Information regarding the Lockheed F-104 Starfighter

F-104 Propulsion System

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1. F-104 PROPULSION SYSTEM

Lockheed Skunk Works propulsion engineers had to find the right engine for the F-104. After investigation of several turbojet engines, Lockheed decided for the General Electric J-79 because of its better specific fuel consumption and lighter weight.
The J-79 was not available until 1956. In the mean time a Buick built J-65 provided propulsion. With this engine installed the XF-104 reached a maximum speed of Mach 1.79. (Mach 1.0 is the speed of sound 760m.p.h. at sea level.) Almost two years later the YF-104 was equipped with the first GE J-79-3 engine, and made it a Mach 2.0 aircraft. (February 1956) Lockheed used for their F-104's different versions of the J-79 such as J79-GE-3/3a, J-79-GE-3B, J-79-GE-7A, J-79-GE-11A, and J-79-GE-19.
The first GE-J-79 engines, were the most advanced production engines, in the USA defence arsenal since the Korean conflict.
Rated in the 15,000-pound-trust-class, it had the highest trust-to-weight ratio of any United States large jet engine.
The J-79 powered also the Air Force's Convair B-58 Hustler. The US Navy was using J-79 engines in Chance Vought's Regulus II
Missile, the McDonnell F-4H, Grumman's F11F-1F fighter and the North American's A3J weapon system
With the J-79 the F-104 sets new world's speed and altitude records in Mai 1958.
The J-79's Mach 2.0 capability and low specific weight make possible lightweight airframes with "heavy-weight' performance.
The engine's 12:1 compressor pressure ratio assures good subsonic fuel economy. Combined with variable stators, it makes possible excellent performance at Mach 2.0 and provides low weight-saves the many pounds of extra weight necessary in dual-rotor compressor engines. Throughout the J-79's structural and hot static parts, fabricated sheet steel construction replaces castings to save more weight.
Another weight saver: the engine's turbine shaft is "conical". It can transmit up to 70,000 hp at maximum rpm. This J-79 component weighs much less then equivalent cylindrical shafts of the same torsial strength.
On November 6, 1958, Germany decided to fly the F-104G powered by the J-79-GE-11A axial flow, turbojet engine, with afterburner. Major components of the engine are a 17-stage compressor section, an accessory drive section, a combustion section, a 3-stage turbine, a high-trust afterburner, and a variable-area exhaust nozzle.
The F-104's principal deviation from conventional turbojet engine installation is the use of secondary airflow to cool the engine and to improve the exit nozzle efficiency.
As air enters the engine from the duct, it is moved through the compressor by successive stages of rotating and stationary blades.
The inlet guide vanes and the next six stages of stator vanes are variable in pitch, and are positioned to direct air onto the compressor blades at an optimal angle, depending on engine speed.
The compressed air then enters the combustion section where it is mixed with fuel and burned in ten combustion chambers The gases produced by burning are then directed onto the turbine. The turbine is of the three-stage impact type, and is connected directly

to the compressor. The gases impinge on the turbine buckets causing the turbine wheel to rotate. This in turn drives the compressor, sustaining the flow of air through the engine.
In the afterburner section, fuel is sprayed into the discharge of gases from the turbine. Oxygen, still present in the discharged gases, supports combustion of the afterburner fuel, which results in a large thrust increase. The throttle lever controls supply of fuel to the afterburner section. Several increments of afterburner thrust augmentation are available between zero and maximum.
The exhaust ejector has a variable nozzle which automatically adjusts the area of its opening 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.
The accessory drive powers the two hydraulic pumps, two variable-frequency generators, one tachometer generator and the engine fuel and oil system pumps The accessory drive consists of the front gear case (where the starter drive is attached), The transfer gear case, and the rear gear case. The rear and transfer gear sets are driven by radial shafts from the front gear case which in turn is driven by a bevel gear on the compressor stub shaft
The J-79-11A version of the F-104 power plant incorporates numerous improvements over the first version, flown in 1956.
Thrust, times between overhaul, and reliability have been upgraded. Significant improvements in the –11A include the eight-strut front frame and a high stability rotor.

