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ROLAND BEAMONT continues his recollections of test-flying second-generation American jet fighters in the Fifties with the Lockheed F-104 Starfighter

Air Force Flight Test Center photos

TESTING THE AMERICAN JETS: F-104

The Lockheed production and test facility was on the other side of Palmdale Airport, and there on June 26, 1958, began a comprehensive and distinctly serious briefing conducted by a combined team of USAF project test pilots and Lockheed pilots and engineers.

The reason for the underlying seriousness of the briefing soon became apparent when the safety and precautionary aspects were covered. The F-104 had been having an unhappy reputation since it had entered USAF testing in the previous year, and already 19 test pilots had been lost. The main cause, engine flame-out, had not been eradicated at this stage, and much attention was given in briefing on all possible engine-out situations.

In the main these recommendations boiled down to "eject", but with the proviso that if the engine flamed out on the climb below 1,000ft or on the approach below 2,000ft, the only way out would be to try to roll inverted before using the downward-ejecting seat!

It was confirmed that the F-104 was cleared to Mach 2 (with very careful throttle handling to avoid compressor surge flame-out) and that the writer was permitted to "try it if he wished"!

But enthusiasm for this small, almost wingless, fighter seemed at best muted and overshadowed by predominance of items which were not permitted for investigation over those which were.

This was all impressive, particularly the briefing on high angle-of-attack handling and spin avoidance by project pilot Dave Holloman. But when I was strapping in to fly on the following day, the flight was delayed and a column of smoke could be seen out on the desert. It marked Holloman's last flight: his '104 flamed out when approaching to land at Palmdale.

After about an hour's delay, flying was resumed, and I flew three interesting sorties. Extracts from the briefing details and the final test report on the last of these sorties follow:

Lockheed F-104A
Introduction
Morning of June 26, 1958: Lockheed production plant, Palmdale. Discussions and briefing were held with:

Captain Jordan	USAF Fighter Test Operations, Edwards AFB
Captain Rushworth	USAF Fighter Test Operations, Edwards AFB
Mr I. Pratt	Senior Production Test Pilot, Lockheed, Palmdale
Mr Schalk	Engineering Test Pilot, Lockheed, Palmdale
Mr Holloman	Engineering Test Pilot, Lockheed, Palmdale
Mr D. Brown	Engineering Test Pilot, Lockheed, Palmdale
Mr G. Guisler	Production Flight Test Engineer, Lockheed, Palmdale

