal between S/N 1 and S/N 4, 14.

2.4.3 Wrong SMRD and torque test box was installed causing another half day lost in troubleshooting system.

2.4.4 During system checks it was discovered that the yaw system was not compatible between the original flight system and the spare system. The difference is suspected in the washout characteristics. This difference is being investigated at Sperry Flight Systems Division.

2.4.5 Decided to reinstall S/N 10 roll/yaw box which required reworking of SMRD and torque test box and vehicle.

2.5 System appeared to be working properly so requested a preflight.

2.5.1 Pitch axis gave improper comparator outputs.

2.5.2 Roll axis gave improper comparator outputs.

2.5.3 Yaw axis gave improper comparator outputs.

2.5.4 It was discovered that roll comparator tests where not completely improper.

2.5.5 Pitch and roll would not pass switch off testing procedures with test cart removed.

2.6 Tested pitch S/N 2 box in lab and discovered the box had internal problems. Sperry is investigating these problems.

2.7 Suspected portion of the improper comparator output problems to be associated with low torqueing voltage. Modified test cart and vehicle for proper voltage levels.

2.8 Portion of the improper comparator lights on preflight was due to revers torqueing characteristic of the dual coil gyro. Rewrote preflight to reflect the reversal.

2.9 Test procedure was improper when test cart was removed which explains 2.5.5.

2.10 Installed S/N 1 pitch box and rewired SMRD and torque test box.

2.11 Replaced the yaw gyro in S/N 10 box but the 25% error was still present.

2.12 Since the electronics in roll/yaw S/N 1, 2 and 3 aug. assy's were not suspected as being in error the gyros from S/N 4, 10 and 14 were installed in S/N 1, 2, and 3.

2.13 Due to the problems associated with the pitch S/N 2 box the decision to have Sperry investigate the roll/yaw S/N 2 electronics box and fly with the roll/yaw S/N 1 electronics box.

2.14 Discovered that a loading problem existed between instrumentation and the yaw B channel, requested that the yaw B channel be removed from instrumentation.

With the following configuration:

Pitch Aug Assy S/N 1
Roll/Yaw Aug Assy S/N 1, 2 and 3
Roll/Yaw Electronics Assy S/N 1

The X-24B stability augmentation system has performed properly and as of this date two flights have been accomplished.

The spare SMRD and torque test box is being rewired for the present vehicle configuration. The vehicle test cart has been rewired. Information for the Lab test box is being obtained from Sperry so that the bench testing procedures can be updated. Twelve dual coil gyros are on order from Sperry and will be installed in the proper assy's as soon as possible and Sperry Flight Systems Division is investigating the reported problem areas.

George Sitterle
Flight Systems Engineer

Postflight: B-11-22
Pilot: John Manke
Date: May 24, 1974

OK, this is flight B-11-22, flown on the 24th day of May and this was another real good operation. The preflight things went real good. The bomber people had a couple of problems. They sure have a nifty way of handling things. When something goes wrong they try all kinds of things, and they pulled 2 or 3 things out today that I thought might stop us. Good group on there.

Shortly after we got airborne my microphone started getting looser and looser and looser on that thing, and Id pull it up a little bit and it just flopped down. Finally it just flopped down on the bottom of my helmet so I spent much of the preflight time with my head down like that, talking into the mic and then at 3 minutes to launch I was able to grasp it with my lower lip and pull it up and I held it up there the best I could. I lost it again at low key so some of the transmissions may have been a little bit wierd, but that was the problem.

OK, SAS sure looked good on all the checks all the way through and all throughout the flight. George did a commendable job on that. The tank pressures seemed to be a little bit low, but they were just about what we saw at the engine run, I guess. I guess we put new regulators on and they are running 41 to 42 pounds when they first come up. Maybe they are going up higher as we get towards launch, but they use to run 46, 7 and 48. I guess you are not concerned about that.

OK, after we got the plotter board fixed, I guess it was pretty hectic in the Control Room. I was pretty disappointed because I did not think they would ever get it fixed. When he said 60 seconds, why I knew we were OK, but I guess we really weren't. He had done that on the clock.

OK. Anyway it worked out good. It was a good mild launch just like this airplane is when it is heavy. I tried #1 and 3 chambers and #3 came up and #1 did not. I looked at it for a little while and shut off #1 and got 2 and 4 on, and they came up just like planned. The start on #1 and 3 seemed to be a normal start for one chamber. Everything timing-wise and nothing. It was a smooth start except that #1 did not go. Then after I got 2 and 4 up I tried #1 again and it did not come on so I just turned the switch off and went on our pre-planned 3 chamber flight. Not a great deal of a problem holding 15 α, although I did overshoot a little bit one time and I got stick shaker. That is a pretty good reminder on the airplane. It comes on at a little over 16. I looked up and I was there, back down to 15 again. About this time Mike said we were climbing a little steep, and I got that impression too. The theta that I was seeing was a little bit higher than we had seen when on a 15 α simulator run, and also my Mach number had dropped down to a lower value than I had when in the simulator. So just every indication that the airplane does climb steeper at this constant 15 α than our simulator. That's about the only difference I noticed in the performance than our simulator was.

We got as many or more clurds on the way up this time as I recall for a long time. This must have been either a lot of turbulence or different wind directions or something. I bet we got 5 or 6 little inputs in beta, and maybe one or so in roll. Nothing to be alarmed about, but they are just noticeable. When Mike said we were climbing steep and it looked like my Mach was low, I did come off the 15 A some, just to try to get it to come closer to the profile and make sure that I could get my Mach number eventually. I came down between 13 and 14 α. Thatdid help and as I got to my 53,000' push-over altitude my Mach number was coming up towards .85 like we had expected in the simulator. So I guess I waited another 500' and then pushed over. So that all started to work out alright. Down to 10° α and I still got a clurd or two in here. The thing impressed me a lot here was how long it took to go sub-sonic. But I guess I had been so use to flying the normal profile with 4 chambers that I expected it to punch through quicker, and we just waited and waited for the Mach jump. I got a good mechanization on the Mach jump in the simulator because the airplane looks just like it. It just took a long time this time. OK, we got the 1.05 and it seemed to move out pretty good once I got the Mach jump. So I got the impression that I was going to go a little bit faster than we planned, so I threw in an extra rudder aileron doublet at 7 α and that probably occurred right close to 1.1 Mach number. Maybe just a little bit shy of 1.1.

Then I could see that we were starting downhill again and I had expected the engine to shut down. The simulator showed 147 seconds and we went beyond that and we were still burning pretty well. Started down hill and I became a little concerned about the airspeed because it was picking up. I guess we got up to 270 - 280 and I was just about ready to reach over and shut it off, because I did not want to see 300 knots. For no particular reason, but I kind of set that as a limit. But then we did get burnout, though I am guessing a little bit over 1.1 Mach number. I was not watching Mach number at shutdown, I was watching airspeed. Pushed over to 5 α, got the pulse there. It seemed like I got a little more rudder in than I got in the simulator. Maybe the rudder effectiveness is a little bit higher in the airplane. It just seemed like the total motion was a lot, although the damping looked very much like the simulator. So I think the only difference that I saw was just more rudder authority. That might have done it too, yes.

Then up to 10° α and by that time we had gone, in fact that 5° α pulse we probably got as we were decelerating from Mach 1 on down to 95, something like in that ballpark. the 10° α pitch pulse was a sub-sonic one. Pulled up to 10 α, did a damper-on pitch pulse and the airplane is quite a bit better damped than the simulator. The simulator is just dead beat. At least in the simulator when you do a pitch pulse the α will come back to 10 again. In the airplane, why I had to help it back to 10. So well damped there with the pitch gain at 6. Got a pitch pulse and the nose went down, and then it did come up to about 8-9° and I would have to pull it back up to 10 for the second pulse. So the damping is really good in the airplane. We went to 12° α for some handling qualities things, and I did not have a heck of a lot of time to look at it there, and we were at a lower Mach number than we had planned on being there. It flew very nice actually, very much like the simulator. Put some aileron inputs in and you do get some yaw just like you do in the simulator. Got the yaw damper off at about 86 and I really could not tell the difference with the yaw damper off. The airplane is just like the simulator there. It flies very nicely with the yaw damper off. Did a push-over at 6° α, turned the pitch damper off and did a pitch pulse. It went down to about zero and back up to 8 or 9 just exactly like the simulator. In fact, the pulse looked identical to the simulator. It swings through a few cycles but it is comfortable and pretty well damped. Probably 4 or 5 cycles.

OK, then back up to 13 α to kill off some energy and fortunately we had planned these high energy profiles this morning. The wind had been doing it to us this morning so we were pretty well aware that we were going to swing quite a way beyond the intersection today, and it looked good on the simulator so we planned on doing it today and it worked out well. We did go beyond the intersection. I did clean-up about 32,000', pushed over to get the .65 Mach number and it worked just like we had been practicing in the 104 and in the simulator. Went up to 12 α and bot a buffet. I don't know what on-set, but I think the on-set was at about 10 α at this 65 Mach number. Pulled up to 12 and the buffet increased a little bit. This buffet is exactly like an F-104 at about 300 knots with the flaps up and you pull into a mild buffet. It seemed just like that. In fact, I pulled a little bit beyond the 12 and got just a little bit of wing rock. The 104 will do that too. I don't know whether rock was from some turbulence or actual wing rock due to buffet, but it was just exactly like you get in a 104. It was amazing how similar. Held about 11.5 to 12° then until we ran out of buffet. I don't know what my Mach number ran out at. We can get that out of the data. Then we were quite a way right of track. I followed Mike's heading. He gave me a good heading, 340 or 330 to fly. In fact, I did not take my head out of the cockpit at all until Mike called about one miles from the highway. I looked out and there we were, like he said. Needless to say the practice this morning really helped in the simulator. It gave us all confidence that we could go beyond the intersection turn and come back and be able to handle the energy, and it worked out just like that.

OK, the rest of the flight went real well. A little bit of an east wind in the pattern. I had seen it in the 104 and I ended up getting high on energy once I passed the 90° position. I did the same thing here today. The pattern looked real good until I got to the 90, and then I suddently got real high. Ran the brakes out 32° and Bill made a real good call. We got a good tower setting on the 104. With the big brakes he was at idle and still able to hang in there with 32 on the speed brakes. So that is pretty fantastic. I sing praise to the 104, but there is nothing else in the world that can do a thing like that. We got a good data point there. And as I always do, with the speed brakes, I left them out too long and was slow retracking and by the time I got them back in I had run myself just a little bit low. So my aim point dropped back 1/4 mile or so. 290 knots final, and quite a bit of turbulence on final. Light turbulence, but all the way down. The flare was very comfortable. Lets see, somewhere just before or after I got the gear down I got a good kick of turbulence. I don't know what it was. Wing probably dropped 5 or 10°. No problem receovering. I just held it off and listened to Willie's call and I would guess we were somewhere around 170/175 at touchdown. The roll-out was great. I did not use nose gear steering until I got very slow. I used some braking. Probably would call it moderate braking from about 80 knots on down. That's all that there was to it.

Oh yes, I wanted to tell you that over-drive came on at 30 seconds and I could feel it. There was just no question that there is a thrust there. We were wondering whether a guy in the cockpit would feel it. There isn'nt very much change in chamber pressure but I could feel the acceleration. That is a super deal. That is nifty to have that.

Yes, in fact it did. It gives you just about the same thrust as you get with a 1000# of landing rocket. About the same sort of feel. I can feel those each time at low key --- Felt a lot better with the yaw SAS on then with it off, George

FLIGHT:	B-11-22	ENGINE START:	0845
PILOT:	J. Manke	TAXI:	0855
NASA 1:	M. Love	TAKE-OFF:	0910
B-52:	008	LAUNCH:	1003
LNCH PANEL:	J. Russell	LAND:	1010

<u>24 Minutes to launch</u>

Manke: SAS gain are 6, 5, 3
Ready for a calibrate
NASA 1: Roger
Manke: And there it is
NASA 1: A good calibrate
X-24 air is 300
Cabin pressure altitude is 22
Pylon is holding at 6
2 & 4 hydraulics coming on
OK, the pressures are 31 each and the lites are out
NASA 1: Roger
Manke: SAS modes are on
All circuit breakers are in except vehicle release and brake
NASA 1: Roger
Manke: Mach repeater is at auto
α is reading 2.5°
Airspeed reads 230
Altitude 40,000
Indicated Mach .76
NASA 1: Please start your turn 008
008: 008
Manke: Mach repeater is manual 1.0
OK, that is about one on the lowers
NASA 1: Roger
Manke: Comes the emergency flaps
Got 30
Back 25
Coming open
With the normal switch to 40
Got 40 and no rudder
Coming in to 20
And I got 20
-10 coming back to 40
OK, there is 40 and 0 Mike and rudder coming to manual
Coming in to 10
Going out a little
Now going to auto and it goes back to 0
OK, aileron bias mode going to back up
NASA 1: 008, steepen your turn
008: 008
Manke: And am going to 5

Manke: Back to 9
Switch going to normal
Back to 5
Now I will reset it at 7
NASA 1: Chase 1, be sure and let us know when you see LOX out the vent
Manke: OK, stick coming full aft
Stick trim forward, aft
Trim is set at 10
Here comes some aileron
Left, right
NASA 1: Shallow your turn, 008
008: 008
Manke: Aileron is set at 0
OK, rudders right, left
Yaw trim, right, left
Left 0
1° left
How does that look, Mike?
NASA 1: A little more left, John
A little more left, John
Manke: OK, there is left
NASA 1: That's good
Manke: OK, KRA going to 50
Here comes the stick
I got rudder
Chase: You're getting a little LOX vent now
NASA 1: Roger
Manke: Back to 0
No movement
KRA going emergency
NASA 1: Shallow your turn, 008
008: 008
Manke: 50 percent
I get movement
KRA to normal
It's programming back to 0
Stick shaker-test, it works and it's on
OK, my Mach repeater is 1.0
Flap mode is manual
Rudder mode is auto
NASA 1: 008, rool out 245
And we would like precool off, John
Manke: Precool is off
NASA 1: Roger, and 008, 245
Manke: Gains set 5, 5,5, and here is the old SMRD
No lites
Torque
No lites

Manke: #1 servos off and a torque
3 yellows
#2 is off and a torque
3 reds
OK, SAS gains 6, 5, 3,
Servos auto
They are reset and a torque
No lites
Good work, George
SAS modes are on and I will wait for 14 minutes
NASA 1: OK John, it looked real good down here
We are just passing 17 minutes

17 Minutes

NASA 1: John could you give us a little bit of left roll trim
Manke: Alright
NASA 1: A little more
That's good
Manke: Alright
How do the aileron bias's look to you?
NASA 1: Aileron bias is good
Manke: OK, Mike

16 Minutes

NASA 1: 16 minutes, John
Manke: OK, Mike, 16 minutes
NASA 1: Bill Dana, how do the campsites look at Lake Cachuma?
Dana: OK, let me look at them, John
Manke: I can see one open one over there
Dana: No, John, that has got a small camper in it.
John Armstrong, there are no spots available at Lake Cachuma.
NASA 1: Thank you very much, Bill
Dana: It is nice to have someone you can count on for a straight information, isn't it?
NASA 1: 15 minutes, John

15 Minutes

Manke: Alright, 15 minutes
NASA 1: OK, 008 come 3 left and give us your heading
008: Roger, heading 242
NASA 1: Copy

14 Minutes

NASA 1: 14 minutes, John, 14
Manke: Alright Mike
OK, swapped hydraulics
Lites are out and I read 2700 on the pair
NASA 1: Roger
Manke: And I am ready for a pitch and yaw pulse, 008
008: Roger, going to have a pitch pulse, now
NASA 1: Good pitch pulse
008: Yaw pulse coming

NASA 1: Good yaw pulse
MANKE: Very good, I can see them here too, Mike
NASA 1: Roger
Manke: If you are on this heading for a bit Mike I will set up my gyros
NASA 1: Roger, heading is good
Manke: Erect, fast erect
NASA 1: Roger, 13 minutes John, 13

13 Minutes

Manke: Alright
OK, I've got 40 on the uppers
10 on the lowers
My ailerons are zero
My aileron bias 7
Rudder is 1° left and rudder bias is 0
NASA 1: We agree
12 minutes, John, 12

12 Minutes

Manke: OK, Mike, 12 minutes
Save 45: Mothership 008, SAVE 45 on station
008: Roger
NASA 1: Copy, thank you
11 minutes, John, 11

11 Minutes

Manke: OK, Mike, 11
Chase 1: I didn't have a camera man today. Had to bring my own
Chase 2: You'll find it behind the back seat stick
That's a good place for it on final
Chase 1: I will wait until I get on final
NASA 1: 10 minutes, John, 10 minutes

10 Minutes

Manke: OK, Mike, 10
#1 is 4000
#2 is 4100
Control gas 505
Governor balance 470
Fuel tank 0
LOX about 3
Landing gear about 3000
Ready for the pump heater off and on
NASA 1: Rog, go ahead with it off
Manke: Heater coming off now
Coming back on now
NASA 1: Roger
OK, that was a good check
Manke: Roger
Good thing you are not going to San Diego this week, the coast is definitely not clear
NASA 1: Thank you, John
9 minutes, John, 9 minutes

9 Minutes

Manke: OK, Mike, 9 minutes
Erect switch cut-off
Fast erect is off and my attitudes are very good
NASA 1: Roger
Manke: I don't like Dana's attitude but there is not much we can do about that
NASA 1: 10 seconds, Dana, 10 seconds
8 minutes, John

8 Minutes

NASA 1: B-52 start your turn
008: 008
Manke: OK, 8 minutes, Minke and Chase 1 are you ready for a throttle check?
Chase: Go ahead
That looks pretty
Manke: OK, looks good here
NASA 1: We had 2 down here, John
Manke: OK, Mike, here comes the aileron activity cycle
NASA 1: Roger
Manke: That looked good here
NASA 1: OK, it looked good down here, John
7 minutes, John, 7

7 Minutes

Manke: OK, Mike, I am on X-24 radio, going to secondary
NASA 1: Roger
Manke: OK, back primary, Mike
NASA 1: Five square, John
Manke: Good show

6 Minutes

NASA 1: 6 minutes, John, and chase aircraft check windshield heat
Chase: 1, 1α and 2, 2α, 3
Manke: I have got 27° on the lowers
NASA 1: OK, looks good down here
Chase: Chase 3, remember only 2 chase can go down
B-52: NASA 1, launch panel, is there any indication of LOX top-off as yet?
NASA 1: Roger, we have it
Chase: We have a good steady flow out now
NASA 1: 5 minutes, John, 5

5 Minutes

Manke: OK, I am on battery
Have reset emergency battery
Lite is out
I am on 2 & 4 hydraulics
The lites are out
I am reading 3500

Manke: I am reading 3500
Bus loads, 120, 110, 105 and about 35
SAS gains are 5 and the old SMRD
B-52: X-24 adapter power off and ammeters are zero
Manke: No lites
Going to torque
NASA 1: 060, 008
008: Roger
Manke: No lites and #1;s coming off
Torque
3 yellows
2's are off
A torque
3 reds
SAS gains are 6, 5, 3.
Servos are auto
Lites are reset
And a torque
No lites
SAS looks good
NASA 1: Good here, John
We're inside 4
NASA 1: 3 minutes
3 Minutes
Manke: OK, Mike, 3
I'm on X-24 oxygen
Regulated pressure 85
Cylinders about 75
Just went to X-24 air
Cabin altitude is 25
Canopy defog is in heat and forward canopy is on
Suit vent is low
1 helium 4000
#2 41
Control gas 505
Governor balance about 440 and erect and fast erect is on
NASA 1: OK, and what is the X-24 air?
Manke: X-24 air is about 2800 now
NASA 1: Roger
Manke: And my trim looks good
NASA 1: OK, looks good here
Chase: Looks good outside
NASA 1: 2 minutes
2 minutes

Manke:	OK, 2
	Precool is off
	Engine bleed on
	Prop supply on
B-52:	Top-off complete
Manke:	And I pressurized the tanks
NASA 1:	OK, John
Manke:	The fuel looks like about 42-43 and LOX is coming up at about 40-41
NASA 1:	Roger
Manke:	Release pressure low lite is out
NASA 1:	Roger
	3° right, 08
B-52:	008
Launch Pl.	B-52 Radar beacon off
NASA 1:	Roger
B-52:	Release pressures look good
NASA 1:	Roger
	We got a problem with the plotter, John
	OK, John, 1 minute now
<u>1 Minute</u>	
Manke:	OK, got the one minute
	Started my clock
NASA 1:	OK, we got the plotter fixed
Manke:	#1 OK, #2 OK, SAS lites are out, α 4, β 1° needle left
	Everything looks good
NASA 1:	45 second, John
Manke:	Engine master is on
	Erect cut-off
	Fast erect is off
NASA 1:	30 seconds, John, and everything is good down here
Manke:	OK, my release circuit breaker is in
	I'll wait a second on the camera
NASA 1:	Roger
Manke:	Camera/recorder is on and the fin camera is on
	OK, Mike, 5 seconds
<u>LAUNCH</u>	
NASA 1:	OK, John, check your α
	We got 3 good ones down here
Manke:	I got 3 good ones
NASA 1:	OK, John, it will be a 3 chamber profile
	Got a good heading
	You are on a 3 chamber profile
	--- check 15 α max
Manke:	OK, 15
NASA 1:	OK, we are 28 seconds, get overdrive on
Manke:	I can feel the thrust
NASA 1:	You got a good overdrive, disregard your theta, we'll hold 15 α max

NASA 1: You are going to be pushing over at 53,000 to 10 α, at 105 you will push over to 7 α and leave the overdrive on to burnout
Manke: OK, lets cover those things again as we get to them
NASA 1: Roger
Get the 5 α doublet after burnout at 105 and proceed as planned
Good heading
Holding about a 1000 low on the 3 chamber profile
Manke: OK, got a few klurds and got beta out about a degree
NASA 1: Roger, we have you thru 50 and you are high on the 3 chamber profile
Excellent heading
Manke: OK, my Mach is kind of low
NASA 1: OK, check your Mach
Standby for a pushover to 10 α
I have you thru 53,000 now
Manke: OK, I'm reading 52 and I've got .75 Mach
NASA 1: Roger, check your α and β
MANKE: Check, there is 10 α
NASA 1: Roger
Manke: Beta 1° needle left
NASA 1: OK, standby for 105 and 7 α
Leave the overdrive on
You are right on track
You have a good profile
See you going to 7
You are approaching burnout
Remember it is 5 α and doublet after burnout
You are right on tractk
Manke: Roger
NASA 1: Burnout
5 α and doublet
See your 5
See your doublet
10 α and pitch pulse,
Good heading
On profile
See you going to 10
Do your pitch pulse
12 α and get your handling qualities
You are 5 miles,
Good heading
On profile
Approaching 4 miles
Check your Mach
Standby for yaw damper off at 6 α
4 miles you get to 6
Pitch damper off

NASA 1: 13 α
Prop supply off
Go jettison
2 miles
Good profile
About 1500 low
MANKE: Roger
NASA 1: And there is a mile, John
Good heading
Get your damper (yaw) on and hold that heading
You are 1500 low
You 're abeam the intersection,
Hold that heading
Wait for the jettison
Manke: Cleaning it up
NASA 1: OK, John, stop jettison
Tanks and bleed
350 will be a good heading
You are on profile
See you going clean
Check .65 Mach and standby for buffet
Plan on 345
You are 1500 low
See you up to 12
4 miles
Plan on 335
You are going 2 miles wide but you are only 1000 low
OK, if you're done with the buffet you can check SAS 4, 3, 2
You are about 2 miles wide at 3 miles
Coming up to profile
335 would be good or even 330
Manke: OK, Mike, good
NASA 1: We got you 432, John
You are approaching 2 miles
Get a rocket check when you want
You are 500 high
2 miles
1 and 3 hydraulics
We got your 2 good chambers
We got your hydraulics
You are approaching a miles, that's an excellent heading
You are about 1000 high on the normal
Manke: Roger
NASA 1: You are about 1/2 mile, holding 1000 high
Your're 1/2 mile wide
Over the highway
You can start your turn
Manke: OK, Mike, good calls

Chase: 20,000, 230 knots, John
Manke: OK, Willie
Chase: 87% with the big brake
279
Manke: Check
Got about 275
NASA 1: See your boards, John
Chase: It is about idle thrust on the 104, John
Manke: OK, and I got about 32 on the uppers
Chase: How about that
Manke: 290
NASA 1: OK, John, Mach repeater 3
We see you closing up
Manke: Got it
NASA 1: We see it
Chase: 200'
Manke: OK
Chase: Call that 100, John
Manke: OK
Chase: 50, and you got 3 good ones
25' 10' 5' 3, 2, 1
NASA 1: Nose gear steering arm
OK, we will have debrief at 1100
Another beauty John, the phamton did it again
Manke: Yes, but darn that chamber though
OK, Mike, the throttle is off
KRA manual
Camera is off
Here comes the calibrate
NASA 1: Roger
Manke: And recorder coming off
OK, SAS servos coming off
Hydraulic pumps off and the canopy defog is off

#1 helium 1200
#2 is about 38
Control gas 500
Governor balance 460
NASA 1: Roger
Do you want to erect the platform, John?
Manke: Oxygen 1200
Cabin air is down around 800
Stick shaker's off
Engine timer reads 156
NASA 1: Roger
Manke: Radar coming off
NASA 1: Rog
Manke: And I am into erect and fast erect ---

NASA 1: The real phantom would like to know what you saw for Mach
Manke: --- I think something like a little bit over 1.1
NASA 1: OK, John

The End

FLIGHT 12

Preliminary Results of X-24B

Flight B-12-23

14 June 1974

By

USAF/NASA X-24B Project Team

Flight Summary - Flight B-12-23

Flight B-12-23 was flown on 14 June 1974 by Major Mike Love. The four chamber flight was flown as planned and all objectives were accomplished. The significant flight conditions were as follows:

Maximum Mach Number = 1.23
Maximum Altitude = 65,512 feet
Maximum True Airspeed = 704 Kts.
Flight Time = 6 minutes 45.4 seconds
Burn Time = 106 seconds

A summary of the key data maneuvers performed on the flight is listed below.

Mach No.	α	Maneuver
1.18	6.5 degrees	Rudder/aileron doublet (power on)
1.19	6 degrees	Rudder/aileron doublet
1.07	5 degrees	Rudder/aileron doublet
1.03	10 degrees	Pitch pulses (2)
.77	8 degrees	Rudder/aileron doublet (yaw damper off)
.82-.61	-	Yaw damper off H.Q. (38.6 seconds)
.55-.59	6 degrees- 12 degrees	Aileron Bias POPU (30 degrees upper flaps)

The powered flight performance was higher than planned by the simulation. A comparison of planned and actual conditions is shown below:

	Planned	Actual
Max altitude - feet	62,500	65,500
Max Mach No.	1.25	1.23
Burn time - second	112	106

A postflight simulator match of this difference was performed using preliminary data. A close match to the observed performance resulted with an increase in thrust of 400 pounds. This increase thrust level will be used to plan the next flight.

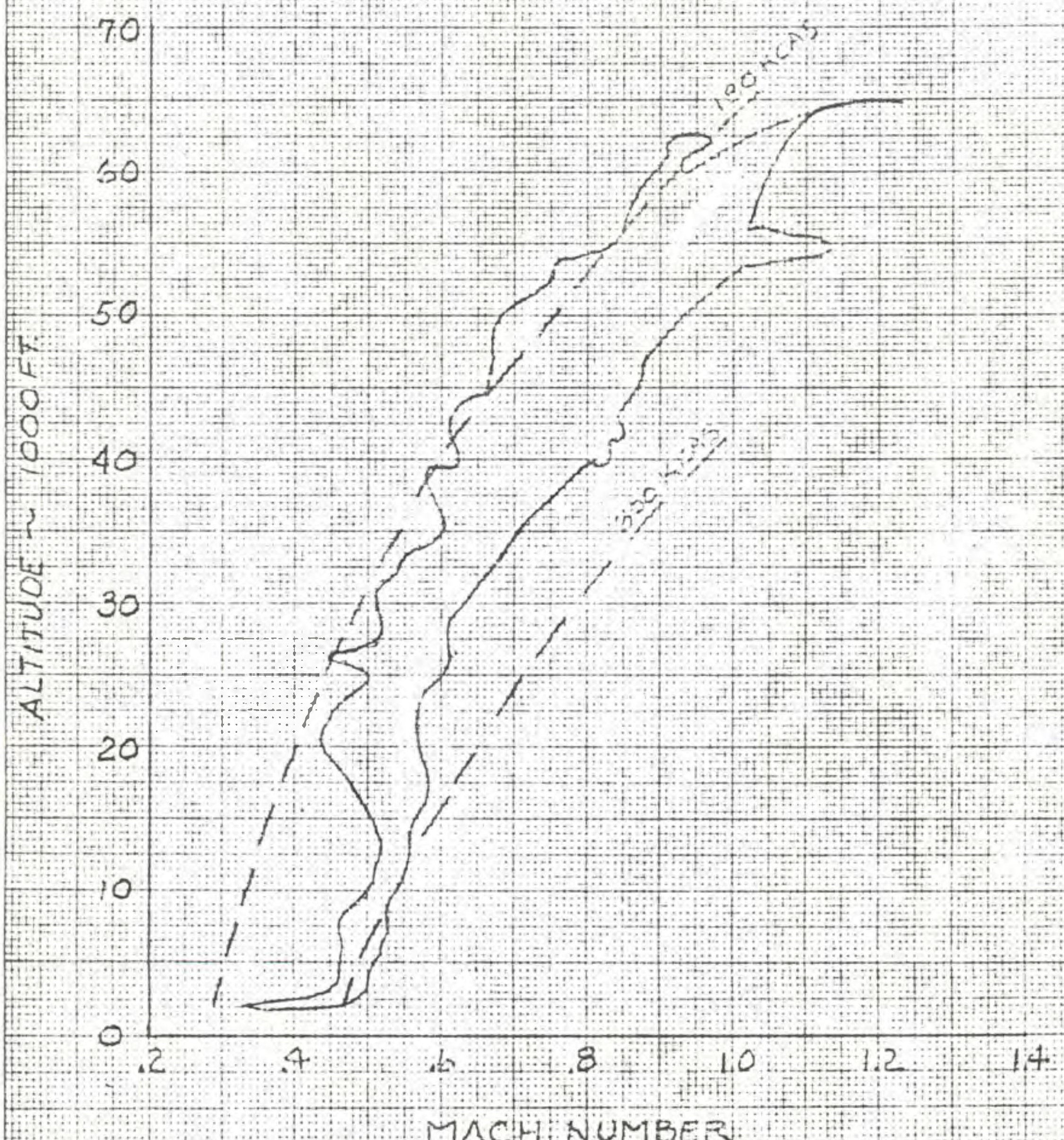
This was the first flight with the "system two" subcom which transmits 39 additional surface pressures. However, the sync failed to work properly and the data was not recoverable.

X-24 B

MACH NO. VS ALTITUDE

ENVELOPE

FLIGHTS 1 THRU 12

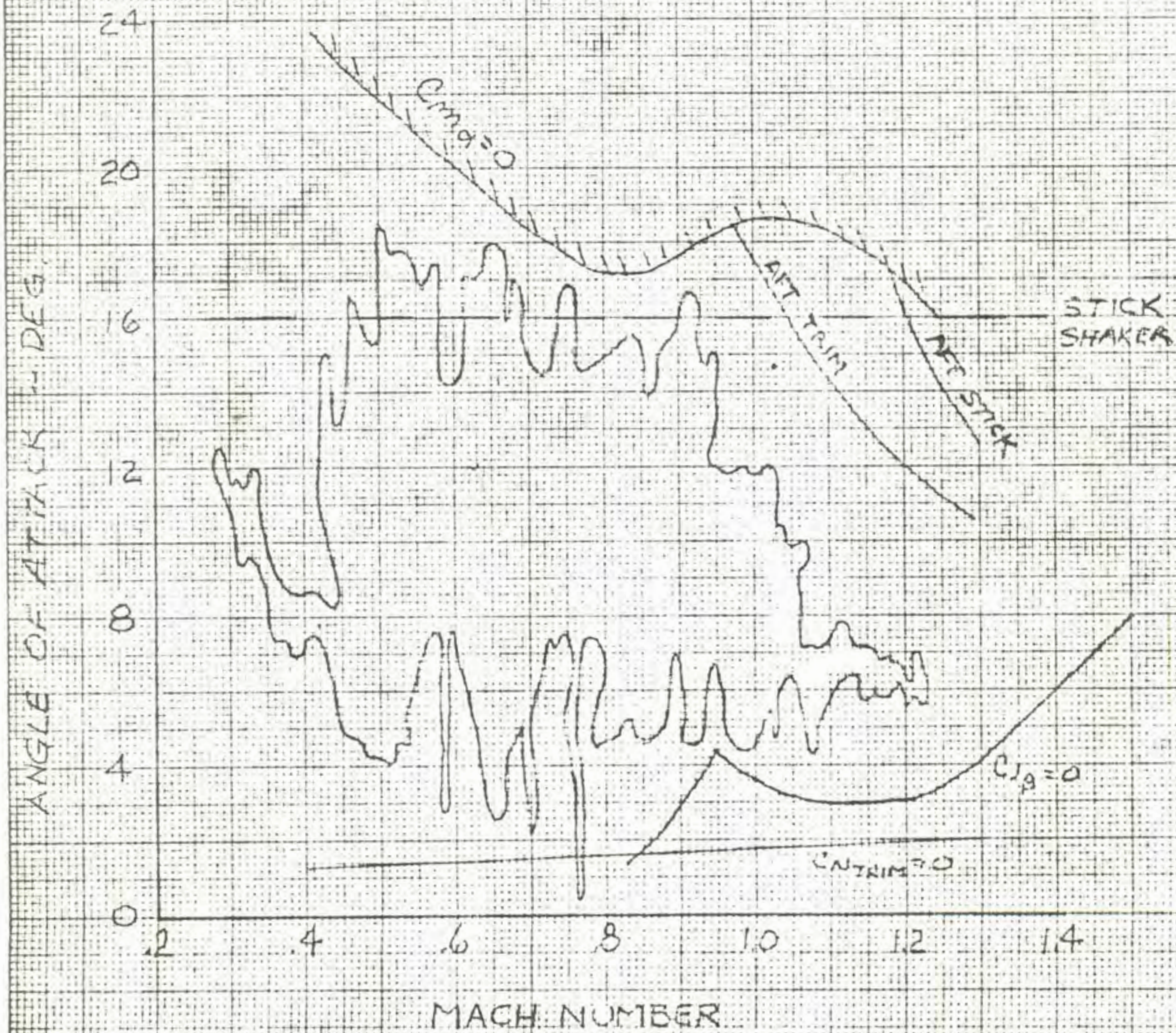


X-24B

MACH NO. VS ANGLE OF ATTACK

ENVELOPE

FLIGHTS 1 THRU 12



X-24B Flight Request

6 June 1974

Flight No: B-12-23

Scheduled Date: 14 June 1974

Pilot: Major Mike Love

Purpose:
1. Envelope Expansion to 1.25 Mach Number
2. Stability and Control at Mach Number >1.0
3. Fin, Rudder and Flap Pressure Survey
4. Boundary layer noise and vibration experiment (RED PLUG)

Launch: West of Rosamond, Mag Heading 060° + Cross Wind Correction Angle. 45,000 feet, 190 KIAS. Flap Bias "Manual", Upper Flaps = -40°, Lower Flaps = 27°, Rudder Bias Mode "AUTO", Rudder Bias = 0°. Rudder Trim = 1° Left. Aileron Bias = + 7°, SAS Gains 6, 5, 3. Mach Repeater 'Manual" = 1.0, KRA "AUTO". Hydraulic Pumps 2 and 4 on.

Landing: Rogers Lakebed Runway 18

B-52 Track: X-24B Track #2 (R2515, Work Area I)

ITEM	TIME	ALT	A/S	α	M_T/M_i	EVENT
1	0	45	190	5	.71 (.70)	Launch, Light 4 Chambers, Trim to and Maintain 15° α
2	30	43	245	15	.84 (.82)	At 30 sec. Turn Overdrive" on.
3	40	45	220	15	.80 (.79)	θ = 37° Maintain θ = 37° (cross check α)
4	75	56	180	14	.85 (.83)	At 56K (.85 $Mach_T$) Pushover to 10° α.
5	96	62	205	10	1.05 (1.05)	At 1.05 $Mach_T$, overdrive off, pushover to 7° α.
6	104	62	220	7	1.15 (1.15)	Perform rudder and aileron doublets

ITEM	TIME	ALT	A/S	α	M_T/M_i	EVENT
7	112	62	248	7	1.25 (1.25)	At 1.25 $Mach_T$ shut down engine. Perform rudder and aileron doublets.
8	121	60	235	7	1.12 (1.12)	Pushover to 5^o α, perform rudder and aileron doublets.
9	129	56	240	5	1.07 (1.07)	Pull up to 10^o α, set pitch gain to 4, perform two pitch pulses, then pull up to 12^o α and evaluate flying qualities to .85 M_T, at .85 M_T Yaw damper to "zero gain"
10	161	44	240	12	.84 (.82)	Pushover to 8^o α, Perform rudder and aileron doublets. Trim to 13^o α. Jettison propellants. Yaw damper to "on"
11	200	35	195	13	.58 (.57)	Intersection, Turn to low key heading. Change configuration to -30^o upper flaps. Trim to 11^o α and cycle the aileron bias 7^o -11^o -5^o -7^o. Trim to 10^o α.
12	255	25	225	10	.54 (.53)	Change configuration to -20^o upper flaps. Vector to low key. Set SAS Gain to roll 3, Yaw 2.
13	285	21	230	10	.50 (.49)	Low key, rocket check, #1 and #3 hydraulic pumps on.
14						Change Mach repeater to 0.3 during final

NOTES:

1. Nose Ballast = 220 lbs (+100 AMP HR Equp Batt)

2.

	Weight-lbs	cg-%
Launch	13530	65.9
Shutdown	9203	64.1
Landing	8467	64.0 (gear down)

3. Engine S/N 8, Pump S/N 8A

	Normal	Overdrive
Thrust - lbs/chamber	2100	2350
LOX Flow Rate - lb/sec/chamber	4.51	5.045
WALC Flow Rate - lb/sec/chamber	4.05	4.53

4. Power on Base Drag Reduction C_C = -.005

5. Pitch Attitude Null at 37°

Ground Rules for NO LAUNCH:

1. Radio, radar, PCM failure
2. Electrical or SAS malfunction
3. A/S, altitude, Machmeter failure
4. Angle of attack or sideslip malfunction
5. Any control system malfunction
6. Loss of cabin pressure
7. Turbulence below 10K in excess of moderate
8. Surface winds greater than 20 kts or crosswind greater than 10 kts
9. Failure of engine control box heater
10. Failure of stick shaker

(In addition to standard ground rules published in Lift Body Joint Operations Plan)

Alternate Situations After Launch:

	Failure	Action
1.	Radio, radar, PCM	Proceed as planned.
2.	Only One Chamber Operates	Vector for RW 02 Rosamond, shutdown chamber, jettison, change configuration.

	Failure	Action
3.	Only Two Chambers Operate	Maintain 15^{o} α. Change configuration to 35^{o} upper flap at .7 Mach No. Shutdown on NASA I call (≈210 sec). Evaluate dampers off handling qualities at pilot's discretion. Perform δA_B PO-PU (-30^{o} $\delta \upsilon$) if energy permits.
4.	Only Three Chambers Operate	Maintain 15^{o} α. Overdrive on at 30 sec. at 53K ($.85M_T$) pushover to 10^{o} α. At $1.05M_T$ pushover to 7^{o} α(overdrive stays on). Burn out approximately $1.15M_T$ (156 sec). Observe hands off transonic trim change (M_t 1.1 to 0.9), trim to 12^{o} α and proceed as planned. Change Pitch gain to 4 at low key point.
5.	Delayed Engine Light	Proceed as planned. Use 40^{o} θ (15^{o} α MAX). At 57K pushover to 10 α.
6.	Overdrive Failure	Proceed as planned. Maintain 15^{o}. At 57 K pushover to 10^{o} α (129 sec Burn Time).
7.	Total damper failure any axis	Fly 3 chamber profile, turn the overdrive off, maintain 13^{o} α, limit M_T to .9. Shutdown on NASA one call. If control is marginal go to two chambers. Roll or Yaw failure set Mach Rep. to 0.3. Pitch failure close-up to -24^{o} upper flap at low key.
8.	KRA "AUTO" Failure	Set to manual 10% and proceed as planned. If "MANUAL" mode inoperative-switch to "EMER" position and set to above value.
9.	Angle of Attack (Indicator Only)	Proceed as planned using backup angle of attack gage. KRA "MANUAL" 10%, stick shaker off.
10.	Total Angle of Attack	Fly two Chamber profile, use 200 KTS instead of 15^{o} α. To rotate fly 1.0 g to 230 KCAS then fly 1.2 g to 200 KCAS. (KRA Manual 10%, stick shaker off)
11.	A/S, altitude, Mach	Proceed as planned using α, θ and time for profile control.
12.	Attitude System	Proceed as planned using backup attitude indicator.

Failure	Action
13. Rudder Bias "AUTO" failure	Switch to "MANUAL" mode and toe-in to -10°. If "MANUAL" fails proceed with δA_B PO-PU and then close-up to -24° upper flap.
14. Upper flaps fail to close	Cycle emergency flap switch to close-up to -20° upper flaps. If emergency flap switch fails, move δA_B to 11° and Land on RW 23.
15. Aileron Bias "Normal" failure	Switch to "Backup" and move the aileron bias to 7°. If "Backup" fails, pull the C/B'S. If the aileron bias is stuck at less than 7° proceed as planned, if the aileron bias is greater than 7° close-up to -24° upper flaps.

16. Premature Engine Shutdown

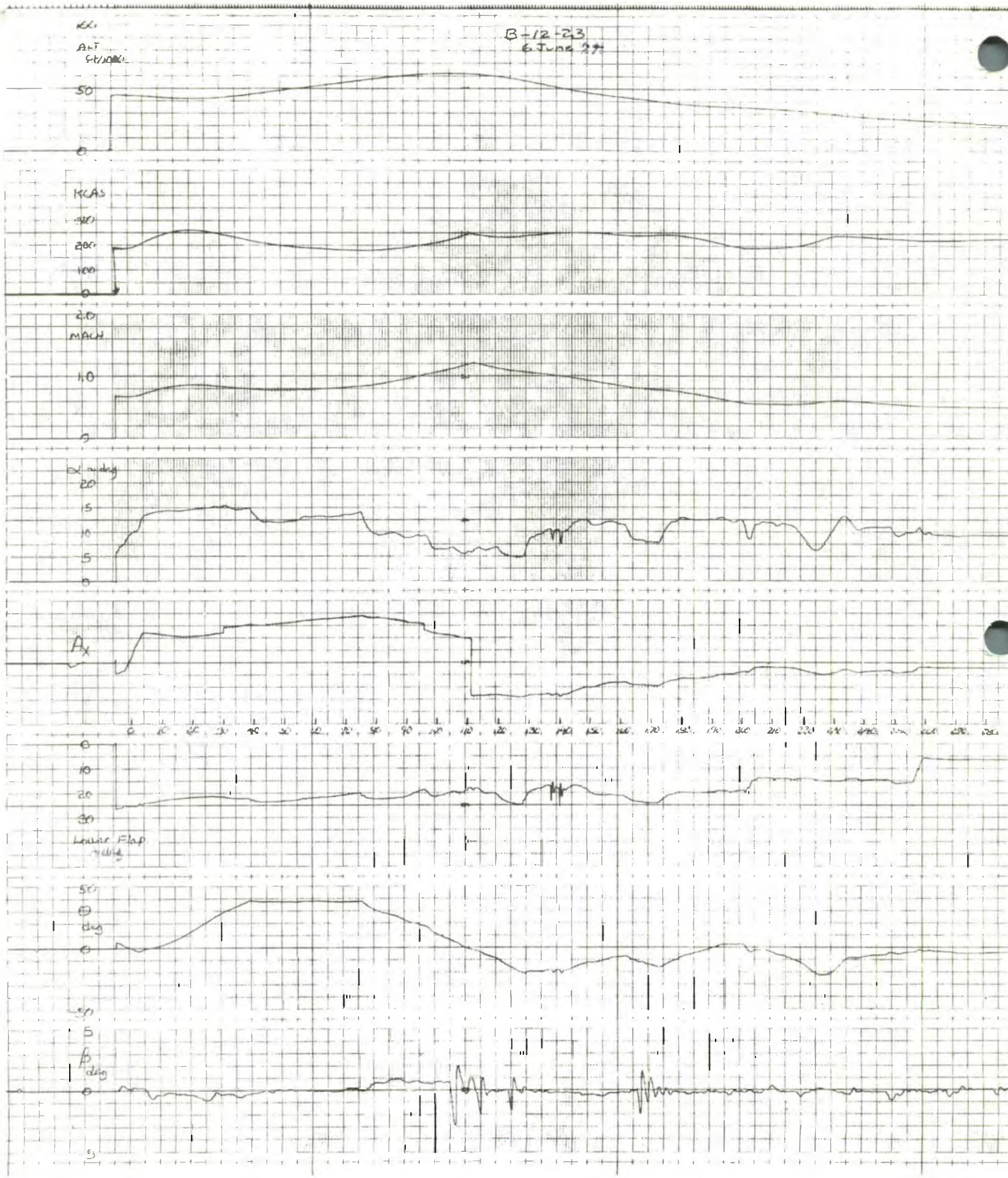
0 - 20 Sec RW 02 Rosamond
20 - 40 Sec RW 20 Rosamond
40 - 72 Sec RW 36 Rogers
72 - 82 Sec RW 18 (RHP) Rogers
82 - up Sec RW 18 (LHP) Rogers

Robert G. Hoey

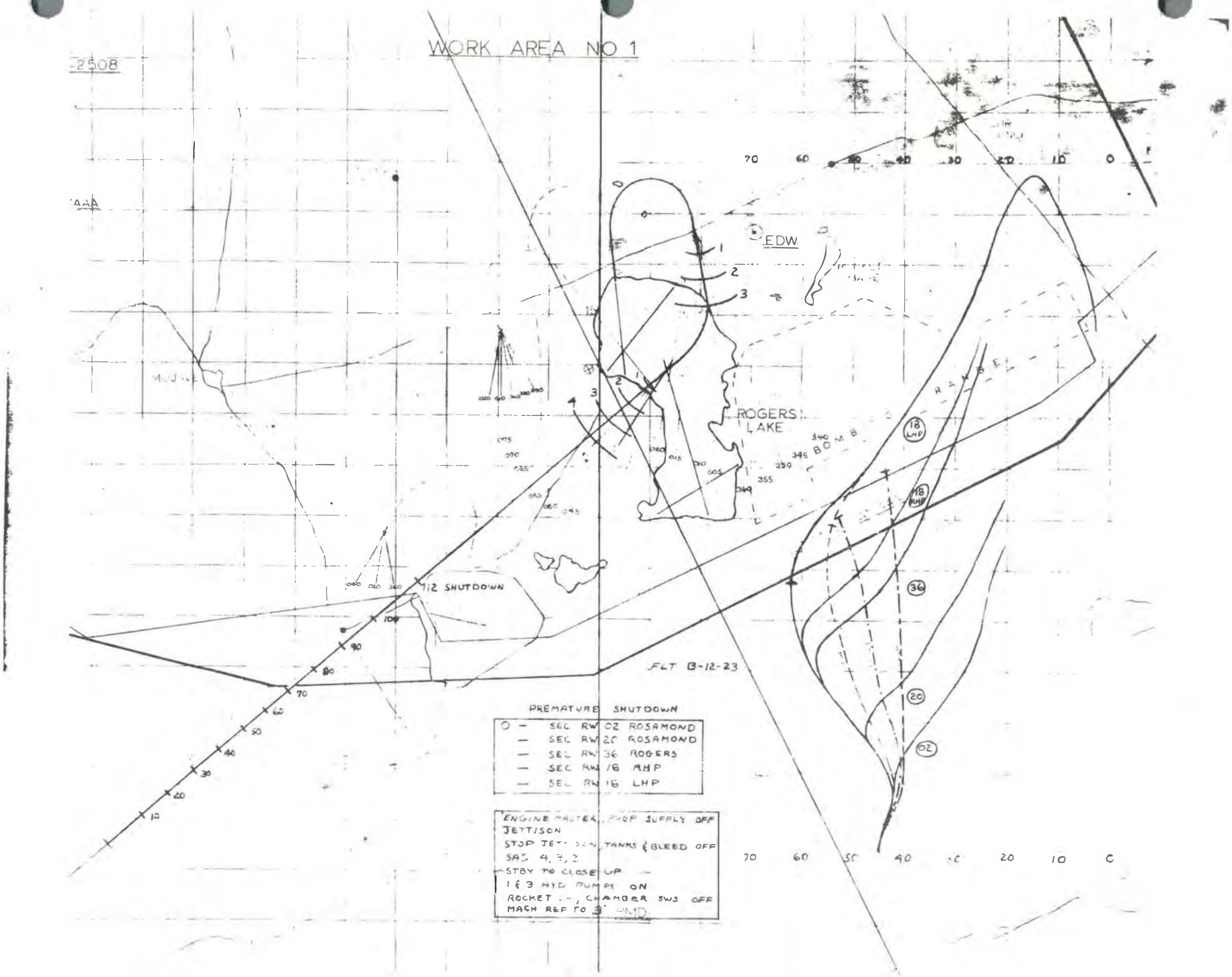
ROBERT G. HOEY

Jack L. Kolf

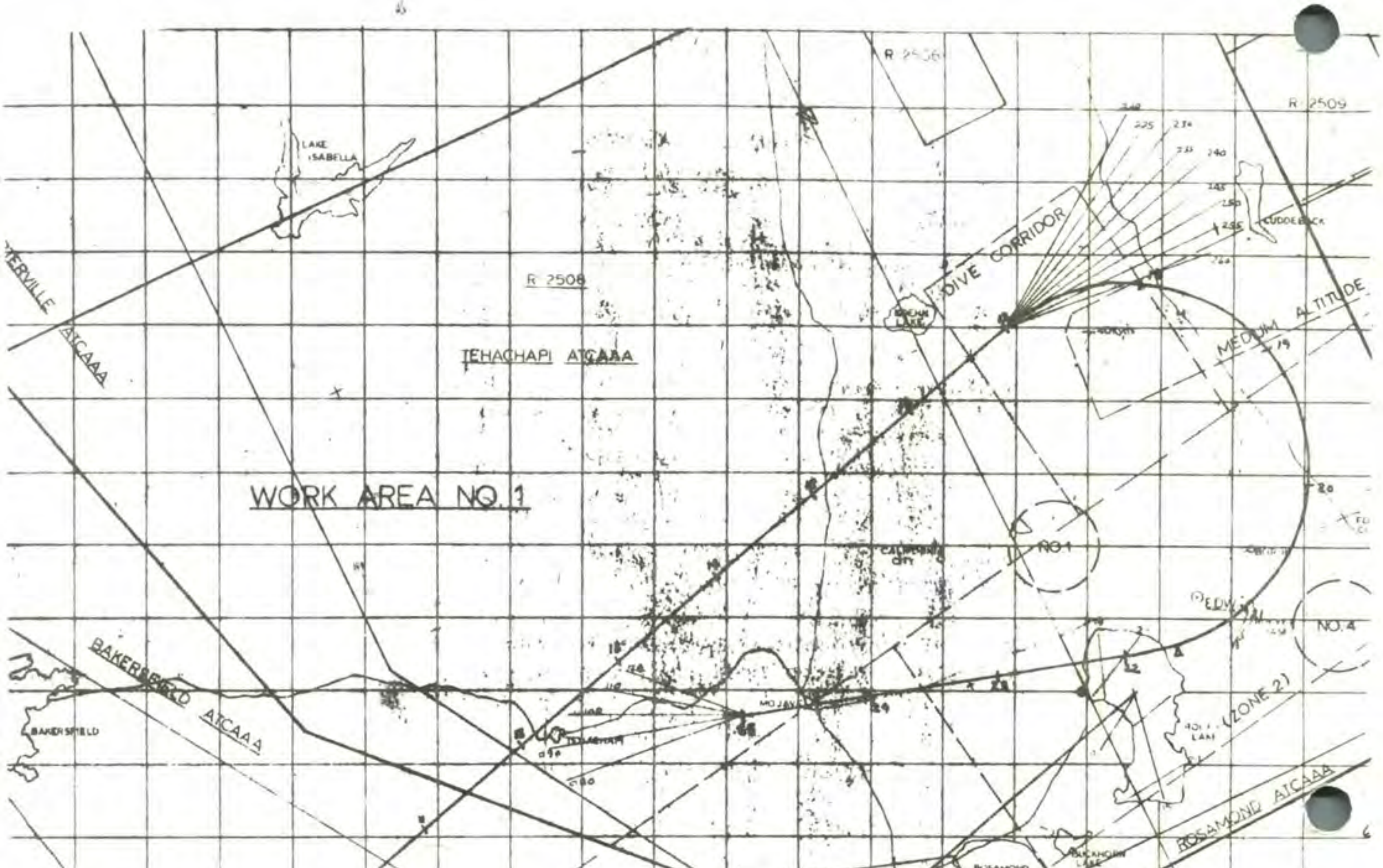
JACK L. KOLF



B-12-23
6 June 2?
KCAS
MACH
A_x
Lower Flap
deg
β
deg



WORK AREA NO 1
2508
AAA
EDW
ROGERS LAKE
BOMB RANGE
MOJAVE
112 SHUTDOWN
FLT 13-12-23
PREMATURE SHUTDOWN
○ — SEC RW 02 ROSAMOND
— SEC RW 20 ROSAMOND
— SEC RW 36 ROGERS
— SEC RW 18 RHP
— SEC RW 18 LHP
ENGINE MASTER, PROP SUPPLY OFF
JETTISON
STOP JETTISON, TANKS & BLEED OFF
SAS 4, 3, 2
STBY TO CLOSE UP
1 & 3 HYD PUMPS ON
ROCKET, CHAMBER SWS OFF
MACH REF TO 3
18 LHP
18 RHP
36
20
02



R 2506
R 2509
LAKE ISABELLA
DIVE CORRIDOR
CUDDLEBACK
MEDIUM ALTITUDE
R 2508
TEHACHAPI ATCAAA
WORK AREA NO. 1
CALIFORNIA CITY
NO. 1
EDW
NO. 4
BAKERSFIELD ATCAAA
BAKERSFIELD
MOJAVE
TEHACHAPI
(ZONE 2)
ROSAMOND ATCAAA
ROSAMOND LAKE
ROSAMOND
LANCASTER
PMD
PALMDALE
GMN
GORMAN
LHS
(ZONE 1)
NEWHALL
B-12-23

X-24B EVENT SHEET FLT B-12-23

TIME	MACH	ALT	α	KCAS	EVENTS
11:45:15.9					ENGINE MASTER ON
11:45:21.6					GOX PRIME
11:45:23.4					LOX PRIME
:45:46.4					CENTER FIN CAMERA ON
11:46:00.4	.704	44725.	3.5	189.	LAUNCH
:46:02.7	.687	44586.	9.5	185.	#1 & #3 CHAMBER PRESSURES START UP
:46:04.4	.687	44586.	11.6	184.	A_x STARTS INCREASE
:46:05.6	.692	44477.	11.9	186.	#1 AT 100%
:46:05.9	.694	44455.	11.8	187.	#3 AT 100%
:46:06.0	.695	44445.	11.8	187.	A_x LEVEL (2 CHAMBERS)
:46:06.5	.699	44391.	12.0	189.	#2 & #4 CHAMBER PRESSURES START UP
:46:06.9	.701	44347.	12.4	189.	WALC MANIFOLD PRESSURE
:46:07.7	.704	44260.	12.9	191.	A_x STARTS INCREASE
:46:07.7	.704	44260.	12.9	191.	LH FIN PRESSURE GLITCH
:46:09.4	.722	44045.	14.1	197.	#4 AT 100%
:46:09.7	.726	44002.	14.1	198.	A_x LEVEL (4 CHAMBERS)
:46:10.0	.730	43959.	14.3	200.	#2 AT 100%
:46:10.0	.730	43959.	14.3	200.	15° α
:46:30.2	.854	42835.	15.0	244.	MAX MACH DURING ROTATION
:46:34.4	.846	43444.	14.1	239.	OVERDRIVE ON
:46:34.4	.846	43444.	14.1	239.	A_x STARTS INCREASE FROM .47g

FLT. B-12-23 CONT

TIME	MACH	ALT	α	KCAS	EVENTS
11:46:35.0	.847	43555.	14.5	238.	A_X LEVEL AT .56g (4 CHAMBERS, OVERDRIVE)
:46:43.7	.821	45737.	15.4	219.	θ = 37°
11:47:15.0	.848	57020.	12.1	174.	PUSHOVER TO 10° α
:47:15.0	.848	57020.	12.1	174.	A_X MAX, .72g
:47:17.0	.851	57722.	10.2	172.	10° α
:47:33.0	1.016	62696.	9.8	189.	START MACH JUMP
:47:34.5	1.025	63052.	10.0	189.	END MACH JUMP
:47:36.5	1.050	63634.	9.4	192.	PUSHOVER TO 7° α
:47:37.3	1.055	63813.	8.8	193.	OVERDRIVE OFF
:47:40.0	1.080	64337.	6.7	196.	7° α
:47:46.1	1.166	65244.	5.9	211.	RUDDER DOUBLET, α = 6°
:47:49.1	1.207	65389.	6.5	219.	AILERON DOUBLET, α = 6½°
:47:50.6	1.227	65422.	5.8	223.	ENGINE SHUT DOWN
:47:50.8	1.228	65422.	5.5	223.	MAX MACH (703.96 KTAS)
:47:52.2	1.211	65400.	5.9	220.	RUDDER DOUBLET, α = 6°
:47:53.9	1.197	65512.	6.7	216.	MAX ALTITUDE
:47:55.9	1.169	65232.	6.9	211.	AILERON DOUBLET, α = 7°
:47:59.5	1.193	64719.	7.1	219.	PUSHOVER TO 5° α
11:48:04.8	1.086	63624.	4.6	200.	5° α
:48:05.4	1.087	63423.	4.4	200.	RUDDER DOUBLET
:48:08.1	1.068	62630.	4.7	201.	AILERON DOUBLET
:48:09.5	1.065	62094.	5.5	203.	PULLUP TO 10° α
:48:10.0	1.067	61904.	7.1	204.	PITCH GAIN TO 4
:48:12.0	1.058	61156.	10.2	206.	10° α
:48:15.6	1.040	59577.	10.1	209.	PITCH PULSE, α = 10½°
:48:18.0	1.027	58407.	10.5	212.	PITCH PULSE, α = 10½°
:48:20.1	1.031	57380.	10.8	218.	PULLUP TO 12° α

FLT. 8-12-23

TIME	MACH	ALT	α	KCAS	EVENTS
11:43:20.8	1.029	57060.	12.2	219.	12° α
:48:21.3	1.025	56581.	12.1	220.	START MACH JUMP
:48:24.2	1.015	55420.	11.7	224.	END MACH JUMP
:48:28.7	.984	53419.	12.0	226.	START LEFT HEADING CORRECTION (MAX φ = 16°)
:48:39.6	.906	48728.	11.8	228.	φ = 16°
:48:46.9	.867	46185.	10.2	230.	LH FIN PRESSURE GLITCH
:48:47.1	.864	46123.	10.3	230.	LH FIN PRESSURE GLITCH
:48:47.4	.859	46022.	10.4	229.	END LEFT HEADING CORRECTION
:48:52.9	.818	44367.	10.4	225.	YAW DAMPER TO ZERO GAIN
:48:56.5	.803	43362.	11.2	225.	PUSHOVER TO 8° α
11:49:00.0	.778	42399.	7.6	223.	8° α
:49:04.1	.775	41255.	7.4	227.	RUDDER DOUBLET, α = 7½°
:49:10.0	.764	39441.	7.7	233.	START PULLUP TO 13° α
:49:10.3	.762	39352.	7.9	233.	AILERON DOUBLET, α VARIABLE
:49:11.9	.751	38839.	12.5	232.	13° α
:49:13.5	.739	38360.	13.5	231.	START LEFT HEADING CORRECTION (MAX θ = 15°)
:49:15.4	.725	37846.	14.4	229.	START WALC JETTISON
:49:16.3	.717	37611.	12.4	277.	START LOX JETTISON
:49:20.7	.692	36607.	11.7	224.	θ = 15°
:49:21.3	.686	36994.	11.4	222.	END WALC JETTISON
:49:22.9	.672	36202.	12.7	219.	LH FIN PRESSURE GLITCH
:49:23.6	.669	36079.	12.9	219.	END LOX JETTISON
:49:31.5	.612	35021.	12.6	203.	YAW DAMPER GAIN TO 3
:49:37.3	.564	34452.	9.7	189.	END LEFT HEADING CORRECTION
:49:42.2	.558	33898.	10.8	189.	UPPER FLAPS START IN FROM 40°
:49:46.0	.552	33377.	10.1	189.	UPPER FLAPS AT 29°
:49:51.5	.553	32550.	10.8	193.	START TURN TO DOWN WIND (MAX θ = 32°)

FLT B-12-23 CON'T

TIME	MACH	ALT	α	KCAS	EVENTS
11:49:57.5	.553	32385.	10.6	194.	START AILERON BIAS POPU, $\delta A_B = 7^\circ$ ($\delta u = 21^\circ$, $\delta L = 26^\circ$, $\delta R = -10^\circ$, $\alpha = 10\frac{1}{2}^\circ$)
:49:59.4	.564	31209.	6.2	204.	$\delta A_B = 10^\circ$, $\alpha = 6^\circ$
11:50:02.2	.579	30586.	7.9	212.	$\theta = 32^\circ$
:50:08.6	.605	28990.	12.6	230.	$\delta A_B = 5^\circ$, $\alpha = 12\frac{1}{2}^\circ$
:50:11.9	.596	28295.	10.5	230.	END AILERON BIAS POPU $\delta A_B = 7^\circ$, $\alpha = 10\frac{1}{2}^\circ$
:50:18.5	.588	27028.	6.4	233.	END TURN TO DOWNWIND
:50:22.8	.577	26167.	7.6	233.	UPPER FLAPS START IN FROM 29°
:50:26.0	.579	25552.	9.1	237.	UPPER FLAPS AT 20°
:50:34.4	.572	24066.	8.5	241.	ROLL GAIN TO 3
:50:35.2	.572	23945.	8.3	242.	YAW GAIN TO 2
:50:47.1	.572	23957.	8.3	242.	START LANDING ROCKET CHECK
:50:48.5	.560	21887.	5.8	247.	END LANDING ROCKET CHECK
:50:49.0	.560	21810.	6.0	247.	#3 HYDRAULIC PUMP ON
:50:49.4	.561	21744.	6.0	248.	#1 HYDRAULIC PUMP ON
:50:52.7	.565	21164.	6.0	253.	LOW KEY, START TURN (MAX θ 75°)
11:51:13.7	.582	16670.	7.6	285.	UPPER FLAPS START OUT FROM 20°
:51:18.6	.568	15566.	6.0	284.	UPPER FLAPS AT 31° (SPEED BRAKES)
:51:31.9	.524	12332.	7.1	278.	UPPER FLAPS START FROM 31°
:51:41.9	.527	9908.	7.1	293.	UPPER FLAPS AT 20°
:51:56.3	.509	6916.	5.1	298.	LEVEL ON FINAL
11:52:17.5	.475	3600.	5.4	295.	START FLARE
:52:37.5	.366	2303.	9.0	232.	GEAR DOWN
:52:45.8	.298	2251.	10.7	189.	MAIN GEAR TOUCHDOWN, $\alpha = 10\frac{1}{2}^\circ$
:52:46.2	.298	2251.	8.4	189.	CROSSOVER TO UPPER FLAP
:52:47.7	.282	2241.	1.9	179.	NOSE GEAR TOUCHDOWN
:52:48.7	.269	2244.	-3.4	171.	CROSSOVER TO LOWER FLAP

X-24B DERIVATIVES

Alex G. Sim

On flight 12, four sets of lateral-directional and one set of longitudinal derivatives were obtained.

Of particular interest were three of the lateral-directional sets which were obtained at Mach numbers between 1.07 and 1.17 with an angle of attack range between 5.2° and 6.7°. These three sets tend to further identify the lateral-directional characteristics in the low angle of attack---low supersonic flight regime and thus approach the time when flights can be routinely conducted in this area. These data are shown in figure 1.

The other lateral-directional set of derivatives was obtained near a Mach number of 0.8 with an angle of attack of 7.7°. These data fill a gap in the previously obtained results.

The one longitudinal set of derivatives was obtained at a Mach number of 1.03 and an angle of attack of 9.7°. It was the first supersonic longitudinal data obtained and is shown in figure 2. Of significance are the good level of longitudinal stability, control effectiveness and damping.

FIGURE 1,

X-24B DERIVATIVES

$\delta_{U_B} = -40°$, $\delta_{r_B} = 0°$, cg = .65 $\bar{c}$

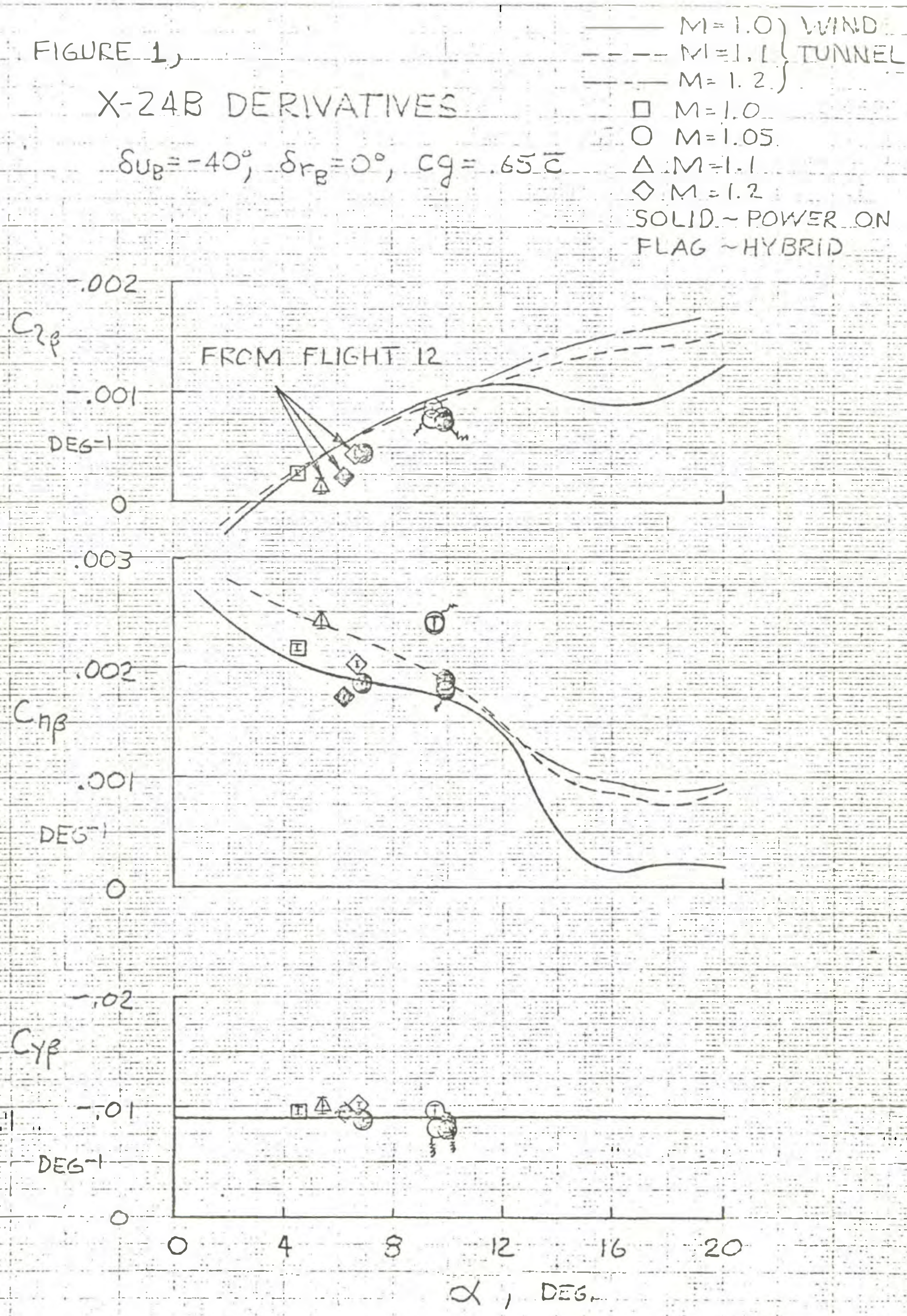


FIGURE 1, CONT.

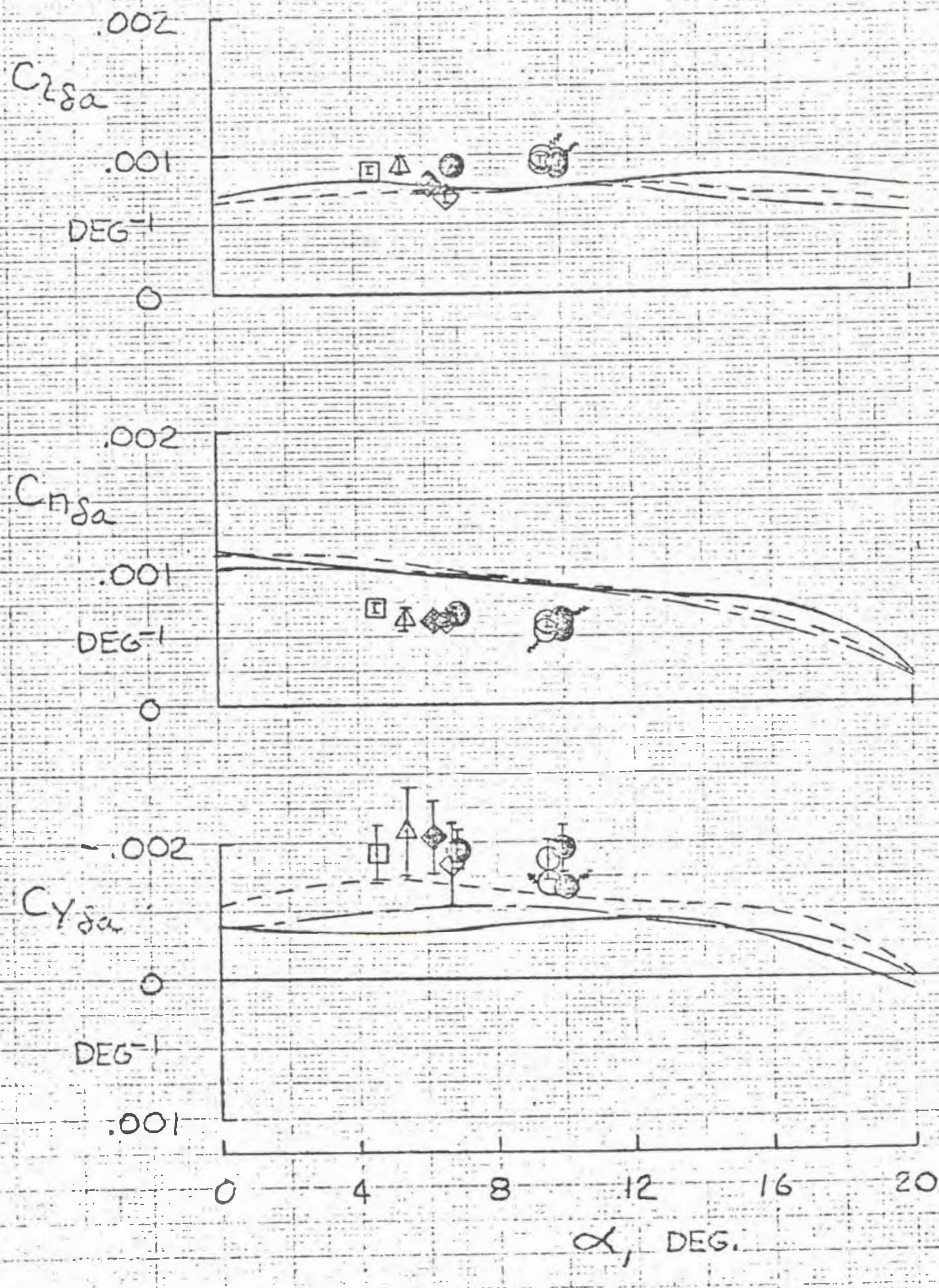


FIGURE 1, CONT.

