# SECTION VI

# FLIGHT CHARACTERISTICS

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## INTRODUCTION

The operational speed and altitude capabilities of this aircraft are considerably greater than for other fighter aircraft. These capabilities include level flight and climb speeds of Mach 2.1 and an altitude capability in excess of 116,000 feet.

## STALLS

### PRACTICE STALLS.

The information concerning practice stalls contained in T.O. 1F-104A-1 is not applicable to the NF-104A. For AST minimum operating and control speeds see figure 6-1.

## PITCHUP

The information contained in T.O. 1F-104A is applicable to the AST and information concerning high altitude pitchup is added as follows.

### HIGH ALTITUDE PITCHUP

High altitude pitchup was not evaluated during the AST flight test program; however, limited experience has shown that pitchups and subsequent spins can be encountered. If pitch attitude is maintained as the apogee of the zoom is approached, angle of attack will increase because the flight path is becoming horizontal. If the angle of attack is permitted to increase significantly, a pitchup condition may be entered. During pitchup, the airplane will wallow at high angle of attack in a random manner.

MINIMUM OPERATING SPEEDS - KNOTS INDICATED

AND MINIMUM CONTROL SPEEDS (VALUES IN PARENTHESES)

SEA LEVEL TO 10,000 FEET

NO EXTERNAL STORES

| Gross Weight | Gear and Flaps up, Power on or Off | | | TAKEOFF Flaps, Gear Up or Down, Power on or Off | | | LAND Flaps, Gear Down, Power On | | |
|---|---|---|---|---|---|---|---|---|---|
| Bank Angle<br>Load Factor | 0°<br>1.0g | 40°<br>1.3g | 60°<br>2.0g | 0°<br>1.0g | 40°<br>1.3g | 60°<br>2.0g | 0°<br>1.0g | 40°<br>1.3g | 60°<br>2.0g |
| 21,500 lb | 220 (200) | 255 (230) | 310 (280) | 195 (185) | 225 (210) | 280 (260) | 165 (155) | 190 (180) | 230 (220) |
| 19,500 lb | 210 (190) | 240 (220) | 295 (265) | 185 (175) | 215 (200) | 265 (250) | 155 (145) | 180 (170) | 220 (210) |
| 17,500 lb | 200 (180) | 230 (205) | 280 (255) | 175 (165) | 205 (190) | 250 (235) | 150 (140) | 170 (160) | 210 (195) |
| 14,500 lb | 180 (160) | 205 (190) | 255 (230) | 160 (150) | 185 (175) | 225 (215) | 135 (125) | 155 (145) | 190 (180) |

NOTE:
1. Minimum operating speeds are the speeds at which automatic stick-shaker action is experienced.
2. Minimum control speeds are the speeds at which:
   a. Kicker is experienced - flaps up and maneuvering flaps.
   b. Lateral instability is experienced - TAKEOFF flaps and gear down.
   c. Wing drop is experienced - LAND flaps.
3. Full stall will be encountered if there is further reduction of speed.
4. Speeds in excess of limits shown for interpolation purposes only.

Figure 6-1

with the nose remaining from 5 to 15 degrees above the horizion, occasionally pitching down and then returning to the nose high condition. As altitude decreases a spin may be entered before recovery can be effected. The following procedure is recommended should a pitchup or spin be encountered during high altitude zooms:

1. Neutralize controls and wait for oscillations to stop.
2. If a spin should develop the following is recommended:
   a. Aileron and rudder limiter switch - OFF.
   b. Refer to spin recovery procedure of T.O. 1F-104A-1. Use RCS manual control system (if operative) as well as aerodynamic controls.
   c. If spin recovery is not effected using the above procedure, deploy the drag chute. Use caution during spin recovery to insure that adequate flying speed is attained to prevent spin reentry.

## FLIGHT CONTROLS

AILERONS.

The ailerons are fully powered and have stick forces supplied by feel springs. This results in essentially constant stick forces for a given amount of stick travel regardless of airspeed.

The ailerons, which are capable of developing high roll rates, have less travel when the gear is retracted; this is to reduce their effectiveness and avoid inertial coupling tendencies in rolls over the wide operating limits of the airplane. During high altitude flight, within the airspeed limits of Section V, the aileron travel may be increased to provide increased lateral control by placing the rudder and aileron limiter switch in the OFF position.

RUDDER

The rudder is a fully powered irreversible control surface. Feel forces are provided by springs, up to the power limit of the system. In order to maintain rudder deflection tail loads below structural values, the rudder travel is reduced when the gear is retracted. The rudder travel limiter can be removed for flight at extreme altitudes, within the airspeed limits of Section V, by setting the rudder and aileron limiter switch to the OFF position.

STABILITY AUGMENTERS

In addition to the information contained in T.O. 1F-104A-1, the following also applies to the AST. A reaction control damping system is provided to improve damping about all three airplane axes during high altitude zoom flights when the aerodynamic surfaces become ineffective for damping.

## PERFORMANCE CAPABILITIES

The information contained in T.O. 1F-104A-1 is representative of the performance capabilities of the NF-104A airplane with the rocket engine inoperative.

ZOOM CLIMB

Maximum altitude capability is attained by accelerating to the maximum allowable speed and rotating to the optimum climb path angle with a minimum loss in speed. The flight path angle is then maintained until the optimum airplane angle of attack is attained and thereafter maintaining this angle until the reentry to low altitude is completed.

To realize maximum altitude, it is imperative that the zoom profile be accurately preplanned to account for existing weather conditions. This requires acceleration at the best altitude (35,000 feet), prediction of the acceleration starting point and rocket light-off Mach number. During hot-day operations, the fuel required and distance to accelerate are increased, of course, due to the slower acceleration. Nevertheless, the fuel required to accelerate will be a minimum at 35,000 feet. On a 10°C hot day, the jet engine will require approximately 700 pounds additional fuel and 23 more nautical miles to accelerate to 1.9 Mach at 35,000 feet. On a standard day with the jet engine operative and rocket engine at 100 percent thrust, 200 pounds of JP-4 and 7 nautical miles will be required to accelerate from Mach 1.9 to Mach 2.1; on a 10°C hot day, the requirements are 280 pounds of JP-4 and 8 nautical miles. This seemingly small change is because 85 percent of the excess thrust is being supplied by the rocket which is unaffected by ambient temperature. Once Mach 2.1 is attained, 400 pounds of JP-4 will be required from zoom pullup until the jet engine is started prior to landing.

Afterburner blowout will be experienced as the minimum operating pressure level of the afterburner is crossed. The speed-altitude combination is approximated in figure 6-7 of T.O. 1F-104A-1. The blowout boundary is a fairly wide band because the blowout point is affected by individual afterburner performance and is also sensitive to angle of attack variations. As blowout is sensed, the throttle should slowly be retarded to Military thrust to maintain engine operation. EGT should be monitored to maintain operation within limits. Throttle reduction to Idle and subsequent stopcock will be necessary.

Above approximately 100,000 feet the aerodynamic controls are not effective in maintaining the aircraft attitude about any axis, and it will be necessary to use the manual Reaction Control System to maintain attitude control. Optimum attitude control is attained by employing the RCS in short duration bursts. Angle of attack must be monitored closely near the top of the zoom. Pitchup is avoided by control of angle of attack. RCS inputs will be required to bring the nose down as the airplane arcs over the top. The airplane may tend to roll slightly as the peak altitude is approached. Therefore, it is important to recognize this so early corrections can be applied before a large roll displacement develops.

Angle of attack should be maintained as closely as possible to 11 degrees during the initial portion of the descent. Maintaining an angle of attack of 11 degrees will minimize speed buildup. Also speed brakes may be used to control speed buildup. As airspeed increases above approximately 270 KIAS (65,000 to 75,000 feet), an airframe buffet may be experienced. This is due to duct spillage because the wind milling engine cannot ingest the air available. Reduction of angle of attack in this area will permit a more rapid transition through the buffet region. However, angle of attack should not be reduced below 8 degrees to prevent excessive speed buildup. The buffet will diminish and stop during the recovery to level flight even though the engine has not yet started.