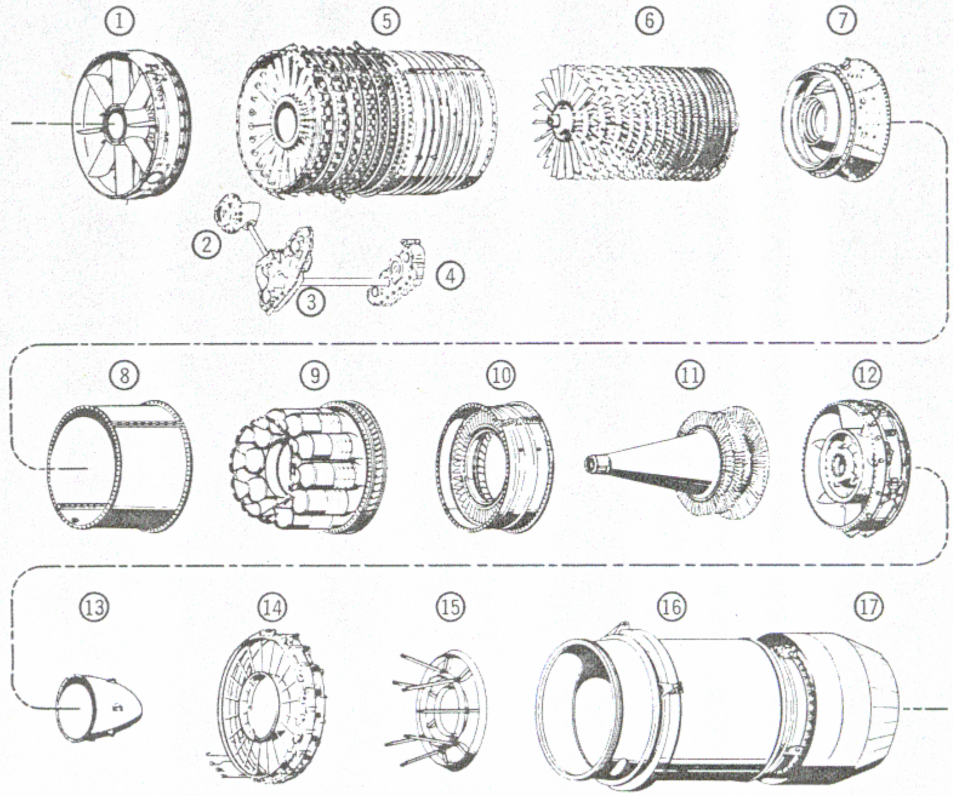
Technical data:

Basic weight, dry:	3560 lbs.
Overall length:	With jet pipe 207,96 inch. Hot: 209,46 inch.
Max. envelope diameter:	Colt: 35,18 inch. Hot: 35,48 inch.
Primary airflow:	160 lbs/sec.
Secondary airflow:	10 lbs/sec.
Performance:	Sea level / 15°C / Static pressure 30 inch mercury

Throttle / pos	RPM	RPM %	Thrust	EGT in °C
Idle	5000	67%	500 lbs	120-420
Normal	7460	100%	9700 lbs	560
Military	7460	100%±1%	10000 lbs	590 ±10
Min A/B	7460	100%±1%	12320 lbs	590 ±10
Max A/B	7460	100%±1%	15800lbs	590 ±10