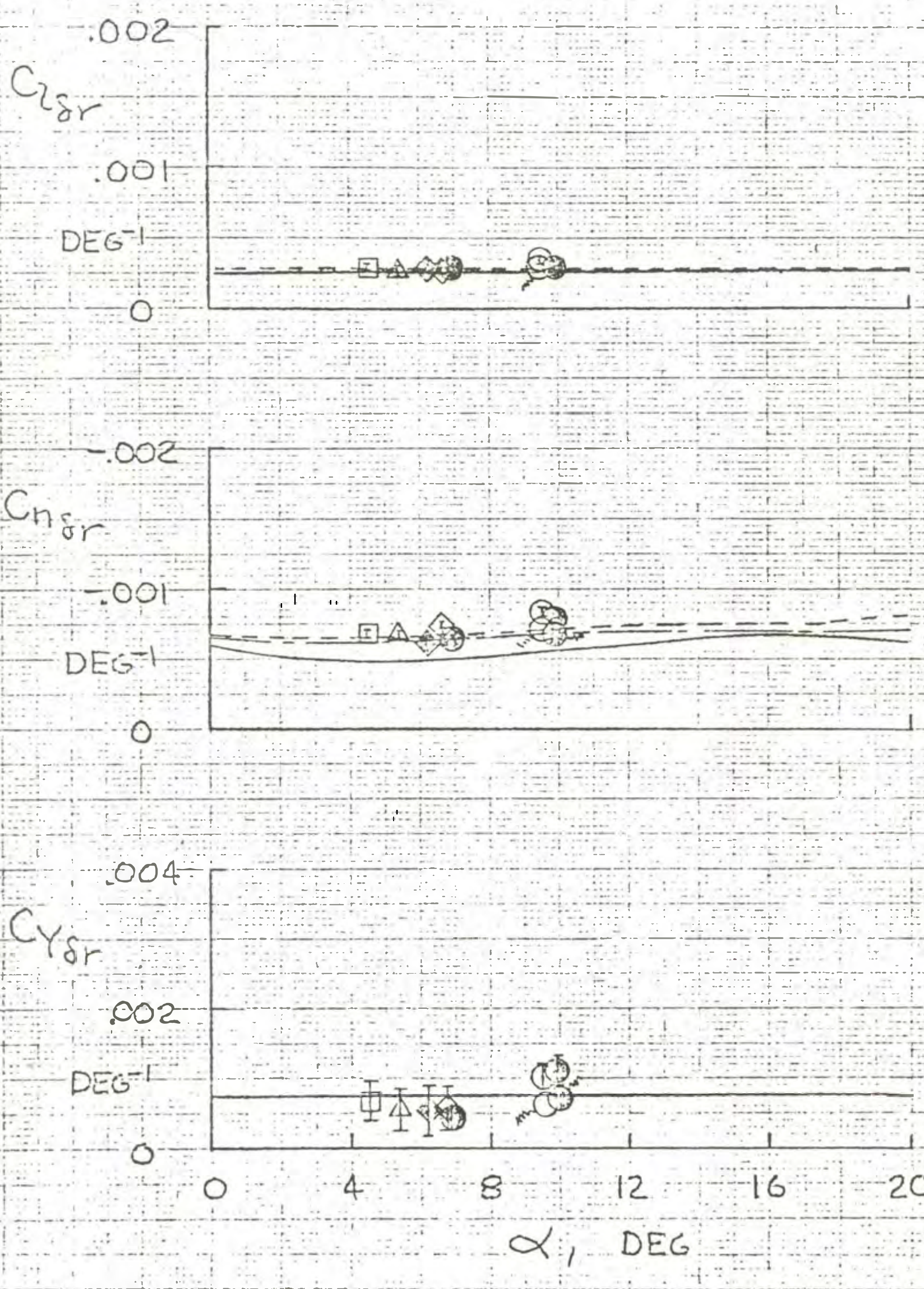


FIGURE 1, CONCLUDED

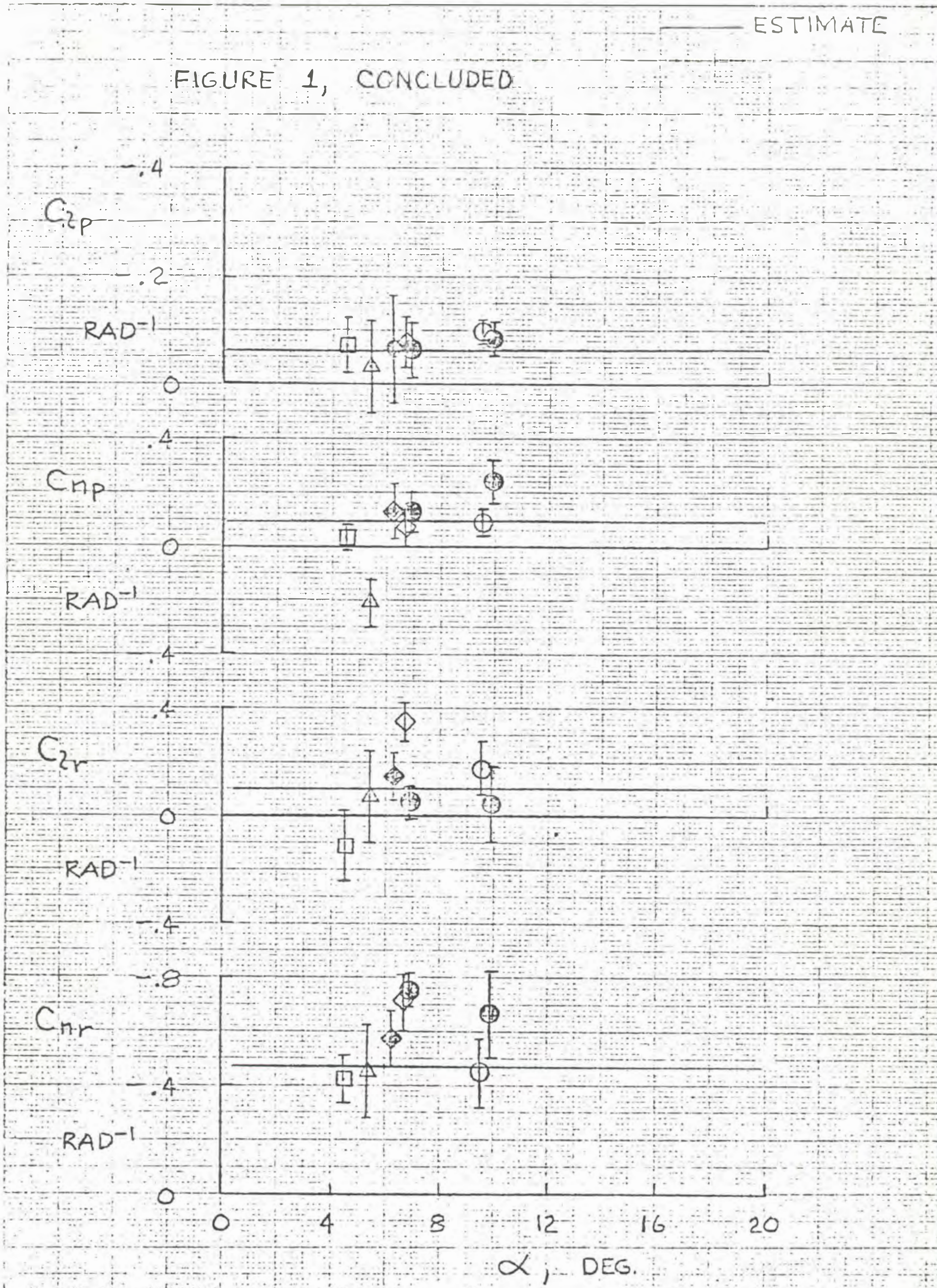
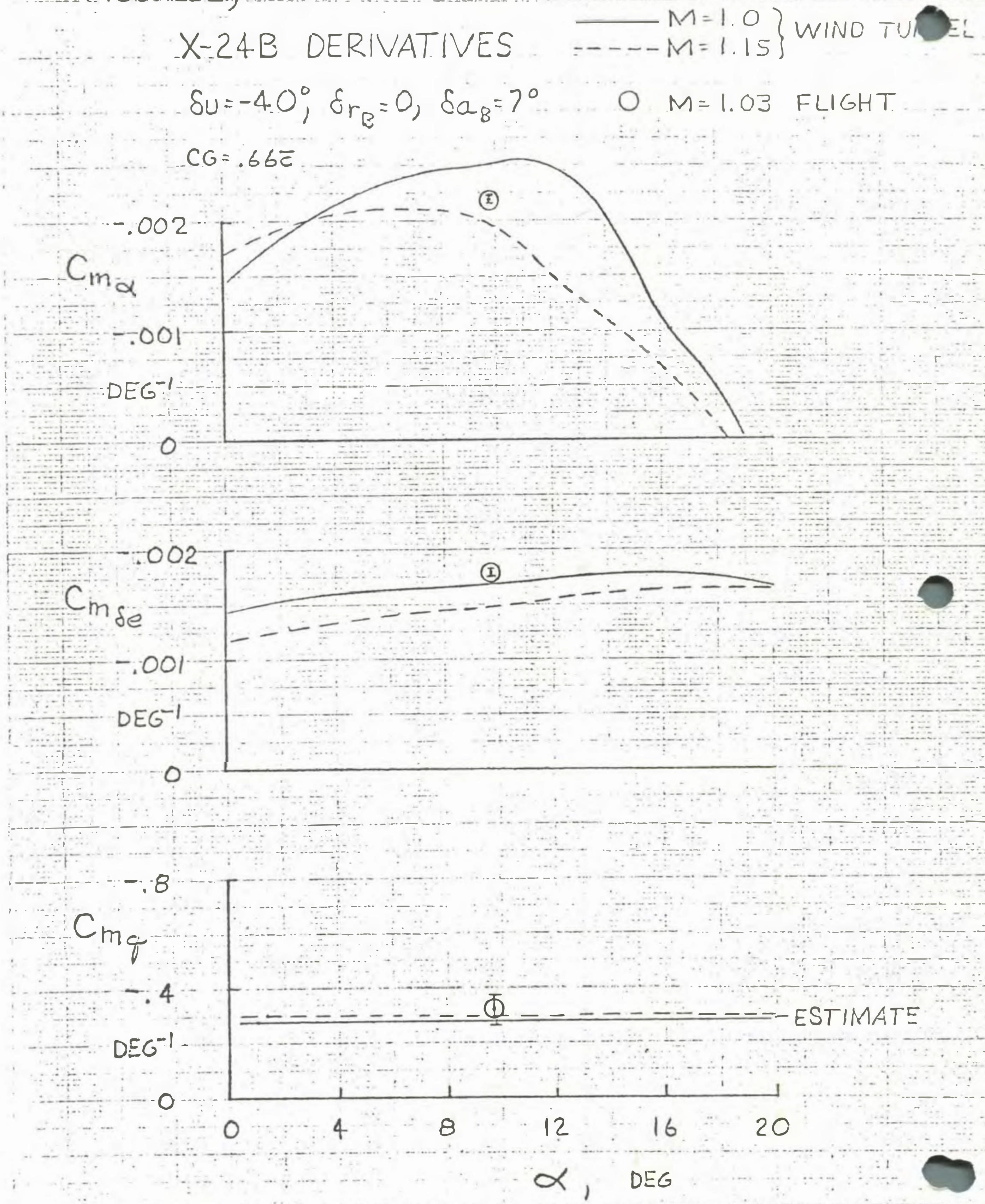


FIGURE 2,

X-24B DERIVATIVES

$\delta_U = -40°$, $\delta_{r_B} = 0$, $\delta_{a_B} = 7°$



FLT. B-12-23

HANDLING QUALITIES SUMMARY

HQ DURING ROTATION	PITCH	3
	LATDR	3
TASK TO MAINTAIN 37° θ DURING BOOST		3
HQ FROM .85 TO 1.05M (PWR ON)	PITCH	2
	LATERAL	2
	DIRECTIONAL	3
HQ ABOVE 1.0M (PWR ON)	PITCH	2
	LATDR	2
HQ AT 7° α, 1.2M (PWR OFF)		3
HQ AT 5° α, 1.1M (PWR OFF)		2
HQ DURING DECEL FROM 1.0 TO .85M (HEADING CHANGE)		3
HQ WITH YAW DAMPER AT ZERO GAIN		2*

*NO LATERAL-DIRECTIONAL TASK PERFORMED

Technical Debriefing for X-24B

Flight B-12-23

14 June 1974

Pilot: Major Love

1. Discuss the engine light sequence and any associated trim changes.

Answer:

I've been thinking about trim changes after launch in relation to the simulator. I find that when you trim the simulator up and launch, that it hesitates when coming up to 10^o -- in fact you almost feel like you need to pull it up to 10^o. I find that, at least in time period between hitting the launch switch and hitting 1 and 3 chambers switches in the A/P, the A/P is already at 10 or 11^o alpha. It comes up and flies itself without any effort on the pilots part so that the engine light sequence can be done without really paying any attention to α. I think I got probably two or three calls to watch my α today, it seemed like that, and each time I'd look up it would be okay, the airplane was just doing it itself. The light sequence was normal with 1 and 3 on, 2 and 4 with # 2 coming a little late and no pitch trim changes as the chambers come on line.

2. Discuss the handling qualities during the rotation. Rate pitch, and lateral directional.

Answer:

I'll discuss this again in relation to the simulator. In the simulator I said that the pitch task is an easy task-to come up to 15^o and to trim to 15^o. I'd rate the A/P as being as easy except that the response of the α needle is different than in simulator plus the outside cues you get from the rotation make me tend to rotate a little more shallow than I do in the simulator and I find it more difficult to trim exactly to the aim α. However, I still feel that this has nothing to do with the A/P, per se, and its handling qualities, I think it's just something I have to overcome with more experience in doing that maneuver. I'd rate pitch in the A/P a 3 and lateral-directional the same and I would rate the simulator as being worse than the A/P because with the 1^o of needle left beta in the A/P it flies pretty much with no requirement for lateral stick trim.

3. (a) Discuss the task to maintain 37^o θ and rate.

Answer:

I've been thinking about this again and I've said the simulator was easier to hold 15 α than it was 37θ and I felt that one of the reasons was the difference in the scaling of the two indicators. One degree change in α is a bigger increment on that indicator than it is on the θ bug indicator so in the simulator I always found that holding alpha was easier than holding θ. In the A/P today I got just the opposite impression although I did drop down to 36^o probably more than I wanted to, I did find that holding 37^o θ was an easy task and I'd rate it as a 3 also. Now when you rate something as a 3 you say it has some mildly unpleasant deficiencies and I go back saying that you have to gain some experience at doing that rotation and climbing on that angle and I would say thats whats bugging me, It's just simply the feeling of climbing there and perhaps after some more experience I'll have a better rating.

3. (b) How did α to maintain θ compare with the simulator?

Answer:

It was low at about the time John asked me to check my α I would have had at least 13 in the simulator, this was around 60 seconds engine burn, I had 11 in the A/P or there abouts not over 11 $1/2^{\circ}$.

4. Discuss the handling qualities above .85 Mach number with power on. Rate.

Answer:

My pitch task above .85 Mach number was to hold 10° α, initially. I guess its best to discuss this between .85 to .95... or until 1.05 let's say - discuss the period of 10° α. The pitch task was easier than the simulator. The pitch trim change in the transonic area was not as marked in the A/P, to me, as it was in the simulator. I'd rate pitch at a 2. The lateral roll task at the same time was easier than the simulator. In the simulator as you rotate to 15°, and the indicated airspeed goes down, you find yourself trimming more and more to the right with the associated unnatural feeling of the stick moving to the right and the aileron position staying the same because of the SAS washout and the way that the simulator is mechanized. In the A/P I didn't have to trim to the right at 15°. In the simulator as you go from 15° to 10°, in this area we're talking about, then you start having to take some of that right trim out, so in preparing for this flight the biggest thing I had to learn how to do was to push to an aim α and then trim out the roll off in the simulator that wasn't apparent in the A/P. I'd rate the lateral axis as a 2 because it didn't take any effort to hold wings level. The directional axis at .85 was sitting there at 1° left beta - somewhere around .9 to .95 I could feel airframe vibration similar to going .9 Mack in a F-4 - it's not a buffet and it's not a buzzing, its just that the thing is vibrating and the slideslip is moving from 1° left out to at least two and then moving back in by about somewhere/above .95 indicated - somewhere around the Mach jump. However,the A/P wasn't doing anything as far as the task, you're just sitting there and flying straight ahead. I'd still have to rate it as pretty good - at a 3 lateral-directionally, even though beta goes out.

5. (a) Discuss the handling qualities above 1.0 Mach number with power on. Rate.

Answer:

As I moved from 10° α to 7° at 1.05, I turned the overdrive off. First of all I didn't notice any change in the A/P with the overdrive going on. I found that I could go right to 7° and that I didn't have near the pitch trim task to maintain 7° that I do in the simulator and the total task, which was the hardest task in the simulator, of trimming out the lateral... or trimming up the lateral axis, was non-existent. So pitch and lateral axis, in trimming to 7 α and preparing for those doublets, I'd rate as a

2. Directional axis - I'd have to rate the same because nothing was occurring at that time and I found that beta was right back in there at 1^o or less to the left, maybe it was 0^o, I don't remember. So I'd just rate right across the board at 7 α with power on a 2.

5. (b) Compare the vehicle's response to the Mach 1.20 doublets (power on) at 7^o α with the simulator.

Answer:

I felt that the control effectiveness was the same. I felt the beta needle moved about the same and I don't think that there's a whole lot of rudder effectiveness in that area. It would be kind of interesting to see what would be left at Mach 2.

6. (a) Discuss the performance aspects of the boost.

Answer:

As far as I was concerned all I knew was that it was going up and I had low angle of attack and that as John said, we'd probably climb a little faster. I wasn't too much aware that I had shutdown at 1.06 vs 1.12, so I really didn't know much about it. From inside the airplane it didn't look like that much different - it looks a lot different on the map.

6. (b) Discuss the trim changes at engine shutdown.

Answer:

I felt no pitch trim, roll or yaw trim changes. The biggest thing that I noted was the deceleration in the X-axis. In fact, the simulator shows about a 1^o of α trim change. Now I don't think I saw that in the A/P. My technique in the simulator had been to trim to 7^o with power on for the rudder doublet and by the trim I'd done that the α will be at six- I'd trim back to 7^o, do the aileron doublet, by the time I'd done that and hit the engine master switch it would be back at six. As soon as the engine master switch was off, the simulator goes from 6^o to 7^o or about a 1^o rise - the A/P didn't do that.

6. (c) If not previously covered, discuss the roll task during the boost with respect to two hands, roll trim, resulting sideslip, compare to simulator.

Answer:

Was covered previously.

7. Compare the vehicle's response to the doublets at 7^o α (M_t=1.2) after engine shutdown with the "power on" doublets. Compare to simulator and rate the handling qualities if possible.

Answer:

I think the vehicle's response before and after at 1.20 was the same and, as far as I'm concerned, it looked like the simulator. I will have to admit that things are moving pretty fast at that time and its just a little hazy for me, but nothing hit me as being "now thats really different" and so it must have looked pretty much the same. I rate the handling qualities at a 3 and thats because I'm having a little trouble being real confident that I was inside my plus or minus a half degree of α at 7 α pitch pulse particularly. After I see the data and its right on 7 I'd feel a little more confident, but things were moving so fast at that time... the thing that was bothering me was that I couldn't put it right on there - I know the α gauge is moving around a bit.

8. Discuss the doublets at 5^{o} α (M_t=1.1) after engine shutdown. If possible rate the handling qualities.

Answer:

Initially had trouble trimming to 5^{o} α whereas comparing this to the simulator, probably the easiest task in the simulator the whole flight is trimming to 5^{o} α. I don't know exactly why, but finally when I did get the nose down far enough I was able to hit a good solid 5, get rudder and aileron doublets that looked very much like the simulator and then come back up and get the 10 α pitch pulse. I would rate the handling qualities there as the same its very nice A/P and a 2..., couldn't complain about a thing.

9. Discuss the pitch pulses at 1.05 Mach number at 10^{o} α with respect to the vehicle response to pulse as compared to simulator.

Answer:

First I'd like to talk about trimming to 10 α. The simulator is easy to trim to 10α and so was the A/P. It's very nice to be able to trim up and hit an α the way the A/P will do it. The pitch pulses I tried to make the same as the simulator except near the second one I was a little more vigorous with it and I got probably a degree more on the first one and two degrees more response on the second one. I'd say the second one I got almost a 5^{o} α change, but the movement of the needle and the recovery to 10 was like the simulator. I did not have to pull the nose back up to 10 α. So changing to four on the pitch gain seemed to work very well.

10. Discuss the flying qualities while decelerating from Mach 1.0 to .85 at 12^{o} α.

Answer:

After the pitch pulse I went to 12 α and I still had about 1.1. I was able to tell John I think that I had 1.08 and it didn't seem to decelerate too fast. I got the Mach jump - about that time John asked me for a heading change. I made the heading change after really noting that beta wasn't doing a thing - it was sitting there at 1^{o} left, it was very dull in comparison to what it was suppose to be, so I just turned left - it was easy to turn left,beta didn't move around and there's not much to say about it. It was a very relaxed time. I got the yaw damper off at .85 and trimed over to 8 α and got the 8 α doublet set at .8. I'd rate it at a 3 - to make the 5^{o} heading change and the 3 is a result of possibly not quite the roll response I'd like in moving it over. Maybe that's because the dampers were still up high.

11. Discuss the doublet set at .8 Mach number at 8^{o} α. Compare to the simulator.

Answer:

This was the second easiest thing to do on the simulator - second to the 5^{o} α doublets. It takes just a little bit of timing to go from 12^{o} to 10^{o} to 8^{o} and have it at .8 but it was easy to do on the simulator and I felt that it was just as easy in the A/P - that's the pitch task of hitting 8^{o} α at .8 Mach. In the simulator I was giving good healthy rudder doublets to it and I was getting about 3^{o} of beta change and at least four or five overshoots then I would wait and do the aileron doublet. I either put in a lot more rudder or the rudder is more effective because I pegged beta indications in the cockpit on both sides and it didn't whip back and forth at the same frequency as the simulator - it was slower. The aileron doublet did show some response, got a little roll with the aileron doublet, I thought, and I could see some yaw and I felt that I saw more response from the aileron doublet than you get in the simulator, but part of that possibly comes from the fact that the A/P is a moving base whereas the simulator just sits there.
(Was the large beta oscillation an uncomfortable maneuver?)
The A/P wasn't uncomfortable there because I trust the A/P there - I did get some side forces that I could feel in the cockpit but it wasn't uncomfortable.

12. Discuss handling qualities with the Yaw damper at "zero gain". Rate.

Answer:

This is not going to be possible, I don't think, because at that time I got too busy going 'Prop Supply-off, Jettison' and trimming to 13 α to take care of being a little low on profile. I'd hoped to do a couple of aileron back and forth movements and watch how much beta movement I got and I just didn't get it done. I didn't do a directional task during that time and from what I did do, just flying the A/P going 'Prop Supply and Jettison', it was no problem and I'd have to rate it a two without really doing a directional task.

13. Comment on the pushover-pullup maneuver using the aileron bias.

Answer:

That's a very easy thing to do. I got 'Stop Jettison, Tanks in Bleed' and trimmed to 11^{o} with a close up from 30 and, incidentally, that close up looked just like the simulator-little bit of fight as α drops down and then trim it back to 11^{o}. Right at the intersection I just pushed on the stick very mechanically to maintain some bank and moved the switch and the A/P goes right over to the same α as the simulator, somewhere along 5^{o}, and right back up to 13^{o}. One of the things I would say happened as it went to five is that it seemed to roll out a little bit of bank for some reason. Anyway, thats the only thing that seemed a little different in the A/P then I saw in the simulator - it rolled out to about 15^{o} of bank down at 5^{o} α and then I put some more pressure on for bank and went up to 13^{o} α. In the simulator you can see that as the α goes up it starts to turn the A/P, but it doesn't change the bank the way bank changed for me today and I don't know whether it was the A/P or just not putting enough pressure on the stick to hold the bank. Other than that minor point it looked just like the simulator.

14. Discuss the energy management from the "Intersection to low key".

Answer:

I think we were back up on profile at the end of the PO-PU. I think that there is something we should look at here. From my experience in practicing for this flight, I'm not sure the simulator would have flown back up to profile the way the A/P did and have the same amount of airspeed. As I was negotiating this portion of the profile I called to Dana that I had 240. I closed up and without increasing α a whole lot I still kept 240 and we came right up to profile. Now the simulator would come back to profile but it would bleed off airspeed to do it. What I'm trying to say is that you may see a difference in sumulator performance and A/P performance here with power off that might have some bearing on the difference with power on. We possibly should get at the same Mach number and altitudes and try to fly back to the profile the same way to match it and see if the simulator will do it. Other than that the energy management into low key was nominal.

15. Discuss the pattern.

Answer:

I closed up, held around 10° α and around 250 and then started a turn at low key - which makes it a pretty high energy pattern. I lowered the nose a little bit and started a turn coming around Petersen Lake - Bill called me at 290 and I confirmed 290 and I felt that rather than use all the airspeed for L/D control, I'd put out the boards which brought my airspeed down a little bit and allowed me to come out to where I felt would have been 9000 feet and 300 kts. The one thing that I noticed there as I was trying hard to get closed up so I didn't get my aim point back and my aim point remainded at the first dashed line on 18, was that the glide angle seemed shallow and, as I said before, I felt that this may have been from the wind.

16. Discuss the landing and roll out.

Answer:

The aim point stayed constant, at my best evaulation, on that first dotted line with a pretty standard initial flare to break the rate of descent then coming to about 100 feet with roughly 255 and waiting just to around 50 ft and 240 to get the gear. Again I felt a little bit of gear transient today and was just aware that, 'There's a gear transient, today', and a little pitch down and me pulling back to take over on in. Down to under 20 ft and I would say down to the area of 5 ft - I wasn't getting calls at the time - I got a little balloon, 2 - 3 ft and relaxed and back on to the ground. I wasn't aware of being in the cross over or aware of large stick movements to control the A/P I just felt like I hit a little gust with a lot of airspeed, 180 - 190 kts at the time, and thats a lot of airspeed in the A/P- you could pull it up considerably at the time. I relaxed and got a touch down - right main, left main. The nose did stay up as long as the last flight but I'd say it was longer than the other flights I'd seen and then down again to say 30% from full down to the ground and then it really gets with it for the last 2 to 3 feet - or 2 ft or whatever that distance is.

Roll out to me was a roll out done in a cross wind. I got 'Nosewheel Steering - arm', and engaged the nose gear steering well above a 100 kts because I'd been sitting there with right rudder in and looked at 110 and thought to myself "I won't brake because I don't want to skin the tires". I became aware that I was holding right aileron in - just a natural reaction to help steer the thing and I had to hold steering in - I'd feel almost half rudder deflection. It would be something to look at on the traces and see just how much rudder deflection I had in to stay on the runway. I landed as usual to the right of the dash line and drifted over on to the dash line and then made a concerted effort to stop that and got it back over to the right of the dash line out there, so I had some control task during the roll out today. Finally below about 60 kts or so I used a little brakes and below about 20 kts I just didn't pay any attention any more - It rolled out straight as I started cleaning up the cockpit and it rolled to a stop.

(Discuss the Aircraft vibration noted at .8 m and 13° α).

At .8 Mach following the 8 α doublet when I pulled up to 13° α, I was aware of an aircraft vibration that felt very similar to the vibration I felt at .92 to .95 Mach numbers. It triggered my awareness, I felt that there was something going on back at the rudders and I thought to myself,' well that's not buffet but thats something'. Something or some vibration in the A/P associated with airflow over it and as soon as I relaxed α, Mach bled off, and it went away - it didn't last very long. I did relax α during that time and I had been doing that in the simulator too so that the airspeed didn't go below 200 kts. In the close up I had .56 Mach so I had bled off the Mach pretty good during that time - it was during the initial pull-up, right after that doublet that I felt it.

Aft Body Tuft Analysis - Flight 12

BY

Captain John L. Stuart

The camera mounted atop the left vertical fin was aimed so as to photograph the tufts on the aft body of the vehicle. An unusual phenomenon was discovered during analysis of the Flight 12 film. It was noted that all the tufts except one acted as expected with no unusual patterns or changes in patterns. The most aft tuft, located on the forward crown hatch just forward of fuselage station 180 between pressure taps 235 and 184 (see figure 1), alternated between a very steady, almost motionless, condition and an extremely oscillatory condition. The transitions between steady and oscillatory conditions were virtually instantaneous.

The tuft was steady from launch, through engine light, and until the Mach number exceeded 0.83 during the rotation when the motion became oscillatory. As the rotation continued and the Mach number decreased through 0.82 the tuft became steady. Oscillation started again above 0.84 Mach and continued until shortly after engine shutdown when the ocillations stopped. None of the other tufts showed a corresponding change in motion.

It was postulated that this change in flow pattern can be attributed to the generation of a vortex or the formation of a local shock wave in this area. To facilitate further analysis of this phenomenon, it is suggested that additional tufts be added to the area aft of the tuft in question, and that the camera be realigned or the lens be changed to enable photography of this area. A detailed study of the surface pressures in this area is suggested when pressure survey configuration II is employed (tentatively scheduled for flight 15).

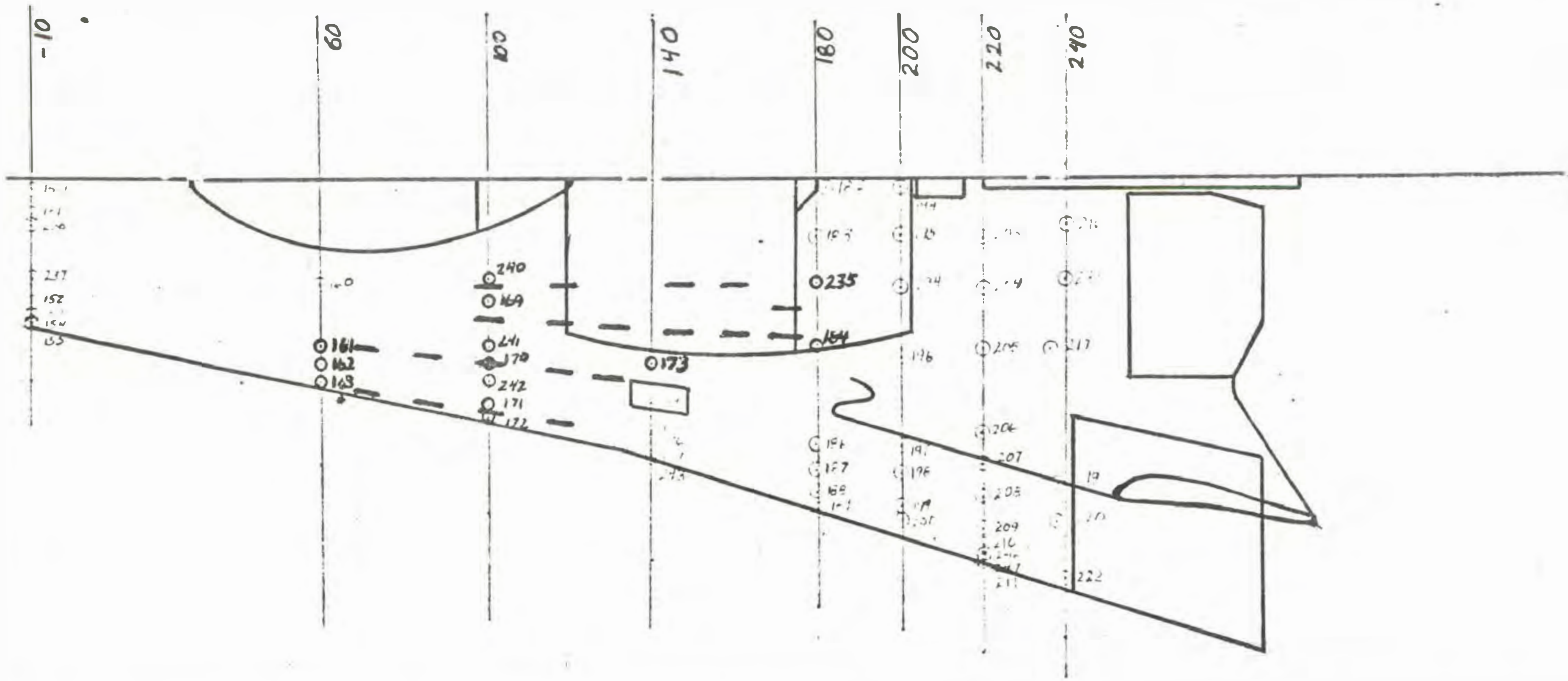


FIGURE 1. TUFT LOCATIONS
FLIGHTS 10 THRU 12

○ PRESSURE TAPS

X-24B PLANFORM

X-24B Aileron Deadband
By
Captain John L. Stuart

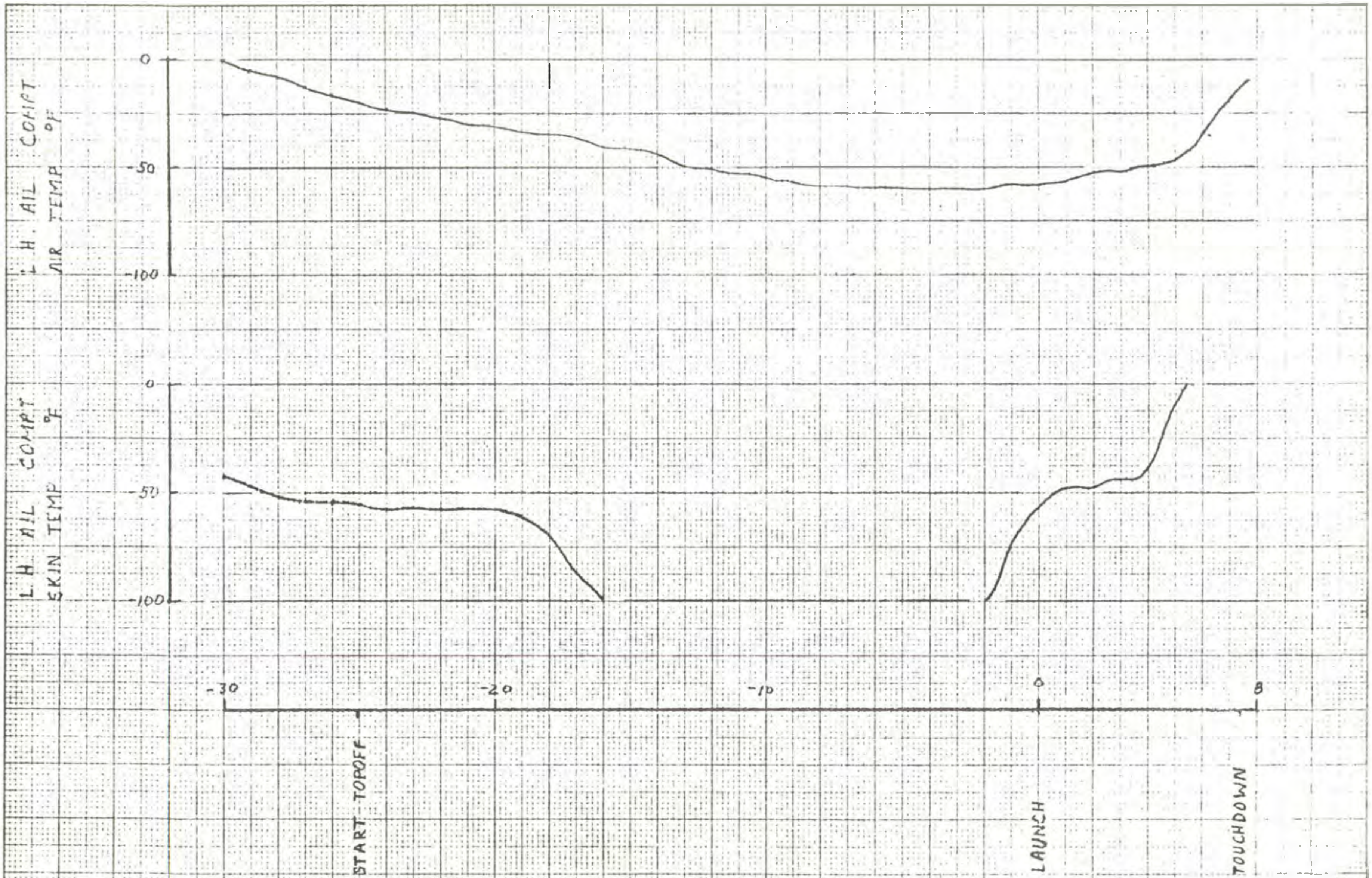
As noted in the Flight Report for Flight B-10-21, a significant loss of motion was detected in the left aileron, and it was thought to be temperature dependent and caused by liquid oxygen flowing from the LOX vent line during topoff. It was concluded that the relocation and insulation of the aileron actuator hydraulic lines and components prior to Flight 10 had reduced the losses to an acceptable level.

During Flight 11, the aileron control system insturmentation indicated that there was a substantial loss of motion between the Aileron Preload Spring and the Aileron Actuator Control Rod, but that there was no corresponding loss of motion of the aileron itself. This was thought to be virtually impossible, so another explanation was sought.

A comparison of the aileron compartment temperature time histories for Flights 10 and 11 showed that the compartment temperatures were significantly lower for a longer period of time during the prelaunch activities on Flight 11 than on Flight 10. It was proposed that the instrumentation itself was in error because the CPT's are only accurate above 50 degrees F. To inhibit cooling of the CPT's, a thin insulating block was placed between the CPT and the aileron compartment structure. Each CPT was also wrapped in an insulating blanket.

The LOX topoff procedure was modified to reduce the quantity of LOX which vents overboard. The rate of flow of liquid oxygen from the mothership during topoff was reduced; after it was confirmed that the LOX was flowing from the LOX vent line (via LOX vent temp measurement) topoff was suspended until approximately 8 minutes before launch. Figures 1 through 4 show the aileron compartment temperature time histories for Flights 10 through 13, respectively. It is evident that this procedure has produced significantly higher aileron compartment temperatures.

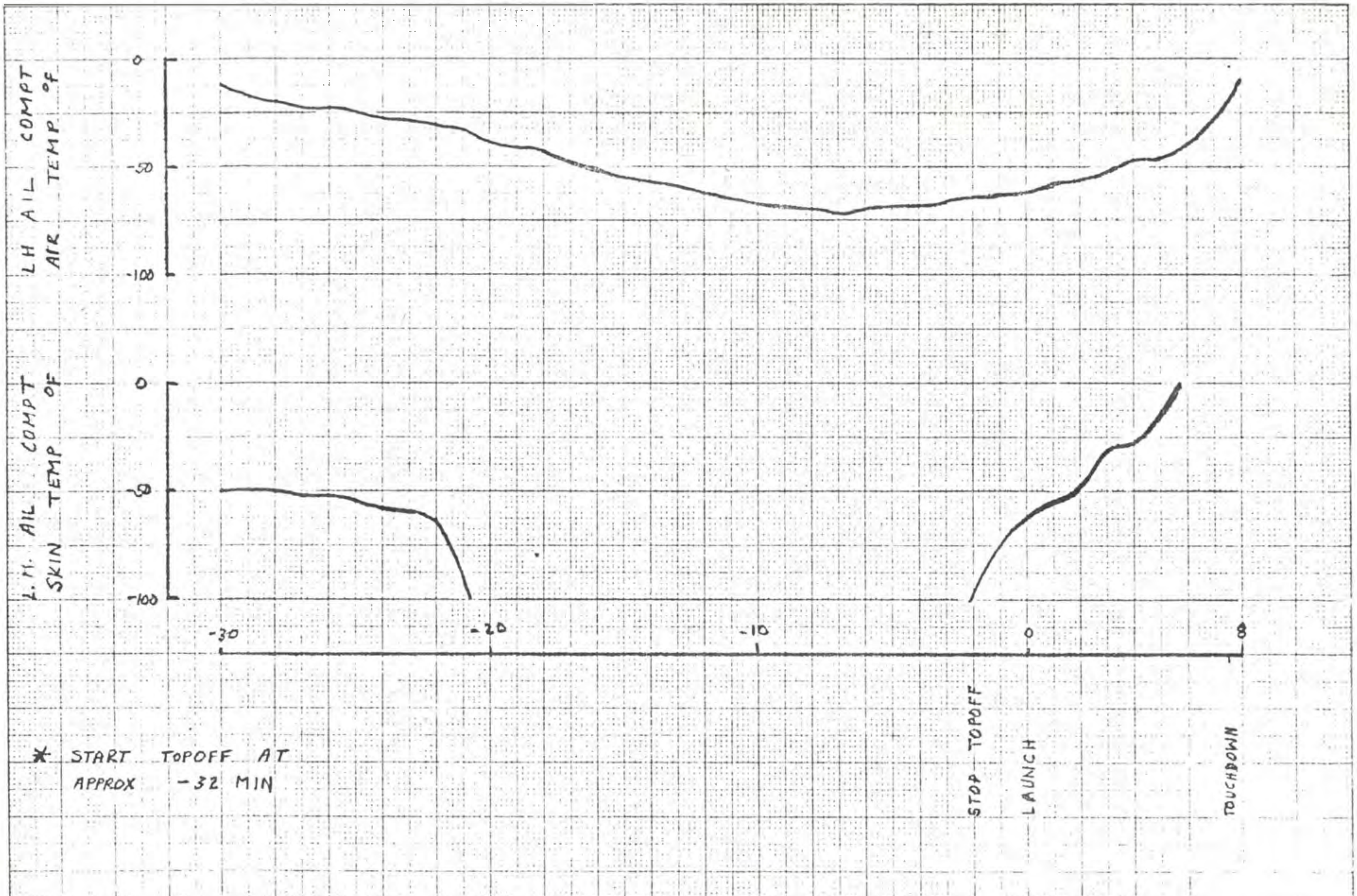
Telemetry data from Flights 12 and 13 indicates that the aileron deadband and the possible instrumentation errors have been eliminated.



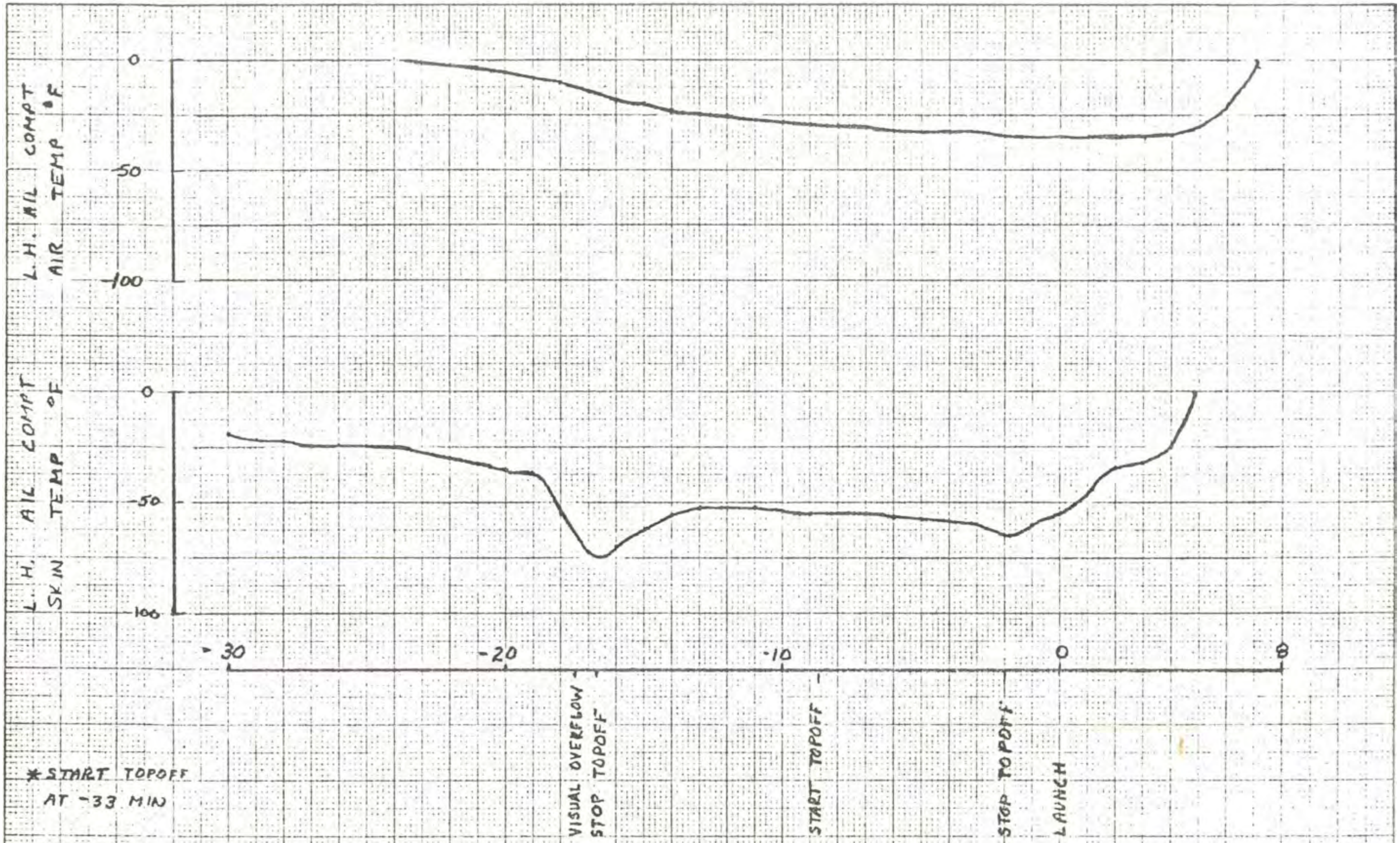
FLT 10

TEMPERATURE TIME HISTORY

FIGURE 1.



FLT 11
TEMPERATURE TIME HISTORY
FIGURE 2

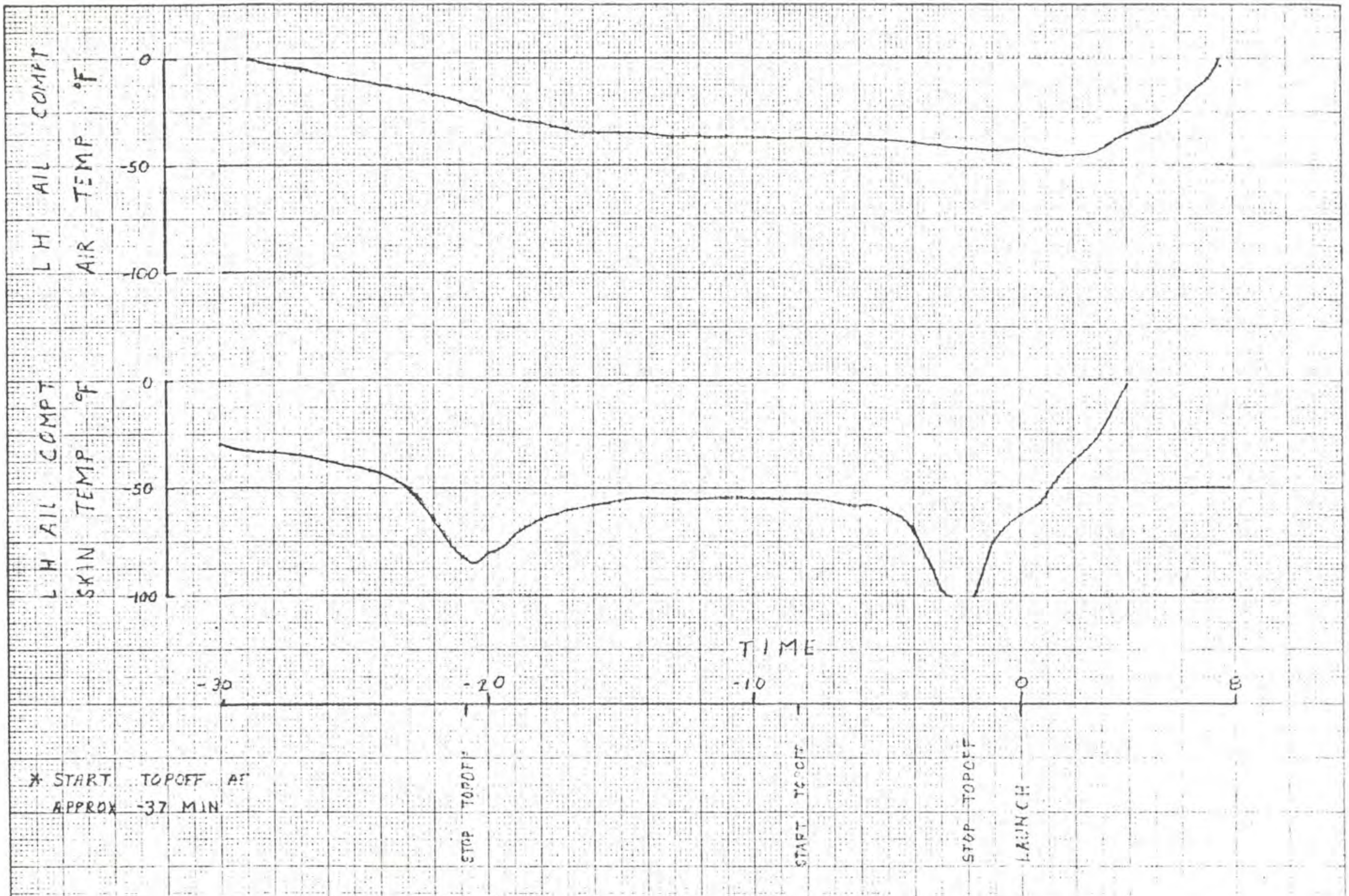


FLT 12

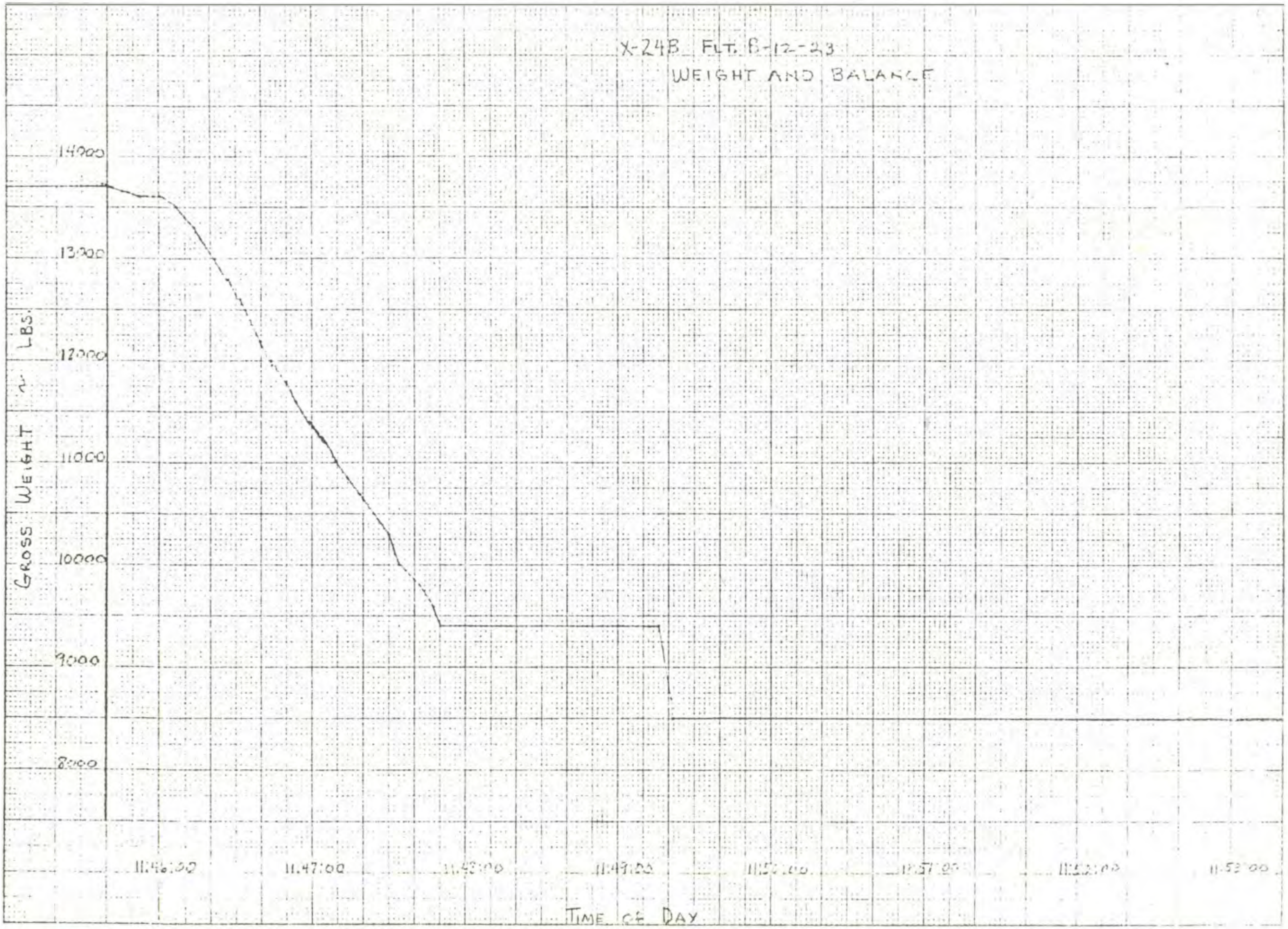
TEMPERATURE TIME HISTORY

FIGURE 3

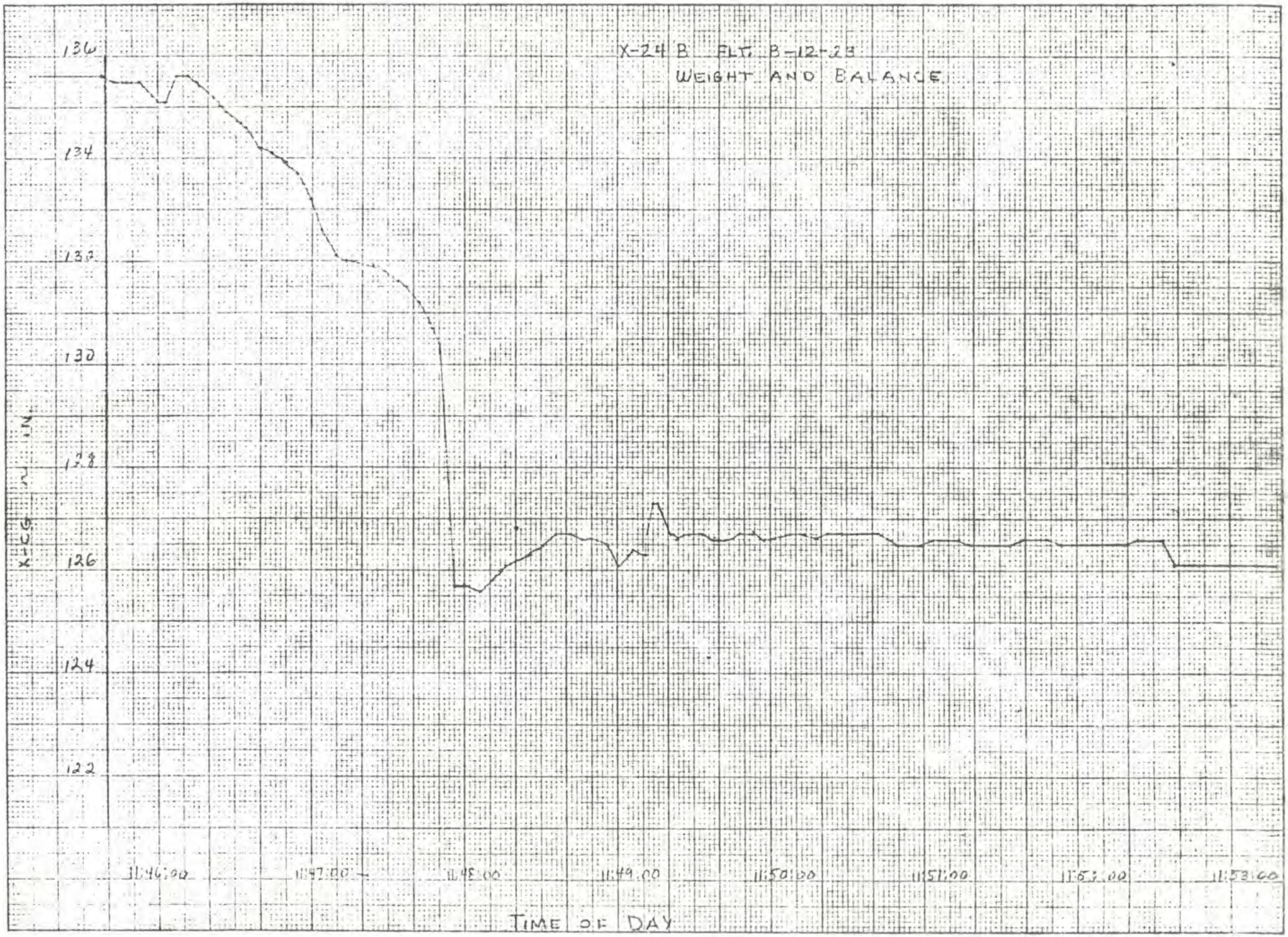
K+E 10 X 10 TO THE CENTIMETER 46 1516
18 X 25 CM. • ALBANENE
KEUFFEL & ESSER CO.
MADE IN U.S.A.

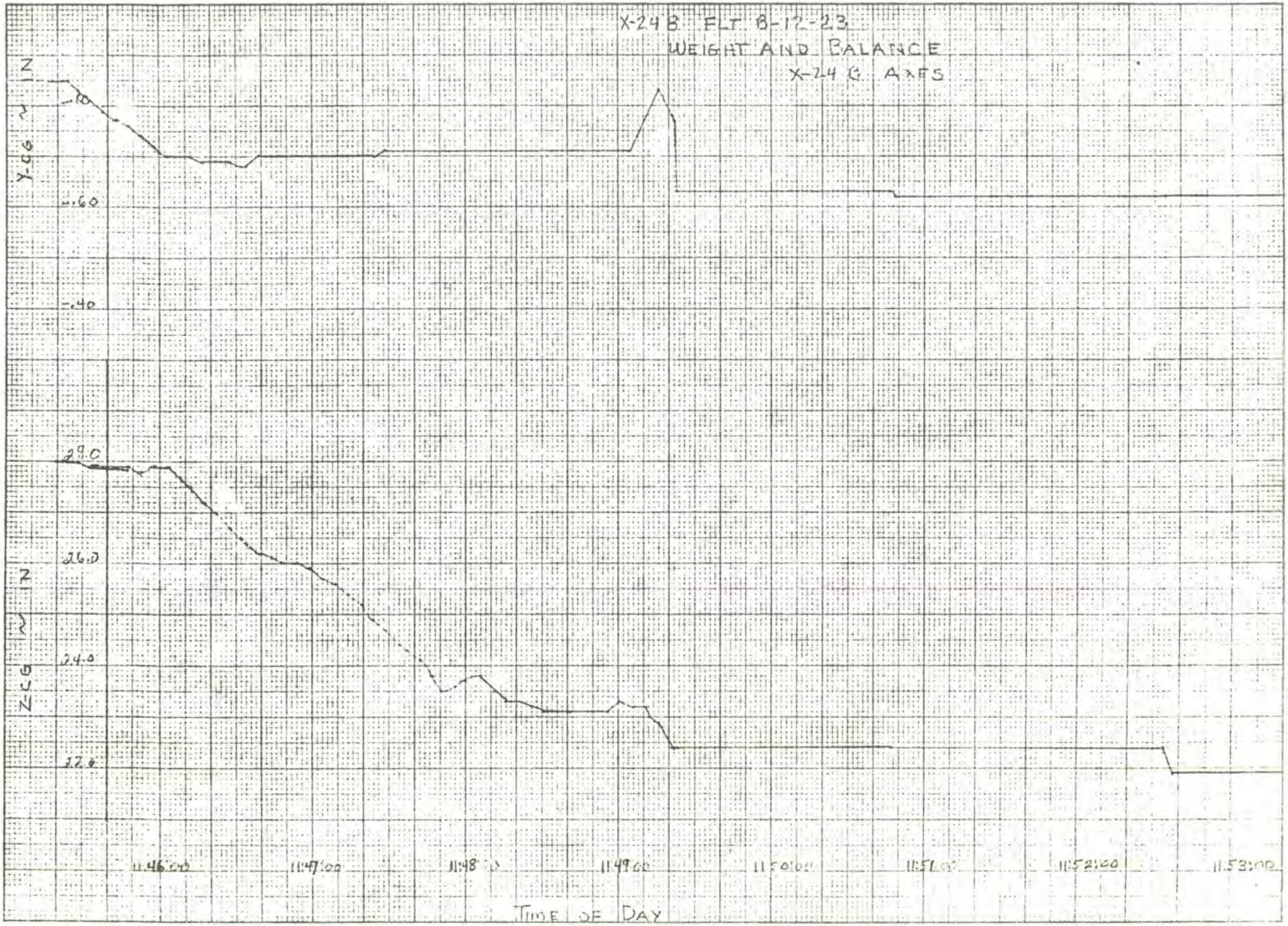


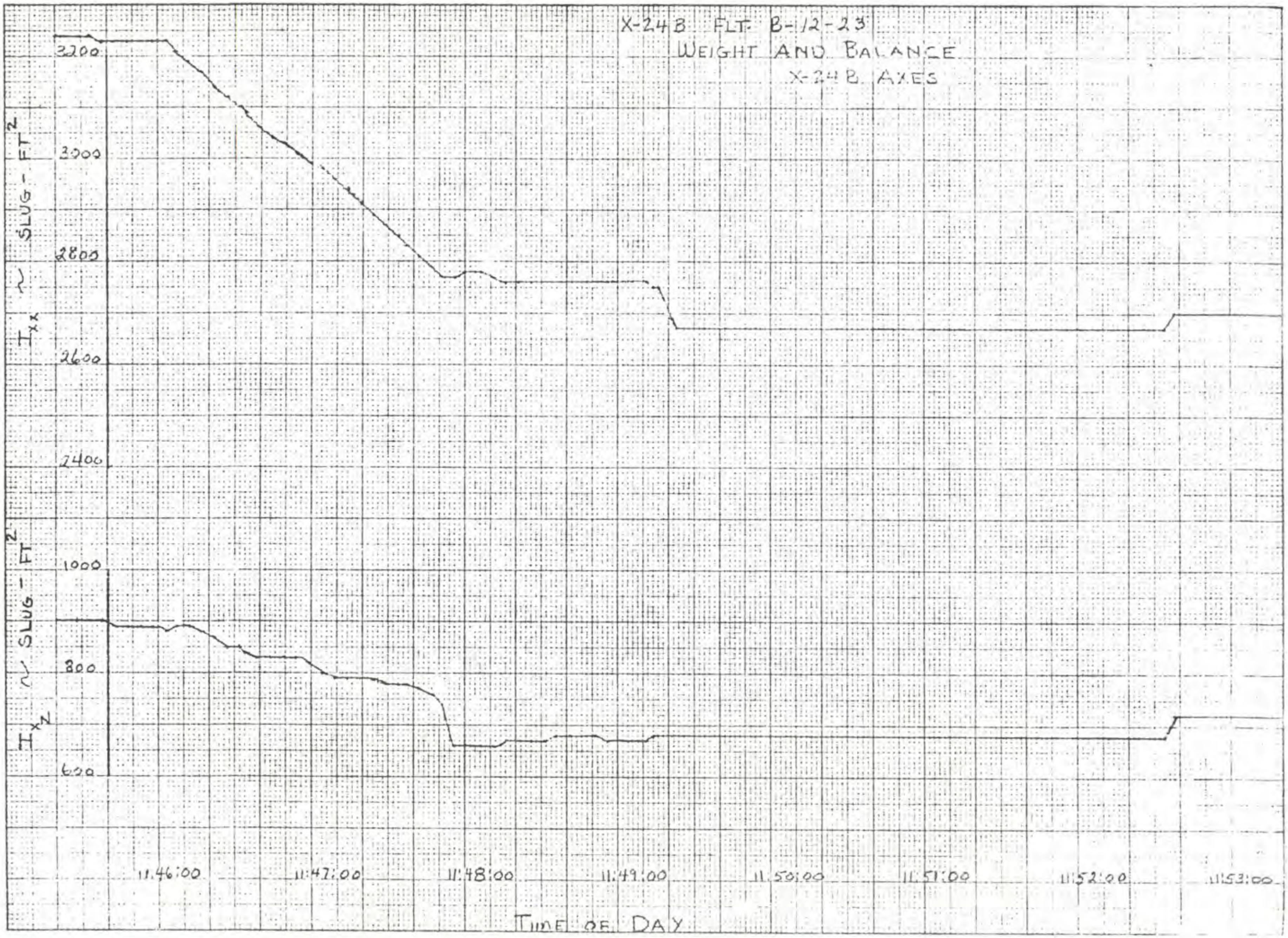
FLT 13
TEMPERATURE TIME HISTORY
FIGURE 4.

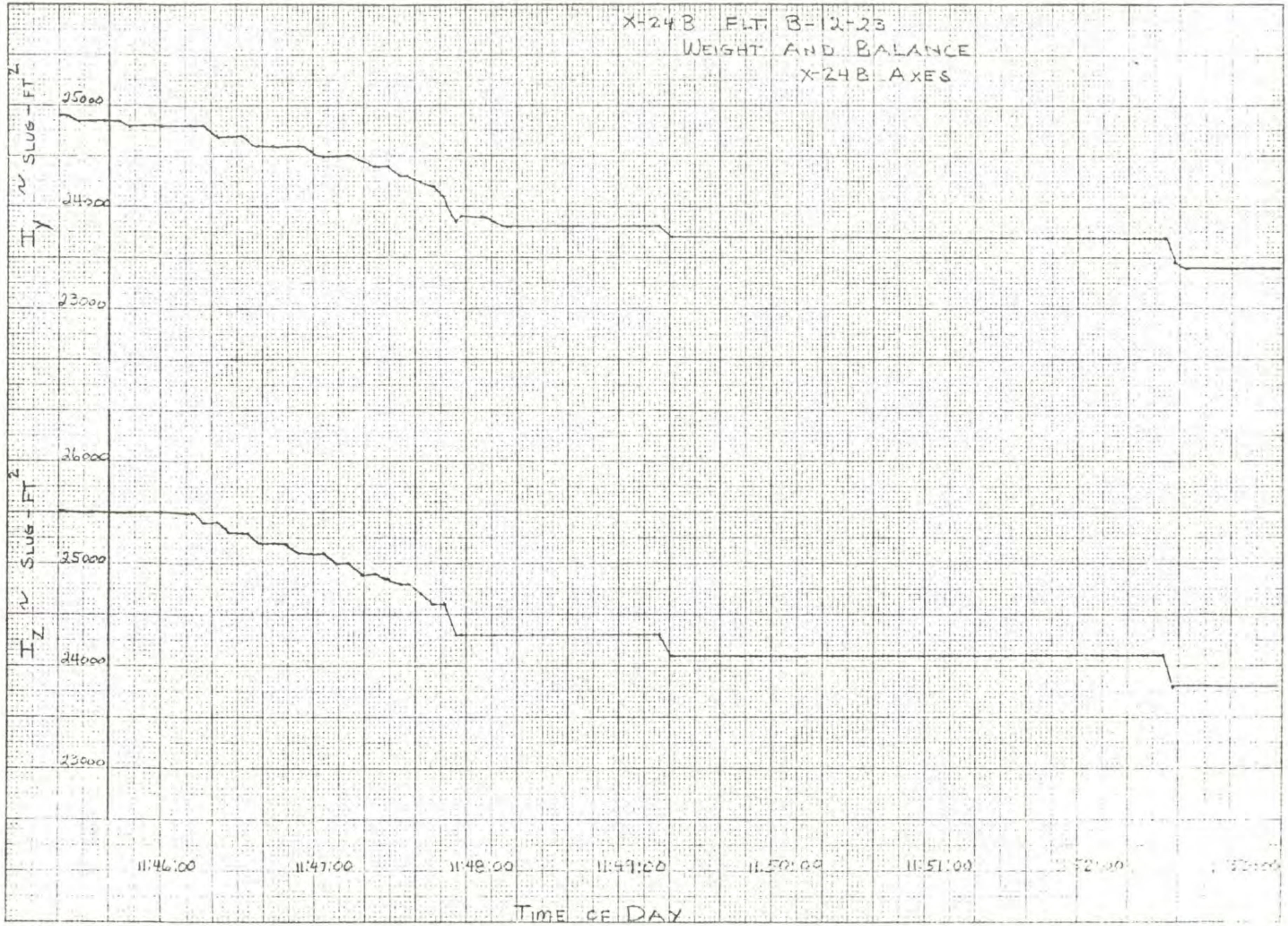


X-24B FLT. 8-12-73
WEIGHT AND BALANCE
GROSS WEIGHT ~ LBS.
14000
13000
12000
11000
10000
9000
8000
11:46:00
11:47:00
11:48:00
11:49:00
11:50:00
11:51:00
11:52:00
11:53:00
TIME OF DAY


X-24 B FLT. B-12-23
WEIGHT AND BALANCE
136
134
132
130
128
126
124
122
X-CG ~ IN
11:46:00
11:47:00
11:48:00
11:49:00
11:50:00
11:51:00
11:52:00
11:53:00
TIME OF DAY


X-24 B FLT 8-12-23
WEIGHT AND BALANCE
X-24 G AXES
Y-CG ~ IN
-.80
-.60
-.40
Z-CG ~ IN
28.0
26.0
24.0
22.0
11:46:00
11:47:00
11:49:00
11:52:00
11:53:00
TIME OF DAY


X-24B FLT B-12-23
WEIGHT AND BALANCE
X-24B AXES
I_{xx} ~ SLUG - FT^2
3200
3000
2800
2600
2400
I_{xz} ~ SLUG - FT^2
1000
800
600
11:46:00
11:47:00
11:48:00
11:49:00
11:50:00
11:51:00
11:52:00
11:53:00
TIME OF DAY


X-24B FLT. B-12-23
WEIGHT AND BALANCE
X-24B AXES
I_Y ~ SLUG-FT^2
25000
24500
23000
I_Z ~ SLUG-FT^2
26000
25000
24000
23000
11:46:00
11:47:00
11:48:00
11:49:00
11:50:00
11:51:00
TIME OF DAY

X-24B OPERATIONS FLIGHT REPORT

FLIGHT: B-12-23 DATE OF REPORT: 8/2/74

PILOT: Maj. Love DATE OF FLIGHT: 6/14/74

CARRIER AIRCRAFT: B-52 #008 LAUNCH LAKE: Rogers Lakebed

PURPOSE OF FLIGHT: (1) Envelope Expansion to 1.25 Mach Number

(2) Stability and Control at Mach number >1.0

(3) Fin, Rudder and Flap Pressure Survey

(4) Boundary layer noise and vibration experiment (RED PLUG)

I. Discussion of Previous Operations

Failure of the #1 65 psi igniter chamber pressure switch resulted in no operation of the #1 chamber during flight B-11-22.

All other systems worked properly.

II. Vehicle Configuration Changes

A. The invertor transfer system which provides automatic switchover of the essential 115 volt A/C. buss to one leg of the attitude invertor if the primary invertor fails was modified to provide pilot manual control.

The new system utilizes a three position switch with Auto, Primary & Backup positions.

1. In the auto position the system is unchanged.
2. In the prim. position the voltage sensor is deactivated and the primary invertor is locked in to the buss.
3. In the backup position the voltage sensor is bypassed and the attitude invertor is locked in to the buss.

B. The CPT's previously installed to monitor the aileron control linkages were insulated to eliminate suspected chilling problems.

III. Instrumentation Changes

A. Installed two additional pressure transducer boxes, a signal conditioning box, and a sub-com into system 2 to add 79 more body pressure top measurements.

B. Added parallel recording of #1 battery voltage. Ref. Flight Report B-11-22 item V-C.

IV. Preflight Events

A. The engine was removed and sent to the PSTS to resolve and repair the cause of #1 chamber malfunction.

Ref. Memo from W.B. Arnold dated 6/5/74, attached.

B. Mr. Arnold suggested that an increase in the helium purge flowrate could help alleviate the moisture problem. He was directed to perform tests on the PSTS to evaluate engine operation with 10,000 cc/min flowrate vs. the present 5,000 cc/min orifices.

C. The #2 igniter spark plug failed to fire during the preflight ground engine run. Upon examination the electrode was found to have broken off. The igniter was removed to insure that no damage had been incurred. The igniter was not damaged and was replaced.

The spark plug was replaced and the engine operated satisfactorily. The other three plugs were replaced prior to flight.

D. The left hand main gear oleo strut was disassembled and all seals replaced to eliminate oil leakage.

V. Flight Events

A. Preflight servicing proceeded normally until the primary radio in the B-52 failed during communication checks. The radio was replaced with no delay.

B. All systems work normally during the flight.

C. The vehicle was in good shape after landing.

Approved by: [signature] for WPA.
William P. Albrecht
Chief, Operations
Engineering Branch

Written by: [signature]
Norman E. DeMar
X-24B Project Engineer
Operations Engineering Branch

June 5, 1974

TO: DOEER

FROM: W.B. Arnold - THIOKOL

SUBJECT: Propulsion System Operation Flight B-11-22

SUMMARY OF ENGINE OPERATION

1. The prelaunch igniter test was eliminated for this flight.
2. The post launch attempt to start chambers #land #3 resulted in a satisfactory start of chamber #3 and igniter operation only in chamber #1.
3. The #1 fire switch was deactuated and chambers #2 and #4 were started satisfactorilly.
4. A second attempt to start chamber #1 again resulted in igniter operation only.
5. The engine was placed in overdrive (high Pc) approximately 30 seconds after chamber #3 had stabilized.
6. During the advance to the overdrive condition the fuel manifold and chamber pressures responded as predicted. The lox manifold pressure entered an excursion cycle 0.3 seconds after the advance was started. This excursion reached a low point of 299 psi and did not stabilize again for 9.0 sec.
7. Fuel and lox tank pressures were lower than on previous flights but were well within operating limits.
8. Engine shutdown was caused by liquid oxygen exhaustion after approximately 155 seconds of engine run time.

DISCUSSION

The engine was removed from the aircraft and returned to the maintenance shop for investigation of the failure of the #1 chamber to start. Final Flight data was not available for analysis so it was assumed that the 65# chamber pressure switch was defective. It was suspected that the switch actuating piston "O" ring had lost sealing ability similar to failures experienced in the past. The #1 65# chamber pressure switch was removed from the control box and cold soaked at $0^{o}F$ for 20 minutes.The actuation pressure was determined to be 109 psia and no vent port leakage was detected which indicated that the piston seal was satisfactory. The switch was disassembled and a considerable amount of moisture was found in the piston area. This moisture when frozen can change the actuation pressure.

FLIGHT B-11-22

DISCUSSION continued:

The components were dried and reassembled and the cold soak was repeated. The switch actuation pressure returned to normal. This test indicated that the failure mode was due to moisture rather than piston seal failure. The moisture accumulation was probably the result of the low chamber pressure line bleed flows which were found after Flight B-10. All of the pressure switches in the control box were disassembled, cleaned and rebuilt with new "O" rings as a precautionary measure. A procedure to detect reduced flowrates of the Pch line bleed orifice will be established.

The pressure excursion which occurred in the lox manifold pressure cannot be explained from the preliminary data. The transfer into overdrive appeared to be normal as indicated by the fuel manifold and chamber pressures. The #4 chamber pressure appears to b e slightly damped and lags the #2 and #3 pressures. Figure 1 is a copy of the data showing the transfer and excursion. The low point of lox manifold pressure was 299 psi which is approximately 41 psi above the cutoff level. The shape and duration of the excursion provides some doubt of validity of the data. This doubt is further warranted by the fact that there was no indication in fuel manifold and chamber pressures that the excursion was occurring in the lox manifold. Normally the chamber pressures are greatly affected by lox manifold pressures. The fuel manifold will also respond as a result of lower turbopump power requirements due to reduced or changing lox flowrates.

Figure 2 is a data copy of the shutdown transient showing manifold pressures and the #2 chamber pressure. It must be remembered that the liquid oxygen manifold pressure reading is delayed by 0.15 seconds due to accumulator damping. At time marked 0 the first indication of a change in lox manifold pressure occurs. This is reflected 0.1 sec later in the #2 chamber pressure. The shutdown was signalled at about 1.2 sec. The decrease in fuel manifold pressure indicated that the fuel was probably almost exhausted at this time. The affect lox manifold pressure has on chamber pressure is shown in this shutdown sequence where instantaneous lox exhaustion is not encountered. This data also indicates that the lox pressure excursion indicated during the overdrive initiation should have provided a significant change in chamber pressures.

W. B. ARNOLD

cc: N. DeMar
J. Kolf
TC-Elk.

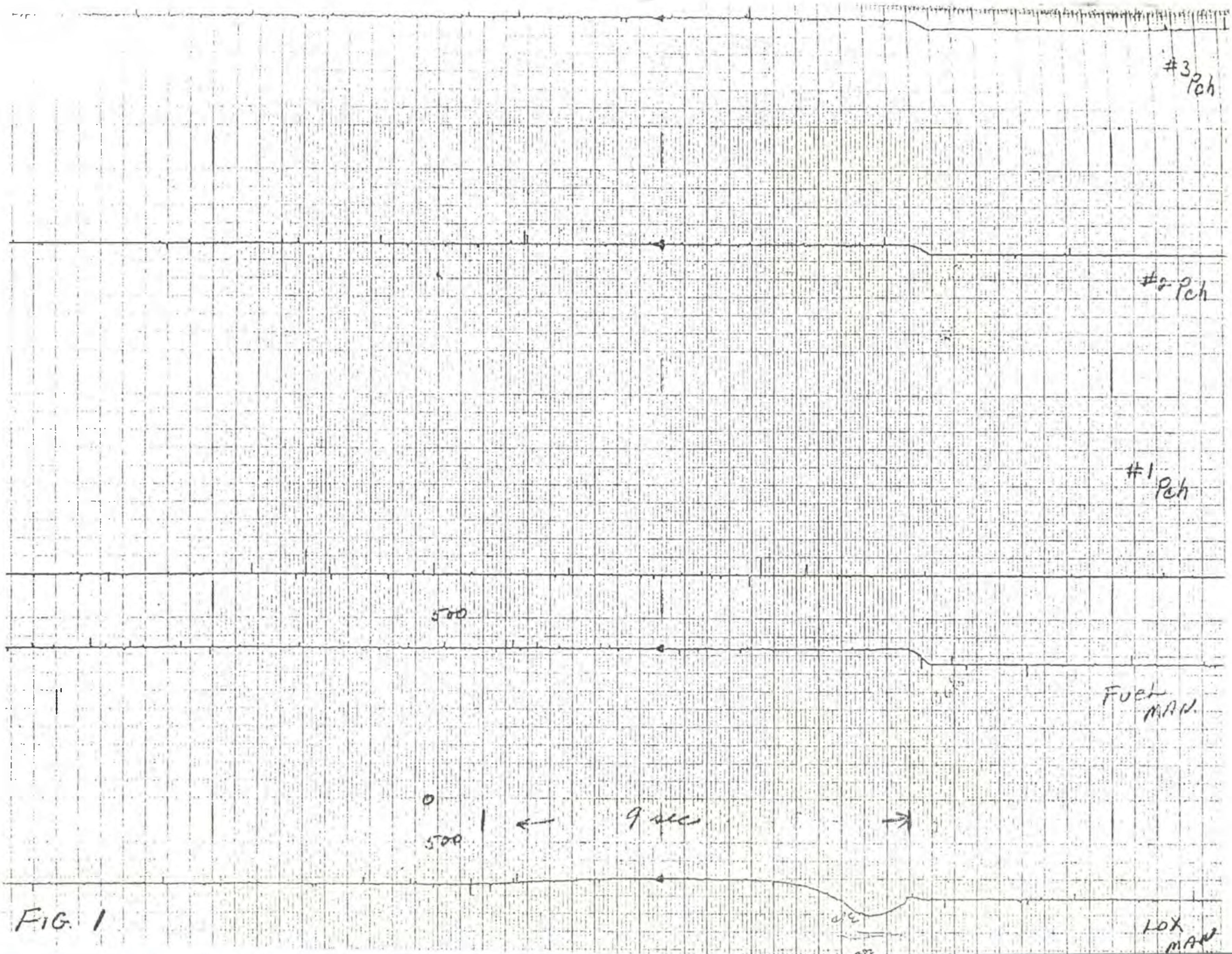


FIG. 1

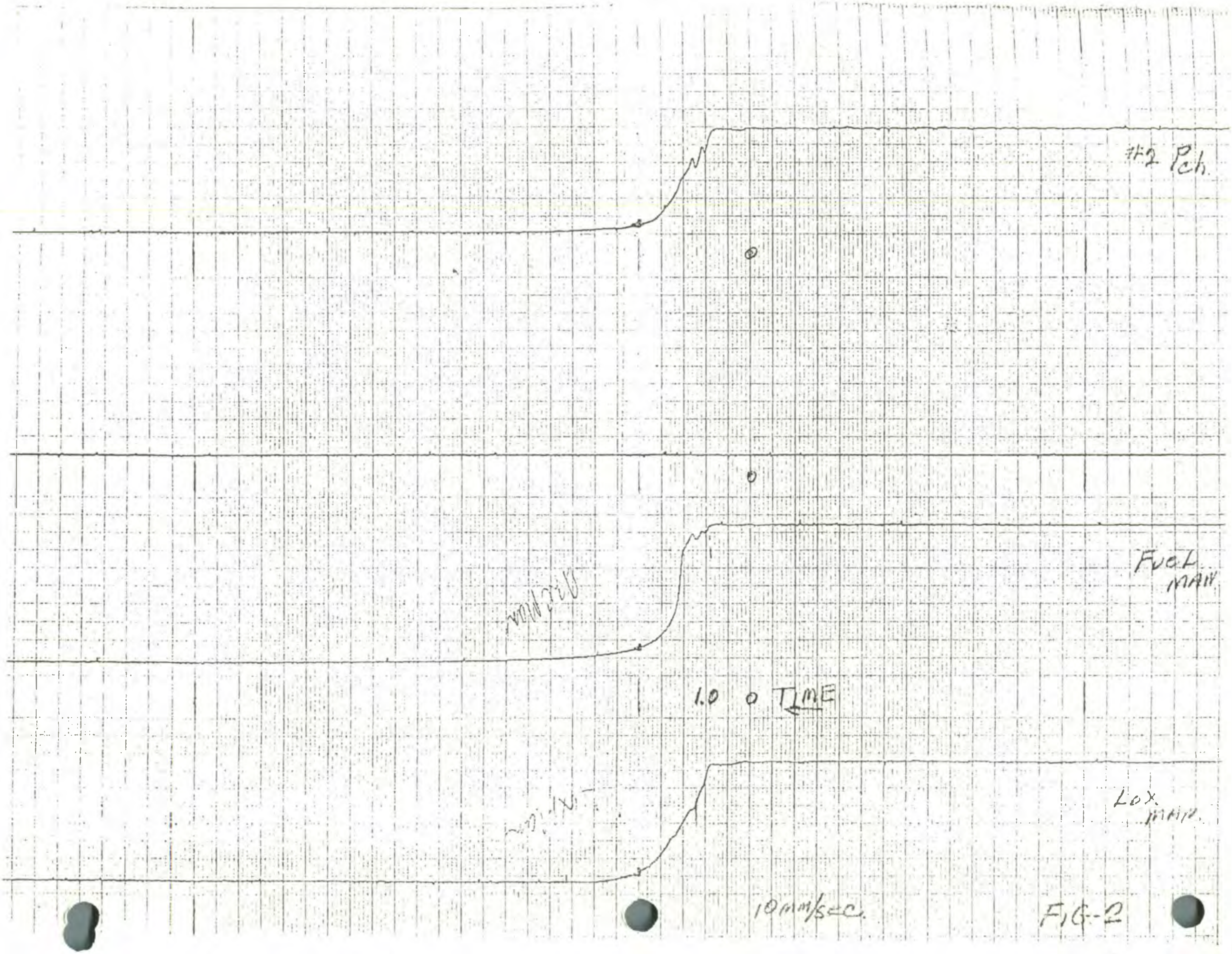


FIG-2

TO: DOEER

FROM: W. B. ARNOLD - THIOKOL

SUBJECT: Propulsion System operation Flight B-12-23

SUMMARY OF ENGINE OPERATION

1. No prelaunch igniter test was utilized.
2. Engine Start was normal.
3. The transfer to overdrive was normal with the exception that the #4 chamber pressure did not show any increase on the data.
4. The return to normal chamber pressure was slightly slow.
5. Engine shutdown was normal.