Engine air start can be initiated as high as 65,000 feet; however, it is recommended that starts be delayed until the aircraft has been returned to approximately level flight in the 40,000 to 50,000-foot altitude range.

# SECTION V

## OPERATING LIMITATIONS

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Page No.



Section V of T.O. 1F-104A-1 applies to the NF-104A aircraft except as follows:

### INTRODUCTION

The instrument markings diagram in T.O. 1F-104A-1 is applicable to the NF-104A except that the engine air inlet temperature gage maximum limit is 121°C up to 35,000 feet and up to 155°C above 35,000 feet; and the accelerometer limitations are listed on the maximum allowable acceleration limits chart (figure 5-3). The rocket engine instruments limitations are as follows:

ROCKET CHAMBER PRESSURE GAGE.

| | |
|---|---|
| Red | 275 psi - Minimum. |
| Yellow | 275-300 psi - Pressure instability may be encountered. |
| Green | 300-585 psi - Normal operating pressure range. |
| Yellow | 585-600 psi - Instability range. |
| Red | 600 psi - Maximum. Automatic cutoff can occur above this value. |

ROCKET ENGINE $H_2O_2$ PRESSURE GAGE.

| | |
|---|---|
| Red | 38 psi - Minimum |
| Yellow | 38-40 psi - Marginal supply pressure. |
| Green | 40-56 psi - Normal operating pressure. |
| Yellow | 56-65 psi - Marginal engine operation. |
| Red | 65 psi - Maximum. |

ROCKET ENGINE TEMPERATURE GAGE

| | |
|---|---|
| Green | -25 to +45°C - Normal. |
| Yellow | +45°C - Maximum. |
| Red | +60°C - Jettison $H_2O_2$ |

RCS $H_2O_2$ TEMPERATURE GAGE

| | |
|---|---|
| Green | -30 to +45°C - Normal. |
| Yellow | +45°C - Maximum |
| Red | +60°C - Jettison $H_2O_2$ |

## ENGINE LIMITATIONS

ENGINE AIR INLET TEMPERATURE.

The engine air inlet temperature limit is determined as a function of the outside air temperature and flight Mach number. Therefore, the speed, where the limit temperature condition occurs, will vary with altitude and from day to day at a given altitude. Figure 5-1 illustrates the flight regions where this limit will be encountered.

$T_2$ RESET LIMITATION

T.O. 1F-104A-1 applies except that reset may occur as low as 85°C CIT.

## AIRSPEED LIMITATIONS

For maximum allowable airspeeds see figure 5-1 and 5-2.

## ACCELERATION LIMITATIONS

For maximum allowable acceleration limits see figure 5-3.

MANEUVERING BOUNDARIES

The operating flight limits diagram figure 5-3 of T.O. 1F-104A-1 is not applicable to the AST. The AST airplane is capable of somewhat higher load factors before stall due to the larger wing area of the AST. Also, the structural limit load factor is less than the F-104A due to the wing tip extensions. Complete structural operating limits are provided in figure 5-3 of this supplement.

CENTER OF GRAVITY LIMITATIONS

Takeoff flaps are required for landing at any fuel loading that results in a CG location forward of +2.0 percent MAC. This will occur only with $H_2O_2$ loads of 87 gallons (1000 lb) or more.

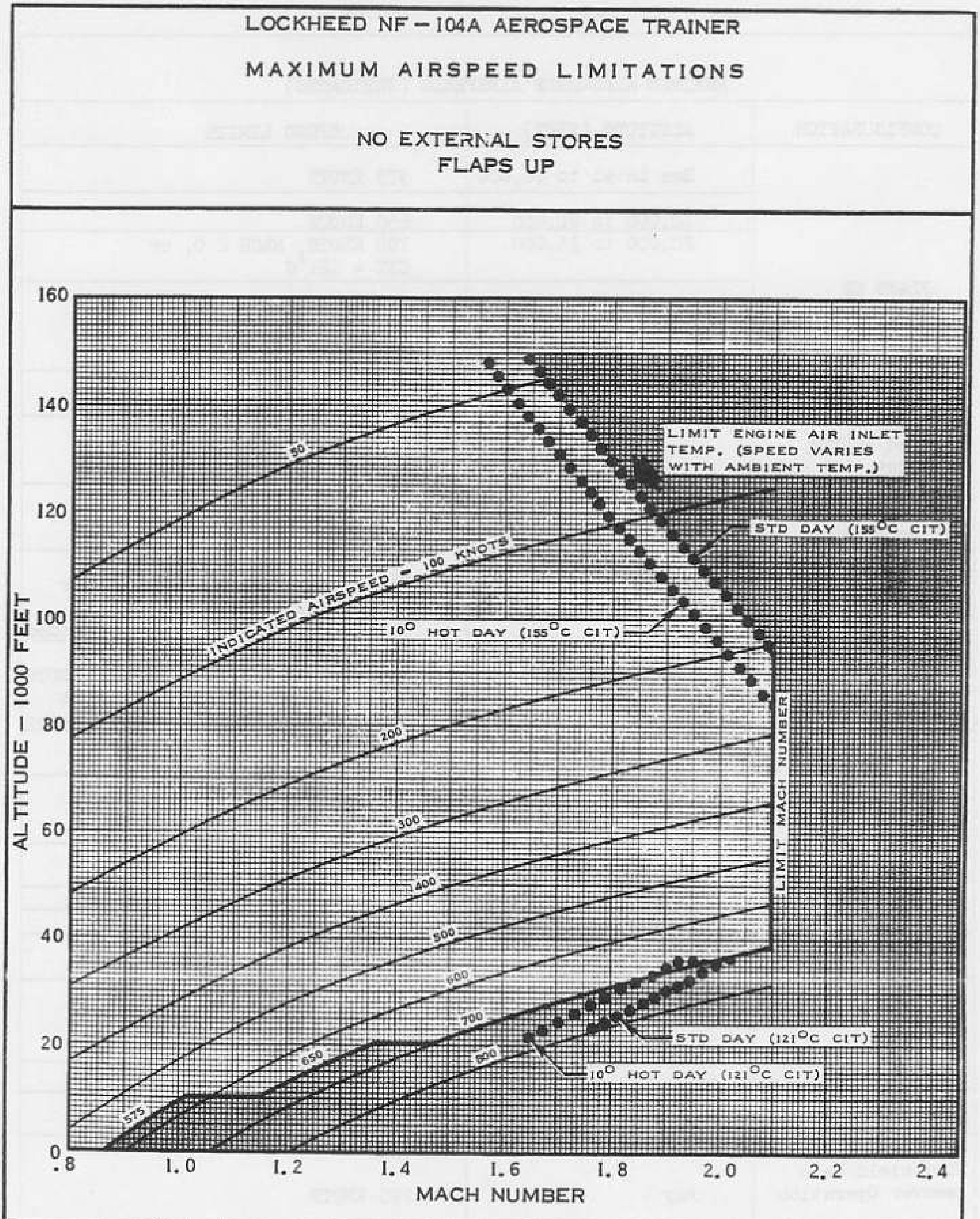

LOCKHEED NF-104A AEROSPACE TRAINER
MAXIMUM AIRSPEED LIMITATIONS
NO EXTERNAL STORES
FLAPS UP
LIMIT ENGINE AIR INLET TEMP. (SPEED VARIES WITH AMBIENT TEMP.)
STD DAY (155°C CIT)
10° HOT DAY (155°C CIT)
INDICATED AIRSPEED - 100 KNOTS
50
200
300
400
500
600
650
700
575
800
LIMIT MACH NUMBER
STD DAY (121°C CIT)
10° HOT DAY (121°C CIT)
ALTITUDE - 1000 FEET
160
140
120
100
80
60
40
20
0
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
MACH NUMBER