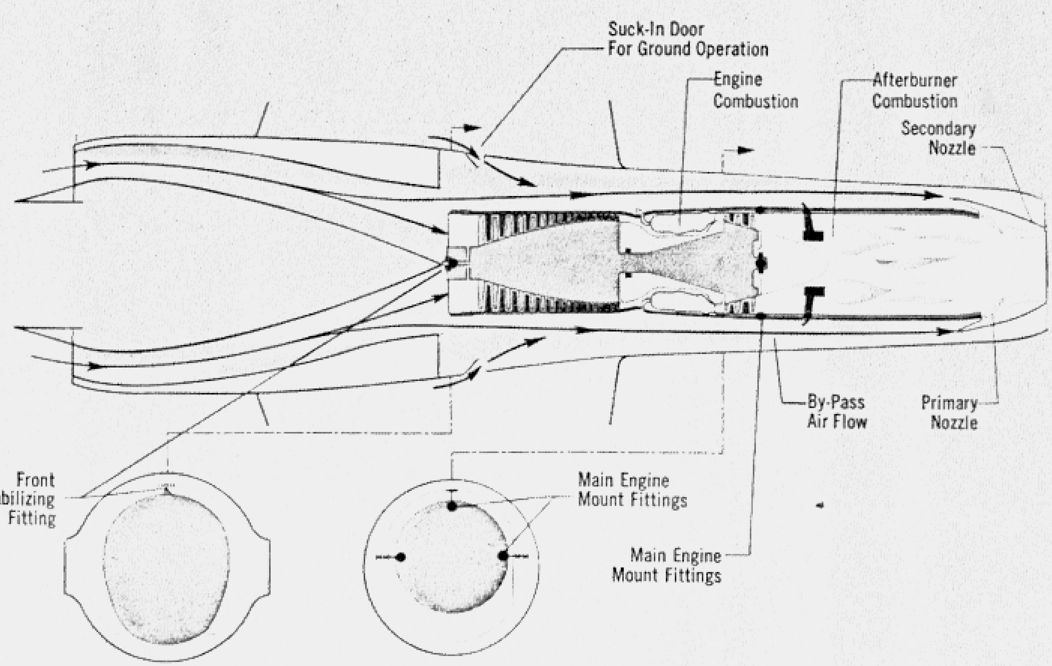
Fuel consumption: 1,97 lbs/hr (Take off thrust 15800lbs)