DISCUSSION

The failure of the #4 chamber pressure recording to increase during the overdrive portion of the flight was probably the result of a defective transducer. The transducer was removed and replaced.

The deactuation of the overdrive system is slightly slower than that encountered on the test stand. On this flight it required approximately 5.5 seconds to return to the normal chamber pressure. This slow return is probably caused by the venting ability of the standard governor balance pressure regulator which is used to reduce the overdrive balance pressure. This function will not present any problems during engine operation.

During the engine start transient a slight decay in lox tank pressure has been attributed to the cracking pressure of the quad check valve in the pressurization system.

The lox manifold pressure excursion which appeared on data during the overdrive transfer on flight B-11 did not occur on this flight.

During the preflight ground run for this flight an igniter misfire was encountered. Investigation revealed that a defective spark plug was the problem. All spark plugs were replaced prior to flight.

W. B. ARNOLD

cc: N. DeMar
J. Kolf
TC-Elk.

POSTFLIGHT: B-12-23
PILOT: Maj. Love
DATE: June 14, 1974

This is Flight B-12-23 on 14 June, Major Love. I guess my best opera- to date, airplane, weather, everything just went perfectly and it was as normal as we could possibly get. A normal launch with the airplane coming up to 10 or 11 by the first time I looked at it.

Hit one and 3 chamber switches and 1 and 3 came right on up. As soon as they were up I hit 2 and 4 and 2 and 4 came up with 2 lagging just a little bit, looked like. That was terrific.

Then I tried to rotate to 15 α and it seems like when I had trouble going to 14. This time I was able to get 14 easy and 15 was harder. Part of that is because it looks a little different than the simulator in response to the needle I think. The α needle in the airplane responds faster because it's real I believe than the one in the simulator, so I feel that I have to be just a little more careful of it. The airplane feels good during that rotation.

Had plenty of time to think about aileron trim which is a big problem for me in the simulator, and I didn't feel much need for it. Beta out about 1° left. At 30 seconds I got the overdrive. I did not look at the gages but I felt it just like you said, John. A good positive indication that you got it. Then got on theta and I had a little easier time holding theta than I expected to. In fact, I felt that it was easier than holding 15 α. It did feel steep though, and it took a little getting used to. About this time I looked at the aileron trim and I had less than 1/2° aileron trim as far as my indicator looked like.

John said to check my α. Had about 11. At the time I had 11, I probably would have had 13 in the simulator. Pushed over to 10 α. Pushover came about .85 just as advertised and at 56. I had to wait just a little bit, maybe 500 feet and about .9, then I could feel some airframe vibrations similar to an F-4 at .9 Mach. The beta was out 2° to the left. About .95 beta was coming back and I was concerned with catching the Mach jump and getting the overdrive off. I looked down for that switch, and I did not feel that buffet anymore, and beta was back in so I did not think about it anymore.

Got the overdrive off, went to 7 α and was pleased with the way it is easier to hold 7α in the airplane than it is in the simulator and also the way there is no requirement to take all that aileron trim out that you just put in during the climb. Just pushed the airplane over at 7 α it seemed easier to hold. Got the doublets there and a certain amount of time to look up and shutdown, and what looked like 1.25 to me. During this period I guess the hardest thing to do is to read the Mach meter. Very difficult to decide that you are at 1.05 or 1.1, because of the index on that Mach meter.

Shut down, deceleration was marked, but the airplane stayed right at 7 α and I got those doublets. Now in the simulator, what I was doing, when I'd accelerate, I'd push over to 7, put in a whole bunch of left aileron trim and then did the rudder doublet at 7, then trimmed from 6 to 7 in pitch and did the aileron doublet. After shutdown, -then I tried to shutdown at about 6 in the simulator and the simulator would come up to 7 and then I'd get the doublet. Get the rudder doublet at 7, push the trim into --- from 8 to 7 and get the aileron doublet. You don't have to go thru that drill in the airplane. Then I would push over to 5. The simulator goes over to 5 easier than the airplane. It was harder for me to make it stay at 5 then it is in the simulator, and it could be that I just did not want to push it over that much. When i realized I was not getting 5 like I wanted, I became aware that pitch angle, it was down about 25 or 30 I suppose. And then it stayed right at 5. Response to the rudder doublets was about the same as the simulator at that time-it seemed to be.

Back up to 12, no up to 10, trimmed at 10 and the pitch trim in the airplane was easier at all times. Couple of pitch pulses; they looked just like the simulator. Up to 12, beta sat about 1/2° left during that time. As I decelerated I had about 1.08 indicated. Decelerated to .85 and the beta never did come out, but however, I did make a little turn in there and I may have been taking the beta out that way. I don't know if that would cause that or not. But I did make a heading correction at that time. A small one. Got the yaw damper off at .85 and trimmed to 8° angle of attack. I don't know, I guess you are so excited you put in bigger inputs, but I had no intention of putting in bigger inputs then I put in the simulator. But I got an awful big response on that yaw pulse with the rudders. I felt that the frequency was lower in the simulator. In order words the needle does not move back and forth as many times or it did not seem to in the airplane to me, as the simulator. I seemed to get a little more response out of the aileron doublet at .87 than you expect from the simulator.

The yaw damper back on and I was up to 13 α. Prop supply and jettison, that was just as advertised, holding a little higher so we could get back on track. Two mile call and I got the yaw damper on and that was nothing to comment on there. Stopped jettison, tanks and bleed came right on then, it was about like normal. As soon as I did that I closed up to 30 and trimmed to 11. You called intersection, did the popu and went down somewhere around, I'd say 6° α, and back up to 13 just like the simulator and then as soon as I finished that, had another call to stop jettison and that was done.

Had 240 knots on downwind. I was a little surprised I was still at 27,000. Closed up and went into low key. Pattern was like the ones I had been practicing in the 38, coming in there. 30° flaps out at the 90° point and got them back in and tried to hit 9000' at 300 knots and did. John asked if I felt a little low on final and I did feel low and I looked to the aimpoint and I see the aim point is right. I just felt shallow. So I think it probably was the wind that we were passing thru. There was a little turbulence somewhere in there too, as I recall. Did not mean anything. Flare and gear extension, felt the headwind.

Then touchdown came with the right main first and then left and nose down, but the nose came down straight. Then got nose wheel steering. I was holding right aileron too to steer straight. So if we did not have a cross wind, we ought to look at the transients.

It did not just go straight down the runway like it has on the last 3 times I landed it. It took a lot of steering to hold it straight compared to the other times, and I braked just a little bit. --- --- No, I was just watching it. It was only, I could feel the airplane. The other things I mentioned to you John, I mentioned those things because I wanted to remember them. I did not notice the ball during the rest of the flight but as I turned downwind I noticed the ball was flying 1/2 ball out to the left with the beta 1/2° needle left. I don't know if that makes any sense or not. But thats --- . Not much beta but showing some side forces if the ball was installed in the airplane right.

FLIGHT:	B-12-23	ENG. START:	1035
PILOT:	Maj. Love	TAXI:	1040
B-52:	008	TAKEOFF	1055
LNCH PANEL:	R. Young	LAUNCH	1146
NASA 1:	J. Manke	LAND	1153
DATE:	June 14, 1974		

24 Minutes

NASA 1: OK Mike, 24 minutes, 24
LOVE: OK, John, SAS gains 6, 5, 3,
Ready for a calibrate
NASA 1: Yes sir, we are ready
OK, that was a good calibrate
LOVE: Pressure altitude 20,000
X-24 air 3050
Pylon down to 600
2 and 4 coming on
NASA 1: Roger, Mike
LOVE: Lites out
3200
NASA 1: Roger
LOVE: Switches are on
OK, all circuit breakers are in except vehicle release and brake
NASA 1: Roger, Mike
22 minutes, Mike and 008 start your turn

22 Minutes

008: 008
LOVE: OK, Mach repeater is auto
α is about 2
Airspeed 238
Altitude coming up on 37
Indicated Mach .74
Mach repeater is .75
NASA 1: Roger, Mike
LOVE: Mach repeater is manual - set 1.0, going lower
NASA 1: Roger, Mike
LOVE: Emergency flap, 30, 25, 40 and pick up
Rudders at 30 and they are at zero
OK, 20 and -10 on the rudders
40 and zero
NASA 1: Roger, Mike
LOVE: Back up, going to 5
Down to 9
Aileron bias back to normal
Set at 7
Full aft stick
Forward and aft stick trim
Set at 10

NASA 1: Roger, Mike
LOVE: Right and left aileron
Trim set at zero
Full right rudder
Full left rudder
NASA 1: Roger, Mike
LOVE: Rudder trim right and left
Set 1° left
KRA increased to 50
Right and left stick
The rudder follows
Zero
Right and left stick, no rudder
NASA 1: OK, Mike
LOVE: KRA emergency, going to 50
Right and left stick
The rudders follow
NASA 1: Roger
LOVE: KRA is auto, went back to zero
Stick Shaker good and it is on
NASA 1: Roger
LOVE: Mach repeater 1.0
Flap mode is manual
Rudder mode is auto
NASA 1: Roger, Mike
LOVE: SAS servos going to auto
Set 5, 5, 5, and the old SMRD
No lites
NASA 1: Very good
LOVE: Torque
No lites
#1's are off
A torque and 3 yellows
2's are off
A torque and 3 reds
NASA 1: Roger, Mike, looks good
LOVE: 6, 5, 3,
Servos are auto
Lites are reset
Torque and no lites
NASA 1: OK, good check, Mike
LOVE: SAS mode switches are on and I will hold up here
NASA 1: Alright
Mike we want a little bit of left roll and a little bit of left yaw trim
Rollout 240, 008
008: 008
CHASE: The left side's starting to vent a little bit

NASA 1:	A little more yaw trim, Mike
	Looks good
	Both your trims
	Looks good here
	Roger
	OK, for chase, this is what we would call a good top-off from down here from our temperature. You might take a look at that
CHASE:	The ones on the left have just started pulsating and the one on the right is venting pretty good
NASA 1:	Roger
	We just past 16 minutes, Mike
<u>16 Minutes</u>	
LOVE:	Roger
NASA 1:	Ray Young, you can get top-off, off now, and Mike, precool off
YOUNG:	Topoff coming off
LOVE:	Precool is off
NASA 1:	OK, we just past 15 minutes, Mike
<u>15 Minutes</u>	
LOVE:	Roger
DANA:	OK, Mike, do you know how to grease a Volkswagan?
LOVE:	How do you do that, Bill?
DANA:	Drive over a Marine
LOVE:	That is a good way
DANA:	If you really want it greasy drive over him when he is in his flying suit
LOVE:	Right on
	NASA 1, radio check
NASA 1:	Loud and clear, Mike
	Dana I think I found out who is putting that razor in my shoe
NASA 1:	OK Mike, 14 minutes, 14
<u>14 minutes</u>	
LOVE:	Hydraulics are swapped
	2700
NASA 1:	OK, good show and we are ready for a pitch and yaw if you are up there
008:	Right
NASA 1:	We are ready for the pulses, Tom
008:	Roger, pitch pulse now
NASA 1:	OK, that was a good pitch pulse, Tom
008:	And yaw pulse
NASA 1:	Good yaw pulse, Tom
CHASE:	OK, Mike, I'm in here
NASA 1:	OK, Mike we are 13 minutes and you can get the erect switch to erect and fast erect on. We are going to be here for a while
MIKE:	OK, they are on
	Say your heading, Tom

LOVE: 008, say your heading
008: --- 239
NASA 1: What is the LOX quantity in the cruise tank, please
008: Quantity is 450 gallons
NASA 1: 450
008: Affirmative, correction 550
NASA 1: OK, 550
Mike, 12 minutes

12 Minutes

LOVE: Roger
NASA 1: OK, Mike, there is 111 minutes and the trims are looking good here

11 Minutes

LOVE: OK, I got 40, 10, 0, 7, 1 left and rudder bias is 0
NASA 1: Roger
CHASE: Good here too
NASA 1: Save helicopter, NASA 1
SACE: Save's in position
NASA 1: Roger, thank you very much sir
OK, Mike there is 10 minutes, 10

10 Minutes

LOVE: #1 is 39
#2 is 41
Control gas is 500
Governor balance is down to 455
Fuel and LOX tank 0
Gear 3100
Ready for the pump heater
NASA 1: OK, lets go ahead, Mike
LOVE: Pump heater is off
NASA 1: OK, back on
LOVE: Pump heater is on
NASA 1: OK, good check, Mike
And Ray Young we will be starting our top-off at 8 minutes
I will give you a call
YOUNG: Roger, NASA 1
NASA 1: OK, there is 9 minutes, Mike, 9 minutes

9 Minutes

LOVE: OK, 9 minutes
Erect switch cutoff
Fast erect off and outstanding attitudes up here
NASA 1: Alright
There is 2 that I did not like too well
NASA 1: 8 minutes, you can start your tur
8 minutes, start topoff

8 Minutes

008: Roger
YOUNG: LOX topoff is resumed
LOVE: John, are you ready for a rocket check?
NASA 1: Yes
OK, good rocket check
LOVE: Roger, and standby for aileron activity

NASA 1: And we are ready for that oo
OK, thats good, Mike
LOVE: Roger
NASA 1: 7 minutes, Mike, 7 minutes

7 Minutes

LOVE: OK, 7 minutes
Lets go secondary
NASA 1: Roger
LOVE: 551 on primary
NASA 1: Read you loud and clear, Mike
OK, Mike 6 minutes, 6 minutes

6 Minutes

NASA 1: Chase airplanes check your windshield heat
CHASE: 1, 1α, 2, 2α
NASA L: And Tom Higgins will you shallow your turn a little bit, please
008: Roger
MIKE: OK, there is 27
NASA 1: Give us a little beep forward, Mike
CHASE: OK, Mike, check the aileron too, I get a nervous twitch on the aileron
---
NASA 1: Ailerons look OK
OK, we are OK on the pitch trim too
OK Mike, there is 5 minutes, 5 minutes

5 Minutes

LOVE: Roger, I am on battery and emergency battery lites out
Hydraulics are swapped
3200
I had to reset the battery light again
OK, #1 is 125
2 is 110
#3 is 110
#4 is 45 and the lite is still out
NASA 1: Alright
LOVE: SAS gains are 5, 5, 5, and the old SMRD
008: X-24 adapter power is off
LOVE: No lites
NASA 1: Roger
LOVE: Torque, no lites
NASA 1: OK, roll out this heading 008
008: Roger
LOVE: 3 amber
NASA 1: And we just past 4 minutes, Mike, and we are doing good

4 Minutes

LOVE: 3 reds, auto, lites, torque
No lites,
NASA 1: OK, good check, Mike
LOVE: I am on X-24 oxygen
I got 85 and 1700

NASA 1: OK, Mike we are not quite 3 minutes yet
Why don't you just hold on your air for a secon here
LOVE: OK
NASA 1: OK, Mike, there is 3 minutes, 3 minutes

<u>3 Minutes</u>

LOVE: OK, I am on X-24 air
Cabin altitude is 28
Canopy defog is heat
Forward canopy defog is on
Suit vent is low
NASA 1: 5° left
LOVE: #1 is 39
#2 is 41
Control gas is 500
Governor balance is 455
Erect switch erect and fast erect on and my trims look good
NASA 1: OK, Mike and give X-24 air pressure reading
LOVE: 2800
NASA 1: Very good
008: That last correction was 5° left?
NASA 1: Affirmative, 5, left
OK, Mike, there is 2 minutes, 2 minutes

<u>2 Minutes</u>

LOVE: OK, precool is off
Engine bleed is on
Prop supply is on
Fuel and LOX tanks are pressurizing
008: ---
LOVE: LOX is 44
Fuel is 46
NASA 1: Roger
LOVE: Release pressure low lite is out
NASA 1: OK, good show, Mike
YOUNG: B-52 beacon is off
And pressure is good, 1300
NASA 1: OK, Ray, very good
OK, Mike, there is 70 seconds, now

<u>70 Seconds</u>

LOVE: Roger
NASA 1: 1 minute, mark

<u>1 Minute</u>

LOVE: OK, clocks started
#1 is 36
#2 is 41
SAS lites are out
I've got 062 heading
α is 4
β is 1 left

NASA 1: Roger
LOVE: Engine master is on at 45
NASA 1: Roger, good call
LOVE: Erect switch cutoff
Fast erect is off
NASA 1: Roger
OK, Mike, systems are OK from NASA 1
LOVE: OK release circuit breaker is in
NASA 1: Roger
LOVE: Recorder and cameras are on
NASA 1: OK
LOVE: 10
NASA 1: Roger
LOVE: 5

<u>LAUNCH</u>

NASA 1: OK, Mike, you are on your way
Watch your angle of attack, 15°
LOVE: 4 good ones
NASA 1: OK, we see 4 good ones, Mike
Looks real good
NASA 1: Watch your α 15°
We got a real good track
We launched you right on track
Good heading
We show a good 15°and you can standby for your overdrive on, Mike
Your are rounding out very handily
Standby for theta, Mike
And we see a good overdrive
LOVE: Roger, on theta
NASA 1: OK, we got a nice profile
OK, Mike, somewhere along here you can check your angle of attack
LOVE: I read 12 now, John
NASA 1: Roger, that means that we are going to get a little bit high
LOVE: Rog
NASA 1: You got a good track and it is a good profile
Standby, check your Mach
Standby for a pushover
56,000', now
LOVE: Roger
NASA 1: And you should be going down to 10 α here
LOVE: I got 10
NASA 1: Very good, looking good
LOVE: Watching beta
NASA 1: OK
LOVE: OK, its swinging out to the left

NASA 1: OK, we are going to go a little high.
You can stand by for over drive off and 7° α
LOVE: Roger
NASA 1: OK, early shutdown line now
We see the overdrive off
Standby for doublets
We see your doublets, Mike
Standby for shutdown and doublets
We got the shutdown
Give us some doublets
OK, go to 5 α and give us some more doublets, Mike
OK, and we see the doublets
You can trim to 10 α,
Pitch gain to 4
Pitch pulse
You are going to end up a little bit low this time
We were early at the shutdown, Mike
LOVE: I am up at 12 and I still got 1.05
NASA 1: OK, watch your beta as you go thru this area here
LOVE: Roger
NASA 1: And when you get a chance we are going to want a 5° -10° left correction, Mike
LOVE: Coming left
Beta is holding around zero
NASA 1: OK
LOVE: Going out
It is 1 left now
NASA 1: OK, you can check your Mach
Yaw damper off and 8° α
Standby for doublets
We see your doublets
Lets go to 13 α
Prop supply off and start your jettison
And bring her about another 5° left
LOVE: Coming left
NASA 1: OK, and I got you running about 4000 feet below the profile Mike
LOVE: OK, I will hold it up
NASA 1: Yes, bring it a little bit more left here, Mike
2 miles
Get your damper back on
LOVE: It is on
NASA 1: You are converging nicely on the profile
Stop jettison, tanks, bleed now
OK, did you get stop jettison, Mike
LOVE: Roger
NASA 1: Very good
OK, close up to 30
You are crossing the intersection
You can start your turn
Get your 11° popu

NASA 1:	You are right back on the profile, Mike Your profile is perfect The energy is perfect We see your α changing You got a nice turn going
LOVE:	I got 240
NASA 1:	OK, inbound to the low key will be about 010, Mike
LOVE:	OK
NASA 1:	OK, you can standby to close her up You are right on profile Check your Mach
LOVE:	240, Bill
CHASE:	Roger, I am joining up, Mike
LOVE:	OK
NASA 1:	We got you coming up on 2 miles This is a good heading to the low key Get your SAS 4, 3, 2 We see SAS 4, 3, 2 You are going just a little bit above profile now You can drop your α At one mile Give us a rocket check OK, good rocket check 1 and 3 hydraulics on You are at the highway, now Right on altitude Right on course
LOVE:	OK John, the ball is flying about 1/2° out left
NASA 1:	Alright
CHASE:	290, 17,000 Mike
LOVE:	Roger
CHASE:	90 percent
NASA 1:	OK, we see Mach repeater .3
LOVE:	Roger
CHASE:	303 1200'
LOVE:	Roger
CHASE:	100, 50, 3 good ones, Mike 20', 3, 2, 1 very nice
NASA 1:	OK, Mike, looks good You can arm your nose gear steering Mike, that was very nice
LOVE:	Another normal
NASA 1:	Roger
LOVE:	 KRA manual Throttle off Cameras are off

LOVE: Ready for a calibrate
NASA 1: Roger we are ready
LOVE: Recorder off
NASA 1: Roger
LOVE: SAS servos are off
Hydraulic pumps coming off
NASA 1: OK, Mike
LOVE: Defog coming off
Erect switch erect, fast erect on
#1 is 900
#2 is 3800
Control gas is 510
Governor balance is 465
Landing gear is 2600
02 cylinder is 1100
Cabin air is 800
Engine timer 106
Radar coming off
Stick shaker off
Fast erect off
Erect switch cutoff=
LOVE: Roger, it's off
Attitudes coming off
Canopy is coming open and I will see you upstairs
NASA 1: OK, Mike, that was really a dandy, a good flight
12:30 postflight

FLIGHT 13

PRELIMINARY RESULTS OF X-24B

Flight B-13-24

28 June 1974

By

USAF/NASA X-24B Project Team

FLIGHT SUMMARY - FLIGHT B-13-24

Flight B-13-24 was flown on 28 June 1974 by John Manke. This flight was flown as planned and proved to be one of the most fruitful flights flown to date. A total of nineteen data maneuvers were accomplished. The significant flight conditions were:

Maximum Mach Number = 1.39
Maximum Altitude = 68150 feet
Maximum True Airspeed = 799 knots
Flight Time = 7 min 7.6 sec
Burn Time = 117 sec

A summary of the key data maneuvers is listed below:

Mach	Degrees	Maneuver
1.16	4	Rudder/Aileron Doublets (power on)
1.27	4	Rudder/Aileron Doublets (power on)
1.36	4	Rudder/Aileron Doublets
1.28	8	Pitch Pulse (damper off)
1.2-1.12	3-15-8	Push-Over - Pull-Up
1.0-.64	7-8	14 Rudder/Aileron Doublets

Included in this report is a discussion of the correlation of surface pressure measurements, tufts, and stability derivatives. Of significance is that observed large instantaneous changes in fin pressures lead to verification of a drastic flow change via analysis of motion picture photographs of tufts. This in turn lead to detail flight planning to perform maneuvers to determine if stability derivative changes resulted from the flow changes. Indeed a significant change in the directional stability derivative (C_n) was found to exist. This is considered as a unique use of surface pressure data.

An additional 400 pounds of engine thrust was used in the simulation to plan this flight. The actual flight profile performance was the closest achieved of any flight to date. A comparison of the planned and actual conditions is shown below:

	Planned	Actual
Maximum Altitude Feet	67,000	68,150
Maximum Mach No.	1.40	1.39
Engine Burn Time - sec	117	117

X-24B Flight Request

21 June 1974

Flight No: B-13-24

Scheduled Date: 28 June 1974

Pilot: John Manke

Purpose:

1. Envelope Expansion to 1.40 Mach number
2. Stability and Control at Mach number >1.0 and 5^{o} α.
3. Fin, Rudder and Flap Pressure Survey
4. Boundary layer noise and vibration experiment (RED PLUG)

Launch: West of Rosamond, Mag Heading 060^{o} + Cross Wind Correction Angle. 45,000 feet, 190 KIAS. Flap Bias "Manual", Upper Flaps = -40^{o}, Lower Flaps = 27^{o}, Rudder Bias Mode "AUTO", Rudder Bias = 0^{o}. Rudder Trim = 1^{o} Left. Aileron Bias = + 7^{o}, SAS Gains 6, 5, 3. Mach Repeater "Manual" = 1.0, KRA "AUTO". Hydraulic Pumps 2 and 4 on.

Landing: Rogers Lakebed Runway 18

B-52 Track: X-24B Track #2 (R2515, Work Area I)

ITEM	TIME	ALT	A/S	α	M_T/M_i	EVENT
1	0	45	190	5	.71 (.70)	Launch, Light 4 Chambers, Trim to and Maintain 15^{o} α.
2	30	43	245	15	.84 (.82)	At 30 sec. Turn Overdrive on.
3	40	46	215	15	.81 (.80)	$\theta = 40^{o}$ Maintain $\theta = 40^{o}$ (cross check α)
4	74	57	175	14	.85 (.83)	At 57K (.85 $Mach_T$) Pushover to 12^{o} α.
5	98	65	190	12	1.05 (1.05)	At 1.05 $Mach_T$, pushover to 5^{o} α, KRA to "MANUAL".
6	105	67	205	5	1.15 (1.15)	Perform rudder and aileron doublets.
7	111	67	225	5	1.25 (1.25)	Perform rudder and aileron doublets

ITEM	TIME	ALT	A/S	α	M_T/M_i	EVENT
8	117	66	260	5	1.40 (1.40)	At 1.40 $Mach_T$ shut-down engine. Perform rudder and aileron doublets.
9	127	64	253	5	1.30 (1.30)	Pullup to 8^o α, pitch damper to zero gain and pitch pulse.
10	138	58	258	5	1.20 (1.20)	Pitch damper to "ON" Perform pushover-pullup (8^o-4^o-12^o-8^o α)
11	153	51	260	8	1.10 (1.10)	Trim to 8^o α, Perform rudder and aileron doublets while decelerating to $Mach_i$=0.65. Target $Mach_i$ numbers for these doublets sets are .93, .88, .77 and .66.
12	196	34	265	8	.76 (.75)	Intersection, continue doublet sets while turning to the low key heading until $Mach_i$= .65, then trim to 12^o α.
13	227	24	250	12	.58 (.57)	Change configuration to -20^o upper flaps. Trim to 10^o α and jettison propellants. Vector to low key. KRA to "AUTO" Set SAS Gains to pitch 4, roll 3 and Yaw 2.
14	270	20	220	10	.50 (.49)	Low key, rocket check, #1 and #3 hydraulic pumps on.
15						Change Mach repeater to 0.3 during final

NOTES:

1. Nose Ballast = 240 lbs (93 lb Inst Batt and 93 lb Equip Batt)

2.

	Weight-lbs	cg-%
Launch	13530	65.9
Shutdown	9203	64.1
Landing	8467	64.0 (gear down)

3. Engine S/N 8, Pump S/N 8A

	Normal	Overdrive
Thrust - lbs/chamber	2200	2450
LOX Flow Rate - lb/sec/chamber	4.51	5.045
WALC Flow Rate - lb/sec/chamber	4.05	4.53

4. Power on Base Drag Reduction C_C = -.005

5. Pitch Attitude Null at 40°

Ground Rules for NO LAUNCH:

1. Radio, radar, PCM failure
2. Electrical or SAS malfunction
3. A/S, altitude, Machmeter failure
4. Angle of attack or sideslip malfunction
5. Any control system malfunction
6. Loss of cabin pressure
7. Turbulence below 10K in excess of moderate
8. Surface winds greater than 20 kts or crosswind greater than 10 kts
9. Failure of engine control box heater
10. Failure of stick shaker

(In addition to standard ground rules published in Lift Body Joint Operations Plan)

Alternate Situations After Launch:

Failure	Action
1. Radio, radar, PCM	Proceed as planned.
2. Only One Chamber Operates	Vector for RW 02 Rosamond, shutdown chamber, jettison, change configuration.

	Failure	Action
3.	Only Two Chambers Operate	Maintain 15^{o} α. Shutdown on NASA I call (≈225 sec). At shutdown pushover to 8^{o} α and perform doublet sets while accelerating to $Mach_i$ = .75.
4.	Only Three Chambers Operate	Maintain 15^{o} α. Overdrive on at 30 sec. at 53K (.85M_T) pushover to 12^{o} α. at 1.05M_T pushover to 8^{o} α (overdrive stays on). Shutdown on NASA I call (≈150 sec), 8^{o} α and proceed as planned.
5.	Delayed Engine Light	Proceed as planned. Use 45^{o} θ (15^{o} α MAX). At 57K pushover to 12^{o} α.
6.	Overdrive Failure	Maintain 15^{o}. At 60K pushover to 12^{o} α, at 1.05 $Mach_t$ pushover to 10^{o} α, at 1.2 $Mach_t$ (watch β) pushover to 5^{o} α and proceed as planned (130 sec Burn Time).
7.	Total damper failure any axis	Fly 2 chamber profile, turn the overdrive off, Maintain 15^{o} α (13^{o} α for a pitch damper failure). Change configuration to 35^{o} upper flap at .7 Mach number. Shutdown on NASA I call. Roll or Yaw failure set Mach Rep. to 0.3. Pitch failure close-up to -24^{o} upper flap at low key.
8.	KRA "AUTO" Failure	Set to manual 10% and proceed as planned if "MANUAL" mode inoperative-switch to "EMER" position and set to above value.
9.	Angle of Attack (Indicator Only)	Proceed as planned using backup angle of attack gage. KRA "MANUAL" 10%, stick shaker off.
10.	Total Angle of Attack	Fly two Chamber profile, use 200 KTS instead of 15^{o} α. To rotate fly 1.0 g to 230 KCAS then fly 1.2 g to 200 KCAS. (KRA Manual 10%, stick shaker off)
11.	A/S Altitude, Mach	Proceed as planned using α, θ and time for profile control.
12.	Attitude System	Proceed as planned using backup attitude indicator.

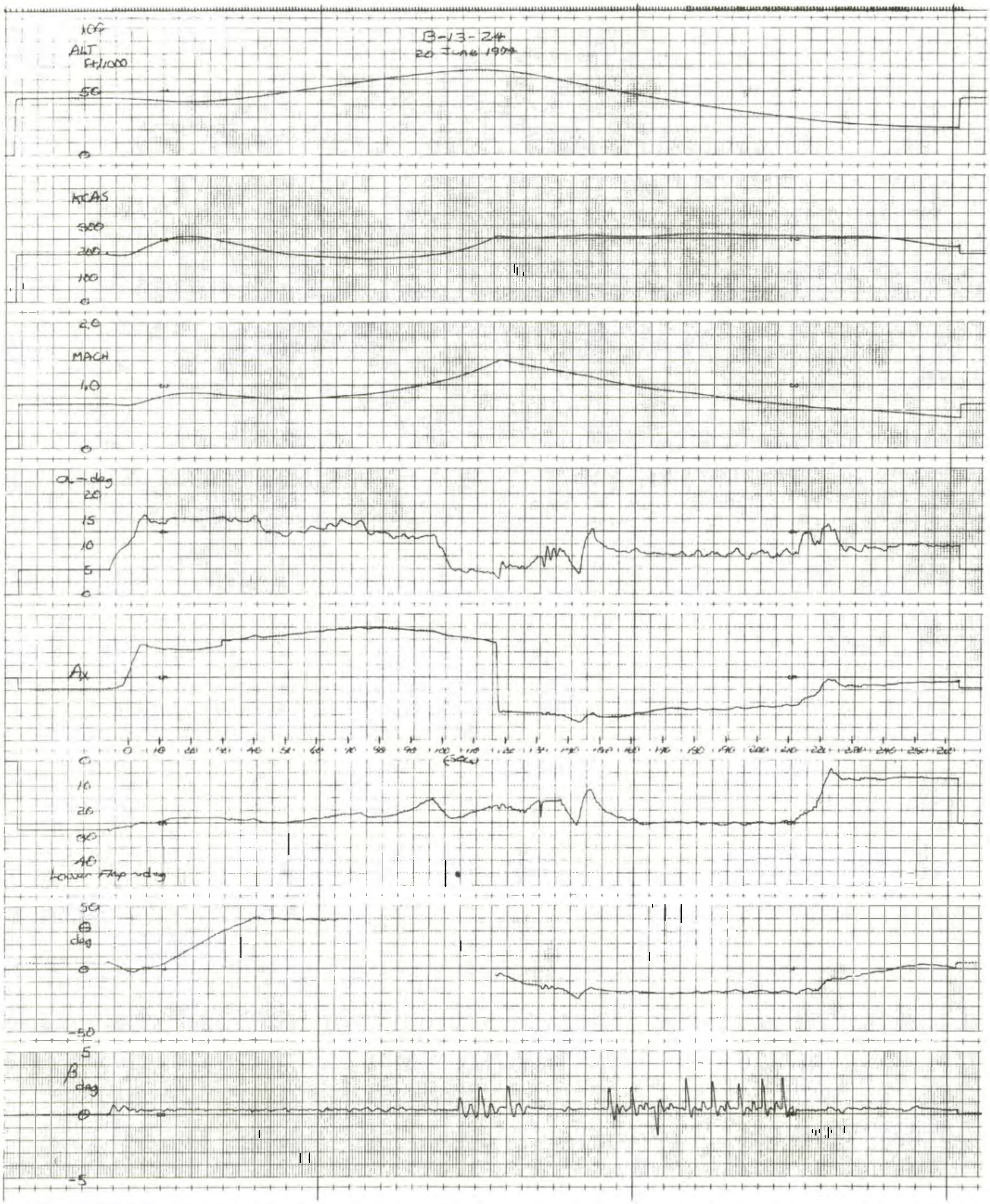
Failure	Action
13. Rudder Bias "AUTO" failure	Switch to "MANUAL" mode and toe-in to -10°. If "MANUAL" fails close-up to -24° upper flap.
14. Upper flaps fail to close	Cycle emergency flap switch to close-up to -20° upper flaps. If emergency flap switch fails, move δA_B to 11°.

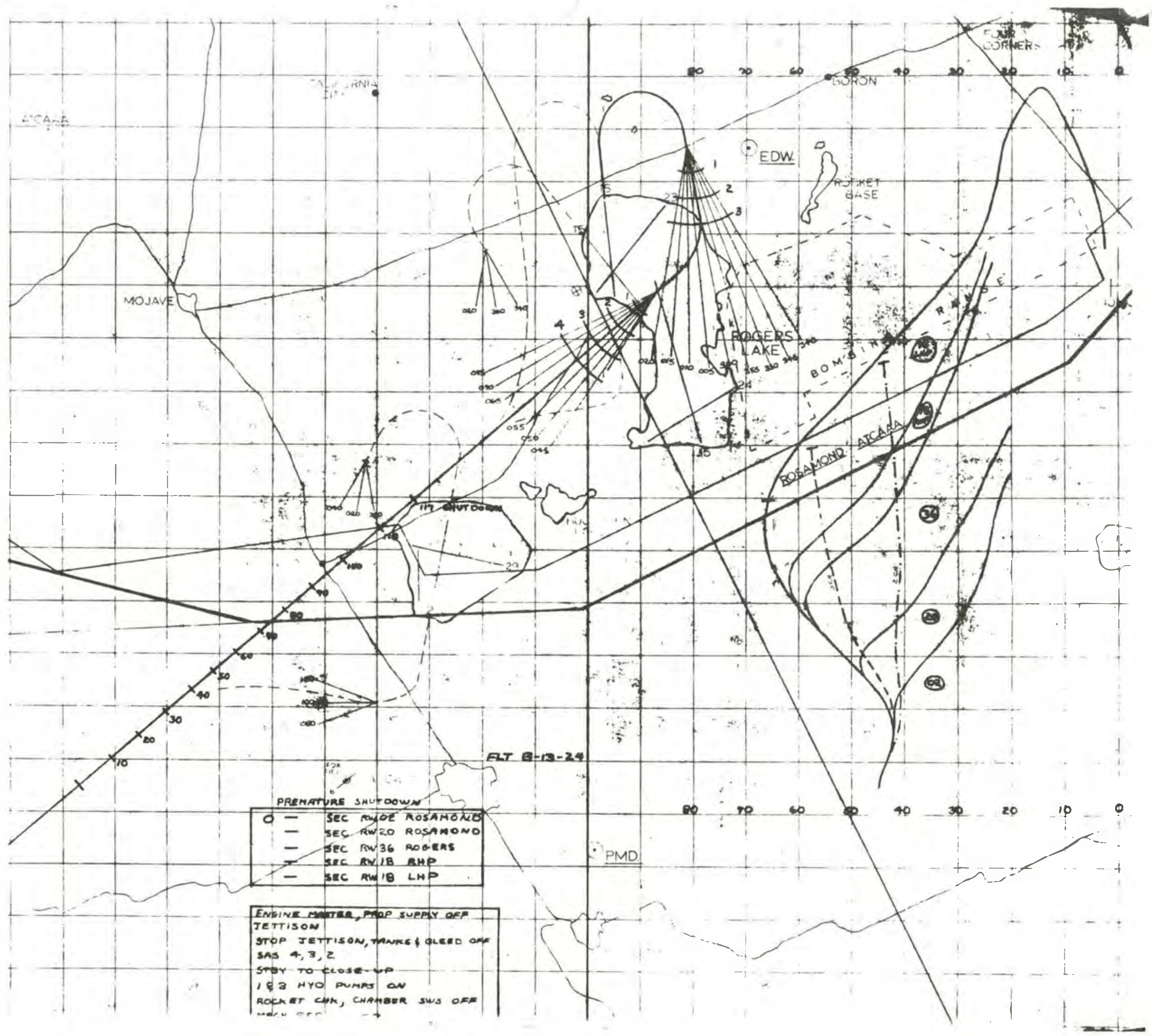
15. Premature Engine Shutdown

0 - 18 Sec RW 02 Rosamond
18 - 40 Sec RW 20 Rosamond
40 - 70 Sec RW 36 Rogers
70 - 80 Sec RW 18 (RHP) Rogers
80 - up Sec RW 18 (LHP) Rogers

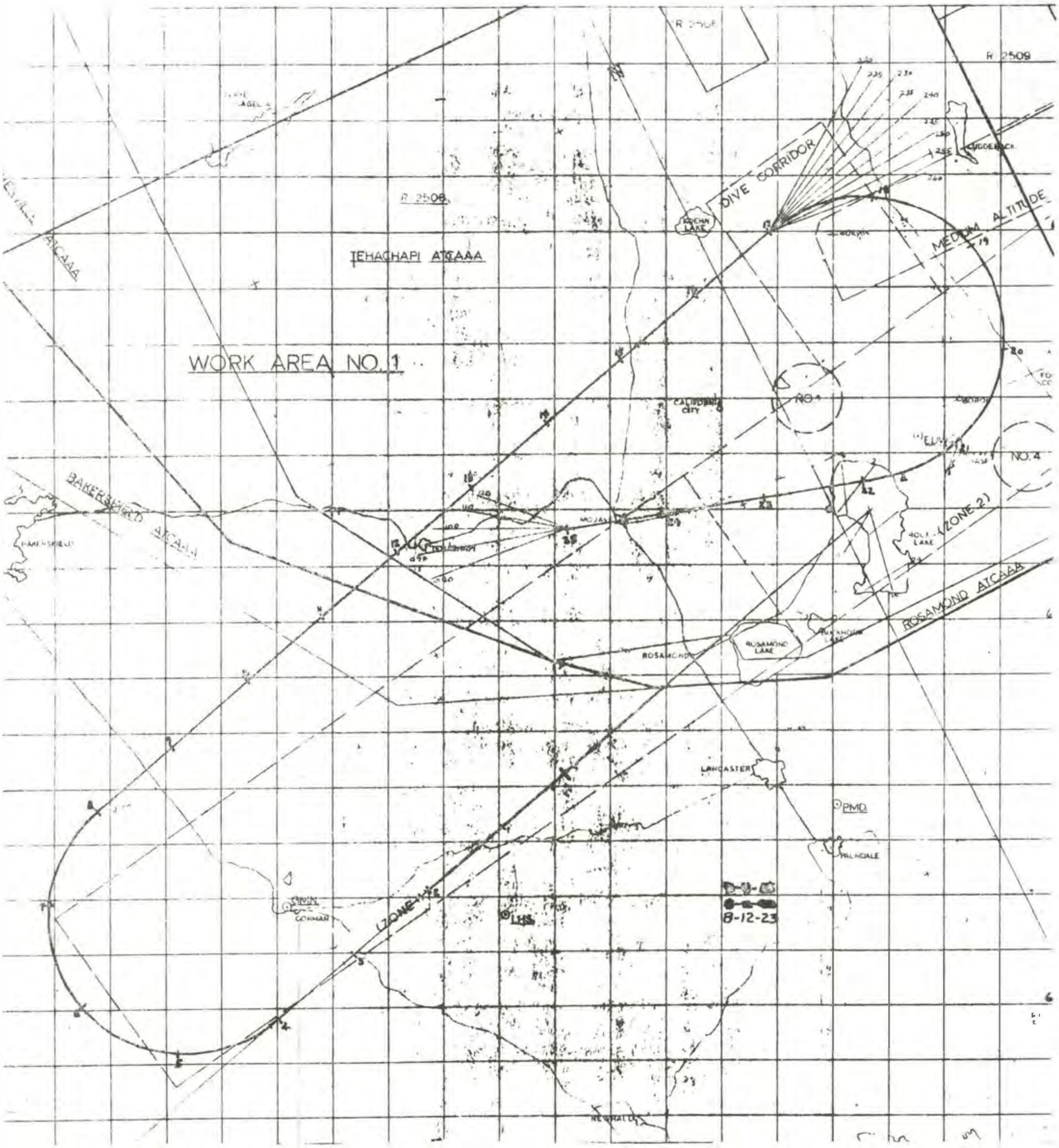
for Johnny G. Armstrong
ROBERT G. HOEY

for
JACK L. KOLF


B-13-24
20 June 1994
ALT ft/1000
KCAS
MACH
α - deg
Ax
(sec)
Lower Flap - deg
θ deg
β deg



FOUR CORNERS
BORON
CALIFORNIA CITY
EDW.
ROCKET BASE
MOJAVE
ROGERS LAKE
BOMBING RANGE
ROSAMOND ATCAAA
117 SHUTDOWN
FLT 8-13-24
PMD
PREMATURE SHUTDOWN
SEC RW02 ROSAMOND
SEC RW20 ROSAMOND
SEC RW36 ROGERS
SEC RW18 RHP
SEC RW18 LHP
ENGINE MASTER, PROP SUPPLY OFF
JETTISON
STOP JETTISON, TANKS & BLEED OFF
SAS 4, 3, 2
STBY TO CLOSE-UP
1 & 2 HYD PUMPS ON
ROCKET CHK, CHAMBER SWS OFF



R 2509
R 2508
DIVE CORRIDOR
MEDIUM ALTITUDE
TEHACHAPI ATCAAA
WORK AREA NO. 1
NO. 1
NO. 4
CALIFORNIA CITY
BAKERSFIELD ATCAAA
BAKERSFIELD
MOJAVE
ROSAMOND
ROSAMOND LAKE
ROSAMOND ATCAAA
(ZONE 2)
ROGERS LAKE
LANCASTER
PMD
PALMDALE
(ZONE 1)
GORMAN
LHS
NEWHALL
B-12-23

X-24B

MACH NO. VS ALTITUDE

ENVELOPE

FLIGHTS 1 THRU 13

X-24B

MACH NO. VS ANGLE OF ATTACK

ENVELOPE

FLIGHTS 1 THRU 13

X-24B EVENT SHEET FLT B-13 24

TIME	MACH	α	ALT	KCAS	EVENTS
09:56:14.7					ENGINE MASTER ON
:56:20.6					GOX PRIME
:56:23.7					CENTER FIN CAMERA ON
:56:29.6					LOX PRIME
:56:56.6	.704	3.3	44736.	189	LAUNCH
:56:59.1	.691	7.0	44598.	185	#1 & #3 CHAMBER PRESSURES START UP
09:57:00.4	.691	10.7	44587.	186	AX STARTS INCREASE
:57:01.6	.706	11.9	44489.	187	#1 AT 100%
:57:02.0	.699	12.3	44446.	188	#3 AT 100%
57:02.0	.699	12.3	44446.	188	AX LEVEL (2 CHAMBER)
:57:02.2	.700	12.5	44423.	189	#2 & #4 CHAMBER PRESSURES START UP
:57:02.6	.703	12.6	44392.	170.	RH FIN PRESSURE GLITCH
:57:02.7	.704	12.7	44382.	190.	WALC MANIFOLD PRESSURE DIPS TO 300 PSI
:57:03.3	.708	13.5	44305.	192.	LH FIN PRESSURE GLITCH
:57:03.4	.709	13.7	44295.	192.	AX STARTS INCREASE
:57:04.0	.719	14.4	44197.	193	15° α
:57:05.6	.734	14.9	44005.	201.	# 4 AT 100%
:57:06.0	.738	14.9	43951.	202	AX LEVEL (4 CHAMBER)
:57:06.6	.745	14.6	43865.	205	#2 AT 100%
:57:22.6	.869	15.2	42615.	247.	MAX MACH DURING ROTATION, α = 15½°
:57:30.3	.846	15.2	43531	238	OVERDRIVE ON
:57:30.4	.846	15.1	43553.	238.	AX STARTS INCREASE FROM .50g
:57:30.9	.845	15.1	43641.	237.	AX LEVEL AT .58g (4 CHAMBERS, OVERDRIVE)
:57:49.1	.779	12.9	49396.	189.	θ = 42°
09:58:10.6	.834	14.3	57462.	169	PUSHOVER TO 12° α
:58:13.2	.855	11.9	58333.	170.	12° α

TIME	MACH	α	ALT	KCAS	EVENTS
:58:21.4	.874	12.1	61237.	163.	L.H. FIN PRESSURE GLITCH
:58:21.5	.877	12.1	61283.	164.	Ax MAX, .76g
58:22.0	.890	11.4	61523.	166.	R.H. FIN PRESSURE GLITCH
:58:23.4	.895	11.3	61625.	167.	β STARTS OUT TO RIGHT
:58:24.2	.920	[illegible]	62277.	169.	β AT 3.4° NOSE RIGHT, PRESSURES RETURN TO NORMAL
:58:28.5	.963	11.4	63819.	177.	β RETURNS TO 1° NOSE RIGHT
58:30.5	1.01[illegible]	11.3	64563.	181.	START MACH JUMP
:58:34.1	1.024	11.5	65005	181.	END MACH JUMP
58:37.6	1.0[illegible]	10.5	66125.	183	PUSHOVER TO 5°α
:58:44.1	1.12	4.9	67446.	191	5°α
:58:45.6	1.19[illegible]	3.7	67569.	194.	KRA TO MANUAL
:58:46.2	1.16[illegible]	4.3	67726.	198.	RUDDER DOUBLET, $\alpha = 4\frac{1}{2}°$
:58:47.9	1.16[illegible]	3.9	67927.	204.	AILERON DOUBLET, $\alpha = 4°$
58:50.8	1.2[illegible]	3.7	68124.	215.	RUDDER DOUBLET, $\alpha = 4°$
:58:52.7	1.29[illegible]	4.6	68151.	223.	MAX ALTITUDE
:58:53.2	1.30[illegible]	5.1	68140.	225	AILERON DOUBLET, $\alpha = 5°$
:58:57.8	1.391	4.7	678[illegible]	245	ENGINE SHUTDOWN
:58:58.0	1.391	4.9	67823.	245	MAX MACH (799.1 KTAS)
9:59:00.2	1.378	4.4	67714.	242	RUDDER DOUBLET $\alpha = 4\frac{1}{2}°$
:59:03.5	1.350	3.7	66[illegible]	242	AILERON DOUBLET, $\alpha = 4°$
:59:05.3	1.332	3.5	66405.	240	PULL UP TO 7½°α
:59:07.2	1.308	7.4	65165.	242.	7½°α
:59:10.4	1.296	7.6	64730	242.	PITCH GAIN TO ZERO
:59:10.7	1.292	7.3	64618.	242.	PITCH PULSE, $\alpha = 7\frac{1}{2}°$

TIME	MACH	α	ALT	KCAS	EVENTS
:59 16.[illegible]	1.217	9.4	62396.	237.	PITCH GAIN TO 6
:59 17.4	1.205	7.9	62061.	236.	START POPU, α = 8°
:59.21.4	1.189	2.1	60141.	243.	MIN α = 3°
:59:26.8	1.135	14.5	57481.	244.	MAX α = 14½°
:59.31.3	1.123	8.3	55196.	254.	α = 8°
:59.31.3	1.123	8.3	55196.	254.	KRA TO ZERO
:59:33.8	1.069	8.9	53471.	246.	RUDDER DOUBLET, α = 9°
:59.36.3	1.056	8.1	52768.	249.	AILERON DOUBLET, α = 8°
:59.38.2	1.024	8.7	51919.	245.	START MACH JUMP
:59 39.8	1.017	7.6	51208.	247.	RUDDER DOUBLET, α = 7½°
:59 40.5	1.005	7.3	50646.	247.	END MACH JUMP
:59.41.5	.991	[illegible]	[illegible]	245.	AILERON DOUBLET, α = 7½°
:59 43.5	.982	7.2	49452.	247.	RUDDER DOUBLET, α = 7½°
:59 46.2	.976	7.8	48100.	253.	AILERON DOUBLET, α = 8°
:59 52.6	.917	6.5	44816.	254.	RUDDER DOUBLET, α = 7½°
59.50.8	.931	7.5	45714.	255.	RH FIN PRESSURE GLITCH
59.53.2	.917	6.6	44595	254.	AILERON DOUBLET α = 7°
59.56.2	.901	7.1	43195	258	RUDDER DOUBLET α = 7°
59:56.8	.901	7.1	43109.	259.	RH FIN PRESSURE GLITCH
59:58.6	.884	7.4	42093.	257.	AILERON DOUBLET α = 7°
10:00:01.1	.862	7.2	41053	258.	RUDDER DOUBLET α = 7½°
:00:03.7	.850	7.3	39364.	261.	AILERON DOUBLET α = 7½°
:00 06.0	.839	7.5	38932.	262	RUDDER DOUBLET α = 7½°
:00 09.5	[illegible]	7.8	37561.	260.	AILERON DOUBLET α = 7½°
:00.11.3	.796	7.7	36915.	259.	RUDDER DOUBLET α = 7½°
:00:14.1	.782	7.7	35932	260.	AILERON DOUBLET α = 7½°

TIME	MACH	α	ALT	KCAS	EVENTS
:00 16.9	.761	7.7	34989.	258.	RUDDER DOUBLET, α = 7½°
00:19.4	.744	7.5	34189.	256.	AILERON DOUBLET, α = 7½°
00:21.6	.735	7.5	33501.	257.	RUDDER DOUBLET α = 7½°
00:21.6	.735	7.5	33501.	257.	RH FIN PRESSURE GLITCH
.00:22.2	.731	7.7	33324.	256.	LH FIN PRESSURE GLITCH
:00.24.2	.719	7.3	32724.	255.	AILERON DOUBLET, α = 7°
:00:26.2	.706	7.1	32124.	253.	RUDDER DOUBLET, α = 7°
.00 28.8	.692	7.1	31368.	252.	AILERON DOUBLET, α = 7°
00 31.4	.681	7.3	30615.	252.	RUDDER DOUBLET, α = 7°
:00.34.5	.671	7.5	29719.	253.	AILERON DOUBLET, α = 7½°
00:37.0	.659	7.9	29033.	252.	RUDDER DOUBLET, α = 8°
00. 40.0	.653	8.0	28218.	254.	AILERON DOUBLET, α = 8°
:00.42.2	.647	7.9	27643.	253.	RUDDER DOUBLET, α = 7½°
:00:43.4	.636	8.1	27300.	251.	RH FIN PRESSURE GLITCH
00 44.7	.631	8.2	27001	251	AILERON DOUBLET, α = 8°
:00.46.5	.620	8.6	26568.	249.	PULL UP TO 12½° α
:00 47.0	.617	9.8	26446.	248.	START TURN TO DOWNWIND (MAX ϕ = 38°)
.00.48.3	.608	12.4	26124.	246.	12½° α
.00.53.2	.563	13.3	25282.	231.	UPPER FLAPS START IN FROM 40°
:0:01.00.0	.535	12.2	24557.	222.	UPPER FLAPS AT 20°
.01 03.2	.519	11.7	24133.	218.	START LOX JETISON
01.11.2	.505	12.9	23611.	214	END LOX JETISON
01 11.5	.504	12.7	23589.	213.	ϕ = 30°
:01.22.6	.482	10.9	22613.	208.	KRA TO AUTO
01.23.4	.481	11.1	22547.	208.	PITCH GAIN TO 4
.01:24.2	.479	11.2	22480.	207.	ROLL GAIN TO 3
:01.24.5	.478	11.2	22447.	207.	END TURN TO DOWNWIND
:01.25.4	.476	11.5	22380.	206.	YAW GAIN TO 2

TIME	MACH	α	ALT	KCAS	EVENTS
:01:37.1	.451	11.4	21338.	200.	START WALC JETISON
:01:42.0	.453	9.9	21108.	201.	END WALC JETISON
.01:42.2	.454	9.8	21097.	202.	#1 HYDRAULIC PUMP ON
.01.42.9	.453	10.9	21042.	202.	#3 HYDRAULIC PUMP ON
10.02:03.5	.445	7.1	19193.	206.	START ROCKET CHECK
:02:04.2	.447	8.3	19106.	207.	END ROCKET CHECK
:02:14.2	.470	8.3	17710.	204.	LOW KEY, START TURN (MAX $\phi > 50°$)
.03:29.3	.468	5.7	4450.	286.	LEVEL ON FINAL
:03:37.8	.442	6.1	[illegible]	[illegible]	START FLAME
10.03:53.2	.371	8.2	2289.	236.	GEAR DOWN
10:04:0[illegible].2	.278	11.7	223[illegible]	177.	MAIN GEAR TOUCHDOWN, $\alpha = 12°$
:04:04.5	.275	10.2	[illegible]	175.	CROSSOVER TO UPPER FLAP
:04:06.0	.258	-4.6	[illegible]	164.	NOSEGEAR TOUCHDOWN
:04:06.1	.256	-5.9	2237.	163.	RETURN TO LOWER FLAP
.05:16.0					CENTER FIN CAMERA OFF

X-24B DERIVATIVES

Alex G. Sim

On flight 13, one longitudinal and 17 lateral-directional sets of derivatives were analyzed.

The longitudinal set of derivatives was obtained at 1.25 Mach number and 7.5° angle of attack. These data, shown in figure 1, indicate longitudinal static stability to be slightly lower than wind-tunnel predictions; while longitudinal control effectiveness and damping are slightly higher.

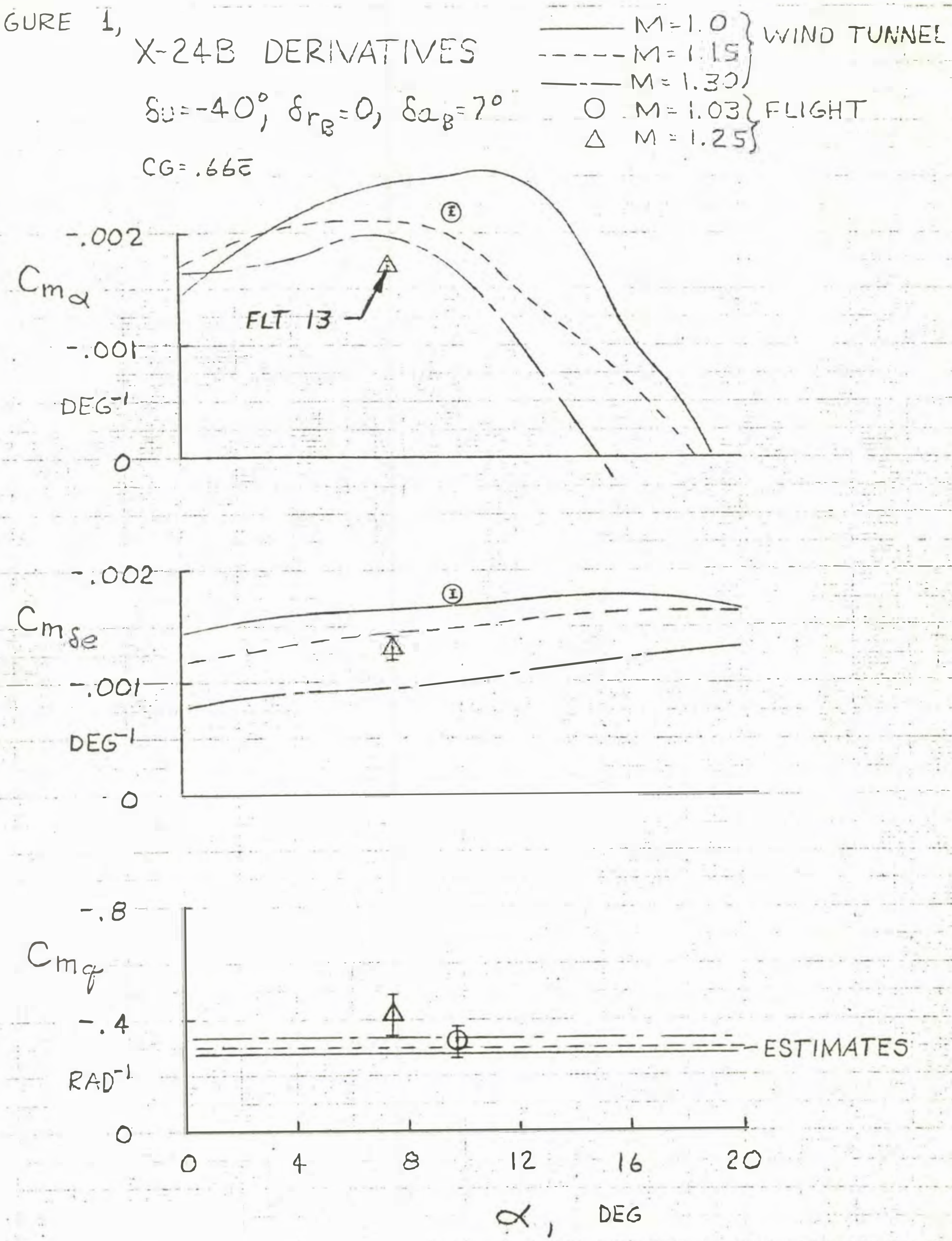
The lateral-directional sets of derivatives obtained were at either 4° or 7.5° angle of attack across the Mach number range. These data for the lateral-directional stability parameters C_{l_β} and C_{n_β} are shown in figure 2 along with previously obtained data. Considering first the effective dihedral parameter, C_{l_β}, the flight and the wind tunnel generally agree (except in the Mach number range from 0.90 to 0.99). The effect of power is to decrease stability (predicted but not shown) which holds true except for the Mach number 1.29 data point. However, more supersonic, power on data is needed to better define this region. In the Mach number range from 0.90 to 0.99, the wind-tunnel predictions and flight do not agree.

The static directional stability parameter, C_{n_β}, is very interesting. At 5° angle of attack, the power-off wind tunnel and flight data correlate very well. Again, a power on decrease in stability is evident. At 7.5° angle of attack and for Mach numbers up to about 0.73, C_{n_β} is significantly higher than predicted. From about 0.75 to 0.97 Mach number, C_{n_β} is lower than predicted but somewhat follows the trend of the wind tunnel predictions. Above Mach number 1.0, the flight and wind tunnel generally agree with the effects of power not being pronounced. However, of specific interest is the jump in the stability level between 0.73 and 0.75 Mach number. This occurs at the same Mach number where visual techniques and pressure measurements indicate flow separation on the upper inside surfaces of the vertical tip fins.

FIGURE 1, X-24B DERIVATIVES

$\delta_U = -40°$, $\delta_{r_B} = 0$, $\delta_{a_B} = 7°$

CG = .66$\bar{c}$



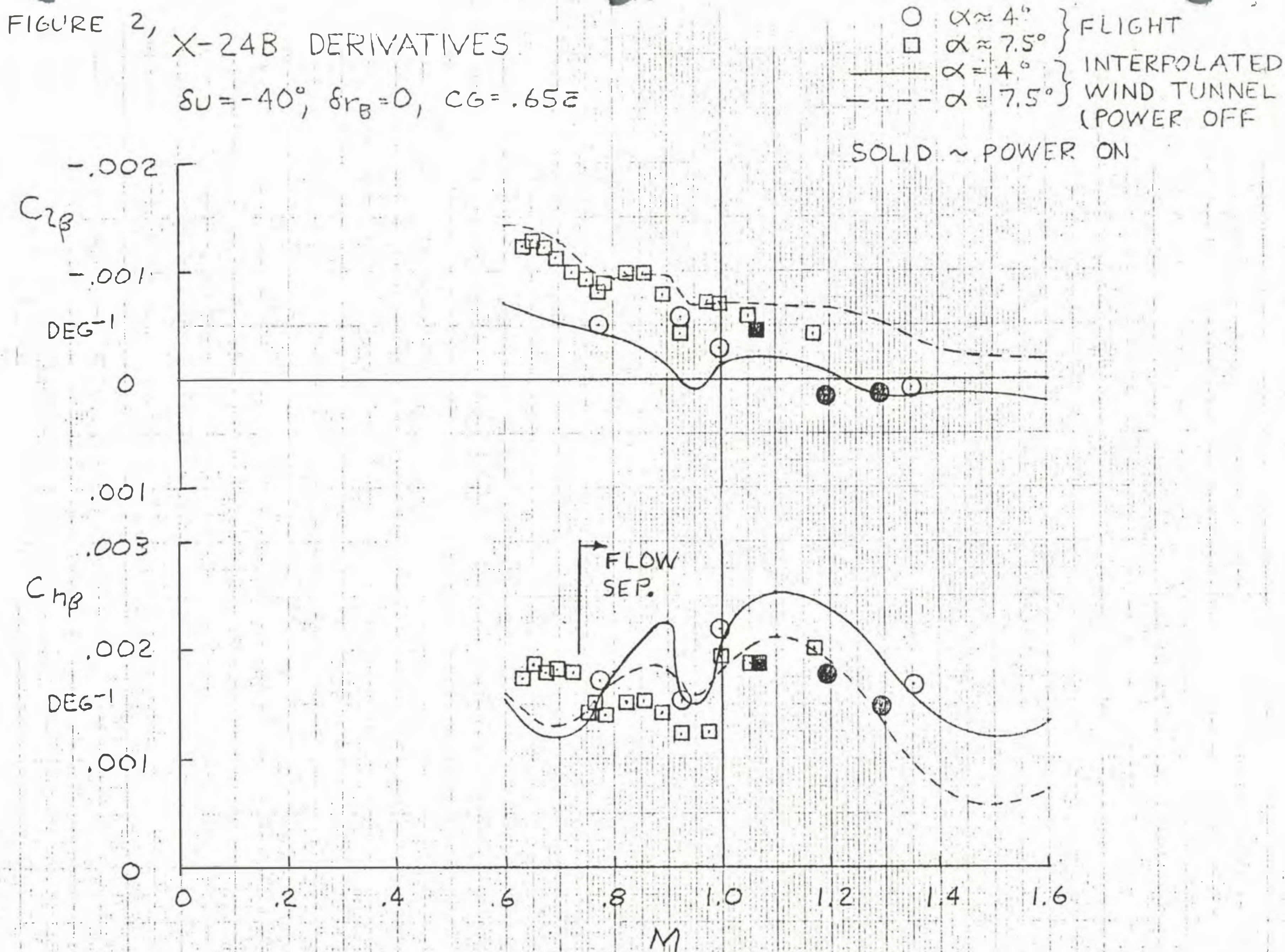


FIGURE 2, X-24B DERIVATIVES
δU = -40°, δrB = 0, CG = .65c̄
○ α ≈ 4°
□ α ≈ 7.5°
FLIGHT
α = 4°
α = 7.5°
INTERPOLATED WIND TUNNEL (POWER OFF
SOLID ~ POWER ON
-.002
-.001
0
.001
DEG⁻¹
.003
.002
.001
0
FLOW SEP.
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
M

FLT B-13-24

HANDLING QUALITIES SUMMARY

ENGINE LITE

- NO TRIM CHANGE NOTED

ROTATION

- LOOSER IN PITCH THAN SIMULATOR

PITCH	3
LAT DR	2

BOOST

- TASK TO MAINTAIN 40° θ — 2 1/2
  - "PRETTY EASY"
- α TO MAINTAIN θ
  - COMPARED WELL WITH SIMULATOR
- ROLL TASK
  - TWO HANDS
  - SIMPLE

HQ ABOVE .85 M AT 12° α (PWR ON)

- WIND UPSETS
- LOOSER IN YAW THEN AT 10° α — LAT DR 3 1/2 - 4
- LAT DR TASK NOT SPECIFIC

HANDLING QUALITIES (CONT'D)

HQ ABOVE 1.0M AT 5° α (PWR ON)

- "SOLID IN PITCH" 2
- "SUPER LATERAL DIRECTIONALLY"

RESPONSE TO 1.15M, 5° α DOUBLETS (PWR ON)

- "THE SIMULATION IS EXCELLENT 2
  IN THIS AREA"

ENGINE SHUTDOWN

- NO TRIM CHANGE NOTED
- DECELERATION VERY APPARENT

PITCH PULSE AT 1.25 M, 8° α (PITCH SAS OFF)

- WELL DAMPED
- COMPARES WELL TO SIMULATOR

HQ DURING DECEL FROM 1.1 TO .65 M AT 8° α

- PITCH TRIMMING FOR α WAS THE
  MAJOR TASK 2½ - 3
- LITTLE CHANGE IN CONTROL EFFECTIVENESS
- "REALLY NICE IN TRANSONIC REGION"

Performance and Longitudinal Trim

By

Dave Richardson

During flight 13 a planned pushover-pullup maneuver was performed at Mach 1.2 with the rocket engine off. A comparison between the performance data extracted from this maneuver and the Cornell wind tunnel data reveals the following trends. The lift to drag ratio compares well, however, maximum $^L/D$ was not reached in the flight vehicle (figure 1). The drag and chord force is slightly less than the predicted data at the lower angles of attack (figures 2 and 3). The slope C_{N_α} is 18 percent less than the predicted data.

The longitudinal trim data at Mach 1.2 still shows a reduction in static margin when compared with the predicted data (figure 4). The broken line in this figure is data from the X-24B simulator which is based on wind tunnel predicted data. The solid line in the figure is the latest X-24B simulator data which contains an update to account for the reduced static margin established from subsonic maneuvers.

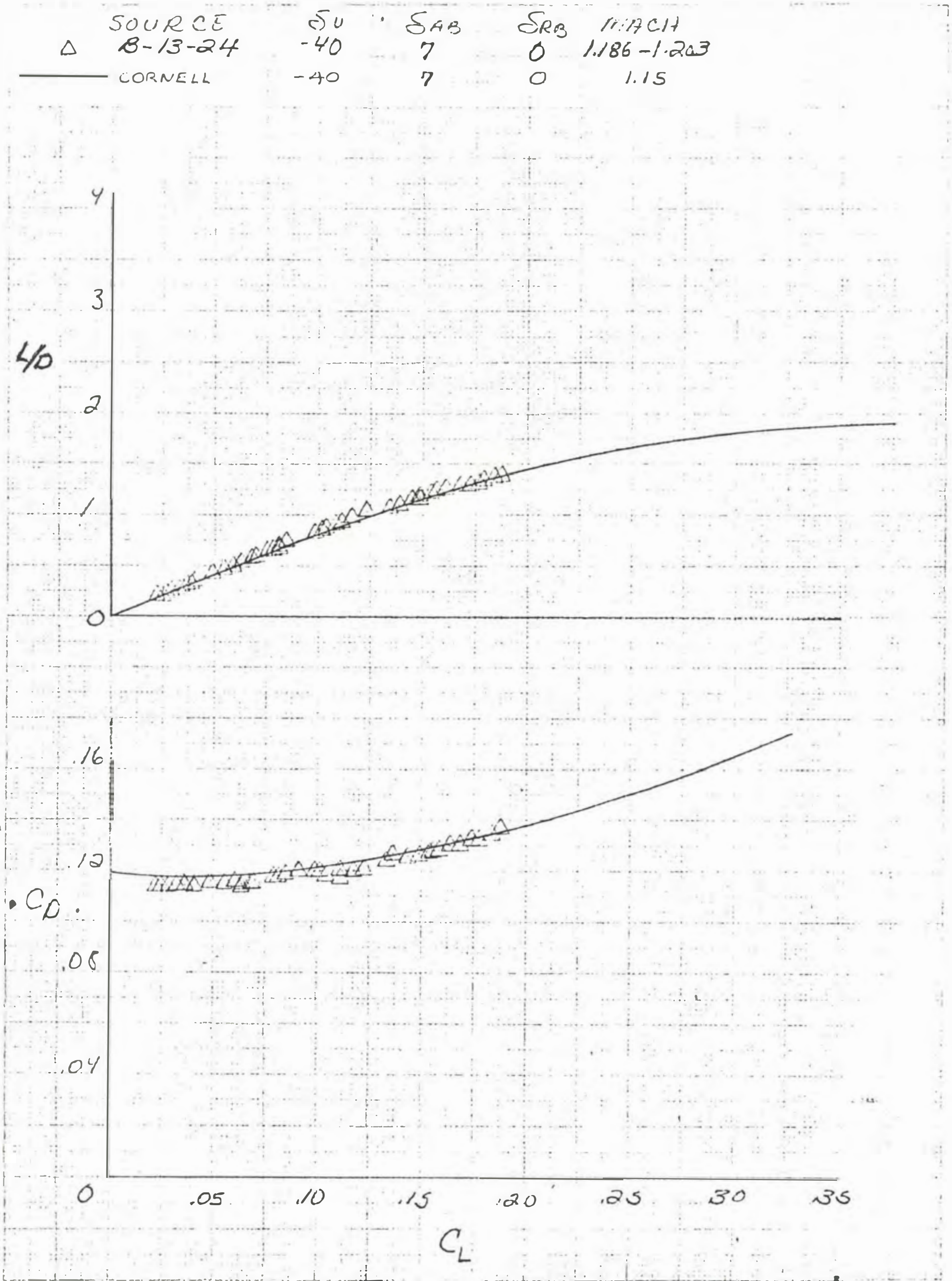

SOURCE δU δAB δRB MACH
△ B-13-24 -40 7 0 1.186-1.203
CORNELL -40 7 0 1.15
L/D
C_D
C_L
0
.05
.10
.15
.20
.25
.30
.35
1
2
3
4
.04
.08
.12
.16

FIG 1

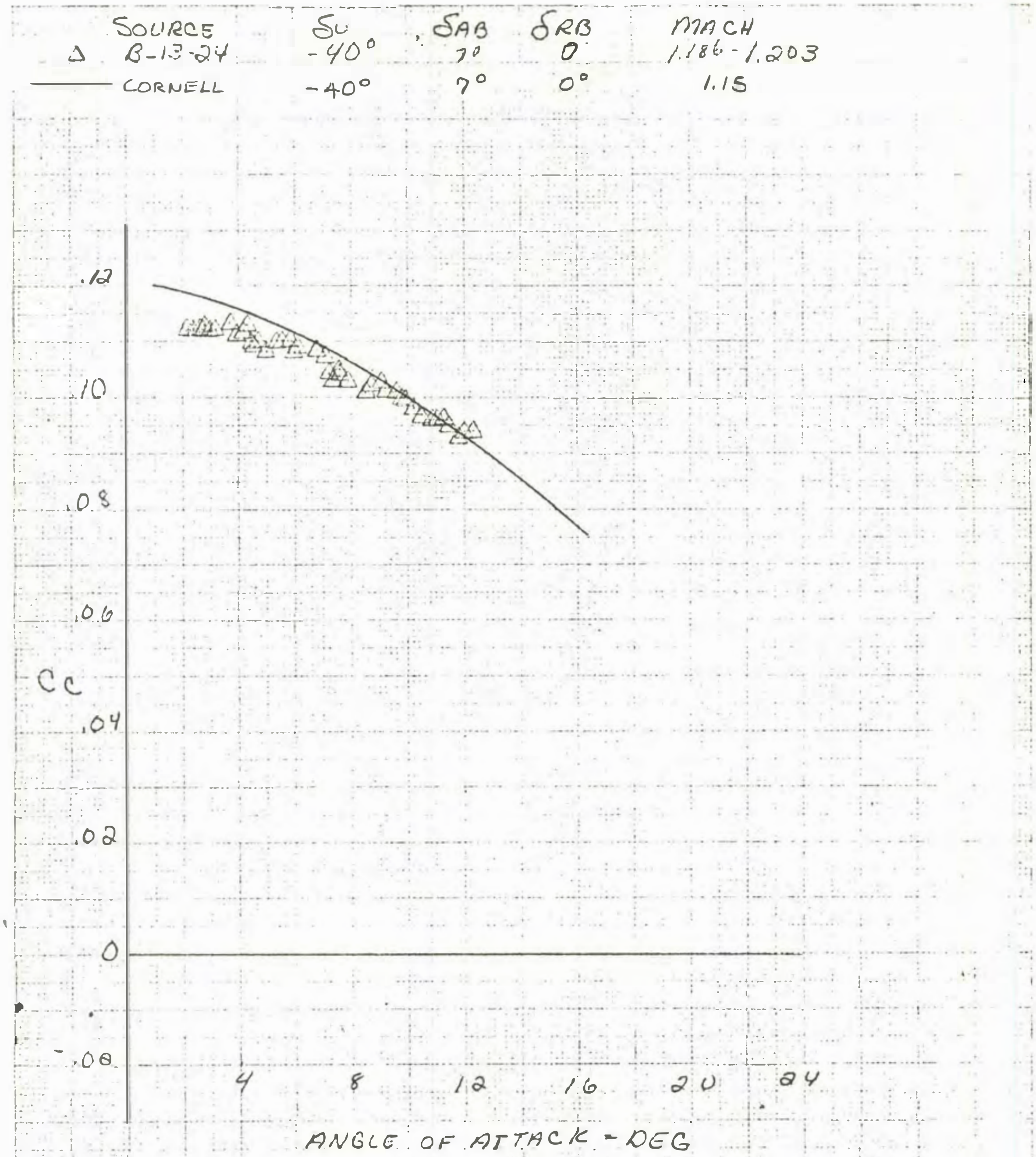

SOURCE
δU
δAB
δRB
MACH
B-13-24
-40°
7°
0
1.186-1.203
CORNELL
-40°
7°
0°
1.15
.12
.10
.08
.06
CC
.04
.02
0
-.02
4
8
12
16
20
24
ANGLE OF ATTACK - DEG

FIG 2

	SOURCE	δ_U	δ_{AB}	δ_{RB}	MACH
△	B-13-24	-40	7°	0	1.186-1.203
——	CORNELL	-40	7°	0	1.15

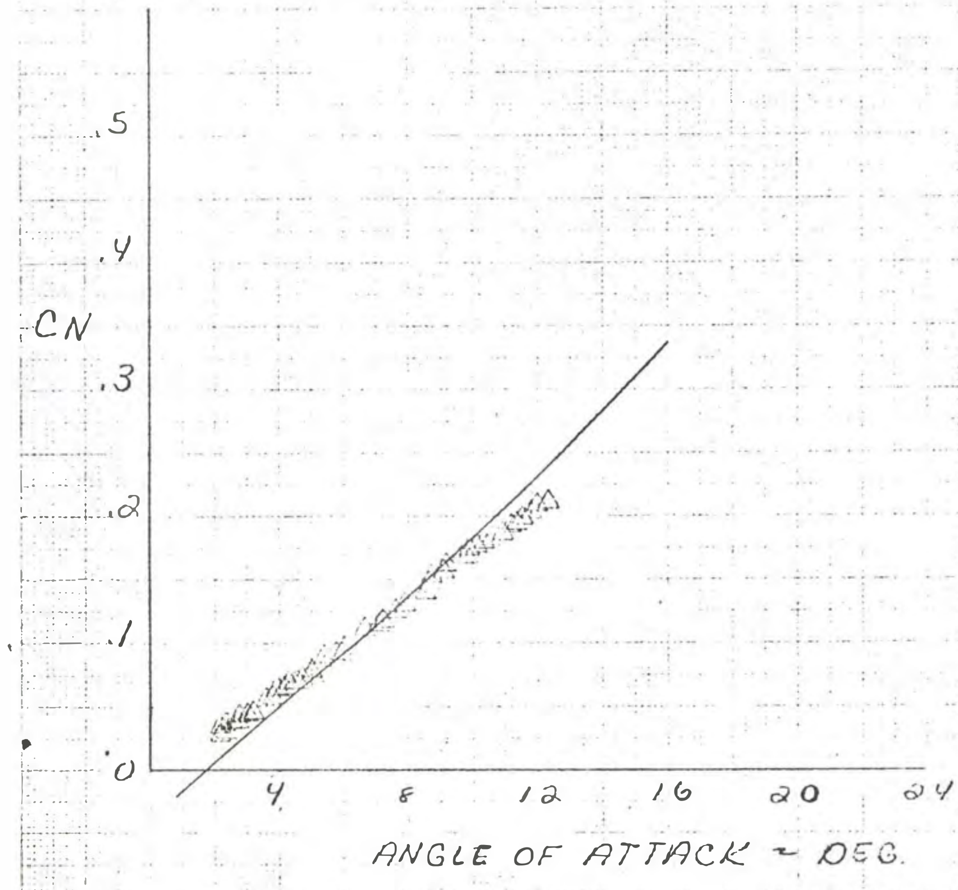


FIG 3

K+E 10 X 10 TO THE CENTIMETER 18 X 25 CM. • ALBANENE® KEUFFEL & ESSER CO. 46 1516 MADE IN U.S.A.