Figure 5-1

<table>
<tr><th colspan="5">MAXIMUM ALLOWABLE ACCELERATION LIMITS</th></tr>
<tr><th colspan="5">SYMMETRICAL MANEUVERS</th></tr>
<tr><th>Mach No.</th><th>$H_2O_2$ Oxidizer used (Gallons)</th><th>JP-4 Fuel on board (Pounds)</th><th colspan="2">Acceleration Limit (G)</th></tr>
<tr><td rowspan="4">Below Mach 1.9</td><td>0</td><td>1000 or more</td><td colspan="2">3.5<br>-1.4</td></tr>
<tr><td>0</td><td rowspan="3">Less than<br>1000</td><td colspan="2">3.5<br>-1.4</td></tr>
<tr><td>75</td><td colspan="2">4.5<br>-1.8</td></tr>
<tr><td>150 or more</td><td colspan="2">5.0<br>-2.0</td></tr>
<tr><td rowspan="4">Mach 1.9 to 2.1</td><td>0</td><td>1000 or more</td><td>3.5<br>-1.4</td><td rowspan="4">Not to Exceed:<br>Angle of Attack / Mach<br>9° / 2.1<br>10° / 2.0<br>11° / 1.9</td></tr>
<tr><td>0</td><td rowspan="3">Less than<br>1000</td><td>3.5<br>-1.4</td></tr>
<tr><td>75</td><td>4.0<br>-1.6</td></tr>
<tr><td>150 or more</td><td>4.5<br>-1.8</td></tr>
<tr><th colspan="5">UNSYMMETRICAL (ROLLING) MANEUVERS</th></tr>
<tr><td>Below Mach 1.6</td><td>0-223</td><td>Any loading</td><td colspan="2">+1.0 to 2/3 symmetrical limit</td></tr>
<tr><td>Mach 1.6 to 2.0</td><td>0-223</td><td>Any loading</td><td colspan="2">+1.0 to +2.0</td></tr>
<tr><td>Mach 2.0 to 2.1</td><td>0-223</td><td>Any loading</td><td colspan="2">Prohibited</td></tr>
<tr><td colspan="5">Also see aileron roll restrictions in T.O. 1F-104A-1</td></tr>
</table>

Figure 5-3

**WING**

| | |
|---|---|
| AREA (PROJECTED) | 232.8 SQ FT |
| ASPECT RATIO | 3.13 |
| TAPER RATIO | 2.65 |
| SWEEPBACK AT 25% CHORD | 18.1 DEGREES |
| DIHEDRAL | -10 DEGREES |
| INCIDENCE, ROOT & TIP | 0 DEGREE |
| AIRFOIL: MOD BI-CONVEX | 3.36% THICK |
| ROOT CHORD | 155.82 IN. |
| TIP CHORD | 48.5 IN. |
| MAC AT 60.8 IN. FROM ℄ APPROX | 111 IN. |

**AILERON**

| | |
|---|---|
| AREA - TOTAL (PROJECTED) | 9.2 SQ FT |
| TRAVEL | ±15 DEGREES |
| TRIM | ±5 DEGREES |

**LANDING FLAPS**

| | |
|---|---|
| AREA - TOTAL (PROJECTED | 22.7 SQ FT |
| MAX DEFLECTION | 45 DEGREES |

**LEADING EDGE FLAPS**

| | |
|---|---|
| AREA - TOTAL (PROJECTED) | 16.2 SQ FT |
| MAX DEFLECTION | 30 DEGREES |

**HORIZONTAL STABILIZER**

| | |
|---|---|
| AREA | 48.2 SQ FT |
| SWEEPBACK AT 25% CHORD | 10.1 DEGREES |
| ASPECT RATIO | 2.95 |
| DIHEDRAL | 0 DEGREE |
| AIRFOIL: MOD BI-CONVEX, ROOT | 4.93% THICK |
| TIP | 2.61% THICK |
| ROOT CHORD | 74.0 IN. |
| TIP CHORD | 23.0 IN. |
| MAC AT 25% CHORD FROM ℄ | 52.97 IN. |
| TRAVEL — LE - UP | 5 DEGREES |
| DOWN | 17 DEGREES |

**DORSAL FIN AND RUDDER**

| | |
|---|---|
| AREA - TOTAL | 41.9 SQ FT |
| RUDDER - AREA | 4.2 SQ FT |
| TRAVEL | ±20 DEGREES |
| SWEEPBACK AT 25% CHORD | 32.2 DEGREES |
| AIRFOIL: MOD BI-CONVEX, ROOT | 3.43% THICK |
| TIP | 4.08% THICK |
| ROOT CHORD AT WL 138 | 139.2 IN. |
| TIP CHORD AT WL 203.5 | 50.33 IN. |
| MAC AT WL 162.6 | 102.73 IN. |
| ASPECT RATIO | 0.68 |

