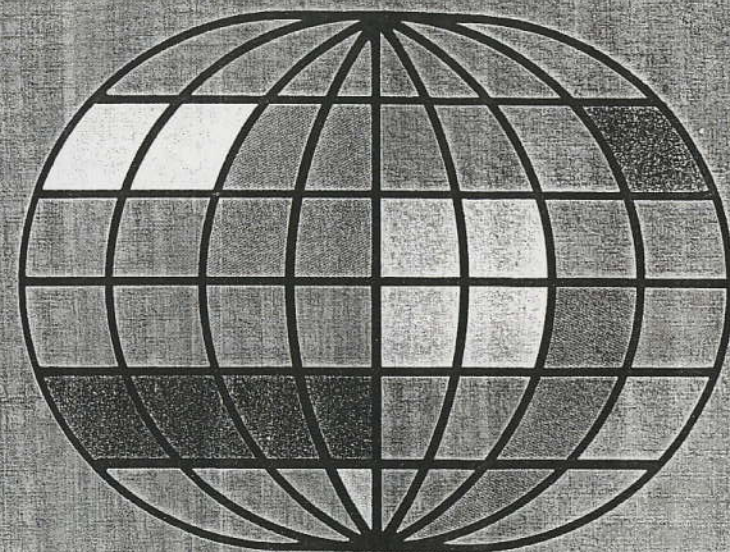


MAP F-104

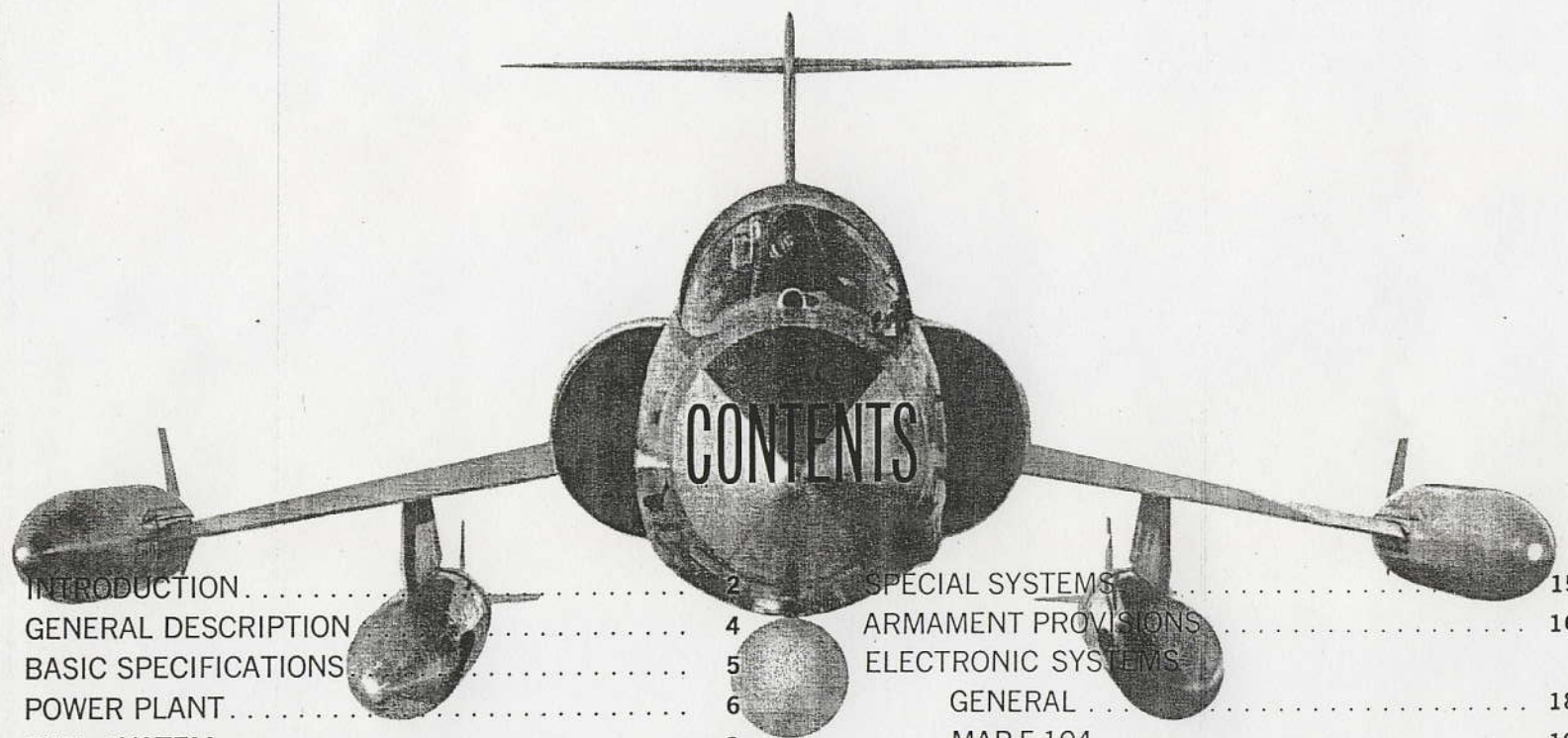


JOINT CONFERENCE


FEBRUARY 1963



LOCKHEED
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.....strength must have substance to cast a shadow

F-104
SUPER STARFIGHTER

MARKET ENGINEERING

CA/ME/2174

FEBRUARY, 1963

LOCKHEED



INTRODUCTION

The F-104 Super Starfighter is derived from a lineage of high-performance fighter aircraft which have established records of excellence unequaled in the history of military aviation.

1958 — The F-104 became the only aircraft ever to hold world records for speed, altitude, and time-to-climb simultaneously.

1959 — The F-104 won the Collier trophy, awarded for "the greatest achievement in aviation in America".

— The F-104 team from the 538th Fighter-Interceptor Squadron won the USAF William Tell Weapons meet at Tyndall Air Force Base, Florida.

1960 — The F-104 team from the 479th Tactical Fighter Wing was the high scoring TAC team at this year's William Tell meet.

1962 — A lone F-104, with Capt. Charles E. Tofferi of the 479th Tactical Fighter Wing at the controls, won the William Tell Tactical Fighter Weapons Meet.

And now, from this family of record holders, comes the F-104 Super Starfighter. The full capabilities of this remarkable aircraft have yet to be realized.

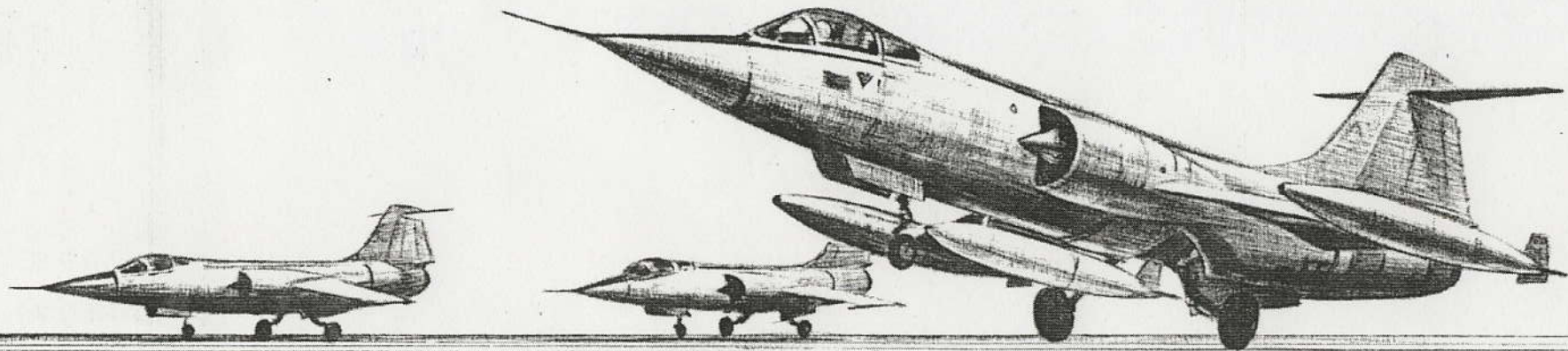
The F-104 is truly a fighter pilot's airplane — an airplane with the plus factors a fighter pilot wants. Unmatched acceleration, Mach 2+ speed with weapons, combat maneuvering at all speeds and the ability to zoom to extreme altitudes provide the necessary ingredients for air superiority over the enemy's aircraft. In addition to its wide performance envelope, the advanced design features of the F-104 permit utilization of the aircraft for a wide variety of tactical mission assignments.



The Super Starfighter is capable of performing the various roles of interceptor, strike bomber and armed reconnaissance. These diverse missions are accomplished by selecting equipment, fuel and weapons options in various combinations. Weapon loading can vary from the 20mm Vulcan cannon through a wide assortment of externally carried rockets, bombs and missiles up to a total expendable weapon weight of 4,800 pounds. Fuel capacity can vary from 896 gallons to a maximum of 1,748 gallons. The Starfighter's maximum radius of action can vary from about 200 nautical miles on a Mach 2.0 dash intercept, to over 800 nautical miles on a long range bombing or reconnaissance mission.

Advanced electronics systems, including multipurpose fire control, navigation and communications systems are available for installation in the F-104 to provide precision navigation and weapons delivery under weather and adverse conditions for a wide variety of combat missions.

The outstanding features of the F-104 Super Starfighter are described in this report. The adaptability of the F-104 to variations in electronic configuration is reflected by the equipments described for two different versions, the MAP F-104 and the F-104-17 (basic).

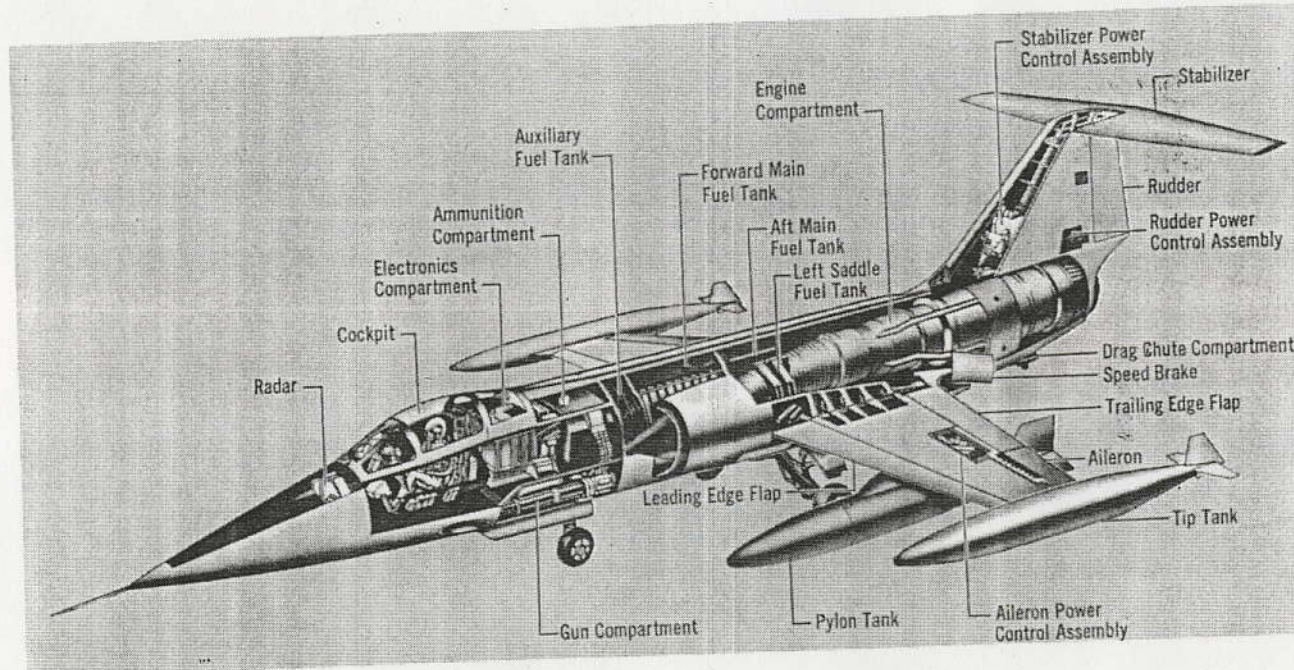


GENERAL DESCRIPTION

The Super Starfighter is a lightweight, high performance fighter-bomber powered by a General Electric J79-11A turbojet engine with afterburner. The aircraft can carry several different combinations of air-to-air and air-to-ground weapons for a variety of combat missions.

The Starfighter was designed for both high subsonic and supersonic speeds and incorporates an extremely thin, short wing mounted well back on the fuselage at a 10-degree negative dihedral angle. In addition to the unconventional wing configuration, the F-104 is further distinguished by its horizontal stabilizer mounted on top of the vertical fin.

The flight control system is hydraulically powered, irreversible, and includes stability augmentation about all three axes. Two completely independent hydraulic systems are used, either of which can operate all control surfaces. Electrically operated leading and trailing



ing edge flaps, with a boundary layer control system, give the Starfighter excellent low-speed handling qualities.

Other features include: An electrically operated 20mm rapid-firing cannon; multipurpose fire control system; self-contained inertial and dead reckoning navigation systems; engine air inlet duct electric anti-icing; high/low altitude pilot escape system; main landing gear tires that permit operation from pierced plank and macadam runways; maneuvering-type automatic flight control system; single-point pressurized refueling system; anti-skid braking system; and a variable-frequency AC electric power system.

The Starfighter's versatility stems from a combination of an advanced electronic fire control and navigation system coupled with the airplane's inherent ability to carry a variety of weapons for air-to-ground and air-to-air missions.

BASIC SPECIFICATIONS

ENGINE	General Electric J79-GE-11A
DIMENSIONS	Wing — Area 196.1 sq. ft. — Span 21.9 ft. Height 13.5 ft. Length 54.8 ft.
WEIGHT	29,027 pounds — Max. Permissible 14,300 pounds — Empty MAP F-104 17,200 pounds — Design Landing
SPEED	Mach 2.0 Normal Limit Mach 2.2 Emergency Overspeed (not thrust limited) 750 kts. EAS (Engine inlet temp. limit) 800 kts. EAS (Airframe limit)
RANGE	Up to 1600 N. Miles Ferry
ALTITUDE	Combat @ 55,000 ft.
ELECTRONICS	Integrated and form factor packaged
ARMAMENT	M-61 20mm Gun & Gun Pods Sidewinder IR Missiles GAM-83A Missiles Unguided Aerial Rockets Special Weapons Demolition and Anti-Personnel Bombs Reconnaissance Cameras
FUEL SYSTEM	Completely automatic, single point refueling Capacity — 896 gal. (with gun) 1018 gal. (w/o gun) 1358 gal. (w/tip tanks) 1748 gal. (w/tip and pylon tanks)
ELECTRICAL SYSTEM	40 KVA, 115/200 volt variable frequency (320-520 cps)
CONTROLS	Hydraulically powered, irreversible ailerons and stabilizer and full power rudder Boundary layer control — trailing edge flaps
ESCAPE SYSTEM	C-2 Seat-Upward Ejection

STRUCTURAL STRENGTH

Structurally, the Super Starfighter is designed for higher loads than the predecessor F-104C. Increased weight of internally-carried electronic gear plus added external stores carrying capability has dictated structural strengthening of the horizontal and vertical stabilizers, fuselage mid and aft section and the wing box section.

LOAD FACTORS

Gross Weight 20,900 pounds (full internal fuel)
Clean Configuration, Gear Up, C.G. 1.6% M.A.C.

Maneuver: 6.5g Positive
2.75g Negative

Gust: Not Critical

Gross Weight 19,150 pounds (67% internal fuel)
Clean Configuration, Gear Up, C.G. 3.2% M.A.C.

Maneuver: 7.33g Positive
3.00g Negative

Gust: Not Critical

Landing Weight 17,200 pounds — Maximum sinking speed at touchdown 9.0 ft./sec., 540 fpm.

POWER PLANT

The F-104 is powered by a J79-GE-11A axial-flow turbojet engine, with afterburner. Major components are a 17-stage compressor section, an accessory drive section, a combustion section, a 3-stage turbine, a high-thrust afterburner, and a variable-area exhaust nozzle.

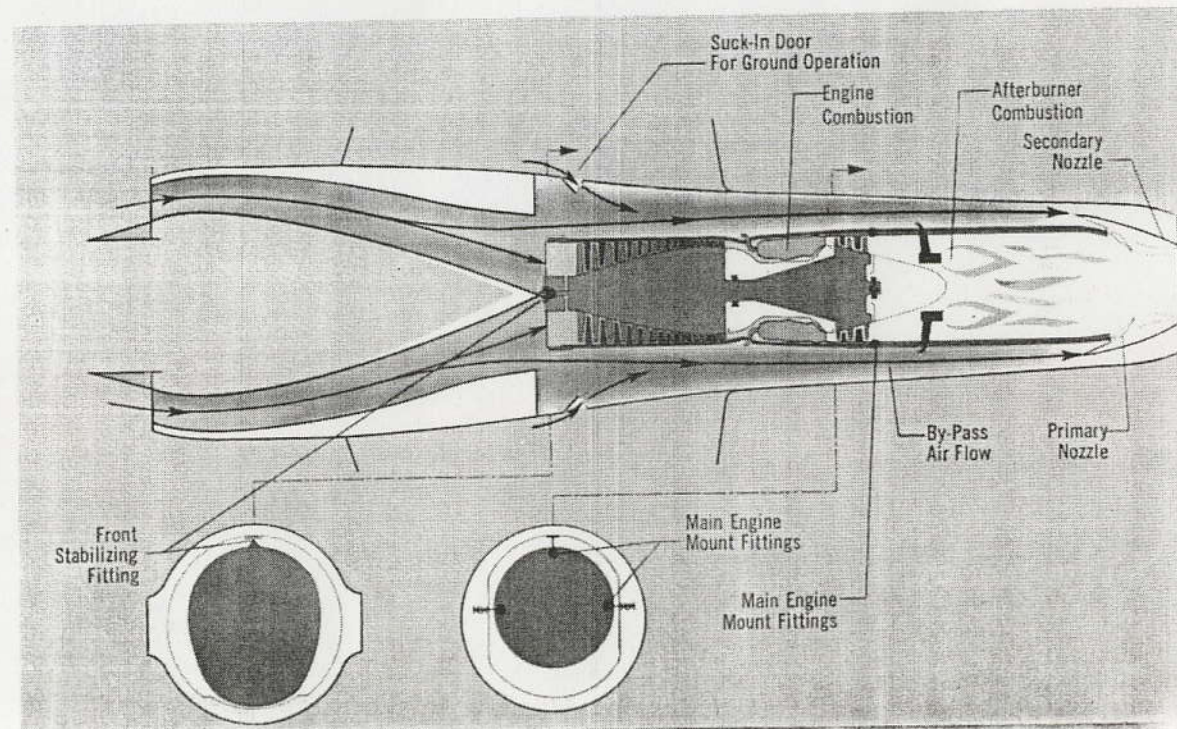
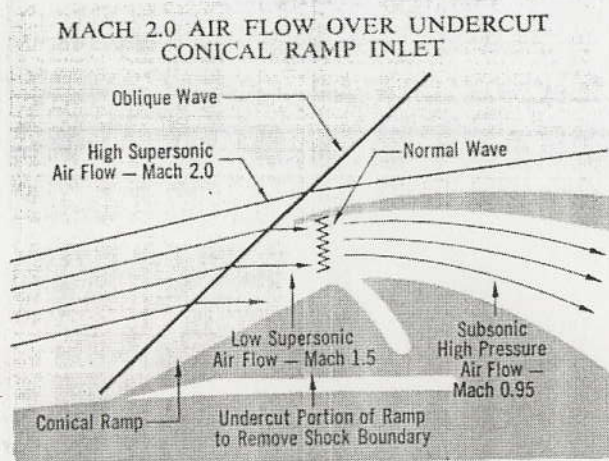
The engine air inlets each contain a conical ramp designed to maintain optimum airflow in supersonic flight. The conical ramps are designed for maximum efficiency at Mach 2.0 and create an oblique shock wave at Mach 2.0 extending from the tip of the cone to the outer edge of the duct. The oblique shock wave slows the high supersonic air to a slower but still supersonic speed at which it enters the duct.