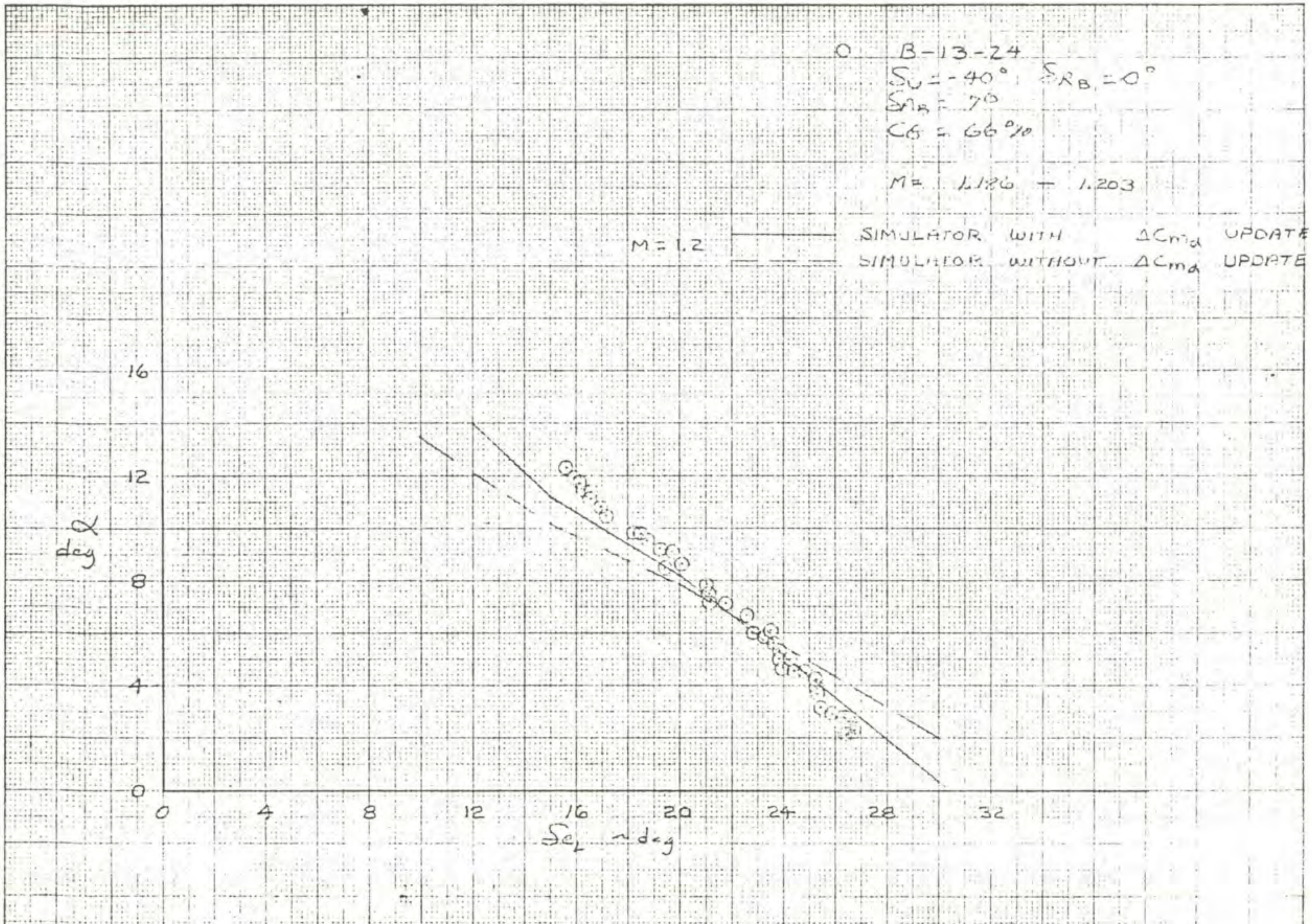


FIG 4

Correlation of Tip Fin Pressure Anomalies
with Right Fin Tuft Photos

by

Captain John L. Stuart & Johnny G. Armstrong

Figure 1 shows the Mach number and angle of attack conditions at which "pressure glitches" occurred on the inside surface of the left and right fins during Flights 6 through 12. Also shown is the flow boundary which was postulated in the Flight 10 Flight Report. It is now felt that the "glitches" which occur at or near 0.9 Mach are unrelated to those which occur between 0.6 Mach at 14° and 0.8 Mach at 4° . Figure 2 shows the conditions at which "glitches" occurred on Flights 6 through 13, and two flow boundaries.

This author is not sufficiently knowledgeable in the field of applied aerodynamics to define the origins or causes of these anomalies, but the following possibilities are offered with little explanation and no defense. The vertical (solid) boundary near 0.9 Mach could result from the formation of a standing shock wave, which would most likely be independent of vehicle angle of attack but would be somewhat dependent on sideslip angle (angle of attack of the fin itself). This might explain the small amount of data scatter. The other (dashed) boundary could be caused by separation of the flow near the fin leading edge due to interference from the vehicle body or impingement of a vortex shed from the vehicle body. Either of these phenomena would be highly dependent on both Mach number and angle of attack; they would also be moderately dependent on sideslip angle, which would again explain the data scatter.

Figure 3 shows a portion of the Flight 13 pressure tap time history. The saw-tooth excursions are responses to rudder doublets and are not considered "glitches"; only step changes in the nominal pressures are considered. It is interesting to note that the "glitch" at tap 6 on the right fin occurs at a significantly lower Mach number than those at the other three taps.

Prior to Flight 10, three tufts were placed on the inside surface of the right fin. They were photographed with a camera mounted high at the trailing edge of the center fin. Analysis of the films from Flights 10 through 13 shows that there are two distinct flow patterns, and that the boundary between these patterns coincides with the "separation" (dashed) boundary described above (see Figure 4). These flow patterns are similar to those observed for the X-24A fin (ref: NASA TM X-2816, Flight-Measured X-24A Lifting Body Control-Surface Hinge Moments and Correlation with Wind-Tunnel Predictions, Ming H. Tang and George P.E. Pearson, June 1973). At lower Mach numbers and angles of attack, the flow is generally spanwise and somewhat unsteady at all three locations. At the separation boundary, the flow characteristics change abruptly. At higher Mach numbers and angles of attack, the forward tuft is very erratic and stands out away from the fin surface indicating separated flow; the center tuft is slightly steader but lies 0° to 15° forward of vertical suggesting that the flow is still separated at this position; the aft tuft indicates unsteady, chordwise flow (see Figure 5).

While in the higher Mach number and angle of attack region, both the center tuft and the aft tuft abruptly assumed the lower Mach and α characteristics for extremely short periods; however, these changes occurred at widely scattered Mach and α conditions, and they very seldom occurred together. They did not cluster around 0.9 Mach. It was this fact that prompted the author to postulate that the 0.9 Mach "glitches" are not related to those which occur at the "separation" (dashed) boundary.

With the knowledge from the pressure taps and tufts that a major change in flow occurs at approximately .7 Mach Number; data maneuvers were planned on flight 13 to investigate the resulting effect on the stability derivatives. To accomplish this, rudder and aileron doublets were performed at the same angle of attack thru this Mach range. Figure 6 presents the resulting Cn_{β}. Note that, as Mach Number exceeds .73, a step decrease in Cn_{β} occurs. This unique use of the pressure and tuft information to gain insight into the test conduct and analysis of aircraft stability speaks well for the X-24B instrumentation system and the aircraft itself as a research vehicle.

It is concluded from the information presented above that a more detailed study of the two phenomena, with emphasis on their causes and effects, should be conducted by the Flight Dynamics Laboratory.

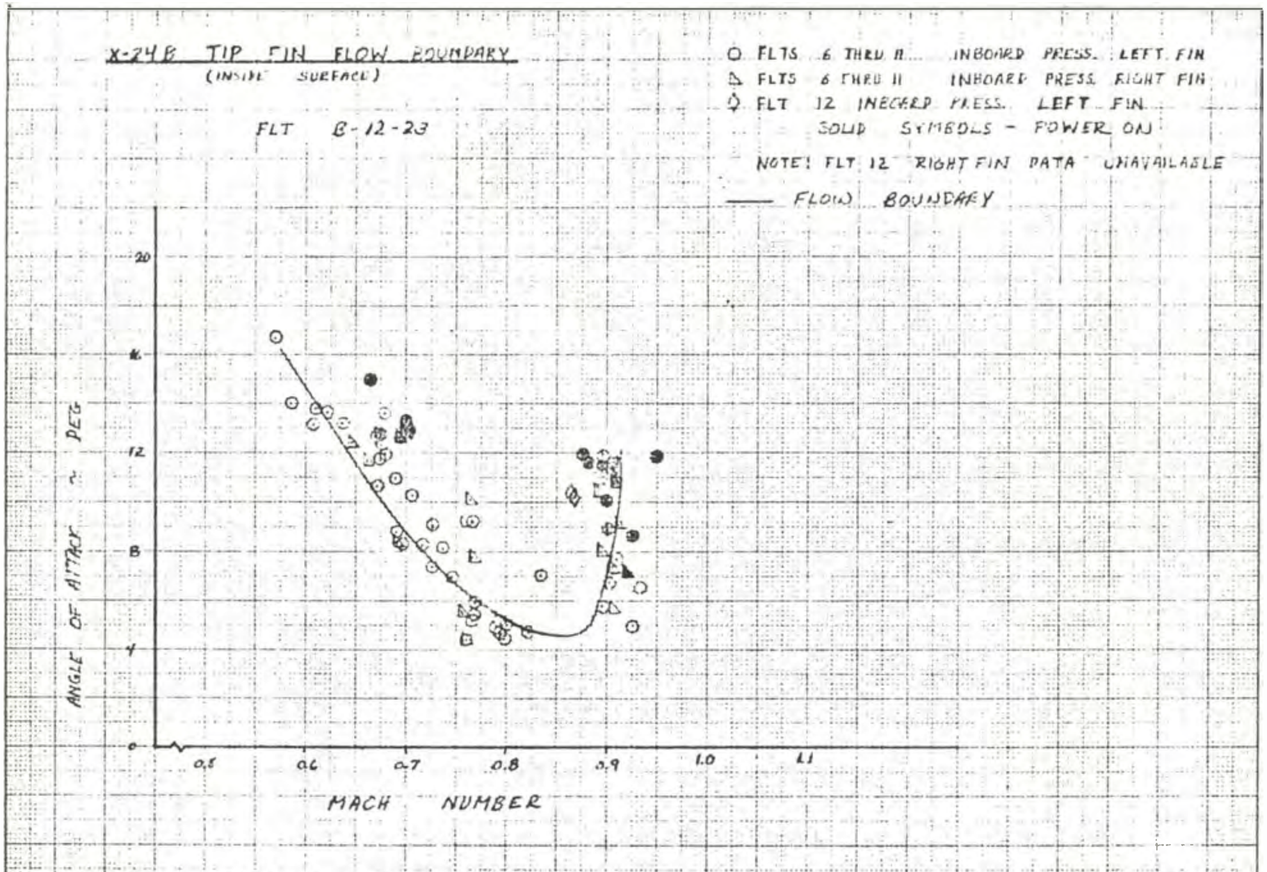


FIGURE 1.

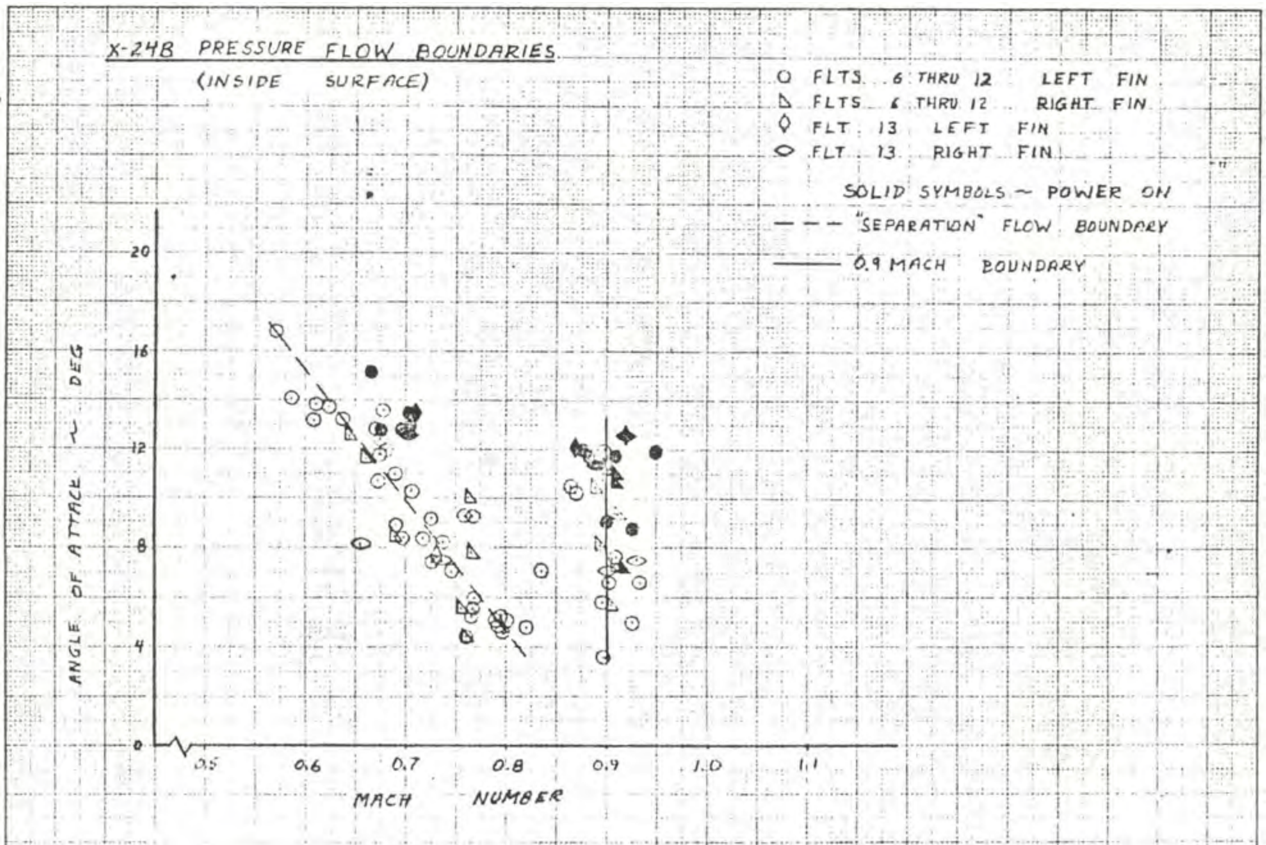


FIGURE 2.

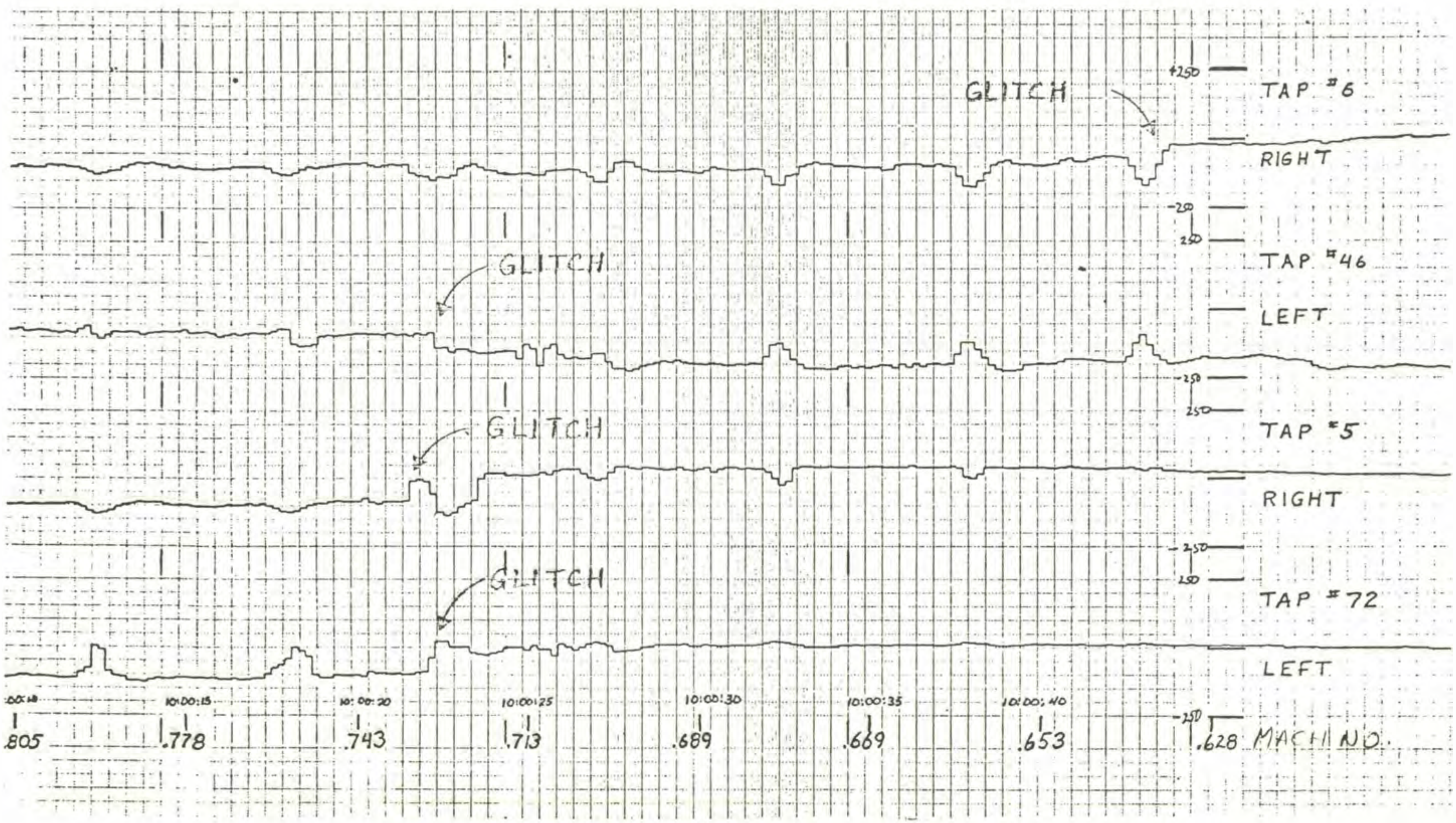


FIGURE 3. FIN PRESSURE TRACES

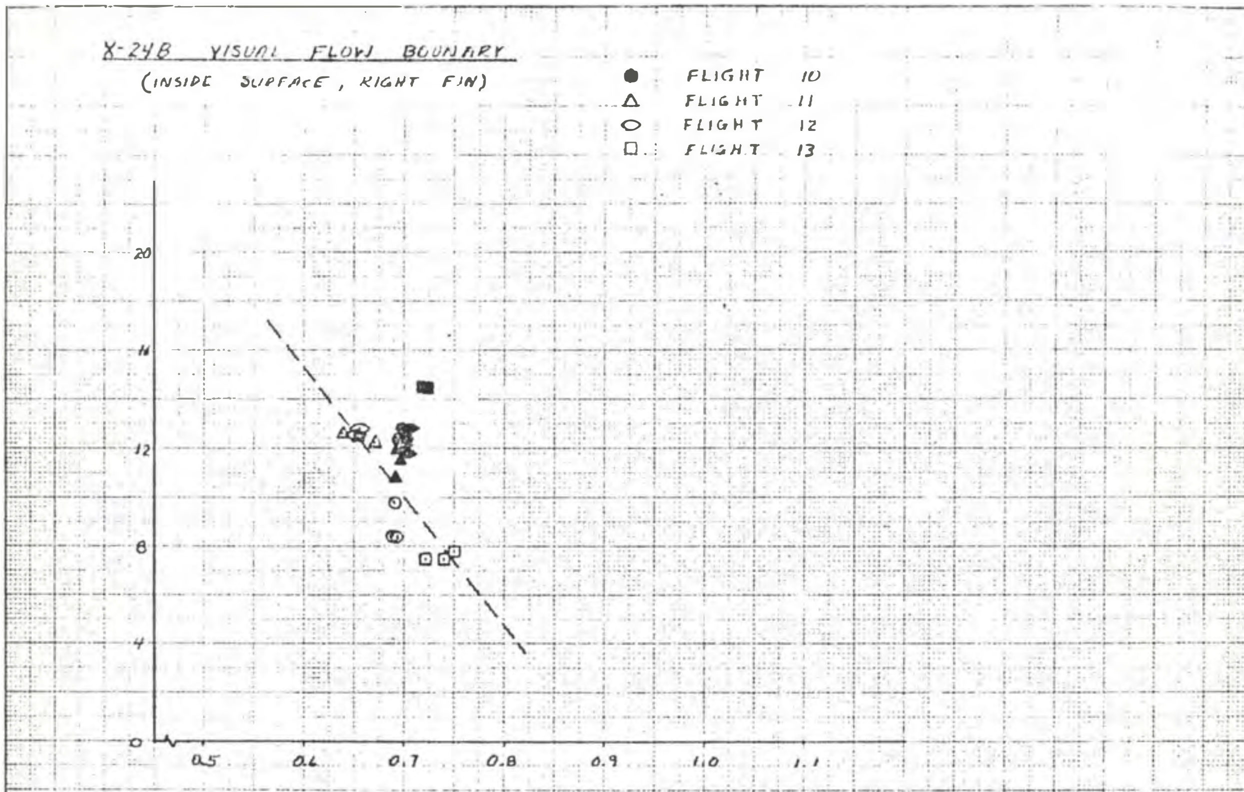


FIGURE 4.

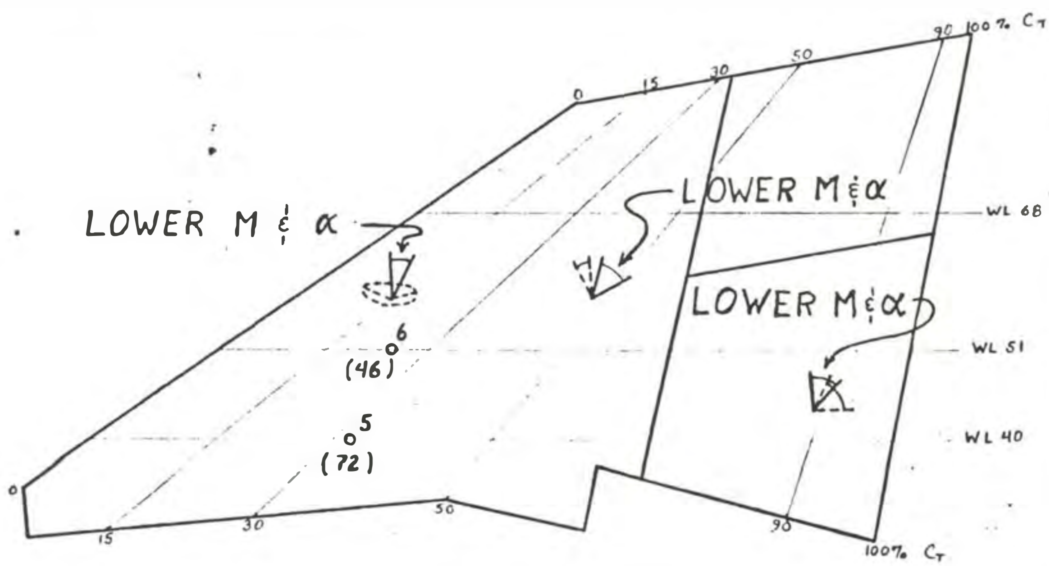
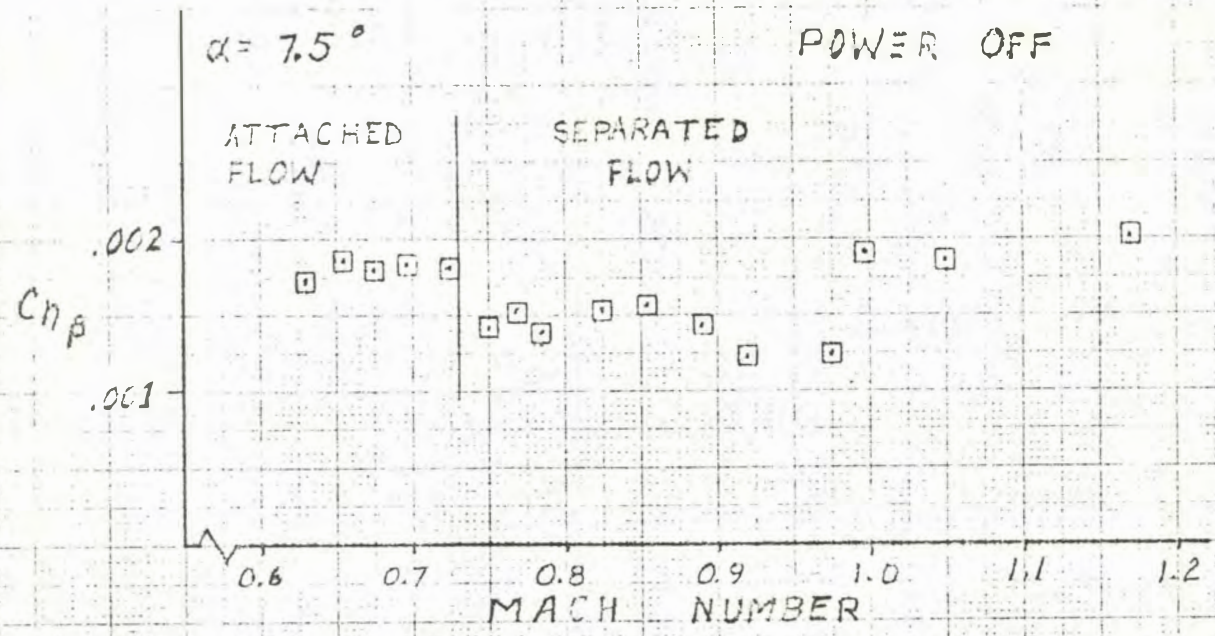


FIGURE 5. FIN FLOW PATTERNS.



α= 7.5°
POWER OFF
ATTACHED FLOW
SEPARATED FLOW
.002
.001
Cn β
0.6
0.7
0.8
0.9
1.0
1.1
1.2
MACH NUMBER

FIGURE 6.

Flt B-13-24 Wind Profiles
by
Dennis J Penka, Capt

Several pilot comments were made during the powered boost portion of this mission concerning wind upsets. Examination of the Jimsphere sidewind profile (Fig 1) shows several wind shifts with altitude. As reported previously, Rawinsonde data do not show these changes. Comparison of the computed profile with the Jimsphere profile was good (Fig 2). Additionally on this flight a wind profile in the aircraft's vertical plane was also computed (an α-disturbance producing component) which compared well with the Jimsphere data (Fig 3).

Attached is a memo summarizing the wind disturbance investigation which was distributed here in the Performance & Flying Qualities Branch.

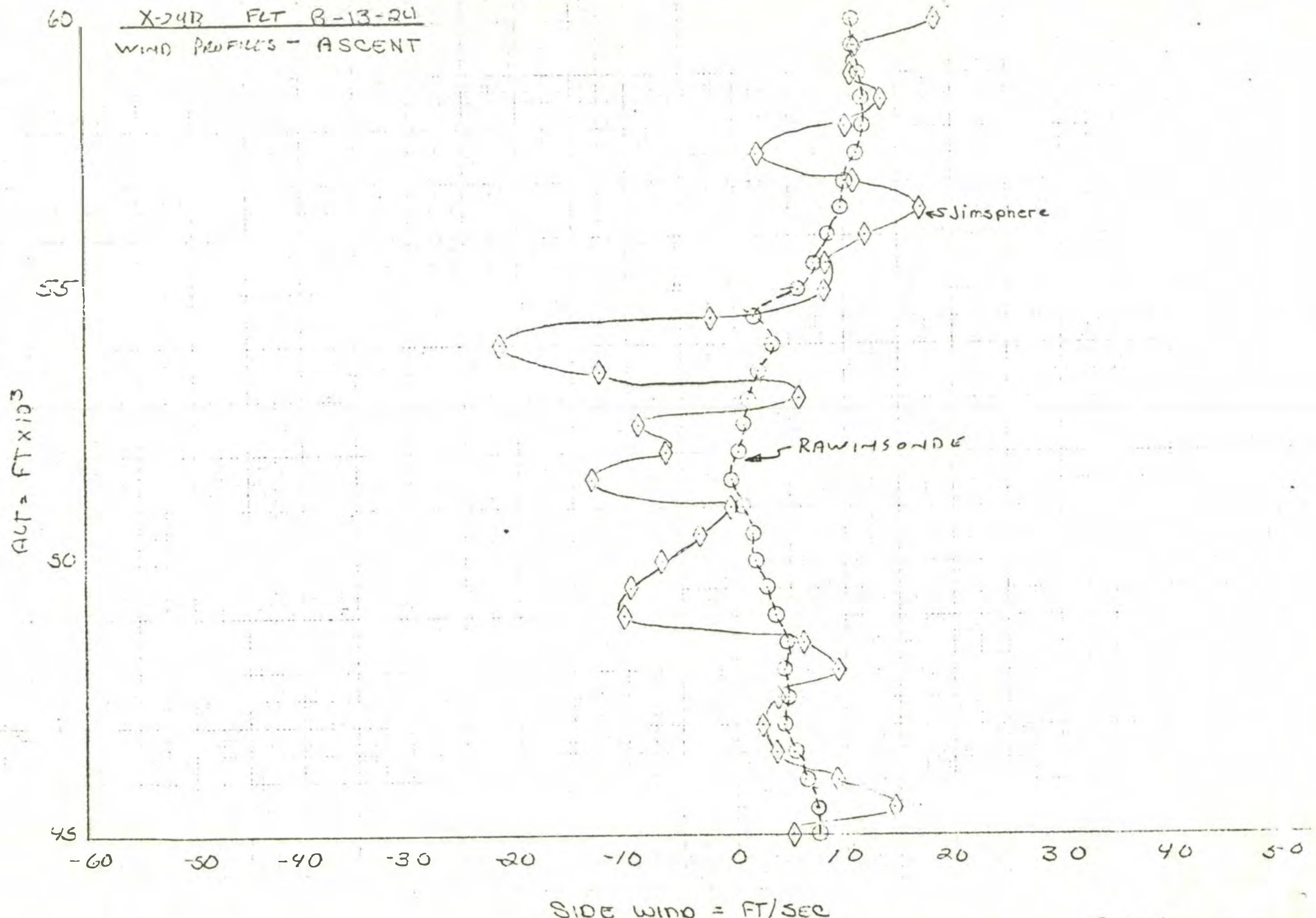
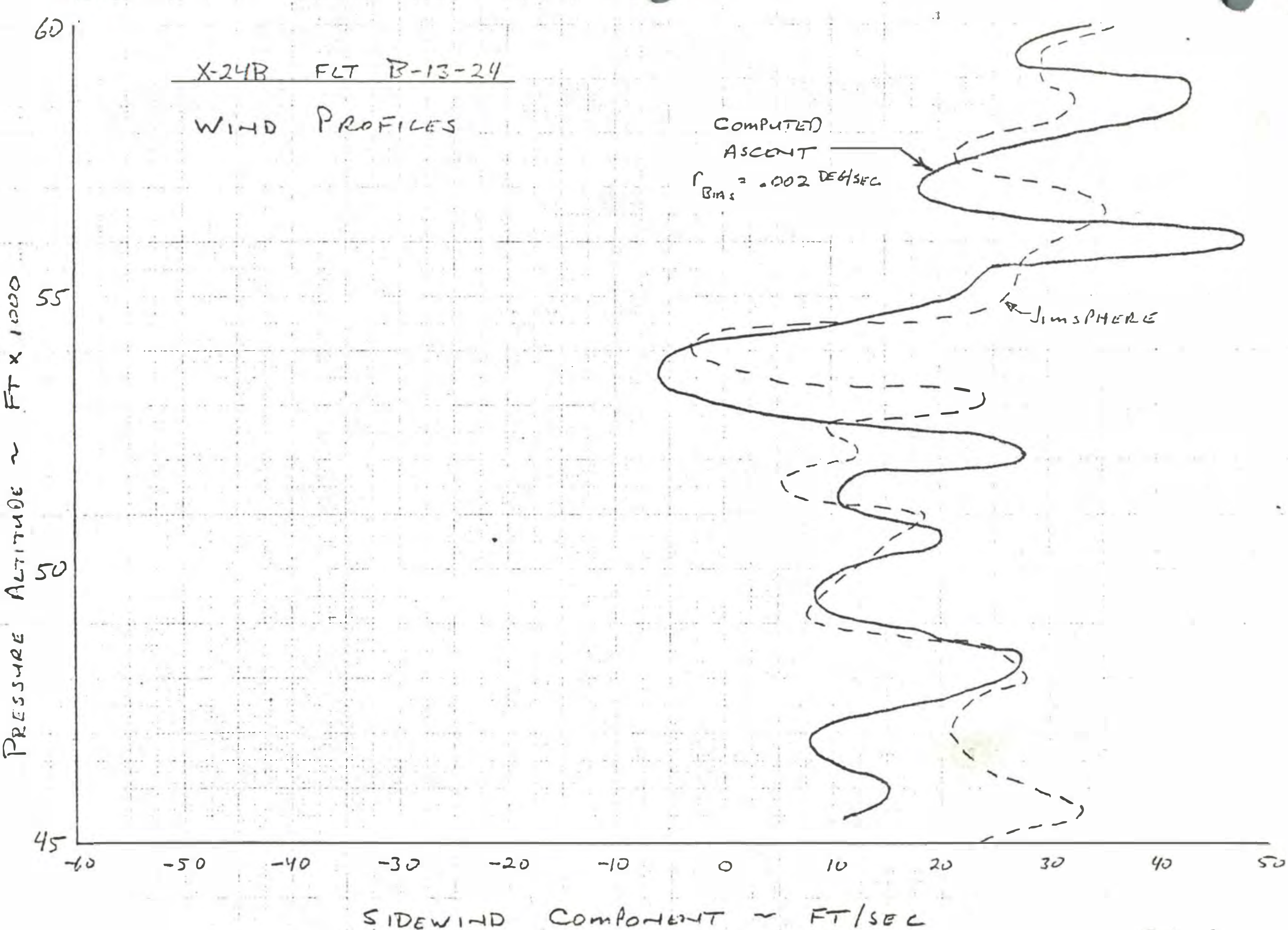
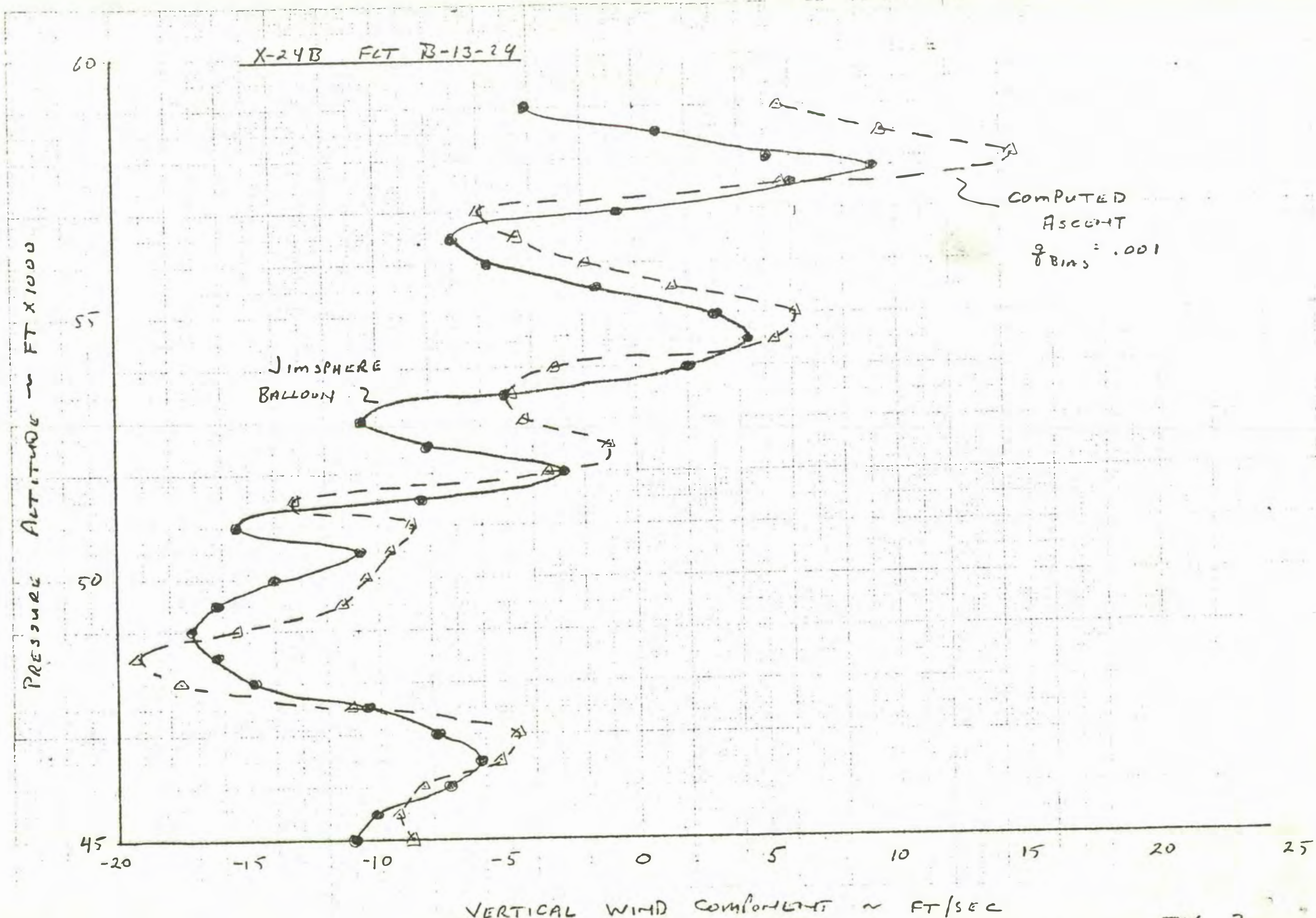

X-24B FLT B-13-24
WIND PROFILES - ASCENT
Jimsphere
RAWINSONDE
ALT = FT x 10^3
60
55
50
45
-60
-50
-40
-30
-20
-10
0
10
20
30
40
50
SIDE WIND = FT/SEC

FIG 1



X-24B FLT B-13-24
WIND PROFILES
COMPUTED ASCENT
r_{BIAS} = .002 DEG/SEC
JIMSPHERE
PRESSURE ALTITUDE ~ FT x 1000
60
55
50
45
-60
-50
-40
-30
-20
-10
0
10
20
30
40
50
SIDEWIND COMPONENT ~ FT/SEC

FIG 2



X-24B FLT B-13-24
60
55
50
45
-20
-15
-10
-5
0
5
10
15
20
25
PRESSURE ALTITUDE ~ FT X 1000
VERTICAL WIND COMPONENT ~ FT/SEC
COMPUTED ASCENT
JIMSPHERE BALLOON 2

FIG 3

X-24B Wind-induced Sideslip Disturbances

During the powered boost phase of several X-24 missions, the test pilots had commented on uncommanded lateral-directional disturbances. This memo summarizes the results of an investigation to determine if these upsets were the result of wind disturbances.

Part of the normal X-24 flight operation calls for the launch of a Rawinsonde weather balloon during the mission in order to obtain current upper atmosphere data, including winds. Initial efforts in this investigation attempted to correlate wind shifts in the Rawinsonde data with the uncommanded aircraft disturbances. A computer program was written to extract a sidewind (β-producing) vs altitude profile from flight measured parameters by comparing test vane measured β to a computed β and attributing any differences to wind effects. In addition, the program computed the sidewind vs altitude profile from the Rawinsonde data for comparison. Figure 1 is typical of the results obtained from this comparison. As can be seen, there is very little correlation between aircraft upsets (indicated by abrupt changes in the computed wind profile) and the Rawinsonde wind data. However, when sidewind profiles were computed from ascent and descent data through the same altitude band for a flight, they were in good agreement (figure 2) indicating that wind disturbances may be present that were not being shown in the Rawinsonde data. Subsequently, radar tracked Jimsphere balloons were used as an additional, and more accurate source of wind data. As can be seen in figure 3, correlation between the computed and the Jimsphere profiles was good, with both showing abrupt wind shifts with altitude, while the Rawinsonde data did not exhibit this behavior. The flight from which these data were taken was one on which the pilot reported several aircraft upsets during the boost.

Summarizing the primary results of this investigation:

1. The reported upsets of the X-24B during the powered boost phase were attributed to abrupt wind changes with altitude.

2. Rawinsonde wind data provide average wind values over intervals of approximately 1,000 feet which do not reflect higher frequency wind changes. Radar tracked Jimsphere balloons provide a better picture of the winds over smaller altitude increments.

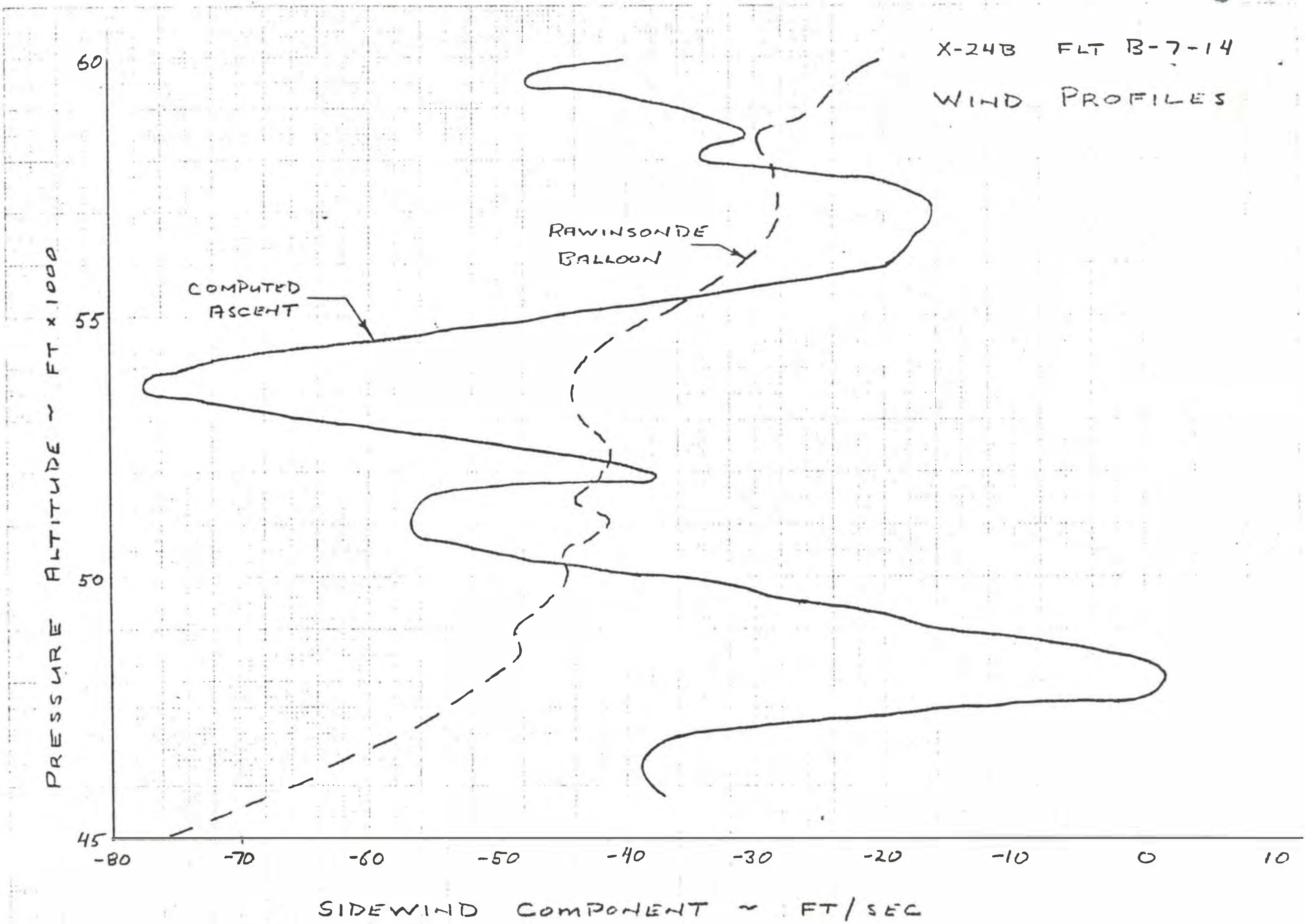
3. The response of an aircraft (or lack of response) to these abrupt wind changes depends upon the rate of climb (frequency of the disturbance) and true airspeed (magnitude of the resulting β-disturbance) and their relationship to the aircraft's lateral-directional dynamics. The manner in which the aircraft exhibits the disturbance depends on its dynamic properties i.e., an aircraft with a high ϕ/β (high C_{ℓ_β}) will respond primarily in roll with an abrupt wing drop.

4. These disturbances may effect flight test data if they are encountered while performing a dynamic test maneuver even though the pilot may not feel the disturbance.

In addition to the above, some work has been done in attempting to extract wind components in the vehicle's vertical plane from differences between measured and computed angle of attack. We have had some success in generating wind profiles in this plane which correlate well with Jimsphere balloons data. If it is possible to obtain good side-wind and vertical-wind profiles from on board data then a complete wind profile with altitude can be computed by assuming that the wind blows parallel to the earth plane.

It is hoped that our experience with this problem will benefit other flight test programs.

DENNIS J. PENKA
Capt, USAF



X-24B FLT B-7-14
WIND PROFILES
RAWINSONDE BALLOON
COMPUTED ASCENT
PRESSURE ALTITUDE ~ FT x 1000
60
55
50
45
-80
-70
-60
-50
-40
-30
-20
-10
0
10
SIDEWIND COMPONENT ~ FT/SEC

FIGURE 1

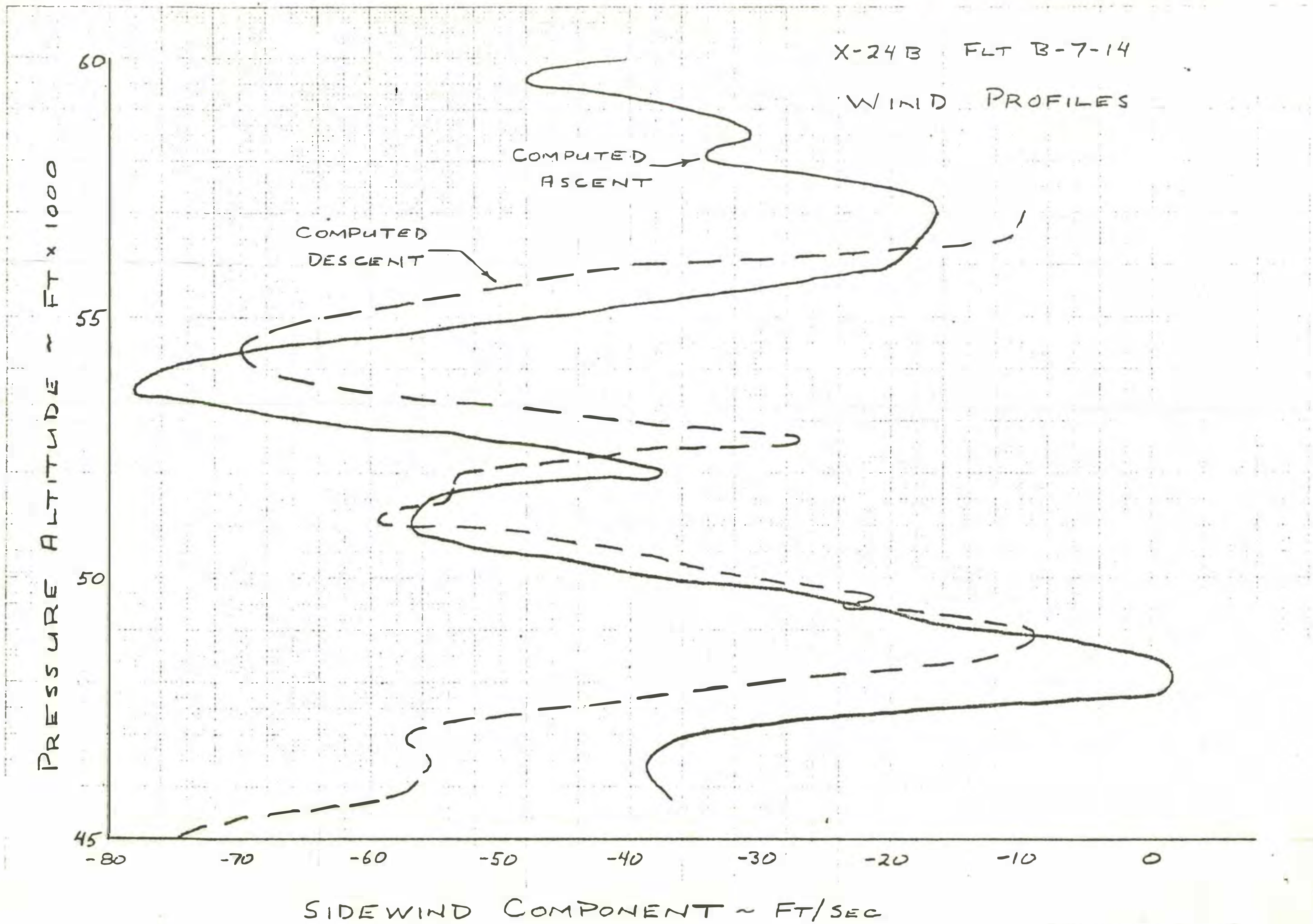

X-24B FLT B-7-14
WIND PROFILES
COMPUTED ASCENT
COMPUTED DESCENT
PRESSURE ALTITUDE ~ FT x 1000
60
55
50
45
-80
-70
-60
-50
-40
-30
-20
-10
0
SIDEWIND COMPONENT ~ FT/SEC

FIGURE 2

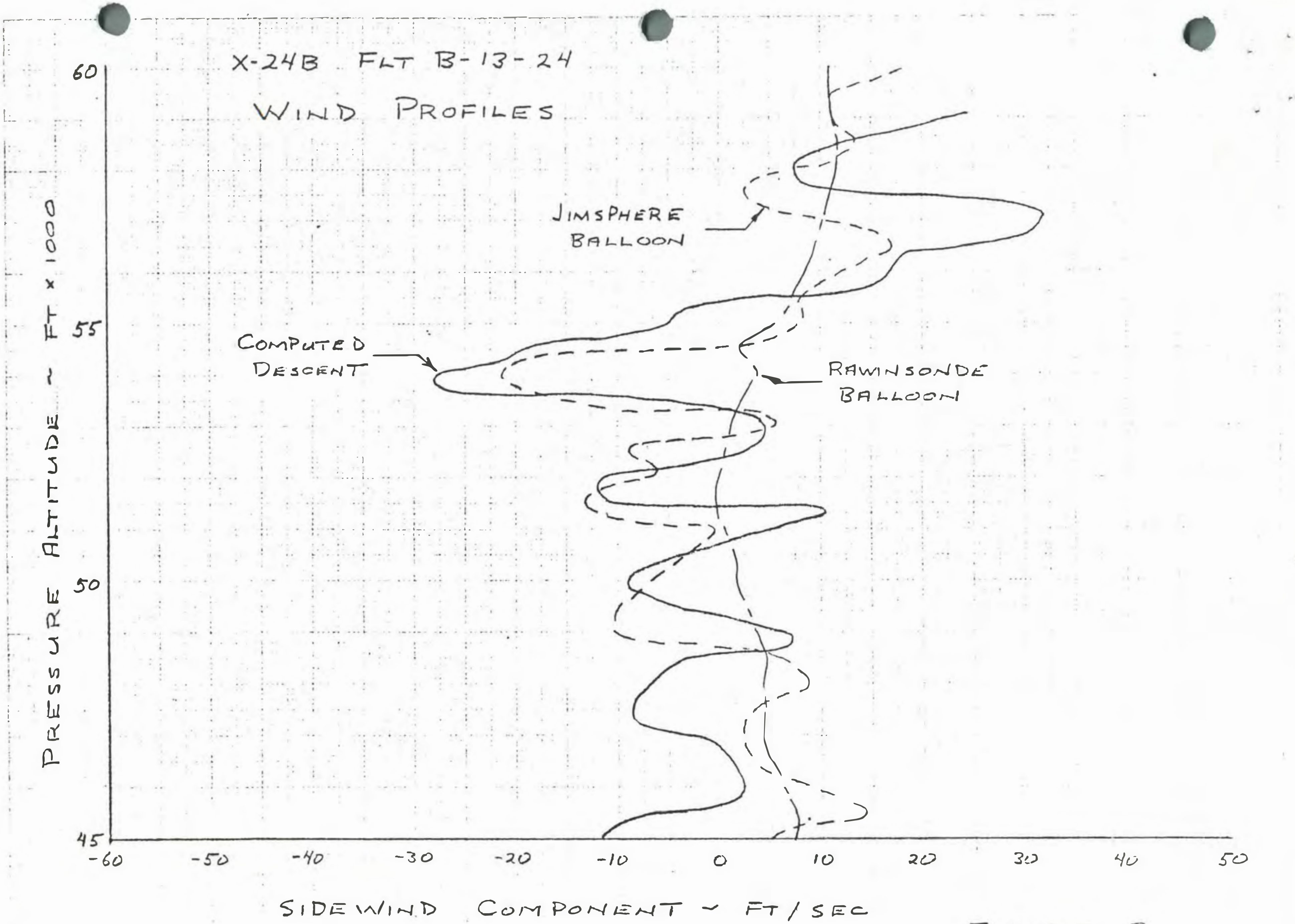

X-24B FLT B-13-24
WIND PROFILES
JIMSPHERE BALLOON
COMPUTED DESCENT
RAWINSONDE BALLOON
PRESSURE ALTITUDE ~ FT x 1000
60
55
50
45
-60
-50
-40
-30
-20
-10
0
10
20
30
40
50
SIDEWIND COMPONENT ~ FT/SEC

FIGURE 3

Appendix

This appendix summarizes the computation scheme used to extract the sidewind profile.

$$\dot{\beta} = p_b \sin\alpha - r_b \cos\alpha + (1/\cos\beta)\left[g/v_t \left\{ \cos\theta \sin\phi - \sin\theta \sin\beta \right\} \right] + \left(\frac{\bar{q} S}{v_T m \cos\beta} \right) \left[C_{y_\beta} \beta + C_{y_{\delta_a}} \cdot \delta_a + C_{y_{\delta_r}} \cdot \delta_r \right] \quad \text{(EQN 1)}$$

The side force equation of motion (EQN 1) is numerically integrated to provide a computed value of β (β_c) as a function of time. Flight-measured parameter values are used in the equation including actual boom measured β (β_m). The difference between measured and computed sideslip over each integration increment is attributed to a wind disturbance. The magnitude of the wind disturbance for that increment (Δv) is computed using equation 2.

$$\Delta v = V_T (\sin\beta_m - \sin\beta_c) \quad \text{(EQN 2)}$$

The convention used is that positive v produces positive β.

These sidewind velocity components are summed to produce a net sidewind component (v) which is presented as a function of altitude. The Rawinsonde and Jimsphere winds are stored as a function of altitude in earth axes. The sidewind component from each of these profiles is computed by a matrix transformation from earth to body axes using the vehicle Euler angles and then presented as a function of pressure altitude for comparison with the computed winds. This method of comparison was selected as best suited for our study and is equivalent to a comparison in earth axes since the vehicle is flying wings-level on a constant heading.

B-13-24 Position Error
by
Dennis J. Penka, Capt

Position error data were reduced for Flt B-13-24 in the transonic and supersonic regions. Trends in these data were similar to those reported for Flt B-9-16, i.e. the acceleration and deceleration points were shifted relative to each other (fig 1). This effect was attributed earlier to pressure lag since the acceleration points were obtained in a climb and the deceleration points at a high rate of descent. In an attempt to verify this, a lag constant was computed using radar Tracking data and a lag correction was applied to the position error data. As shown in Figure 2, correcting for pressure lag tended to group the data together thus supporting the contention that pressure lag error was causing the data bias noted.

The position error curve in use for data reduction has not been revised. It should be noted that the curve used is essentially a zero rate of climb curve (no pressure lag effect). Pressure lag error is not corrected for in the current data reduction program.

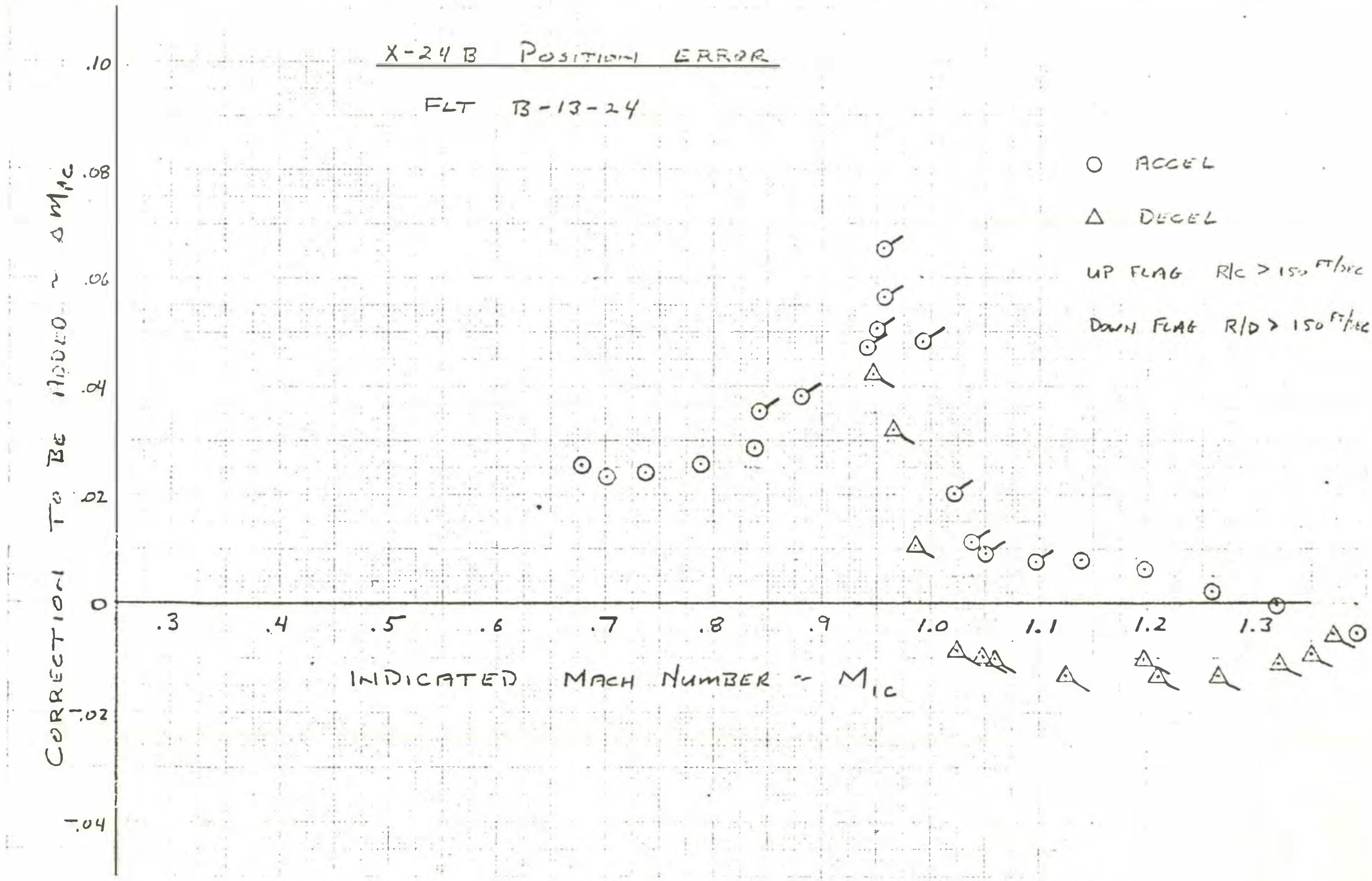

X-24 B POSITION ERROR
FLT B-13-24
○ ACCEL
△ DECEL
UP FLAG R/C > 150 FT/SEC
DOWN FLAG R/D > 150 FT/SEC
CORRECTION TO BE ADDED ~ ΔM_IC
.10
.08
.06
.04
.02
0
-.02
-.04
.3
.4
.5
.6
.7
.8
.9
1.0
1.1
1.2
1.3
INDICATED MACH NUMBER ~ M_IC

FIG 1

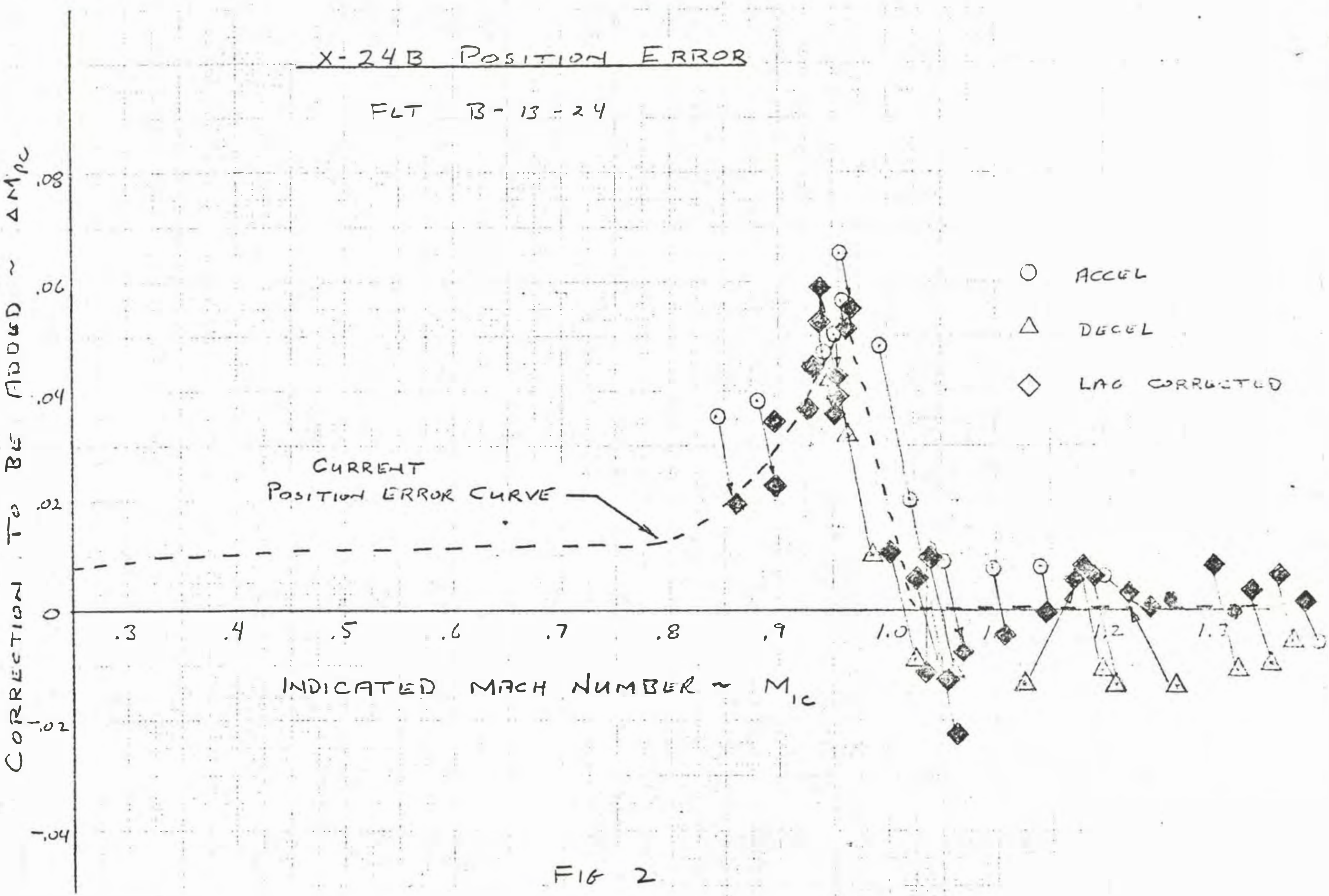


FIG 2

DJP 16 July 74

Weight and Balance

by

Dennis J. Penka, Capt

Following Flt B-13-24 a change was made to the battery configuration in the nose of the aircraft to permit addition of a fifth (emergency) battery. As a result of this change the aircraft was weighed and the X-CG location checked prior to Flt B-14-25 in order to verify the value used in the weight and balance computation. As shown in the attached table, agreement between computed and measured values was surprisingly close. However, in preparation for computing values prior to the weighing an error was found in the X-CG value obtained from the last X-24 weighing (18 Sep 73). This small error was present in all X-CG values computed for flights from that time through B-13-24. It is pointed out because, as can be seen in the table, with 6 ballast plates installed for Flt B-14-25 the X-CG will be in the same computed location it was for the previous mission, however, when the computational error is corrected there is an apparent aft movement of the CG.

WEIGHT AND BALANCE

31 JULY WEIGHING

	WEIGHT (LBS)	X-CG (IN)
COMPUTED	8023	127.05 (CORRECTED)
AS WEIGHED	8026	127.08

FLIGHT B-14-25

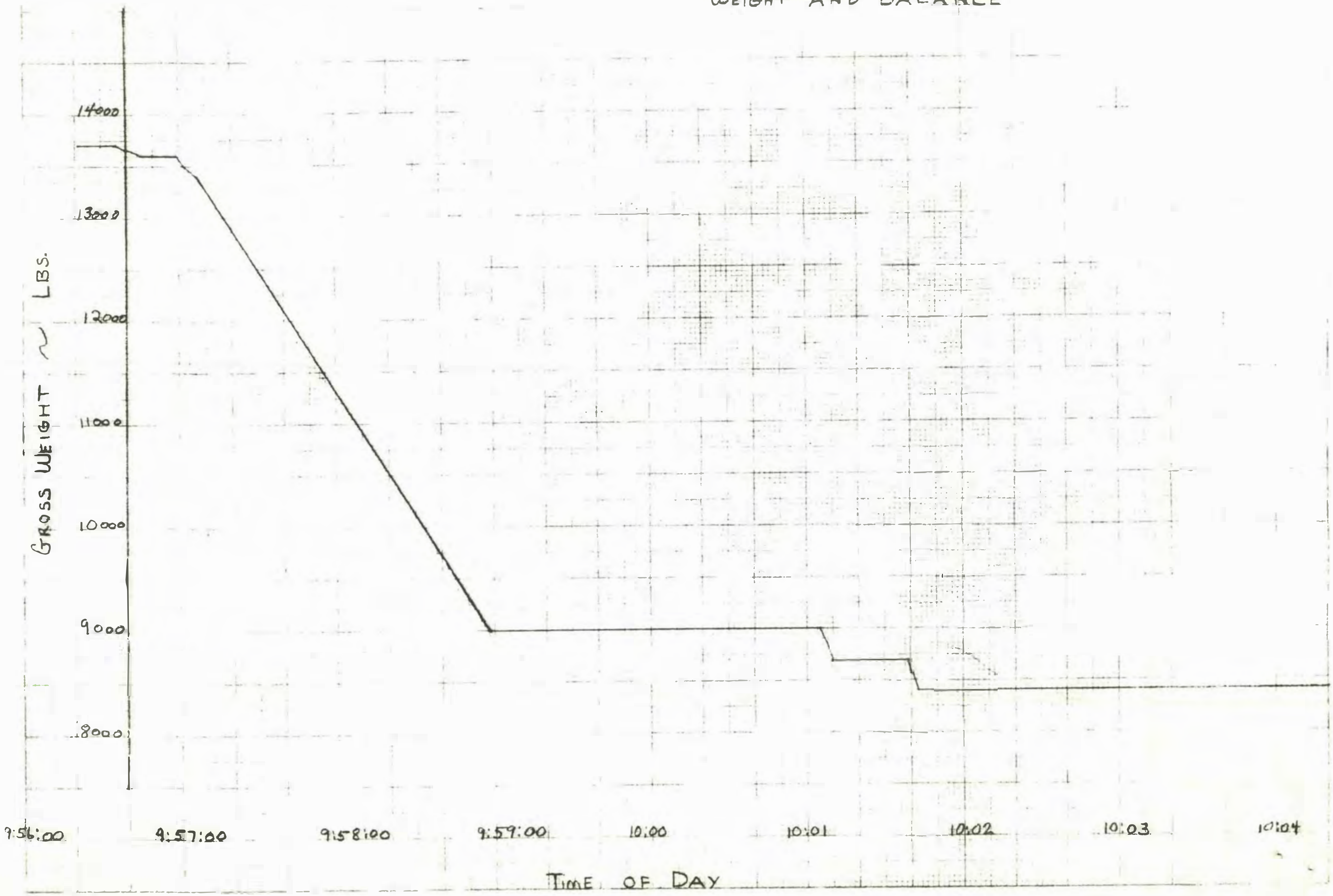
NET WEIGHT CHANGE (W 6 BALLAST) +24.6#

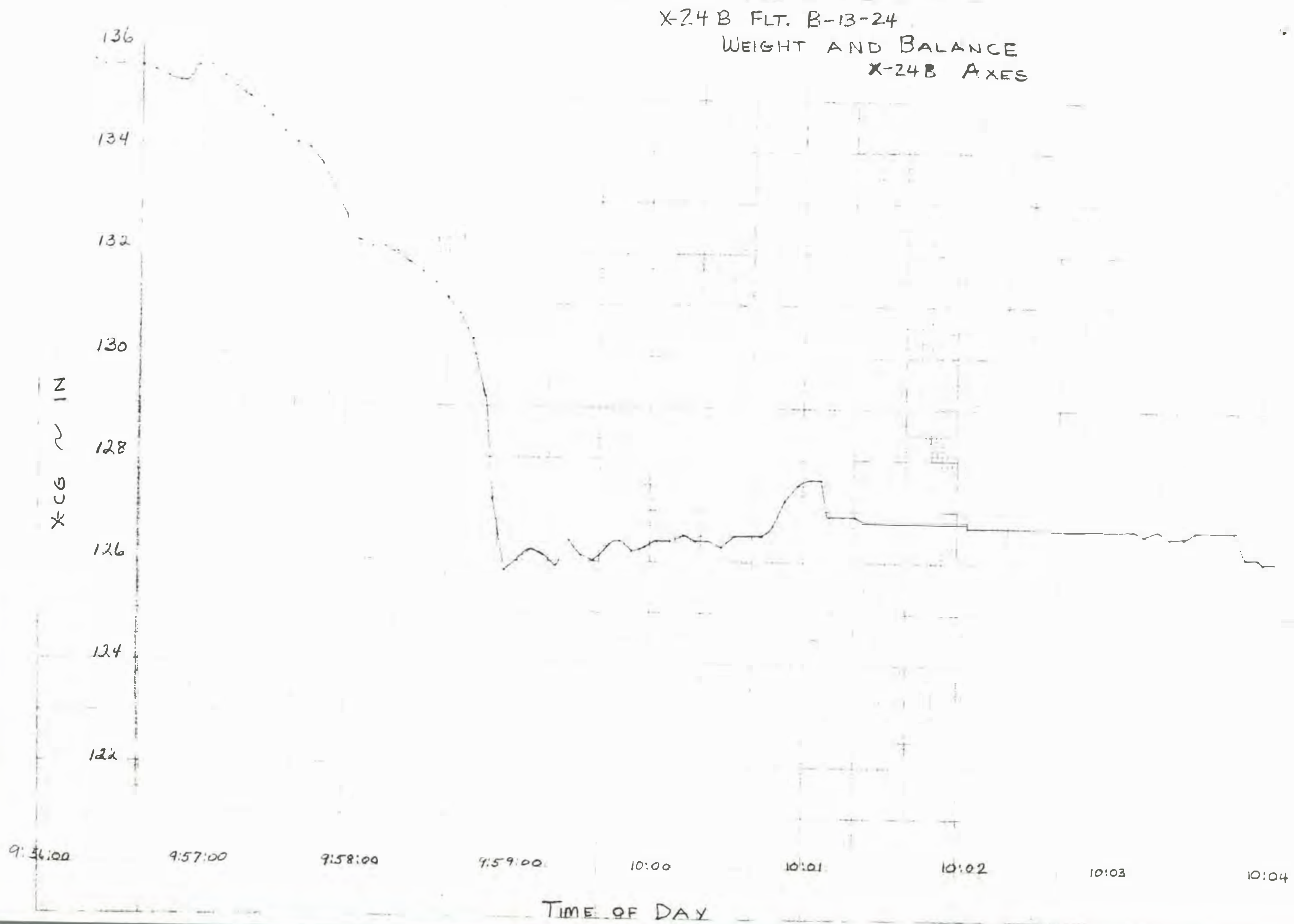
X-CG LOCATION

	W 5 BALLAST	W 6 BALLAST
PRIOR	66.10 %	66.02 %
CORRECTED	66.17 %	66.09 %

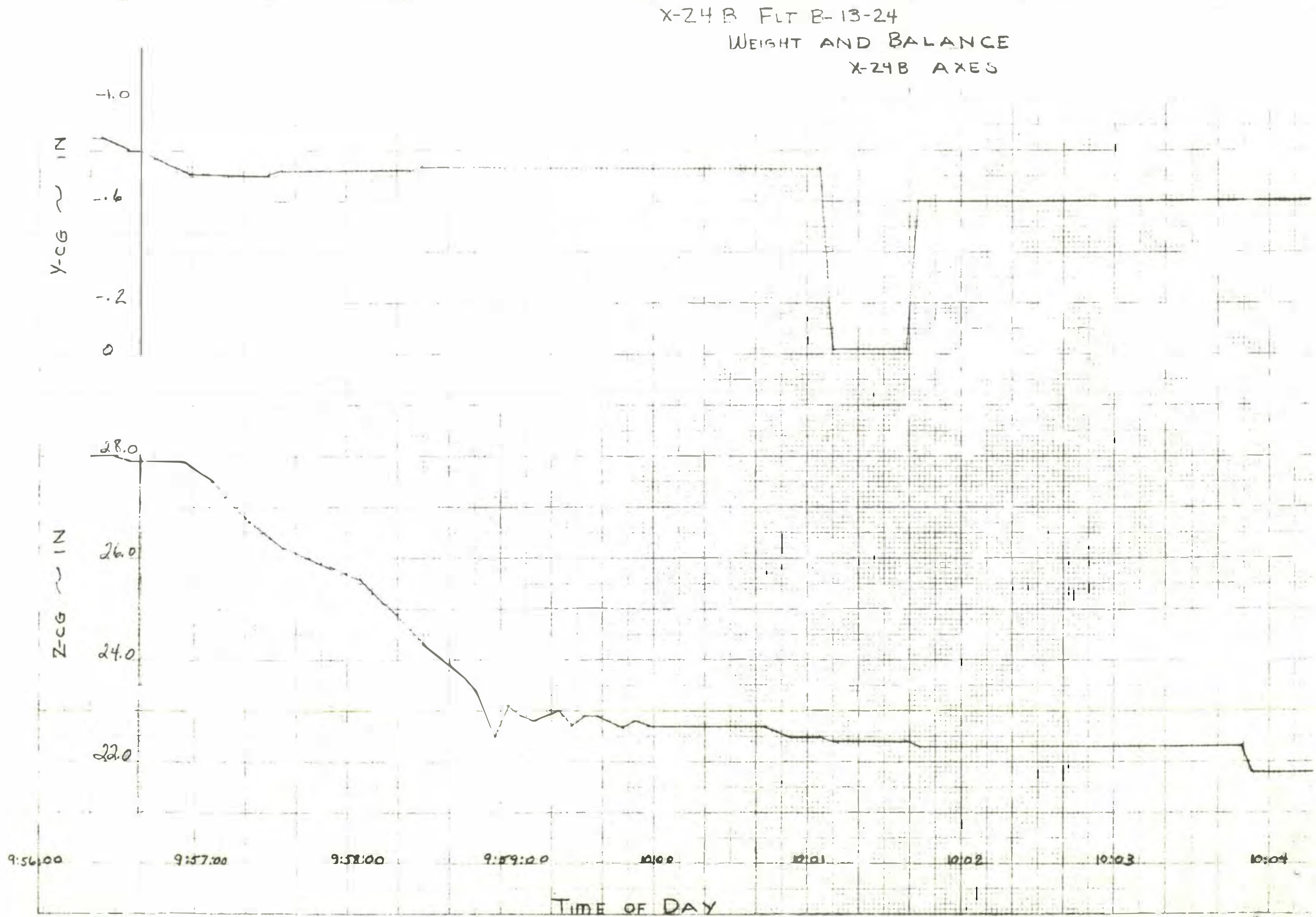
FLT B-13-24 X-CG = 66.02 %

X-24B FLT. B-13-24
WEIGHT AND BALANCE

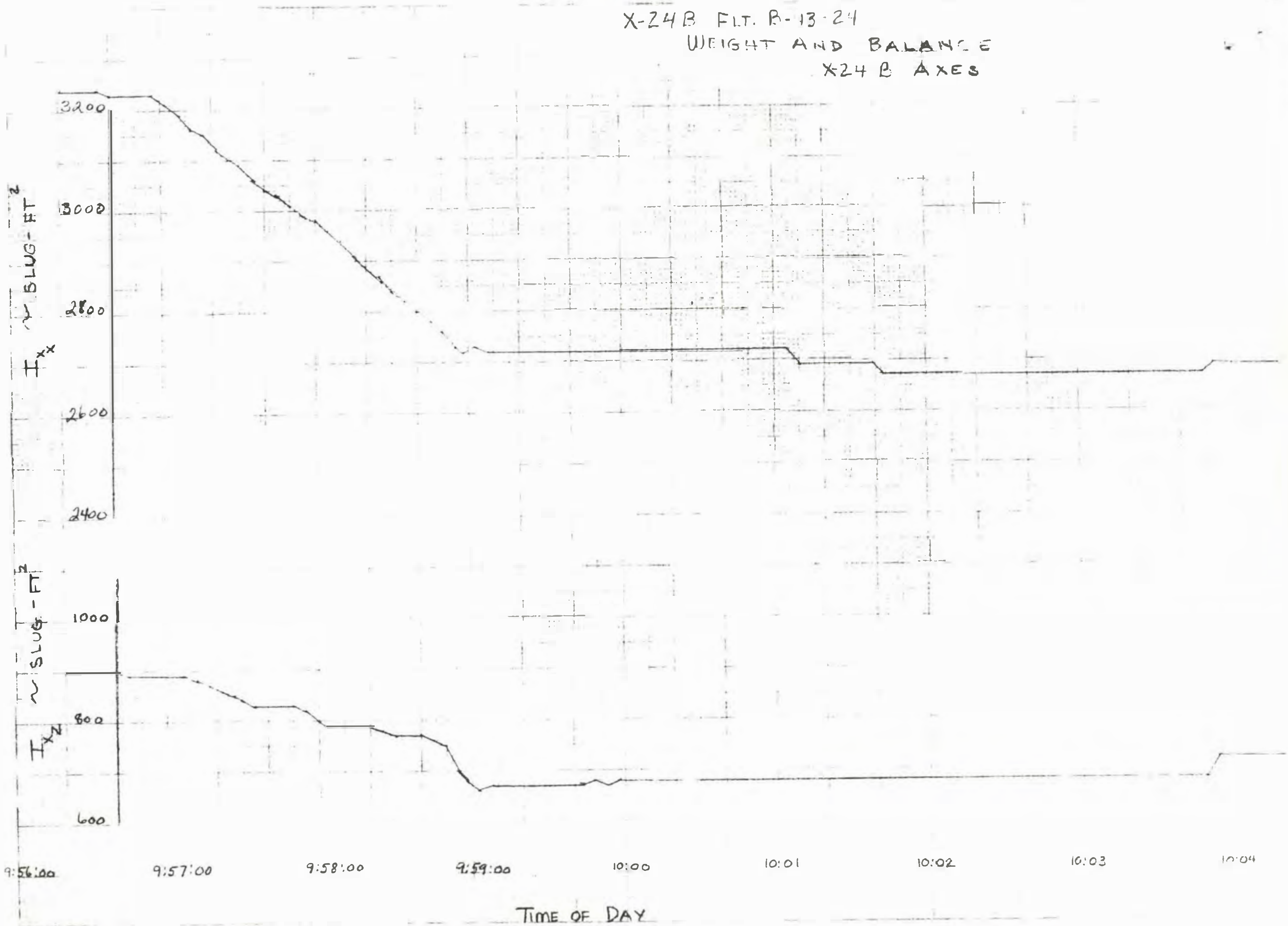




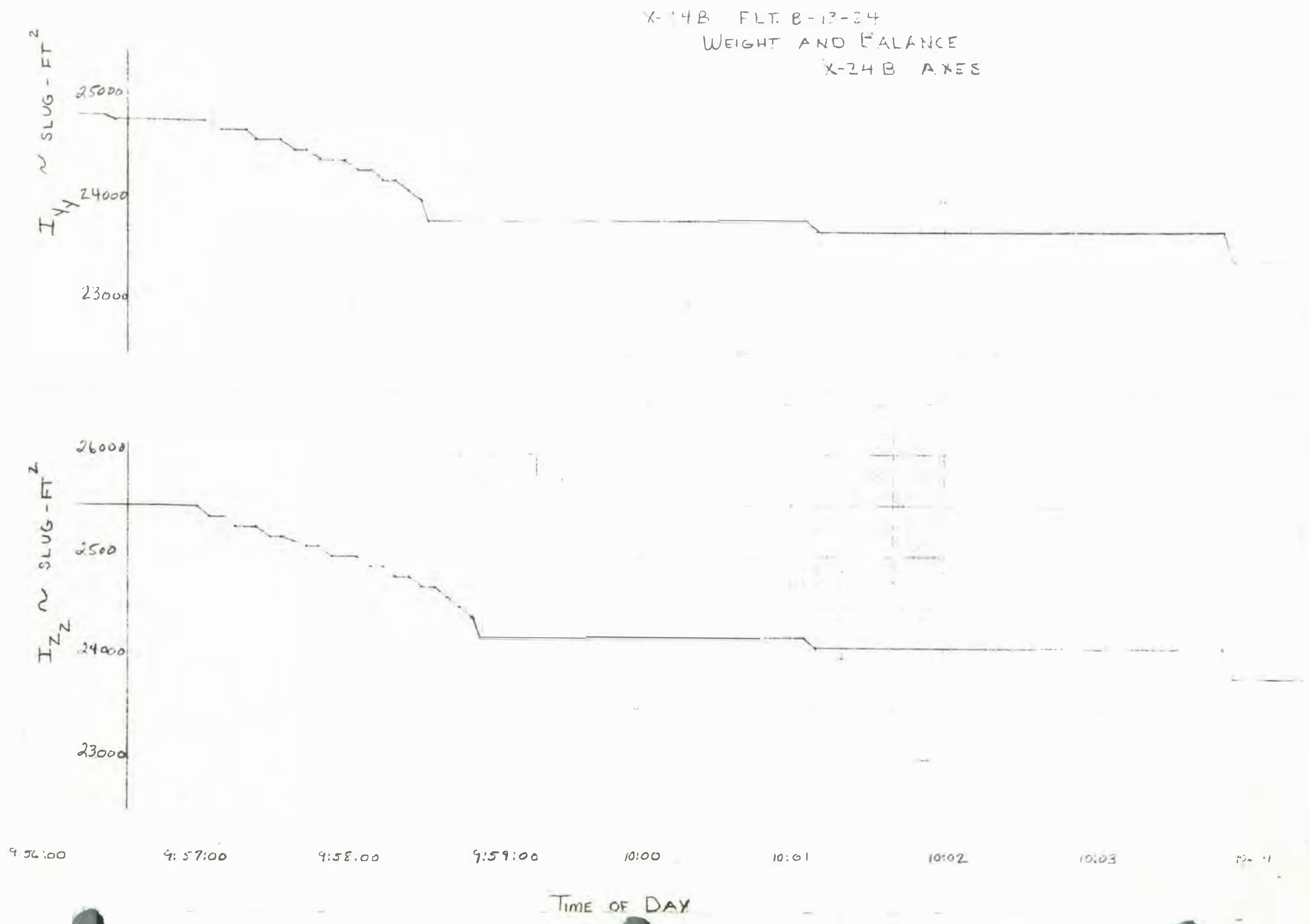
X-24 B FLT. B-13-24
WEIGHT AND BALANCE
X-24B AXES
136
134
132
130
128
126
124
122
XCG ~ IN
9:56:00
9:57:00
9:58:00
9:59:00
10:00
10:01
10:02
10:03
10:04
TIME OF DAY



X-24B FLT B-13-24
WEIGHT AND BALANCE
X-24B AXES
Y-CG ~ IN
-1.0
-.6
-.2
0
Z-CG ~ IN
28.0
26.0
24.0
22.0
9:56:00
9:57:00
9:58:00
9:59:00
10:00
10:01
10:02
10:03
10:04
TIME OF DAY



X-24B FLT. B-13-24
WEIGHT AND BALANCE
X-24B AXES
3200
3000
2800
2600
2400
I_{xx} ~ SLUG-FT^2
1000
800
600
I_{xz} ~ SLUG-FT^2
9:56:00
9:57:00
9:58:00
9:59:00
10:00
10:01
10:02
10:03
10:04
TIME OF DAY



X-24B FLT. B-13-24
WEIGHT AND BALANCE
X-24B AXES
Iyy ~ SLUG - FT²
25000
24000
23000
Izz ~ SLUG - FT²
26000
2500
24000
23000
9:57:00
9:58:00
9:59:00
10:00
10:01
10:02
10:03
TIME OF DAY

July 11, 1974

TO: DOEER

FROM: W. B. ARNOLD - THIOKOL

SUBJECT: Propulsion System operation Flight B-13-24

SUMMARY OF ENGINE OPERATION

1. No prelaunch igniter test was utilized.

2. The start of #1 and #3 chambers was normal.

3. The #4 chamber start was normal but the #2 chamber start was delayed approximately one second.

4. The transfer into overdrive was normal with all pressures operating correctly.

5. Engine shutdown was accomplished in overdrive and was normal.

DISCUSSION

Inspection of the #2 chamber propellant control valve system indicated that the lox delay check valve was flowing 46,000 cc/m. The normal rated flow of this orifice is 72,000 cc/m. This low flowrate explains the one second delay in the chamber start. The chamber pressure excursions are similar to previous rough starts and are still well within the pressure limits of the chamber.