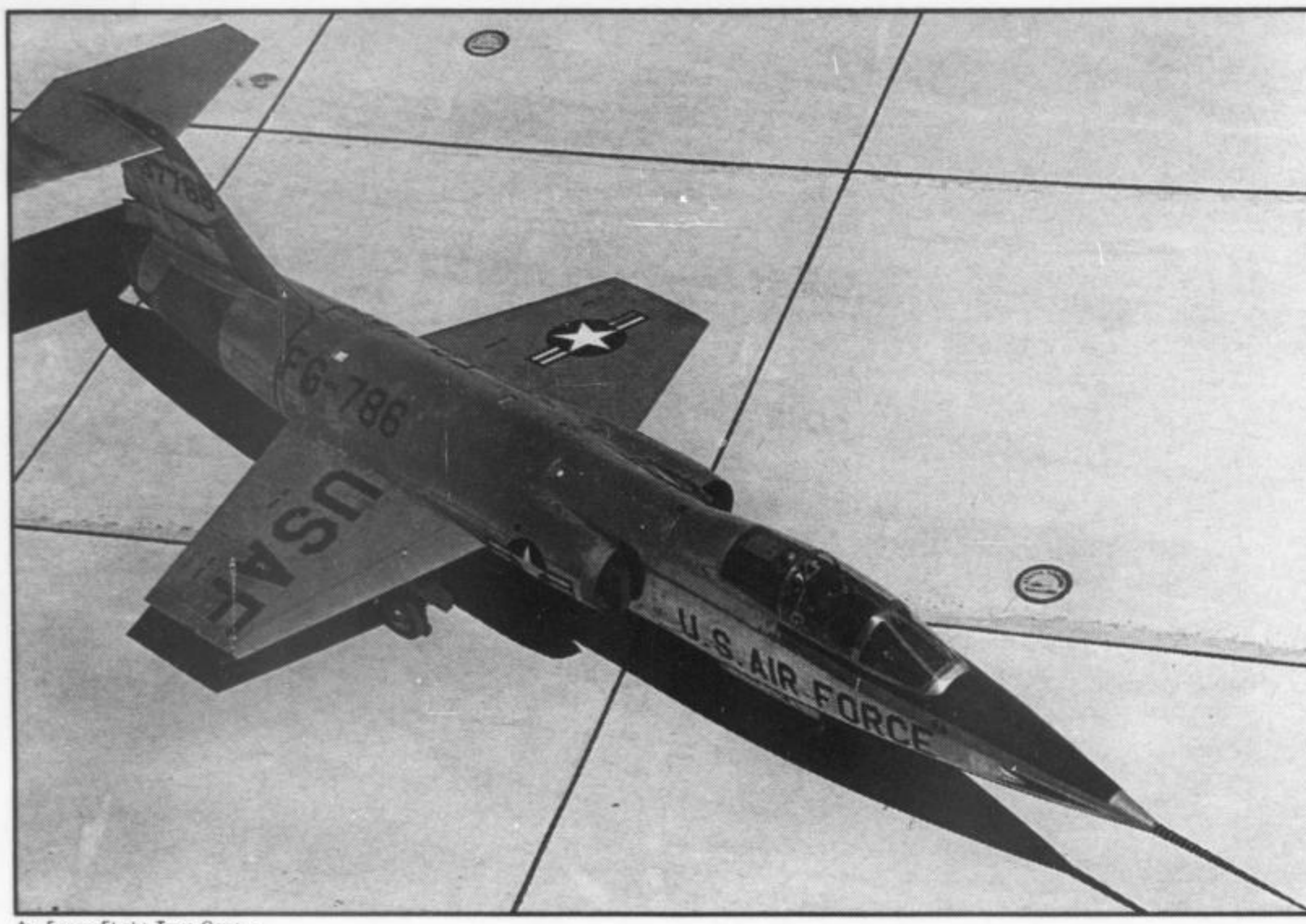
Status: limited squadron service. Day/fair weather only.

Early series aircraft were fatigue-limited to 575kt below 30,000ft, but with the new "steel" tail the q limit is 800kt equivalent airspeed.

Mach limits are M=2 or a compressor inlet

Heading picture *and* **below,** *the first prototype of the "missile with a man in it": Lockheed XF-104-LO 53-7786*

F-104As of the USAF's 83rd FIS over San Francisco's Golden Gate Bridge in 1958



Air Force Flight Test Center

The Wright XJ65-powered first prototype XF-104, 53-7786, made its first full flight on March 4, 1954, in the hands of Tony LeVier.

temperature flight limitation of 100°C (absolute limit 120°C).

Weights:	Clean configuration	19,502lb
	Two Sidewinders	19,936lb
	Two Sidewinders+ pylon tanks	22,986lb
	Tip and pylon tanks	25,057lb

The tip tanks have been cleared to M=2, but are excessively draggy; and the pylon tanks have been cleared to M=1·7 again with very heavy drag. The pylon tanks are intended purely for subsonic ferry purposes.

Engine:	J79-FE-3A
Static sea level thrust	9,000lb-thrust cold 15,000lb-thrust reheat

The J79-7 which is now coming through the production line and was in one of the aircraft subsequently flown has a "T2 reset" modification which restricts rate of engine deceleration in order to prevent intake buzz, and is also uprated to give approximately 2,000lb increased reheat thrust (sea level static).

The wingtip tanks have been jettisoned satisfactorily at M=1·5 and carry 165 US gal each.

The pylon tanks carry 200 US gal each.

The wingtip-mounted Sidewinders which are standard armament in Air Defense Command cause no flight limitations. No increase in drag has been measurable, but the small increase in aspect ratio from the tip attachments is claimed to have improved altitude handling.