The aft shape of the ramp facilitates formation of a shock wave within the duct which is normal, or per-

pendicular, to the walls of the duct. Thus, air flowing past the fuselage at Mach 2.0 is slowed by the shock waves in the duct inlet to subsonic velocity as it enters the engine.

Supersonic duct spillage drag is essentially eliminated by bypassing air in excess of engine requirements around the engine and ejecting it through a secondary afterburner ejector nozzle. The bypassed air serves to increase the propulsive efficiency of the engine as well as cool the structure and engine components.

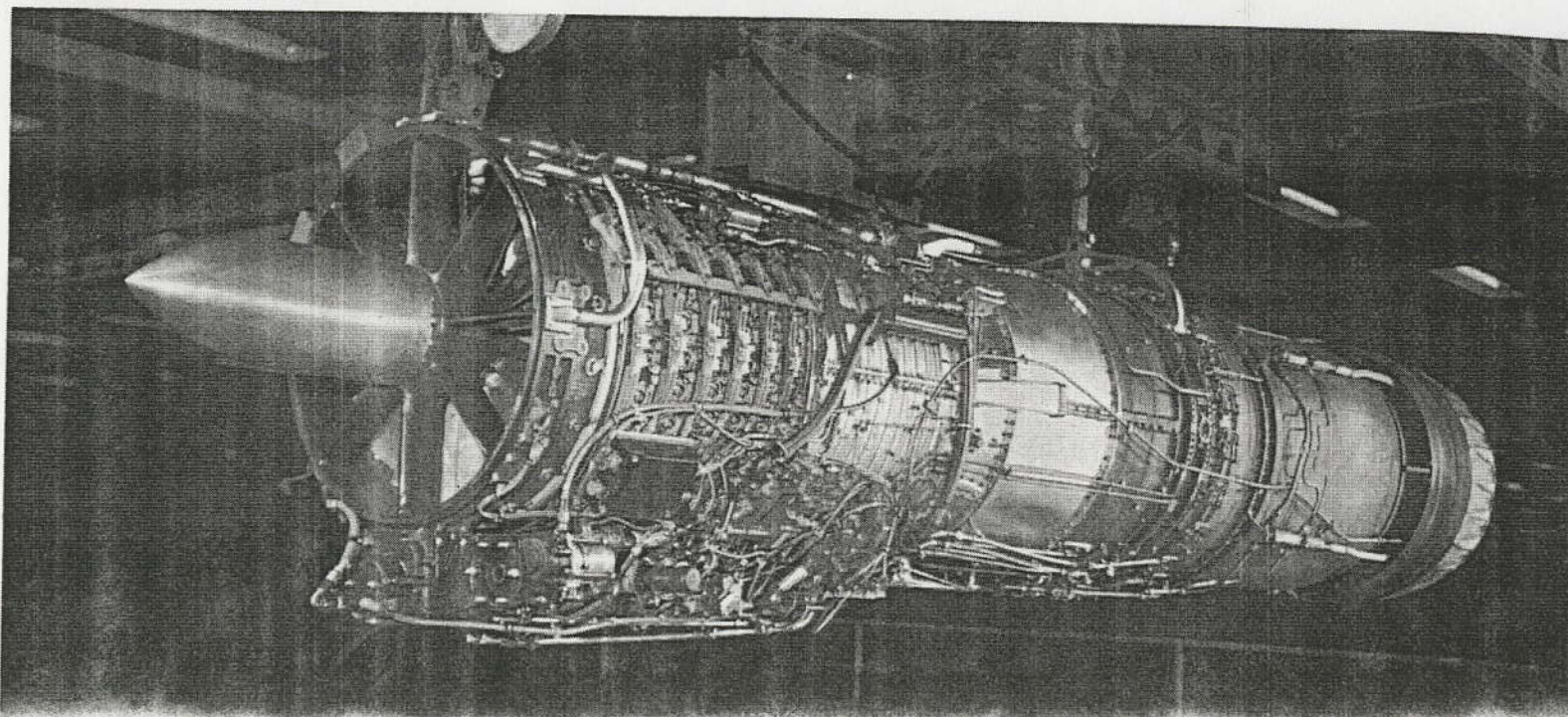
The exhaust ejector has a variable nozzle which automatically adjusts the exit area as required. The nozzle functions as a variable restriction through which exhaust gases are accelerated to their maximum velocity for maximum thrust. The nozzle also controls pressure and temperature in the tailpipe by selecting the optimum exhaust area for greatest thrust at any power setting from idle through afterburner range.



GENERAL ELECTRIC J79-GE-11A

RATING	Altitude Feet	Airspeed Mach/knots	Jet Thrust pounds	Engine RPM	Specific Fuel Consumption
Max. A/B	S. L.	Static	15,800	7,460	1.97
Min. A/B	S. L.	Static	12,300	7,460	1.44
Military	S. L.	Static	10,000	7,460	0.84
Normal	S. L.	Static	9,700	7,460	0.83
90% Normal	S. L.	Static	8,740	7,300	0.797
75% Normal	S. L.	Static	7,270	6,950	0.780
Idle	S. L.	Static	500-600	5,000	5.30
Max. A/B	35,000	2.0/1150	15,600	7,710	2.08
Max. A/B	55,000	2.0/1150	6,100	7,710	2.17
Cruise	35,000	0.9/ 518	2,650	Varies	1.05

Fuel Grade:JP-4 MIL-J-5624 (NATO-F-40)
 Oil Grade:MIL-L-7808 (NATO-O-148)
 Engine Weight:3,380 pounds
 Normal Operating RPM:87 to 104%
 Maximum Continuous Exhaust Gas Temp:560° C
 Maximum Permissible Exhaust Gas Temp:600° C
 Maximum Turbine Inlet Temp:121° C



FUEL SYSTEM

The basic fuel load of the F-104 is carried in five bladder-type tanks in the fuselage. Optionally, the space occupied by the M-61 cannon, ammunition bay and spent cartridge area can be fitted with metal fuel tanks for increased internal fuel capacity.

Additional fuel may be carried in external wing tip or pylon tanks for extended range missions. The external tanks can easily be mounted or removed on the ground and can be jettisoned in flight if desired.

Fuel is transferred from the external tanks to the main tanks by means of bleed air pressure from the engine compressor. This assures use of the externally carried fuel first, maintaining a maximum quantity in the fuselage tanks as long as possible. Four submerged electric fuel boost pumps in the main fuselage (sump) tank supply fuel under pressure to the engine-driven fuel pumps.

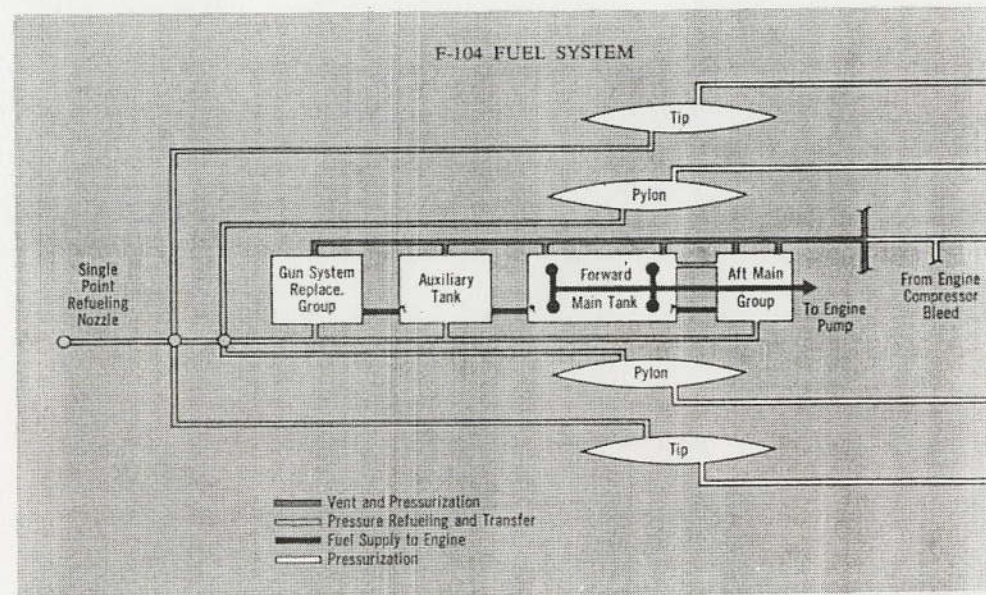
The Starfighter's tanks can be refueled either individually through conventional gravity-flow fillers, or from a single-point filler when pressure fueling facilities are available.

Inflight refueling by the probe and drogue method is accomplished through an externally mounted probe. Location of the probe on the upper left side of the fuselage allows the pilot to see both probe and drogue during refueling.

A density-compensated fuel quantity system measures the amount of fuel remaining in both internal and external tanks. Thus, the pilot can accurately assess the quantity of fuel taken aboard during inflight refueling.

A low fuel level warning light illuminates when internal fuel capacity reaches 200 gallons (1,300 pounds).

Fuel Capacity	U.S. Gallons	Pounds
Internal	896	5,824
Fuel Tanks Replacing M-61 Gun	122	793
Total Internal	1,018	6,617
Wing Tip Tanks (170 gal. each)	340	2,210
Pylon Tanks (195 gal. each)	390	2,535
Total Possible Fuel Load	1,748	11,362



HYDRAULIC SYSTEMS

The F-104 has two completely independent, closed-center hydraulic systems for normal operation. Each of these systems is served by its own engine-driven, constant-pressure, piston-type hydraulic pump. If either of these systems should fail, the other will maintain operation of the flight controls at a reduced rate. An emergency hydraulic pump is also provided; it is driven by a ram air turbine which can be extended into the air stream to supply hydraulic power for reduced-rate emergency operation of the primary flight controls. It operates the actuators in the No. 1 hydraulic system.

Hydraulically actuated components are powered by the No. 1, and No. 2 hydraulic systems, and the emergency hydraulic pump, as follows:

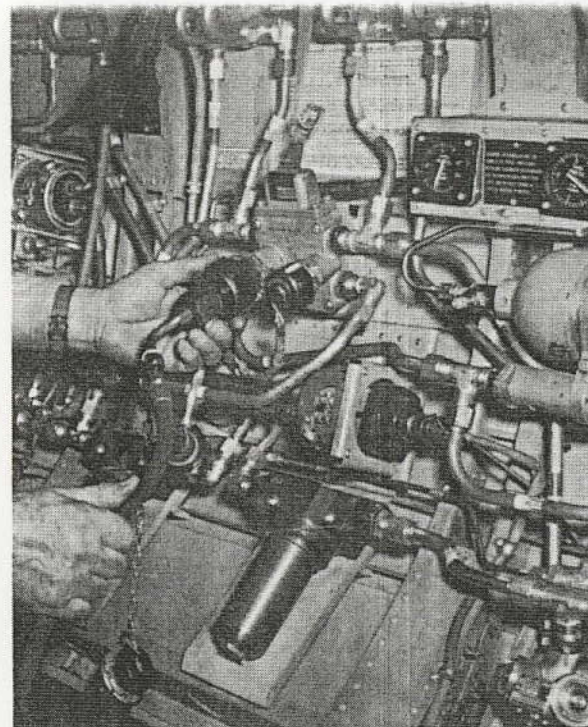
NO. 1 SYSTEM (and Emergency Pump)

Stabilizer (aft cylinder)
Aileron (one of the banks of cylinders on each side)
Rudder (one cylinder of each pair)
Automatic Pitch Control Actuator
Autopilot Actuators (Stabilizer and right aileron)

NO. 2 SYSTEM

Stabilizer (forward cylinder)
Aileron (one of the banks of cylinders on each side)
Rudder (one cylinder of each pair)
Landing Gear (including steering, doors, up-locks, etc.)
Speed Brakes
Engine Air By-Pass Flaps
Power Brakes
Hydraulically Powered Generator

Each hydraulic system has its own piston-type reservoir, accumulator, actuating cylinders and independent valves, lines, etc. The piston-type hydraulic reservoirs are designed so that positive pressure is maintained on the pump inlet by using system pressure, rather



Hydraulic ground cart connections are mounted on the inner side of the hydraulic service center door.

than by use of engine bleed air for reservoir pressurization. Ground cart test connections are provided so that the system can be powered and tested on the ground without operating the engine.

HYDRAULIC SYSTEM DATA

Hydraulic oil type: MIL-H-5606 (red)

Temperature range — 65°F to 275°F (— 53.9°C to 135°C)

Fluid Capacity

	U.S. Gallons	Liters
No. 1 Reservoir	0.49	1.85
No. 2 Reservoir	1.17	4.43
Capacity of Complete Systems	7.59	28.73
(includes capacity of lines, cylinders, actuators, etc.)		

PUMP CHARACTERISTICS

	Maximum Pump Output Speed RPM	Output Pressure		Output Flow	
		Pounds Per Square Inch	Kilograms Per Square Centimeter	Gallons Per Minute	Liters Per Minute
No. 1 Pump	3,403 RPM	3,750	263.85	24	91
No. 2 Pump	3,750 RPM	3,000	211.08	27	102
Emergency Pump	11,400 to 12,600 RPM	1,500 to 3,000	105.54 to 211.08	4.43 to 4.96	16.77 to 18.76

ELECTRIC POWER SUPPLY SYSTEM

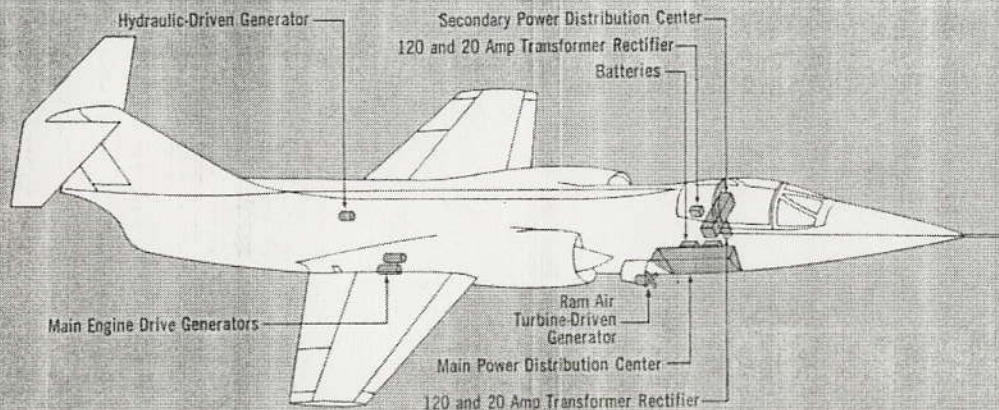
Electric power for normal operation is supplied by two 20 KVA, 115/200 volt, variable-frequency (320-520 cps) generators. These are mounted on drive pads at the engine's forward gear case. Emergency electrical power is generated by one 4.5 KVA, 115/200 volt generator, mounted on a hinged door just forward of the right hand engine air inlet duct driven by the emergency ram air turbine. Fixed-frequency AC power for the frequency sensitive navigation and fire control system elements is produced by a 2.5 KVA, 115/200 volt generator, driven by a constant-speed hydraulic motor powered by the No. 2 hydraulic system.

Direct current 28 volt power is provided by two transformer-rectifiers and two batteries. The normal trans-

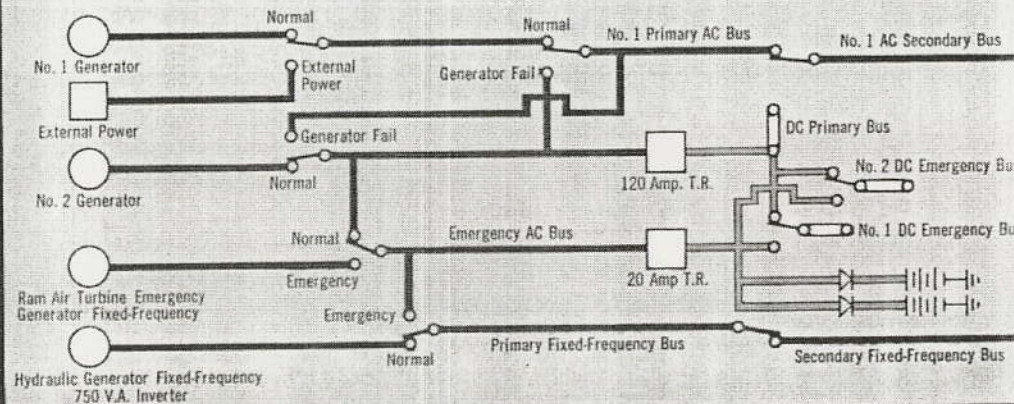
fomer-rectifier is rated at 120 amperes; the emergency standby unit at 20 amperes. Two 3.6 ampere-hour, 24 volt, nickel-cadmium batteries are installed and are charged by the transformer-rectifier to provide an emergency power source.

The electric power distribution system consists of seven alternating current buses and five direct current buses together with their related wiring, relays, circuit breakers, switches, etc. The bus tie system is arranged so that if either of the engine-driven generators should fail, the other will assume its load automatically. Also, if the hydraulically-driven, fixed-frequency generator should fail, a variable-frequency bus accepts its load automatically.

ELECTRICAL POWER SYSTEM COMPONENT LOCATIONS



ELECTRICAL POWER SYSTEM



FLIGHT CONTROLS

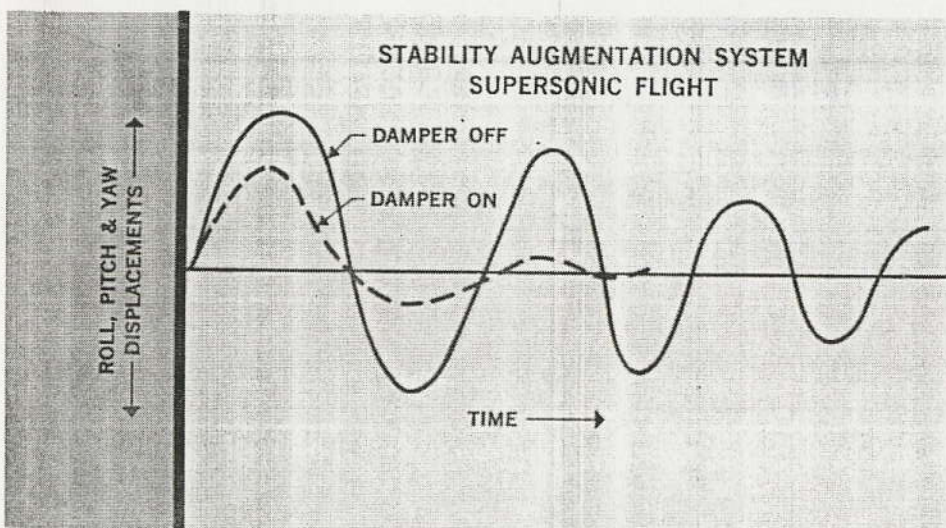
The F-104 primary flight control system consists of hydraulically powered rudder, ailerons and one-piece horizontal stabilizer. The secondary flight control system incorporates leading- and trailing-edge wing flaps for increasing lift and speed brakes for increasing drag. A further increase in lift for landing is achieved with the boundary layer control system which blows bleed air from the 17th engine compressor stage back over the trailing edge flaps when they are extended to the landing position.