**SPEED BRAKE**

| | |
|---|---|
| AREA - TOTAL (PROJECTED) | 8.25 SQ FT |
| TRAVEL | 52 DEGREES |

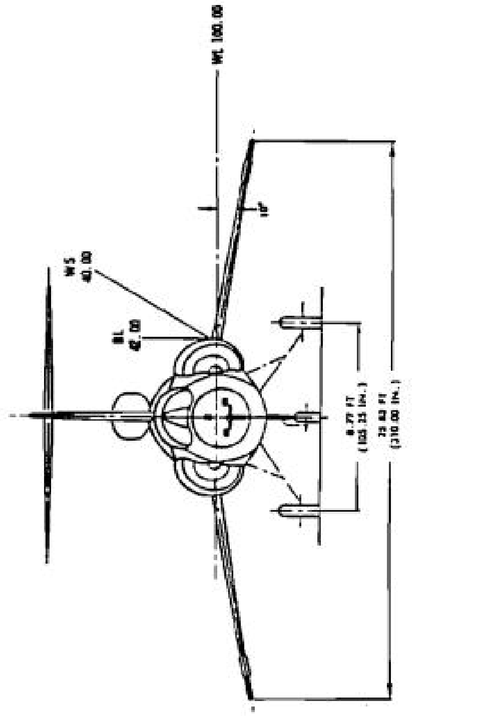
**FUSELAGE FRONTAL AREA** 25 SQ FT

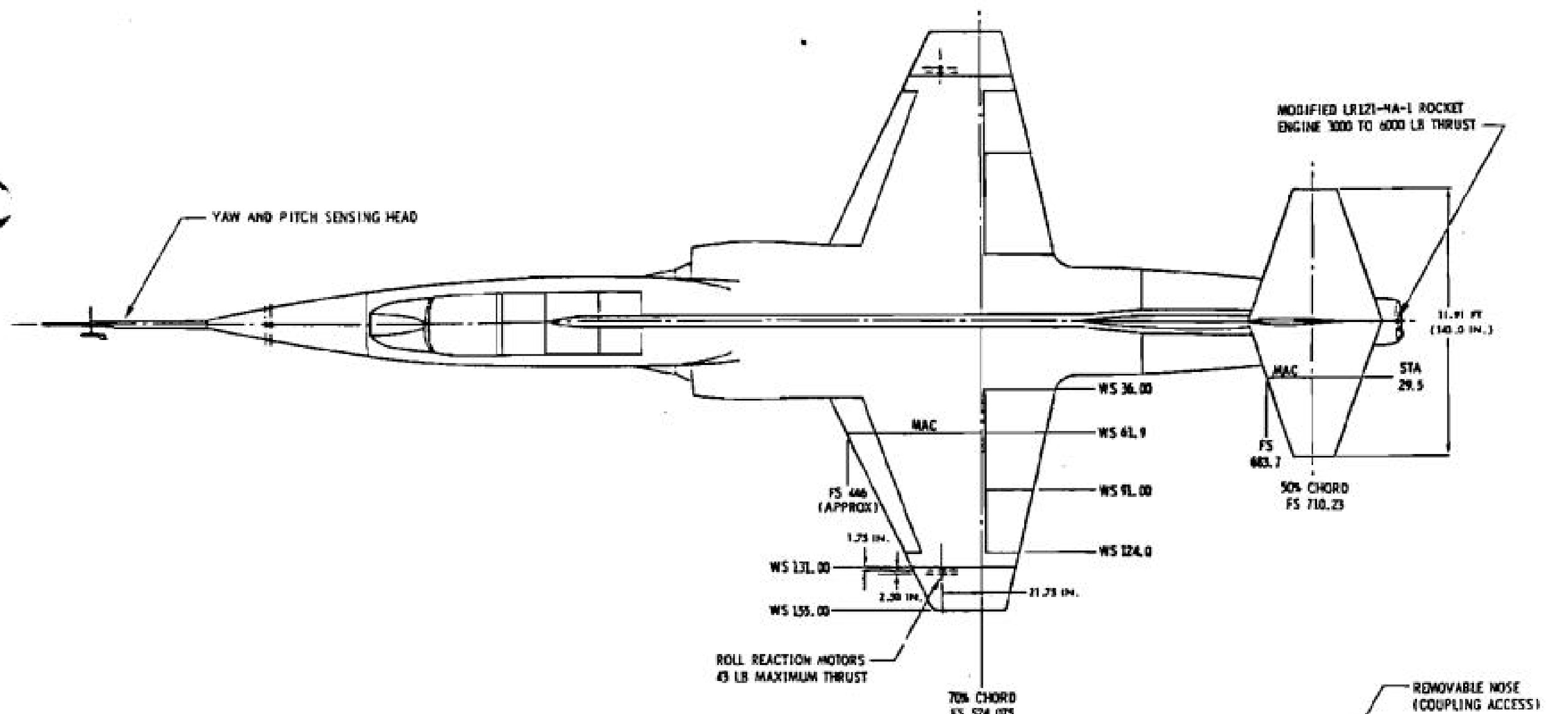
**VENTRAL FIN**

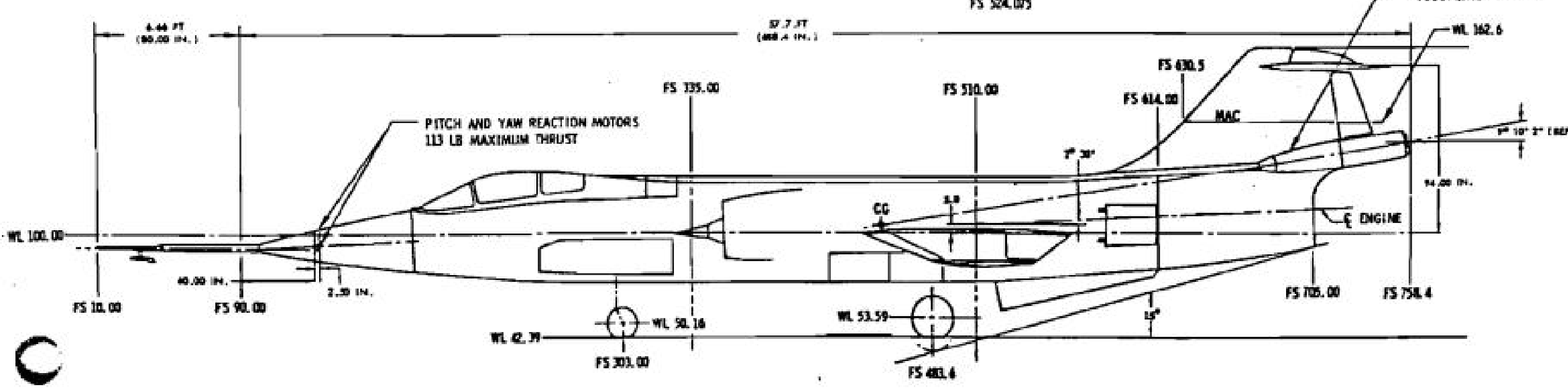
| | |
|---|---|
| AREA | 5.9 SQ FT |
| LENGTH | 7.79 FT |
| DEPTH | 1.38 FT |
| AIRFOIL - PARABOLIC | 2.5% THICK |

**WEIGHTS**

| | |
|---|---|
| EMPTY | 13,500 LB |
| FUEL - JP4 | 4,960 LB |
| OXIDIZER - ROCKET | 2,760 LB |
| MONOPROPELLANT - REACTION | 150 LB |
| USEFUL LOAD | 7,900 LB |
| DESIGN GROSS | 21,400 LB |

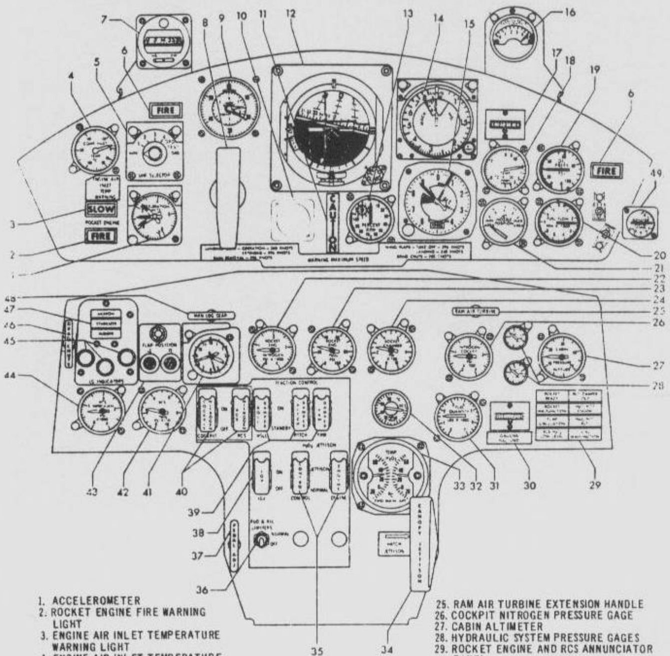


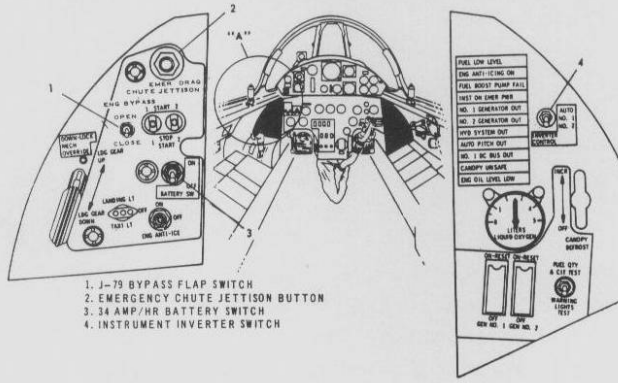

CL-586

# NF-104 INSTRUMENT PANEL



1. ACCELEROMETER
2. ROCKET ENGINE FIRE WARNING LIGHT
3. ENGINE AIR INLET TEMPERATURE WARNING LIGHT
4. ENGINE AIR INLET TEMPERATURE GAGE
5. UHF FREQUENCY SELECTOR
6. JET ENGINE FIRE WARNING LIGHT (TWO)
7. STANDBY COMPASS
8. RCS CONTROL HANDLE
9. ROCKET ENGINE TIMER
10. GROSS ANGLE OF ATTACK
11. MAXIMUM SPEED CAUTION LIGHT
12. AARS INDICATOR
13. JET ENGINE TACHOMETER
14. AIRSPEED INDICATOR
15. HIGH ALTITUDE ALTIMETER
16. AUTOPITCH CONTROL INDICATOR
17. CORRELATION COUNTER
18. EGT GAGE
19. OIL PRESSURE GAGE
20. FUEL FLOW INDICATOR
21. EXHAUST NOZZLE POSITION INDICATOR
22. ROCKET ENGINE NITROGEN PRESSURE GAGE
23. ROCKET ENGINE $H_2O_2$ PRESSURE GAGE
24. ROCKET CHAMBER PRESSURE GAGE
25. RAM AIR TURBINE EXTENSION HANDLE
26. COCKPIT NITROGEN PRESSURE GAGE
27. CABIN ALTIMETER
28. HYDRAULIC SYSTEM PRESSURE GAGES
29. ROCKET ENGINE AND RCS ANNUNCIATOR PANEL
30. $H_2O_2$ FLOW COUNTER
31. JP-4 FUEL QUANTITY GAGE
32. RCS $H_2O_2$ TEMPERATURE GAGE
33. ROCKET ENGINE FORWARD AND AFT $H_2O_2$ TEMPERATURE GAGE
34. CANOPY JETTISON HANDLE
35. CONTROL (RCS) ROCKET ENGINE $H_2O_2$ JETTISON SWITCHES
36. RUDDER AND AILERON LIMITER SWITCH
37. RUDDER PEDAL ADJUSTMENT HANDLE
38. IGV SWITCH
39. RCS DAMPER CONTROL SWITCHES
40. RCS AND COCKPIT NITROGEN SWITCHES
41. CLOCK
42. RCS $H_2O_2$ PRESSURE GAGE
43. WING FLAP POSITION INDICATORS
44. RCS NITROGEN PRESSURE GAGE
45. LANDING GEAR POSITION INDICATOR LIGHTS
46. DRAG CHUTE HANDLE
47. AILERON, STABILIZER, AND RUDDER TAKEOFF TRIM INDICATOR LIGHTS
48. MANUAL LANDING GEAR RELEASE HANDLE
49. STABILIZER (ELEVATOR) POSITION INDICATOR