A spinning programme has been completed to USAF requirements by Lockheed, and these were described by the Project Pilot, D. Holloman.

Right *and* **below,** *the first of 17 YF-104As built, 55-2955. This variant had a much longer fuselage than the XF-104 to accommodate the General Electric J79 engine and improve handling.*

The aircraft does not spin easily as it normally enters from the stall into its characteristic pitch-up manœuvre from which there is no recovery by direct pilot action.

Pitch-up occurs at 23° angle-of-attack, and the aircraft then goes through a pitching and rolling manœuvre from which recovery normally occurs without pilot action in the inverted position after a height loss of 11,000–13,000ft. In order to avoid entering this condition a vane-operated stick-shaker is fitted which operates at 17° angle-of-attack, and if despite the stick-shaker warning the aircraft is still allowed to reach 20° angle of attack, an auto pitch control imparts a sharp forward motion to the stick, moving the tailplane through 1°. This is effective in preventing pitch-up with all but the most determined pilots.

Spinning has had to be achieved by pro-spin control movement immediately before pitch-up, and recovery from the spin is with forward stick only, ailerons and rudder neutral. Anti-spin rudder and pro-spin aileron have prevented spin recovery.

Even with the forward stick technique recovery is critical as, unless a lengthy dive-out is held, the aircraft will go into the pitch-up condition immediately on leaving the spin.

These trials have been conducted to an "acceptable" clearance condition by the company, with observation in the air and on the ground by USAF observers. The USAF "does not require to repeat the trials".

Damping rates at v_{max} were described, with stabilisers IN, as:

Yaw	deadbeat in one cycle/2sec
Roll	deadbeat in three cycles/4sec

With yaw and roll dampers OUT a continuous dutch roll was present at one cycle per second, of unspecified amplitude and undamped, at any speed supersonic and also to a lesser extent subsonic. Directional stability N_v at M=2 was described as "positive".

Pitch damping with stabiliser OUT at M=2 was quoted as half amplitude in two cycles, and deadbeat in six cycles; stabiliser IN, one cycle/2½sec to deadbeat.

In answer to a question on control effectiveness in the recent energy climbs to very high altitude, it was stated that there was adequate though sluggish aileron response and similar control in pitch in the nose-down sense up to the maximum height reached (at that time) of 90,000ft. At this height there was little nose-up control owing to running out of stabiliser trim.

At 90,000ft the cabin altimeter had indicated 55,000ft, and the pilot's personal clothing (PP suit and K1/2 helmet) had pressurised automatically. The latter equipment was regarded as reasonably satisfactory for experimental purposes because the flights were of short duration, and because the faceplate could be removed during the latter part of the descent for return to circuit and landing.

The flap-blowing system was regarded as critical in the approach configuration, and on lowering full flap the pilot was required to check

Air Force Flight Test Center photos

Right, *another view of the first prototype XF-104, fitted with wingtip drop tanks. This aircraft was accepted by the USAF in November 1955.*

for symmetry in the flap-blowing circuit. If more than half an inch of stick displacement were required to correct in the lateral sense the flap-blowing had to be regarded as suspect, flaps retracted, and the landing carried out with hold-off at 190kt. Wheel rotation limit 225kt, drag chute shear link 225kt.

Airbrakes cleared for operation at any speed.