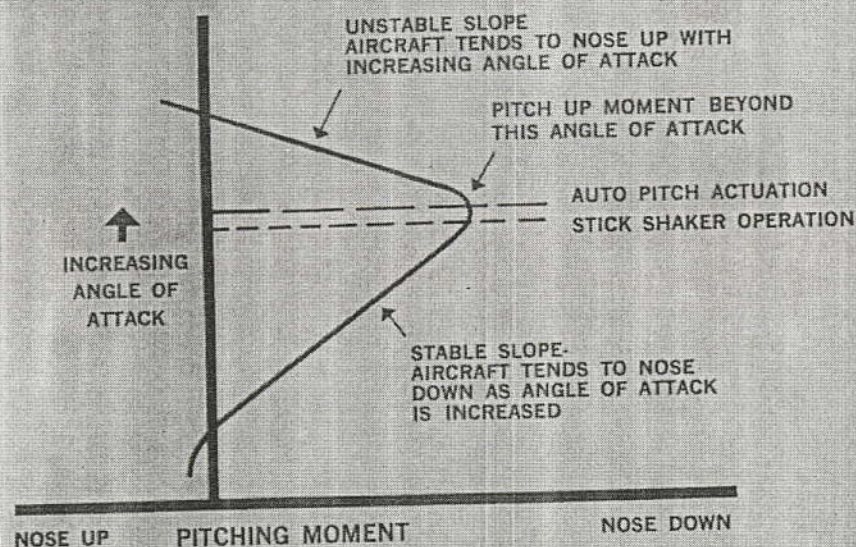
The primary flight control surfaces are actuated by servos which are powered by the Nos. 1 and 2 hydraulic systems. Input signals are sent to the servos from the

pilot's control, the stability augmentation system and from the trim system.

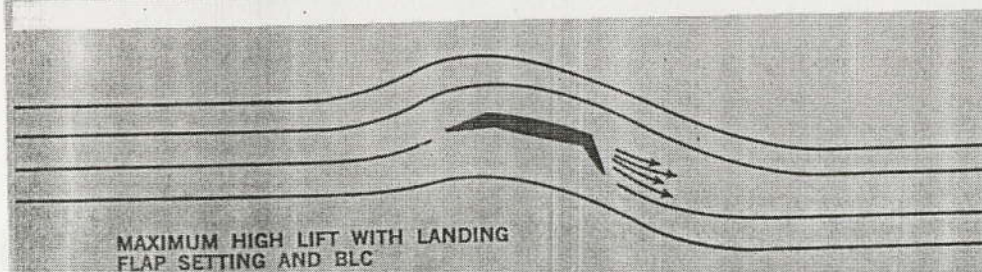
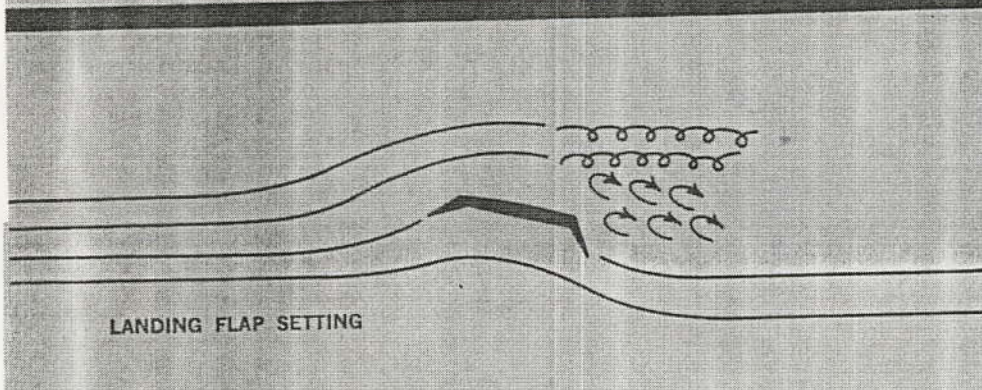
The stability augmentation system provides maximum aircraft stability in any flight attitude or maneuver. Rate-sensing gyros detect any sudden change of attitude about the aircraft's three axes and produce electrical signals proportional to the deviation detected. These signals, after being amplified, are sent to the proper control surface servo valve which produces the proportional surface response for correcting attitude. A synchronous transmitter on the servo valve supplies a feedback signal which cancels the original signal causing the oscillation to be damped.

The trim system is powered and controlled electrically, and the trim actuator output is connected mechanically to its respective servo valve input arm. Energizing the actuator causes the input arm to change position, thereby changing the position of the control surface. In each case, the amount of trim selected limits surface movement in that direction by the same amount.





The automatic pitch control system functions as a stall-prevention device. Inputs from an angle-of-attack vane and a pitch rate gyro are fed into a computer which, when the aircraft first approaches a stall, causes the pilot's control stick to shake as a warning. Should the nose-up attitude be continued until a stall becomes imminent, the computer commands a pitch signal to a hydraulic servo which quickly and firmly moves the control stick forward, while also positioning the horizontal stabilizer for a nose-down attitude. Visual indication of pitch attitude is presented to the pilot on the instrument panel.



The wing leading- and trailing-edge flaps are positioned by electro-mechanical actuators. A flexible shaft interconnects the drive motors for each wing to synchronize the flaps and to enable one motor to drive both flaps should the other malfunction. The flaps have three pre-set positions: Up, which is the faired position; Intermediate, which is 15° downward deflection for both leading- and trailing-edge flaps and is used for take-off or maneuvering flight; and Land, which is 45° downward deflection for trailing edge and 30° deflection for leading edge flaps.

The two speed brakes are hydraulically powered and electrically controlled. They operate in synchronization and the pilot may select any position between "full open" and "full close".

LANDING GEAR

The F-104 is equipped with a tricycle-type retractable landing gear. All three units of the gear retract forward into the fuselage by hydraulic power. In the event of hydraulic failure, the gear can be released manually and will fall into the "down and locked" position.

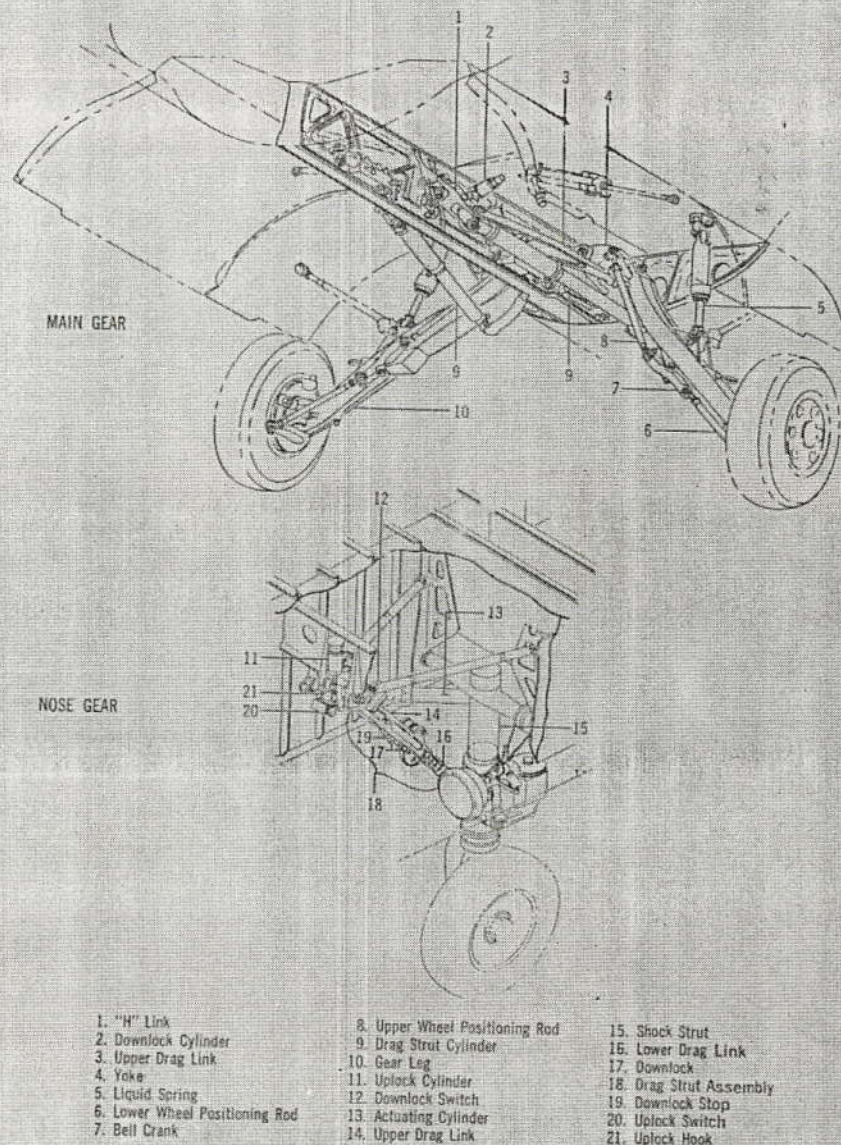
Each main gear strut is supported by a device called a "liquid spring". This unit provides shock absorbing action through a special silicone fluid which compresses under load. A special filler permits adjustment of the fluid pressure for various loads.

The main wheels have hydraulically powered segmented-rotor brakes, fitted with an anti-skid system. This permits maximum braking without the danger of wheel skidding. The anti-skid system is electrically selected at the pilot's option and powered by the No. 2 hydraulic system. When the anti-skid system is not energized, braking pressure is controlled by the pilot's foot pedal pressure, acting through the standby master brake system.

The nose wheel is steerable through a 25° arc on either side of center through a combination power steering and shimmy damper unit powered by the No. 2 hydraulic system. The nose wheel is mounted on a conventional shock absorbing oleo strut.

The main landing gear has 26x8.0-14 type VIII forged aluminum wheels with 26x8.0-14, 16 ply, high-speed, tubeless tires. The nose landing gear has an 18x5.5 type VII wheel which mounts an 18x5.5, 14 ply type VII tire.

MAIN LANDING GEAR AND NOSE LANDING GEAR



COCKPIT

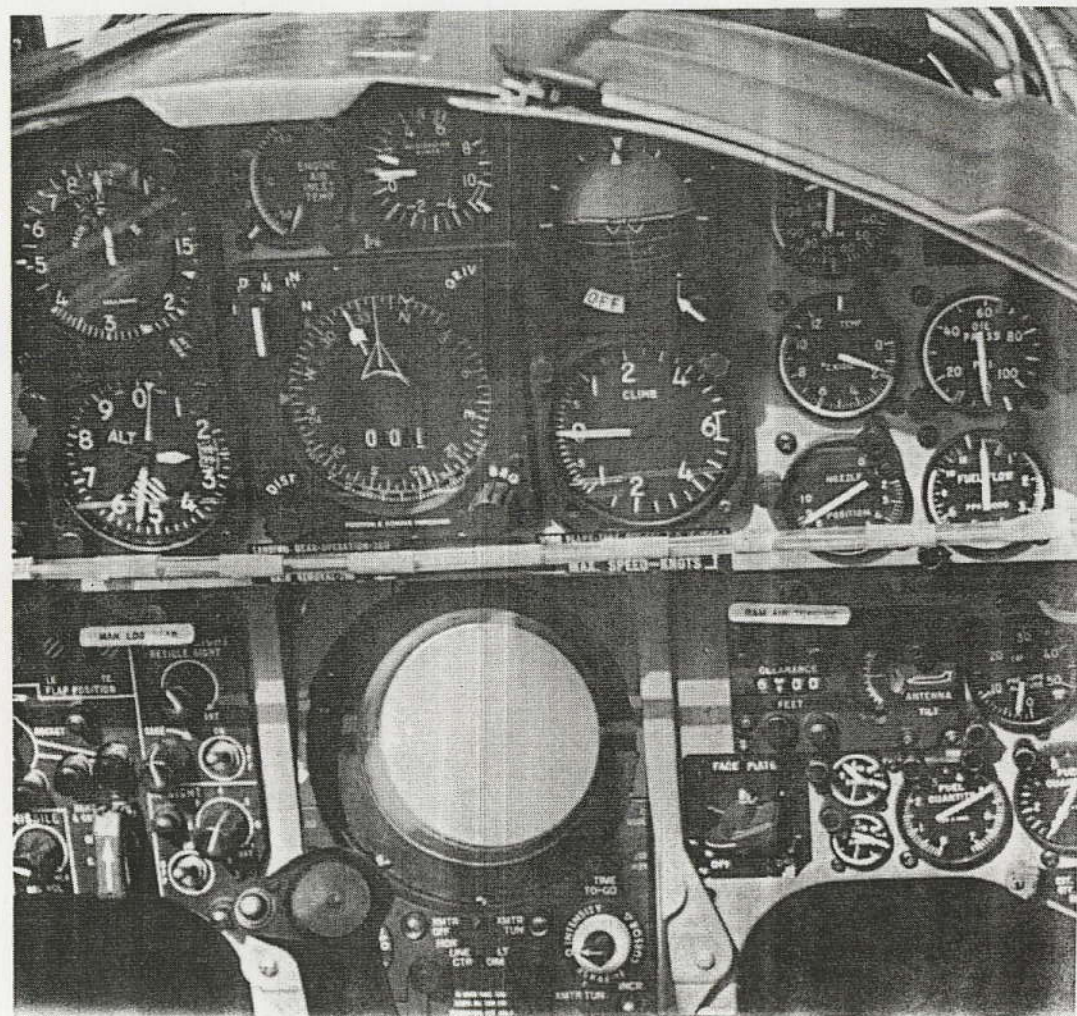
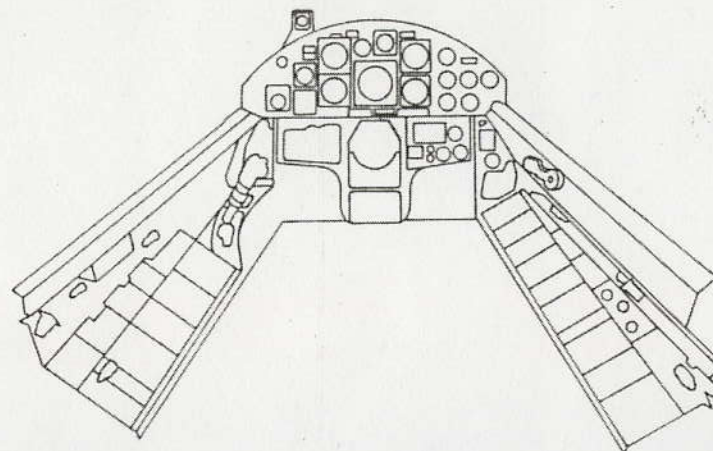
The cockpit and instrument panel layout of the F-104 were designed with human factors given the utmost consideration. Experienced test pilots and highly qualified tactical pilots participated from the beginning in establishing cockpit configuration. Controls and instruments are grouped logically, minimizing the possibility of inadvertent control operation. Safety, convenience and ease of operation were the prime reasons dictating placement of all controls.

Cockpit environment also has been given great attention and provides a wide temperature control range and precisely controlled pressurization schedule. Pilot comfort was given the utmost consideration because of the known degradation to pilot performance caused by annoyance and pilot discomfort. However, in no way is safety compromised.

Flight and engine instruments are located on the upper instrument panel directly in front of the pilot. The center of the lower instrument panel provides the space for mounting a radar scope and related controls. To the left are controls and instruments affecting the landing gear, engine starting and armament control. To the right are controls for the fuel quantity instruments, function warning lights, oxygen quantity indicator and generator switches.

The pilot's left console contains controls for the radar, autopilot, UHF radio, fuel management, trim system and autopilot.

The right console has controls for the oxygen system, TACAN, IFF & SIF, bombing computer, PHI system, inertial navigator alignment, pressure suit, gun clearing and camera controls, and cockpit lights.



SPECIAL SYSTEMS

PILOT ESCAPE PROVISIONS

The Lockheed-developed C-2 ejection seat represents the latest advancement in pilot escape in the event of emergency. By providing a rocket motor which thrusts the seat upward and forward after it has been fired from the aircraft, pilot escape is possible from zero altitude providing indicated airspeed is at least 90 knots. The full airborne recovery capability of the C-2 seat ranges from the stall speed of the aircraft to 550 knots EAS and from zero altitude to 50,000 feet using the standard USAF B-5 parachute.

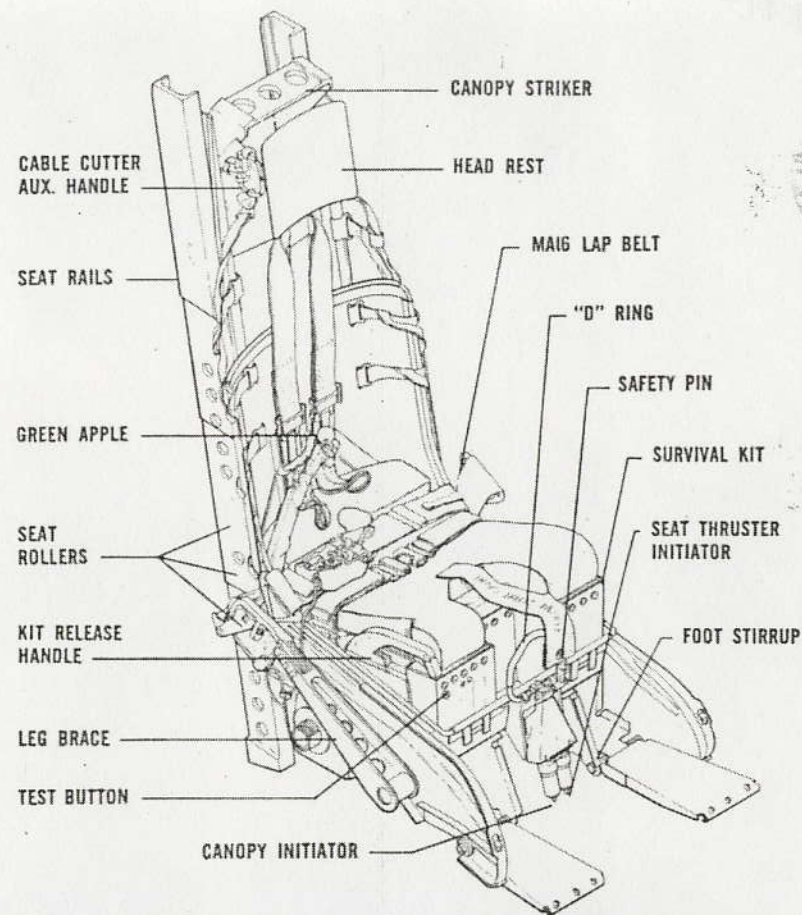
The C-2 ejection seat also is equipped with automatic foot and leg retention devices and arm restraining webs to prevent flailing of limbs during high speed ejection.

To operate the ejection seat the pilot need only to seize and pull up on the D ring located at the base of the seat. In automatic sequence, the canopy jettisons, arm and leg restraining devices actuate and the catapult fires. The pilot then is freed from the seat by an automatic lap belt and foot restrainer cable cutters and his parachute opened either automatically or manually as the situation dictates.

As part of the ejection seat system, a survival kit and bail-out oxygen supply located beneath the seat cushion, both of which are delivered as integral parts of the escape system.

LANDING DRAG CHUTE

The F-104 is equipped with a drag chute which helps to slow the aircraft during the landing roll. The chute is an 18-foot diameter conical ring slot type stowed



in a compartment in the lower aft fuselage. The pilot deploys the drag chute with a pull-handle in the cockpit which triggers the chute compartment. A spring-loaded pilot chute is released when the chute compartment opens which fills with air and pulls out the main canopy. The deployed chute can be released from the aircraft by rotating the chute handle and pulling aft.