All other portions of the propulsion system operated satisfactorilly during this flight.

CORRECTIVE ACTION

1. Remove and replace the #2 chamber lox delay check valve.

2. Inspect the #2 chamber fuel valve hydraulic accumulator for possible leakage.

W. B. ARNOLD

cc: N. DeMar
J. Kolf
TC-Elk.

Technical Debrief

Flight B-13-24

28 June 1974

John Manke Pilot

1. Discuss the engine light sequence and any associated trim changes.

Answer:
The sequence was one and three, and boy they came up as fast as I've ever seen two chambers come up. And then two and four, and four come on just a little bit before two did. I didn't feel any roughness in it that I could tell. I just noted that two came up a little bit slower than four. I didn't notice any trim changes.

2. Discuss the handling qualities during the rotation. Rate pitch and lateral directional.

Answer:
As we mentioned before its just a little bit looser in pitch than the simulator is, particularly as the Mach number gets up above .8. In the simulator you could probably hold alpha within about a plus or minus a quarter degree pretty easy by trimming and it looks like in this thing it runs a half degree to a degree, unless a guy could just concentrate completely on it and if you take your eyes off it too long it seems to drift a little bit on you, so it's not quite as solid as the simulator. Pitch - I'd rate as a three and lateral-directional as a two. Now lateral-directional task is almost a zero task we don't spend any time worrying about it, It's all done peripherally; it's no problem.

3. a. Discuss the task to maintain 40^{o} θ and rate.

Answer:
OK; maintaining 40^{o} θ was pretty easy. I thought that I did reasonably well at it. I also felt that I had some time to get off θ and look at some other things. I had a couple of cross checks during the constant θ portion. Although I think if I spent any more than a second or two off θ it would probably drift a little bit. You get the impression that it would like to drift a little bit on you but if you do keep a pretty tight loop on it why its not a very difficult task. I'd probably rate it about a 2 1/2.

3. b. How did α to maintain θ compare with the simulator?

Answer:
It looked pretty darn good. I noticed even in the simulator there was a rather transient period where it went from 12^{o} to 13^{o} and it really all depended on exactly when I looked at it. It was very time dependent if I wanted to compare the simulator with the airplane that's what I'm saying. The time that we had allotted to do this was rather early in the constant θ portion so my impression was that it was running just about on alpha maybe a half degree less on alpha than we had seen in the simulator. If anything at all.

4. Discuss the handling qualities above .85 Mach number at 12° α with power on. Rate.

Answer:

This is the area that I really wanted to look at and I hoped for some steady state stuff but boy I got so darned many turbulence inputs it was difficult for me to sort those things out from the airplane itself. There was no question in my mind that the airplane was loose in Yaw. I'm talking about three degrees sideslip but it felt that it was looser here in 12 than I'd experienced at 10. As far as the recovery on this sideslip I felt that I got the "Penka" (Note: Wind caused upsets formerly called clurds) just about the time I was interested in looking at recovery and that seemed to aid the recovery. I think we really need to look at the data and see if it had started back by itself. Although I didn't feel at anytime that it was going out at a rate that required any pilot input at that time. I was prepared to let it go out to about 4° before I was going to start back on it. During one of the portions at this time I saw at least 3 1/2 and I think thats about what we showed up there. Now this is a difficult one to rate because if I were trying to fly at θ sideslip thing it would be a pretty difficult problem. But if I'm just sitting there and watching the sideslip I'm not really controlling to it. So its difficult to rate but I think we ought to rate it anyway because we're talking about the airplane itself and this definitely falls down in to this"deficiencies that warrant improvement" so you're talking about a 3.5 to a 4. Just from the standpoint-that here again my back ground brings this rating lower than it really should too with a little more experience in the airplane you might not worry about it.

5. a. Discuss the handling qualities above 1.0 Mach number at 5° α with power on. Rate.

Answer:

As I mentioned before in pitch its a real solid airplane. The pitch sensitivity of course changes considerably with Mach number in this area its real solid and again supersonic lateral-directional is super on this airplane. It's just at least with the damper setting-here again we ought to start thinking about running our damper gains down and see what the basic airplane looks like-but with the damper settings we've got in pitch and roll why its just a real solid airplane. As you can see on supersonic rudder pulses why there wasn't hardly any motion at all. OK item 5 a, I'd rate as a two.

5. b. Compare the Vehicle's response to the Mach 1.15 doublets (power on) at 5° α with the simulator. Rate.

Answer:

I thought it was very much like the simulator, very close response. I'd rate again at two and the same thing would be said of the 1.3 doublet. The simulation is excellent in this area.

5. c. Omitted.

6. a. Discuss the performance aspects of the boost.

Answer:
As I mentioned before it was almost identical to what we saw in the simulator this morning with the winds that Dave had put in this morning. My time to θ was forty-two seconds and thats what its been running in the simulator lately. The fifty second check was precisely what I'd seen in the simulator this morning. The Mach number I had at 57,000 feet was just what I'd seen in the simulator and the shutdown time was a hundred and seventeen seconds which was exactly what we had in the simulator. So just from what I saw this morning without looking at it closer I would say this is the closest simulation in performance that I've ever experienced on a lifting body.

6. b. Discuss the trim changes at engine shutdown.

Answer:
I couldn't determine any trim changes. It might have bobbled alpha a little bit but the deceleration was very apparent to me this time and I think I might have bumped the stick as I went forward in the straps.

6. c. If not previously covered, discuss the roll task during the boost with respect to two hands, roll trim, resulting sideslip. Compare to simulator.

Answer:
OK, I used my two hands bit again. But I really didn't seem to have as much roll miss trim as I've had before. I didn't even notice it. I don't recall putting any roll trim in. The sideslip that we ended up with was very much like I'd seen before in fact I got the impression it was just a bit higher on this flight. The roll task is very simple on this airplane its so simple that we don't even spend any time on it. We've rated it a two continually and it doesn't compare well with the simulator, the simulator doesn't show this left sideslip at all.

7. Compare the Vehicle's response to the doublets at 5^o α (M_t=1.3) after engine shutdown with the "power on" doublets. Compare to simulator and rate the handling qualities if possible.

Answer:
I don't remember it well enough I can't remember any difference. Things were happening so fast I just don't remember. Obviously there was nothing that got my attention. The handling qualities after burn out about a 2.5. The only thing that makes it a little more difficult there is the deceleration and you're up against the straps and it was just a little bit of a surprise.

8. Discuss the pitch pulse (SAS off) at 1.25 Mach number at 8^o α with respect to the vehicle response to pulse as compared to simulator.

Answer:
As I mentioned before the airplane is well damped with the pitch damper off. I'd estimate it at 1-1 1/2 cycles to half amplitude and guess the data shows about two. I think it compares very much to the simulator I think the simulator runs about two cycles to half amplitude. Very good comparison. I popped it a little bit too hard unfortunately I probably got plus or minus about 2 1/2 degrees, 2 1/2 to 3^o and I was hoping for about 2 but once you've hit it why its all too late to change it after that. Really good in pitch.

9. Discuss the handling qualities while decelerating from Mach 1.1 to .65 at 8^{o} α. Rate.

Answer:

Well, I can't really discuss handling qualities because it was just like a machine; bang-bang and bang-bang. As long as Mike was happy with where we were going why I was too. My main task was maintaining angle of attack and just like in the simulator it takes a lot of trimming that-the airplane is Mach sensitive in pitch-so if you're really trying to hold an angle of attack and you're decelerating rather rapidly it takes some trimming. And I also noticed some coupling and I was probably doing it. It seems to be some coupling even with the rudder pulse; a little coupling in pitch. And then when you couple in aileron you can't really say whether its the aileron doing it or whether its you on the stick, ok. But there seems to be a little pitch coupling even with rudder here, so you do a rudder pulse and I'd retrim on angle of attack and then do an aileron. So I tried to retrim in between each pulse, to try to get it back to an angle of attack. So you'll see angle of attack move around a little bit in this area. OK very little change in effectiveness, the change that you're going to see is me deciding I'm kicking it too hard and go ahead and ease off a little bit and then I got right back into the hard kicks again from an airplanes response why there's no big change from a 1.1 pulse all the way down to the .6. But we've got very high damper gains here and that probably explains a lot of it. That's right I've not been able to pick these levels out nearly as well on this airplane that's because this airplane flies really nice in a transonic region, in the X-24A we have the subsonic, transonic and supersonic. In the transonic it was pretty crummy so it gave you a good picture of it each time you went thru it, this airplane isn't like that it isn't as different as night and day like the other one. I'm sure if you look at the pulses here which I haven't done quanitively but I didn't see much difference all the way down from the 1.1 all the way down to .65. And from a task stand point it was strictly a pitch task trying to hold an angle of attack and I'd rate that probably at a 2 1/2 to 3. And man I was booting the airplane a lot too you know so any airplane in the world is going to find a tough job doing what you're asking it to when you're kicking it as hard as we were kicking it. The M2 in a situation like that, you would have been a tiger by the tail, kicking it like we were kicking this thing.

10. Discuss the energy management from the "intersection to low key".

Answer:

OK we did it here just like the simulator. This was an unusual pattern we came through the intersection with very high airspeed and a high rate of sink and actually a pretty low altitude. The plan was to get that .65 pulse and then pull up to (I was using 13 to 14 in the simulator) 14^{o} angle of attack pull right on up to that, let the airspeed bleed down and as soon as it hit .6 to close it up and then fly a fairly high Lift over/Drag until we got back up on a reasonable profile again. Today it worked just like we had planned in the simulator. Here again is where the simulator is such a valuable tool. Mike had conditioned himself to the fact that I was going to go quite a bit beyond the intersection and have to turn back and in other days that would have been a no-no but we'd had so much practice at it that he was prepared to give me a heading you know 340^{o} or whatever it took to get back. So there was just no panic involved and it worked out real well. The airplane handled just like the simulator we came up to angle of attack killed off the airspeed and got back up and on the profile again and I think we ended back up on the profile coming down the downwind leg.

11. Discuss the pattern.

Answer:

The pattern I felt a little bit close then when I looked out I didn't look out until I called the highway. I looked out and I fell in a little bit close but I think the reason for that was that I was actually heading in towards the runway a little bit. I hadn't gotten back to a 360 heading. So I probably had a 10^{o} to 15^{o} left of north. I felt that I had an excess of energy at that time but instead of using speed brakes then I just let the airspeed run up. This pattern was a higher airspeed pattern all the way around than I'd flown before. I had a good 250 or 260 at the 90^{o} position and hit about 280 quite a bit before I got to the final straight in. Then it came right out on 290 and I flew a 290 knot approach from probably 8,000 or 9,000 feet all the way down to flare and the airspeed dropped out two or three knots right down close to the ground. So it was good solid 290 approach and a real comfortable pattern. It's a real nice airplane there. I called out a little bit of turbulence at-I don't know-3,000 feet. Not much just felt a bobble in the airplane, Dana said he didn't feel it.

12. Discuss the landing and roll out.

Answer:

The landing was a nifty one. I had plenty of time after flare and I sat and waited for 240 on the rear and even after that it seemed like I had quite a bit of float. So I could sit there and make real small adjustments all the way down and the touchdown was real soft. Probably as soft a one I've had so far. It seemed I got one wheel first I don't remember which one. The nose came thru like gang busters again-really drops thru. Roll out was straight. I wouldn't have to put one correction in there for directional control but I did anyway. I just put in a little aileron there to see if I could move it right a little bit and then I used some steering and fooled around a little bit. Moderate braking from about 80 knots and then down. One of my best flights ever.

X-24B OPERATIONS FLIGHT REPORT

FLIGHT: B-13-24 DATE OF REPORT: 8/20/74

PILOT: John Manke DATE OF FLIGHT: 6/28/74

CARRIER AIRCRAFT: B-52 #008 LAUNCH LAKE: Rogers Lakebed

PURPOSE OF FLIGHT: (1) Envelope Expansion to 1.40 Mach Number.

(2) Stability and Control at Mach Number >1.0 and 5° α.

(3) Fin, Rudder and Flap Pressure Survey

(4) Boundary Layer Noise and Vibration Experiment (RED PLUG)

I. Discussion of Previous Operations

Engine operation during flight B-12-23 was normal.

II. Vehicle Configuration Changes

There were no changes.

III. Instrumentation Changes

1. The #4 chamber pressure and #1 hydraulic pressure transducers were replaced.
2. The #1 T/M transmitter and RF cables to the multicoupler were replaced.
3. The system #2 subcom was replaced.
4. Calibrated the #3 and #4 transducer boxes.
5. Installed series regulator to regulate voltage to dynamics system.
6. Rewired "calibrate" junction to derive power from higher rated fuse.
7. A periodic inspection was performed on the boomhead. The bearings on the alpha vane were replaced.

IV. Preflight Events

All functionals were accomplished without incident.

V. Flight Events

1. Flight servicing activities were normal until a call came from center scheduling that they had scheduled the YF-16 with T/M frequency of

1442.5 Hz at the same time as the X-24B. We checked our signal and found no interference, so we continued. No problems were noted during flight with the T/M.

2. The pilots suit vent hose came lose at the start of taxi, but he was able to reconnect it with no trouble. The suit worked properly during flight.

3. The #2 chamber start was slower and rougher than normal. Once stabilized, engine operation was normal.

4. The alcohol jettison valve did not open on the pilots first switch operation. The switch was recycled and the valve operated.

5. The vehicle was in good shape following the flight.

Approved by: W P Albrecht
William P. Albrecht
Chief, Operations
Engineering Branch

Written by: Norman E. DeMar
Norman E. DeMar
X-24B Project Engineer
Operations Engineering Branch

POSTFLIGHT: B-13-24
PILOT: J. Manke
DATE: June 28, 1974

OK, this is Flight B-13-25. Boy, it was a real beauty. It was one of the best I have ever had in a lifting body. All the prelaunch stuff went real well. My suit vent connection came loose about the time we taxiied out. I turned the vent up pretty high, but it slipped back on, I put it back on and it stayed on for the rest of the flight. I think it might have a bad "O" ring or something. I told him about it. Take a look. B-52 got his altitude nice and early. ---

OK, that's really super cause we had 45,000' before we even turned at 8 minutes there. That was really great, a little over 200 knots. I think he almost went to 46 right before he started the turn. OK, that was great. That really makes it a lot nicer.

OK, the launch was very normal for this airplane. Number 1 and 3 chambers came up as quickly as I have ever seen 1 and 3 come up. The first one, the pump started, it was a soft light. Then hit 2 and 4 and 4 came on noticeably earlier than 2 and I had an ugly thought come across my mind that I was going to fly another 3 chamber flight. Then No. 2 came up. It was probably one 1/2 second or something, but it seemed like a longer. Then, from there on the engine performance was tremendous. OK, it was a good rotation at 15 α. I find it a little more difficult to hold 15 α in the airplane than in the simulator. I slipped down to 14 every now and then and maybe hold it within plus or minus 1/2 degree. But it takes a little bit more attention than it indicates in the simulator. Particularly so as the Mach number gets up during the rotation. The Mach number gets close to .9 in the rotation and at the higher end it seems to be just a little bit looser in pitch. No real problem. 40° theta was, - let me back up a little bit.

Overdrive came on at 30 seconds and once again I could feel it. No different in level than on the 3 chamber, I couldn't tell, but you can definitely feel it come on. It is a good feeling.

40 theta came at about 42 seconds. Flight plan called for it at 40 but the last few days in the simulator it has been coming at 41-42, so I thought that our match on theta was very good. Somewhere during the rotation we got a few what we call "penkas". Those are actually "klords" or for the uninitiated, when we hit levels of turbulence and we get inputs to the airplane due to turbulence. We call those "penkas" now because of the great work that Dennis has been doing along this line. He is going to be as famous as Mach some day. Anyway, a few of those. One of them in rotation looked like it swung the beta out to somewhat over 2°, 2-1/2° to 2°. Then all the way on up probably got 4 or 5 of these and I think I saw at least 3° and maybe a little bit more in sideslip. I think one time was before the

transonic area and the other time was during this 12° α area.

OK, backing up a little bit, we had a 50 second check and Mike called 50 seconds and the airplane was just precisely like I'd seen in the simulator this morning. By the time I look at the clock and look at the altimeter, why the altimeter is supposed to be coming thru about 300' below 50,000 and there it was, and my Mach number was right on .78 or .79 as I had seen in the simulator. So that was a perfect check.

Pushover, I pushed over at 57,000 on my altimeter, my Mach was about .84-5, just a little short of .85 and I had seen that on the simulator this morning.

Went to 12 α and unfortunately I was, - quite a bit of turbulence in this area, some "penkas" where I didn't reall want them. I really wanted to look at this 12° area in the transonic region because this is where we see the sideslip move out on us some. It got out to as much as 3° once or twice, and I wanted to see if it was going to recover by itself and I had not put any rudder inputs in, and about the time that I felt I was getting a good look at it I'd get a turbulent type input and it would swing it out and swing it back in again, so it was a dynamic recovery on the darn thing, and I could not tell whether the airplane was doing it or whether these turbulence upsets were doing it. So I did not get a real good look at it, although the beta excursions look like its another degree, degree and a half at 12 α from what we see at 10°. So if the trend would continue up, why we could get some pretty good betas on the thing. I think 12 is about all we will need to go anyway for performance in this area.

OK, I saw the Mach jump, held it a little bit longer at 1.05 and pushed over to 5 α, and you can tell the difference in pitch sensitivity once she goes supersonic.

Let me back up a little bit again. Mike mentioned in his last flight he felt a little buffet in the transonic region just before going supersonic. I felt it this time also. It is a little bit different than the X-24A used to feel. The A model was a little bit squirrelly control system wise until we got supersonic and then it would very definitely change. I can't tell much difference in the controlability in this airplane, but there is a little bit of buffet and it seems to hang a little bit longer right in the transonic region. Then once it goes supersonic or once you get the Mach jump, why it smooths out and it flies pretty much like the A used to. And, like the A, this thing has a considerably reduced longitudinal sensitivity once it goes supersonic. This takes a lot more stick and a lot more trimming to change angles of attack.

OK, the rest of it went just like we billed. The rudder doublets and aileron doublets - did two sets of those supersonic and they looked very much like the simulator. The timing was very good. I had time to look up and watch the Mach number come up to 1.4 and I shut it down when I saw about 1.41 or 1.42. We have a little position error in the airplane and I decided to let it go just a little bit beyond the 1.4 to assure that I could get the 1.4. I was more aware of the longitudinal deceleration, I guess, this time than I had been before in the airplane. Maybe it is because the accelleration is pretty good with the 4 chambers going at 1.4 then just the sudden change here. I was very aware of going forward into the straps, and I think I probably put a little pitch input as I went forward in the straps. But there still is not as much pitch change with thrust in the airplane as we are seeing in the simulator.

OK, the doublets came right after shutdown, rudder and aileron, and they again looked like the simulator. It seemed like it took me a little longer to get to 8° α than I had hoped it would, but we got there. Got the pitch damper off and my apologies to Skip, I got a little bit to big a pitch input probably there. Once you do it, it's all done. It was a pretty good oscillation. I probably had a ±2-1/2-3° on that, on α, and I had been hoping for a ±2. Anyway, the damping and the period looked almost exactly like the simulator. Just like the run I had this morning in the simulator. So, I think our dynamics are good there. This airplane is really damped in pitch, supersonic. Time to half amplitude is probably 1 cycle. Maybe, no more than 2 to 1/2 amplitude and thats with the pitch damper off. So it is well damped supersonic.

OK, then we did the push over-pull up. That went well too. I went down to about 3° α and coming thru 8-10 it felt real solid so I went right on up to 14° about. So we should have gotten about 14° on the high end of the push over-pull up. Back on down to 8, and it's really a solid airplane in pitch.

OK, at 8° angle of attack, got the KRA to zero and then we just started doing a whole series of doublets. I have no idea how many doublets we did from there on down to the intersection. A good many of them. I'd guess that I got 3 of them in the transonic before I got the Mach jump and then a whole bunch more. Our energy was just exactly like we had seen this morning. We ended up on the simulator this morning come 2-3000 feet low all the way down, and that is just about what we ended up with this time at the intersection. Mike's calls were really subperb and it really helps when you get good calls like that, because I could relate to what we had seen this morning and the things that I did in the cockpit were a duplication of what we learned this morning.

OK, did my last pulse at about .66 indicated, John. I guess you guys never did get a call on the change, but on my Mach gage I was satisfied that we had gone beyond your point. OK, was a good turn back to 340. I was not aware that we were not getting any jettison on the fuel. I could feel the valve at least one of the valves, open when I went to jettison. I was a little surprised when we got the call that we had not jettisoned fuel. But then when we did hit it the second time, why, Bill came out with a reall good call, that was a dandy.

OK, everything else was pretty normal. It was a real good pattern. I did not look out of the airplane from the time we launched until Mike called "going over the highway". Here again, it is just the confidence that you have in the guys that are in the Control Room. OK, it was a real good pattern. I had a good solid 290 knot approach. It stayed 290 for the longest time and Bill was in there like a rock. We got a real good power check on the 104. I think he called 92% and our airspeeds were checking within 1 knot indicated. So that was a real good chase job and a real good check on our performance. It speaks pretty well on the big speed brakes on the 104. That is about a 3 or 4% change in power that they require, so that is just a lot of pad for a guy chasing something like this.

OK, the flare was normal, gear down was normal and I was able to hold it off quite a while. I guess I touched down at 175 to 180. It was really a nice feeling flying over the runway. The touchdown was very low sink rate. I guess somewhere around 2' per second. Somewhere in that ball park. Roll out was straight as an arrow. Seemed to be a little bit long. I did use some brakes at about 65 or 70 knots. Moderate braking on down. I would not have needed any steering at all, but I did play with the nose gear steering just a bit. It was sure a dandy airplane.

My hat's off to the crew. They came in about 4 o'clock in the morning to mate the airplane and those guys really do a fantastic job. Everything was ready to go and every system in the airplane was perfect. For all the guys involved, thanks a whole bunch, and the Control Room operation; once again superb. I just don't feel that anyone can critize an operation like we have been having up there. Good job by chase too, even though he was rather quiet today. That's all I have.

FLIGHT:	B-13-24	P.E.:	0820
DATE:	Jun 28, 1974	ENG. START:	0845
PILOT:	J. Manke	TAXI:	0850
B-52:	008	TAKEOFF:	0900
LNCH PANEL:	V. Horton	LAUNCH:	0957
NASA 1:	Maj. Love	LAND:	1005

24 Minutes

MANKE: OK, Mike, my SASA gains are 6, 5, 3
Are you ready for a calibrate?
NASA 1: We are ready
MANKE: Here it comes
NASA 1: Good calibrate, John
MANKE: OK Mike, and I got 22,000 on the cabin, X-24 air about 3050
---
2 and 4 hydraulics
Pumps coming on
Pumps are on
Low pressure lites are out and I got about 3200
NASA 1: Roger
MANKE: --- SAS mode switches are on and all the circuit breakers are in except vehicle release and brake
NASA 1: Roger
Vic, what is the cruise tank LOX quantity, please
VIC: About 300 gallons now
NASA 1: Roger

22 Minutes

NASA 1: 22 minutes, John, 22
MANKE: OK, Mike, 22 minutes
α reads about 3°
Airspeed 230
Altitude 40, 400
Indicated Mach about 7
NASA 1: Start your turn, 008
008: 008
MANKE: Mach repeater is auto ---
NASA 1: OK, thank you John
MANKE: OK, Mach repeater is manual
Set 1.0
Trim about 1
Emergency flaps

--- flaps coming open
--- 40 ---
20 and -10
Rudder mode going manual
Toeing out

MANKE: Back to zero
Back in
7, going auto

Bias mode going back-up
Cycle
5, 9
Back to normal
5, that should be about 7
Stick aft and trim
Forward, aft
NASA 1: 008, say your airspeed, please
008: --- .74 Mach
214 ---
NASA 1: Thank you
MANKE: 13°, Mike
NASA 1: Roger
MANKE: Aileron trim right

Trim set zero
Rudder pedals, right
Manke: Left
Yaw trim
Right/ left
Set about 1° left
NASA 1: Steepen your turn, 008
008: 008
NASA 1: Stop top-off
Precool off, John
MANKE: Precool is off
VIC: Top-off stopped
MANKE: KRA is 50
Right/left
I got rudder
Back to zero
Right/left
No rudder
KRA emergency

Rudder, left/rudder
Auto
Program
Stick shaker test
Good, and it's on
Mach repeater is manual 1.0
Flap mode manual
Rudder mode auto
SAS servos are auto

MANKE: 5, 5, 5
Here comes the old SMRD
Lites are off
A torque
3 yellows
Servos are off
A torque
3 reds
SAS gains are 6, 5, 3
SAS auto
Lites are reset
Torque, no lights
NASA 1: OK, John, we are approaching 17 and pylon loads are good
MANKE: Outstanding, Mike
NASA 1: A little forward trim, John
MANKE: How's that?
NASA 1: Little more

17 Minutes

NASA 1: 17 minutes
MANKE: OK, 17 minutes
CHASE: A little more forward
That's good
Left roll trim
A little more
That's good
Little left rudder trim
One more
That's good
Roger
NASA 1: 16 minutes, John

16 Minutes

MANKE: OK, Mike
NASA 1: Vic will you give us LOX quantity in the cruise tank?
VIC: ---
NASA 1: Roger, 15 minutes, John

15 Minutes

MANKE: OK, Mike
NASA 1: 14 minutes, John, 14

14 Minutes

MANKE: OK, Mike
1 and 3 pumps
2700
NASA 1: Roger
MANKE: And we are ready for pitch and yaw pulses
NASA 1: Roger
OK, you can go ahead and give us a pitch and yaw pulse
008: Roger, pitch pulse coming in

NASA 1:	Good pitch pulse
008:	Yaw pulse
NASA 1:	Good yaw pulse
MANKE:	Everything looks good here
NASA 1:	Roger, and you can get the erect switch and fast erect if you want
MANKE:	OK, erect switch erect and fast erect is on
NASA 1:	Roger
	13, John, 13
MANKE:	OK, Mike, 13
	My trims look good
NASA 1:	OK, 12 minutes, John
<u>12 Minutes</u>	
MANKE:	12 minutes
NASA 1:	11 minutes, John, 11
MANKE:	---
NASA 1:	Roger
MANKE:	Notice how much quieter it is today
NASA 1:	I was going to ask for a radio check from Chase 2, but I was afraid to
MANKE:	---

NASA 1:	10 minutes, John, 10 minutes
<u>10 Minutes</u>	
MANKE:	#1 and 2 both 4000
	Control gas 500
	Governor balance is 450
	Fuel tank is 0
	LOX tank ---
	Landing gear ---
	The old heater
NASA 1:	We are ready
MANKE:	Off
NASA 1:	Put it on
	Good check
MANKE:	---
NASA 1:	008, what is your indicated α
008:	---
<u>9 Minutes</u>	
NASA 1:	9 minutes, John, 9 minutes
	008, start your turn
	8 minutes, John, 8
<u>8 Minutes</u>	
NASA 1:	We got good ones
	Roger, Vic, start LOX top-off
?	---
NASA 1:	Good aileron cycle
Manke:	Roger

NASA 1:	Still 5 square
<u>6 Minutes</u>	
NASA 1:	6 minutes, John, 6 minutes
	Chase aircraft check your windshield heat
CHASE:	--- --- ---
NASA 1:	Trims good down here
<u>5 Minutes</u>	
	5 minutes, John
	008, plan on 060
008:	Roger
?	---

NASA 1:	Got 3 reds, John
MANKE:	6, 5, 3,
	SAS switches are auto
	Reset lites and a torque

NASA 1:	OK, we just past 4, John
<u>4 Minutes</u>	
MANKE:	---

NASA 1:	Left 2°, 008
008:	008, left 2
NASA 1:	3 minutes, John, 3 minutes
<u>3 Minutes</u>	

	Suit vent is low
	4035

	Switch going erect
	Fast erect is on

NASA 1:	We like your trim
	2 minutes, John, 2 minutes
<u>2 Minutes</u>	
Manke:	OK, 2 minutes
	Precool is off
	Engine bleed is on
	Prop supply is on
	Pressurized the tanks
	OK, LOX is 45
	Fuel 43-1/2
NASA 1:	Roger

MANKE: Release pressure low lite is out
NASA 1: Roger
MANKE: ---

NASA 1: 70 seconds, John
70 Seconds
MANKE: OK, Mike
NASA 1: Standby for 1 minute, now
MANKE: OK, I got it
Sources look good
SAS lites out
α is 4.5
Beta is 1° left
Heading is 058
NASA 1: 45
MANKE: Engine master on
Erect switch cutoff
Fast erect off
NASA 1: OK, all systems are good down here, John
MANKE: OK, Mike
Release circuit breaker is in
Camera and recorders and fin camera are all on
NASA 1: Roger
MANKE: There is 10 seconds, Mike, 5
NASA 1: Roger
LAUNCH
NASA 1: OK, John, check your α
We got 4 good ones, John
MANKE: Yes, me too
NASA 1: We see 15
Heading is good so far and profile looks good
Coming up on 25 seconds, you can standby for overdrive
MANKE: OK
NASA 1: Good overdrive
NASA 1: Standby for theta
Good heading
Track's good
You are on profile
There is 50 seconds
Check your Mach and your α
MANKE: Rog
NASA 1: Check your Mach
Standby for pushover to 12 α
Have you at 57,000, now
You are right on track
Profile is good
Check your beta
We see you at 12
Track's perfect

NASA 1: OK, standby for pushover to 5 α, and KRA to manual
MANKE: OKay
NASA 1: Tracks perfect
Profile is good
Go to 5, standby for doublets
You've crossed the early
See your doublets, Joh
Standby for shutdown and doublets
You are approaching the normal
We see your shutdown
Get your doublets
Trim 8 α
Pitch damper off, and pulse
And see you at 8 and see your pulse
Track's good, profile good
Check pitch damper on and get a popu
We see you in the popu
Check KRA at 0
8 α and some doublets
KRA is zero,
Track's good
You are on profile
See your doublets
You are about 1000 low on profile
Good track
1500 low
3 miles
Good track
Check your airspeed
MANKE: 270
NASA 1: OK, you are 2500 low
2 miles
Good track
You are about 3/4 outside right now, John
There's a mile
Good track, 3000 low
Abeam the intersection
A mile wide
3000 low
You are coming up abeam the turnpoint, John
3000 low
I don't have a bridge call
Standby for 12 α and clost it up
You can plan on 340
MANKE: Roger
NASA 1: We see you up to 12 and we see you closing
When you get closed, check prop supply off and go jettison
340 will be a good heading
You are coming back up to profile about 500 low

NASA 1: We see your jettison
You are at 3 miles
Check KRA auto
SAS 4, 3, 2
MANKE: Got all that
NASA 1: Stop jettison, tanks and bleed
At 2 miles
John, we would like you to try the fuel jettison again
MANKE: ---
NASA 1: Get 1 and 3 hydraulics on also
CHASE: OK, there is fuel jettison, John
NASA 1: You got a good track
You are on profile at 1 mile
Lets not get a rocket check
MANKE: Roger

NASA 1: Stop jettison fuel
You are over the highway
Start your turn
If you want a rocket check, go ahead
Manke: Alrighty, here comes
CHASE: 2 good ones
MANKE: I felt them
NASA 1: Real good ones
John, go #2 on helium master, please
MANKE: Got it
CHASE: 247, 15 thou and 87 on the turns
MANKE: OK, ---
NASA 1: OK, John, check Mach repeater .3
MANKE: OK, I got it
290, Bill
CHASE: Roger, 291, John
MANKE: Very good
CHASE: 92 RPM
MANKE: Great
Good aim point
Still 290
CHASE: 291
MANKE: Still 290
CHASE: Doing fine, John, there is 1200'
MANKE: OK, Willie
Turbulence
CHASE: Call that 100'
MANKE: OK, Bill
CHASE: 40, --- ---
3 good ones, John
20, 10, 5, 3, 2, 1
How about that
NASA 1: All stations, debrief at 1100
OK, John, you flew another normal

FLIGHT 14

PRELIMINARY RESULTS OF X-24B

Flight B-14-25

8 August 1974

BY

USAF/NASA X-24B Project Team

Flight Summary - Flight B-14-25

Flight B-14-25 was flown on 8 August 1974 by Major Love. The flight was flown as planned and all data maneuvers were accomplished. The signnificant flight conditions were:

Maximum Mach Number = 1.54
Maximum Altitude = 73381 feet
Maximum True Airspeed = 888 knots
Flight Time = 6 minutes 35.8 seconds
Burn Time = 130 seconds

A summary of the key data maneuvers performed is listed below:

Mach No.	α	Maneuver
.84	15	Rudder/Aileron Doublets (power on)
1.23	5	Pitch Pulse (power on)
1.38	4	Rudder/Aileron Doublets (power on)
1.51	4.5	Rudder/Aileron Doublets
1.42	7.0	Rudder/Aileron Doublets
1.38	7.5	Rudder/Aileron Doublets
1.26	7.5	Rudder/Aileron Doublets
1.18	8	Rudder/Aileron Doublets
1.10	8	Rudder/Aileron Doublets
.97	9.5	Pitch Pulse
.89 - .78	9-4-11-10	Aileron Bias POPU
.65	9 - 10	Steady Sideslip ($\pm 4° \beta$)
.57	4	Rudder/Aileron Doublets (20° upper flap)

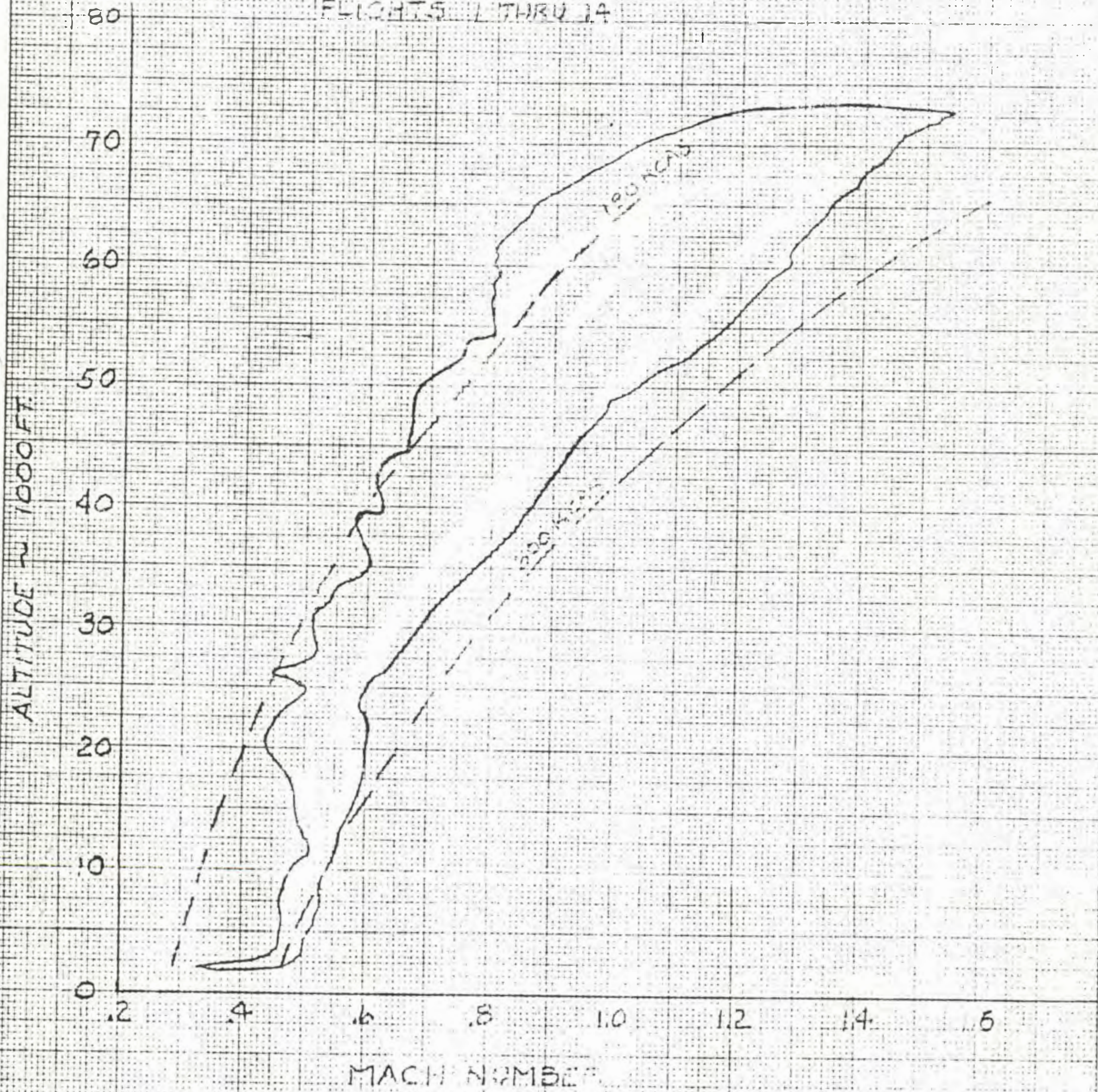
The XLR-11 rocket engine experienced pressure excursions 19 seconds prior to engine shutdown. It has been concluded that the pressure excursions were the result of unsteady pump operation due to interrupted H_2O_2 flow. A detailed discussion of this condition is presented in this report.

X-24B

MACH NO. VS ALTITUDE

ENVELOPE

FLIGHTS 1 THRU 14

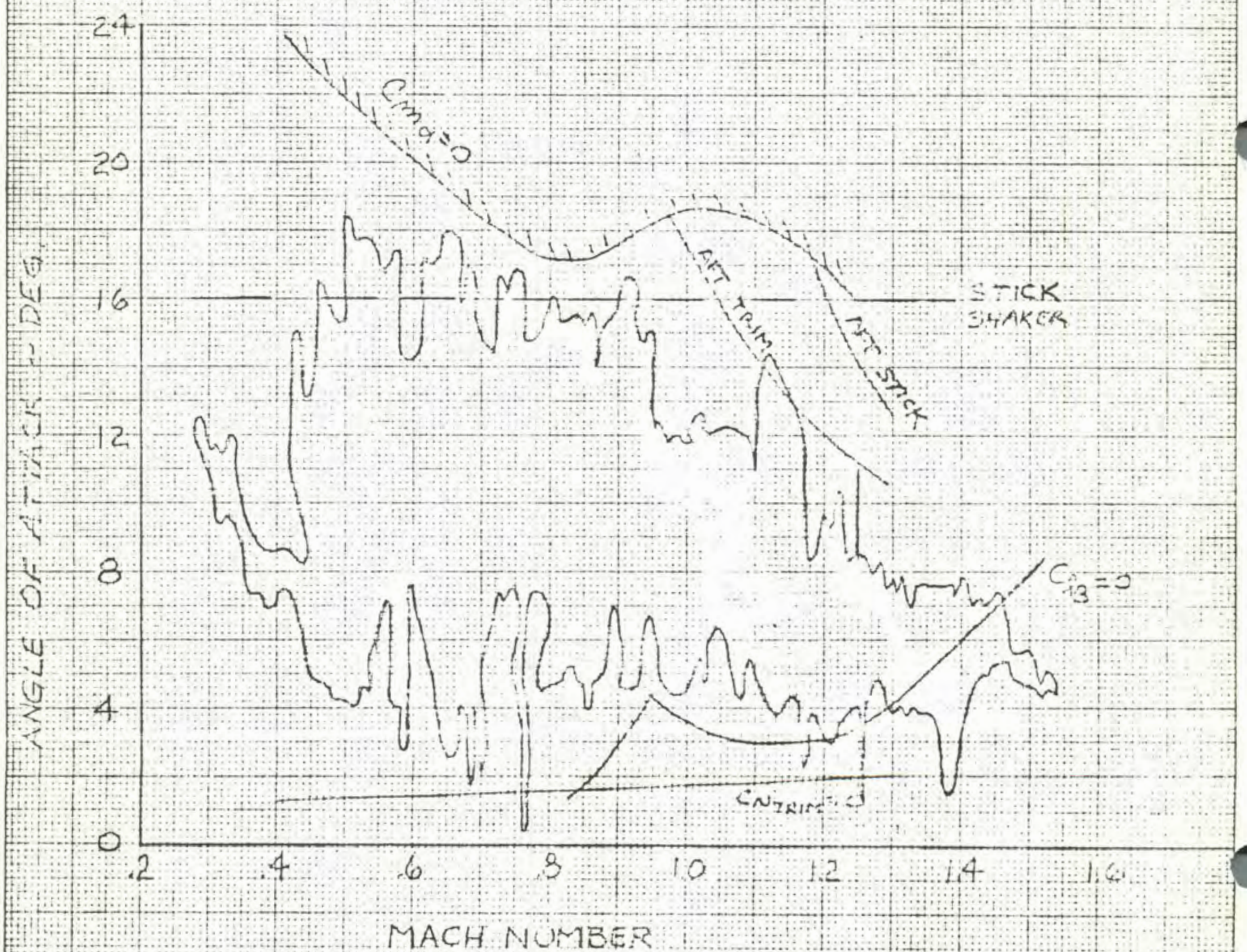


X-24B

MACH NO. VS ANGLE OF ATTACK

ENVELOPE

FLIGHTS 1 THRU 14



X-24B Flight Request

19 July 1974

Flight No: B-14-25

Scheduled Date: 6 August 1974 Flown 8 Aug 1974

Pilot: Major Love

Purpose:
1. Envelope Expansion to 1.55 Mach number
2. Stability and Control at Mach number >1.0 and 5^{o} and 8^{o} α
3. Fin, Rudder and Flap Pressure Survey (GroupI)
4. Boundary layer noise and vibration experiment (RED PLUG)

Launch: West of Rosamond, Mag Heading 060^{o} + Cross Wind Correction Angle. 45,000 feet, 190 KIAS. Flap Bias "Manual", Upper Flaps = -40^{o}, Lower Flaps = 27^{o}, Rudder Bias Mode "AUTO", Rudder Bias = 0^{o}. Rudder Trim = 1^{o} Left. Aileron Bias = + 7^{o}, SAS Gains 6, 5, 3. Mach Repeater "Manual" = 1.0, KRA "AUTO". Hydraulic Pumps 2 and 4 on.

Landing: Rogers Lakebed Runway 18

B-52 Track: X-24B Track #2 (R2515, Work Area I)

ITEM	TIME	ALT	A/S	α	M_T	EVENT
1	0	45	190	5	.71	Launch, Light 4 Chambers, Trim to and Maintain 15^{o} α.
2	30	43	245	15	.84	At 30 sec. Turn Overdrive on. Perform rudder and aileron doublets
3	48	48	200	15	.78	$\theta = 43^{o}$ Maintain $\theta = 43^{o}$ (cross check α)
4	78	60	160	15	.85	At 60K (.85 $Mach_T$) Push-over to 12^{o} α.
5	103	68	175	12	1.05	At 1.05 $Mach_T$, pushover to 5^{o} α.
6	113	70	200	5	1.20	Perform Pitch Pulse
7	121	70	235	5	1.35	Perform rudder and aileron doublets.

ITEM	TIME	ALT	A/S	α	M_T	Event
8	127	69	270	5	1.55	At 1.55 $Mach_T$ shut down engine. Perform rudder and aileron doublets.
9	134	66	270	5	1.45	Trim to 8^o α, perform rudder and aileron doublets while decelerating to Mach 1.10. Target Mach numbers for these doublets sets are 1.4, 1.3, 1.2, and 1.1. After last doublet trim to 10^o α.
10	174	47	260	10	.95	Perform pitch pulse
11	178	45	250	10	.92	Perform aileron bias POPU. δ a bias 7^o to 11^o to 5^o to 7^o. Retrim to 13^o α.
12	208	36	230	13	.70	Trim to 10^o α and perform $\pm 2^o$ Steady sideslip.
13	213	34	220	10	.66	Intersection, turn to low key heading, jettison propellants, set SAS Gains to 4, 3, 2.
14	240	30	210	12	.56	Change configuration to -20^o upper flaps. Perform rudder and aileron doublets at 5^o α/ .6 Mach number.
15	290	21	230	12	.52	Low key, rocket check #1 & #3 hydraulic pumps on.
16						Change Mach repeater to 0.3 during final.

NOTES:

1. Nose Ballast = 120 [redacted] lbs (+ five 93 lb batteries)

2.

	Weight-lbs	cg-%
Launch	13570	65.9
Shutdown	8830	64.1
Landing	8500	64.0 (gear down)

3. Engine S/N 8, Pump S/N 8A

	NORMAL	OVERDRIVE
Thrust - lbs/chamber	2200	2450
LOX Flow Rate - lb/sec/chamber	4.51	5.045
WALC Flow Rate - lb/sec/chamber	4.05	4.53

4. Power on Base Drag Reduction $C_C = -.005$

5. Pitch attitude Null at 43^{o}

Ground Rules for NO LAUNCH:

1. Radio, radar, PCM failure
2. Electrical or SAS malfunction
3. A/S, altitude, Machmeter failure
4. Angle of attack or sideslip malfunction
5. Any control system malfunction
6. Loss of cabin pressure
7. Turbulence below 10K in excess of moderate
8. Surface winds greater than 20 kts or crosswind greater than 10 kts
9. Failure of engine control box heater
10. Failure of stick shaker

(In addition to standard ground rules published in Lift Body Joint Operations Plan)

Alternate Situations After Launch:

Failure	Action
1. Radio, radar, PCM	Proceed as planned.
2. Only One Chamber Operates	Vector for RW 02 Rosamond, shutdown chamber, jettison, change configuration.
3. Only Two Chambers Operate	Maintain 15^{o} α. Shutdown on NASA I call (≈240 sec). At shutdown pushover to 10^{o} α and proceed with steady sideslip maneuver.

Failure	Action
4. Only Three Chambers Operate	Maintain 15^{o} α. Overdrive on at 30 sec. at 54K (.85M_T) pushover to 12^{o} α. at 1.05M_T pushover to 8^{o} α (overdrive stays on). Shutdown on NASA I call ($\approx$159 sec) and proceed as planned with subsonic maneuvers. (Possible engine burnout)
5. Delayed Engine Light	Proceed as planned. Use 45^{o} θ (15^{o} α Max). At 62K pushover to 12^{o} α. (Possible burnout 132 sec/1.45 Mach No)
6. Overdrive Failure	Maintain 15^{o}. At 61K pushover to 12^{o} α, at 1.05 $Mach_t$ pushover to 10^{o} α, at 1.2 $Mach_t$ (watch β) pushover to 8^{o} α and proceed as planned. Shut down at 1.55 or 300 KIAS (138 sec).
7. Total damper failure any axis	Fly 2 chamber profile, ~~turn the over-~~ [redacted], Maintain 15^{o} α (13^{o} α for a pitch damper failure). Change configuration to 35^{o} upper flap at .7 Mach number. Shutdown on NASA I call. Roll or Yaw failure set KRA to "MAN" 0% ~~Mach Rep. to 0.5~~. Pitch failure, close-up to -24^{o} upper flap at low key. IF roll failure turn yaw gain to zero. Limit MACH to 1.1.
8. KRA "AUTO" Failure	Set to manual 10% and proceed as planned if "MANUAL" mode inoperative-switch to "EMER" Position and set to above value.
9. Angle of Attack (Indicator Only)	Proceed as planned using backup angle of attack gage. KRA "MANUAL" 10%, stick shaker off.
10. Total Angle of Attack	~~Fly two chamber profile, use 200 KTS instead of 15^{o} α. To rotate fly 1.0 g to 230 KCAS then fly 1.2 g to 200 KCAS. (KRA Manual 10%, stick shaker off)~~ (see next page)
11. A/S Altitude, Mach	Proceed as planned using α, θ and time for profile control. Don't do steady β maneuver or $5^{o}\alpha$, Mach .6 doublets.
12. Attitude System	Proceed as planned using backup attitude indicator.
13. Rudder Bias "AUTO" failure	Switch to "MANUAL" mode and toe-in to -10^{o}. If "MANUAL" fails close-up to -24^{o} upper flap.

Failure	Action
14. Upper flaps fail to close	Cycle emergency flap switch to close-up to -20^{o} upper flaps. If emergency flap switch fails, move δA_B to 11^{o}.
15. Premature Engine Shutdown	

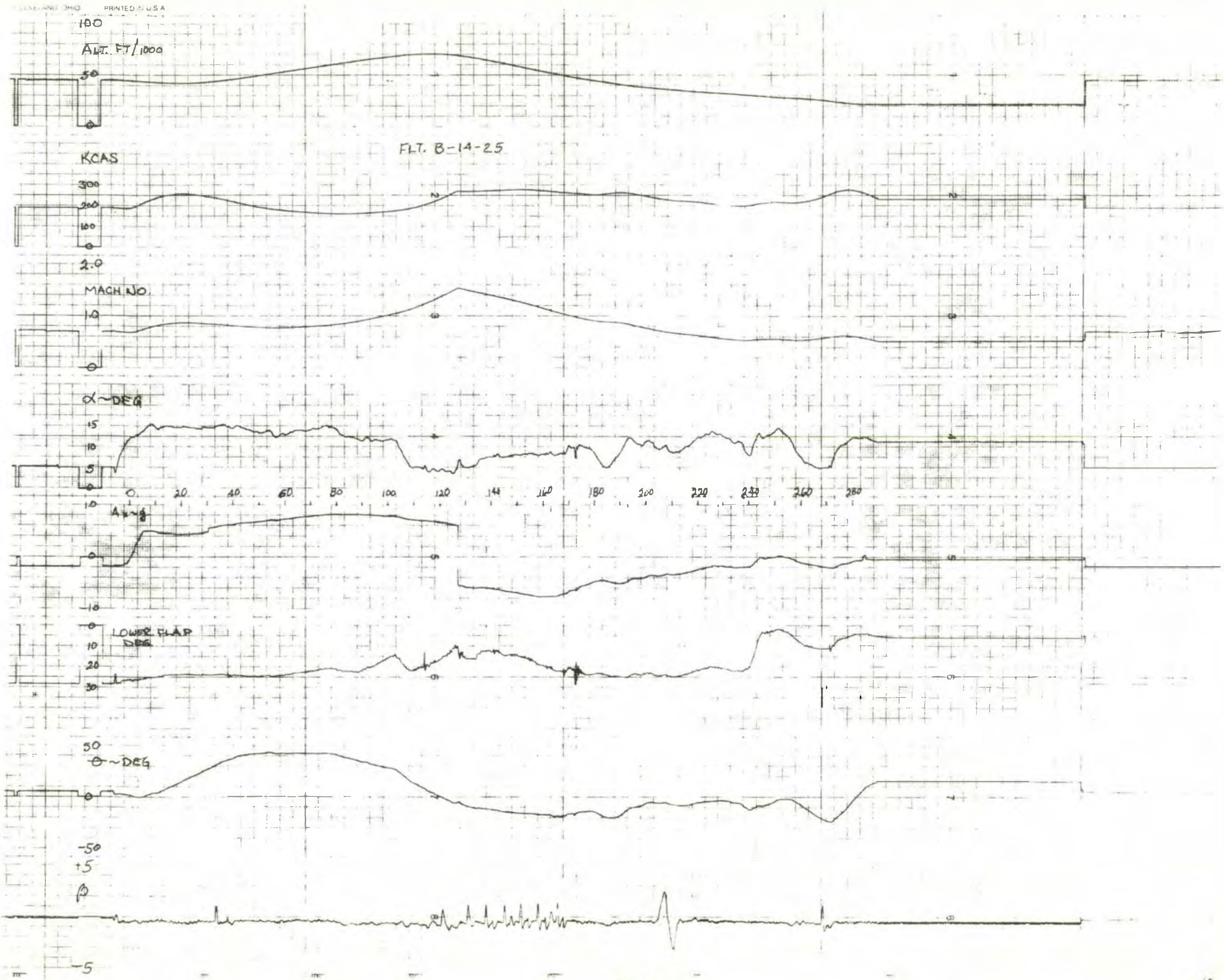
0 - 25 Sec RW 02 Rosamond
25 - 52 Sec RW 20 Rosamond
52 - 82 Sec RW 36 Rogers
82 - 90 Sec RW 18 (RHP) Rogers
90 - up Sec RW 18 (LHP) Rogers

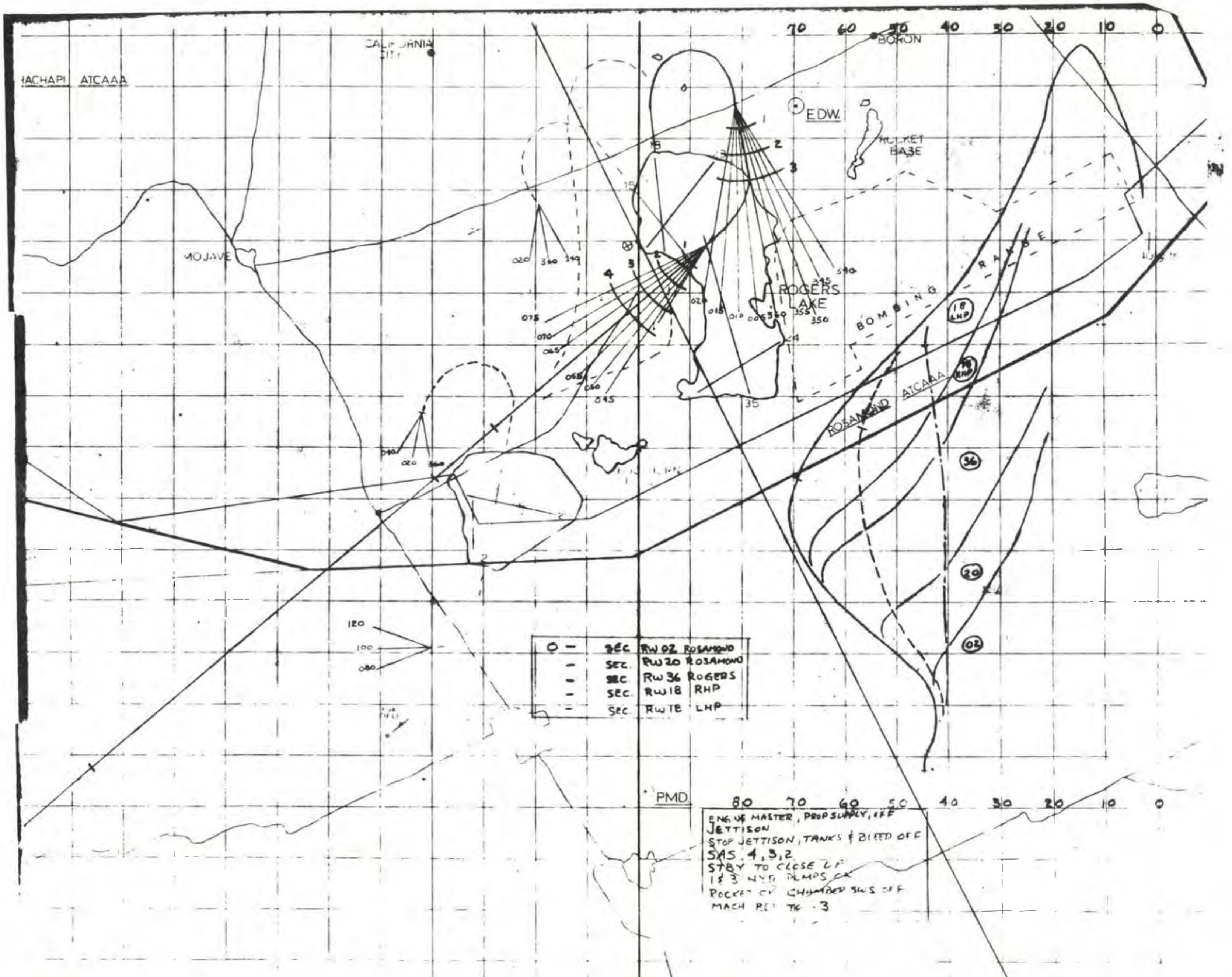
Robert G. Hoey
ROBERT G. HOEY

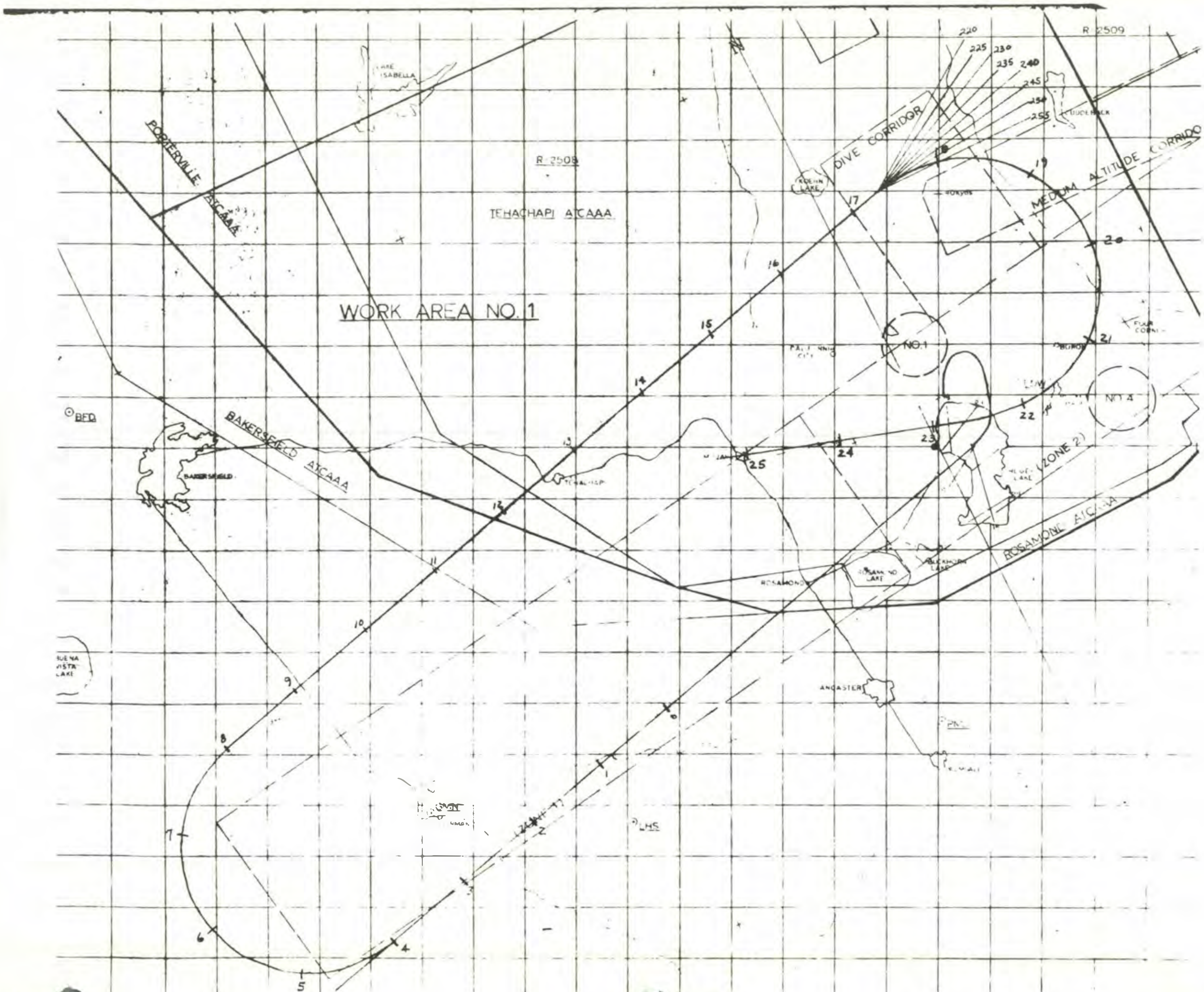
Jack L. Kolf
JACK L. KOLF

correction

FAILURE	Action
10 Total Angle of Attack	0 to 30 seconds; Fly two chamber profile, use 200 KTS instead of 15 degrees α. To rotate fly 1.0 g to 230 KCAS then fly 1.2 g to 200 KCAS. (KRA Manual 10 percent, stick shaker off).
	30 to 110 seconds; Fly three chamber profile, overdrive stays on, pushover to .5 g's until θ=0 degrees then fly 0 degrees θ, shutdown on NASA I call, pushover to .5 g's to 250 KCAS then fly 1.2 g's until Mach = .85 then 1.4 g's to 200 KCAS. (KRA "MAN" 10%, stick shaker off)
	110 seconds; Shutdown, pushover to .5 g's to 250 KCAS then fly 1.2 g's until Mach .85 then 1.4 g's to 200 KCAS. (KRA "MAN" 10%, stick shaker off)


CLEVELAND OHIO PRINTED IN U.S.A.
FLT. B-14-25
100
ALT. FT/1000
50
0
KCAS
300
200
100
0
2.0
MACH NO.
1.0
0
α ~ DEG
15
10
5
0
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280
1.0
Az~g
0
-1.0
0
LOWER FLAP DEG
10
20
30
50
θ ~ DEG
0
-50
+5
β
-5


CALIFORNIA CITY
BORON
EDW.
ROCKET BASE
MOJAVE
ROGERS LAKE
BOMBING RANGE
ROSAMOND ATCAAA
PMD
LH
SEC. RW 02 ROSAMOND
SEC. RW 20 ROSAMOND
SEC. RW 36 ROGERS
SEC. RW 18 RHP
SEC. RW 18 LHP
ENGINE MASTER, PROP SUPPLY, OFF
JETTISON
STOP JETTISON, TANKS & BLEED OFF
SAS. 4, 3, 2
STBY TO CLOSE
1 & 3 HYD PUMPS
MACH
80 70 60 50 40 30 20 10 0



WORK AREA NO. 1
R-2508
TEHACHAPI ATCAAA
PORTERVILLE ATCAAA
BAKERSFIELD ATCAAA
ROSAMOND ATCAAA
R-2509
DIVE CORRIDOR
MEDIUM ALTITUDE CORRIDOR
(ZONE 2)
NO. 1
NO. 4
BFD
BAKERSFIELD
LAKE ISABELLA
KOEHN LAKE
ROSAMOND
ROSAMOND LAKE
LANCASTER
PMD
LHS
BUENA VISTA LAKE
220
225
230
235
240
245
250
255

X-24B EVENT SHEET FLT. B-14-[illegible]

TIME	MACH	α	ALTITUDE	KEAS	EVENTS
10:00:25.4					ENGINE MASTER ON
10:00:31.6					GOX PRIME
:00:34.6					LOX PRIME
:00:56.2					CENTER FIN CAMERA ON
10:01:10.4	.716	1.7	44829.	192.	LAUNCH
:01:13.0	.702	9.1	44714.	188.	#1 & #3 CHAMBERS PRESSURES START UP
:01:14.8	.701	9.0	44658.	188.	Ax STARTS INCREASE
:01:15.3	.703	9.8	44614.	189.	#3 CHAMBER PRESSURE AT [illegible] PSIA
:01:16.2	.709	11.7	44494.	191.	#1 & #3 AT 100%, AX LEVEL (2 CHAMBERS)
:01:16.7	.712	12.5	44440.	192.	LH FIN PRESSURE GLITCH
:01:16.9	.713	12.8	44429.	193.	RH FIN PRESSURE GLITCH
:01:17.1	.715	13.3	44397.	193.	#2 & #4 CHAMBER PRESSURES START UP
:01:18.1	.720	15.0	44277.	195.	Ax STARTS INCREASE
:01:19.1	.729	16.8	44125.	199.	AX LEVEL (4 CHAMBERS)
:01:19.3	.732	16.[illegible]	44093.	200.	#2 AT 100%
:01:19.5	.734	15.7	44071.	201.	#4 AT 100%
:01:40.5	.866	14.9	42735.	249.	LH FIN PRESSURE GLITCH
:01:41.0	.867	15.0	42772.	249.	MAX MACH DURING ROTATION, $\alpha = 15^\circ$
:01:42.2	.862	14.5	42915.	247.	LH FIN PRESSURE GLITCH
:01:45.1	.857	15.3	43334.	243.	OVERDRIVE ON
:01:49.7	.849	15.0	44281.	235.	RUDDER DOUBLET, $\alpha = 15^\circ$
:01:52.5	.837	15.4	45018.	227.	AILERON DOUBLET, $\alpha = 15.5$
10:02:07.7	.797	15.7	50563.	189.	$\theta = 45$

TIME	MACH	α	ALTITUDE	KCAS	EVENT
10:02:29.2	.812	15.2	59614.	156.	PUSHOVER TO 12° α
:02:33.3	.800	11.7	61453.	147.	12° α
:02:45.4	.880	12.5	65870.	148.	RH FIN PRESSURE GLITCH
:02:45.5	.880	12.4	65907.	148.	β STARTS OUT TO RIGHT FROM -1°
:02:45.6	.883	12.4	65950.	148.	Ax MAX 0.30 g
:02:46.7	.910	12.3	66456.	152.	β STARTS IN FROM -2.2°
:02:47.1	.920	12.4	66632.	153.	RH FIN PRESSURE GLITCH
:02:49.1	.919	12.2	67245.	151.	β AT -1°
:02:49.7	.931	12.8	67493.	152.	LEFT RUDDER INPUT
:02:52.2	.960	12.2	68430.	154.	RUDDER RELEASED, β STARTS IN FROM +2.2° (NOSE LEFT)
:02:54.6	1.014	11.3	69421.	161.	β OVERSHOOT TO -1.6°
:02:55.6	1.0046	11.5	69384.	159.	β RETURNS TO -1° (NOSE LEFT)
:02:57.3	1.017	12.7	69625.	161.	START MACH JUMP
:02:58.9	1.029	12.1	70047.	162.	END MACH JUMP
10:03:02.3	1.092	11.7	71199.	169.	PUSHOVER TO 5° α
:03:06.3	1.148	5.1	72139.	176.	ENGINE STARTS TO "POGO"
:03:06.8	1.157	5.1	72239.	177.	5° α
:03:10.9	1.231	4.9	72922.	188.	PITCH PULSE, α = 5°
:03:16.9	1.360	3.7	73348.	210.	RUDDER DOUBLET, α = 4°
:03:19.2	1.407	3.9	73381.	218.	AILERON DOUBLET, α = 4°
:03:19.2	1.407	3.9	73381.	218.	MAX ALTITUDE
:03:23.0	1.497	5.7	73011.	236.	ENGINE "POGO" STOPS
:03:24.7	1.540	4.5	72832.	245.	ENGINE SHUTDOWN
:03:25.0	1.541	4.5	72798.	245.	MAX MACH, KTAS = 888
:03:25.3	1.538	4.4	72720.	245.	#3 CHAMBER PRESSURE AT 155 PSI

TIME	MACH	α	ALTITUDE	KCAS	EVENTS
10:03:27.6	1.516	4.[illegible]	72171.	244.	RUDDER DOUBLET, $\alpha = 5°$
:03:29.5	1.499	4.6	71713.	244.	AILERON DOUBLET, $\alpha = 5°$
:03:31.2	1.473	5.4	71210.	242.	PULLUP TO $7.5° \alpha$
:03:32.7	1.458	7.4	70707.	242.	$7.5° \alpha$
:03:37.1	1.420	7.1	69128.	243.	RUDDER DOUBLET, $\alpha = 7°$
:03:39.4	1.407	7.4	68398.	245.	AILERON DOUBLET, $\alpha = 7.5°$
:03:39.5	1.408	7.5	68353.	245.	START LEFT HEADING CORRECTION MAX $\phi = 29°$
:03:45.6	1.396	7.7	65266.	248.	RUDDER DOUBLET, $\alpha = 7.5°$
:03:48.4	1.330	7.4	64048.	253.	AILERON DOUBLET, $\alpha = 7.5°$
:03:56.2	1.269	7.6	60042.	263.	RUDDER DOUBLET, $\alpha = 7.5°$
:03:58.7	1.240	7.4	58717.	264.	AILERON DOUBLET, $\alpha = 7.5°$
10:04:03.1	1.194	7.7	56200.	267.	$\phi = -29°$
:04:03.3	1.193	7.7	56190.	267.	RUDDER DOUBLET, $\alpha = 7.5°$
:04:06.1	1.163	8.0	54634.	268.	AILERON DOUBLET, $\alpha = 8.0°$
:04:09.6	1.114	8.3	52680	267.	RUDDER DOUBLET, $\alpha = 8°$
:04:12.7	1.051	8.0	50970.	258.	AILERON DOUBLET, $\alpha = 7.5°$
:04:15.5	1.023	7.1	49734.	257.	START MACH JUMP
:04:16.3	1.015	7.9	49895.	254.	PULLUP TO $10° \alpha$
:04:17.4	.9708	9.3	48444.	249.	END MACH JUMP
:04:19.1	.9763	9.7	47960.	254.	$10° \alpha$
:04:19.4	.9718	9.6	47743.	254.	PITCH PULSE $\alpha = 9.5°$
:04:25.9	.9059	9.2	44414.	252.	START AILERON BIAS POPU, $\delta_{A_B} = 7°$, $\alpha = 9.5°$ ($\delta_U = 40°$, $\delta_L = 25.5°$, $\delta_R = 0°$, $\alpha = 9.5°$
:04:26.0	.9050	9.2	44366.	252.	RH FIN PRESSURE GLITCH
:04:27.2	.8934	8.2	43851.	252.	RH FIN PRESSURE GLITCH.