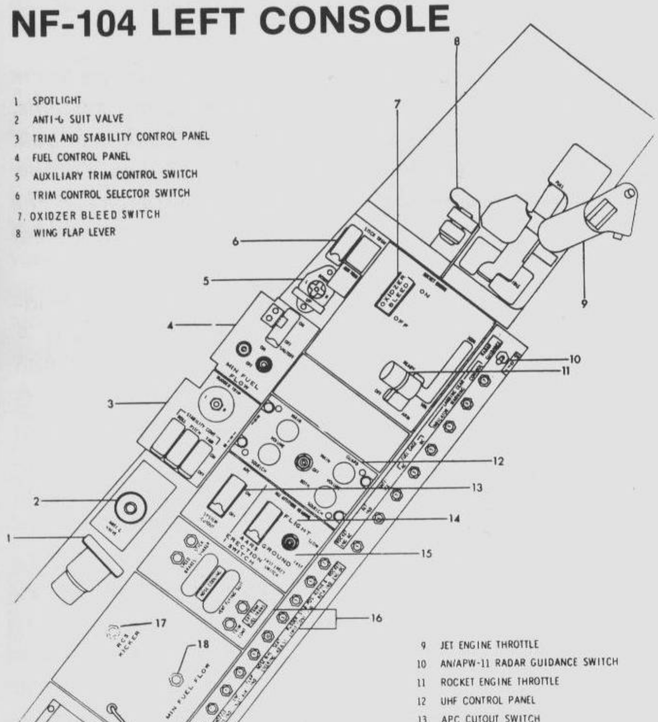
# NF-104 AUXILIARY PANELS



1. J-79 BYPASS FLAP SWITCH
2. EMERGENCY CHUTE JETTISON BUTTON
3. 34 AMP/HR BATTERY SWITCH
4. INSTRUMENT INVERTER SWITCH

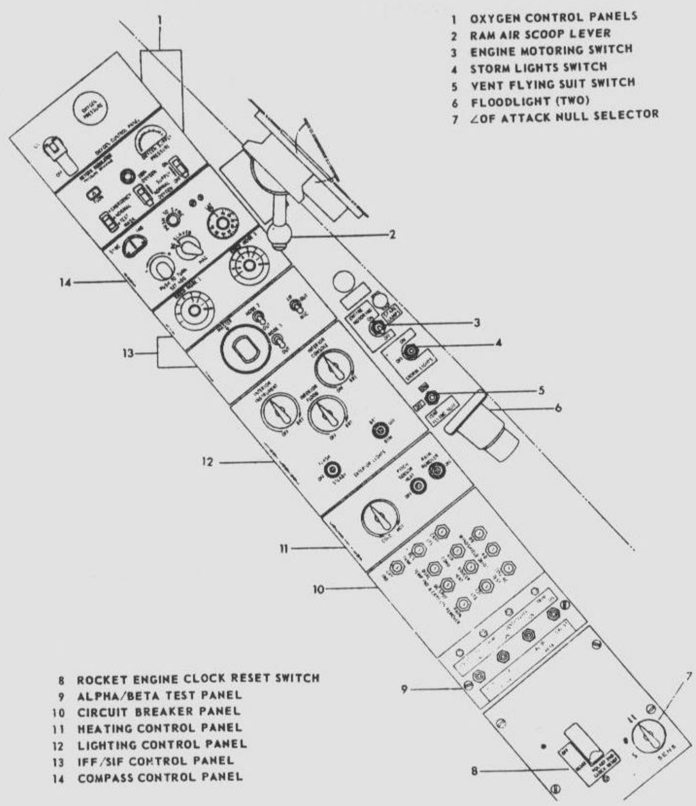
# NF-104 COCKPIT DETAILS

# NF-104 LEFT CONSOLE

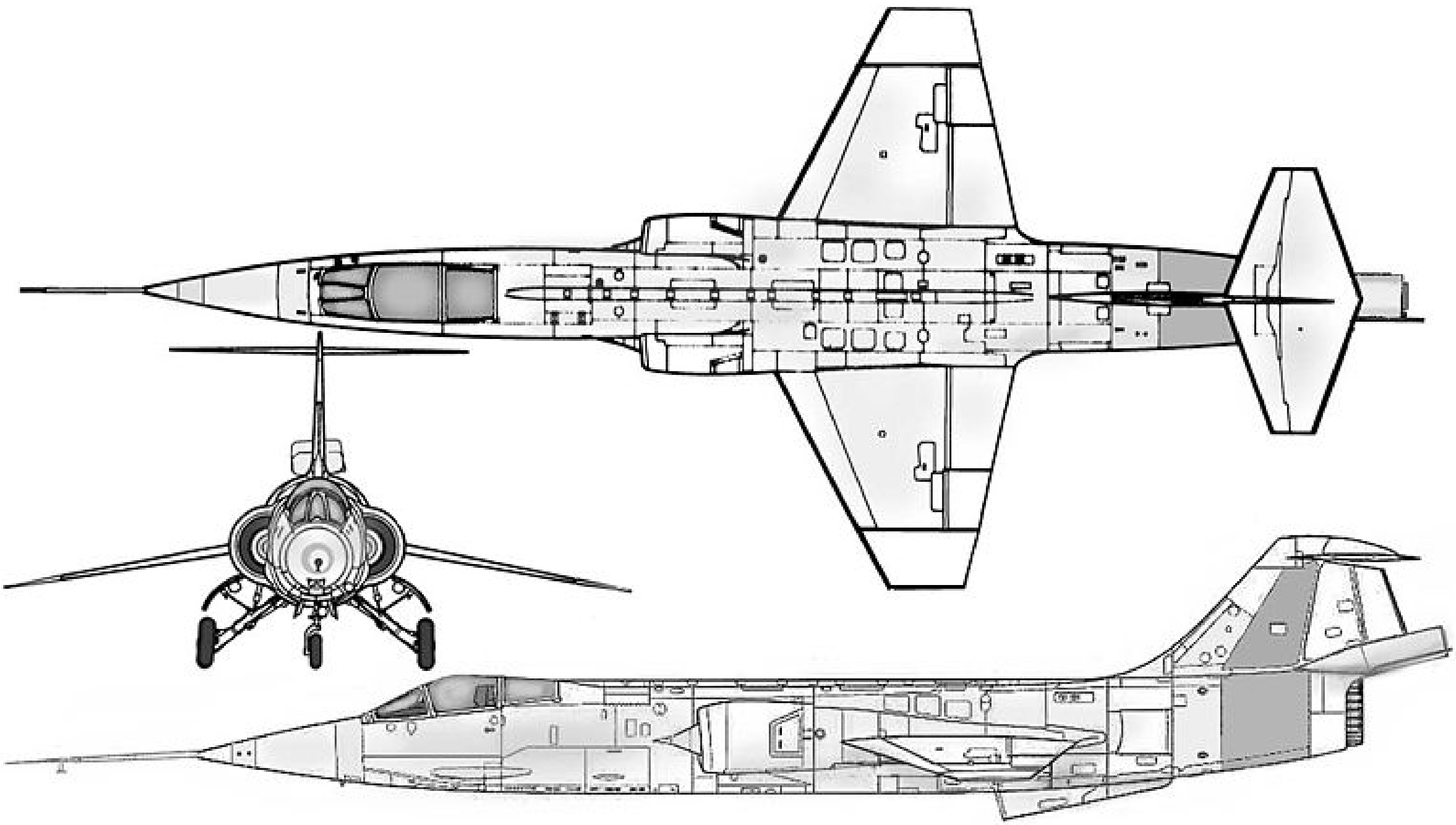


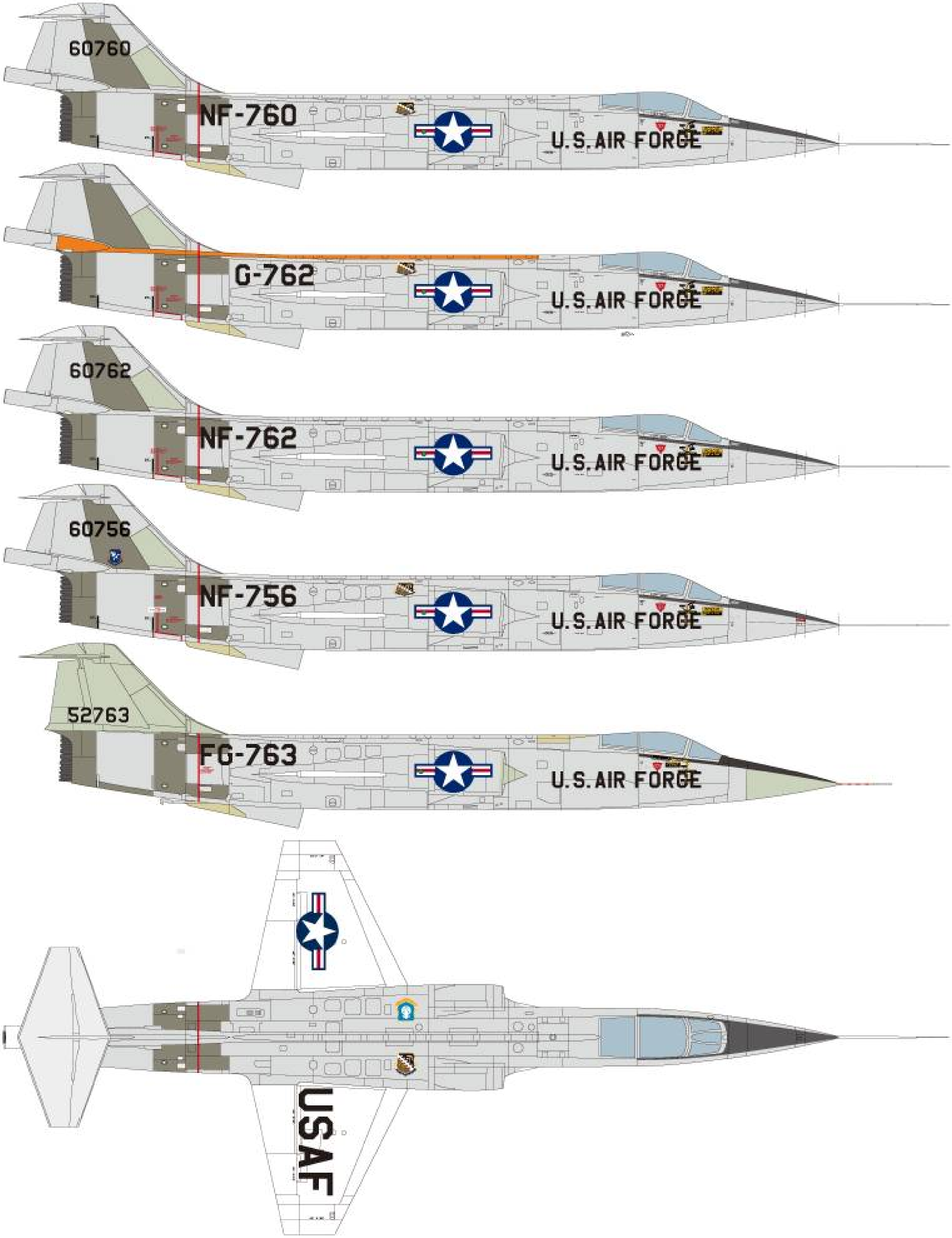
1. SPOTLIGHT
2. ANTI-G SUIT VALVE
3. TRIM AND STABILITY CONTROL PANEL
4. FUEL CONTROL PANEL
5. AUXILIARY TRIM CONTROL SWITCH
6. TRIM CONTROL SELECTOR SWITCH
7. OXIDZER BLEED SWITCH
8. WING FLAP LEVER
9. JET ENGINE THROTTLE
10. AN/APW-11 RADAR GUIDANCE SWITCH