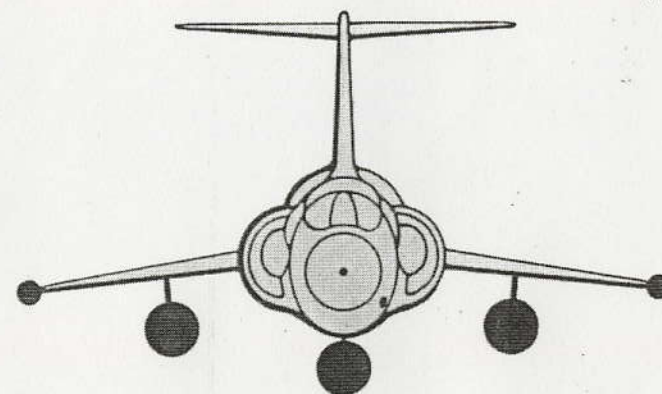
ARRESTOR HOOK

An arrestor hook is installed in the aft lower section of the fuselage. When extended, the hook engages an arresting cable on the runway for emergency stops. The hook is extended by an electrically operated actuator/damper cylinder similar to a shock-strut cylinder.

ARMAMENT PROVISIONS

Mission diversification and convertibility from one combat role to another is inherent in the basic design of the F-104. Provisions on the wing and fuselage permit a wide variety of stores or fuel tank carrying configurations.

The table below shows the various weapon and fuel options the Starfighter can carry. A tabulation of some of the conventional weapons that can be, or have been, carried on the Starfighter are listed on the following page. It must be understood that this table represents general capabilities that can be accommodated in the F-104 design, and that actual operational capability is dependent on the procurement of appropriate launchers, pylons, bomb racks, arming provisions, and electrical control circuits.



ITEM	WING TIP	WING PYLON	FUSELAGE CENTERLINE	INTERNAL FUSELAGE	WING PYLON	WING TIP
GAM 83A Bull Pup	—	1	—	—	1	—
M-61 20 mm Gun and 750 rounds of ammunition	—	—	—	1	—	—
LAU-3 FFAR Pods (19 2.75" rockets per pod)	—	1	—	—	1	—
Various bombs, containers and stores up to 1,000 pound class with 14-inch lug spacing	—	1	1	—	1	—
Various bombs, containers and stores up to 2,000 pound class with 30-inch lug spacing	—	—	1	—	—	—
GAR 8 Sidewinder 1A (up to 4 can be selectively fired)	1	1	2	—	1	1
Optional Fuel Tanks	170 Gal. (643 liters)	195 Gal. (738 liters)	—	122 Gal. (462 liters)	195 Gal. (738 liters)	170 Gal. (643 liters)
Reconnaissance Camera System	—	—	External Pod	3 Internal Cameras	—	—

CONVENTIONAL STORES THAT CAN BE CARRIED ON F-104 EXTERNAL STATIONS

CONVENTIONAL WEAPONS

MAXIMUM QUANTITY

LOADING STATIONS

Air-to-ground Missiles

GAM 83A Bull Pup

2

Wing pylons

Anti-Personnel Weapons

LAU-3/A

2

Wing pylons

M-38 Fragmentation Bomb (cluster)

3

Wing pylons & fuselage C/L

Sadeye

3

Wing pylons & fuselage C/L

Gladeye

3

Wing pylons & fuselage C/L

Bomblet Dispensers

2

Wing pylons

Rocket Pods

LAU-6/A (7-2.75-inch diameter rockets)

2

Wing pylons

LAU-3/A (19-2.75-inch diameter rockets)

2

Wing pylons

LAU-18/A (19-2.75-inch diameter rockets)

2

Wing pylons

LAU-10/A (7-5.00-inch diameter rockets)

2

Wing pylons

LAU-10/B (7-5.00-inch diameter rockets)

2

Wing pylons

Aero-10D (4-5.00-inch diameter rockets)

2

Wing pylons

Fire Bombs

Mk-77 (750 lbs.)

3

Wing pylons & fuselage C/L

Mk-79 (1000 lbs.)

3

Wing pylons & fuselage C/L

M 116 A2 (750 lbs.)

3

Wing pylons & fuselage C/L

BLU-1/B (750 lbs.)

3

Wing pylons & fuselage C/L

Miscellaneous Weapons

Rockeye (750 lbs.)

3

Wing pylons & fuselage C/L

MLU-10B Land Mine (700 lbs.)

3

Wing pylons & fuselage C/L

TMU-10/B Smoke Bomb (750 lbs.)

2

Wing pylons

Weteye (500 lbs.)

3

Wing pylons & fuselage C/L

MC-1 Chemical Bomb (700 lbs.)

3

Wing pylons & fuselage C/L

M-129-E1 Leaflet Bomb

3

Wing pylons & fuselage C/L

General-Purpose Bombs

Mk-81 (250 lbs.)

3

Wing pylons & fuselage C/L

Mk-82 (500 lbs.)

3

Wing pylons & fuselage C/L

Mk-83 (1000 lbs.)

3

Wing pylons & fuselage C/L

Mk-84 (2000 lbs.)

1

Fuselage C/L

M-117 (750 lbs.)

3

Wing pylons & fuselage C/L

Air-To-Air Missiles

GAR 8 Sidewinder 1A

4*

Wing tips, wing pylons and
fuselage C/L

*Note: A total of six mounting positions are available for Sidewinder 1A missiles, however, firing selection controls and circuits limit the number of missiles that can be selectively fired to four on a single flight.

ELECTRONIC SYSTEMS—GENERAL

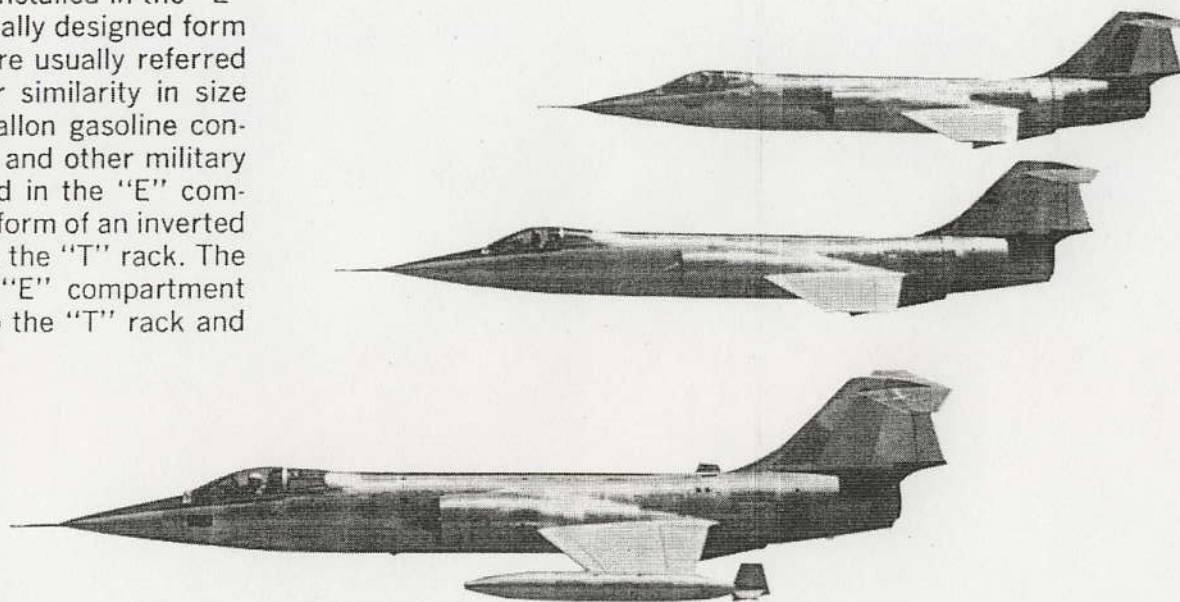
Developed electronic equipments are available for the F-104 to provide operational capability for a wide variety of combat missions. The provisions for installation and integration of these equipments are included in all versions of the F-104 Super Starfighter. Convenient "packaging" of electronic equipments permits selection of specific configurations to meet desired mission requirements without restricting the ability to install additional equipment as mission requirements change.

All major electronic components are installed in either the easily accessible nose section or in a single "E Bay" compartment aft of the cockpit.

Most of the electronic equipments installed in the "E" compartment are packaged in specially designed form factor packages. These packages are usually referred to as "gas cans" because of their similarity in size and shape to the U.S. Military 5-gallon gasoline container strapped externally on jeeps and other military vehicles. The gas cans are installed in the "E" compartment on a rack which takes the form of an inverted "T", and is therefore referred to as the "T" rack. The gas cans slide in and out of the "E" compartment vertically on guide rails attached to the "T" rack and

to the inboard face of each gas can. Test panels are incorporated in the gas cans for ground check and adjustments of the subsystems while installed in the airplane. This type of installation, besides allowing maximum use of available space, permits ease of trouble shooting and rapid component removal and replacement—reducing airplane out-of-service time.

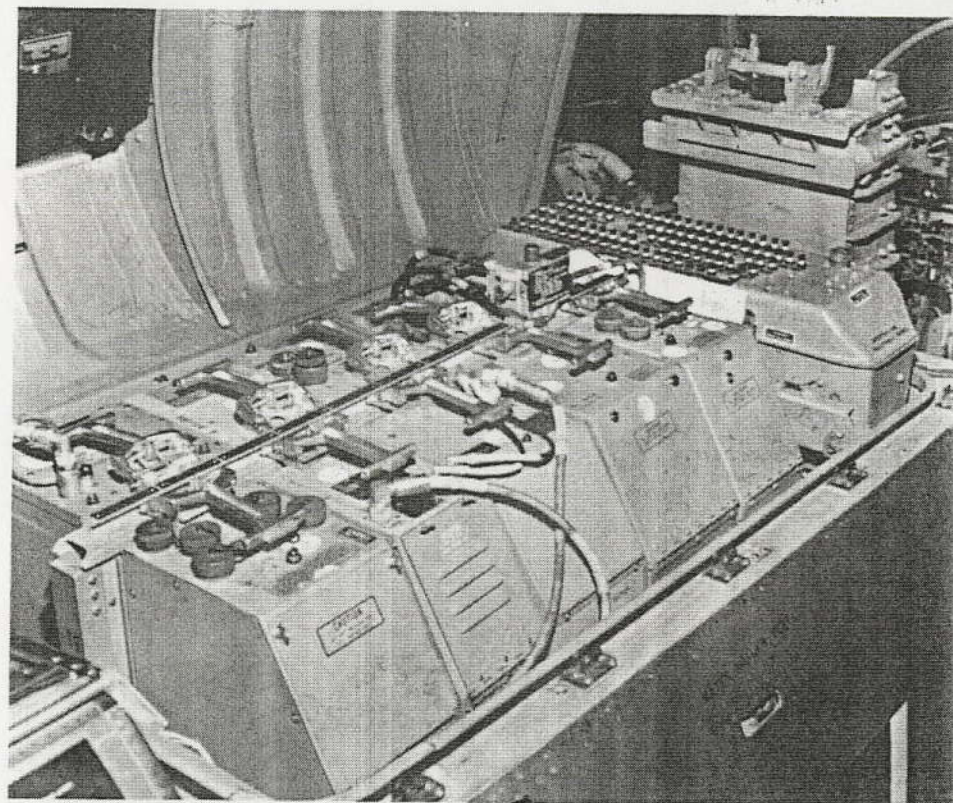
The adaptability of the F-104 to variations in electronic configuration is reflected by the equipments installed in the MAP F-104 all-weather multi-mission fighter and the F-104-17 (Basic) visual fighter.



ELECTRONIC SYSTEMS— MAP F-104

Advanced multi-purpose fire control and precision navigation electronic systems are installed in the MAP version of the F-104 Super Starfighter. These systems provide a high degree of capability in performing the varied roles of interceptor, fighter/bomber and armed reconnaissance under adverse conditions. The installation permits all-weather navigation independent of ground stations and provides all-weather strike capability with special weapons. The MAP F-104 can intercept targets in a clear air mass, day or night, with a high probability of kill. All-weather intercept capability is achieved with the M-61 gun and unguided rockets.

Functions and capabilities of the MAP F-104 electronic systems are discussed on the following pages.



THE F-104G ELECTRONIC SYSTEM INCLUDES:

- Multipurpose Radar System (NASARR)
- Inertial Navigator
- Position and Homing Indicator System (PHI)
- Tactical Airborne Navigation System (TACAN)
- Automatic Flight Control System
- Air Data Computer
- Bombing Computer/Dual Timer
- Optical/IR Sight
- In-Range Computer
- UHF Communication & Interphone
- Identification System (IFF)
- Standby Compass System
- Standby Attitude Indicating System

NASARR FIRE CONTROL SYSTEM

NASARR (North American Search and Ranging Radar)

The heart of the MAP F-104's fire control system is NASARR, a multi-purpose navigation, search and ranging radar designed to support the Starfighter's capability as a fighter/bomber, interceptor and armed reconnaissance airplane.

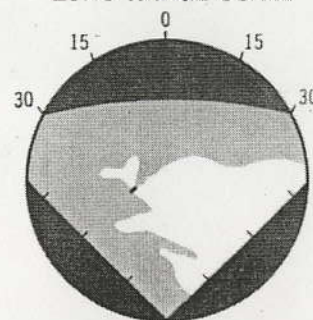
When operating in the tactical role, the NASARR air-to-ground modes include the following capabilities:

- Ground mapping for all-weather navigation and target identification
- Air-to-ground ranging which provides range data for bombing computations in visual and non-visual modes
- Contour mapping for all-weather bombing at low altitudes
- Terrain avoidance for low altitude blind penetration

NASARR, when used in the intercept or air superiority missions, provides the following capabilities in the air-to-air modes:

- Target search
- Tracking
- Lock-on and Range information

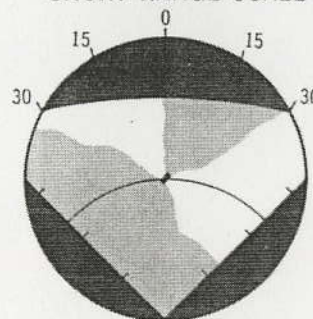
LONG RANGE SCALE



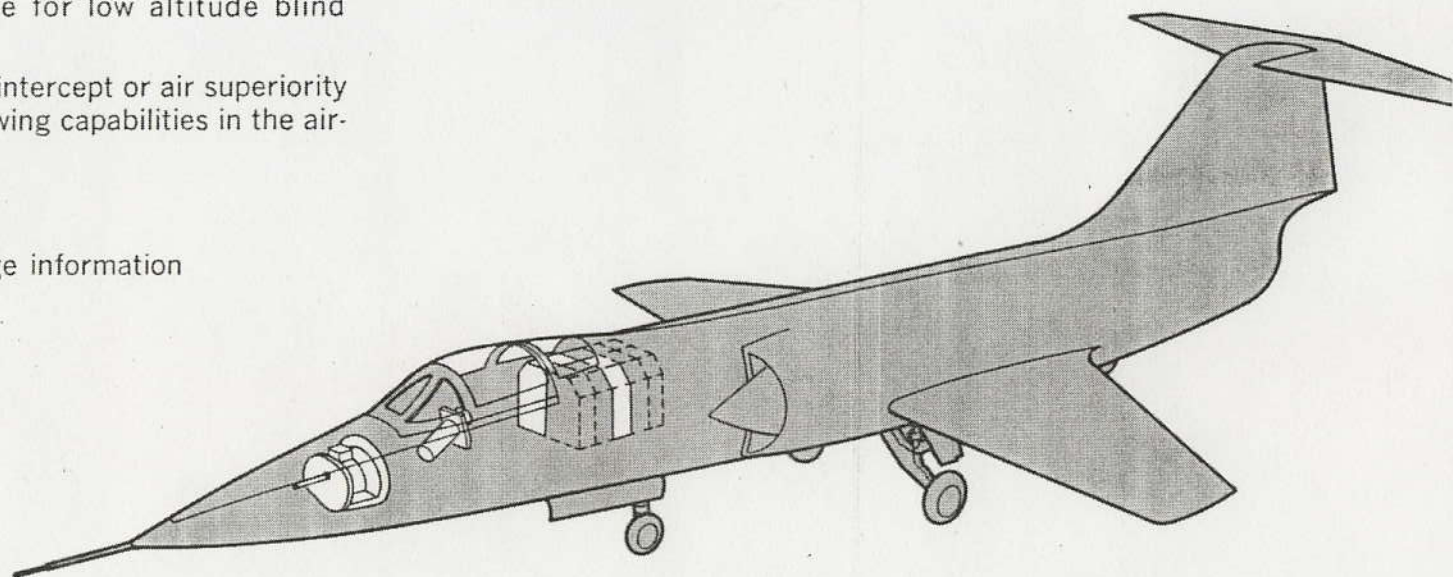
GROUND MAP OPERATIONS

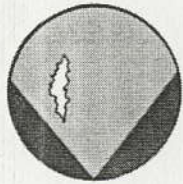
General area identification is made with the 80-mile sweep surface targets such as towers, large metal buildings, coastlines, bridges can be observed and identified.

SHORT RANGE SCALE

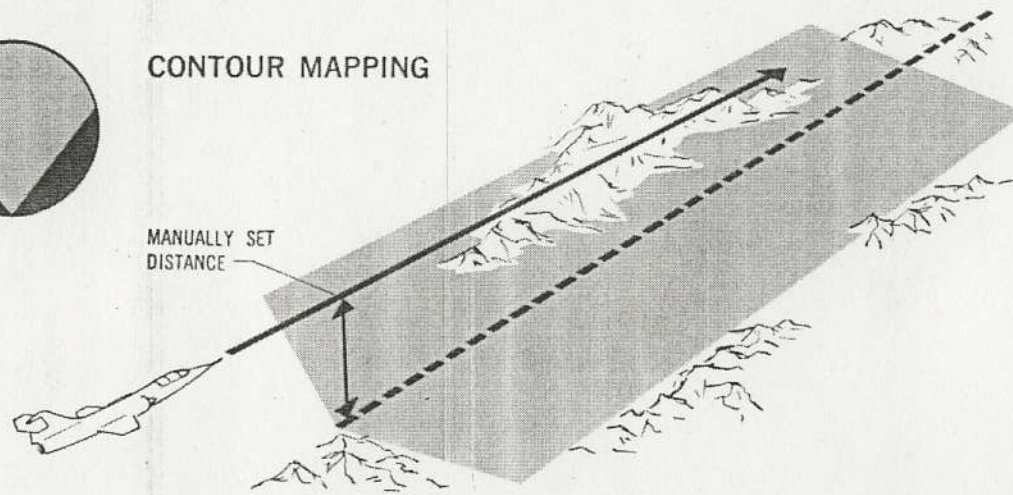


The azimuth cursor is superimposed on the target blip and when the blip intercepts the range cursor the pilot actuates the "pickle switch" to complete weapon release computations and actual weapon release. The 20-mile sweep is used for this portion of the mission.