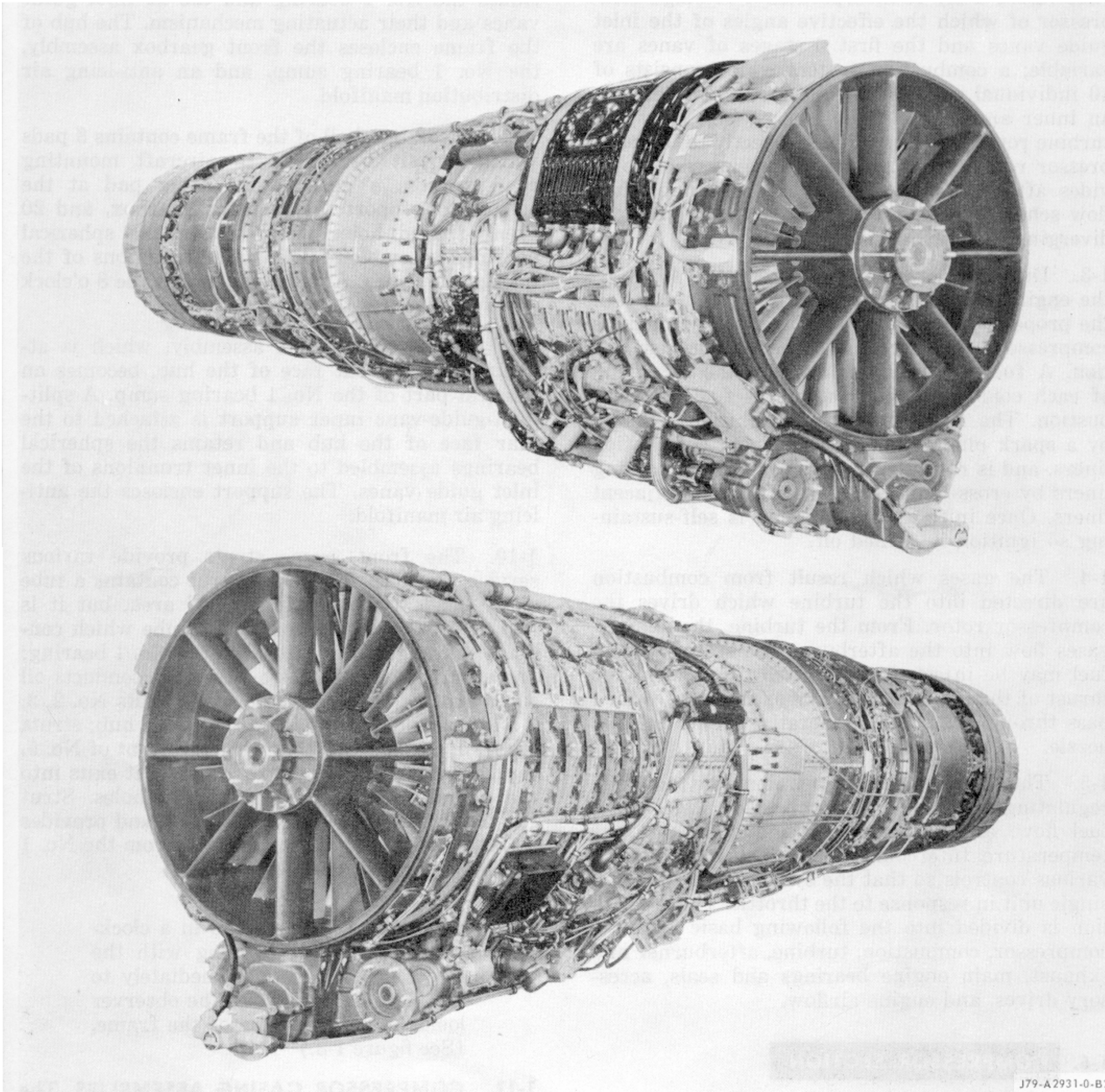
MAJOR COMPONENTS OF J79-GE-11A ENGINE



1. Front Frame
2. Front Gearbox
3. Transfer Gearbox
4. Rear Gearbox
5. Compressor Casings
6. Compressor Rotor
7. Compressor Rear Frame
8. Outer Combustion Casing
9. Combustion Section
10. Turbine Casing
11. Turbine Rotor
12. Turbine Frame
13. Rear Inner Cone
14. Afterburner Fuel Manifold
15. Flameholder
16. Tailpipe
17. Exhaust Nozzle

F-104 ENGINE INSTALLATION





Purpose: 1 Discharge the air intakes at supersonic speeds.

2. Cooling the outside of the engine.
3. Transport of gases and vapours from the engine compartment.
4. Create the divergent part for the aerodynamic nozzle

With landing gear up the secondary airflow has a flow opening of 44 sq.inch. This opening of 44 sq.inch is needed to obtain a secondary airflow of 2,10 lbs/sec at Mach 2.0. At speeds below 350 knots the air intakes deliver too short of air. When pressure decreases in the intakes, lower as in the engine compartment, causes a so-called reversed flow to the air intakes through the by-pass flaps. J79-GE-19 required auxiliary inlet doors on the air intakes!

2. Engine airflow

a**. Primary**

Below 350 knots, the engine not only gets the air through the air-intakes, but also through the boundary layer channel, and also passes the air by-pass flaps, (reversed flow from the engine compartment). The air intakes are constructed for speeds till Mach 2.0, and will give the best airflow control at this high speed. With supersonic flights, there always will be a subsonic airspeed at the engine inlet. This results in rising pressure and temperature. The constant airspeed by the engine is Mach 0,4-0,5.
For instance:
On 35000 ft the temperature will be –56 °C, and the aircraft speed is Mach 2.0, the speed of air will be reduced in the air intakes
till Mach 0.4 - 0.5. By this, the pressure will rise up to 0,7 times, and this will result in the increase of temperature till 100 °C.
In the left-hand cooling duct of the generators there is a measuring point of the “Slow” warning light. In the right-hand cooling duct the air inlet temperature will be measured

b**. Secondary**

Engines:

Wright J-65	Used on XF-104
J-79-GE-3/3A	Used on F-104A/B
J79-GE-3B	Used on NF-104 / F-104A/B
J-79-GE-7A	Used on CF-104 / F-104C/D
J79-GE-11A	Used on F-104A/G/J/F
J79-GE-19	Used on F-104A/S

The engines were built by:

Buick	USA (J-65)
General Electric	USA
BMW /MTU	Germany
Fabrique National	Belgium
Fiat	Italy
Orenda	Canada
Mitsubishi	Japan