11. ROCKET ENGINE THROTTLE
12. UHF CONTROL PANEL
13. APC CUTOUT SWITCH
14. AARS ERECTION SWITCH
15. FASTERECT SWITCH
16. CIRCUIT BREAKER PANELS
17. RCS KICKER CIRCUIT BREAKER
18. MIN FUEL FLOW CIRCUIT BREAKER

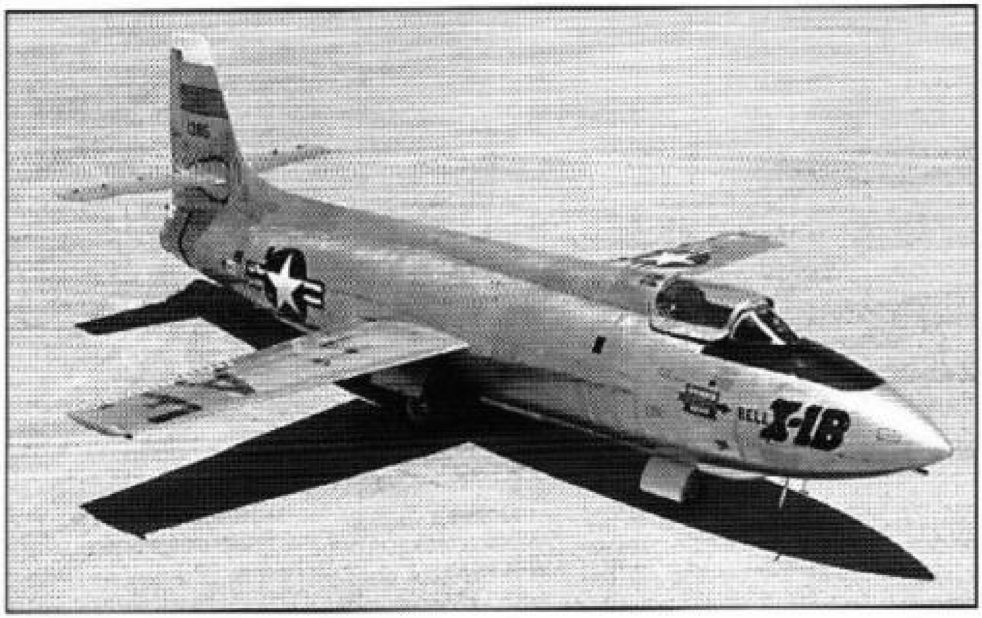
# NF-104 RIGHT CONSOLE



1. OXYGEN CONTROL PANELS
2. RAM AIR SCOOP LEVER
3. ENGINE MOTORING SWITCH
4. STORM LIGHTS SWITCH
5. VENT FLYING SUIT SWITCH
6. FLOODLIGHT (TWO)
7. ∠OF ATTACK NULL SELECTOR
8. ROCKET ENGINE CLOCK RESET SWITCH
9. ALPHA/BETA TEST PANEL
10. CIRCUIT BREAKER PANEL
11. HEATING CONTROL PANEL
12. LIGHTING CONTROL PANEL
13. IFF/SIF CONTROL PANEL
14. COMPASS CONTROL PANEL