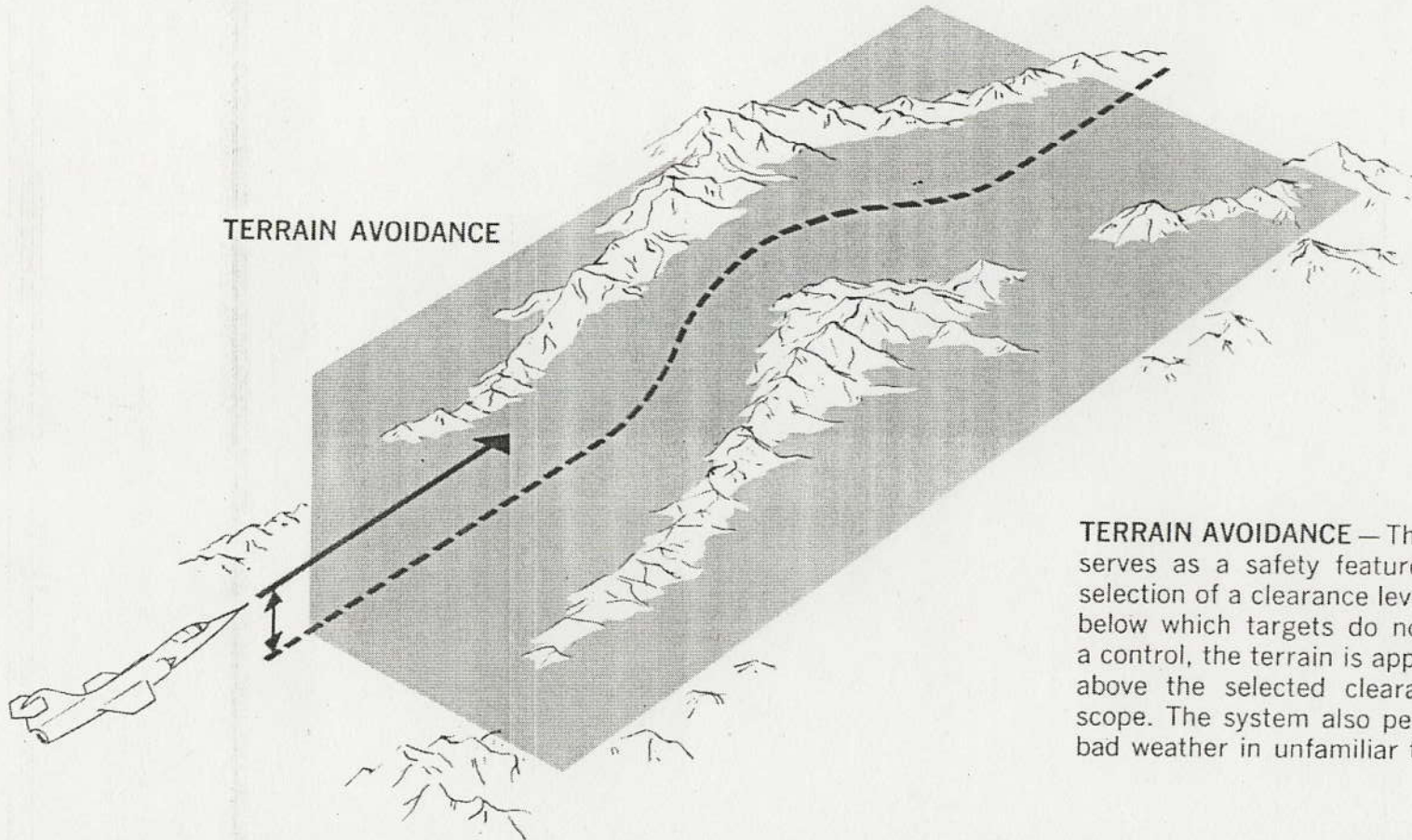


CONTOUR MAPPING



NAVIGATION CHECK POINT—Contour mapping differentiates between terrain altitudes and also serves as a navigational check point. The location of the high prominent points of terrain is usually known quite accurately. With contour mapping the clearance plane can be adjusted to display only the extreme top of peaks.

TERRAIN AVOIDANCE



TERRAIN AVOIDANCE—The terrain avoidance display serves as a safety feature for the pilot. It permits selection of a clearance level parallel to the flight path below which targets do not illuminate. By adjusting a control, the terrain is appraised since only obstacles above the selected clearance level appear on the scope. The system also permits safe let-down during bad weather in unfamiliar territory.

LN-3 INERTIAL NAVIGATOR

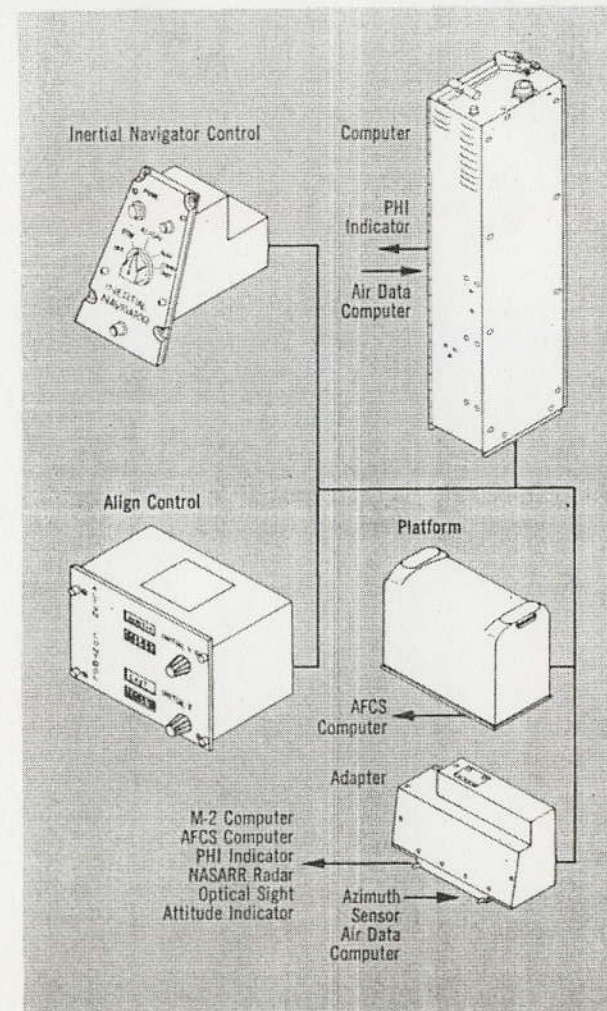
The inertial navigator provides the precision navigational information required for the all-weather strike/bombing and reconnaissance/probing missions. The system also serves as the primary vertical reference for heading information.

The system consists of a platform assembly, an adapter assembly and a navigation computer located in the "E" compartment with the cockpit controls located on the right console.

The heart of the inertial navigator is the platform which consists of a four-gimbal, three axis assembly with the innermost gimbal or stable element, mounting two, 2-degree-of-freedom gyros, and three mutually-perpendicular accelerometers. The platform maintains its vertical axis aligned with the center of the earth and its north-south axis aligned with north regardless of aircraft geographic position or attitude. Aircraft geographic position is continuously computed on the basis of signals from the accelerometers. These units sense aircraft motion along directionally aligned axes and the computer integrates these acceleration signals to determine instantaneously the speed and distance tracked. The inertial navigator adapter serves to resolve various signals supplied to and from the platform.

In conjunction with the position and homing indicator (PHI) system, the inertial navigator provides bearing and distance to any one of 12 preselected navigation check points or destinations. In the inertial mode, the inertial navigator provides aircraft position data in terms of grid coordinates, X and Y, to the PHI computer. The PHI computes the aircraft position with

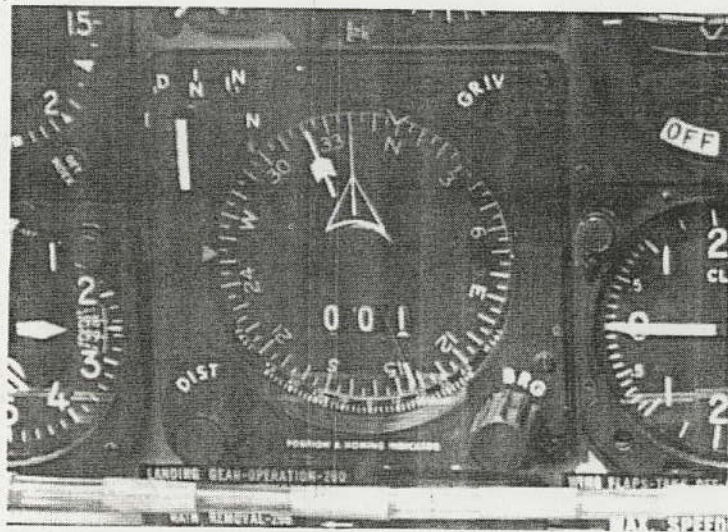
regard to the destination by subtracting the X and Y coordinates of the present position from those of the destination (which have been set into the PHI station storage unit). The results are resolved into distance and bearing and presented on the PHI.



PHI (POSITION & HOMING INDICATOR) SYSTEM

The PHI system is a dead-reckoning navigation system consisting of a cockpit display indicator, navigation computer and control panel. The PHI is integrated with the other F-104 navigation systems and the indicator displays aircraft heading information, and bearing and distance to selected stations for all systems. The indicator also includes a mode selector switch for selecting the desired navigation mode; inertial, dead-reckoning, or TACAN.

The PHI control panel includes the twelve-station selector dial, station storage unit, and wind velocity... and direction setting controls and indicators. The



station selector dial permits selection of pre-set navigation points such as targets, alternate bases, destinations, enroute check points and the home base. Geographic position coordinates of latitude and longitude for these stations are set into the system by the station storage unit.

The coordinates of the selected station are inputs to the PHI system navigation computer. The computer continuously subtracts airplane position coordinates from station coordinates and thereby computes the distance and bearing to the selected station. This computed distance and bearing information is displayed on the cockpit indicator when either inertial or dead-reckoning navigation modes are selected.

In the inertial navigation mode, airplane coordinates are derived from precision position data supplied to the PHI computer by the inertial navigation system.

In the dead-reckoning mode, airplane position is computed on the basis of airplane speed inputs from the air data computer, heading information from the inertial navigator or C-2G compass, and pilot inputs of wind direction and velocity. Navigational accuracy of the dead-reckoning mode is dependent upon the validity of the wind direction and velocity inputs.

The 12-station rotary selector switch and wind information control are a part of the PHI control panel located on the right cockpit console. The station selector is used for either the inertial or dead-reckoning mode. The PHI computer is located on the underside of the "E" compartment cover.

TACAN

TACAN is a homing navigation system that continuously computes the bearing and distance to a selected ground TACAN beacon and presents this information on the PHI indicator. The system is effective within line-of-sight ranges up to approximately 300 nautical miles, depending upon aircraft altitude and station location. TACAN is integrated with the automatic pilot to allow automatic homing on a selected station. The system contains one hundred and twenty-six two-way operating channels.

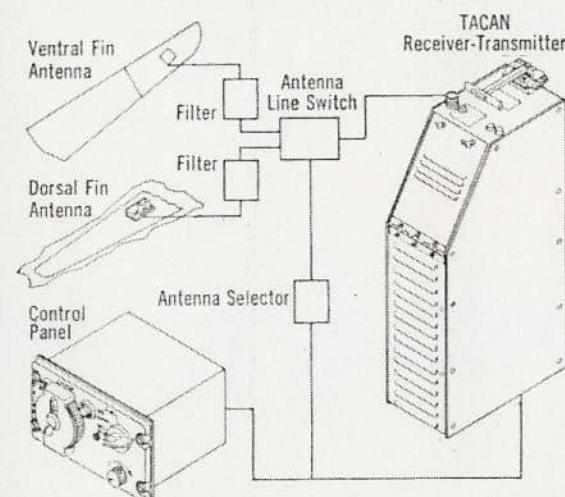
Distance from the selected beacon is determined by an interrogator-responder system that measures round trip time of a radio pulse from the aircraft to beacon, and converts this time into miles from the station. The TACAN receiver processes TACAN ground beacon pulses and converts this information into aircraft bearing to the beacon.

The TACAN transmitter/receiver is installed in the "E" compartment and the control panel is located on the right cockpit console.

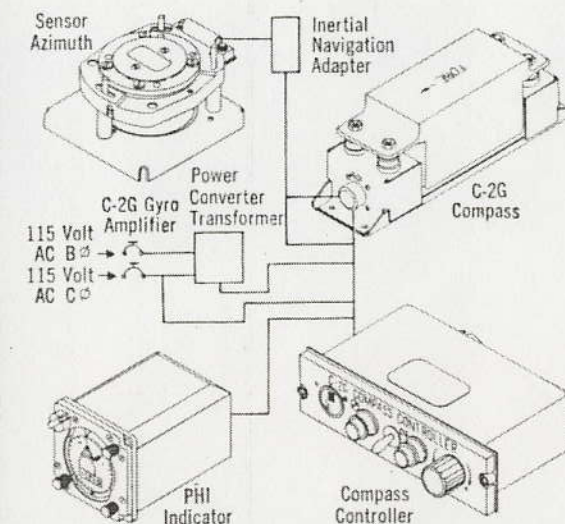
C-2G COMPASS SYSTEM

A magnetic-slaved directional gyro provides stabilized magnetic heading as a back-up source of heading information. The system consists of a gyroamplifier, a compass control panel, a power converter, and a flux valve sensing unit. This system also can be operated as a directional gyro at the pilot's discretion. The display is on the PHI system indicator. F-104's are being fitted with a device that automatically selects C-2G heading information for dead reckoning navigation if the inertial reference source should malfunction.

TACAN SYSTEM COMPONENTS



COMPASS SYSTEM



UHF COMMUNICATION RADIO

The ARC-552 UHF system provides two-way air-to-ground and air-to-air voice communications. The AIC-18 intercommunication system is an integral part of the ARC-552 radio and provides for communication between ground personnel and the pilot. The AIC-18 amplifier also provides amplification of all transmitted and received ARC-552 and TACAN audio signals as well as landing gear warning and missile signal tones.

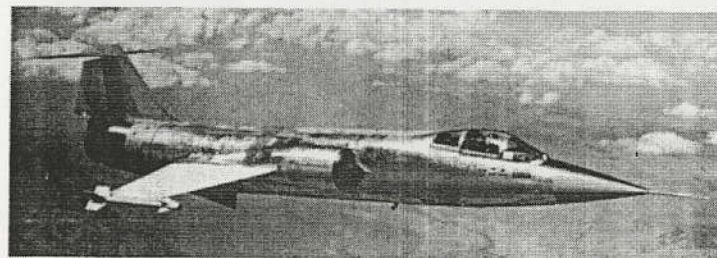
The ARC-552 transmitter/receiver is automatically tuned and transmits and receives on 3500 channels in the 225 to 400 mc frequency band. A second, separate guard receiver tunable over a 228 to 248 mc range is included in the system. When the guard channel is selected the ARC-552 transmitter is automatically tuned to the preset guard receiver frequency.

Cockpit controls include a 27 preselected channel selector located on the left side of the pilot's instrument panel. The system control panel is located on the left cockpit console and includes controls for manually selecting any of the remaining 3473 available frequency combinations. The transmitter/receiver is located in the "E" compartment.

IFF

This APX-46 IFF system is an airborne pulse-type transponder which enables the aircraft to identify itself whenever challenged by a Mark X or SIF (Selective Identification Feature) system. This set does not operate simultaneously in both Mark X and SIF systems. The system to be used must be selected before the flight and cannot be reset in flight. The SIF reply permits the aircraft to be identified as friendly when interrogated as well as providing serial numbers, flight number, mission or any other method of identification previously arranged.

The IFF and SIF control panels are located on the right cockpit console and the transmitter/receiver is installed in the "E" compartment.



AIR DATA COMPUTER

The air data computer consists of a computer unit incorporating two pressure sensors, a computing section, and a total temperature probe. The system accepts the following inputs:

- Pitot pressure
- Static pressure
- Indicated free air temperature
- Angle-of-attack

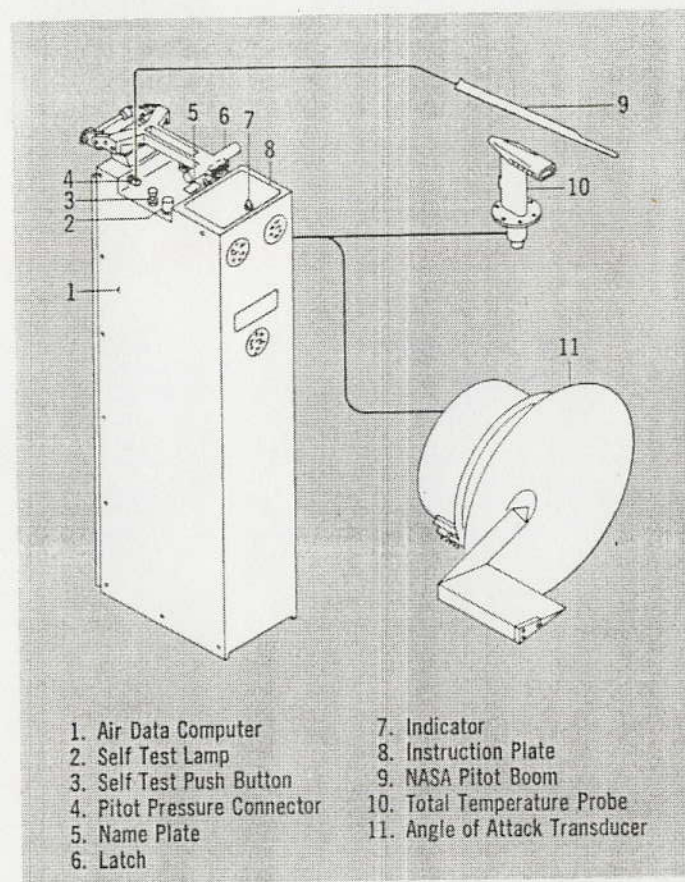
Analog computations are performed on these inputs and converted into electrical signal outputs in the form of:

- Pressure altitude
- True mach number
- True impact pressure
- True airspeed
- True angle-of-attack
- Air density ratio
- Total airspeed

The air data computer electrical output signals are automatically supplied to the following using equipment:

- Automatic Pilot
- Bombing Computer
- Data Link (when installed)
- F-15 A-M Radar
- In-Range Computer
- Inertial Navigator
- Landing Gear Warning
- Navigation Computer

The air data computer is located in the "E" compartment and is operational whenever electrical power is applied to the aircraft.



AUTOMATIC FLIGHT CONTROL SYSTEM

The MH-97 automatic flight control system includes an automatic pilot, stability augmentation (damper) and automatic pitch control (APC). The autopilot and stability augmentation computers are packaged in a gas can and installed in the "E" compartment. Servo actuators and rate gyros are located throughout the airplane. The autopilot control panel is located on the right cockpit console.

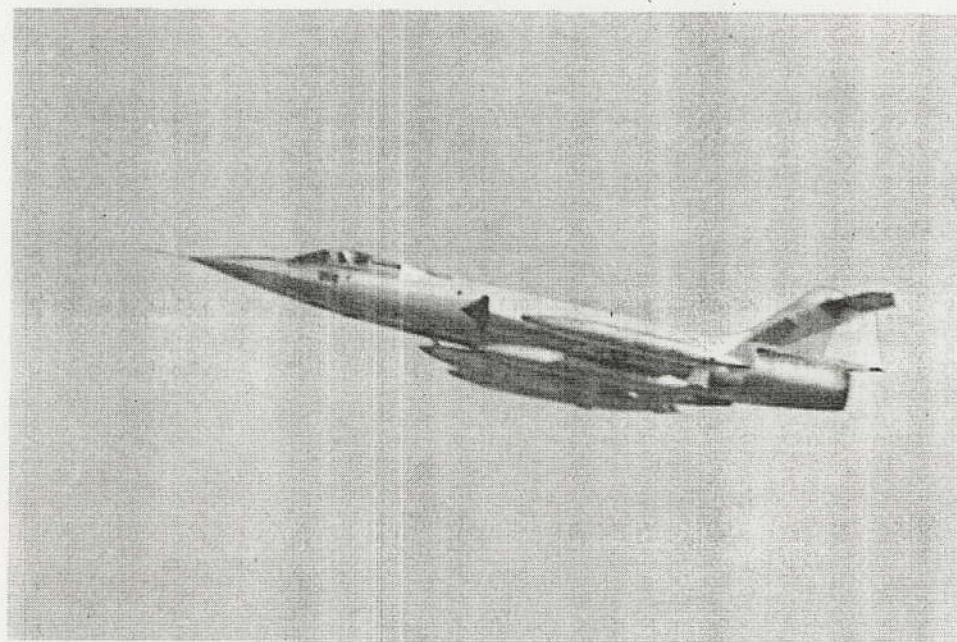
The Automatic Pilot controls the aircraft automatically through the ailerons and stabilizer to obtain the desired attitude and direction. Various flight references can be selected as a basis for automatic flight, and these include:

- Constant Attitude
- Constant Altitude
- Heading
- Mach Number
- Standard Turns
- Automatic Homing for TACAN & Inertial Navigator

The autopilot controls aircraft attitude through the use of electro-hydraulic actuators linked in parallel to the primary flight control system for the ailerons and stabilizer.