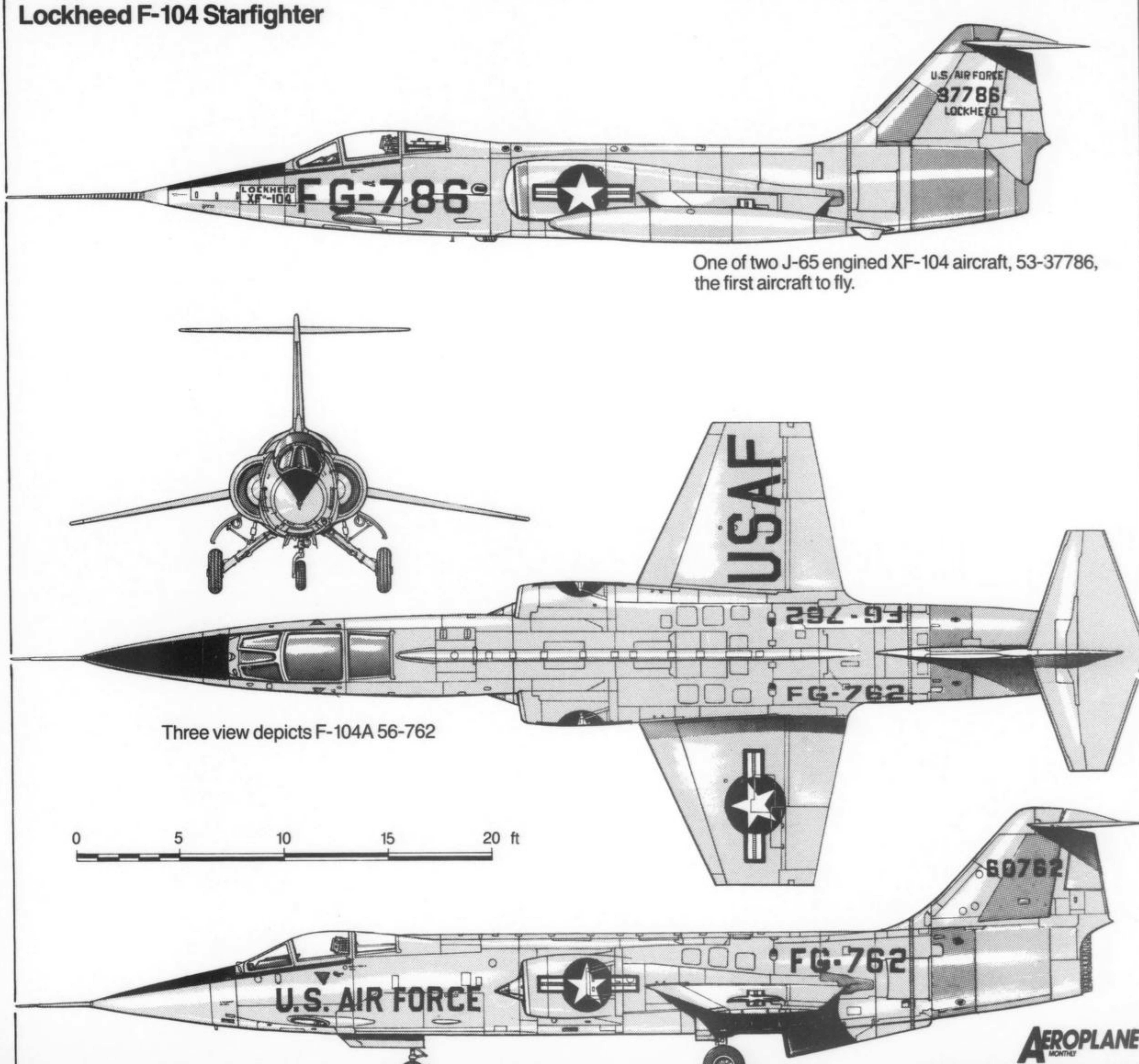
Considerable attention was given to engine handling, and the critical nature of the flame-out recovery was stressed in detail.

Reheat lighting was reliable below 35,000ft, and lighting and cutting below this height were not critical. Above 35,000ft there is a progressive uncertainty, and above 45,000ft instability and reheat flame-out were likely in "intermediate" and possible at any stage. Reheat flame-out would often then result in engine flame-out, and engine relighting in flight could not be relied on.

Variation of reheat thrust was without r.p.m. variation, but care had to be taken when cutting reheat to prevent reducing power below max cold, as this in the unmodified engine was liable to cause intake buzz, compressor stall and flame-out. On the -7 engine a "T2 reset" modification had been incorporated which restricted the rate and conditions under which cold r.p.m. could be reduced. This did not preclude the probability of engine flame-out in the event of reheat instability and flame-out.