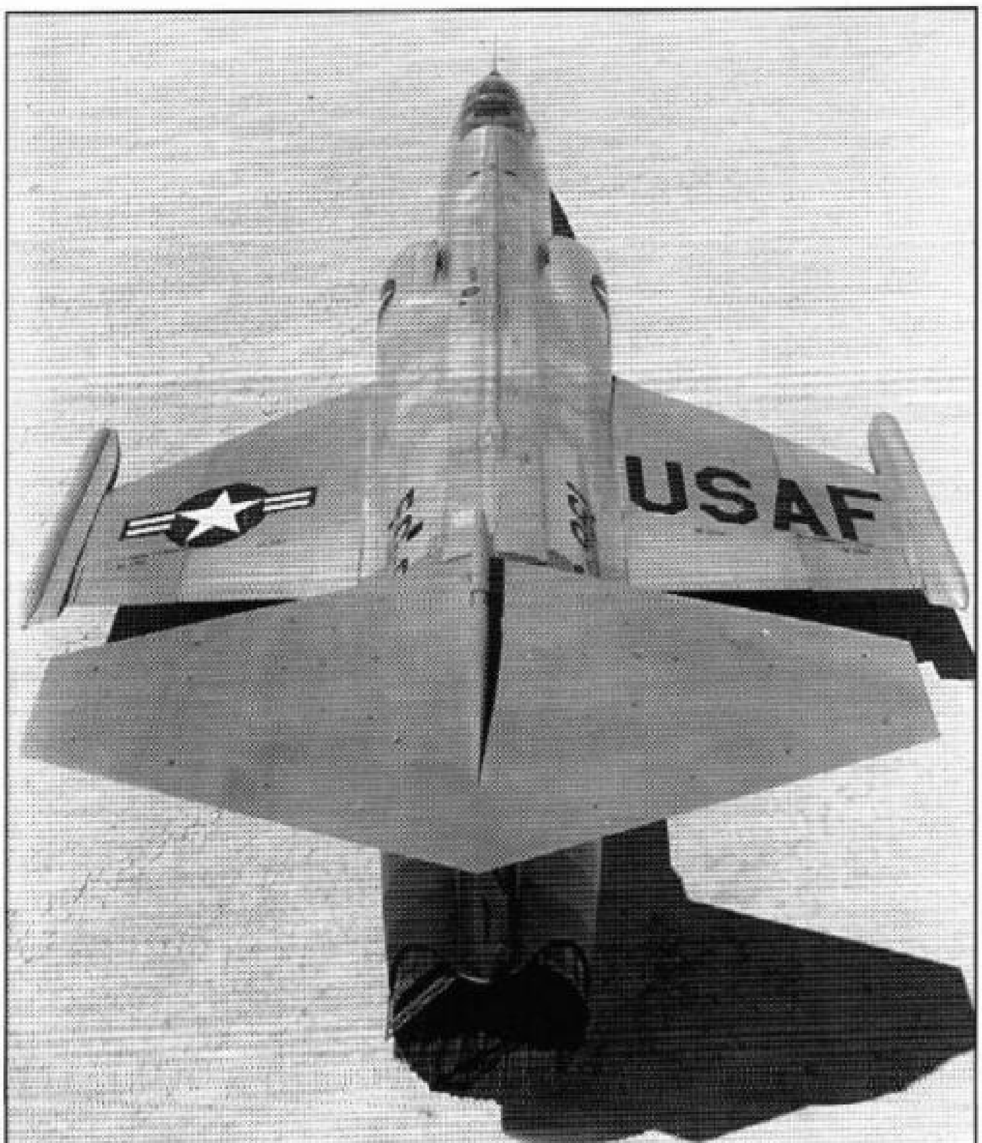



60760
NF-760
U.S.AIR FORCE
G-762
U.S.AIR FORCE
60762
NF-762
U.S.AIR FORCE
60756
NF-756
U.S.AIR FORCE
52763
FG-763
U.S.AIR FORCE
USAF




**Above, the X-1B was being used as a Reaction Control System test aircraft when cracks in a fuel tank led to its permanent grounding. (USAF via Tony Landis)**

**Below, NASA 55-2961 with early wing tip self-contained RCS pods, took over the test work from the X-1B in 1959. The wing tip pods controlled roll. (NASA via Tony Landis)**




trainer. A second cockpit would be added for an instructor pilot and wheels would replace the skids on the landing gear. This proposal, although appealing, proved to be too expensive and received little consideration. Lockheed studies of a rocket augmented version of its popular F-104 proved to be much more economical, even though the '104 would not be able to match the X-15's speed and altitude. Lockheed's compromise in performance was acceptable because it offered one thing that the X-15 could not match. It could takeoff and land under its own power, eliminating the need for the costly mothership.

## REACTION CONTROL SYSTEM TEST AIRCRAFT, NASA #961

In 1959, NASA modified a single JF-104 (S/N 55-2961) with a reaction control system borrowed from an earlier X-plane project. The last three flights of the X-1B were dedicated to checking out a rudimentary $H_2O_2$powered reaction control system. This rocket plane was to have provided the then much-needed data on a "flying reaction control system" in preparation for the upcoming X-15 flights. Cracks in a fuel tank led to its permanent grounding, before useful testing of the RCS could begin in earnest. NASA then elected to substitute an F-104 for the sidelined rocket plane. The new century series of jet fighters, which included the F-104, possessed performance characteristics equal to, or greater than, the early rocket planes.

Pods mounted on the wing tips housed a single reaction control motor and enough $H_2O_2$ to provide roll control. Pitch and yaw inputs would be made by the four reaction control motors installed in the nose in a cruciform layout. This would be the same layout selected for the NF-104. $H_2O_2$ for the nose motors would be contained in a tank just forward of the cockpit. However, unlike the NF-104, this reaction control system would not be dual redundant. Instead of using two motors for each control axis, a single motor would perform the function. Thrust output from these motors was proportional, varying with the deflection of the controller handle. This differed greatly from the NF-104's motors which were full-on or off, with no capability of thrust modulation.