The Stability Augmentation system is a three-axis damper that uses rate-sensing gyros to detect undesirable roll, pitch and yaw motions and automatically makes immediate, precise corrections to eliminate the motion.

Automatic Pitch Control system senses and warns the pilot of an impending excessive pitch-up rate and/or impending stall condition. When the pitch-up rate or angle of attack or combination of both, reaches a predetermined limit, a stick shaker will shake the control stick to warn the pilot that a stall condition is imminent. If the pitch-up rate and angle-of-attack continue to increase, the APC will operate a hydraulic cylinder which causes the stabilizer to assume an airplane nose-down attitude to reduce the angle of attack.



WEAPON DELIVERY SYSTEMS

M-2 INTEGRATED BOMBING SYSTEM

The M-2 bombing system automatically computes the weapon release point for external stores in the following modes of delivery:

- Dive Toss — Low angle release
- Dive Toss — High angle release
- Loft, Level Approach — Low angle release
- Loft, Level Approach — Over-the-shoulder release
- Level Approach — High altitude, level release —
cruise
- Level Approach — High altitude, level release —
high speed

The M-2 computer determines the weapon release point based on radar range-to-target information; aircraft altitude, angle of attack, and airspeed data from the air data computer; and aircraft attitude from the inertial navigator. This information is integrated with inputs from the M-2 control panel for weapon ballistic characteristics, mode of delivery, wind values, and distance from IP (bombing run starting or Initial Point) to target. When the actual aircraft position corresponds to the proper weapon release position along the computed flight path, the weapon is automatically released if the dropable stores release button (pickle switch) is depressed.

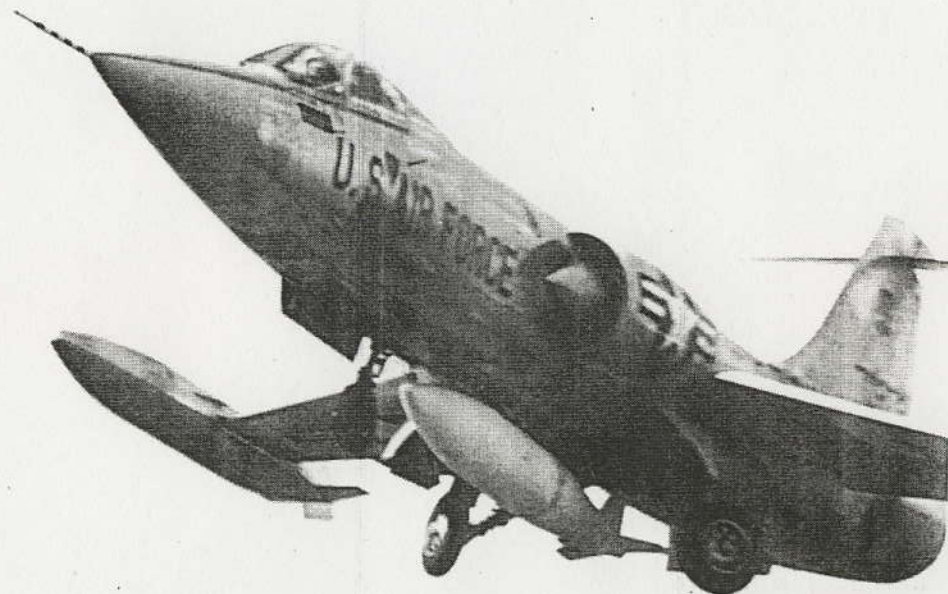
The bombing system computer is located in the "E" compartment and the control panel on the right cockpit console.

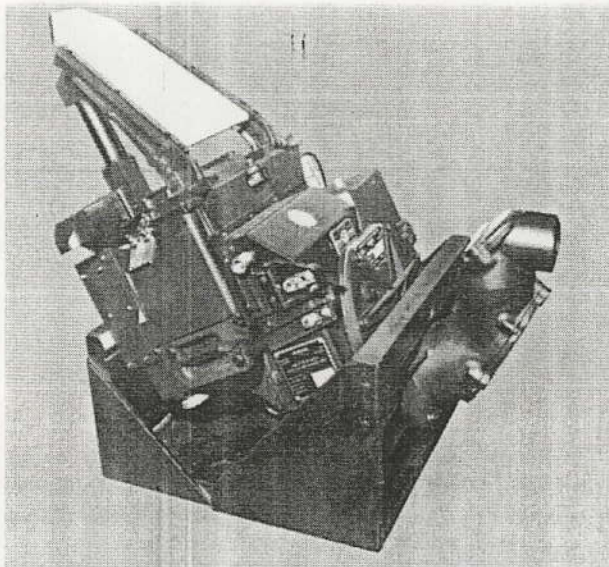
BOMBING DUAL TIMER

The dual timer may be substituted for the M-2 bombing computer. The timer provides a simple, reliable aid for weapon release by a pre-planned maneuver of either free-fall or retarded stores against known, reconnoitered targets. As implied by its name, the item consists of two timer mechanisms operating in series. Each timer may be set for any time interval between 0.1 and 30.0 seconds.

The timers are set on the basis of speeds and altitudes to be flown, delivery maneuvers, and weapon ballistic characteristics. Weapon delivery accuracy is dependent upon precise execution of the pre-planned maneuver.

The dual timer mounts on the pilot's right console in the space provided for the M-2 bomb computer control panel.





OPTICAL SIGHT

The optical sight in the MAP F-104 is of the director type and is designed for use with the M-61 gun, sidewinder missile and in dive bombing.

The sight is located ahead of the pilot's instrument panel and projects a collimated reticle image on the combining glass. When tracking a target the pilot superimposes the reticle center dot over the target. The system, in conjunction with the armament control computer (NASARR) and in-range missile computer, provides visual indication of radar lock-on, point at which the particular armament mode becomes effective, minimum firing range, rate of closure, and aircraft roll attitude.

INFRARED SIGHT

The MAP F-104 infrared detection and tracking system is integrated with the optical sight and the two sights are installed in the aircraft as a single unit. The IR

sight will detect an airborne target and provide visual presentation of the target's location under daylight and night conditions when the aircraft is in position for the IR sight to detect IR energy from the target. The received energy is processed and converted to a visual display consisting of two blue-white curved intersecting lines presented on the optical sight combining glass. The target is tracked by superimposing the reticle centering dot over the intersection of the IR blue-white cross.

MISSILE IN-RANGE COMPUTER

The missile in-range computer determines the launch envelope within which the Sidewinder missile can be effectively released. The computer receives inputs from NASARR and air data computer to determine the maximum and minimum launch ranges for missile firing. The computer also determines the minimum breakaway range to avoid target debris.

After missile lock-on, a steady tone from the missile is channeled through the computer to the pilot's headphones to indicate lock-on. It also indicates to the pilot when the missile "G" limit is being exceeded and when to breakaway.

In the gun mode, the computer furnishes signals to the optical sight combining glass for visual indication of effective gun firing ranges. The computer is located in the "E" compartment.

ELECTRONIC SYSTEMS F-104-17 (BASIC)

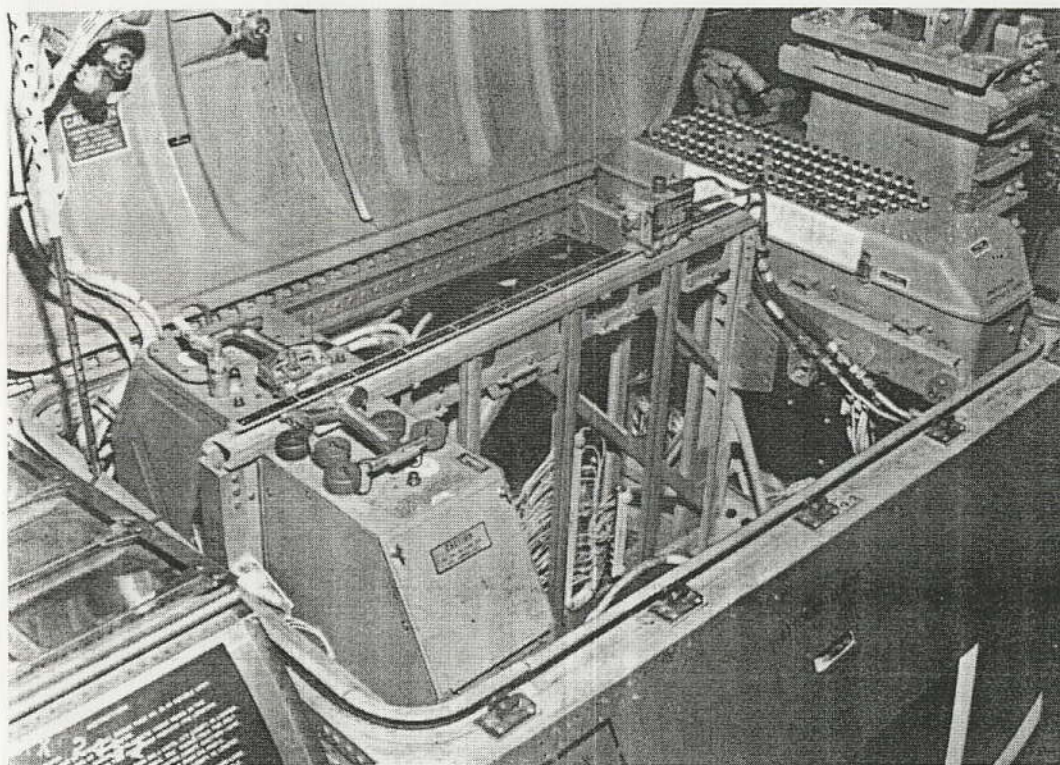
The F-104-17 (Basic), a visual fighter-bomber, can best be described as a MAP F-104 with selected all-weather electronic systems removed to achieve greater simplicity. Elimination of this type of equipment reduces maintenance requirements and procurement costs considerably. The result is a less complex aircraft which still has the speed, altitude, range and full weapon-carrying capacity of the MAP F-104.

To fly effective visual missions, fighter airplanes must have flight performance superior to that of the enemy, and must also have adequate weapon carrying-capacity.

F-104-17 (Basic) fulfills these requirements and provides a very significant combat potential as a visual attack fighter.

Growth potential of the -17 to provide all-weather capability is such that the electronic systems could be procured and installed at a later date if desired, since all wiring, fittings, cables, brackets, etc., will be installed during production. When all-weather capability is required, the necessary modules can be slipped into place and checked out. Under such a plan, it would be possible to equip part of a squadron, or one or more squadrons within an Air Force with the all-weather electronics systems. Pilot training could be conducted on the completely-equipped aircraft in rotation so that all pilots could become trained on the full system if deemed advisable.





ELECTRONIC SYSTEMS IN THE F-104-17 (BASIC)

AN/ARC 552 COMMUNICATION SYSTEM (Collins Radio Company). This 3500 channel UHF communication system operates in the 225.0 mc to 399.9 mc band. A number of the channels are preset (27 plus one guard) for ease of pilot selection while any of the remaining channels may be manually selected in flight.

J-4 COMPASS (Kearfott Division of General Precision, Inc.). The J-4 Gyrosyn Compass system provides an accurate heading reference at all altitudes. The system may be operated either as a magnetic compass or directional gyro.

MM-3 ATTITUDE INDICATOR (Kearfott Division of General Precision, Inc.). The MM-3 indicator system displays the attitude of the aircraft with full freedom of maneuverability.

N-9 OPTICAL GUN SIGHT. The N-9 sight is a simple fixed optical sight located ahead of the pilot's instrument panel. The sight does not possess computing capabilities for determining lead angles. The unit is bore sighted for alignment in the airplane so the projectile and target converge at a predetermined point.

ADF-201 (Collins Radio Company). This automatic direction finding system operates in the low frequency band between 90-1800 kc. The system consists of an indicator, control box located in the cockpit and a receiver installed in the "E" compartment.

ADDITIONAL EQUIPMENT available if required — TACAN, IFF, and UHF-301 Homer.

TF-104 TWO-PLACE TACTICAL FIGHTER-TRAINER

The TF-104 is a fighter with the increased versatility for combat training offered by the two-place arrangement. All outstanding performance characteristics of the single-place airplane are retained in the TF-104. NASARR fire control, navigation and communications systems are the same as in the MAP F-104. The only combat mission concessions made in the TF-104 involve gun firing or centerline stores. This means that the TF-104 need not be supported merely as a trainer, but can also offer substantial increase in combat potential in the event of hostilities.

Main differences which designing for a second cockpit have created in the TF-104 are:

- No gun installation provisions. Nose gear on the TF retracts aft rather than forward and this, among other changes, precludes installation of a gun.
- Fuel tank permanently installed in the gun cavity.
- Some electronic equipment moved from the "E" bay into the ammunition compartment.
- No provision for centerline stores mounting because of nose gear retracting aft.
- No autopilot provisions.
- Doubled-capacity environmental system.

Internal fuel capacity of the two-place F-104 is 700 U. S. gallons compared to 896 gallons for the single-

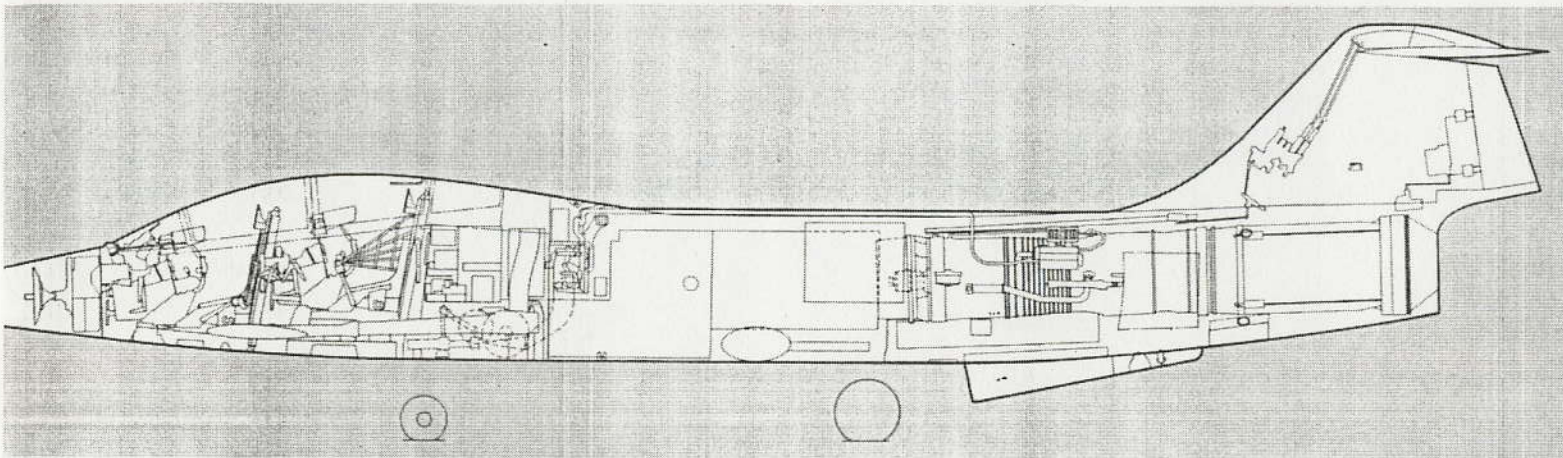
place aircraft. It can, however, mount the same quantity of external fuel tanks on wing tip and pylon stations (up to 730 gallons) as the single-place aircraft.

Normally, the instructor pilot occupies the rear cockpit from which he can completely control the aircraft during all phases of instrument or visual flight, day or night.

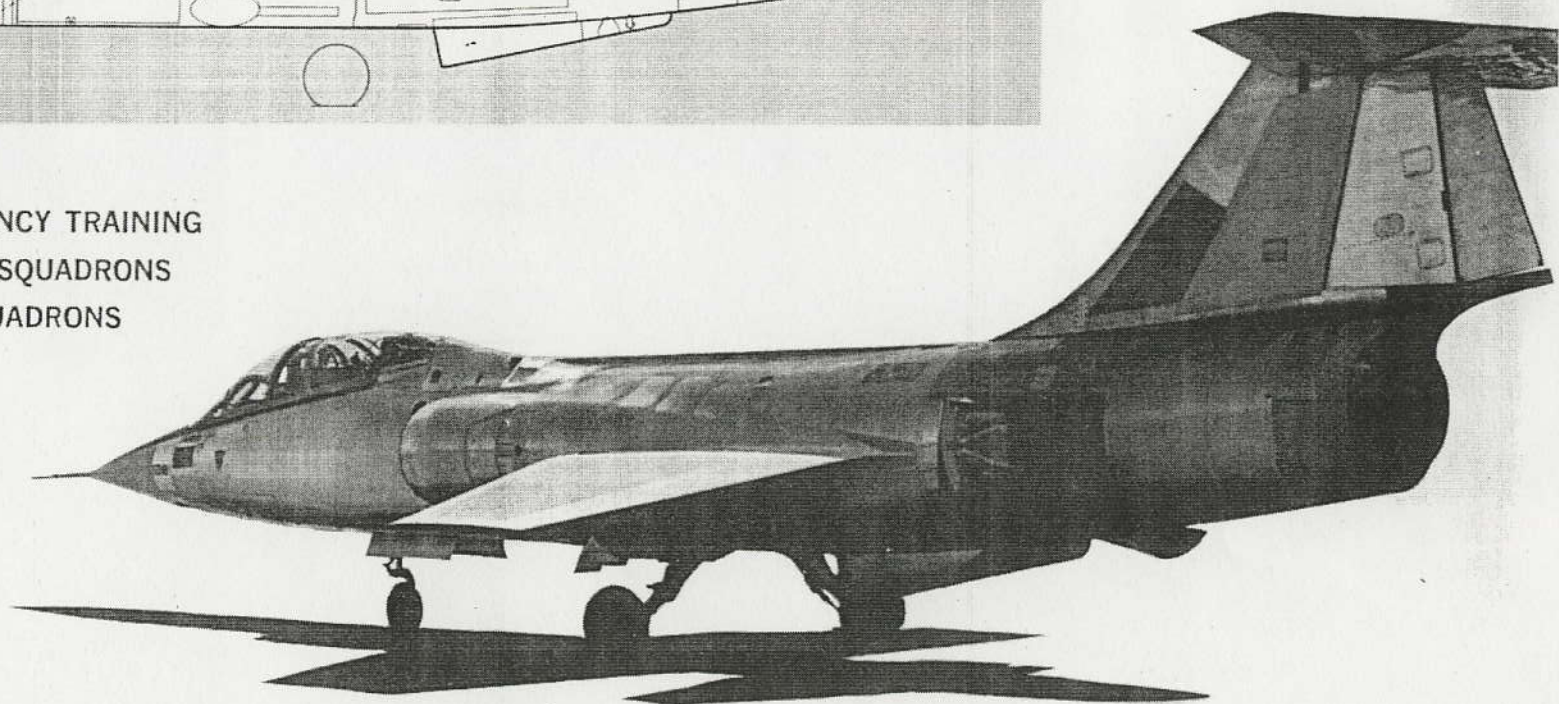
Rocketing and bombing functions, however, cannot be conducted from the rear seat because there is no provision for visual sighting from the rear seat. For these reasons, the armament panel in the rear cockpit is not functional. It does, however, permit the rear seat pilot to monitor the external stores stations selected in the front cockpit. In an emergency, external stores may be jettisoned by the rear seat occupant, and the instructor can also deactivate all weapon release circuits.

A particularly valuable training feature is provided by the electronics transfer panel which permits the NASARR, PHI, TACAN and UHF communications system to be operated from either cockpit with duplicated controls and displays.