TIME	MACH	α	ALTITUDE	KCAS	EVENTS
:04:31.3	.8577	4.1	42096.	250.	$\delta_{A_\beta} = 110$, $\alpha = 4^\circ$
:04:32.3	.8514	4.1	41671.	250.	END LEFT HEADING CORRECTION
:04:40.5	.7993	10.8	38212.	253.	$\delta_{A_\beta} = 5^\circ$, $\alpha = 10.5^\circ$
:04:43.3	.7805	9.8	37190.	252.	$\delta_{A_\beta} = 7^\circ$, $\alpha = 10^\circ$, END AILERON BIAS POPU
:04:44.9	.7661	9.2	36658.	250.	PULLUP TO 13° α
.04:48.1	.7397	12.3	35697.	246.	12.5° α
:04:49.7	.7271	11.0	35285.	244.	START TURN TO DOWNWIND, MAX $\phi > 50^\circ$
:04:53.6	.6918	9.6	34433.	235.	LH FIN PRESSURE GLITCH
:53.8	.6904	9.1	34490.	235.	LH FIN PRESSURE GLITCH
:54.0	.6890	9.0	34355.	235.	RH FIN PRESSURE GLITCH
:04:57.8	.6684	11.1	33598.	231.	PUSHOVER TO 10° α
:04:58.7	.6635	10.0	33419.	230.	LEFT RUDDER INPUT
10:05:00.1	.6594	9.3	33153.	230.	β AT +3.6°
:05:01.5	.6519	9.1	32841.	229.	RIGHT RUDDER INPUT
:05:03.3	.6465	10.3	32486.	229.	β AT −4.0°
:05:04.7	.6410	9.8	32198.	228.	STOP RUDDER INPUT
:05:06.8	.6357	10.7	31744.	228.	β RETURNS TO 0°
:05:11.0	.6191	11.6	31109.	225.	LOX JETTISON
:05:11.2	.6183	11.6	31064.	225.	WALC JETTISON
:05:13.0	.6059	11.2	30530.	223.	STOP LOX JETTISON
:05:13.2	.6054	11.2	30486.	223.	STOP WALC JETTISON
:05:18.0	.5840	11.9	29521.	219.	PITCH SAS GAIN TO 4
:05:18.6	.5812	12.1	29399.	219.	ROLL SAS GAIN TO 3
:05:19.3	.5791	12.0	29244.	219.	YAW SAS GAIN TO 2
:05:24.0	.5673	13.0	28174.	219.	UPPER FLAPS START IN FROM 40°
:05:27.1	.5655	10.6	27492.	221.	END TURN TO DOWNWIND

TIME	MACH	α	ALTITUDE	KCAS	EVENTS
10:05:30.7	.5665	10.6	26811.	225.	UPPER FLAPS AT 20°
:05:38.7	.5633	9.3	25557.	230.	PUSHOVER TO 5° α
:05:40.3	.5593	4.3	25325.	229.	5° α
:05:45.0	.5699	4.0	24494.	238.	RUDDER DOUBLET, α = 5°
:05:47.7	.5797	4.1	23894.	245.	AILERON DOUBLET, α = 5°
:05:49.4	.5874	5.9	23480.	251.	LH FIN PRESSURE GLITCH
:05:49.4	.5874	5.9	23480.	251.	START LANDING ROCKET CHECK
:05:50.8	.5941	5.7	23120.	256.	END LANGING ROCKET CHECK
:05:52.0	.5978	7.3	22814.	259.	#1 HYDRAULIC PUMP ON
:05:52.3	.5983	7.4	22737.	260.	#3 HYDRAULIC PUMP ON
:05:53.0	.5993	6.7	22562.	261.	START VISUAL RUNWAY CHECK, MAX φ = 36°
:05:54.8	.6015	5.2	22102.	265.	φ = -36°
:05:55.9	.6025	7.3	21827.	267.	START RIGHT HEADING CORRECTION, MAX φ = 48°
:05:59.7	.5987	10.7	20881.	270.	φ = 48°
10:06:03.6	.5931	7.3	19979.	272.	END RIGHT HEADING CORRECTION
:06:03.6	.5931	7.3	19979.	272.	LOW KEY, START TURN, (MAX φ > 50°)
:06:18.6	.5856	6.3	16463.	288.	UPPER FLAPS START OUT FROM 20°
:06:22.5	.5771	7.4	15471.	289.	UPPER FLAPS AT 31° (SPEEDBRAKES)
:06:28.3	.5583	9.8	13905.	288.	UPPER FLAPS START IN FROM 31°
:06:30.4	.5532	8.6	13343.	288.	UPPER FLAPS AT 26°
:06:30.8	.5537	8.3	13233.	289.	UPPER FLAPS START OUT FROM 26°
:06:36.3	.5240	8.7	11717.	281.	UPPER FLAPS AT 39° (SPEEDBRAKES)
:06:44.4	.4786	7.0	9854.	266.	UPPER FLAPS START IN FROM 39°
:06:50.1	.4677	8.4	8488.	266.	UPPER FLAPS AT 20°

TIME	MACH	α	ALTITUDE	KCAS	EVENTS
10:06:54.8	.4774	7.8	7418.	277.	MACH REPEATER TO .3
10:07:17.8	.4784	6.3	3393.	298.	LEVEL ON FINAL
:07:26.9	.4375	6.9	2574.	277.	START FLARE
:07:36.5	.3714	8.2	2399.	236.	GEAR DOWN
:07:40.0	.3369	10.6	2360.	214.	CROSSOVER TO UPPER FLAP
:07:41.2	.3266	11.8	2344.	207.	RETURN TO LOWER FLAP
:07:46.2	.2868	10.2	2332.	182.	MAINGEAR TOUCHDOWN, α = 11.5°
:07:46.4	.2852	9.9	2331.	181.	CROSSOVER TO UPPER FLAP
:07:48.5	.2636	-3.1	2318.	167.	NOSEGEAR TOUCHDOWN
:07:51.5	.2342	-4.6	2324.	149.	RETURN TO LOWER FLAP

X-24B DERIVATIVES

by Alex G. Sim

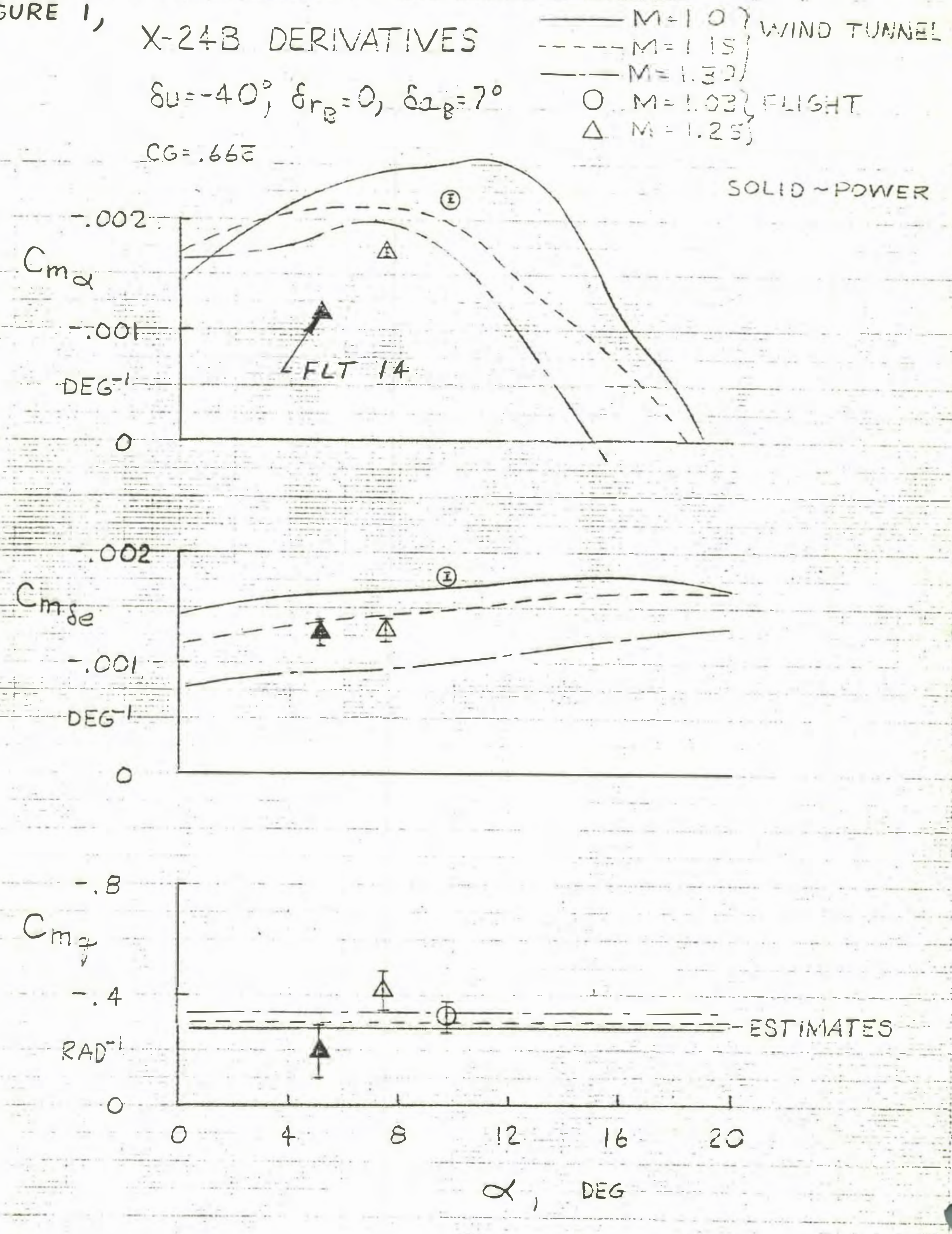
On flight 14, 2 sets of longitudinal and 12 sets of lateral-directional derivatives were obtained.

Longitudinal derivatives obtained are presented in figures 1, 2, and 3. The flight 14 derivatives shown on figure 1 were the first power-on supersonic data to be obtained. They indicate lower longitudinal static stability and pitch damping as a result of power at Mach number 1.25; while, pitch control effectiveness remains at a high level. From figures 2 and 3, the second set of longitudinal derivatives obtained is shown to agree well with the trends in the previously obtained derivatives.

The lateral-directional static stability derivatives obtained near Mach numbers of 0.8 and 0.95 are presented in figures 4 and 5. The flight 14 data tend to better define the levels of power-on stability in these transonic flight regions.

Figure 6 presents the complete sets of lateral-directional derivatives obtained above a Mach number of 1.25. Except for a few specific points, these data are consistent and very reasonable. Figure 7 presents selected stability and control derivatives plotted as a function of Mach number at angles of attack of 4° and 7.5°. Note that rudder control effectiveness is lower than wind tunnel predictions at the higher Mach numbers.

FIGURE 1,



X-24B DERIVATIVES
δu=-40°, δr_B=0, δa_B=7°
CG=.66c̄
M=1.0
M=1.15
M=1.30
WIND TUNNEL
M=1.03
M=1.25
FLIGHT
SOLID ~ POWER
-.002
Cmα
-.001
DEG⁻¹
0
FLT 14
-.002
Cmδe
-.001
DEG⁻¹
0
-.8
Cmq
-.4
RAD⁻¹
0
ESTIMATES
0
4
8
12
16
20
α, DEG

FIGURE 2,

X-24B DERIVATIVES

$\delta_{U_B} = -40°$, $\delta_{r_B} = 0°$, CG = .66$\bar{c}$

○ M=0.8 } FLIGHT
□ M=0.9
△ M=0.95
——— M=0.8 } WIND TUNNEL
—·— M=0.9
– – – M=0.95
SOLID: POWER ON

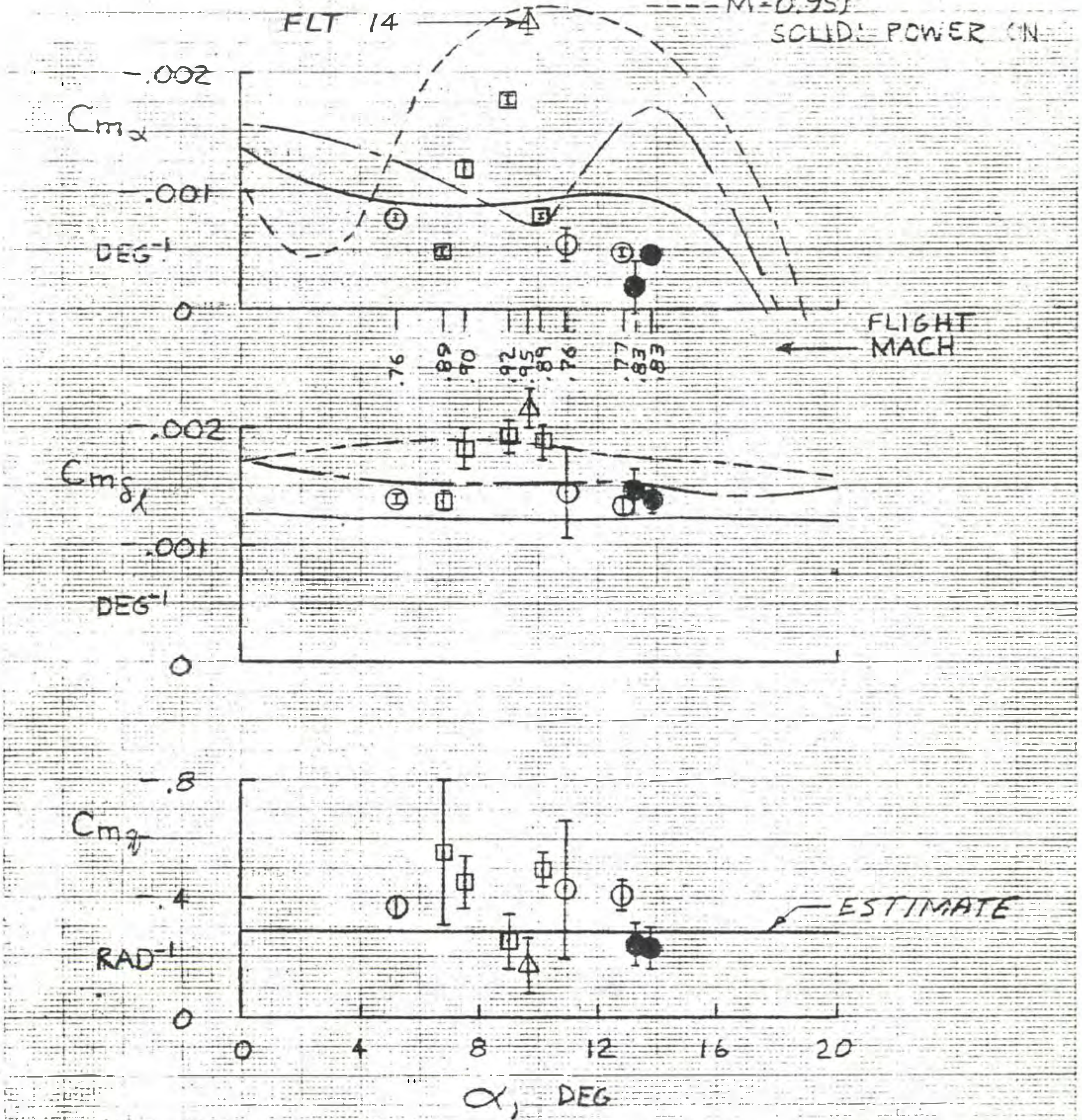


FIGURE 3,

— WIND TUNNEL
--- INTERPOLATION
O FLIGHT

SOLID ~ POWER - ON

X-24B DERIVATIVES

$\delta u_B = -40°$, $\delta r_B = 0°$, CG = .66$\bar{c}$

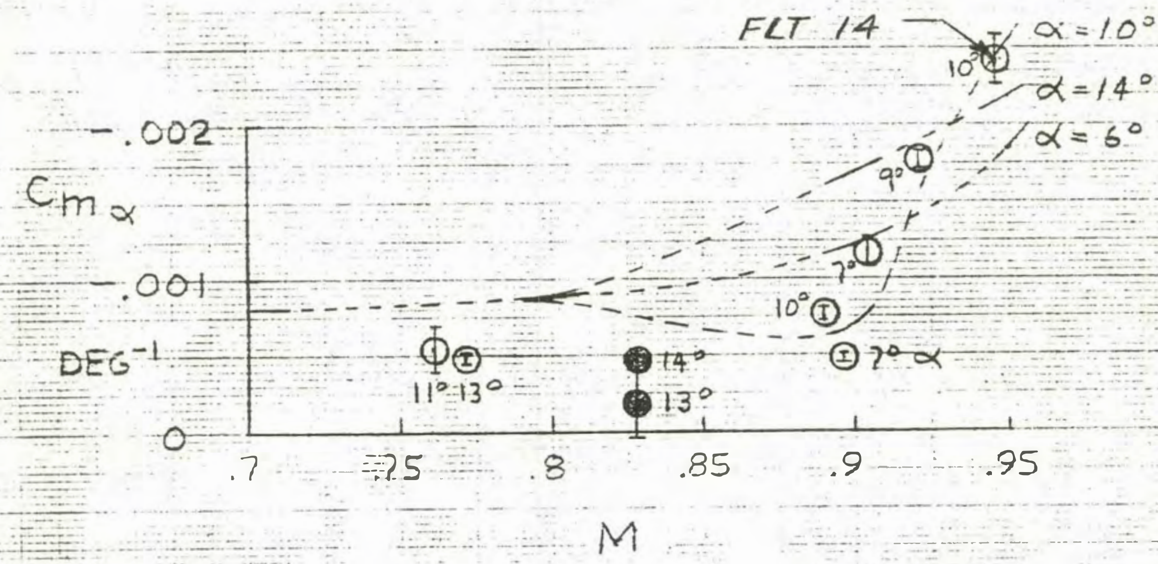


FIGURE 4,

X-24B DERIVATIVES

M=0.8, δu_B=-40°, δr_B= 0°

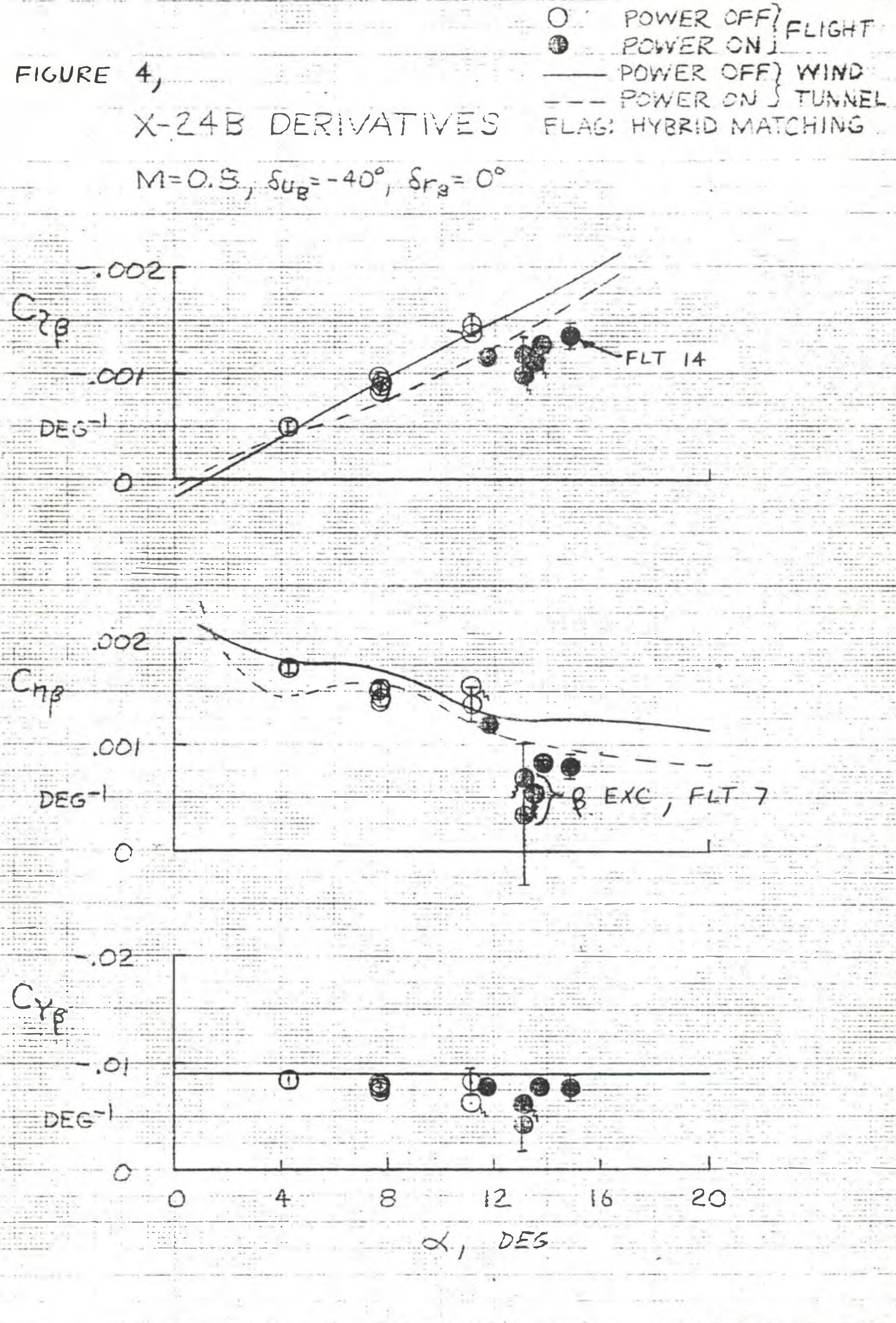


FIGURE 5,

X-24B DERIVATIVES

M=0.95, $\delta_{u_B}=-40°$, $\delta_{r_B}=0°$

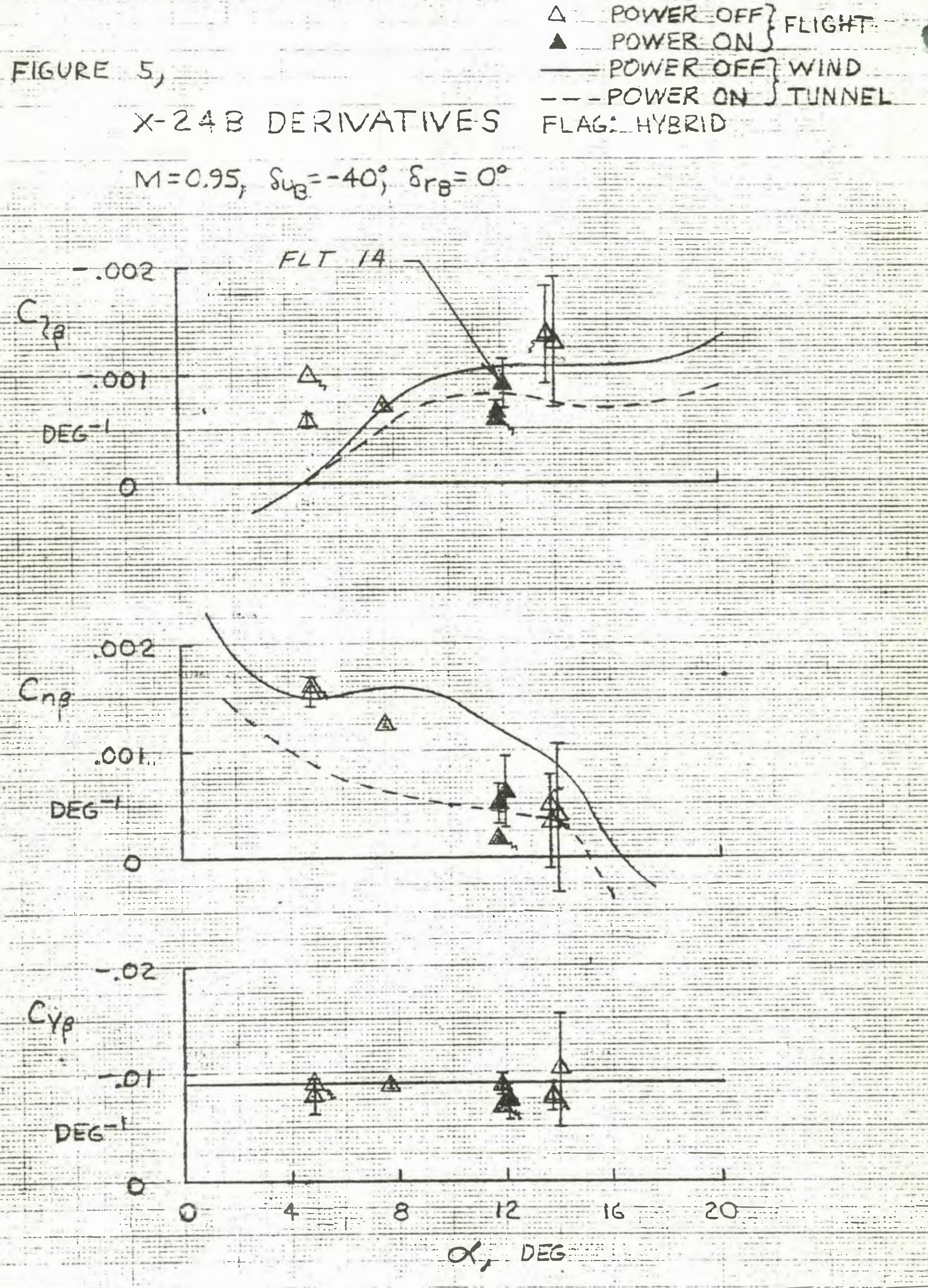


FIGURE 6,

X-24B DERIVATIVES

$\delta_{UB} = -40°$, $\delta_{rB} = 0$, CG=.65

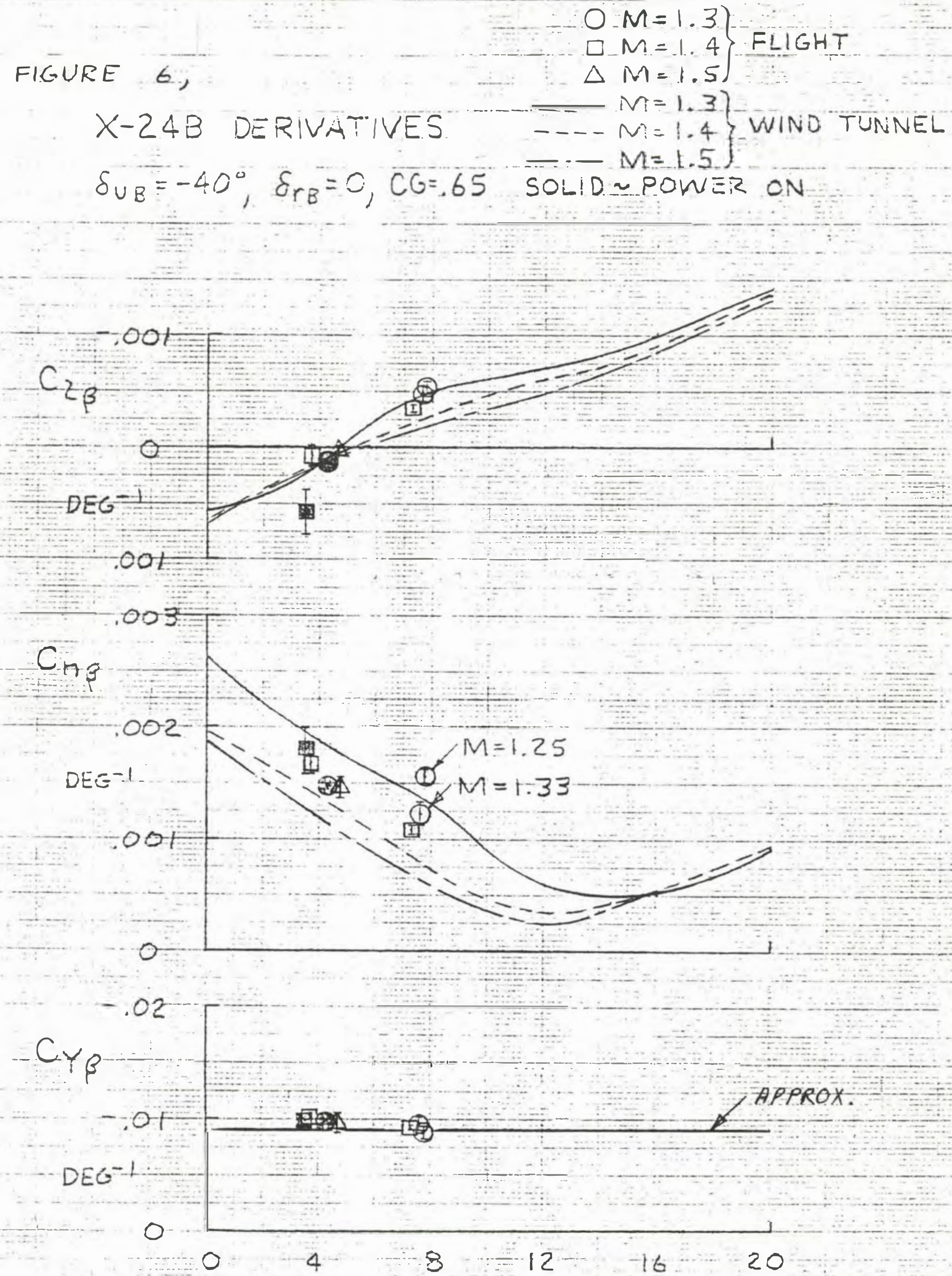


FIGURE 6, CONT.

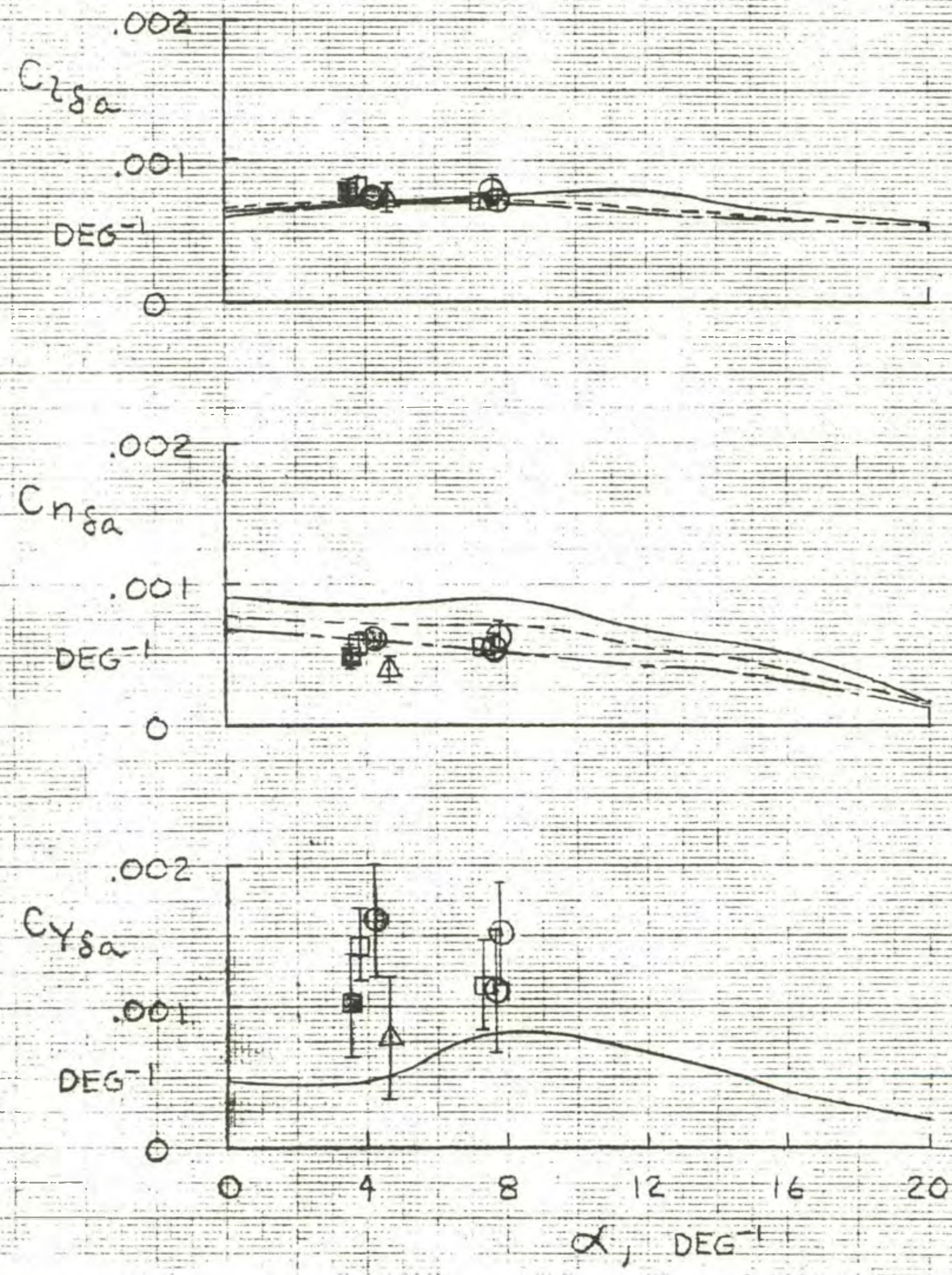


FIGURE 6, CONT.

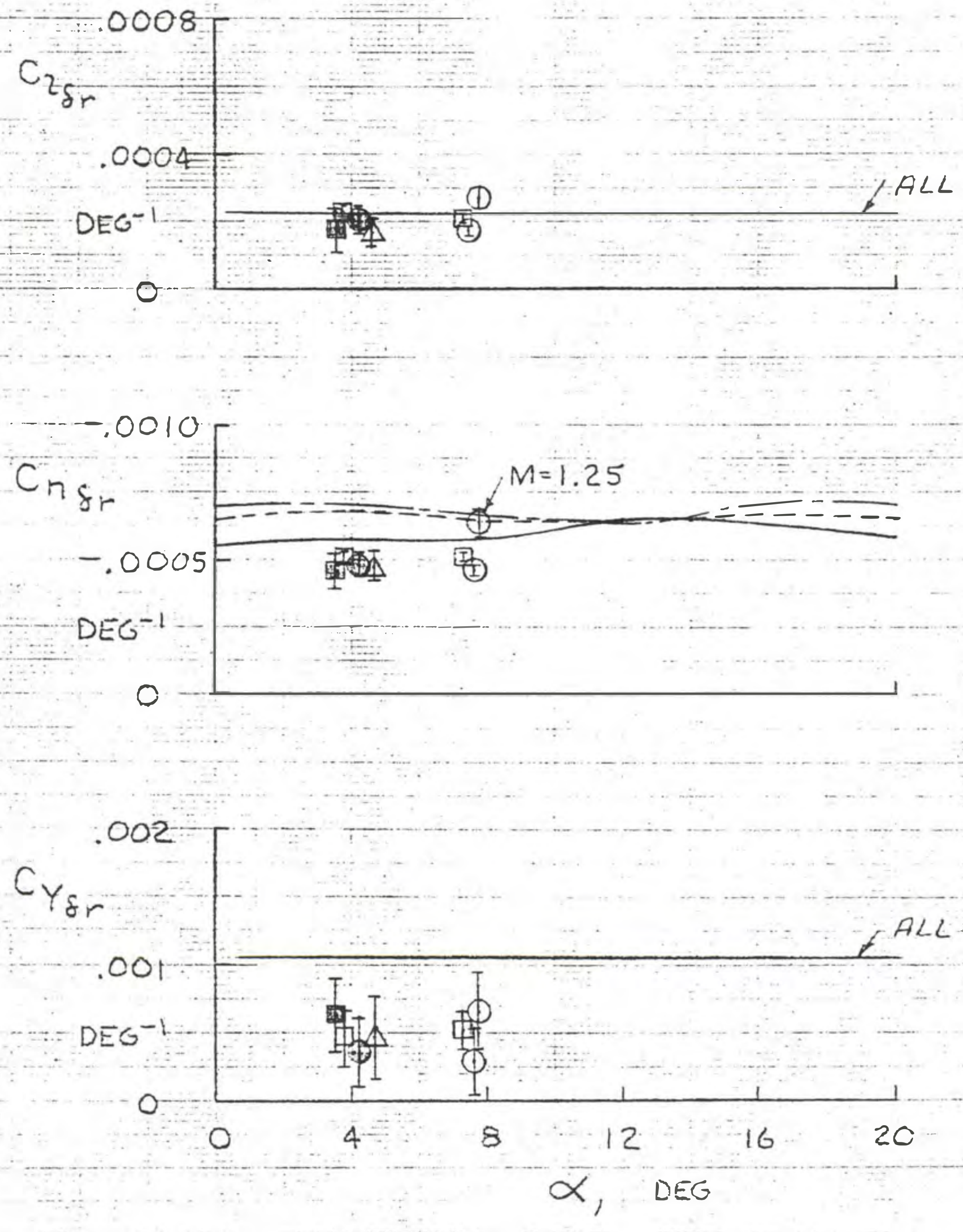
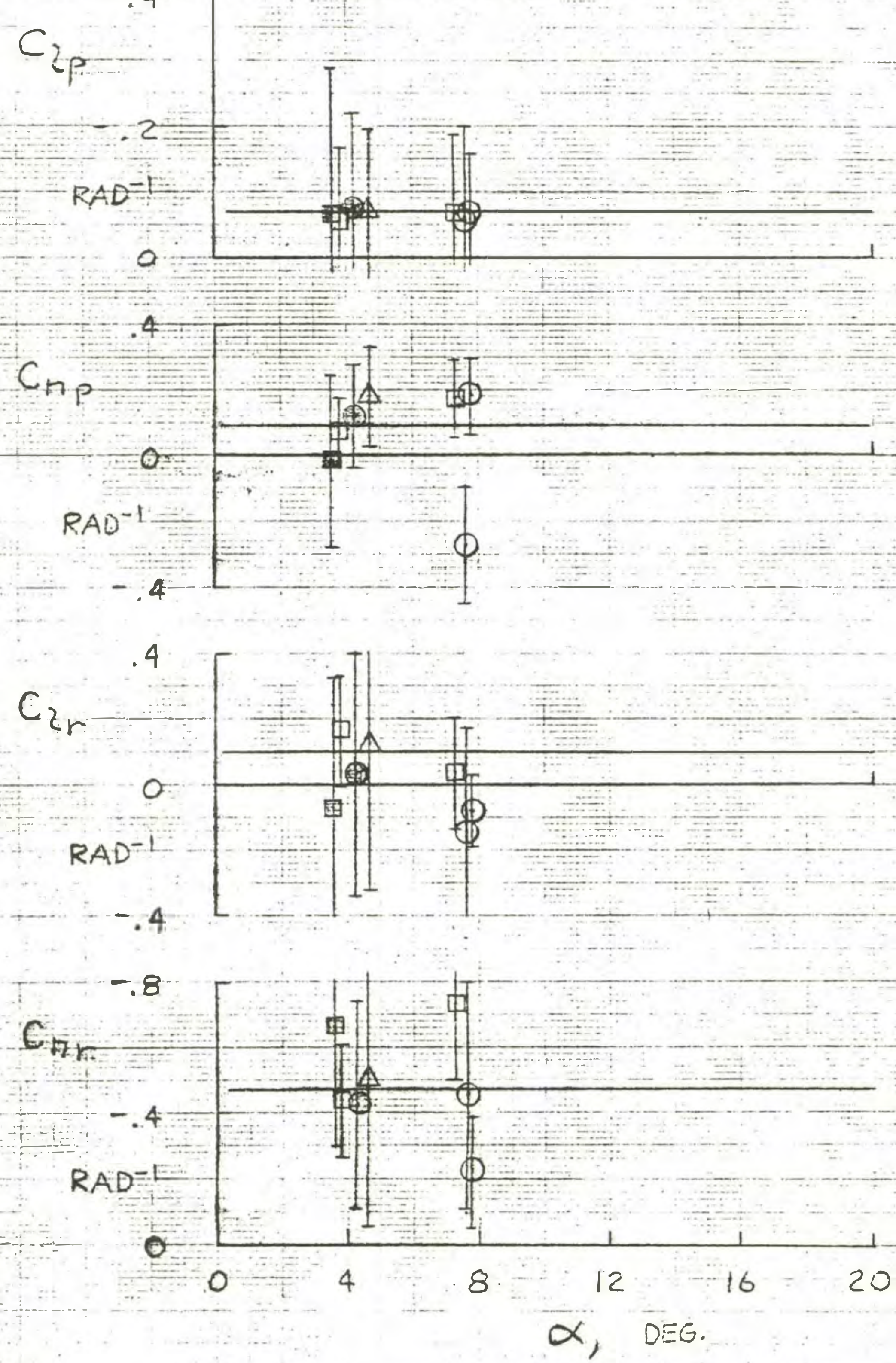


FIGURE 6., CONCLUDED



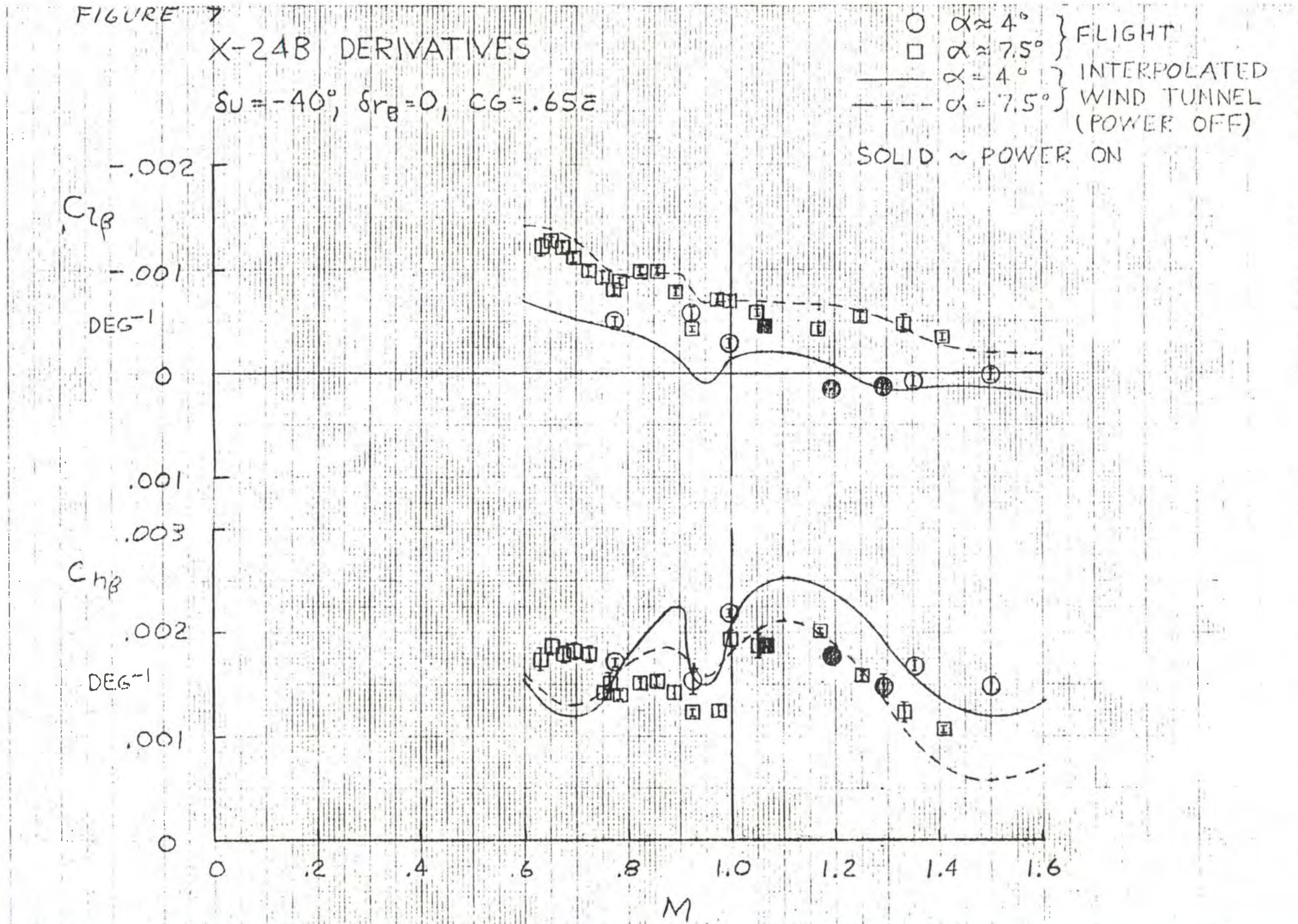
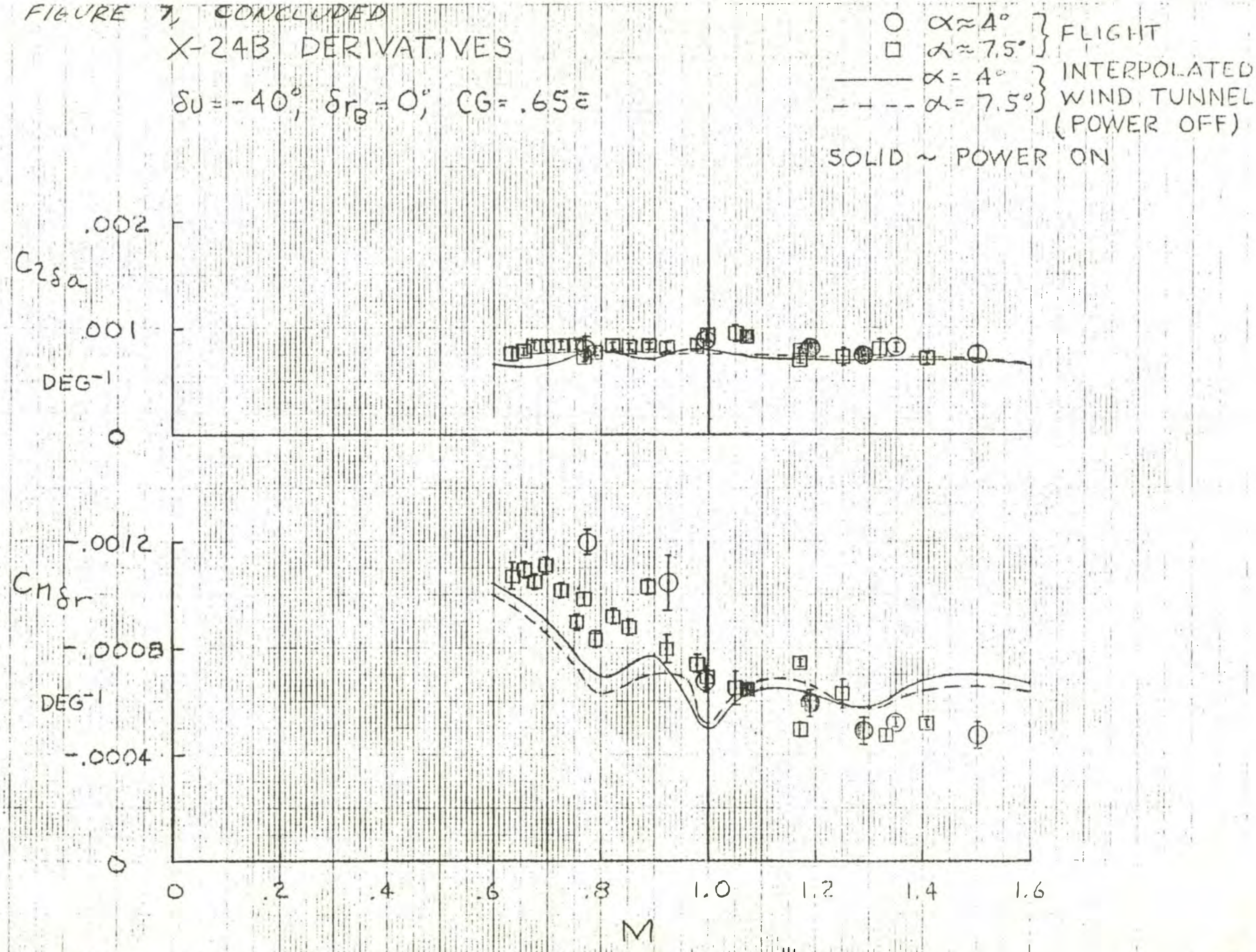


FIGURE 7
X-24B DERIVATIVES
δu = -40°, δr_B = 0, CG = .65c̄
○ α ≈ 4°
□ α ≈ 7.5°
FLIGHT
α = 4°
α = 7.5°
INTERPOLATED WIND TUNNEL (POWER OFF)
SOLID ~ POWER ON
-.002
-.001
0
.001
Clβ
DEG⁻¹
.003
.002
.001
0
Cnβ
DEG⁻¹
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
M

FIGURE 7, CONCLUDED

X-24B DERIVATIVES

$\delta u = -40°$; $\delta r_B = 0°$; CG = .65 $\bar{c}$



FLT B-14-25

HANDLING QUALITIES SUMMARY

ENGINE LITE

- NO TRIM CHANGE NOTED

ROTATION AT 15° α

- INITIALLY EASY - BECAME DIFFICULT
- NOT TRIMMED IN ROLL

{ PITCH 4
LAT 4
DIR 3 }

BOOST

- TASK TO MAINTAIN 43° θ — PITCH 4
  - EASIER TO FLY θ - BUG
- α TO MAINTAIN θ
  - MORE α THAN SIMULATOR
  - SEEMED TO BE CLIMBING SLOWLY
- NO WIND UPSETS NOTED

HQ ABOVE .85M AT 12° α (PWR ON)

- SENSITIVE TO RUDDER INPUTS
- TASK TO MAINTAIN ZERO β WOULD BE DIFFICULT — DIR 5

HANDLING QUALITIES (CONT'D)

HQ ABOVE 1.0 M (PWR ON)

- "GOOD - NO PROBLEM" 3
- ELEVATOR NOT AS EFFECTIVE AS SIMULATOR (1.2 M PITCH PULSE)
- 1.35 M, 5°α DOUBLETS LIKE SIMULATOR "RESPONSE ALMOST NIL"

ENGINE SHUTDOWN (1.55 M, 5°α)

- NO TRIM CHANGE

HQ ABOVE 1.0 M (PWR OFF)

- "FLEW VERY NICELY"
- TASK TO MAINTAIN 8°α FOR DOUBLET SERIES 2

PITCH PULSE AT .95 M, 10°α

- "LOOKED JUST LIKE THE SIMULATOR"

STEADY STRAIGHT SIDESLIP MANEUVER

- NO PROBLEM
- BEHAVED LIKE THE SIMULATOR

Calculation of Rocket Thrust Using

A Longitudinal Accelerometer

By

Dave Richardson

This study was initiated as a result of a recent inquiry about the feasibility of measuring the thrust of the ramjet on the X-24C using accelerometers. The equations are:

$$T = \frac{W \cdot \Delta a_{x_b}}{\cos \theta_J}$$

$$T_\infty = T + A_n \cdot P_a$$

Where:

A_n = nozzle area

Δa_{x_b} = incremental change in long. accel. due to thrust

P_a = ambient pressure

T = thrust

T_∞ = vacuum thrust

W = aircraft gross weight

θ_J = angle between thrust line and body axis

The accuracy of any thrust values determined from this method obviously is a function of the accuracy of the parameters used in the calculation; namely, longitudinal acceleration, weight and ambient pressure. The accuracy of the output from a longitudinal accelerometer is determined by:

1. Temperature sensitivity
2. Cross axis sensitivity.
3. Hysteresis
4. Dynamic response (noise).
5. Basic calibration
6. Pitch rate and acceleration
7. Roll rate and acceleration
8. Location relative to the aircraft center of gravity.
9. Power supply accuracy
10. PCM accuracy
11. Data reduction accuracy

The first three of these factors are of little concern because they should have no effect on an incremental value of acceleration. The next two factors, noise and basic calibration, can be averaged out if they are not excessively large, <.01 g's. Noise can be filtered, however, any filtering will attenuate the signal and introduce some phase lag. In the case of the X-24B, since the data system is a PCM telemetry system, the basic calibration is in terms of octal counts and one octal count is equivalent to .0042 g's for the sensitive accelerometer and .0172 g's for the course accelerometer. The effect of this limitation can be seen in figure 1.

The next three factors involve the effect of the location of the accelerometer relative to the aircraft center of gravity (cg). Ideally the accelerometer should be located at the cg, however, this is not always practical because of fuel tanks, structure etc. This effect can be corrected for using the following equation:

$$a_{x_b} = a_{x_{b_i}} + \overline{\Delta x}\ (Q^2 + R^2) - \overline{\Delta z}\ \dot{Q} + \overline{\Delta y}\dot{R}$$

Where $\overline{\Delta x}$, $\overline{\Delta z}$ & $\overline{\Delta y}$ are the distances from the cg, to the accelerometer. In the case of the X-24B, the effect of accelerometer location was small (<.0002 g's) for small pitch and yaw rates (<2 deg/sec).

The last three factors, power supply, PCM and data reduction, are function of dollars and maintenance.

The accuracy of the aircraft gross weight is determined by the accuracy the initial weighing on the ground (X-24B, ± 30 lbs). The in flight determination is a function of time, flow rates and fuel angle (accelerations).

The accuracy of ambient pressure is determined by the basic instrument, calibration, data system etc., (X-24B, 3.7 psf) plus the ability to determine the position error.

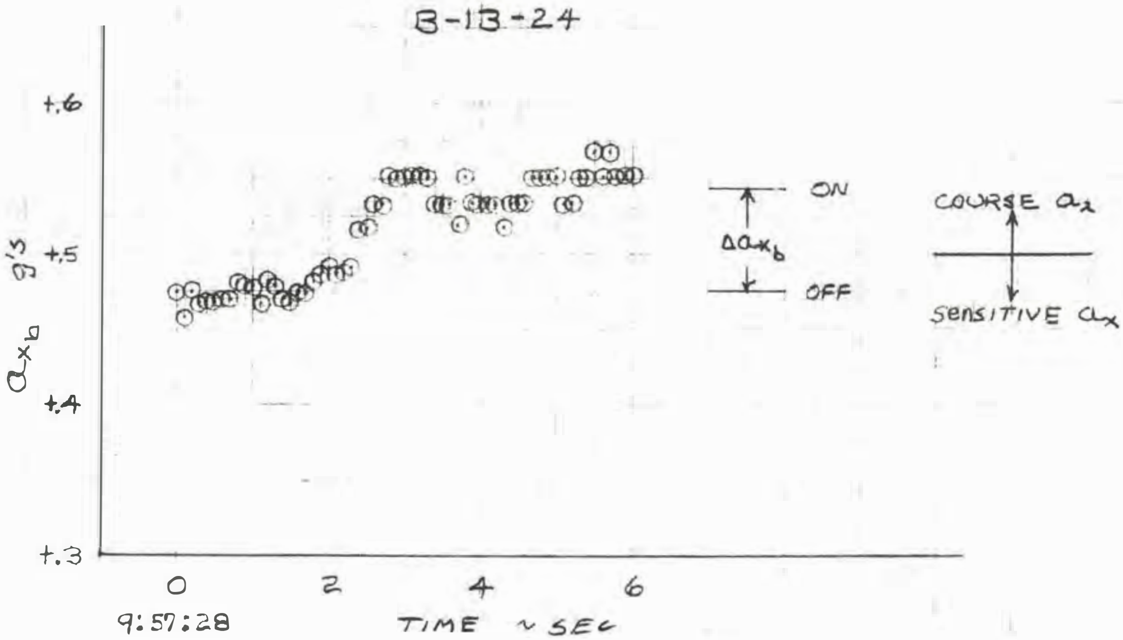
Of importance also are the flight conditions during the time period of interest, because the longitudinal acceleration is a function of dynamic pressure, gross weight, angle-of-attack and aircraft configuration. Angle-of-attack and configuration can be held reasonably constant unless there is a significant thrust moment requiring movement of the control surfaces to compensate for it (trim drag change). In a high climb/descent rate vehicle such as the X-24B the gross weight and dynamic pressure are usually changing, however, in the short time internal involved, average values can be used.

Figures 1, 2 and 3 are sample calculations of XLR-11 overdrive thrust, landing rocket thrust and XLR-11 four chamber plus overdrive thrust for the X-24B. The numbers are quite reasonable.

In summary, this method is not considered accurate for very low thrust to weight ratio changes (<.01).

XLR-11 OVERDRIVE OPERATION

B-13-24



$$T = \frac{W \cdot \Delta a_{x_b}}{\cos \theta_J} \qquad T_\infty = T + A_n \cdot P_a$$

Using average values for W & Δa_{x_b}

$$T = \frac{12500 \cdot 0.0681}{\cos 17'} = 851 \text{ lbs}$$

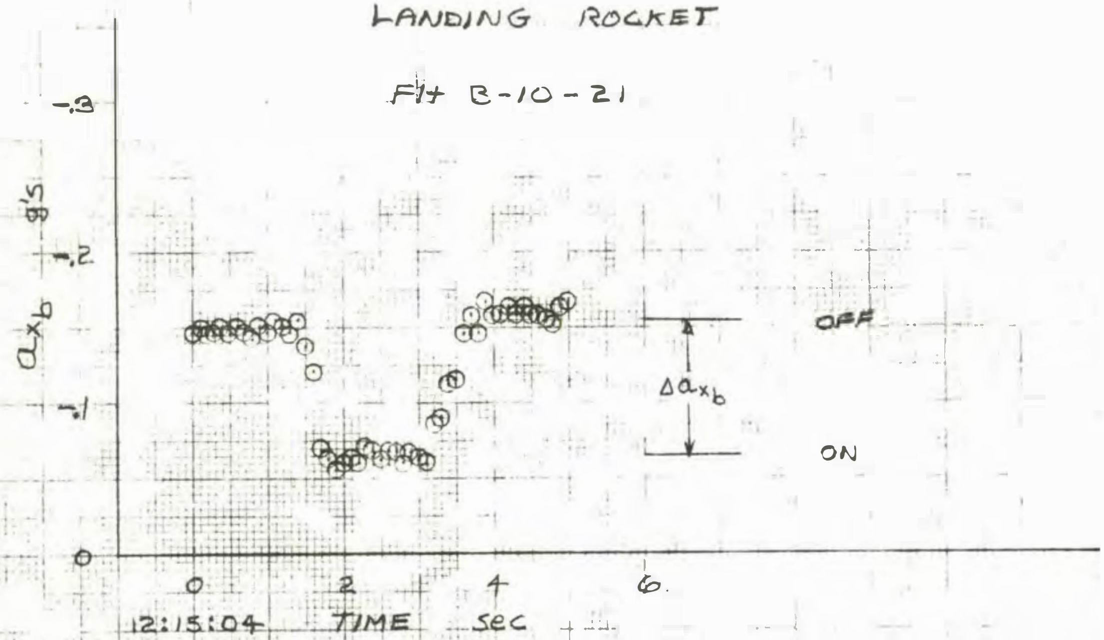
using average value for P_a

$$T_\infty = 851 + .985 \cdot 330 = 1176 \text{ lbs}$$

FIG 1

LANDING ROCKET

Flt B-10-21



$$T = \frac{W \cdot \Delta a_{x_b}}{\cos \theta_j} \qquad T_\infty = T + A_n \cdot P_a$$

using average values for W & Δa_{x_b}

$$T = \frac{8376 \cdot 0.0923}{\cos 17'} = 773 \text{ lbs}$$

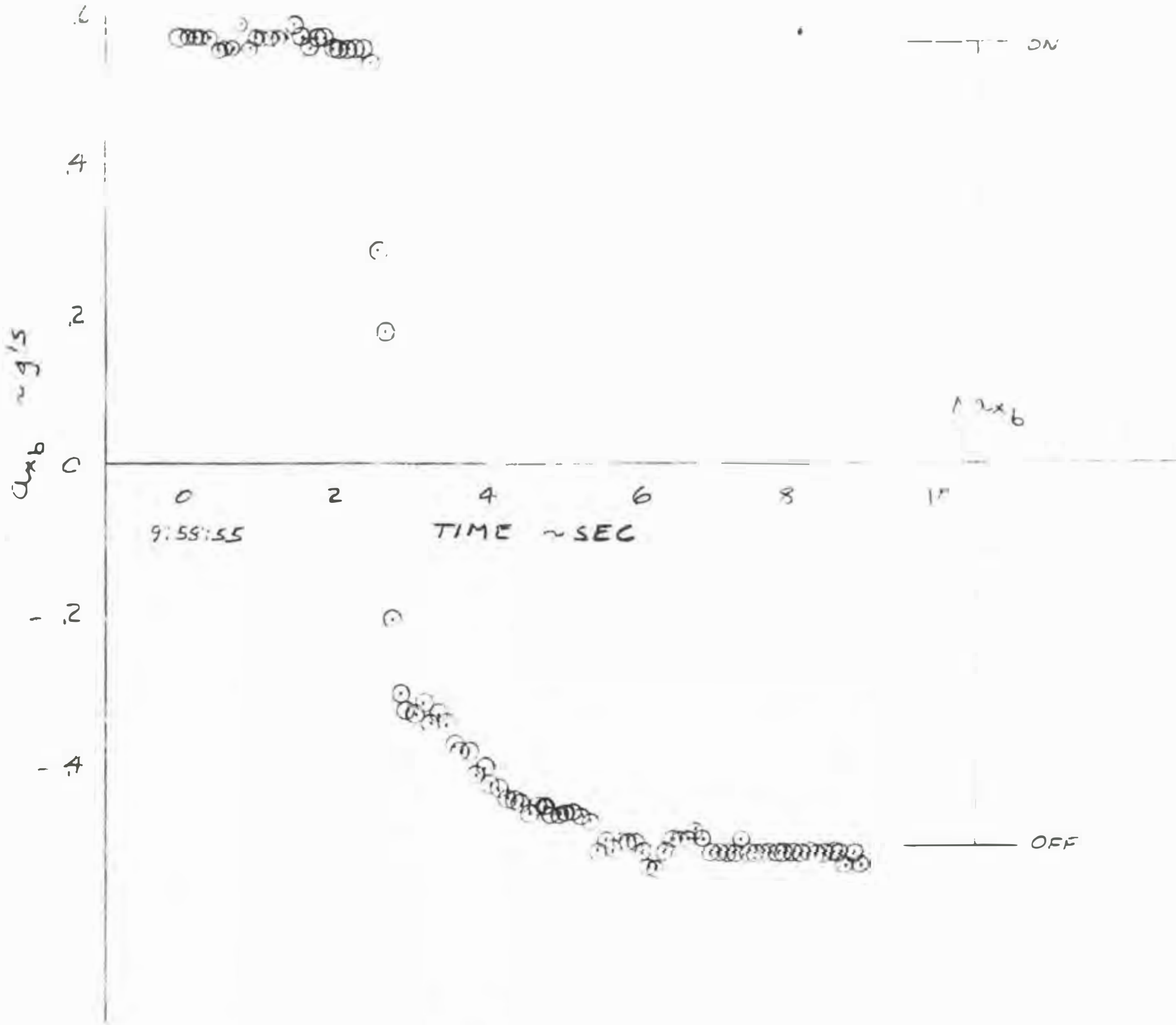
using average value for P_a

$$T_\infty = 773 + .048 \cdot 900 = 816 \text{ lbs.}$$

FIG 2

XLR-11 4 CHAMBER PLUS OVERDRIVE THRUST

B-13-24



$T = 9000 \times 1.069 = 9621$ lbs

$T_{\mathcal{L}} = 9621 \times 1.04(.985) = 9723$ lbs

FIG 3

Technical Debriefing

Flight B-14-25

8 August 1974

Pilot: Major Love

1. Discuss the engine light sequence and any associated trim changes.

Answer:

I launched hands off and hit the first two chambers and felt no trim changes. The airplane came up to 10 degrees α rather rapidly, more rapidly than the simulator. I watched the first two chambers come up and as soon as I knew they were up I hit the other two and was aware I was putting in a aft-stick and wasn't watching alpha and I easily went up and got shaker. However, that wasn't associated with engine lite it was simply too much aft stick on my part.

2. Discuss the handling qualities during the rotation. Rate Pitch, and lateral directional.

Answer:

I felt that the initial part of the rotation was not too bad, 15 degree α was easy to hold for almost five or six seconds. After that I felt that rotation was really a difficult task for me. I have a very hard time holding 15 degree angle of attack, the AoA goes back and forth from 15 1/2 degrees to 14 degrees it spends a lot of time at 14 degree I just can't make it stay at 15 degree. I also noticed that after I got the overdrive on I wanted to do the doublet without having to hold the stick and I couldn't do that. I noticed that I had a roll off to the left and that I hadn't really trimmed out yet and which required flying the airplane in roll. Directionally there's no problem but laterally and longitudinally its a difficult task. Its a four in pitch, a four in lateral, and a three or two in directional I guess a three in directional.

3. Compare the vehicles response to the Mach 0.82 doublets (power on) at 15 degrees α with the simulator. Rate.

Answer:

If you disregard the fact that it probably was not right at 15 degree α the response was very similar to the simulator. The larger response as far as the cockpit was concerned come from the aileron and smaller movement in the airplane from the rudder.

4. (a) Discuss the task to maintain 43 degree θ and rate.

Answer:

It took more alpha. It took 14 degree α or there abouts to hold 43 degree theta. I felt that it was easier to fly the theta bug but it also had the tendency to drop below 43 degrees. Although the θ bug to me was easier to fly I still rate it a four because its still a difficult pitch task.

4. (b) How did α to maintain θ compare with the simulator?

Answer:

The alpha in flight was higher than the simulator, I went to 15 degrees sooner than I would have in the simulator.

5. Discuss the handling qualities above .85 Mach number at 12 degrees α with power on. Rate.

Answer:

I got a good call from John, just about the time the beta went out. I had considered before the flight bringing the nose to the left to bring the beta to zero. So I pushed in just a little bit of left rudder to do that and beta over shot 0 degrees and went out at least 1 degrees to the right. I was very surprised at how quickly the nose went to the left with so little rudder and I would say that if you made a task to fly 0'beta with the pilot doing it, he would have a tough time in that area because the response to the rudder is so rapid. I over controlled, my goal, was going to 0 degree beta and I went to 1 degree nose left. I rate it a five because of the task to control the beta in that area would be so difficult. I'm rating it in this case in the directional task of going from about 2/3 of a degree at left beta to zero which I wasn't able to do.

6 (a). Discuss the handling qualities above 1.0 Mach number at 5 degrees α with power on. Rate.

Answer:

The handling qualities above Mach 1 at 5 degree α are good. I had really no problem in pitch, roll or yaw. I rate it as a three thru out the whole range of Mach numbers that I flew.

6 (b). Compare the vehicle's response to the Mach 1.20 pitch pulse (power on) at 5 degrees α with the simulator.

Answer:

I didn't think the α moved up quite as much as the simulator when I pulsed it. It felt like the elevator wasn't quite as effective as it is in the simulator.

6 (c). Compare the vehicle's response to the Mach 1.35 doublets (power on) at 5 degrees α with the simulator. Rate.

Answer:

I think that its very similar and there is a lack of response is the thing that I noticed. Its even more apparent in the airplane because you'd expect the airplane to move around a little bit from a doublet, it doesn't move around its like sitting in the simulator. The amount of A/C response is almost nil.

7 (a). Discuss the performance aspects of the boost.

Answer:

The performance aspects of the boost caused me a lot of consternation. It increased my work load such that I really feel it decreased my ability to fly. Here's what happened: The angle of attack was higher than it should have been, the Mach was lower than it should have been and I felt that I was climbing steeper than 43 degrees. I don't just mean the disorientation you get from the seat of the pants feel and your inner ear. I just felt that something was wrong in the boost because it was climbing slowly to me as far as Mach. I even checked the eight ball to see if it agreed with 43 and it did. I checked the chamber pressure gauges to see if I really had 300 and I did. I think we were climbing with low thrust. That's all I can say, I don't know whether it was or not but that's what it felt like.

7 (b). Discuss the trim changes at engine shutdown.

Answer:

The trim changes at engine shutdown are nil. Absolutely no problem to just have it at 5 degrees α and hit the engine master and do a doublet right then. Because you don't have to retrack the alpha.

7 (c). If not previously covered, discuss the roll task during the boost with respect to two hands, roll trim, resulting sideslip, compare to simulator.

Answer:

Today I didn't feel yaw and roll upsets from the atmosphere and so I had no problems in tracking bank angle or maintaining wings level, except for the fact that as I said before the airplane rolls off to the left during the boost. Once I'd accepted that and was more or less flying holding it up it wasn't a problem. I think if I go back to my last flight I had worked hard on trimming laterally in the simulator and so I come off ready to trim. But this flight I quit doing that in the simulator and so I didn't make an effort to do much lateral trimming and later on I found out I should have. If I go back to heading during the boost I think really my consternation over the lack of performance caused me to finally just completely cut heading out of my cross-check. I wasn't paying any attention to heading because the work load was high enough that I was thinking of other things.

8. Compare the vehicle's response to the doublets at 5 degrees α (M_t=1.50) after engine shutdown with the simulator and rate the handling qualities if possible.

Answer:

I can hardly remember the doublet at 1.5 at 5 degree α. In fact I almost considered asking you if I did one. So I really can't rate it, I do think the airplane flew very nicely there. I remember that I felt I was a little above 1.55 when I shutdown. I did the doublet and I noticed it was really nice to fly the airplane and it held 1.5 longer than I thought it would. That's about all I can say for it. I'd rate the overall airplane at a 2. It's a much nicer airplane when you shut the engine off for sure.

9. Discuss the flying qualities while decelerating from Mach 1.40 to 1.1 at 8 degrees α. Rate.

Answer:

I found it an easy task to go up to 8 degrees α and I feel that the task in retrimming to 8 degrees α was slightly easier than the simulator. I don't have a whole lot of confidence of being right at 8 degrees α, however, just because of the speed things were happening. One thing that's apparent and kind of surprised me. The last time I shut the engine down I really noticed the deceleration right at engine shutdown. Today I didn't notice much deceleration at engine shutdown but I was very aware of being forward in the straps during the doublets from 1.4 to 1.1. The airplane flys very nicely in that regime. John asked me for a good healthy heading change at that time and it was no problem to lay it over in a bank angle and continue on with the doublet. I'd rate the entire Mach range and the task of flying 8 degrees α at a 2.

10. Discuss the pitch pulse at .95 Mach number at 10 degrees α with respect to the vehicle response to pulse as compared to simulator.

Answer:

It looked just like the simulator. The alpha in the simulator comes back to 10 degrees α with a couple of over shoots on the way and its fairly tight oscillations and thats just the way the airplane looked.

11. Comment on the Mach .92 POPU with the aileron bias. Compare to simulator.

Answer:

The POPU is a very mechanical maneuver. First of all after the pitch pulse in the simulator you need to retrim to make sure you're at 10 degrees α because there's pretty good trim change in that area. I found that was true in the airplane too. So I took a little bit to retrim and then the POPU just completely mechanical the AoA changes down to 6 or 7 and back up to 12 exactly like the simulator. The bias needle moves at the same rate and the α moves at the same rate. Not much more you can say about it.

12. Discuss steady sideslip maneuver with respect to rudder/aileron required, compare to simulator.

Answer:

We did this sideslip maneuver in a 30 degree α bank and found that although I can't really give you a good quanity of rudder and aileron its about the same amount as the simulator. It looks just like the simulator. The beta goes out easily just like the simulator and the airplane doesn't do anything, its very nice. It appears to me that the amount of aileron required for 4 degrees of sidelip and that amount of rudder is the same as the simulator in other words it doesn't over bank or under bank. Although you have to realize that I did that in a 30 degree bank so that made it a little harder to evaluate.

13. Compare the vehicles response to the doublets at 5 degrees α (Mach .6) with the simulator.

Answer:

The beta needle moves the same as the simulator and unlike the simulator of course you feel more aircraft response and thats one area where you can feel some response. The airplane moves around and it feels nice and tight.

14. Discuss the energy management from the "Intersection to low key."

Answer:

Well, it was a lot of fun. We were high and outside and had a lot of things to do and basically all we did was leave the nose down. I was wondering if I was going to get the Mach down to close up and I think that it worked just like the simulator. I just left the nose down a little bit and got lower in altitude and the Mach came off. I believe if we looked at the traces we'd find that I pulled the nose up, increased the alpha to get the Mach down and closed up.

15. Discuss the pattern.

Answer:

The pattern was the highest energy pattern that I'd flown. It was no problem to fly. I used the most flaps I've used and they worked very well. Had close to three hundred at low key, at 300 at the 90 degree point with the requirement for a lot of flaps to get down to final. Got the flaps in a little late, later than I wanted to as we've been prone to do and the airspeed bled off to 270 as I rolled out on final but I had a steep enough glide slope that it went back to 300 while still holding the aim point.

16. Discuss the landing and roll out.

Answer:

Flare was started at 3400 also at the same time that Bill called me. Completed the flare at 100 feet in my opinion and waited for 240 and got the gear at 50 feet with everyting going normally and then between 50 feet and the final flare I allowed a sink rate to develop for one reason or another. When I sensed the sink rate I came back rather rapidly on the stick and had all kinds of authority and good control of the airplane. I did cause a balloon, was able to retrack descent rate and retrack a landing attitude to make a nice landing and I think this really speaks well for the airplane. You don't have to do it perfectly on the first try you can make a mistake like that and recover from it without getting a bad landing. I got a nice landing and had it well under control after arresting what was developing into a pretty good sink rate there at about 20 feet or less.

Flight B-14-25 Engine Operation

By

Johnny Armstrong

The XLR-11 rocket engine performed in an erratic manner 111 seconds after engine start. As can be seen in figure 1, maximum manifold pressure and chamber pressure fluxuation of 125 psi and 90 psi respectively, were experienced. It has been concluded that this unusual characteristic was caused by unsteady propellant pump operation resulting from intermittent H_2O_2 flow to the gas generator.

It was observed that this characteristic began after the vehicle was pushed over to 5 degree α for the final acceleration to planned shutdown conditions. It was also noted, as can be seen in figure 1, that the oscillation changes with variations in angle-of-attack. This implied that the outlet in the H_2O_2 tank was unporting as a function of propellant angle. This was in part verified by observed changes in H_2O_2 tank pressure during that time period.

The steady state propellant angle was computed in this area of flight using the measured longitudinal and normal accelerations with the following relationship: $\theta_p = \text{ARCTAN}\frac{A_x}{A_n}$. It was noted that at the time the engine oscillation began the propellant angle (θp) was slightly in excess of 70 degrees. When the resulting propellant angle was in the area of 60 degrees, either due to α changes or increased dynamic pressure near shutdown, the engine oscillation tended to steady out. This would indicate with the amount of H_2O_2 remaining in the tank at that time, the critical propellant angle for unport was probably angles in excess of 65 to 70 degrees. It is interesting to note that flight 13 experienced similar propellant angles at similar flight conditions and within 6 seconds of engine operation time as flight 14 without experiencing engine oscillations.

In an attempt to explain the cause of the H_2O_2 unporting, the tank geometry and H_2O_2 utilization was studied. Figure 2 presents a scale drawing of the 17 gal. H_2O_2 tank which is mounted vertically in the vehicle with the outlet at the bottom centerline. Also shown are various propellant angles intersecting the outlet. This geometry was used to estimate the H_2O_2 unport conditions as a function of propellant angle and the amount of H_2O_2 remaining in the tank. The resulting unport curve is shown in figure three. Note that when the propellant angle is 70 degrees to 75 degrees the outlet will unport with 3.5 to 4 gallons remaining in the tank. Figure 4 presents an attempt to account for the H_2O_2 consumed during the flight. The solid line starts with an assumed full H_2O_2 tank. Post flight measurement determined that 1.75 gallons remained in the tank. Note that approximately 4 1/2 gallons cannot be accounted for. This would also indicate that at the time of the engine oscillation there should have been 8 1/2 gallons remaining in the tank and no unport would have resulted. The dotted line is an attempt to work backwards starting with the known amount remaining in the tank. Of significance here in that this would indicate that only 4 gallons remained at the time of the engine oscillation and this agrees with the estimated volume for unport at 75 degrees propellant angle.