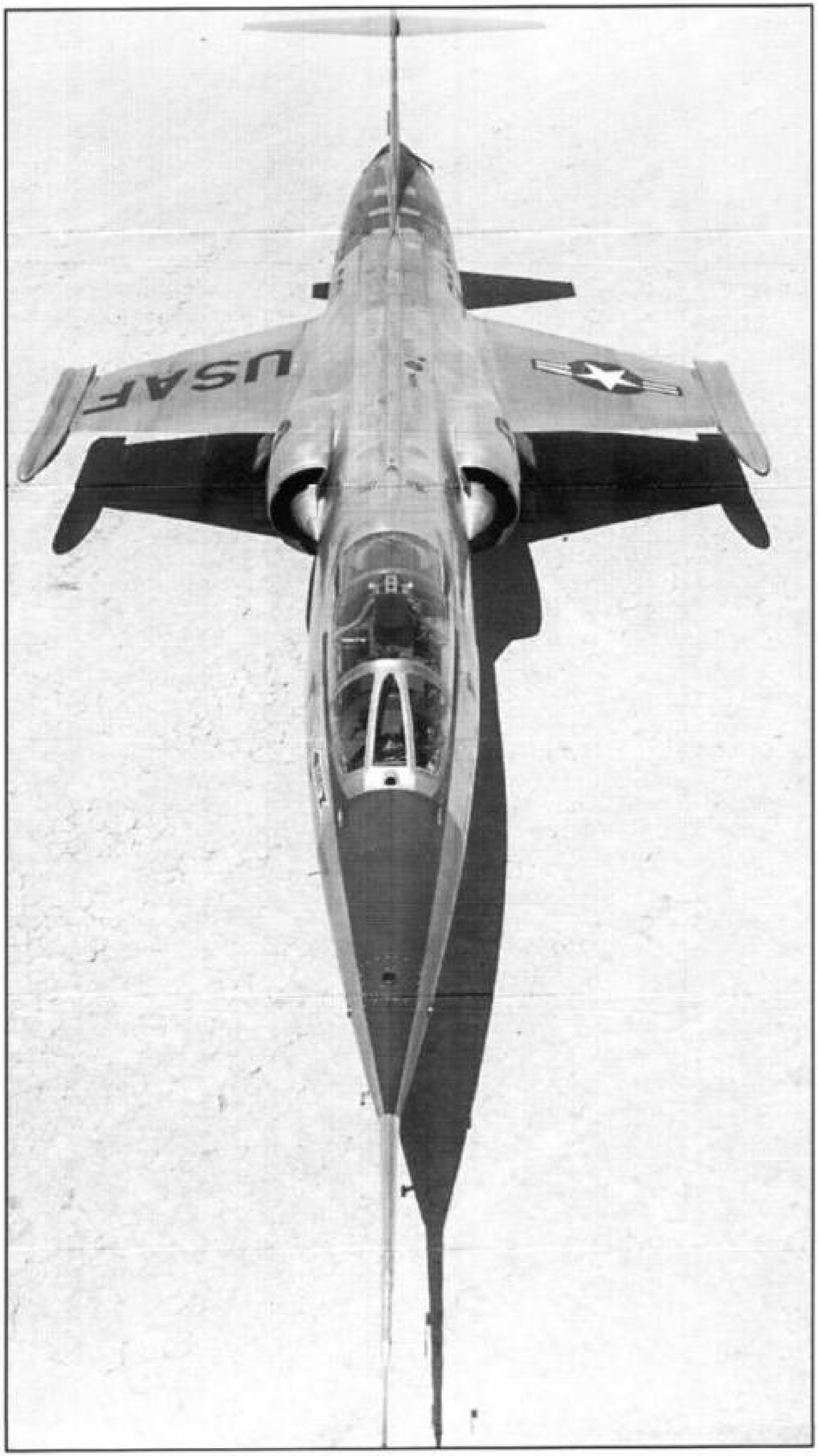
NASA #961, as the aircraft came to be known, flew in this configuration for 28 flights from 1959 to 1961. During this program the aircraft would be subjected to dynamic pressures as low as 6.8 psf. A program Max altitude of 83,000 feet would be recorded on another flight. Initial pilot complaints centered around the cockpit instrument displays crucial for monitoring zoom performance. The angle of attack indicator and the alpha and beta cross-pointers weren't centrally located and the time it took to scan for information increased the difficulty of the piloting task. Pilots Neil Armstrong (first man on the moon), Joe Walker and Robert White flew this aircraft gaining experience flying with an active reaction control system.

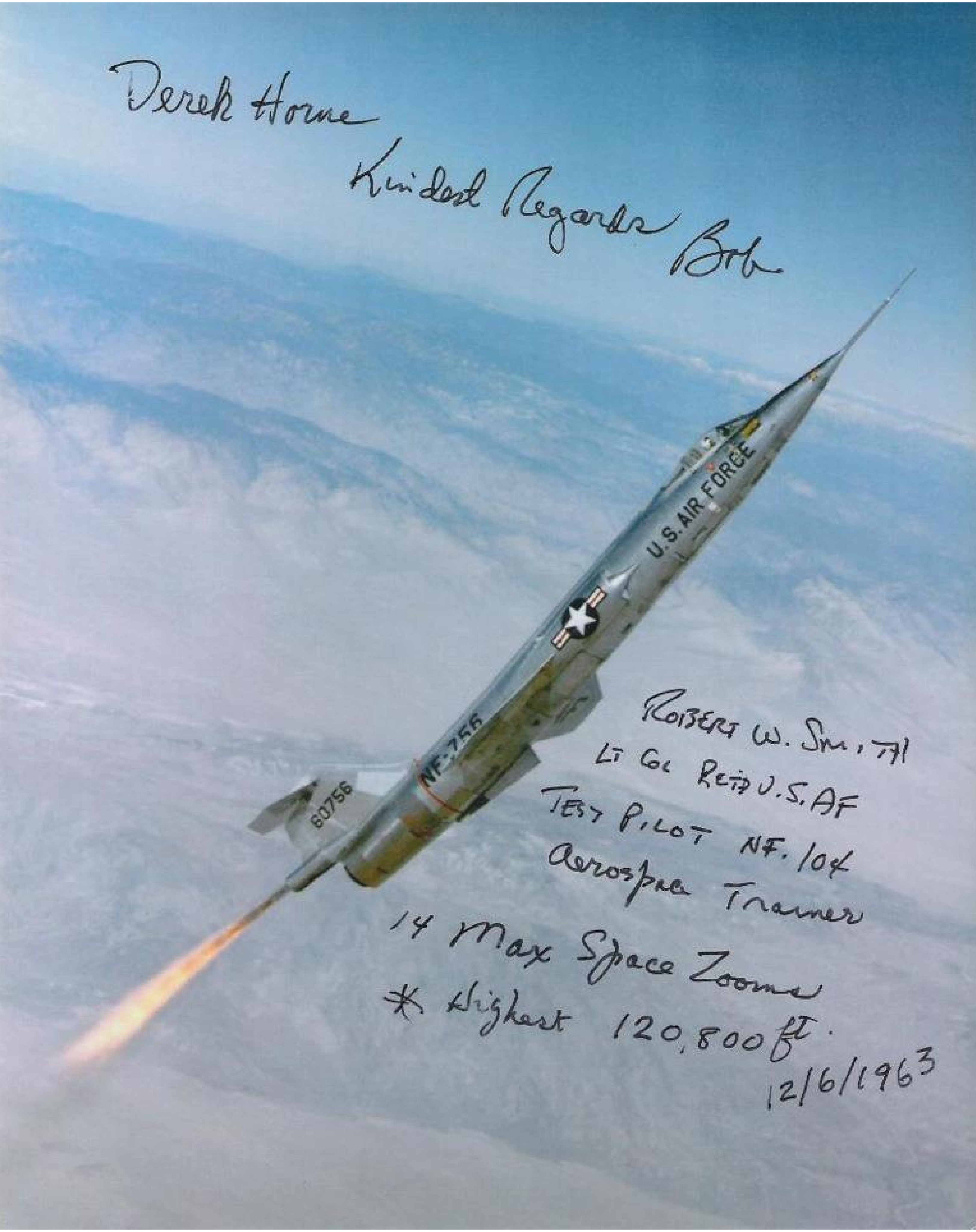
Additionally, an onboard experiment was carried on most flights. The experiment was a dust filter and high altitude air samples were collected. An in-depth analysis was then made of the airborne particles found and any effect they might have on a vehicle traveling at high altitudes.

**METEMORPHOSIS TO AST**

Extensive is the word that best describes the scope of the modification that transformed an F-104A into a aerospace trainer. Three "A" model F-104s, tail numbers; 56-756, 56-760 and 56-762, were selected for the modification. Total cost of the modifications for the three aircraft was $5,363,322. When completed, these trainers would provide a pilot experience in transition training from conventional aircraft to spacecraft. Flying the NF-104, a pilot would gain vital experience in the four phases of space flight: boost to sub-orbit, zero gravity (approximately two minutes), use of a reaction control system and reentry. The trajectory of a rifle bullet fired into the air is a good comparison when examining the flight profile of the NF-104. The bullet's trajectory (path) follows a ballistic arc. At the peak of the arc, the energy of the bullet has dissipated to a level where gravity becomes the influencing factor. The bullet then falls to earth. The same principals apply to the NF-104's

**Below, NASA #961 looking rearward from above. Wing tip RCS test pods are fitted on the missile rails. The outlets for the RCS pitch and yaw jets are seen in the forward nose. Also compare the stock inlets with the NF-104 inlets on page 41. (via Tony Landis)**

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12/6/1963