Replenishing, servicing, and maintenance provisions and a large percentage of spares are identical for both the single and two-place versions of the Super Starfighter.



- TRANSITION TRAINING
- SYSTEMS AND PROFICIENCY TRAINING
- COMBAT READINESS IN SQUADRONS
- TACTICAL USAGE IN SQUADRONS



PERFORMANCE

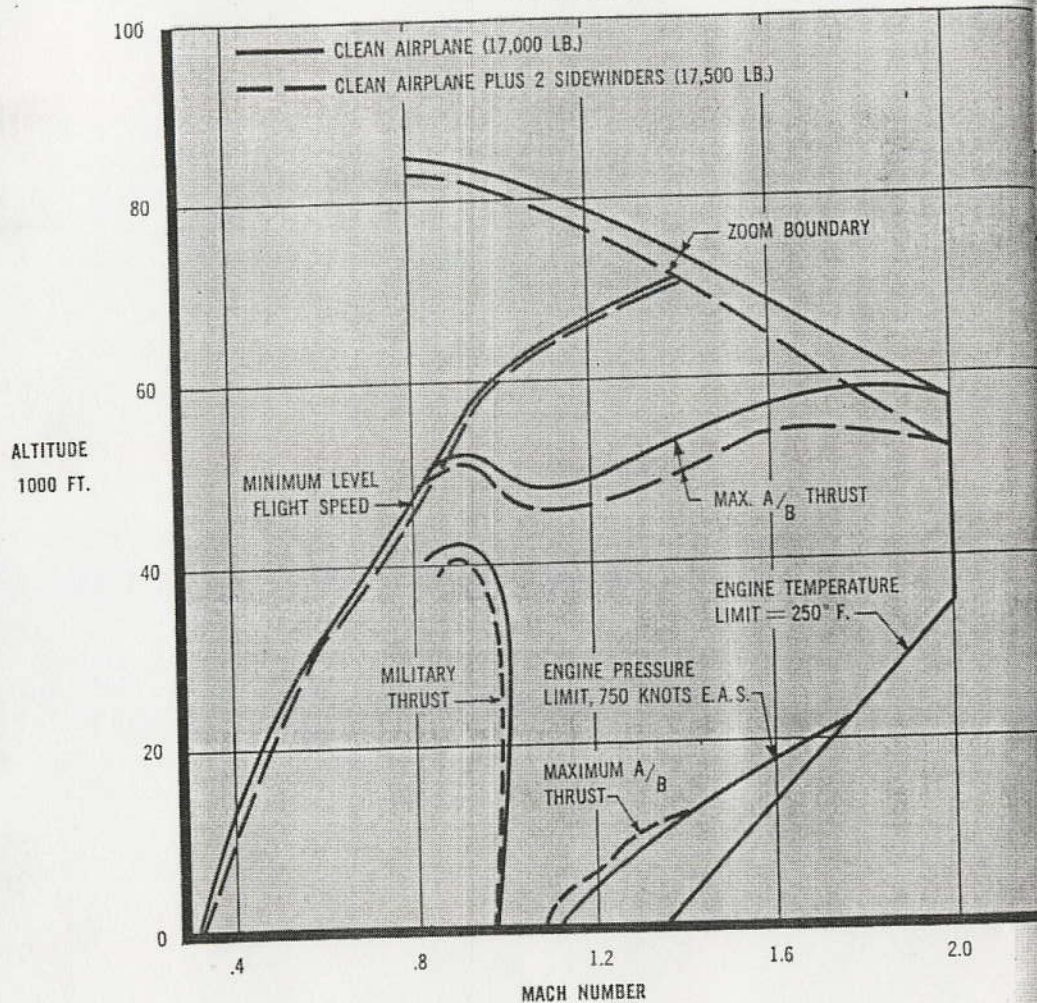
SPEED ALTITUDE

Superior performance is characteristic of all versions of the F-104 Super Starfighter. The airplane, powered by the General Electric J79-GE-11A engine, is capable of Mach 2.0+ speeds at altitudes above 35,000 feet. Transient speeds in excess of Mach 2.2 have been repeatedly demonstrated. Altitudes from 80,000 to 90,000 feet are routine with the zoom maneuver and altitudes well above 100,000 feet have been attained.

At altitudes below 35,000 feet, airplane speed is limited by compressor inlet temperature of 250°F or the engine pressure limit which restricts flight speed to 750 knots equivalent air speed. Near sonic speeds can be maintained with military thrust from sea level to over 40,000 feet. The speed and altitude capability of the F-104, together with the high rates of climb and acceleration, provide outstanding tactical flexibility.

SPEED-ALTITUDE SUMMARY

STANDARD DAY



CLIMB & ACCELERATION

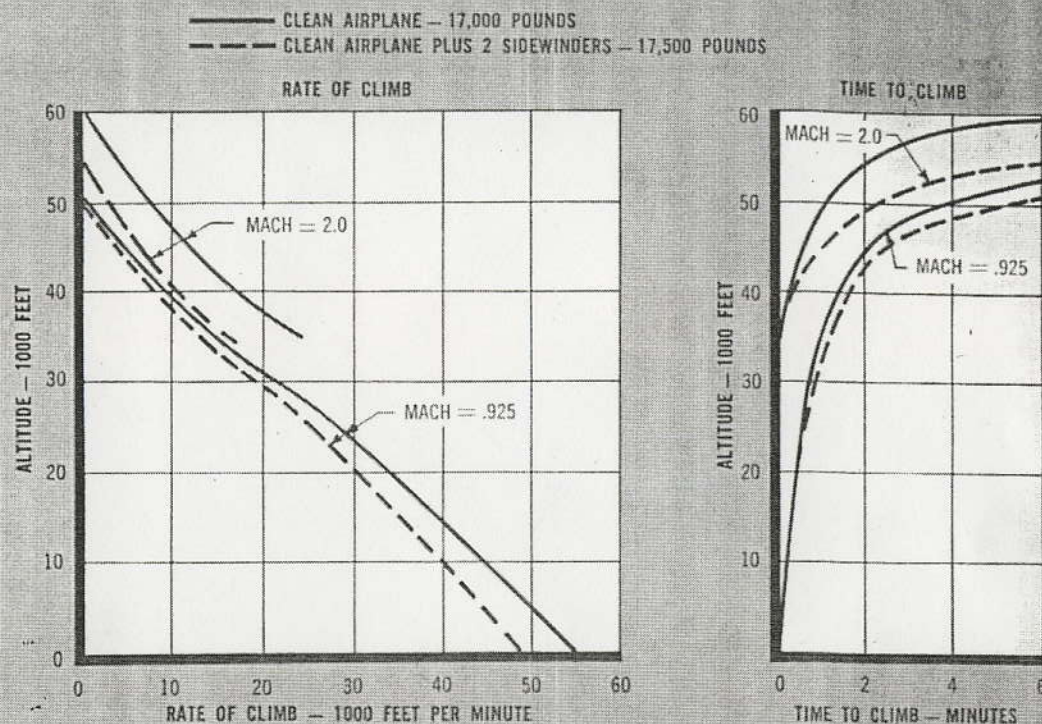
Climb and acceleration capability have long been recognized as the important criteria of high performance aircraft. The F-104 can reach 35,000 feet in 90 seconds. Following acceleration to Mach 2.0, 50,000 feet is attained in 140 seconds. Associated rates of climb are in excess of 50,000 ft./min. at sea level at subsonic speed and 20,000 ft./min. at 35,000 feet at Mach 2.0.

Intercept potential depends heavily on the interceptor's ability to accelerate rapidly since an adequate excess speed margin is essential for achieving high kill probability. The combination of high thrust and minimum supersonic drag inherent in the F-104 design permits acceleration to Mach 2.0 in less than 4 minutes with two Sidewinder missiles and less than 3 minutes in the clean configuration.

These high performance capabilities were forcibly demonstrated in 1958 when an F-104A established a time-to-intercept record against a 35,000 feet target a distance of 178 miles in less than 9 minutes for an average speed of 1186 miles per hour. The record still stands.

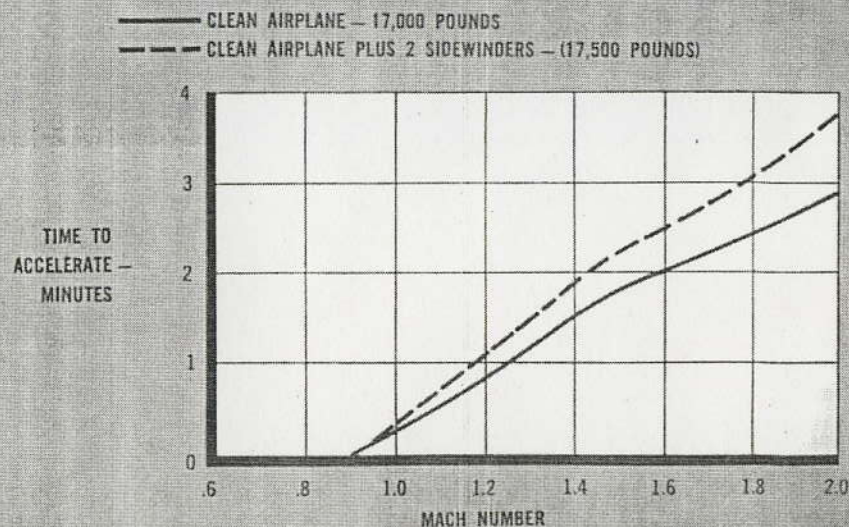
CLIMB SUMMARY

STANDARD DAY



ACCELERATION

STANDARD DAY 35,000 FEET



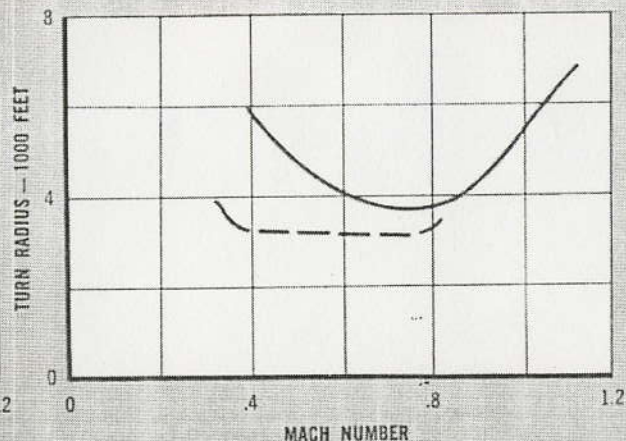
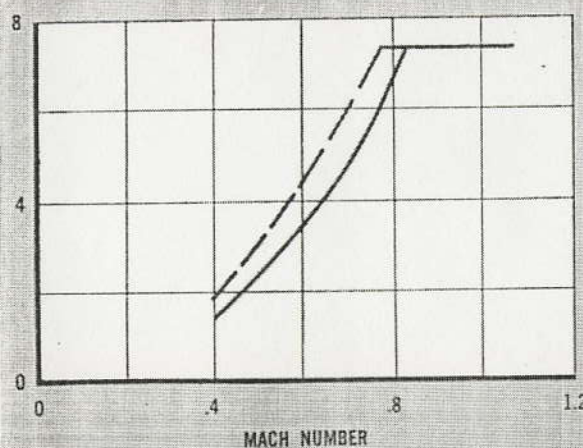
MAXIMUM LOAD FACTOR AND MINIMUM TURN RADIUS

SEA LEVEL

CLEAN AIRPLANE — 19,000 POUNDS

LIMITED BY: STICK SHAKER ACTUATION
STRUCTURAL LOAD FACTORS
AIRFRAME/ENGINE SPEED PLACARDS

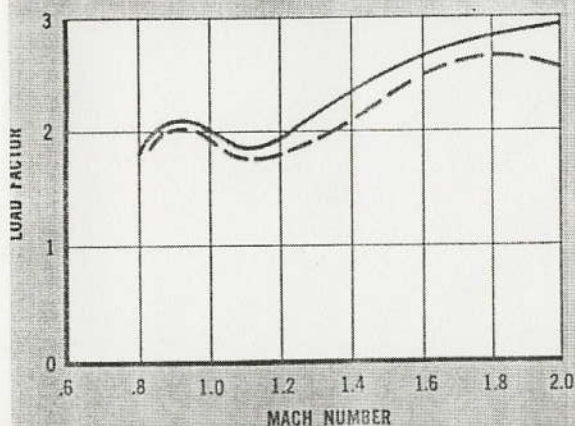
— WITHOUT MANEUVER FLAPS
- - - WITH MANEUVER FLAPS



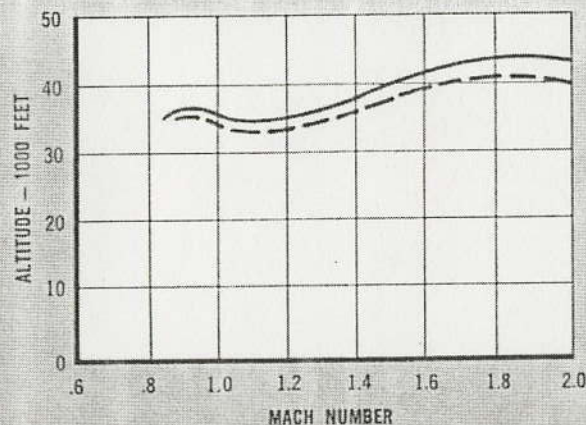
SUSTAINED SPEED MANEUVER LOAD FACTOR

— CLEAN AIRPLANE — 17,000 POUNDS
- - - CLEAN AIRPLANE PLUS 2 SIDEWINDERS — 17,500 POUNDS

ALTITUDE — 35,000 FEET



2.0 "G" CEILING



MANEUVER CAPABILITY

High climb and acceleration rates, though essential, are almost meaningless, unless, after achieving combat speed and altitude, sufficient excess thrust remains for combat maneuvers. Maneuvering capability can be assessed by comparing the maximum load factor which an aircraft can develop with the corresponding required turn radius.

At a typical fighter-bomber weight of 19,000 pounds at low altitude the F-104 requires a turn radius of only 4,000 feet. With maneuvering flaps extended the turn radius is reduced to 3,000 feet. Few aircraft, specifically designed for high performance functions, can match these minimum turn radius values.

Design limit load factors, applicable within the operating speeds shown in the Speed-Altitude Summary, are 6.50 positive and 2.75 negative at the design weight of 20,900 pounds, and 7.33 positive and 3.00 negative at 19,150 pounds.

Pursuit of aerial targets requires that the attacking interceptor possess both a speed and maneuverability advantage over the target. The accompanying curves show the Starfighter's ability to maneuver at sustained speed at 35,000 feet. The second curves illustrate speed capability in a steady 2 G turn.

TAKE-OFF & LANDING

Current versions of the F-104 incorporate 26x8.0-14 low profile tires together with a MLG liquid spring with improved camber angle which extends take-off capability to heavier fighter-bomber gross weights.

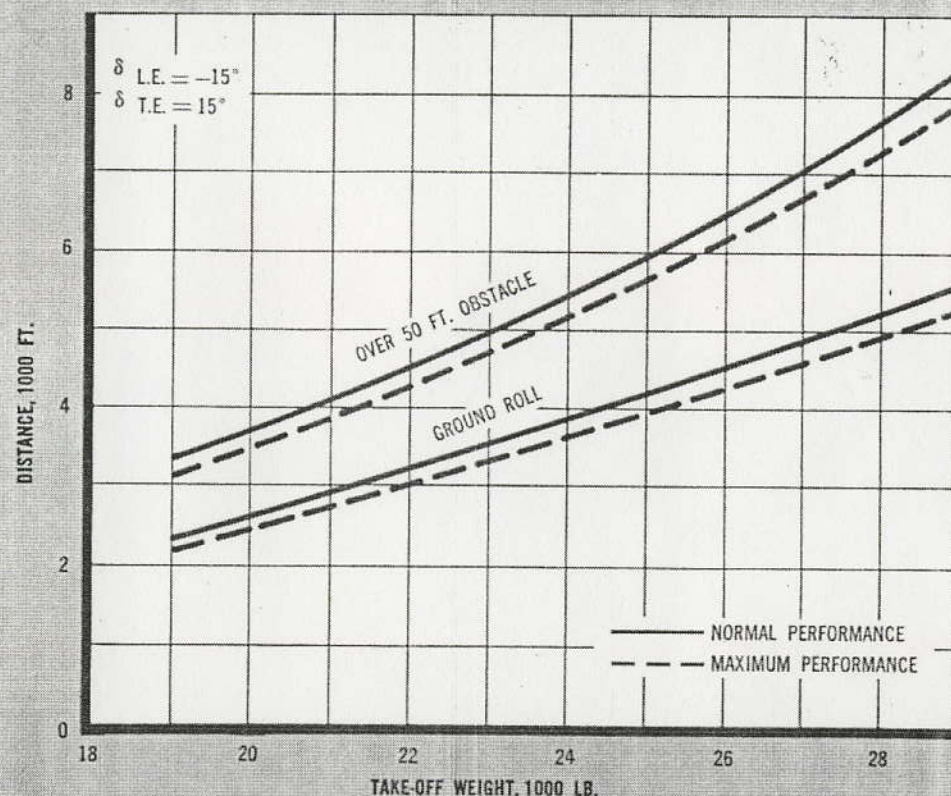
Airfield requirements for take-off on a standard day at sea level are shown for normal and maximum performance take-off procedures. Both techniques utilize maximum afterburning thrust. The two methods differ only in that maximum performance is achieved by rotation to higher angles of attack during nose wheel lift-off. Maximum performance is readily demonstrated by average squadron level pilots. Reference should be made to the standard F-104 Flight Manual for effects of airport altitude, atmospheric and wind conditions on take-off distance.

The 18 foot drag chute is normally deployed during the early portion of the landing ground roll regardless of runway length available. If the drag chute is not utilized, stopping distances are kept to a minimum by applying normal braking procedures.

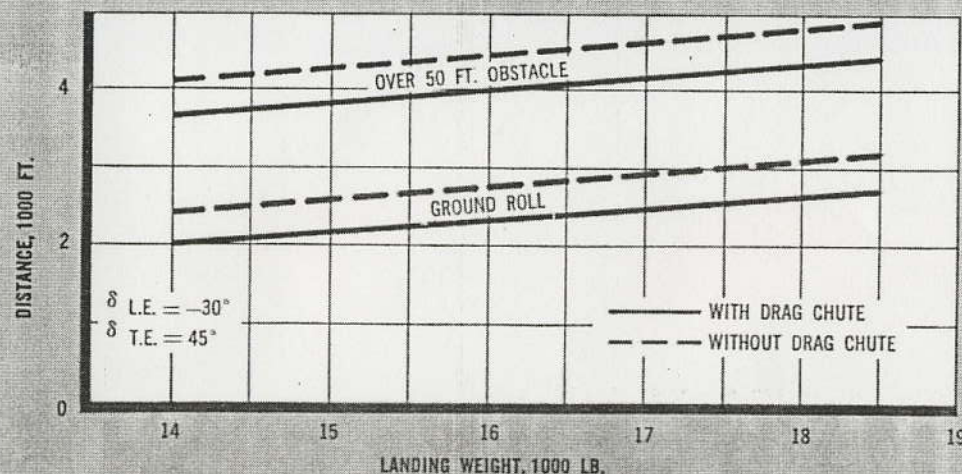
AIRPORT PERFORMANCE

SEA LEVEL STANDARD DAY

TAKE-OFF



LANDING



MISSION CAPABILITY

FUEL CRITERIA

Evaluation of radius capabilities requires establishment of certain discrete parameters not specifically related to the type of flight profile or the fuel and armament loading selected. For example, the fuel allocation made for ground handling prior to flight, and the fuel held in reserve for loiter at the destination airport are quantities which are usually dictated by operational experience. For comparison, radius information is presented for two such criteria, labelled MIL reserves and MIN reserves, corresponding respectively to MIL C-5011A fuel requirements and minimum combat reserves. MIL reserves consists of 5 percent of the total initial fuel plus 20 minutes loiter at sea level. MIN reserves is the fuel required for a 10 minute loiter at sea level. For both criteria, the actual fuel required for take-off is used and a 150 pound fuel allowance made for engine warmup and ground taxi. Each mission includes a 5 minute combat segment at mission radius. Missions under MIN criteria include distance and fuel credit for all descents except let down at home base. No descent credit is included in MIL criteria.