It is thereby concluded that at the time of the engine oscillation less than the normal amount of H_2O_2 remained in the tank. The possibilities to account for the missing H_2O_2 are:

1. The tank was serviced with less than 17 gallons.

2. Higher landing rocket flow rate.

3. Higher H_2O_2 rate during engine operation.

4. A combination of all

Aging of catbeds can result in higher rates of H_2O_2 usage in landing rockets and the gas generator. The procedure used in the H_2O_2 tank servicing could result in a short service. Since flight 13 did not encounter a problem it is suggested that a short service may be the most likely cause.

For flight 15 the following changes are under consideration:

1. Service the tank to overflow

2. Change the catbed in the gas generator

3. Eliminate the prelaunch rocket check

4. Consider propellant angle during flight planning.

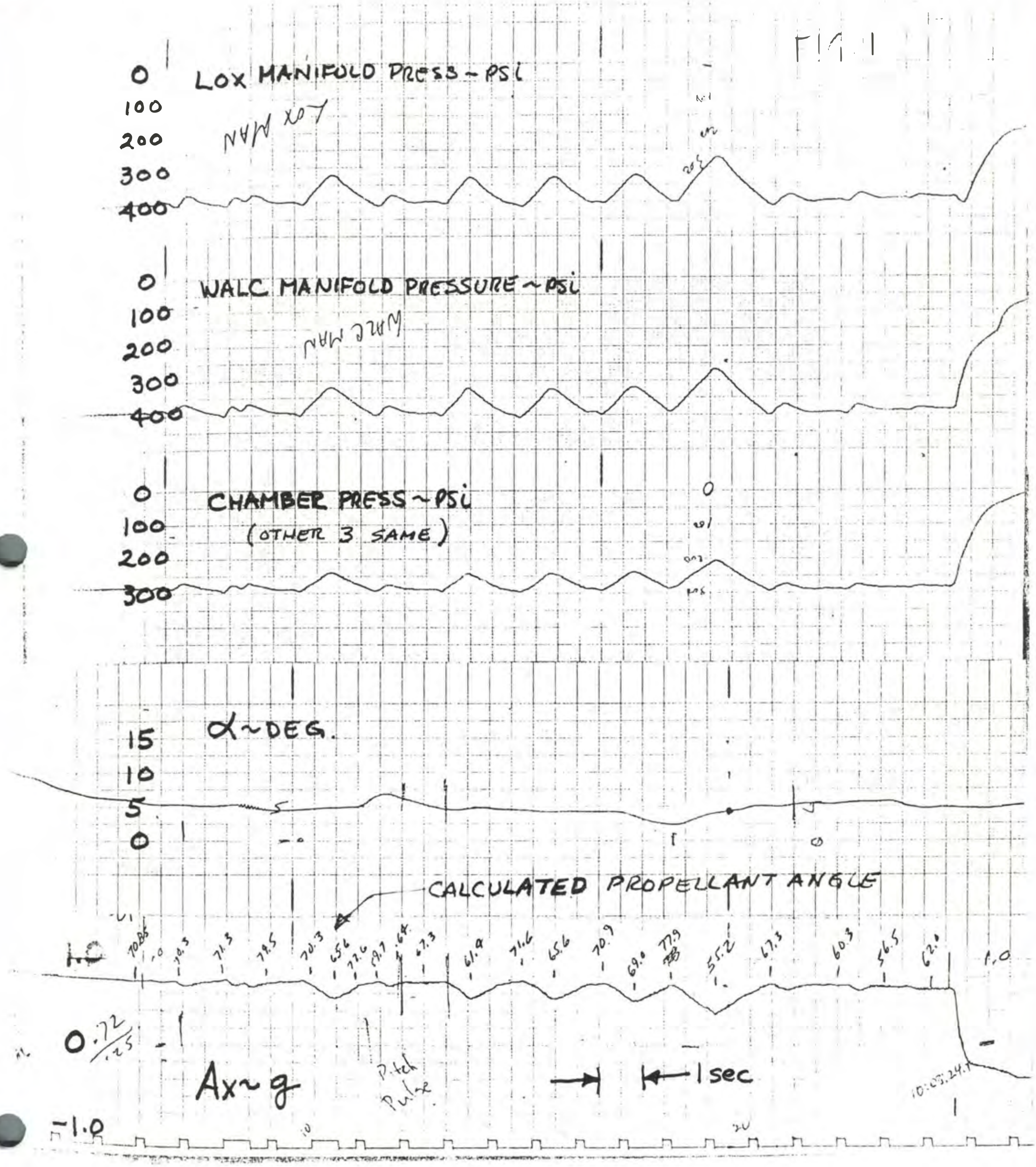


FIG. 1
LOX MANIFOLD PRESS ~ PSI
0
100
200
300
400
LOX MAN
WALC MANIFOLD PRESSURE ~ PSI
0
100
200
300
400
WALC MAN
CHAMBER PRESS ~ PSI
(OTHER 3 SAME)
0
100
200
300
α ~ DEG.
15
10
5
0
CALCULATED PROPELLANT ANGLE
1.0
70.3
71.3
79.5
70.3
65.6
67.3
61.9
71.6
65.6
70.9
69.0
77.9
55.2
67.3
60.3
56.5
62.0
1.0
0.72
Ax ~ g
Pitch Pulse
1 sec
-1.0

X 24B H_2O_2 TANK

$r = 7.19''$
$l = 14.62''$

$V = 3930$ cu.in. $= 17.01$ GAL

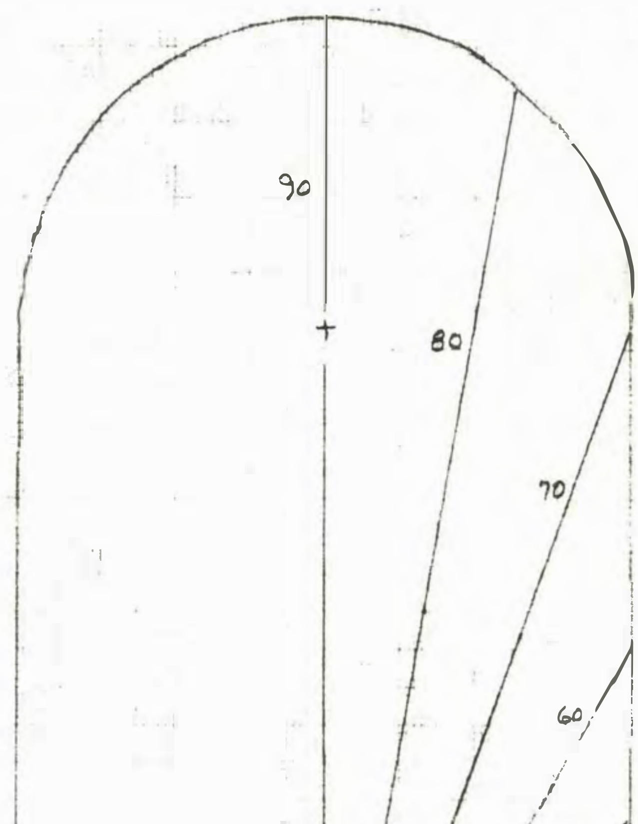


FIG. 2

X-24B

H₂O₂ UNPORT CONDITIONS

(ESTIMATED)

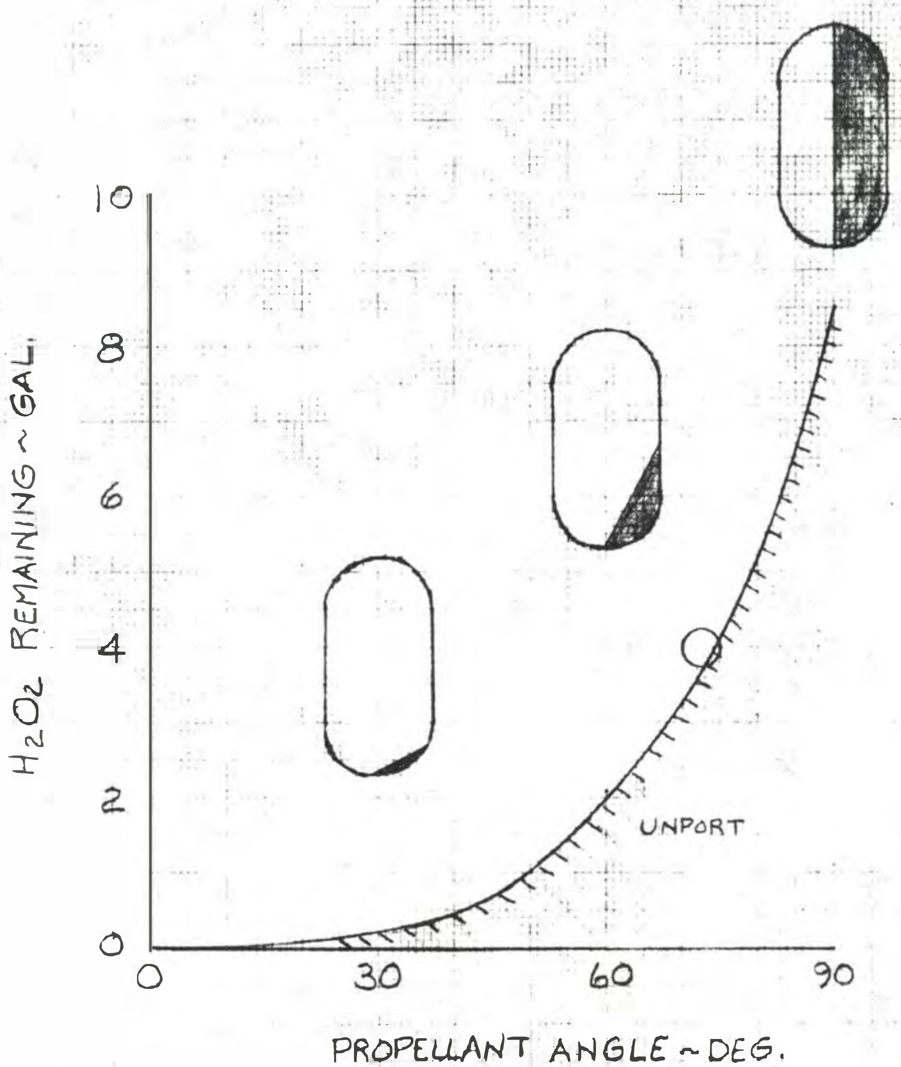


FIG. 3

X-24B

FLT. 14 H_2O_2 USAGE

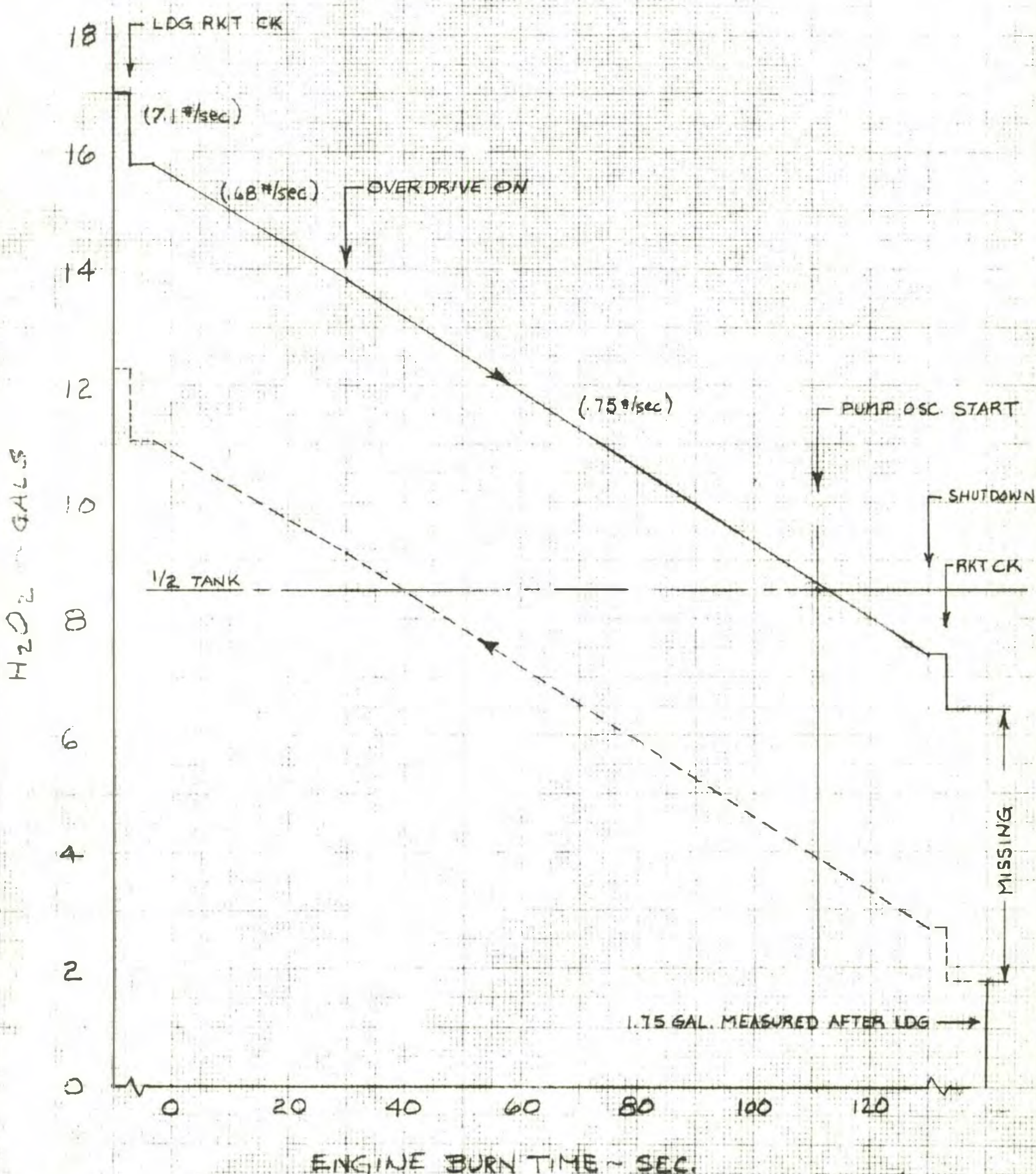


FIG. 4

August 16, 1974

TO: DOEER

FROM: W. B. Arnold - THIOKOL

SUBJECT: Propulsion System operation Flight B-14-25

SUMMARY OF ENGINE OPERATION

1. All chamber starts were normal and more smooth than have been previously experienced.

2. Engine chamber and manifold pressure oscillations occurred approximately 114 seconds after engine start.

3. Engine shutdown was normal at approx. 132.5 seconds.

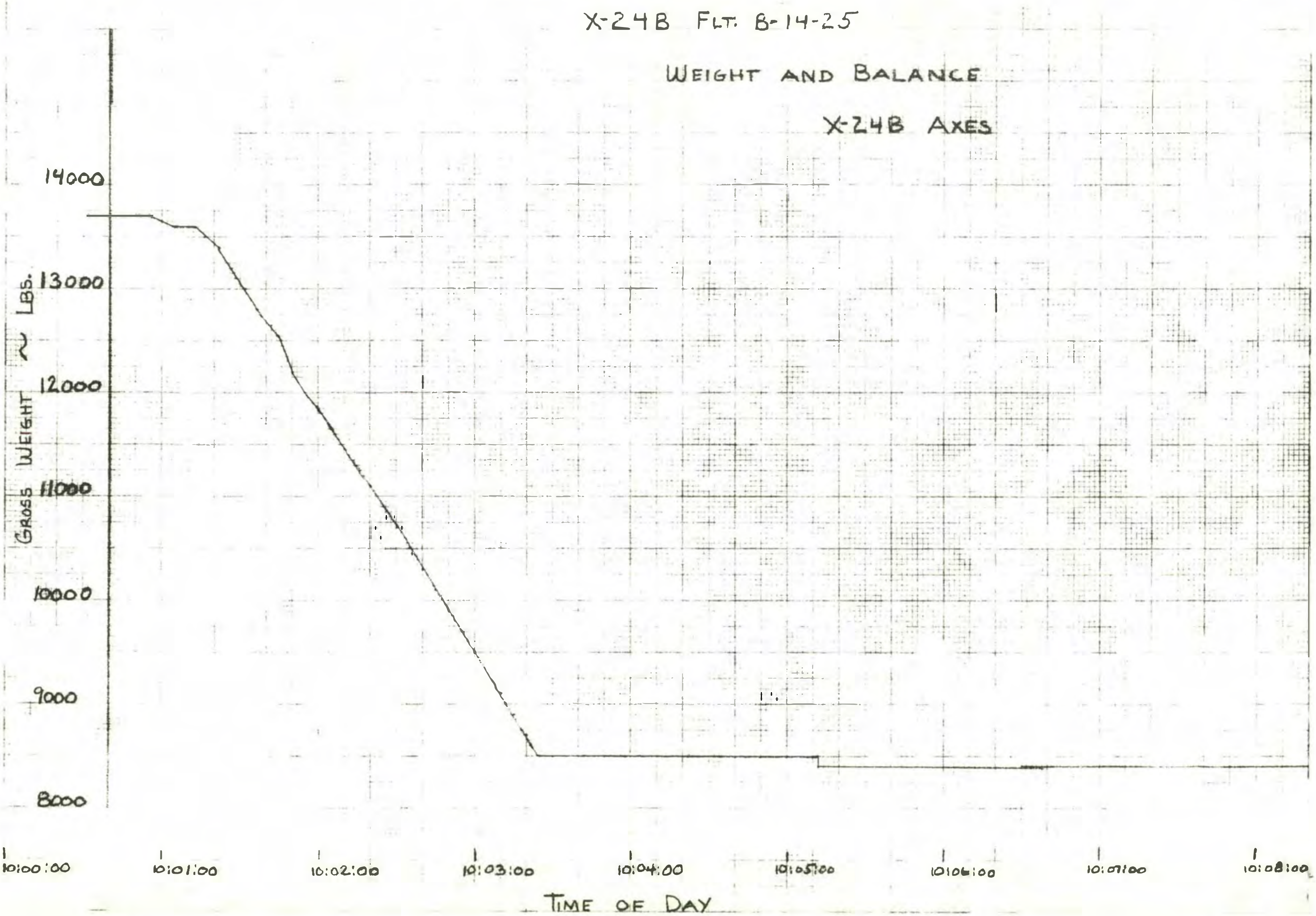
DISCUSSION

The chamber starts on this flight were as smooth as those on the preflight ground run. During the engine inspection following Fligh Flight 13 the "O" rings were changed in the fuel propellant valve hydraulic accumulators. It appears that this change improved the chamber start transient.

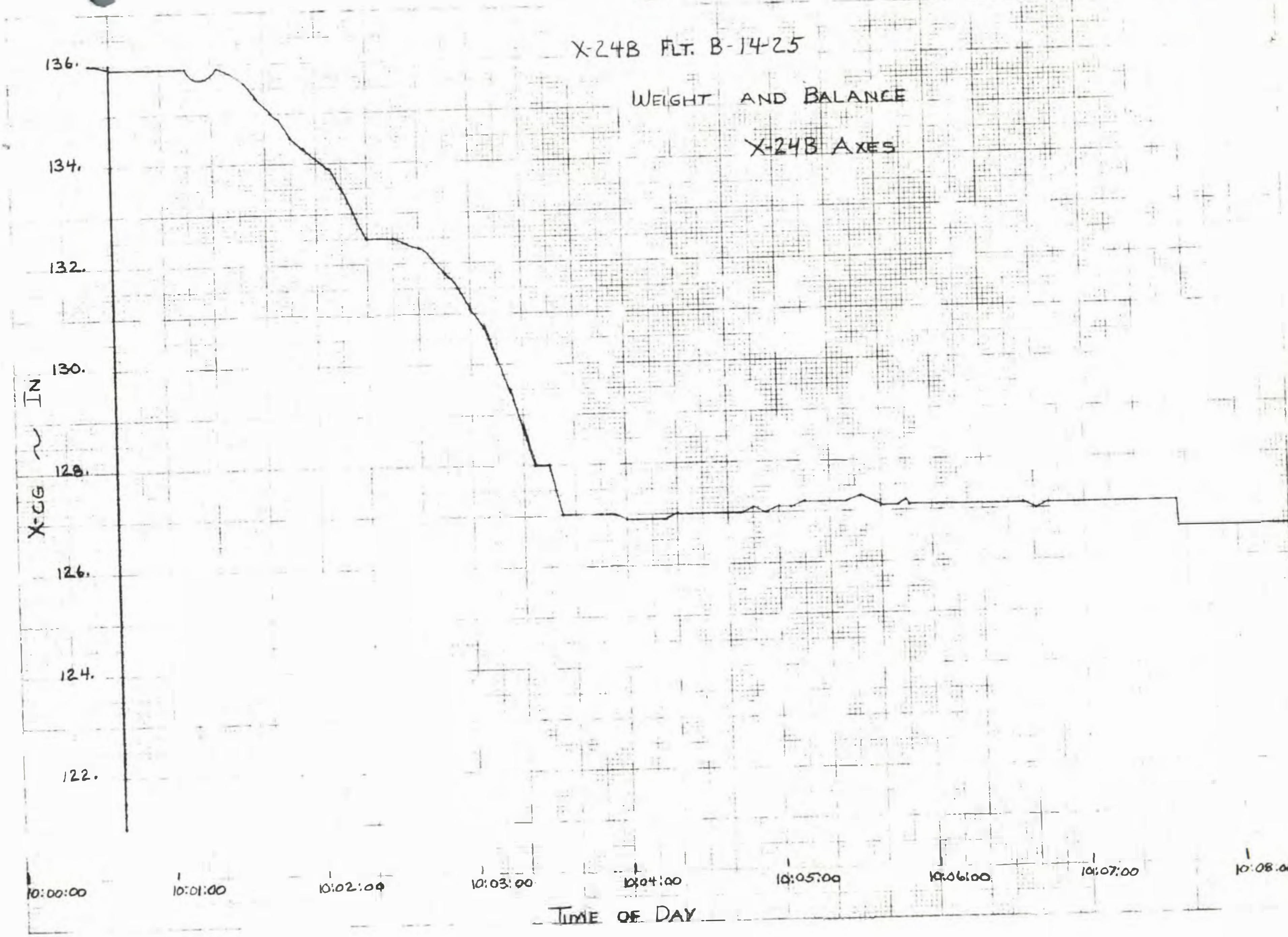
The engine pressure excursions experienced during this flight have been attributed to unporting of the H2O2 tank outlet as a result of aircraft pushover. Review of Control gas and H2O2 tank pressures verify that pressurizing gas was ingested for a period of 12 seconds. The pressure excursions appeared to damp and engine operation was normal for 3.5 seconds prior to shutdown.

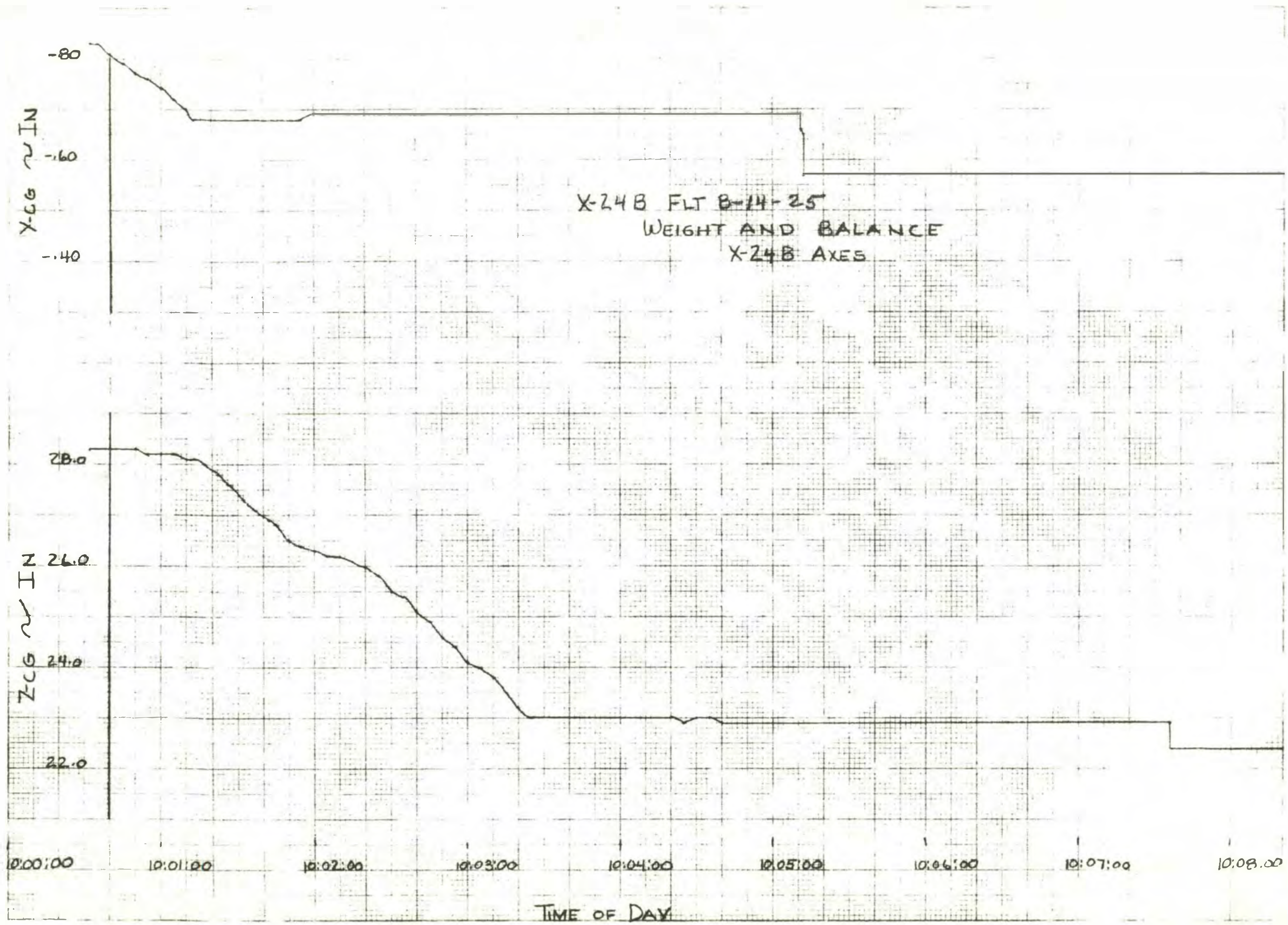
CORRECTIVE ACTION

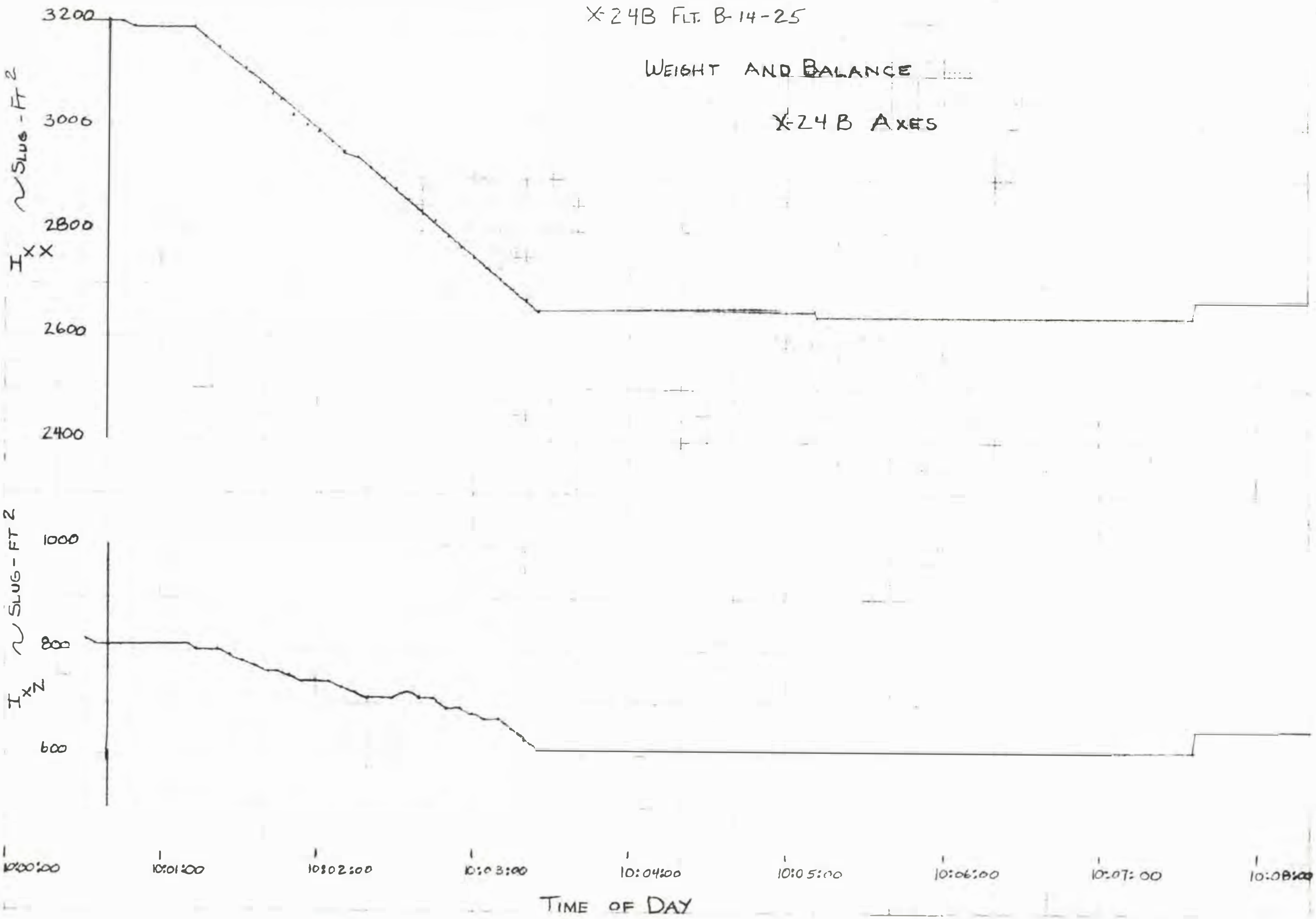
The H2O2 service procedure will be changed for the next flight. The H2O2 tank will be serviced to overflow to assure that a maximum amount of H2O2 will be available. The landing rocket check will be eliminated to conserve H2O2. The engine catalyst bed was changed to reduce H2O2 consumption by approximately 0.2/ lb.sec.



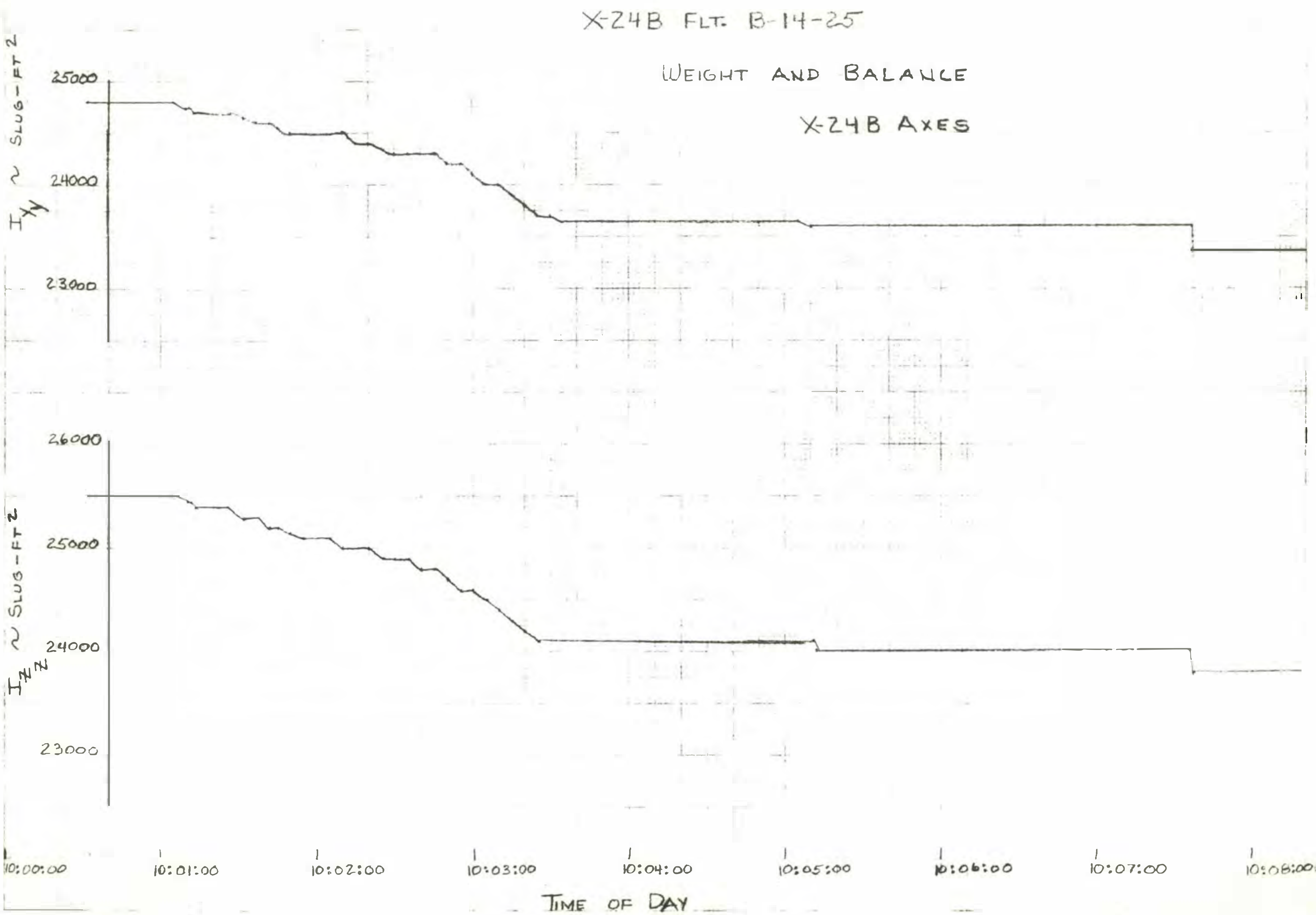
X-24B FLT. B-14-25
WEIGHT AND BALANCE
X-24B AXES
GROSS WEIGHT ~ LBS.
14000
13000
12000
11000
10000
9000
8000
10:00:00
10:01:00
10:02:00
10:03:00
10:04:00
10:05:00
10:06:00
10:07:00
10:08:00
TIME OF DAY


X-24B FLT. B-14-25
WEIGHT AND BALANCE
X-24B AXES
136.
134.
132.
130.
128.
126.
124.
122.
X-CG ~ IN
10:00:00
10:01:00
10:02:00
10:03:00
10:04:00
10:05:00
10:06:00
10:07:00
10:08:00
TIME OF DAY


X-24B FLT B-14-25
WEIGHT AND BALANCE
X-24B AXES
Y-CG ~ IN
-.80
-.60
-.40
Z-CG ~ IN
28.0
26.0
24.0
22.0
10:00:00
10:01:00
10:02:00
10:03:00
10:04:00
10:05:00
10:06:00
10:07:00
10:08:00
TIME OF DAY



X-24B FLT. B-14-25
WEIGHT AND BALANCE
X-24B AXES
IXX ~ SLUG - FT 2
3200
3000
2800
2600
2400
IXN ~ SLUG - FT 2
1000
800
600
10:00:00
10:01:00
10:02:00
10:03:00
10:04:00
10:05:00
10:06:00
10:07:00
10:08:00
TIME OF DAY


X-24B FLT. B-14-25
WEIGHT AND BALANCE
X-24B AXES
I_{yy} ~ SLUG-FT 2
25000
24000
23000
I_{zz} ~ SLUG-FT 2
26000
25000
24000
23000
10:00:00
10:01:00
10:02:00
10:03:00
10:04:00
10:05:00
10:06:00
10:07:00
10:08:00
TIME OF DAY

X-24B OPERATIONS FLIGHT REPORT

FLIGHT: B-14-25

DATE OF REPORT: 8/20/74

PILOT: Major Love

DATE OF FLIGHT: 8/8/74

CARRIER AIRCRAFT: B-52 #008

LAUNCH LAKE: Rogers Lakebed

PURPOSE OF FLIGHT: (1) Envelope Expansion to 1.55 Mach Number.

(2) Stability and Control at Mach Number >1.0 and 5° and 8° α.

(3) Fin, Rudder and Flap Pressure Survey (Group I)

(4) Boundary Layer Noise and Vibration Experiment (RED PLUG)

I. Discussion of Previous Operations

1. The #2 chamber start was slower and rougher than normal on flight B-13.
2. The alcohol jettison valve did not open on the initial switch operation, but operated normally on recycling of the jettison switch.

II. Vehicle Configuration Changes

1. An orifice was installed in the B-52 lox topoff system in the "climb tank" feed line to decrease lox flowrate to improve the temperature on the L.H. aileron.
2. The electrical power supply system was modified to add a 5th battery to provide a true "emergency" battery. The new system utilizing the new 85 A.H. yardney cells is configured to provide backup to the hydraulic pump batteries and equipment and the instrumentation system is completely isolated from the ships systems with no backup.

III. Instrumentation Changes

1. Added Pressure Transducer Box Temperature Measurements (4).
2. Made provisions to record System 1 on on-board tape. Both systems now telemetered and recorded on-board.
3. Changed System 1 transmitter frequency from 1441.5 to 1452.5 MH3 to avoid conflict with AFFTC program. Also changed multi-coupler.
4. Performed check calibration of forward and aft tension strut loads, and B-52 pylon hook load.

IV. Preflight Events

1. The alcohol jettison system was checked over and no malfunction could be found.

2. The engine was removed and sent to the PSTS to correct the slow start on #2 chamber. The fuel valve hydraulic accumulator on the #2 chamber was found to have a leaking 'o' ring. All four accumulators were torn down and the 'o' rings replaced with the new ethylene propalene material 'o' rings.

3. The lox tank in the B-52 was removed for repair of the support saddle which had developed new cracks during the recent "blown" tire landing.

4. Preflight functionals were made with no problems.

   The engine start with the reworked fuel valve accumulators was very smooth.

V. Flight Events

1. Preflight servicing was accomplished without incidents.

2. The engine operation was very smooth until shortly before planned shutdown when the manifolds and chamber pressures began to oscillate. The oscillations lasted for approximately 10 seconds and then ceased. Shutdown was on time and completely normal. Unporting of the H_2O_2 tank from propellant angle variations was suspected.

3. The alcohol jettison valve worked normally when required.

4. The electrical system worked satisfactorily with the new 5 battery configuration.

5. The vehicle was in good shape after the flight.

Approved by: [signature]
William P. Albrecht
Chief, Operations
Engineering Branch

Written by: [signature]
Norman E. DeMar
X-24B Project Engineer
Operations Engineering Branch

POSTFLIGHT: B-14-25
DATE: August 8, 1975
PILOT: Maj. Love

B-14-25 on 8, August with Major Love flying. Another real smooth typical X-24 operation. Told John I had to do one thing since Norm had to slip the 9 o'clock takeoff, and that was because I was late. I just simulated too late this morning, so I'll take care of that next time. The new checklist worked fine. As far as the climbout and up to launch, the only thing I was aware of that might have been unusual was the conversation about LOX in the bomber. I guess it was flowing faster than we thought it was. We had good airspeed. The last time I looked, 203 and 45,000 so we can probably up our launch air speed if we wanted.

At launch I made a hands off launch to see if the α comes up like the α comes up in the simulator, because I think the simulator α comes up a little slow, and it does. The airplane jumps right to 10 and then it starts back down and rolls off and starts flying. I lit the first two chambers. They came right on up and while I was lighting the other two and watching the chamber switches, I was pulling back on the stick and got shaker. It is real easy to go from a trimmed α to a shaker without being too much aware of it. Initially, 15 α felt pretty good as far as trimming it up, but as I went on, say toward the time to go to overdrive it got harder and harder to hold 15 α. Alot harder than the simulator. It was hard to hold 15 α for the doublets and they probably came somewhere between 14 and 16. I guess not 16 because I did not get the shaker, but it just wasn't right at 15 like the simulator. During that time, as I was trying to track 15 and let go of the airplane so that it would really be trimmed, I noticed that it was rolling off to the left. I did not seem to have time or the right method for trimming it out. The whole flight, that part of the flight was most disconcerting, I think, as far as flying the airplane. Theta is easy to hold. I felt that way las time. I feel that way this time. Easier to track that theta bug. The α, the track, the theta bug were higher than in the simulator. It was up around 14 I think and the Mach was low. The Mach just did not build up. At 60,000 I had .78 where I should of probably had, if you consider the position error, .83 or closer to .85. It felt pretty steep and John has been doing a good job of talking to me about that, he said blank it out of your mind and fly the bug and the α you can overlook it, but it feels like it is going straight up. Nothing but sky there.

OK, the response to the doublets after overdrive felt very much like the simulator, and other than having a hard time holding α, the doublets were a pretty easy thing to do. Pushed over at 60 to 12 and was watching the α. Got a good call from John to watch my beta. Looked down at beta and said I am going to see if I can bring the airplane back to zero beta. I wanted to do that, so I touched the left rudder and it went about a degree out the other side. Rudder response was probably way too much I think, You have a lot of rudder control but if you want to track zero beta with those rudders at that time, if you stopped in that Mach area, you'd have a hard time holding zero beta with the rudders.

The Mach jump, I don't know what time it came, if it came on time or not. The one thing I did notice is that the Mach meter moves more smoothly than I thought it would through the Mach jump area. Over at 1.05 to 5 α and when you get down to 5 it is a nice airplain again. It's a pretty nice airplane at 12 too during the theta portion. John was exactly right, boy the beta went back, it felt good when it went supersonic. 1.2 Mach and a pitch pulse and just almost nothing when ypu pull the stick back. You just don't have much effectiveness, it feels like, and I don't think the α jumped as far as the simulator α and so we will have to look at that on the data. Seemed to be about the same as the simulator in holding 5 α. It seems that the curve you got in there now looks pretty good as far as the airplane goes.

I got a doublet at 1.35 ending above 1.4 and sometime during that period the engine started, what I call chuffing, and that really started to get my attention because I thought it was going to shutdown, you know, and I wanted to be ready to do whatever was necessary after shutdown. The response to the doublet at 1.35 to 1.45 was very low. You could almost not feel anything from the rudders. A little more from the ailerons.

Shutdown at 1.55 at least, and doublet set and 5 α was easy and it doesn't go like the simulator, of course. It sits right there on the α that you have when you hit the engine master switch. Then I had the feeling, possibly comes from a, you know in the simulator you have the task of retracking the α before you can do the doublet there; in the airplane you don't have to do that so it seems like it just sits there at 1.5 for a long time. That seemed like a long time to go to 1.4 and 1.3 and 1.2, etc., and pretty soon the doublets were coming in instead of 1.2 and 1.25, they didn't come exactly where you wanted them.

At 1.05 I knocked it off and went to 10 and probably got a pitch pulse at about .97 or .98 indicated and it looked very similar to the simulator. In fact, I was think to myself right then, this looks just like the simulator. Up to 13, the Mach looks just like the simulator, just happens that we were already at or past the intersection I guess, so we started a turn, did a slideslip in the turn; the sideslip was a piece of cake and very similar to the simulator. Jettisoned, (what?), oh yes, I forgot about that aileron POPU. It is such a mechanical thing that it is hardly worth describing. Down to 11 and α goes down like the simulator, and up to 5 and the α goes up just like the simulator, back to 7 and it is no problem to reset it. Nothing to it. The Mach was about the same. I think as I said it looked like the simulator.

Jettison, SAS 4, 3, 2, and I bumped the switch. That was just to see if you were on your toes. Anyway, got that back on and sometime stopped jettison, tanks, and bleed and I closed up before you said John, because of the Mach, and pushed over and got the doublets set. Nice response. It starts to feel like an airplane again. Came into low key with a lot of energy and a real wild pattern. It was a lot of fun, but I felt we were coming in at an angle and alreay close in, I thought, so I went out to the right and then back and lowered the nose and still had so much energy I needed lots of flap. The flaps took care of it and I got them in, possibly a little late as we are prone to do again. I had 270 when I got them back in; so I had enough glide angle, it went right back to eventually 300. Started the flare and dropped the gear down at a nice altitude, I thought, and then allowed a sink rate to develop somewhere around 10' above the ground. This is a real nice think about the X-24B. When I allowed that sink rate to develop I just came back on the stick and was able to actually balloon it up and retrack the landing. This is a nice feature. Really speaks well for the airplane when you can do that. Touchdown left main, right main, it felt like a nice touchdown and nose down. If there were winds out there they were right down the runway, because it went straight ahead. I did not use the steering or anything. I just probably braked just at the last at 20 knots or so. I didn't see any turbulence in the pattern. That's about all I can think of.

FLIGHT:	B-14-25	ENGINE START:	0850
DATE:	August 8, 1975	TAXI:	0853
PILOT:	Maj. M. Love	TAKEOFF:	0907
B-52:	008	LAUNCH:	1000
LAUNCH OPER:	V. Horton	LAND:	1007
NASA 1:	John Manke		

15 Minutes

NASA 1: OK Mike, we just past 15 minutes
LOVE: Roger, 15
NASA 1: Vic has topoff flow ceased?
We are still showing a high temperature
OK, it is starting to come down now
VIC: I can't see any on TV, John
NASA 1: OK, Mike there is 14 minutes, 14

14 Minutes

LOVE: OK, John
Hydraulics are swapped
Pressures are down to 2700
NASA 1: OK, good show and 008 we are ready for a pitch and yaw pulse
008: Roger, pitch now
NASA 1: OK, that was a good pitch pulse
008: Yaw
NASA 1: That was a good yaw pulse
OK Mike, this is a good heading
Why don't you go erect and fast erect on
LOVE: Roger
OK, say your heading, George
GEORGE: --- 248
NASA 1: Roger
008, could you come left 3° please, 3°
008: That makes it 245
NASA 1: Roger
OK Mike, there is 11 minutes, 11 minutes and we are happy with the trim

11 Minutes

LOVE: OK, it looks good up here, John
NASA 1: Alright
CHASE: It looks good here, Mike
LOVE: Roger
NASA 1: OK Mike, there is 10 minutes, 10 minutes

10 Minutes

LOVE: Roger
#1 is showing 39
#2 is showing 41
Control gas 500
Governor balance 450
LOX and fuel are 0 and the gear is down to 3000
Ready for the pump heater check?

FLIGHT: B-14-25

NASA 1:	We are ready
LOVE:	Off
NASA 1:	And back on
LOVE:	On
NASA 1:	Good check, Mike
LOVE:	Roger
NASA 1:	OK, Mike there is 9 minutes, 9 minutes
9 Minutes	
LOVE:	OK, 9 minutes
	Erect switch cutoff
	Fast erect off and outstanding attitudes
NASA 1:	Alright, thank you
008:	45,000
NASA 1:	Say again, 008
008:	We are level at 45
NASA 1:	Outstanding
	You can start your left turn and Mike we are 8 minutes
8 Minutes	
LOVE:	OK, throttle on and off
NASA 1:	Landing rocket was good
LOVE:	OK, here comes aileron cycle
NASA 1:	Vic, can you start topoff?
VIC:	I will
NASA 1:	OK, start topoff
	OK, the aileron cycle was good, Mike
LOVE:	Roger
NASA 1:	OK, Mike there is 7 minutes, 8 minutes
7 Minutes	
LOVE:	OK, I am on X-24
	Going secondary
NASA 1:	Roger
LOVE:	5 5 1 back on primary
NASA 1:	OK Mike, loud and clear
	Good radio check
	OK Mike, 6 minutes, 6 minutes
6 Minutes	
LOVE:	Roger
	Got 40 on the uppers
	I guess 27 on the lowers
CHASE:	---
NASA 1:	OK, we like them Mike
LOVE:	The other trims are 0, 0, 1
NASA 1:	OK Mike it looks good
	Chase airplanes check the windshield heat
CHASE:	Chase 1, Chase 2, 2 α
NASA 1:	008, shallow your turn just a little please
008:	OK
NASA 1:	OK Mike, there is 5 minutes, 5 minutes

5 Minutes

LOVE: Roger, 5 minutes
I am on battery, going auto, and the lite is out
Hydraulics are swapped
I got 3200
Bus loads are 110, 105, 110 and 40

NASA 1: Roger, Mike

LOVE: SAS is 5, 5, 5, and another old SMRD
No lites

NASA 1: Roger

LOVE: Torque and no lites

VIC: 45 gallons remaining, John

NASA 1: Roger
Roll out 060

LOVE: #1's off
Torque and 3 yellows

NASA 1: Thank you, Mike

LOVE: 2's off, a torque and 3 reds
Reset 6, 5, 3
Servos are auto
Lites are reset
Torque and no lites

NASA 1: OK Mike, and we past 4 minutes
We are in good shape and Dick Vochl, did you have a comment a little earlier?

VIC: 30 gallons only remaining in the climb tank, John

NASA 1: Run it out, Vic

?: ---

VIC: Did you say shut it off, John?

NASA 1: No leave it going

VIC: OK

NASA 1: When you get down to about 30 gallons just turn it off, Vic.

VIC: Rog, I'm going to turn it off now, John

NASA 1: Roger

Heli: Launch control, runway check is complete

NASA 1: Roger, save
OK Mike, there is 3 minutes, 3 minutes now

3 Minutes

LOVE: Roger
I am on X-24 oxygen
I got 85 and cylinder is 1700
X-24 air and it is at 2800
Cabin altitude is 24,000
Canopy defog is in heat

NASA 1: Roger, Mike

LOVE: Suit vent is low

NASA 1: Roger

NASA 1:	Roger
LOVE:	#1 is 39
	#2 is 48-50
	Control gas 505
	Governor balance 450
NASA 1:	Roger, Mike
LOVE:	Erect switch erect
	Fast erect on
	Trims are checked
NASA 1:	Roger
	OK Mike 2 minutes, 2 minutes
<u>2 Minutes</u>	
LOVE:	Roger, precool is off
	Engine bleed
	Prop supply
NASA 1:	Roger, 008, 1° left
008:	Roger
LOVE:	Fuel is 47
	LOX 46
	Release pressure low lite is out
NASA 1:	Roger Mike, good show
VIC:	Power is off
	Topoff is complete
	Beacon off and pressures are good, John
NASA 1:	Alright Victor, thank you
	OK Mike, there's 70 second
LOVE:	Roger
NASA 1:	OK Mike one minute, mark
<u>1 Minute</u>	
LOVE:	Clock is running
	#1 is 36
	#2 is 4000
	SAS lites are out
	Heading 55
	α is 4
	Beta 1 left
NASA 1:	Roger
LOVE:	Engine master is on
NASA 1:	Roger
LOVE:	Erect switch cutoff
	Fast erect is off
NASA 1:	OK Mike, systems are OK at NASA 1
LOVE:	Release circuit breaker's in
	I will wait just a little for the cameras and recorders
NASA 1:	Alright, Mike
LOVE:	OK cameras and recorders are on
NASA 1:	Roger
LOVE:	--- 10 seconds
NASA 1:	OK, Mike

LAUNCH

NASA 1:	OK Mike, you are on your way
	12 α
	Here we got 4
	Watch your α Mike, 15
	4 good chambers
	15 α
	You got a good track
	Good heading and we are starting to round out
	You can standby for overdrive and get your doublets
NASA 1:	We got your doublets Mike, and we got overdrive
	You are on your way
	Standby for theta
LOVE:	Roger
NASA 1:	Got you going thru 50,000' here
	Check your α
LOVE:	OK
	Theta is good
NASA 1:	OK, Check your α here
LOVE:	Coming up on 15
NASA 1:	OK check your Mach
	Standby to pushover to 12 α
LOVE:	Roger, Mach is low right now
NASA 1:	We see you at 60,000'
LOVE:	Pushing over at .78 Mach
NASA 1:	Alright
	Check your beta in here
LOVE:	I got .8
NASA 1	OK
	Watch your beta
	We see you slipping out a little bit
LOVE:	Watching it
NASA 1:	OK, standby for pushover to 5 α, Mike
LOVE:	There is the Mach jump
NASA 1:	OK, looks like your beta settle down real nicely
	Standby for your pitch pulse
LOVE:	Roger
NASA 1:	OK, standby for doublet
	Standby for shutdown, doublets
	We got the shutdown, we got the doublets
	Standby for 8 α and some more doublets, Mike
	We are going to need about 10° α left, Mike and I got you about 3000' high
LOVE:	Roger
NASA 1:	And you can PPOI
LOVE:	Roger
NASA 1:	I would like about 2 045 heading ,Mike, as you come in to the intersection

NASA 1: And we'd like to have you work on that a little bit
LOVE: Yes, it is in a left bank, John
NASA 1: That a boy
OK Mike you can stand by for your 10° α pitch pulse
Check your Mach
LOVE: I got 101
NASA 1: Alright
We got you coming sub-sonic
OK, standby for aileron bias POPU at 3 miles
LOVE: There is POPU
NASA 1: Alrighty
You are about 2 miles
OK Mike, go back to 7, 13°
Start the left turn now
LOVE: Roger, starting left
NASA 1: I got you about 3000 high and make it a pretty good left and you will have to get that sidesli in the turn
We see your sideslip
When you finish that lets go prop supply off and jettison
SAS to 4, 3, 2 and keep her coming left
I am going to need about a 340 heading
LOVE: I got low key, John
Coming clean
NASA 1: Get your roll servo
Stop jettison
#1 roll is off, Mike
Put her back again
Stop jettison, tanks and bleed
2 miles and get a configuration change when your Mach is good
OK, we got you closed up
You can get your pulse here
Got your pulse and you are 1 mile
Your energy is great
Give us a rocket check
Good rocket check
1 and 3 hydraulics on and you got it
LOVE: Roger
I got 280, Bill
CHASE: I am a little outside of your, Mike
I will be in there in a minute
NASA 1: Helium master #2, Mike
On the left side
Helium master switch #2
LOVE: I think I did it
NASA 1: Alright
CHASE: 302, Mike
Milt Thompson will be pround of you

NASA 1: Got you at 40 flaps, Mike
LOVE: Rog
NASA 1: OK, you got all closed up
Mach repeater to .3
LOVE: Got my flaps
CHASE: 5000, 290 and the rpm is 92, Mike
LOVE: Roger
CHASE: 1200'
LOVE: Roger
CHASE: Call that 100, Mike
LOVE: OK
CHASE: 50, you got 3 good gear, Mike
20', 15, 10
OK, balloon just a little
5, 4, 3, 2,
How about that
NASA 1: OK, Mike when you get your airspeed down ---
Your nosewheel steering off
LOVE: Roger

TAPE #2

NASA 1: OK, Mike that was a dandy
LOVE: I got 130 on the clock
NASA 1: Alright
Page 22, on the checklist
LOVE: Roger
NASA 1: All stations, we will have a debrief at 1045
LOVE: OK, throttle is off
KRA is manual
Camera is going off
Ready for a calibrate?
NASA 1: Yes sir, ready for a calibrate
OK, we got a calibrate
LOVE: OK, recorders going off
Servos going off
Hydraulic pump going off
NASA 1: Roger, Mike
LOVE: #1 is 700
#2 is 3500
Control gas 510
Governor balance 475
Landing gear 2600
Oxygen 1100
Cabin air about 600
Engine timer 129 1/2 as I said
Radar off, stick shaker coming off, fast erect off, erect switch cutoff, 2 attitude switches off
Getting the canopy open and see you on the ground, John

Flight 15

PRELIMINARY RESULTS OF X-24B

Flight B-15-26

29 August 1974

BY

USAF/NASA X-24B Project Team

Flight Summary - Flight B-15-26

Flight B-15-26 was flown on 29 August 1974 by John Manke. The plan to perform a max Mach type profile by flying to propellant depletion was not successful due to a premature engine shutdown. As a result, the primary supersonic data maneuvers were not accomplished. However, sufficient energy existed to perform a normal landing on runway 18. The significant flight conditions were:

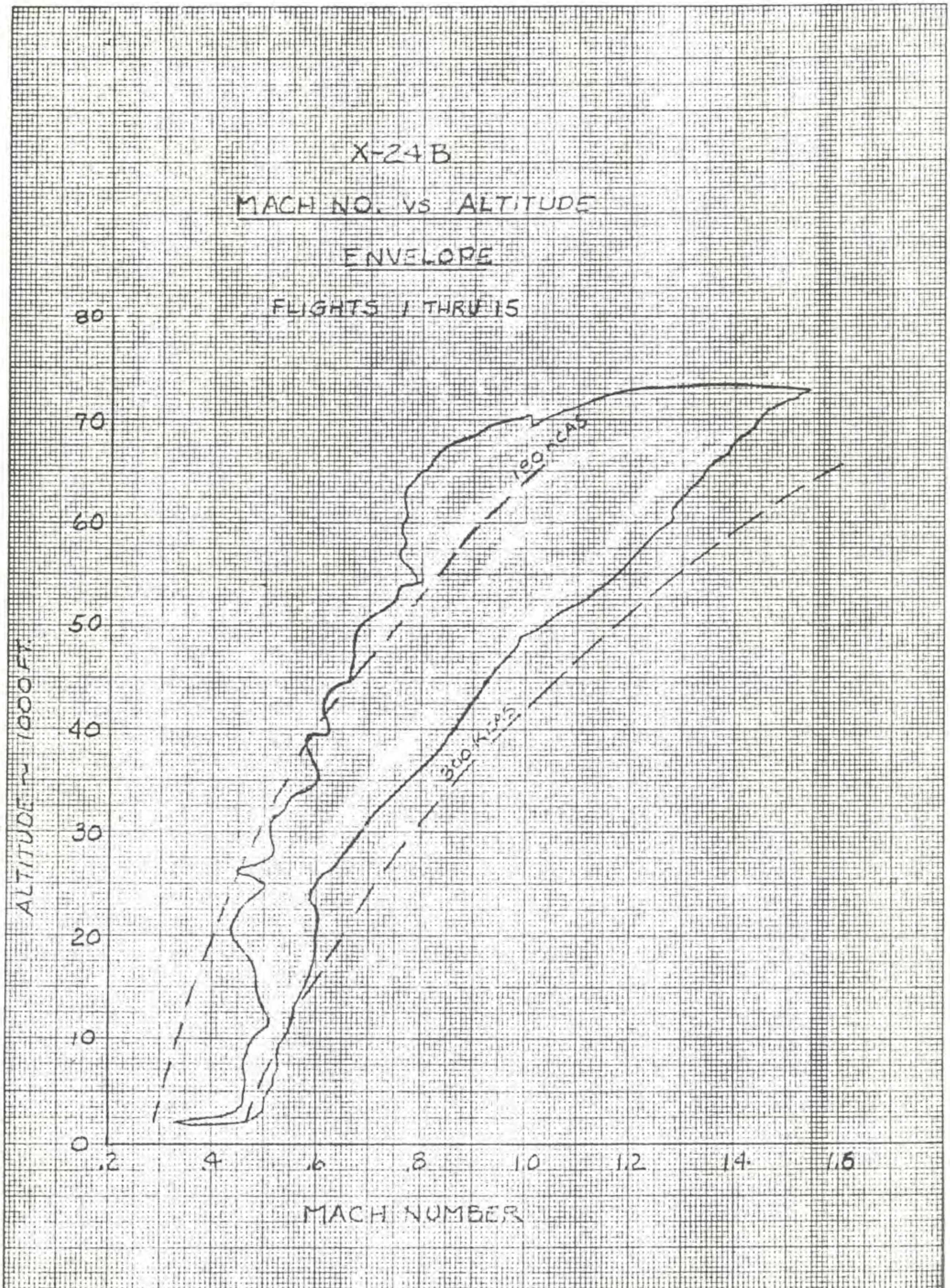
Maximum Mach Number	1.097
Maximum Altitude	72,440 feet
Maximum True Airspeed	632 knots
Flight Time	7 minutes 47.6 seconds
Burn Time	109 seconds

The data maneuvers that were accomplished are listed below:

Mach No.	α	Maneuver
.84	15	Pitch pulse (power on)
.98	10	Pitch pulse (power on)
.68 - .70	14-2-16-13	Pushover-pullup
.55 - .59	10-2-15-8	Pushover-pullup (20° upper flaps)

A detailed analysis of the data did not reveal the cause of the premature engine shutdown except that it appeared to be from fuel starvation. Upon inspection of the fuel tank a two inch crack in a weld joint was found on the bulkhead between the two compartments in the tank. It is felt that this crack prevented the complete transfer of the fuel from the aft compartment to the forward compartment thus causing a fuel starvation shutdown. The tank has been shipped to Martin Marietta Co. for repar.

The fueslage pressures (group II) were hooked up for this flight. However, the pressure connected to Box 3 were invalid due to frozen moisture in the reference line. The center fin camera was reorientated to view the left hand fin and aft body tufts. These photos are being analyzed.



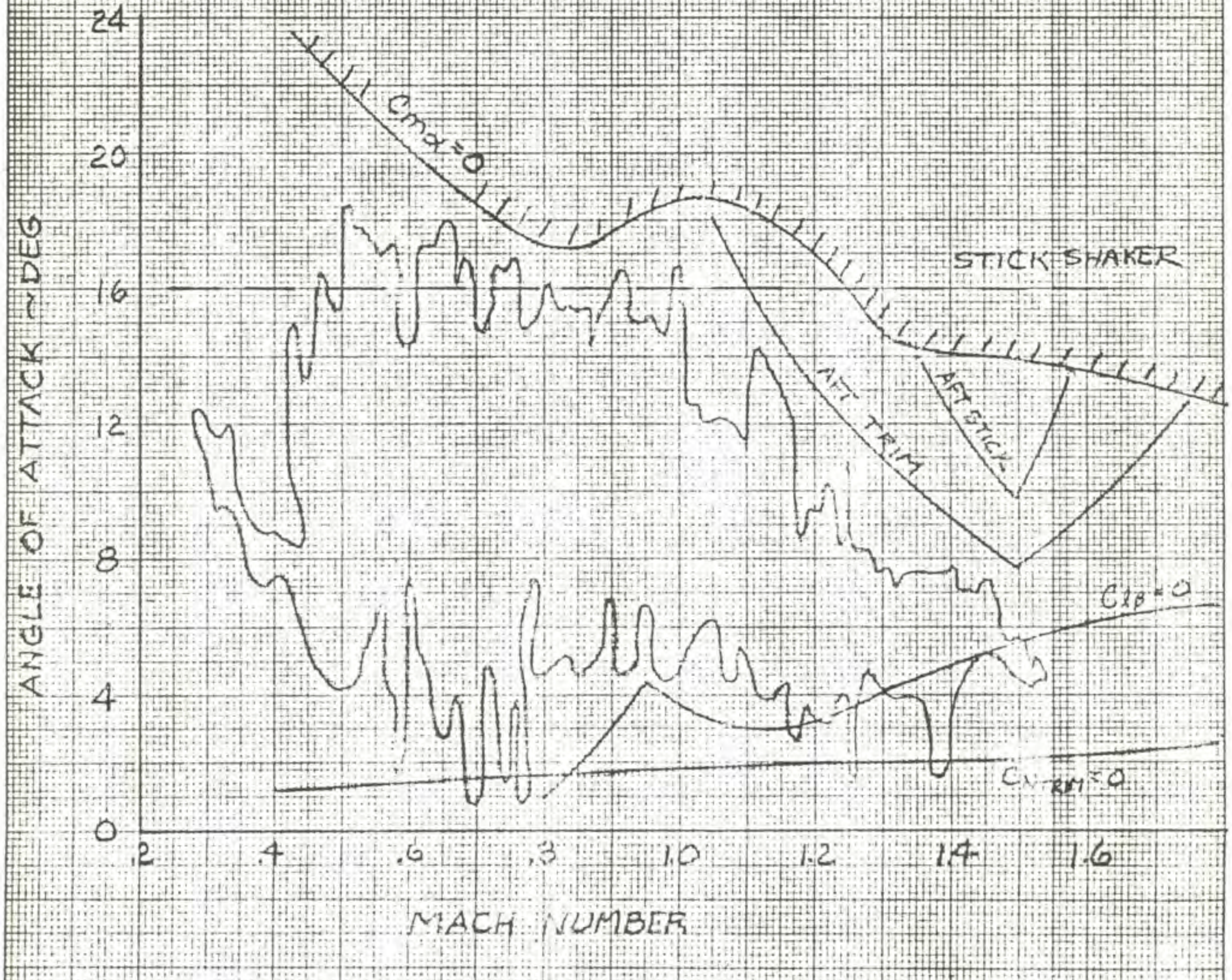
X-24B
MACH NO. VS ALTITUDE
ENVELOPE
FLIGHTS 1 THRU 15
ALTITUDE ~ 1000 FT.
80
70
60
50
40
30
20
10
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
180 KCAS
300 KCAS
MACH NUMBER

X-24B

MACH NO. VS ANGLE OF ATTACK

ENVELOPE

FLIGHTS 1 THRU 15



X-24B Flight Request

15 August 1974

Flight No: B-15-26

Scheduled Date: 23 August 1974 Flown 29 August 1974

Pilot: John Manke

Purpose:
1. Envelope Expansion to 1.68 Mach number.
2. Stability and Control at Mach numbers >1.0 and 5°, 8° and 12° α.
3. Supersonic performance and longitudinal trim.
4. Body Pressure Survey (Group II).
5. Boundary layer noise and vibration experiment (RED PLUG).

Launch: West of Rosamond, Mag Heading 060° + Cross Wind Correction Angle. 45,000 feet, 200 KIAS. Flap Bias "Manual", Upper Flaps =-40°, Lower Flaps = 27°, Rudder Bias Mode "AUTO", Rudder Bias = 0°. Rudder Trim = 1° Left. Aileron Bias = +7°, SAS Gains 6, 5, 3. Mack Repeater "Manual" = 1.0, KRA "AUTO". Hydraulic Pumps 2 and 4 on.

Landing: Rogers Lakebed Runway 18

B-52 Track: X-24B Track #2 (R2515, Work Area I)

ITEM	TIME	ALT	A/S	α	M_T	EVENT
1	0	45	200	5	.74	Launch, Light 4 Chambers, Trim to and Maintain 15° α.
2	30	45	230	15	.85	At 30 sec. Turn Overdrive on. Perform pitch pulse.
3	83	63	147	15	.83	At 63K pushover to 10° α.
4	95	68	150	10	.95	At .95 $Mach_T$, perform a pitch pulse.
5	104	71	165	10	1.05	At 1.05 $Mach_T$, pushover to 6° α.

ITEM	TIME	ALT	A/S	α	M_T	EVENT
6	116	72	205	6	1.30	At 1.30 $Mach_T$, pushover to 5° α.
7	123	72	242	5	1.45	Perform rudder and aileron doublets.
8	131	69	300	5	1.68	Engine burnout. Perform rudder and aileron doublets. Trim to 8° α.
9	142	64	310	8	1.55	Perform rudder and aileron doublets.
10	146	61	310	8	1.48	Perform POPU 8° -4° -12°-8° α. Trim to 12° α.
11	161	53	290	12	1.20	Perform rudder and aileron doublets. Pushover to 5° α.
12	178	48	240	5	.92	Perform POPU, 5° -3° -15°-5° α. Retrim to 15° α.
13	199	39	255	15	.80	Perform pitch pulse. Pushover to 5° α.
14	210	36	240	5	.72	Perform POPU, 5° -3°-15° -12° α.
15	221	32	245	12	.69	Intersection, turn to low key heading, set SAS Gains to 4, 3, 2, at .58 $Mach_T$, change configuration to -20° upper flaps.
16	251	25	260	12	.60	Perform PUPO, 12°-15°-4°-10° α.
17	290	21	230	10	.52	Low key, #1 & #3 hydraulic pumps on.
18						Change Mach repeater to 0.3 during final.

NOTES:

1. Nose Ballast = 120 lbs (+ five 93 lb batteries)

2.

	Weight-lbs	cg-%
Launch	13550	65.9
Shutdown	8630	64.0
Landing	8630	63.9 (gear down)

3. Engine S/N 8, Pump S/N 8A

	NORMAL	OVERDRIVE
Thrust - lbs/chamber	2150	2450
LOX Flow Rate - lb/sec/chamber	4.51	5.045
WALC Flow Rate - lb/sec/chamber	4.05	4.53

4. Power on Base Drag Reduction $C_C = -.005$

5. Pitch attitude null at 47° [redacted].

Ground Rules for NO LAUNCH:

1. Radio, radar, PCM failure
2. Electrical or SAS malfunction
3. A/S, altitude, Machmeter failure
4. Angle of attack or sideslip malfunction
5. Any control system malfunction
6. Loss of cabin pressure
7. Turbulence below 10K in excess of moderate
8. Surface winds greater than 20 kts or crosswind greater than 10 kts
9. Failure of engine control box heater
10. Failure of stick shaker

(In addition to standard ground rules published in Lift Body Joint Operations Plan)

Alternate Situations After Launch:

Failure	Action
1. Radio, radar, PCM	Proceed as planned
2. Only One Chamber Operates	Vector for RW 02 Rosamond, shutdown chamber, jettison, change configuration
3. Only Two Chambers Operate	Turn overdrive ON, maintain 15°α. Pushover to 10° α on NASA I Call. Shutdown at 0.9 $Mach_T$. At shutdown pullup to 15° α and proceed with the Mach .8 pitch pulse.