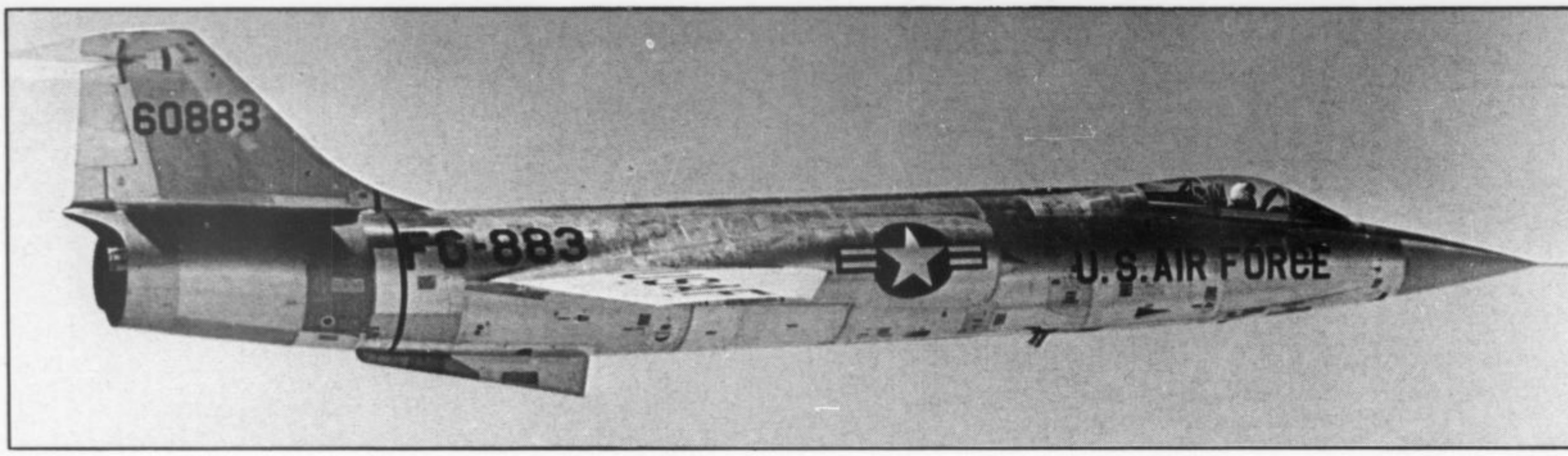
In view of the record of this aircraft in terms of the proportion of fatal accidents to attempted flame-out landings, it was advised that the aircraft should be abandoned in the event of not being able to relight a flamed-out

Lockheed F-104 Starfighter



One of two J-65 engined XF-104 aircraft, 53-37786, the first aircraft to fly.

Three view depicts F-104A 56-762



Above, *56-883 was the first of 77 F-104C tactical strike variants delivered to the USAF. Note the ventral fin, added from the YF-104A onwards to improve supersonic directional stability.*

engine by 20,000ft. After some five hours' experience on the type it was recommended that an attempt should be made to land a flamed-out aircraft on the 7-mile runway at Edwards; but this could be done only if the aircraft could be positioned at a minimum of 17,000ft over Edwards outbound. From this point at 240kt IAS a 180° gliding turn was made on completion of which the pitot probe would be pointing at the point of contact with the ground. If this did not coincide with the landing end of the dry lake the pilot would abandon the aircraft. Alternatively, if the touchdown could be made on the lake, the dive/glide would be continued until passing through 2,000ft where the undercarriage would be lowered without checking glide angle, and it should then lock down when rotating for touchdown at around 200kt/200ft.

Some successful flame-out landings had been made in this manner, and a new one was in fact made during the first day of this visit, by a Lockheed test pilot from Palmdale who landed successfully with a full compressor stall at Edwards.

An unfortunately large number of fatal accidents had occurred under similar circumstances, however, and on the second day at Lockheed, Mr Holloman, the Engineering Test Pilot who had described the spinning trials, was killed just short of the runway threshold at Palmdale when an engine flamed out apparently during a normal approach.

V_{max} was limited by a compressor inlet temperature flight limit of 100°C (actual 120°C), or by M=2, whichever was the lower.

Cabin pressure differential 5lb/in^2.

The downwards ejection seat system seemed unlikely in the extreme to provide a safe escape facility below about 1,000ft, and only then if the aircraft was rolled inverted before ejection.