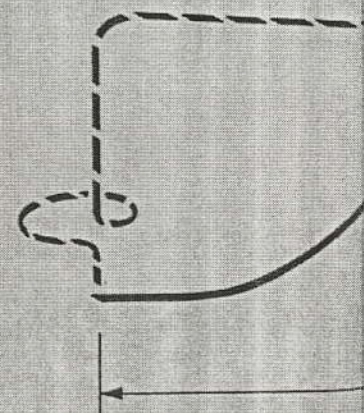
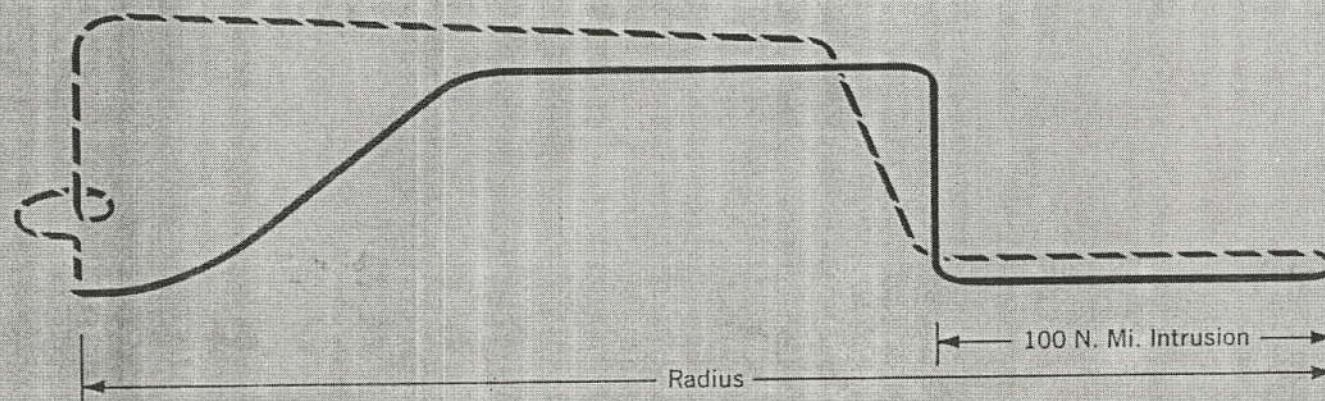
TACTICAL MISSIONS

Tactical mission flexibility of the F-104 is illustrated with selected armament and fuel loadings on typical strike, air superiority, ground support, and ferry flight profiles.

Strike capability is exemplified by the Hi-Lo-Lo-Hi profile with the final 100 nautical miles to and from the target flown at low altitude. Primary armament is a 2,000 pound centerline store. Radius variations with external fuel loading and with the 20mm gun installed in lieu of extended range fuel tanks are tabulated.

External Fuel Load	External Tanks Jettisoned	20mm Gun or Extended Range Fuel Tanks	Radius, N. Mi.	
			MIL	MIN
Pylon Tanks & Tip Tanks (730 Gal.)	Yes	Fuel	548	661
	No	Fuel	448	549
	Yes	Gun	470	575
	No	Gun	385	480
Tip Tanks (340 Gal.)	Yes	Fuel	406	512
	No	Fuel	386	490
	Yes	Gun	325	424
	No	Gun	309	406

HI-LO-LO-HI PROFILE
1 2000 POUND STORE



FIGHTER-BOMBER

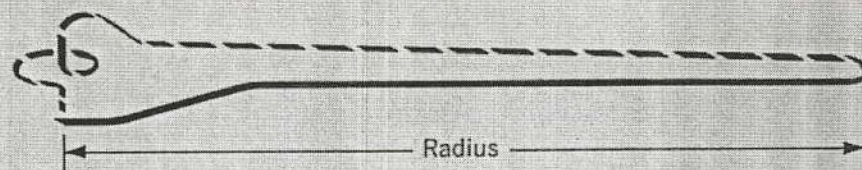
In the role of fighter-bomber, the F-104 provides excellent offensive striking power in close support, interdiction and isolation functions. Starfighter capability is depicted on long range profiles (Hi-Lo-Hi), low altitude penetration (Lo-Lo-Lo), and a combination of the two (Hi-Lo-Lo-Hi).

Tactical surprise is achieved on the Hi-Lo-Lo-Hi profile by flying the final 100 nautical miles into the target zone at low altitude. Survivability is improved by low altitude escape from the target area.

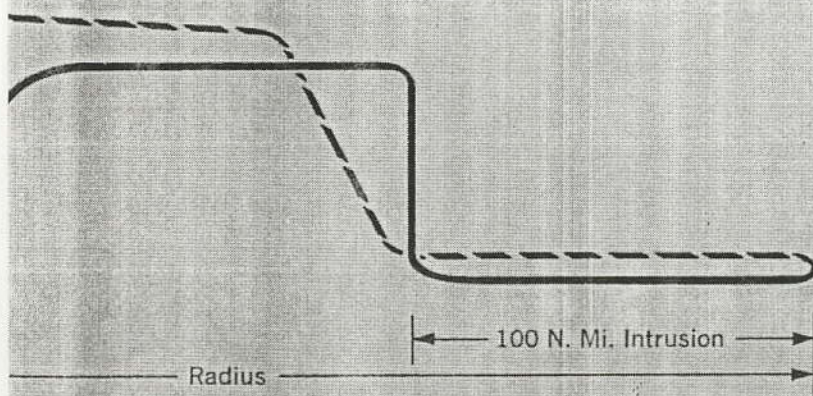
The M-61 gun with 750 rounds of ammunition provides concentrated ground strafing capability and protection against hostile air superiority fighters.

Armament and Fuel Loading	External Fuel Tanks Jettisoned or Retained	Reserve Criteria	Radius, N. Mi.		
			Hi-Lo-Hi	Hi-Lo-Lo-Hi	Lo-Lo-Lo
M-61 GUN 2 GAM 83A Bullpup Missiles or 2 LAU-3 Rocket Pods and Tip Tanks	Jettisoned	MIL MIN	400 502	320 419	260 305
	Retained	MIL MIN	382 480	304 401	253 296
M-61 GUN 2 MK-83 Bombs and Tip Tanks	Jettisoned	MIL MIN	397 497	319 416	262 307
	Retained	MIL MIN	377 474	303 396	253 297
M-61 GUN 1 MK-84 and 2 MK-83 Bombs and Tip Tanks	Jettisoned	MIL MIN	352 444	282 371	246 290
	Retained	MIL MIN	338 428	270 358	238 280

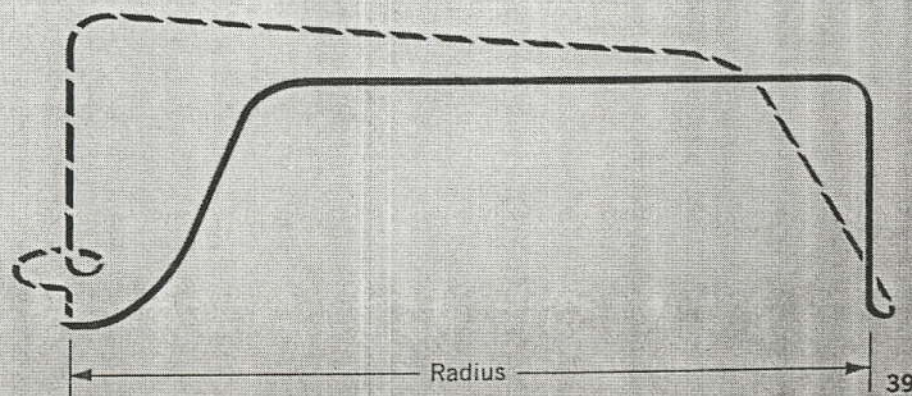
LO-LO-LO PROFILE



HI-LO-LO-HI PROFILE



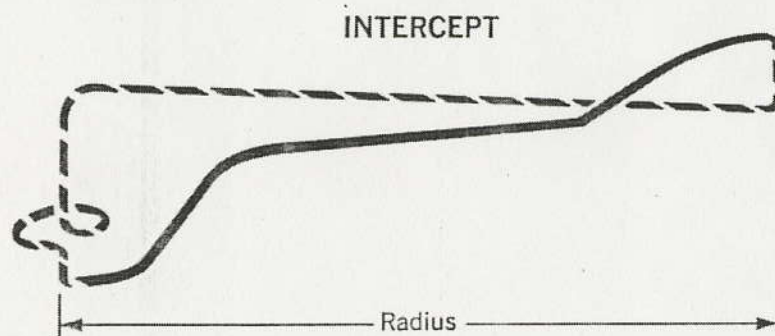
HI-LO-HI PROFILE



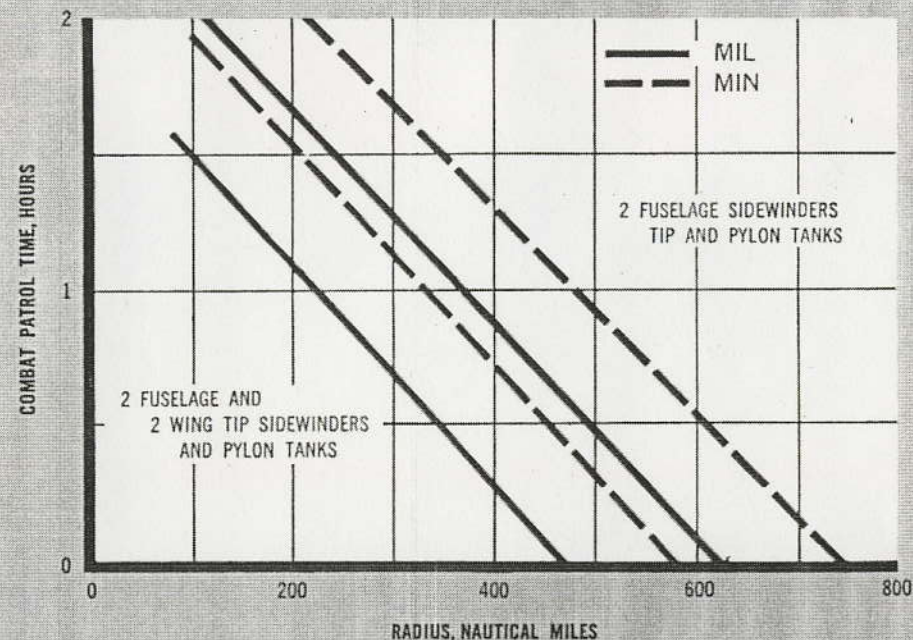
INTERCEPTOR

The F-104 is well qualified to fulfill the functions required of both a high performance interceptor and air superiority fighter. As an interceptor, the Starfighter can be committed against penetrating targets in minimum time. Armed with 2 Sidewinder missiles and by jettisoning pylon fuel tanks when empty, a Mach 2.0 interception at 55,000 feet, 223 nautical miles from base, requires but 16.6 minutes from brake release. With 2 additional Sidewinders mounted on the fuselage 216 nautical miles is attained at a Mach 1.7 combat speed.

Subsonic combat patrol missions require that the attacking fighter possess adequate holding capability near the combat perimeter. Using the standard area intercept profile as a model, the upper chart depicts the rate at which radius can be exchanged for patrol or loiter time. The information presented assumes that the loiter is conducted just prior to the climb to combat altitude.



COMBAT PATROL



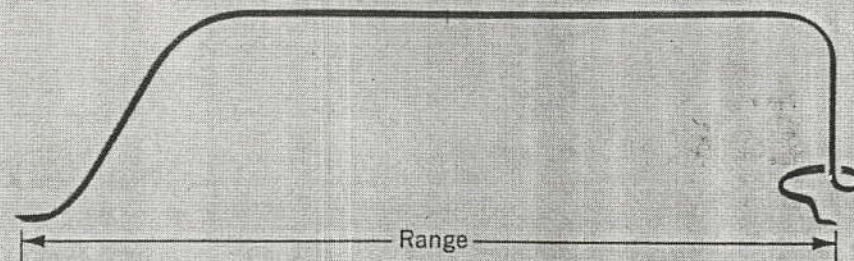
Armament	Fuel	Combat Mach	Radius, N. Mi.	
			MIL	MIN
2 Sidewinders	1408 Gal.	.92	512	627
		1.70	208	268
		2.00	165	223
4 Sidewinders	1408 Gal.	.92	469	576
		1.50	187	238
		1.70	165	216

FERRY

F-104 ferry capability has been thoroughly proved in transatlantic flights by Starfighter squadrons of Tactical Air Command and Air National Guard units.

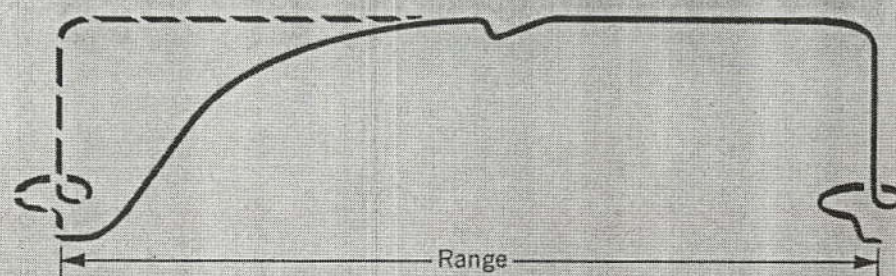
The maximum fuel, long range flight profiles depicted show a maximum ferry range of 1,893 nautical miles with no inflight refueling, 2,728 nautical miles with inflight refueling at the point of no return, and 3,477 nautical miles with refueling made at maximum range. Realistic fuel allowances are included for rendezvous and hook-up. Each successive IFR at maximum range extends the total ferry range by 1,474 nautical miles when MIL reserves are employed and 1,650 nautical miles with GAF reserves.

NO INFLIGHT REFUELING



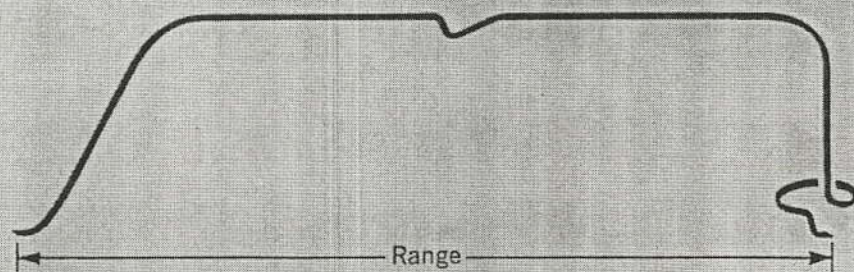
	Range, N. Mi.	
	MIL	MIN
Tanks Jettisoned	1659	1893
Tanks Retained	1307	1483

IFR AT POINT OF NO RETURN



	Range, N. Mi.	
	MIL	MIN
Tanks Jettisoned	2410	2728
Tanks Retained	2054	2318

INFLIGHT REFUELING AT MAXIMUM RANGE



	Range, N. Mi.	
	MIL	MIN
Tanks Jettisoned	3247	3477
Tanks Retained	2891	3067

SERVICE AND MAINTENANCE

Servicing the Super Starfighter requires little in the way of specialized equipment not already on hand in the average fighter squadron.

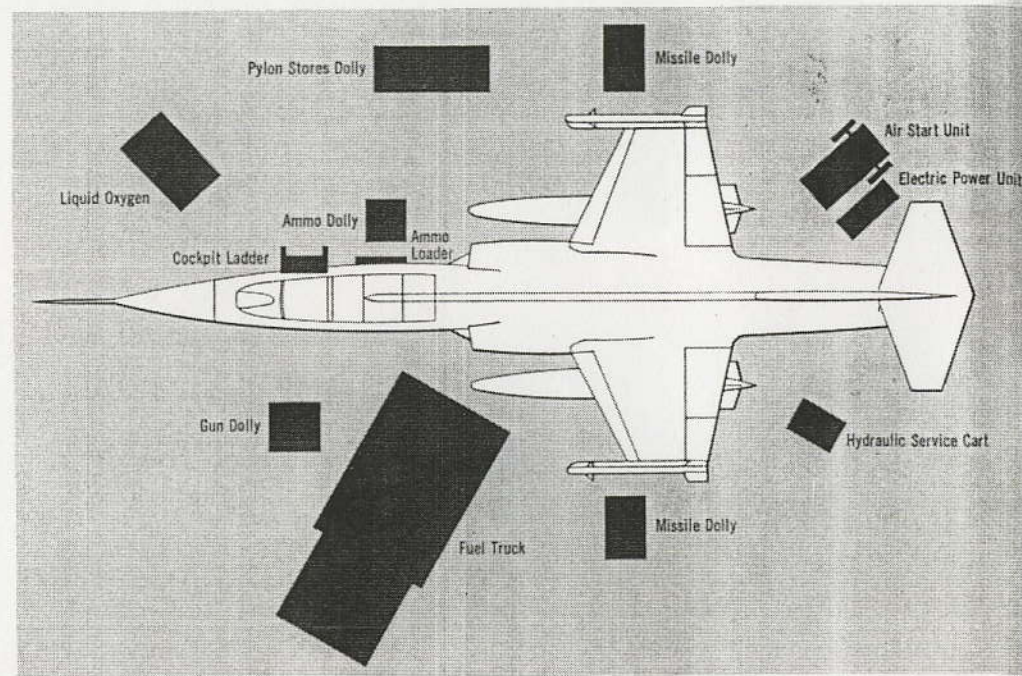
Refueling with MIL-J-5624 JP-4 fuel is accomplished either through the gravity system into each tank separately or by use of a single-point pressure refueling nozzle. Either pit or tank trucks may be used.

Engine oil, MIL-L-7808D, is replenished by use of a hand operated pump and suction line. The oil is applied in sealed, one-quart containers and no special servicing unit is required.

Hydraulic oil, MIL-H-5606, is replenished through use of a special tank servicing unit which is applied as a part of the Aerospace Ground Equipment (AGE).

Pilot's breathing oxygen is replenished from an MA-1 liquid oxygen servicing cart. Capacity of the system is 5 liters of liquid oxygen. Under normal conditions, the system will need servicing only every other day even if the aircraft flies several sorties per day. However, inasmuch as liquid oxygen is not storable, it will boil off and need replenishment even if the aircraft is not flown.

Distilled water is added to the cockpit heat exchanger water boiler after every flight. The water boiler, which supplements the expansion cooling system, is replen-



ished at the steam outlet which also serves as a filler port. If distilled water is not available, tap water may be used providing it is passed through a demineralizing cartridge which can be fitted into the replenishing funnel.

Bottled nitrogen gas is used to inflate the landing gear tires and to pressurize the hydraulic system accumulators. Nitrogen also is used to pressurize the radar during ground checkout.

Turnabout time for the Starfighter, that is the elapsed time from landing to takeoff readiness, can be as little as 13 minutes with a well-trained crew of 5 men. However, the normal turnaround is accomplished in 30

minutes including rearming, refueling, water boiler refilling and visual check of engine and hydraulic oil quantities. This does not include replenishment of liquid oxygen which is a separate servicing done before the first flight of the day.

Scheduled maintenance consists of daily postflight inspections, 25 hour postflight inspections occurring after every 25 flying hours and periodic inspections

which are performed after 200 flying hours. The F-104 is unique in that it is the first USAF fighter aircraft which has been allowed 200 flying hours as the interval between periodic inspections.

25-hour postflight inspections usually require 9.2 maintenance manhours. The manpower required for the 200 hour periodic inspection usually amounts to 192 hours or requires 8 men for 3 days.