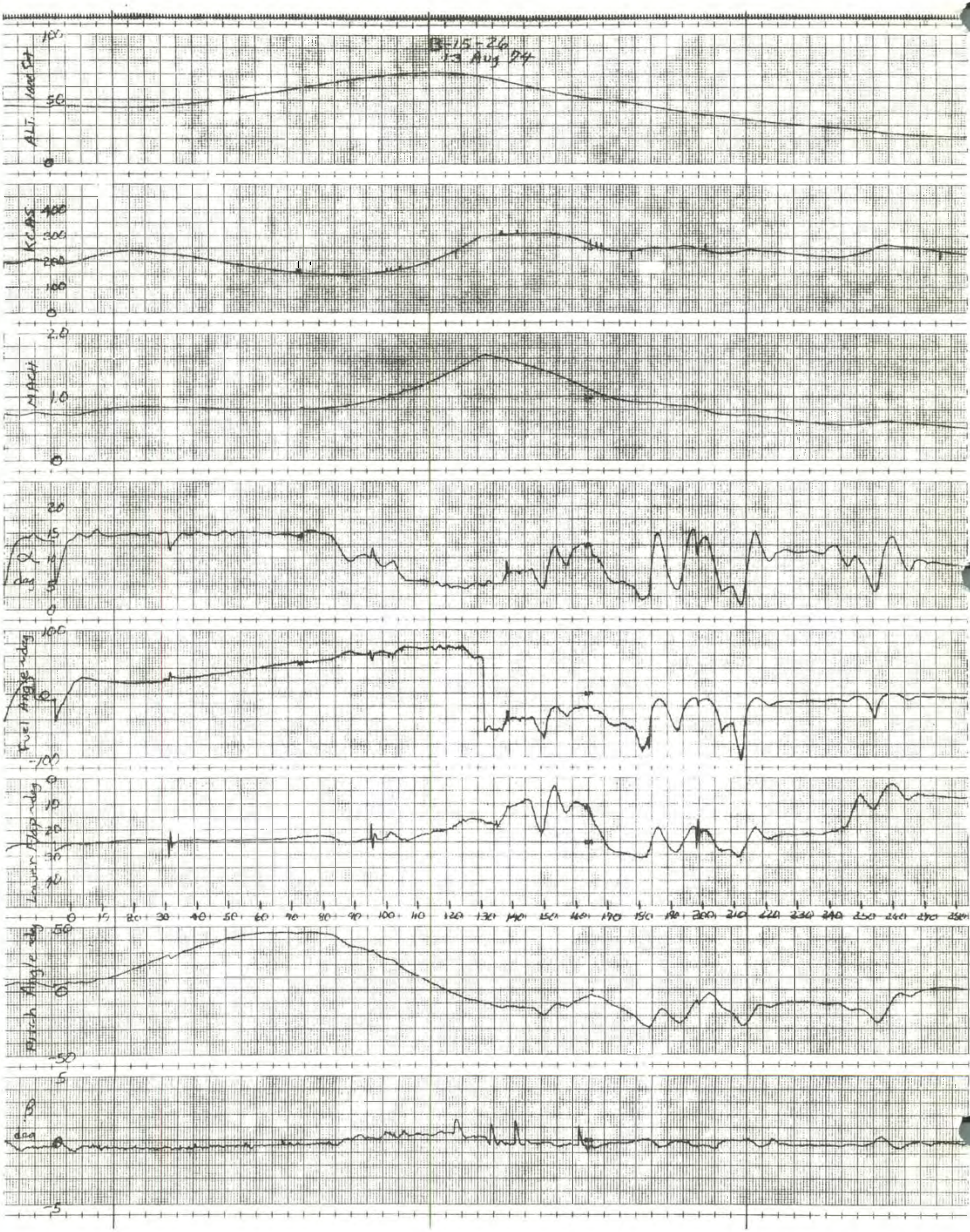
	Failure	Action
4.	Only Three Chambers Operate	Turn overdrive ON and maintain 15° α. At 58K (.9M_T) pushover to 12° α. At 1.05M_T pushover to 5° α (overdrive stays on). Engine burnout at 159 sec, Mach 1.25, proceed as planned with ~~pitch~~ doublets ~~pulse~~ at Mach 1.2 and 12° α.
5.	Delayed Engine Light	Proceed as planned using 15° α but limit θ to 50°. Possible burnout 132 sec/1.53 Mach No.
6.	Overdrive Failure	Maintain 15°. At 61K (.85 M_T) pushover to 12° α, at 1.05 $Mach_t$ pushover to 10° α, at 1.2 $Mach_t$ pushover to 5° α and proceed as planned. Burnout at 139 sec, 1.50 Mach and 310 KIAS.
7.	Total damper failure any axis	Fly 2 chamber profile, Maintain 15° α (13° α for a pitch damper failure). Shutdown on NASA I call. Roll or Yaw failure set KRA to "MAN" 0%. If roll failure turn YAW damper OFF. Pitch failure,close-up to -24° upper flap at low key. Limit Mach to 1.1.
8.	KRA "AUTO" Failure	Set to manual 10% and proceed as planned. If "MANUAL" mode inoperative-switch to "EMER" Position and set to above value.
9.	Angle of Attack (Indicator Only)	Proceed as planned using backup angle of attack gage. KRA "MANUAL" 10%, stick shaker off.
10.	Total Angle of Attack	0 to 30 seconds; fly two chamber profile use 200 KTS instead of 15 degrees α. To rotate set the lower flap at 24° until 230 KCAS then fly 200 KCAS. (KRA Manual 10 percent, stick shaker off). 30 to 100 seconds; Fly three chamber profile, overdrive stays on, set the lower flap at 24°, shutdown on NASA I call, Fly 250 KCAS until Mach = .85 then fly 200 KCAS. (KRA MAN 10%, stick shaker off) 100 second and up; shutdown, fly 250 KCAS until Mach .85 then fly 200 KCAS. (KRA MAN 10%, stick shaker off)

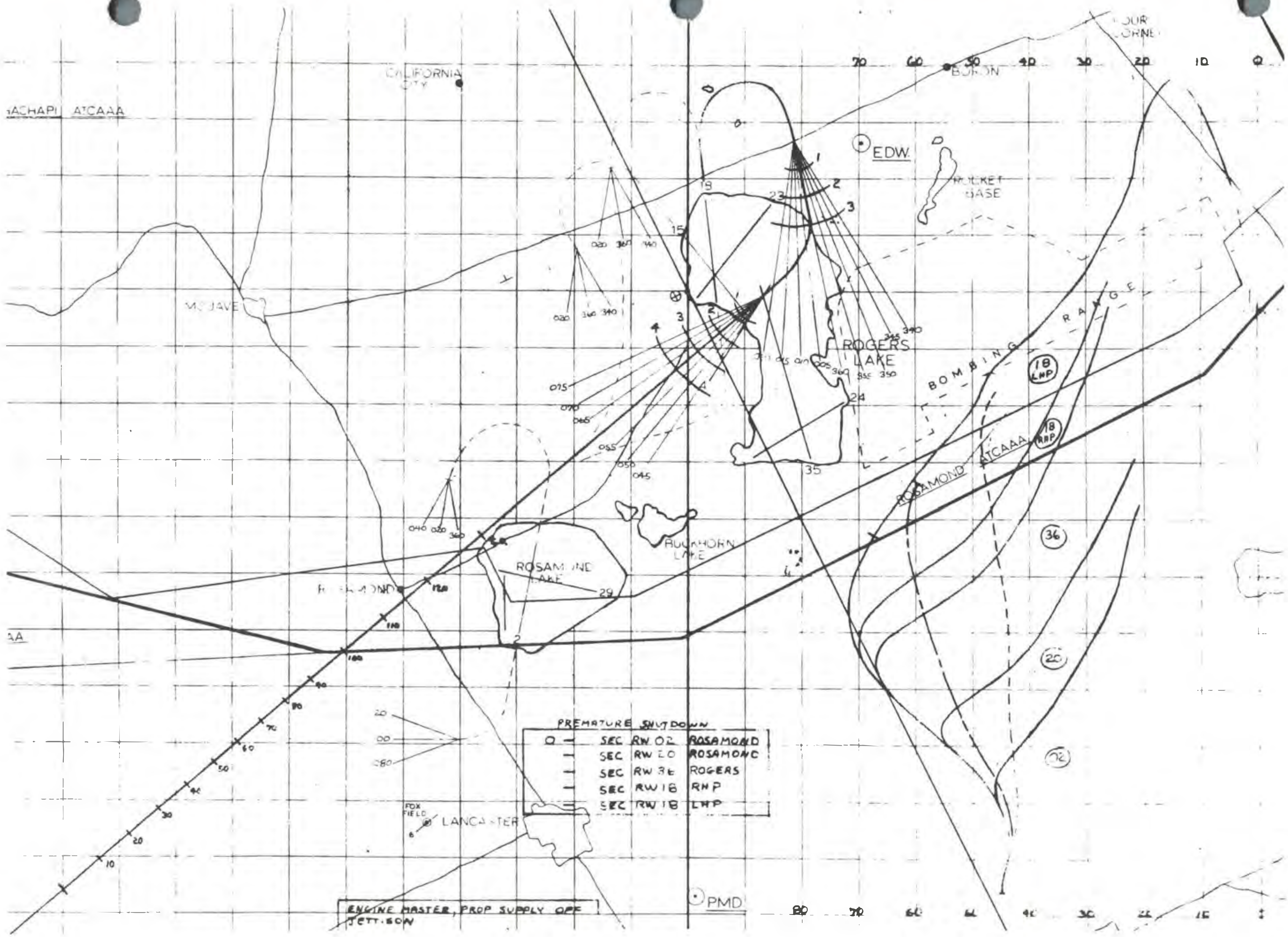
	Failure	Action
11.	A/S, Altitude, Mach	Proceed as planned using α, θ and time for profile control. Don't do Mach .6 PUPO.
12.	Attitude System	Proceed as planned using backup attitude indicator.
13.	Rudder Bias "AUTO" failure	Switch to "MANUAL" mode and toe-in to -10°. If "MANUAL" fails close-up to -24° upper flap.
14.	Upper flaps fail to close	Cycle emergency flap swith to closeup to -20° upper flaps. If emergency flap switch fails, move δA_B to 11.
15.	Premature Engine Shutdown	

0 - 30 Sec RW 02 Rosamond
30 - 56 Sec RW 20 Rosamond
56 - 85 Sec RW 36 Rogers
85 - 95 Sec RW 18 (RHP) Rogers
95 - up Sec RW 18 (LHP) Rogers

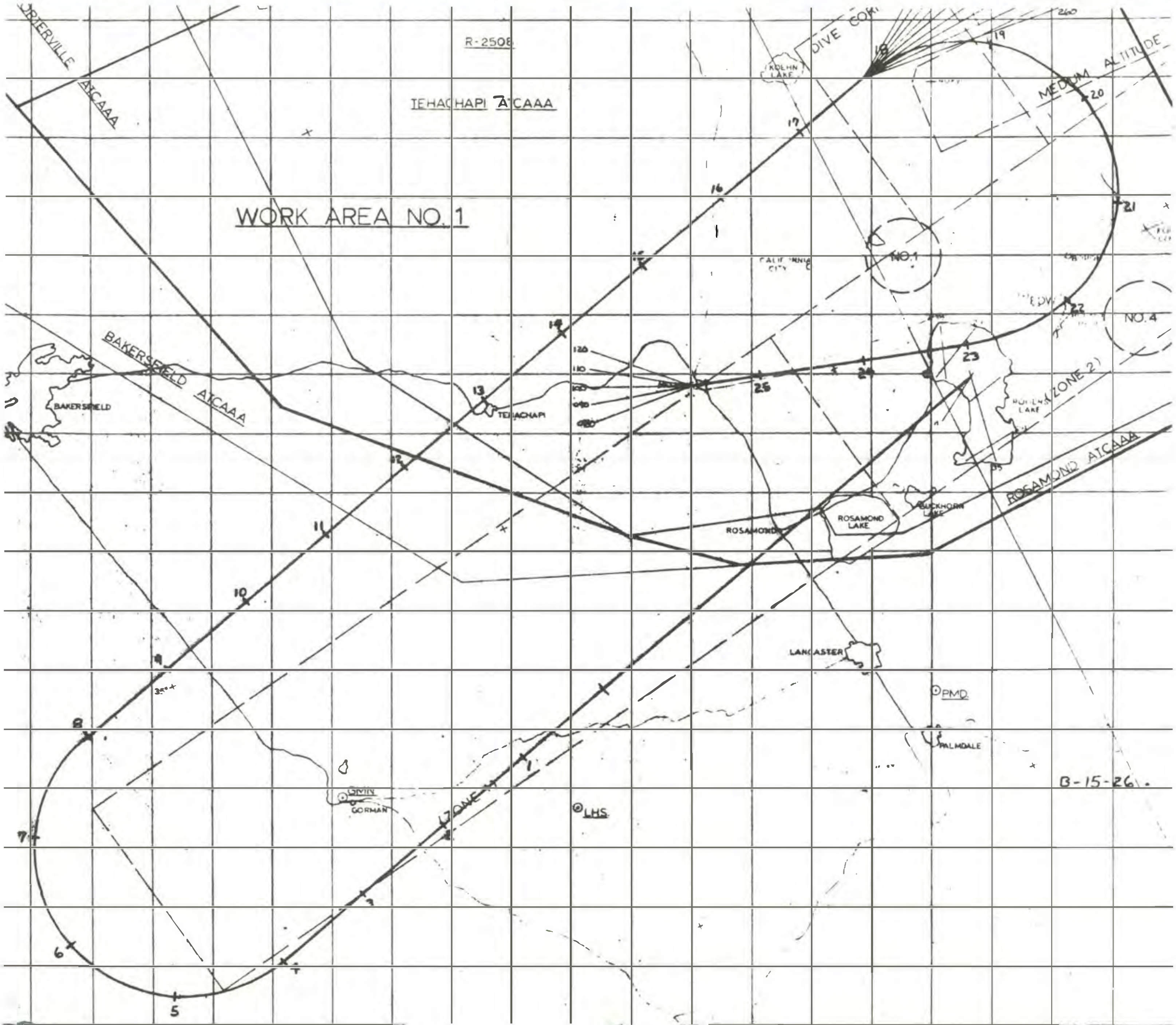
JOHNNY G. ARMSTRONG

JACK L. KOLF


B-15-26
13 Aug 74
ALT. 1000 ft
KCAS
MACH
α deg
Fuel Angle ~deg
Lower Flap ~deg
Pitch Angle ~deg
β deg



CALIFORNIA CITY
BORON
EDW.
ROCKET BASE
ROGERS LAKE
BOMBING RANGE
ROSAMOND ATCAAA
BUCKHORN LAKE
ROSAMOND LAKE
ROSAMOND
FOX FIELD
LANCASTER
PMD
PREMATURE SHUTDOWN
SEC RW 02 ROSAMOND
SEC RW 20 ROSAMOND
SEC RW 36 ROGERS
SEC RW 18 RHP
SEC RW 18 LHP
ENGINE MASTER, PROP SUPPLY OFF
JETTISON



PORTERVILLE ATCAAA
R-2508
TEHACHAPI ATCAAA
DIVE COR
KOLHN LAKE
MEDIUM ALTITUDE
WORK AREA NO. 1
CALIFORNIA CITY
NO. 1
NO. 4
BAKERSFIELD ATCAAA
BAKERSFIELD
TEHACHAPI
ROGERS LAKE
ZONE 2
ROSAMOND ATCAAA
ROSAMOND
ROSAMOND LAKE
BUCKHORN LAKE
LANCASTER
PMD
PALMDALE
GMN
GORMAN
LHS
ZONE 1
B-15-26

X-24B EVENT SHEET

FLT. B-15-26

TIME	MACH	ALTITUDE	α	KCAS	EVENTS
10:45:26.7					ENGINE MASTER ON
:45:32.9					GOX PRIME
:45:34.8					LOX PRIME
:46:10.0	.742	44728.	1.9	200.	LAUNCH
:46:13.0	.723	44577.	11.2	195.	#1 & #3 CHAMBER PRESSURE START UP
:46:13.0	.723	44577.	11.2	195.	RH FIN PRESSURE GLITCHES
46:13.4	.722	44377.	11.7	195.	LH FIN PRESSURE GLITCHES
46:14.7	.712	44578.	13.5	192.	Ax STARTS INCREASE
46:15.2	.710	44484.	13.9	192.	#3 CHAMBER PRESSURE PASSES 155 PSIA
46:16.0	.711	44384.	15.0	192.	#1 AT 100%
46:16.3	.712	44362.	15.3	193.	#3 AT 100%, Ax LEVEL (2 CHAMBERS)
46:16.8	.713	44307.	15.5	193.	#2 & #4 CHAMBER PRESSURES START UP
46:18.0	.718	44187.	15.4	195.	Ax STARTS INCREASE
46:19.0	.726	44057.	16.1	198.	Ax LEVEL (4 CHAMBERS)
46:19.2	.729	44047.	15.9	199.	#2 AT 100%
46:19.4	.732	44015.	15.8	200.	#4 AT 100%
46:45.1	.843	43979.	15.2	235.	OVER DRIVE ON, Ax STARTS INCREASE
46:45.4	.842	44022.	15.1	234.	Ax LEVEL (4 CHAMBERS, OVERDRIVE)
46:45.9	.843	44123.	15.0	234.	PITCH PULSE, $\alpha = 15^\circ$
46:48.1	.851	44584.	14.1	234.	MAX MACH DURING ROTATION, $\alpha = 15^\circ$
10:47:36.0	.779	63662.	15.3	135.	PUSHOVER TO 10° α
47:41.1	.821	65664.	9.6	137.	$10^\circ \alpha$
47:54.7	.985	70543.	9.9	151.	PITCH PULSE, $\alpha = 10^\circ$

TIME	MACH	ALTITUDE	α	KCAS	EVENT
10:47:58.0	1.016	70962.	9.4	156.	START MACH JUMP
47:59.6	1.032	71064.	9.5	158.	PUSHOVER TO 6° α
47:59.7	1.036	71120.	9.5	159.	END MACH JUMP
10:48:02.4	1.093	71825.	6.5	167.	PREMATURE ENGINE SHUTDOWN
48:03.0	1.096	71914.	6.4	167.	6° α
48:03.6	1.097	71993.	6.6	167.	MAX MACH, KTAS = 632
48:06.1	1.076	72283.	6.4	162.	PULL UP TO 16° α (FOR ENERGY MANAGEMENT)
48:10.0	1.043	72440.	7.1	155.	MAX ALTITUDE
48:15.8	1.023	72274.	11.1	152.	START MACH JUMP
48:17.3	1.013	72053.	12.8	151.	END MACH JUMP
48:23.4	.997	70529.	16.4	154.	16° α
48:46.1	.999	62756.	14.0	185.	START LOX JETTISON
48:47.1	1.000	62364.	14.2	187.	START WALC JETTISON
48:53.4	.999	59640.	13.6	199.	STOP LOX JETTISON
48:56.4	.972	58391.	14.9	198.	STOP WALC JETTISON
10:49:41.7	.688	45839.	13.3	179.	START POPU, α = 14°
49:42.0	.686	45772.	12.7	179.	LH FIN PRESSURE GLITCH
49:42.2	.686	45727.	11.9	179.	LH FIN PRESSURE GLITCH
49:43.0	.686	45539.	9.0	180.	RH FIN PRESSURE GLITCH
49:44.4	.682	45216.	5.9	180.	RH FIN PRESSURE GLITCH
49:50.6	.693	43314.	1.1	192.	α = 2°
49:51.7	.699	42883.	7.8	195.	RH FIN PRESSURE GLITCH
49:52.4	.702	42619.	12.8	198.	LH FIN PRESSURE GLITCH
49:52.6	.703	42530.	14.0	198.	RH FIN PRESSURE GLITCH
49:52.6	.703	42530.	14.0	198.	LH FIN PRESSURE GLITCH
49:53.4	.703	42231.	16.2	200.	α = 16½°
49:55.9	.702	41266.	12.9	204.	END POPU, α = 13°

TIME	MACH	ALTITUDE	α	KCAS	EVENT
10:50:05.2	.680	38282.	12.8	211.	LH FIN PRESSURE GLITCH
50:05.7	.678	38149.	12.8	211.	LH FIN PRESSURE GLITCH
50:10.8	.652	36968.	12.4	208.	RH FIN PRESSURE GLITCHES
50:36.0	.546	33177.	11.9	188.	UPPER FLAPS START IN FROM 40° (CONFIGURATION CHANGE)
50:40.3	.554	32551.	11.7	194.	START TURN TO DOWNWIND, MAX $\phi = 41°$
50:43.7	.561	32134.	11.8	198.	UPPER FLAPS AT 20°
10:51:18.0	.585	26983.	10.9	232.	$\phi = 41°$
51:20.1	.586	26632.	10.9	234.	PITCH SAS GAIN TO 4
51:21.2	.586	26434.	10.8	235.	ROLL SAS GAIN TO 3
51:22.3	.584	26301.	10.8	235.	YAW SAS GAIN TO 2
51:24.6	.583	26048.	10.3	236.	START POPU, $\alpha = 10\frac{1}{2}°$
51:28.2	.586	25247.	1.6	241.	$\alpha = 2\frac{1}{2}°$
51:31.2	.593	24613.	12.0	248.	END TURN TO DOWNWIND
51:35.0	.572	24044.	15.2	241.	$\alpha = 15\frac{1}{2}°$
51:37.2	.555	23873.	8.2	235.	END POPU, $\alpha = 8°$
51:39.7	.546	23704.	7.0	231.	#1 HYD PUMP ON
51:40.4	.543	23659.	7.0	230.	#3 HYD PUMP ON
51:41.6	.539	23559.	7.7	229.	START VISUAL RUNWAY CHECK (MAX $\phi = 30°$)
51:43.7	.531	23380.	7.3	226.	$\phi = 30°$
51:45.3	.527	23225.	7.9	225.	START RIGHT HEADING CORRECTION (MAX $\phi = 21°$)
51:48.1	.523	22915.	7.4	225.	$\phi = 21°$
51:51.9	.523	22432.	7.8	227.	LOW KEY, START TURN (MAX $\phi > 50°$)
10:53:17.0	.506	5193.	4.9	306.	LEVEL ON FINAL

TIME	MACH	ALTITUDE	α	KCAS	EVENT
10:53:28.4	.473	3435.	5.4	275.	START FLARE
53:47.3	.368	2310.	9.0	234.	GEAR DOWN
53:57.6	.277	2260.	12.1	176.	MAIN GEAR TOUCHDOWN
53:58.0	.277	2260.	10.0	176.	CROSSOVER TO UPPER FLAP
53:59.3	.264	2252.	-3.7	168.	NOSE GEAR TOUCH DOWN
53:59.7	.260	2250.	-6.3	165.	RETURN TO LOWER FLAP

X-24B DERIVATIVES

BY

Alex G. Sim

On flight 15 three sets of longitudinal derivatives were obtained from flight data. These derivatives were obtained at Mach numbers of 0.846, 0.953, and 1.001 with angles-of-attack of 14.33°, and 15.66° respectively and are shown in figures 1 and 2. In all cases longitudinal static stability and control effectiveness are consistent with previous trends. Pitch damping derivatives agrees with previous result at the Mach numbers .846 and 1.001 data but not at the Mach number 0.953 point. The reason for this discrepancy is not completely understood; however, it is suspected that this Mach number regime cannot always be adequately modeled with linerized parameters (derivatives).

FIGURE 1,

X-24B DERIVATIVES

$\delta_{UB} = -40°$, $\delta r_B = 0°$, CG = .66Z

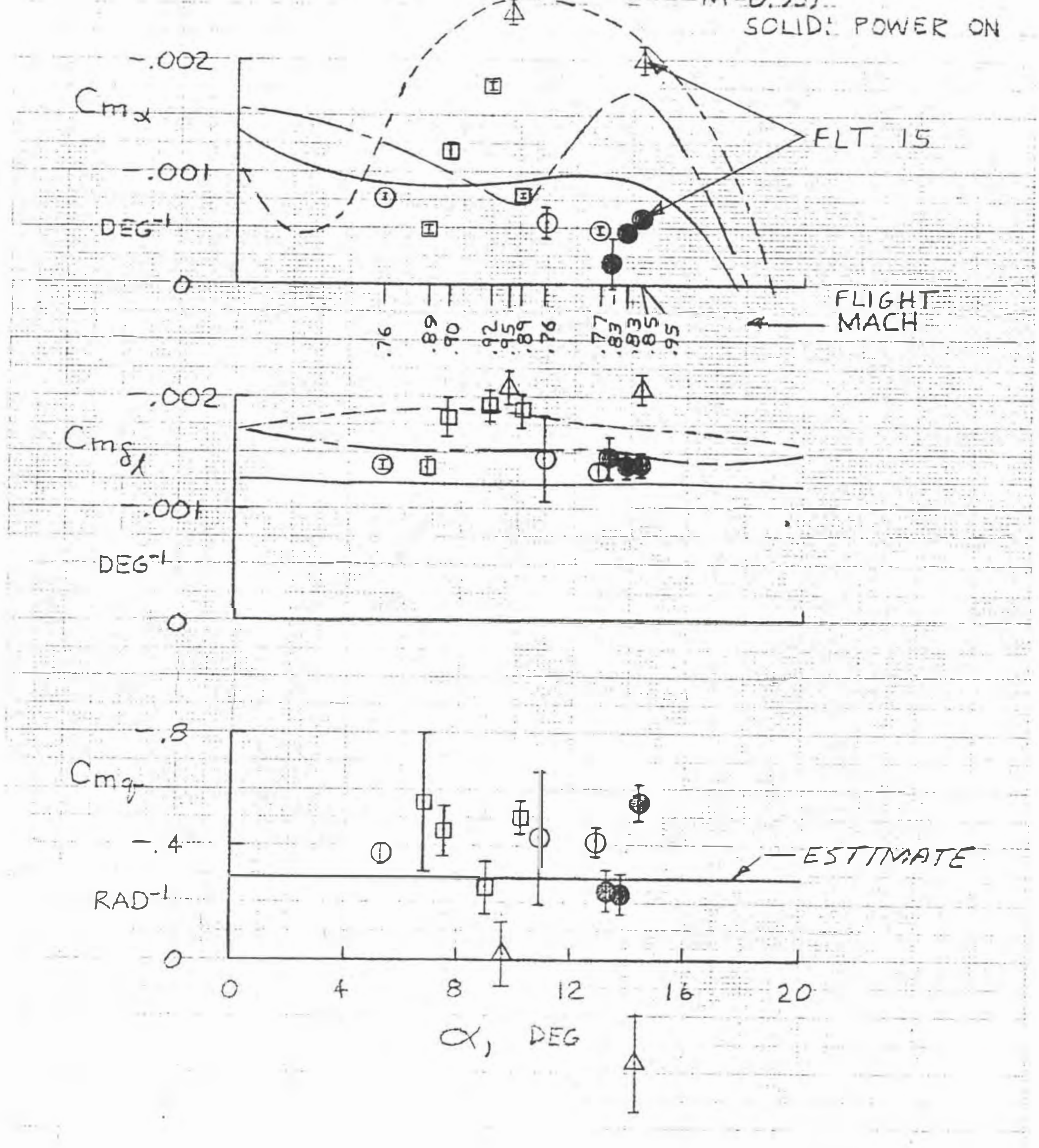
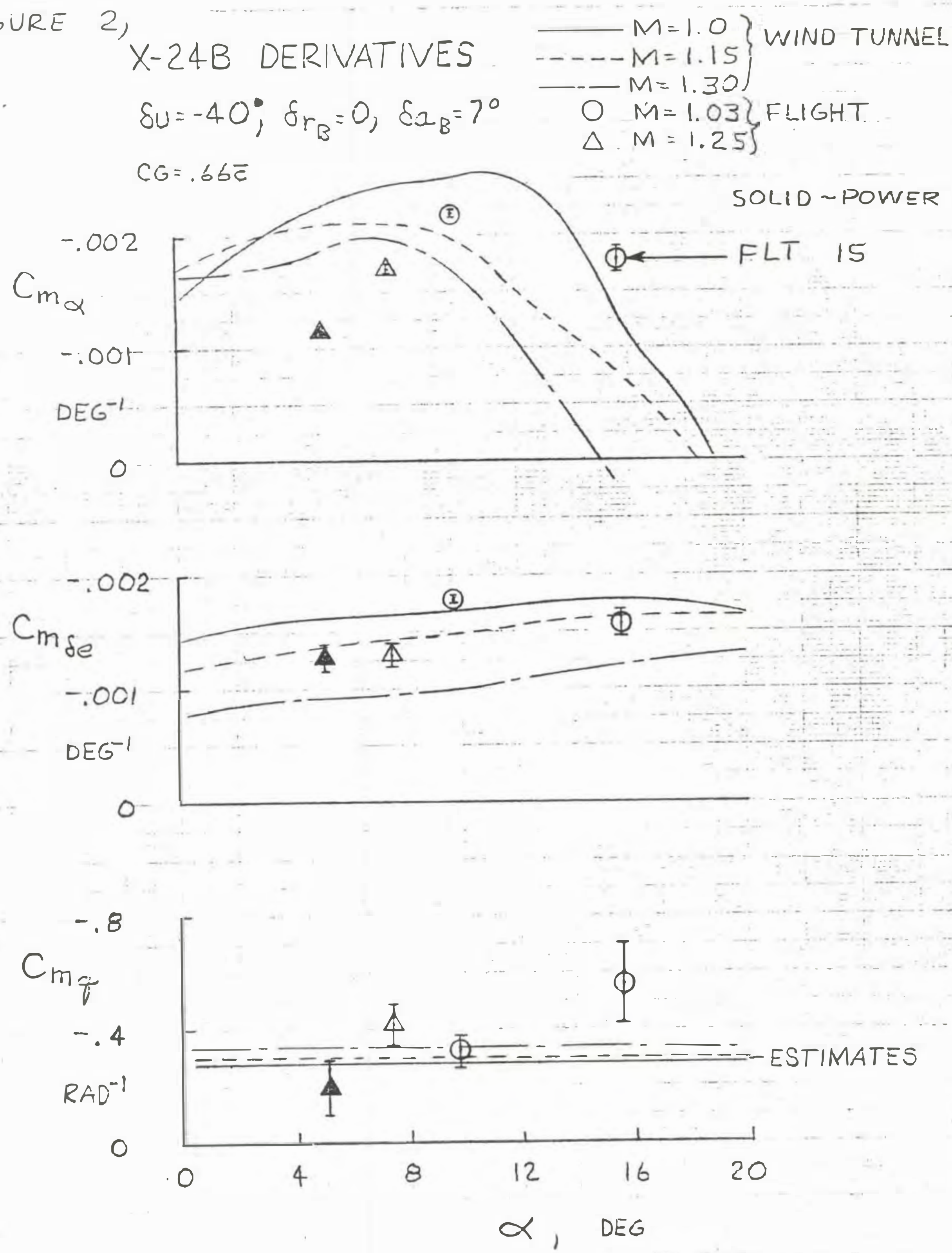


FIGURE 2, X-24B DERIVATIVES

$\delta_U = -40°$; $\delta_{r_B} = 0$, $\delta_{a_B} = 7°$

CG = .66c̄



FLT. B-15-26

HANDLING QUALITIES SUMMARY

• LAUNCH TRANSIENT AT 200 KIAS	SAME AS 190 KIAS
• ROTATION AT 15°α	2½
• CLIMB AT 15°α	
EARLY	2½
LATER	3½ TO 4
• H.Q. ABOVE .85M @ 10°α	3
• APPROACH	PERFECT SET-UP NO SPEEDBRAKE SMOOTHEST YET
• LANDING	NORMAL

COMMENTS ON HANDLING QUALITIES

Noted During Climb on Flight 15

BY

Johnny G. Armstrong

On Flight 15 the pilot noted two distinct levels of longitudinal stability during the climb. The vehicle was described as one that was easy to control early in the climb; changing to one that was more difficult to control. The attached figure presents a time history of this time period. Note that initially the pilot could maintain the target angle of attack of 15 degrees to ±.5 degrees; whereas later the angle of attack deviations were ± 1.5 degrees. It is felt that this lack of precise control is due to low levels of dynamic pressure at a flight condition (Mach & α) where Cm_{α} is at a low value (sec X-24B Derivatives in this report). Note in the figure the rapid decay in dynamic pressure to a minimum value of 51 psf.

The following table summarizes the conditions during climb on the past four flights where maximum performance type profiles were flown. Note that on successive flights each pilot flew higher climb angles resulting in lower dynamic pressures in the climb. Each pilot observed the reduction in controllability as indicated by the higher pilot rating.

Flight No	Pilot	Pitch Angle Deg	Min A/S KTS	Min $\bar{q}$ PSF	Pitch PR
12	Love	37	171	84	3
13	Manke	40	164	76	2 1/2
14	Love	43	145	62	4
15	Manke	47	134	51	3 1/2 to 4

In summary, this handling qualities characteristic can be expected to occur on future flights when similar low q flight conditions are encountered.

Technical Debriefing

Flight B-15-26

29 August 1974

Pilot: John Manke

1. Describe the launch transient (200 KIAS) and compare to the 190 KIAS launches.

Answer:

Launch transient 200 knots compared with 190 knots, launch couldn't tell any difference as far as launch transient goes. This was a head in the cockpit launch and I was attempting to get to the chamber switch just about as quickly as I could, I hit the launch switch and then looked right down at the chamber switches and hit 1 and 3. So from my standpoint this launch didn't change at all from the other ones. It was a very mild launch.

2. Discuss the engine light sequence.

Answer:

Engine light sequence was chambers 1 and 3 first and then 2 and 4. It was a good quick light, engine came up nicely on the first two chambers and the next two came up very nicely too, so it was a very good light.

3. Discuss the handling qualities during the rotation. Rate pitch, and lateral directional.

Answer:

Handling qualities during the rotation are much like they have been. I tried to get the 15 degrees α as quickly as I could. It handled much like the simulator. No problem at all getting up to alpha and getting the engine going. I guess at this point I'll mention again as we did in the other debriefing that the task to maintain 15 degrees angle-of-attack changed apparently with Mach number somewhere in the rotation. It goes from an airplane that's very nice to hold angle-of-attack and bank angle to an airplane that becomes much more difficult to hold angle-of-attack within the original limits. Today was the first time that I could really sense the change in the airplane it seemed to be a very difinite step from one airplane to the other, one that was easy to control in α to one that became more difficult. It also seemed to indicate more of task to keep the bank angle straight. The airplane seemed to wobble a little bit when we reached this particular threshold and the pilot rating task all the way round would probable deteriorate at least one and a half points on the Cooper scale. You might go from a 2 1/2 to a 3 1/2 to a 4, so if I'd rated it before this particular threshold I probably would have rated the airplane about a 2 1/2, this is overall handling qualities. Then once we get beyond this threshold I'd rate it down to 3 1/2 to 4, and its interesting to pick up the change so readily. This time its very similar to the thing we see when we go transonic when you get that change in the airplane there. The pitch effect is so much different when you go supersonic you feel light in the airplane but here then was something else I could feel. We should persue this pressure thing that Armstrong had been doing. I don't remember in what Mach number range he was seeing these things. We noticed then before decelerating power off and there was definitely something here this time and I think it was around .7 or .8 Mach number.

4. Compare the vehicles response to the Mach 0.84 pitch pulse (power on) at 15 degrees α with the simulator.

Answer:

Here again the airplane appeared to be just a little bit better damped. I pushed it over and then had to physically pull it back up to 15 degrees α. The simulator shows the same tendency but it seemed like it was more damped in the airplane than it was in the simulator.

5. (a) Discuss the task to maintain 15 degrees α and rate.

Answer:

The task to maintain 15 degrees α and rate, I've already done that on question 3. For overall handling qualities the task to maintain angle-of-attack is noted about a 2 1/2 early in the rotation and as we reached this threshold it goes to 3 1/2 to 4.

5. (b) How did maximum θ compare with the simulator?

Answer:

Compared pretty much with what we saw this morning in the simulator. The θ bug came down and went just below the line indicating that we hit about 48 degrees and maybe 48 1/2 degrees.

6. Discuss the handling qualities above .85 Mach number at 10 degrees α with power on. Compare to previous flights where 12 degrees α was used. Rate.

Answer:

We don't seem to get the magnitude of the sideslip at 10 degrees α as we do at 12 degrees α. My last flight was at 12 degrees α through this Mach region and we got some pretty good sideslips. There were some sideslips here on this flight but didn't seem to be the magnitude and sideslip doesn't tend to stay out here at 10 degrees α like it does at 12 degrees α. At 12 degrees α the pilot gets the feeling like its going to stay out there for a while . I don't get that tendency at 10 degrees α. It looks like it goes out and comes right back in. I noticed here at 10 degrees α before the Mach jump that I was having some difficulty in holding 10 degrees α. This is a trim change area in here so the angle-of-attack does start changing on you a little bit. I had a little more difficulty with the 10 degrees α in the airplane today than I had been in the simulator, part of it I guess was trying to get it set up for the pitch pulse but even at that I worked at it a little bit harder and I'd probably rate that at a 3.

7. Compare the vehicles response to the Mach .95 pitch pulse with the simulator.

Answer:

The vehicles response to the .95 pitch pulse as compared to the simulator was very much the same, I couldn't really tell the difference.

8. Discuss the handling Qualities above 1.0 Mach number at 6 and 5 degrees α with power on. Rate.

Answer:

I Can't say very much about the handling qualities above 1.0 Mach number because right after the Mach jump I pushed over going to 6 degrees α and before I got to 6 degrees α the engine quit. From that point on I held a high angle-of-attack so we could get the airspeed down and get it cleaned up. I flew about an average of 15 1/2 degrees α just up on the stick shaker boundary continually, 15 to 16 degrees.

9. Discuss pushover - pullup maneuver at .7 Mach number.

Answer:

This actually occured a little above .7 Mach about .73. I pushed over to about 4 degrees α back up to a little over 15 degrees and then back down to 12 degrees, about the same as practiced in the simulator.

10. Discuss pullup - pushover maneuver at .6 Mach number with -20 degrees upper flaps. Comment on any buffet encountered.

Answer:

That went just as we had planned. I saw right around .6 Mach number when we did it. The only buffet I got was around 13 1/2 degrees to 14 degrees α and up to 15 degrees α. I expected to see buffet about 11 1/2 degrees to 12 degrees but it was delayed a little bit. Maybe my Mach had slipped down but I don't think so, also if I did get to the crossover region it was much easier to fly thru the cross-over in the airplane than its been in the simulator. The simulator takes a real effort to get to 15 degrees α, I did the cross over at about 14 degrees α in the simulator and really had to pull on it to get 15 degrees α in the simulator.

11. Discuss the energy management from the "Intersection to low key".

Answer:

The energy management to low key was strictly on Mike's calls, I didn't look out of the airplane. I did look out a couple of times but I was just flying according to Mike's calls.

12. Discuss the pattern.

Answer:

The pattern was set up perfectly for low key I don't remember the altitude but what ever it was, it was a textbook pattern I didn't use speedbrakes at all. Rolled out on final must have been 10,000 feet or 11,000 feet at almost 300 knots. Airspeed stayed between 300 and 280 knots all the way on final approach. I had a long time at that airspeed and it was just the nicest flying airplane during that portion of the flight that I'd ever flown. I had time to sit there and look and listen and the airplane was so smooth. It was like flying on an arrow there wasn't any bobbling. I can't explain how smooth it was. I was overwhelmed at how the airplane sits there like a rock and just go on down the line. Lucked out and got a good glide slope so I didn't have to change it at all. It was almost a hands off 300 knot approach and boy its stable!

13. Discuss the landing and roll out.

Answer:

The flare and landing were very normal. Very nice airplane to flare and today I thought I could see a ground effect in the aircraft. I had a lot of time after the flare with the extra 7 or 8 knots that I had. I had quite a bit of time to adjust the rate of sink and alpha while waiting for 240 knots for the gear. When the gear came out I set up a rate of sink and was just flying it on down and I reached the point where I felt that I had a change in magnitude of controllability of the airplane. I continually work with the airplane on the way down. I think you see that if you look at the pilot stick, he's moving it all the time and that's his way of trying to find out what response he's got in the airplane and what the airplane's doing. I had a lot of time to do that today and I kept flying it on down until I reached a certain point where I felt I had superior control over the airplane.

September 12, 1974

TO: DOEER

FROM: W.B. Arnold - THIOKOL

SUBJECT: Propulsion System operation Flight B-15-26

SUMMARY OF ENGINE OPERATION

1. All chamber starts were normal.

2. During the transfer into overdrive pch the #1 and #2 chamber pressures increased normally. The #3 chamber pressure indication delayed six seconds. The #4 chamber pressure never indicated any increase.

3. Engine shutdown was prematurely encountered at approximately 108 seconds due to loss of fuel manifold pressure.

4. The #4 chamber pressure recording delayed responding approximately one second during the shutdown transient.

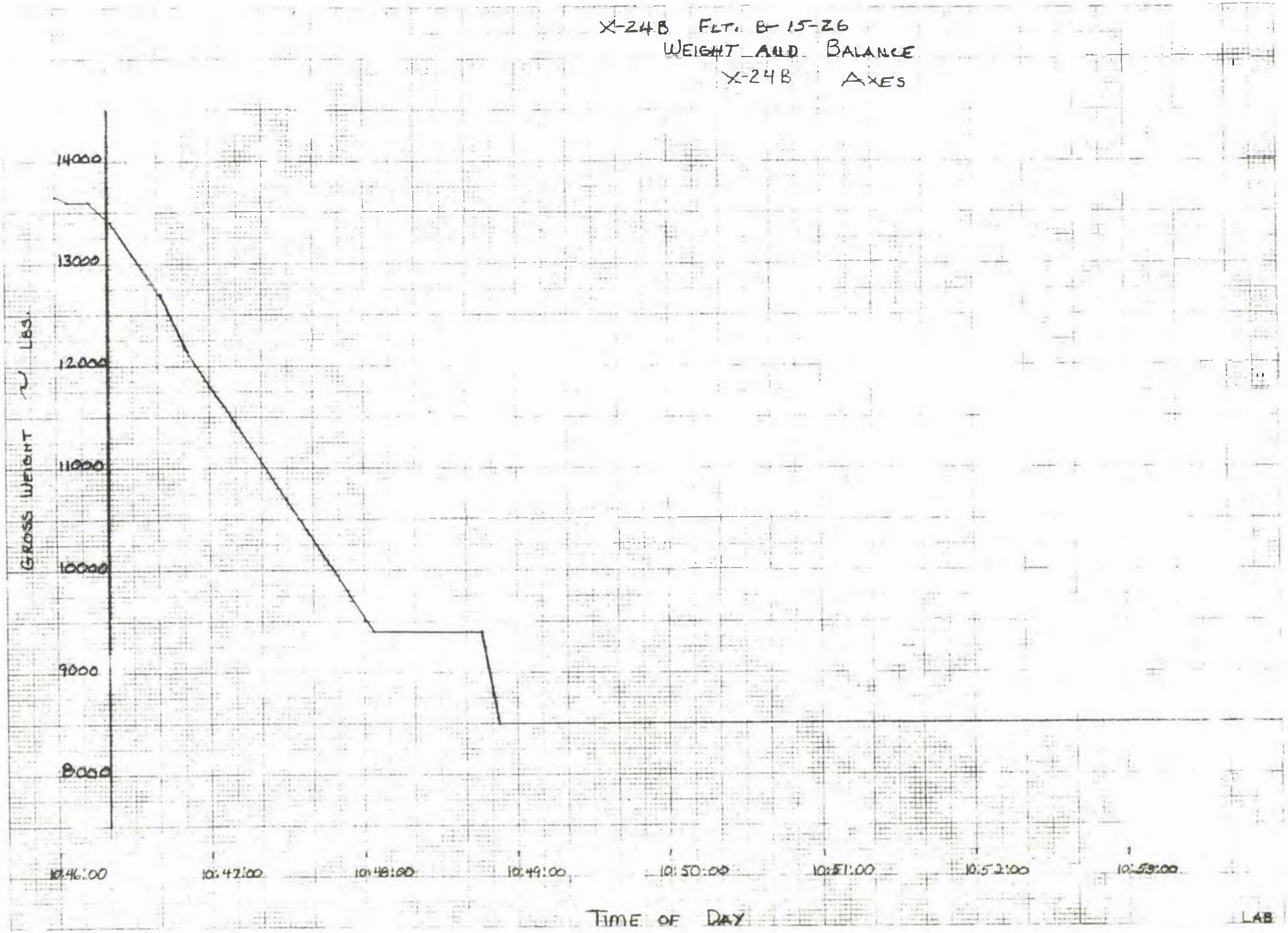
DISCUSSION

The failure to obtain correct chamber pressure indications are again the result of freezing in the #3 and #4 chamber pressure lines. The #3 pch indication was normal during the shutdown transient. The #4 pch decay was delayed one second as a result of the freezing.

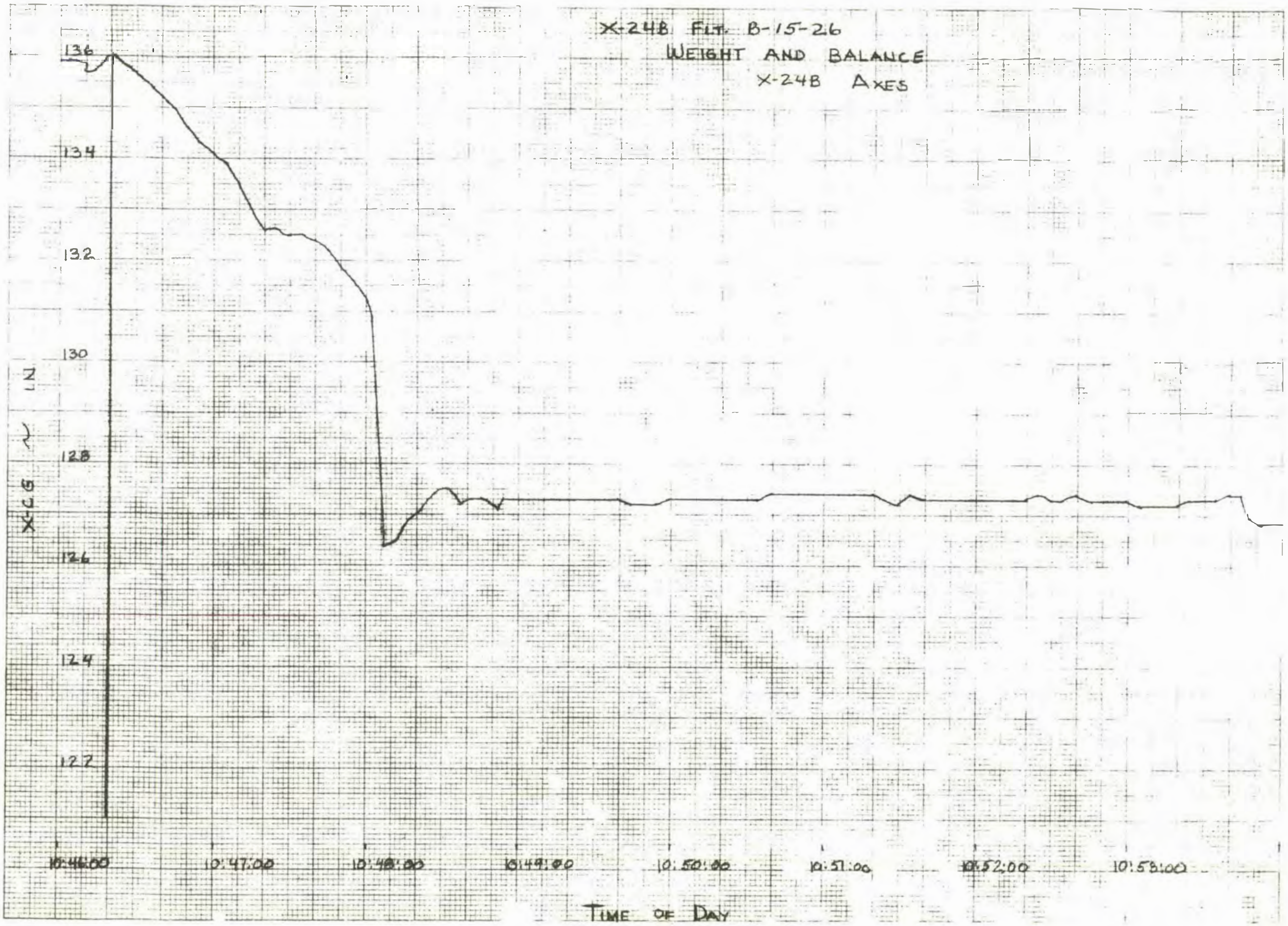
The premature engine shutdown was initiated by low fuel manifold pressure due to loss of fuel pump discharge pressure. The loss of fuel pump discharge pressure is normally associated with fuel exhaustion or fuel tank unporting. However, there should have been a large amount of fuel remaining and predicted propellant surface angles indicated that tank outlet unporting was not likely. Suspicions were then directed to a possible leak in the bulkhead between the forward and aft compartments of the fuel tank. A leakage test of this bulkhead was accomplished by filling the forward compartment with water and inspecting the bulkhead through a port in the aft compartment. This inspection revealed a gross leak in the right hand upper half of the bulkhead with only the head pressure of the water in the forward compartment. It is assumed that this leak prevented complete fuel transfer from the aft compartment due to pressure differentials caused by leakage of the pressurizing gas into the forward compartment.

CORRECTIVE ACTION

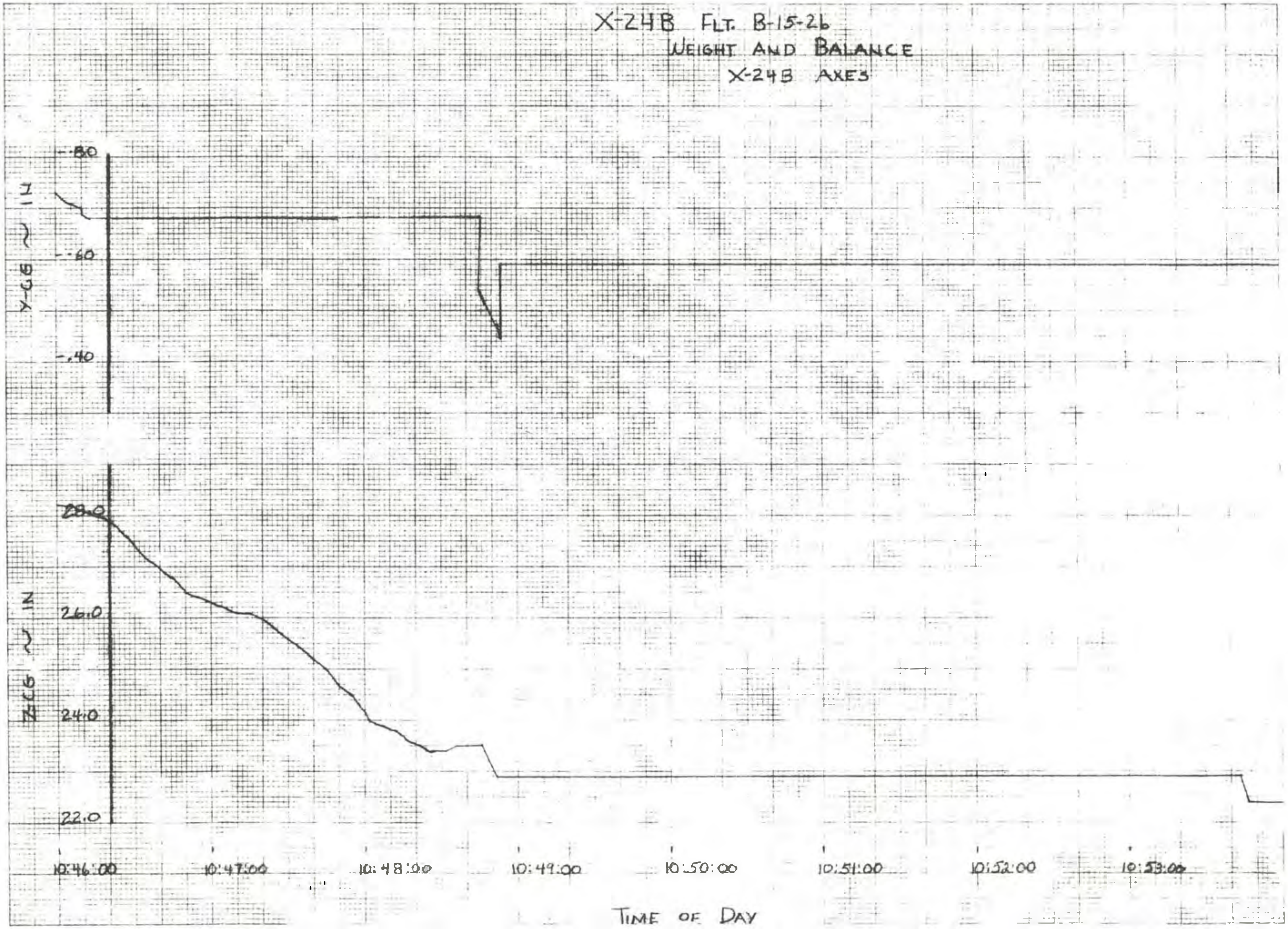
1. Flowcheck all engine chamber pressure line bleed orifice and correct as required.
2. Purge all pch sensing systems.
3. Repair aircraft fuel tank bulkhead.

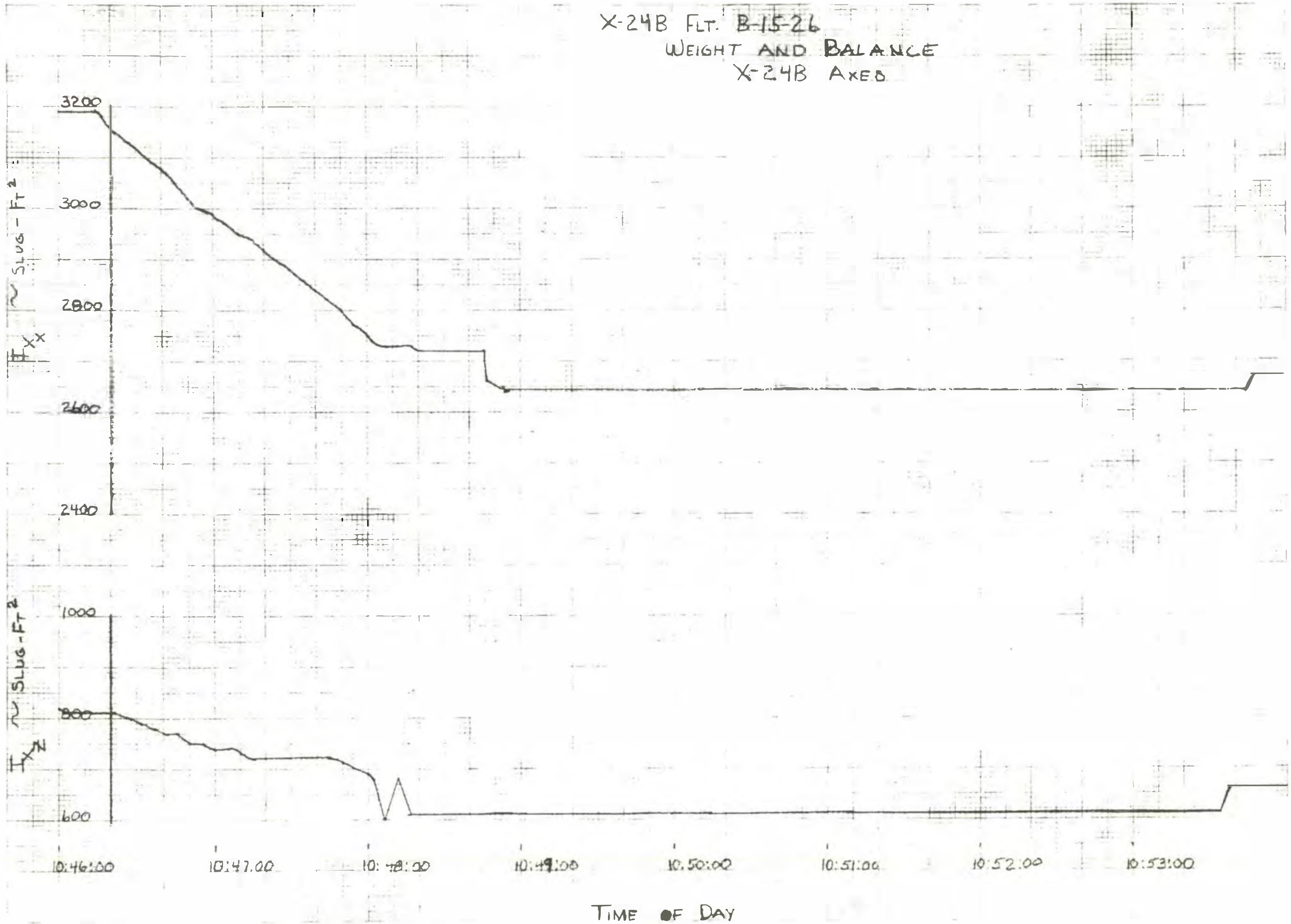


X-24B FLT. B-15-26
WEIGHT AND BALANCE
X-24B AXES
14000
13000
12000
11000
10000
9000
8000
GROSS WEIGHT ~ LBS.
10:46:00
10:47:00
10:48:00
10:49:00
10:50:00
10:51:00
10:52:00
10:53:00
TIME OF DAY
LAB

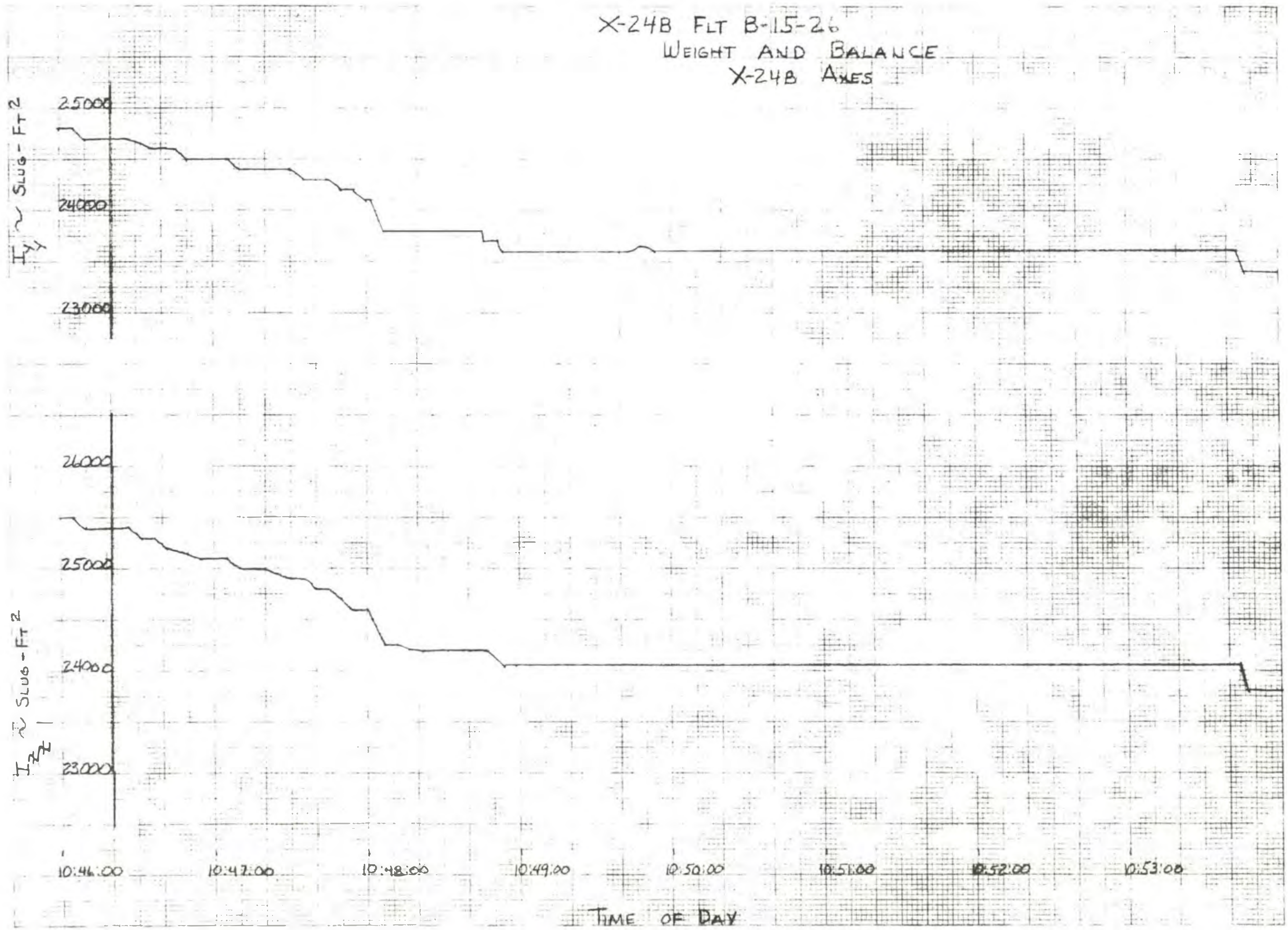


X-24B FLT. B-15-26
WEIGHT AND BALANCE
X-24B AXES
136
134
132
130
128
126
124
122
XCG ~ IN
10:46:00
10:47:00
10:48:00
10:49:00
10:50:00
10:51:00
10:52:00
10:53:00
TIME OF DAY


X-24B FLT. B-15-26
WEIGHT AND BALANCE
X-24B AXES
Y-CG ~ IN
-.80
-.60
-.40
X-CG ~ IN
28.0
26.0
24.0
22.0
10:46:00
10:47:00
10:48:00
10:49:00
10:50:00
10:51:00
10:52:00
10:53:00
TIME OF DAY



X-24B FLT. B-15-26
WEIGHT AND BALANCE
X-24B AXES
3200
3000
2800
2600
2400
I_{XX} ~ SLUG - FT²
1000
800
600
I_{XZ} ~ SLUG-FT²
10:46:00
10:47:00
10:48:00
10:49:00
10:50:00
10:51:00
10:52:00
10:53:00
TIME OF DAY



X-24B FLT B-15-26
WEIGHT AND BALANCE
X-24B AXES
25000
24000
23000
I_{YY} ~ SLUG-FT²
26000
25000
24000
23000
I_{ZZ} ~ SLUG-FT²
10:46:00
10:47:00
10:48:00
10:49:00
10:50:00
10:51:00
10:52:00
10:53:00
TIME OF DAY

X-24B FLIGHT LOG

DATE	Flight Number	Pilot	Launch ALT/A/S	Launch Area	MAX MACH	MAX True A/S KTS	MAX ALT Feet	Flight Time Min:Sec	Burn Time Sec	Land Runway	REMARKS
2 Jul 73											-11 Engine run, 6 taxi runs with L/D rockets
5 Jul 73											2 taxi runs with -11 engine
6 Jul 73											1 taxi run with -11 engine
10 Jul 73											Mated taxi test
19 Jul 73	B-1C-1	Manke									Systems check, Pylon damping
24 Jul 73	B-A-2	Manke									Abort due to failed SAS Gyros
1 Aug 73	B-1-3	Manke	40/175	S. Rogers	.652	400	40000	4:11.5	Glide	18	20° Upper Flaps
17 Aug 73	B-2-4	Manke	45/175	S. Rogers	.661	390	45000	4:27.3	Glide	18	
31 Aug 73	B-3-5	Manke	45/180	S. Rogers	.730	416	45000	4:37.8	Glide	18	Fuel jettison test
18 Sep 73	B-4-6	Manke	45/185	S. Rogers	.691	391	45000	4:30.8	Glide	18	Fuel jettison test
3 Oct 73	B-2C-7	Love									Pilot training
4 Oct 73	B-A-8	Love									Abort due to Rudder CALB Fixture
4 Oct 73	B-5-9	Love	45/185	S. Rogers	.689	395	45000	4:39.0	Glide	18	Pilot checkout
30 Oct 73	B-3C-10	Manke									Prop systems, Pylon damping
31 Oct 73	B-A-11	Manke									Abort due to Igniter failure
13 Nov 73	B-A-12	Manke									Abort due to clouds
15 Nov 73	B-6-13	Manke	40/185	Rosamond	.917	519	52764	6:44.7	150	18	First powered flight
12 Dec 73	B-7-14	Manke	45/185	Rosamond	.993	560	62604	7:14.8	131	18	
15 Feb 74	B-8-15	Love	45/185	S. Rogers	.683	391	45000	5:07.7	Glide	15	
5 Mar 74	B-9-16	Manke	45/184	Cuddeback	1.086	615	60334	7:17.2	116	36	
19 Mar 74	B-A-17	Love									Abort due to clouds
22 Apr 74	B-4CA-18	Love									Abort due to T V Monitor fire in B-52
23 Apr 74	B-4CA-19	Love									Abort due to B-52 Lox Top Off System
25 Apr 74	B-4C-20	Love									Aileron Deab Band investigation
30 Apr 74	B-10-21	Love	45/190	Rosamond	.876	502	52040	6:59.1	139	18	Delayed lite profile
24 May 74	B-11-22	Manke	45/190	Rosamond	1.14	654	55979	7:28.9	156	18	# 1 didn't lite, 3 chamber alternate
14 Jun 74	B-12-23	Love	45/190	Rosamond	1.23	704	65512	6:45.4	106	18	
28 Jun 74	B-13-24	Manke	45/190	Rosamond	1.39	799	68150	7:07.6	117	18	
8 Aug 74	B-14-25	Love	45/190	Rosamond	1.54	888	73380	6:35.8	130	18	Engine POGO due to H_2O_2 UNPORT
29 Aug 74	B-15-26	Manke	45/200	Rosamond	1.097	632	72440	7:47.6	109	18	Premature shutdown, crack in fuel tank

X-24B OPERATIONS FLIGHT REPORT

FLIGHT: B-15-26

DATE OF REPORT: 10/2/74

PILOT: John Manke

DATE OF FLIGHT: 8/29/74

CARRIER AIRCRAFT: B-52 #008

LAUNCH LAKE: Rogers Lakebed

PURPOSE OF FLIGHT: (1) Envelope Expansion to 1.68 Mach Number.

(2) Stability and Control at ach Number >1.0 and 5°, 8° and 12° α.

(3) Supersonic Performance and Longitudinal Trim.

(4) Body Pressure Survey (Group II).

(5) Boundary Layer Noise and Vibration Experiment (RED PLUG).

I. Discussion of Previous Operations

Engine operation during flight 14 was normal until shortly before planned shutdown when all engine pressures oscillated for approximately 10 seconds. The oscillations damped out prior to shutdown which was normal.

All other systems operated normally.

II. Vehicle Configuration Changes

A new mount was fabricated to realign the center fin camera to view the inboard surface of the L.H. fin, the aft crown hatch and the transition area between them.

III. Instrumentation Changes

1. The body pressure taps were repatched to pickup body pressures.

2. The original #1 hydraulic battery voltage sensing system was deleted in favor of a parallel system.

IV. Preflight Events

1. The propulsion system was checked over for possible causes for the pressure oscillations. Data analysis indicated a probable unparting of the H_2O_2 tank during the period of oscillations.

   Procedures for flight 15 were changed to:

a. Service the H_2O_2 tank to overflow to increase quantity from 17 to ≈ 18 gallons.

b. Delete prelaunch landing rocket check firing.

c. Replace the turbopump catalyst pack with a new unit to decrease H_2O_2 flowrate.

d. Pushover to 6° α instead of 5° to improve the propellant angle condition.

2. All preflight functionals were accomplished satisfactorily.

V. Flight Events

1. The flight was slipped from 8/23 to 8/29 for a special B-52 inspection.

2. Flight servicing on 8/29 was made without incident.

3. Takeoff was delayed approximately 45 minutes while a problem which the yaw SAS amber light was resolved.

4. The #4 engine starter would not operate electrically on the B-52 and the ground crew operated the control valve manually to get the engine started.

5. The flight was normal until the engine shutdown prematurely after 109 seconds of normal operation.

6. The vehicle was in good shape after landing.

Approved: W P Albrecht
William P. Albrecht
Chief, Operations
Engineering Branch

Written by: WPA for N. DeMar
Norman E. DeMar
X-24B Project Engineer
Operations Engineering Branch

POST-FLIGHT: B-15-26
DATE: August 29, 1974
PILOT: J. Manke

OK, this is Flight B-15-26. Today is the 29th of August. OK, we started out with a little SAS problem this morning. Chet Bergner fixed that someway or other. Whatever he did it never occurred again. George, you had better get Chet on your team. (You want the bulb back now?). The B-52 had a little trouble starting the #4 engine. The little valve in the starter did not operate. Hats off to Galeno again. He comes thru every dog-gone time. He took the cowl off the engine, got in there on the starter and manually opened the starter valve, got it going and he held it open while it started. Those guys do a fantastic job down there.

OK, everything else went reall well. Boy, it was a good day. I don't think we had any hang-ups on our checks. Had a good indication that we had a lot of peroxide in the tank. The peroxide tank pressurization was a little bit different this time than before. Just like there was not anything at all, it just popped right off. At least we had that full. Can't think of any other hang-ups.

The launch was very normal. A real good engine lite. I got the 2 chambers right after I hit the launch switch and the engine started right up. I got 15 α and then the other two chambers came up and I really thought that we were on our way. Everything looked real good, at 30 seconds and we got the overdrive on and I could feel the change in thrust at that time and knew we had a good one. Got the pitch pulse. It is even a little more deadbeat here in the airplane than it was in the simulator. I pushed it down a little bit but it did not come back up so I had to pull it up again. The simulator shows that that tendency but not quite as much. May Mach number appeared to be low during the boost. I think I called that out to you. I had some check points at 50 and 60 seconds and both times the Mach number was low ther, and the altitude was just a little bit low too. About 500' low at both points. As I approached 63,000', I don't think I even had .8 Mach number and we normally have .83 or .84 something like that. So that was considerably lower than we had expected to see. (You say normally, simulator) Simulator, yes, I am basing these on simulator calls.

I want to back up just a little bit. Mike ahd I have both noticed in the profile, as we get a little higher on Mach, it is not as easy to hold α as it is right after launch. Today I could see, somewhere or other there is a definite break point. After launch was able to hold 15 real well and then all at once, whether it was a shudder in the airplane or a change, it is a change that I could feel in the airplane and α became a little bit loose again and also the airplane takes more aileron to keep the wings up. It just starts sloshing around a little bit. It is not unusual for these type things, we have seen that in other airplanes, but today was the first time I was able to distinguish exactly when that happened. We could check the Mach number. We could see it very well on the traces so I think we can get a pretty good Mach number check on that. That may be the .75 or .78 areas that Armstrong has been looking at with pressure changes. (It is all that excess peroxide sloshing around). The task to hold angle of attack gets considerably more difficult at that particular point and it is not in the transonic region yet.

OK, pushover at 63,000 to 10 α, that all went well. Just a little bit of trouble with 10 α. I dropped it one time, it scooted down a bit, pulled it back up and got the pitch pulse, and here again, we were at this 10 α for a little longer than the simulator had showed before we got the Mach jump. Mach jump is not as apparent in the airplane as we have it set up in the simulator. I see very little jump on the Mach gage itself. I got the clue with the altimeter. Maybe a 3 or 400' jump in the altimeter. Right at the Mach jump, pushed over to 6° α was what the flight plan called for, and before I even got to 6, I felt the engine chug a little bit and before I could even get back on the stick to get a little g on it, it quit. It was a rather quick shutdown. Damn disappointing at that time. Mike's calls were great at that time. Here again, I can't say enough about our NASA GCA type of approach that we use around here with the guy on the ground helping the guy in the cockpit, because Mike's calls were superb from there on in. I did not even look out of the airplane. He told me we had enough energy to get 18 left hand pattern so I did not even bother to look out. Got on angle of attack and held high angle of attack at that point. Chris you probably saw stick shaker any number of times after that. I went for 15 because we were pitched up pretty good, pretty good climb at the time of the shutdown, so the airplane started back down so I went to the high α to keep the airspeed down and conserve energy. So we bobbled between 15 and 16 quite a bit of the time. It works real well though, because you can keep the Mach down and you can slow the airplane up and pick up some energy, as it turned out we gained all of our energy back again.

Because of the high angle of attack we slipped through the .9 area too quickly to get any data and besides we were a little low on energy at the time, so I did not want to do the pushover pull-up. We got a pushover pull-up at about .73 Mach number, .73 or .74, and also got the .6 data point. Jettison was just like it's been before. Did not notice any roll off in the airplane or anything like that. We hit low key, very good altitude, 33-34,000'. Closed it up and then did the .6 popu and I did not get any buffet this time until 13-1/2-14° angle of attack, and it seemed to be a little bit easier to get to than the 15 in the simulator. The simulator crosses over at about 13-1/2-14 and I thought the crossover occurred a little bit later here, and that is not the way I remember it from before. So, we will look at that. Just a little buffet at 14 and went up to 15 and back down again. The pattern was very normal. It was a nice pattern. Mike's calls were superb. Just listened to those and drove it on into low key.

It was an excellent pattern. I did not use any speed brakes in the pattern at all. We picked up 300 knots a long way out. We had a long time at 300-308 knots and it was just the smoothest flying thing I have ever flown in that area. Today was an excellent day from a turbulence standpoint. There wasn't any until I got close to the ground, so it was a real pleasure flying that thing down the glide slope, just hanging at 300 and had plenty of time. Touchdown probably right around 175-180. Very smooth touch down. Good control of the airplane above the runway. Fairly long rollout because I did not use much brakes. And that is about all I have.

FLIGHT:	B-15-26	ENGINE START:	0920
PILOT:	J. Manke	TAXI:	0935
B-52:	008	TAKEOFF:	0945
LNCH PANEL:	V. Horton	LAUNCH	1046
NASA 1:	Maj. Love	LAND:	1053

<u>15 Minutes</u>

NASA 1: 15 Minutes, John, 15
MANKE: OK Mike, 15
NASA 1: 14, John, 14

<u>14 Minutes</u>

MANKE: OK Mike, 14 minutes
NASA 1: 2° left, 008
008: 2 left, 08
MANKE: OK, the pumps are swapped and I got about 2700 on each
Lites are out
NASA 1: Roger
MANKE: I am ready for a pitch and yaw pulse
008: Pitch first
NASA 1: Good pitch pulse
008: Yaw
NASA 1: Good yaw pulse and when it settles down John this is a good heading for the erect switches
MANKE: OK, Mike
OK, I am erect and fast erect is on
NASA 1: Roger,
MANKE: And 008 say your heading, please
008: 240
MANKE: OK, thank you
NASA 1: OK, we just past 13, John

<u>13 Minutes</u>

MANKE: OK, Mike
My trims all look good here, Mike
NASA 1: Roger
MANKE: I put some left aileron in there but I guess that's OK with you
OK, its back up
I put my damper up
NASA 1: You can put a little right in if you want, John
MANKE: OK, I put a little in there
NASA 1: OK, they still like it
MANKE: Easy to please
NASA 1: Right
Vic we need cruise tank quantity, please
VIC: 200 gallons
NASA 1: Roger

<u>12 Minutes</u>

NASA 1:	12 minutes
MANKE:	OK Mike, 12 minutes
?	---
	This is --- 24 I read you
MANKE:	Roger, understand, thank you very much
	Mike, --- 8 is on station already
NASA 1:	OK, thank you John. We are just past 11 minutes
11 Minutes	
NASA 1:	10 minutes, John 10
10 Minutes	
MANKE:	OK Mike, 10 minutes
	#1 is 4000
	#2 is 31
	Control gas 500
	Governor balance 455
	Fuel and LOX tanks are zero
	Landing gear is about 3000 and ready for the pump heater cycle
NASA 1:	We are ready, turn it off
MANKE:	Coming off
NASA 1:	Turn it on
MANKE:	It is on
NASA 1:	Good check
MANKE:	Thank you
	Say your heading again, please
008:	238 this time
MANKE:	Thank you
NASA 1:	9 minutes, John
9 Minutes	
MANKE:	OK Mike, 9,
	Erect switch cutoff
	Fast erect off
	Both attitudes look very good
NASA 1:	Roger
	OK, start your turn 008
008:	008
NASA 1:	8 minutes, John, and Vic you can start topoff
8 Minutes	
HORTON	Roger,
MANKE:	OK, Mike, here comes the aileron cycle
NASA 1:	Roger, we are ready
	Good cycle, John
MANKE:	OK, thank you
	OK, we can get the radio bit, Mike
	Still on X-24 radio, primary, going secondary
NASA 1:	Roger
MANKE:	I actually read you loud on guard, Mike
NASA 1:	OK, John, five square back here
MANKE:	Thank you

NASA 1: 7 minutes, John, 7

7 Minutes

MANKE: OK Mike, 7 minutes

NASA 1: Shallow your turn 008

008: 008

NASA 1: 6 minutes, John, 6

6 Minutes

MANKE: OK, Mike
Uppers going to 40
OK, I see 40 and 27
Ailerons zero
Rudder bias 0
Rudder trim is 1° left

NASA 1: Roger
27 looks good down here
Chase aircraft check windshield heat

CHASE: 1, 1α, 2, 2α

NASA 1: OK, resume normal turn, 008

008: 008

NASA 1: 5 minutes, John, 5

5 Minutes

MANKE: OK, Mike, 5 minutes
Going to battery
Got battery
Emergency battery switch going auto
Emergency battery lite is out
OK, pump 2 and 4 are on
The lites are out and I got 3100
Bus loads are 120, 100, 110, and about 45
SAS gains are 5, 5, 5, and the old SMRD
No lites
Got a torque
No lites
#1's are off and a torque
3 yellow
2's off and a torque

NASA 1: 008, roll out 059

008: 008

MANKE: 3 reds
Going 6, 5, 3,
SAS servos are auto
My lites are set and a torque
No lites

NASA 1: No lites
OK, we are past 4 minutes John, not to 3 yet

MANKE: OK, Mike

NASA 1: About 3-1/2 now

MANKE: Very good

NASA 1: Left 2°
008: Left 2 more
NASA 1: 3 minutes, John 3

3 Minutes

MANKE: OK, Mike, 3 minutes
On X-24 oxygen
I have 1700# and the regulator looks good
OK, I am on X-24 cabin air
I have got about 2950 and cabin altitude is about 24,5
OK, canopy defog is heat and the forward canopy is on
Suit vent is low.
#1 is 39
#2 is about 41
Control gas 500
Governor balance about 440
Erect switch going erect
Fast erect is on and my trims look good
CHASE: They are good here
NASA 1: We like them down here
3° right, 008
008: 008
NASA 1: 2 minutes, John

2 Minutes

MANKE: Precool is off
Engine bleed coming on
Prop supply off
Pressurize tanks
And they are coming up
HORTON: Topoff's off, beacon's off, adapter is off and pressures are good, Mike
NASA 1: Roger
MANKE: Got about 47 on each
LOX about 49
NASA 1: Roger
MANKE: Release pressure low lites out
NASA 1: Roger
70 seconds, John
MANKE: Alright
NASA 1: And standby for one minute, 1 minute, now

1 Minute

MANKE: OK, I got the clock
My sources are good
SAS lites are out
α is 3
β is 1° needle left
NASA 1: 2 right, 008
008: 2 right

MANKE: Engine master is on
Erect switch cutoff
Fast erect is off
NASA 1: Systems are all OK John
MANKE: OK Mike, release circuit breaker is in
And I will wait a second on the cameras
NASA 1: Roger
MANKE: Both cameras are on
Recorder is on
NASA 1: Roger
MANKE: 10 seconds, 5 seconds, Mike
NASA 1: Alright
LAUNCH
NASA 1: OK, John check your α
You got 4 good ones, John
Watch your α
MANKE: Got it
NASA 1: Track looks good right now
Profile looks good
I have you thru 25 seconds
Standby for overdrive on and a pitch pulse
Got your pitch pulse
You got a good overdrive
MANKE: Roger
NASA 1: Got a good track
Profile is good
MANKE: OK
NASA 1: Check your α 15
MANKE: Got it
NASA 1: Beautiful track
You are right on profile
MANKE: Roger, a little bit low
NASA 1: OK, standby for 60 seconds
60 seconds, mark
MANKE: A little low
NASA 1: Check your β
MANKE: Looks good
NASA 1: OK, check your Mach
Standby for pushover to 10 α
We have got you thru 60
Come up on 63,000 now
MANKE: Mach is way low
NASA 1: Check your beta
Standby for a pitch pulse
You got a beautiful track
Profile is good
We see you at 10
OK, check your Mach
Standby for your Mach jump and push over to 6 α

NASA 1: Got your pitch pulse
See you going to 6
MANKE: Got a shutdown, Mike
NASA 1: OK, John, you will be good for a 18 left hand pattern
MANKE: OK
NASA 1: Prop supply off
Engine master off
Good energy for a left hand pattern
We can come left about 3-4°
MANKE: OK, Mike
NASA 1: Watch your α, john
MANKE: Got it
NASA 1: When you get some "G" and you feel like it, go to jettison
MANKE: OK, going jettison
NASA 1: You are right in the middle of the 18 left hand pattern
You got a good track
You are about 1/2 mile outside right now
MANKE: OK
NASA 1: OK, John, if you could come left about 5, now
MANKE: OK Mike, left 5
NASA 1: Stop jettison,
Tanks and bleed
MANKE: Roger
NASA 1: You are only about 5000 low on the normal
You are right in the middle of the energy
That's a good heading correction
MANKE: OK Mike
NASA 1: I see your Mach about .8
You are coming up 15 and get a pitch

Tape #2

NASA 1: OK, a .7 popu
OK, you are only about 4000 low
Good heading correction
You are 5 miles
A good popu
You are 4 miles
A beautiful track and you are holding 4000 low
MANKE: OK
NASA 1: 3 miles, coming up to 2500 low at 2 miles
And you are coming right into the intersection
MANKE: Roger
NASA 1: OK, you are about 1000 low at a mile
You will be right at the intersection
We can plan on the .6 Mach popu
MANKE: OK, Mike, I will clean it up
NASA 1: Roger
We see them closing up
An easy turn to 360, John
MANKE: OK, Mike

NASA 1: Check your Mach
Standby for a .6 Mach popu
MANKE: Yes, I am just about at that point 6
I will swing it around a little here
NASA 1: OK, you got a nice turn going
60 will be the right heading
You are going a little high on the profile now
You are approaching 3 miles
And we are going to have to come left to 345
MANKE: OK, Mike
NASA 1: We need to go SAS 4, 3, 2 when you have a chance
2 miles
MANKE: Here it comes
NASA 1: See your popu
Good heading
You are approaching a mile
Get 1 and 3 hydraulics after the popu
You are about 2500 high
Over the highway
Swap your hydraulics
It is all yours John
MANKE: I got hydraulics on
I guess I'm all cleaned up, huh?
NASA 1: Roger
Norm said the sources are good you don't need to switch
MANKE: OK
CHASE: 246, John
20,000
The RPM is 90
MANKE: OK
CHASE: --- 290 knots and we are coming up on 11 thou
MANKE: OK
NASA 1: Mach repeater .3
MANKE: Good call
QK, I got 300 knots, nice pattern
CHASE: 300 here, John
MANKE: Nice and smooth
I got about 305-8
CHASE: I got 305
1200'
MANKE: Thank you, Bill, turbulence
CHASE: 100', John
MANKE: OK, Bill
CHASE: 50, got 3 good ones, John
MANKE: OK
CHASE: 10', 5, 3, 2, 1
How about that
NASA 1: Nose wheel steering arm still on
Tell John Galeno we thank him for the nice ride

008:	OK, did you heat that, John?
NASA 1:	We are going to debrief at 1200
	All stations, this is NASA 1, debrief at 1200
MANKE:	Alright, Mike I got that
?	---
MANKE:	OK, Mike throttle is off
NASA 1:	Roger
MANKE:	KRA is manual
	Calibrate
NASA 1:	We are ready
	We got a good calibrate
	SAS servos are off
	Hydraulic pumps are off
	Canopy defogs are off
	Erect switch erect, fast erect is on
	#1 helium ---
	#2 is about 38
	Control gas 5
	Governor balance 460
	Landing gear is down to about 25
	Oxygen cylinder about 12
	Cabin air down to about 600
	Engine timer is 109
	Radar is off
	Stick shaker off
	Fast erect off
	Erect switch cutoff
	The attitude inverters are off
	I will see you later
NASA 1:	Rog, John, beautiful recovery

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(03-20-1969-05-28-1971)* 09/05/2019	Preliminary Reports of the X-24B Flight Reports	**3. DATES COVERED** *(From - To)*

4. TITLE AND SUBTITLE
Preliminary Reports of the X-24B Flight Records (Flights 18-28)

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

AF/NASA X-24B Project Team

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) AND ADDRESS(ES)

412th Test Wing
195 E Popson Ave
Edwards AFB, CA 93524

8. PERFORMING ORGANIZATION REPORT NUMBER
412TW-PA-19223

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Air Force Test Center History Office
305 East Popson Ave,
Edwards AFB, CA 93524

10. SPONSOR/MONITOR'S ACRONYM(S)
N/A

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release A: distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
These documents are historical documents for the X-24B Flight Reports.

15. SUBJECT TERMS
X-24B Flight Records, X-24B Flight Reports

16. SECURITY CLASSIFICATION OF: Unclassified			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON** 412 TENG/EN (Tech Pubs)
a. REPORT Unclassified	**b. ABSTRACT** Unclassified	**c. THIS PAGE** Unclassified	None	485	**19b. TELEPHONE NUMBER** *(include area code)* 661-277-8615