I reported the fourth F-104 sortie as follows:

Flight report No 6

Aircraft:	F-104A No 762
Engine:	J79-7
Date:	June 27, 1958

Lockheed Production, Palmdale

Weight:	18,886lb
Fuel (usable):	5,889lb
Limitations:	M=2 or CIT 100°C 575kt EAS below 30,000ft
Flight time:	35min

After a third '104 sortie had been aborted on the runway owing to UHF radio failure, a final sortie was successful.

As before, entry into the cockpit, seat adjustment, accessibility, readability and layout of all controls and instruments was appreciated.

Engine start satisfactory. Systems and warnings normal.

Engine idling 68 per cent, 420°C, nozzle $\frac{3}{4}$.

The view on taxying was again noticeably improved over the Convair fighters, but holding in of the nosewheel-steering button on the stick was inconvenient, especially on the long taxying involved between the Lockheed plant and the threshold of the runway in use (25, approximately $1\frac{1}{2}$ miles from start-up point). Fuel 5,400lb.

With power at 95 per cent, 590°C, reheat was lit by simple rotation of the throttle outboard and, after the initial roughness had steadied, power was increased to max reheat with brakes off.

Acceleration was of a similar order to the English Electric P.1B at max cold, and during initial acceleration short periods of stick-shaker vibration occurred.

Rotation was initiated at the briefed speed of 165kt and, as the aircraft flew off smoothly, periods of stick-shaker vibration occurred on passing through rough air. This condition continued until the angle of climb was reduced very slightly, when the climb-away was continued smoothly during undercarriage retraction and landing flap retraction at 260kt IAS.

While initiating a required traffic pattern turn to starboard at this speed the stick-shaker was again in evidence, but at upwards of 300kt IAS normal course-changing manœuvres could be executed without coming on to this condition.

(Altimeter setting 29·9 millibars)

16,000ft AMSL	M=0·85	Zero+2
	Max reheat climb continued	
36,000ft AMSL	M=0·86	Zero+3

A 1·5g turn to port was initiated at max reheat, 91 per cent/595°C, fuel 3,850lb. The ASI system jump-up occurred during this turn which was held through 210° prior to levelling and continuing the acceleration.

36,000ft AMSL	M=1·2	Zero+5·30
36,000ft AMSL	M=1·5	Zero+6·30 Fuel 3,000lb
36,000ft AMSL (Compressor inlet temp 80°C)	M=1·8/500kt IAS	Zero+7.10
37,000ft AMSL	M=2·0/700kt IAS	Zero+ 8 Fuel 2,500lb

Noise level and roughness increase from M=1·84. Compressor inlet temp 90°+ and SLOW light indicator flashing.

From subsonic and throughout this acceleration a small amplitude 1Hz directional oscillation had been present, and this was disturbing to the point of being nearly unacceptable for gun platform conditions.

The yaw damper was disengaged before decelerating and the directional oscillation was immediately trebled in amplitude, although it did not become divergent.

Pitch damping with stabilisers IN at this point was satisfactory, and the aircraft could be pulled into a turn and levelled out without overcorrection in pitch or in roll. Aileron response was noticeably more sluggish than at lower speeds, but was still adequate although the lumpy breakout force was not liked.

Engine roughness at Mach 2 was considerable and, owing to the critical nature of the engine installation in these flight conditions, care was taken in following the briefing as closely as possible to avoid flame-out. Reheat was cut to max cold, and the resultant deceleration was sharp and associated with 1–2 cycles of oscillation in pitch.

Below, *YF-104A 55-2965 undergoing afterburner testing at night at Edwards AFB.*

Air Force Flight Test Center

At Zero + 12min the descent was begun with indicated fuel now at 2,900lb, 90 per cent/400°C, nozzle $\frac{1}{4}$, oil pressure 42lb/in^2, hydraulics 3,000lb/in^2.

The next four minutes were devoted to navigation as the high-speed run had taken the aircraft out of sight of Muroc on an easterly heading [over the sun-drenched mountains and desert of California]. These flights are not conducted under radar or UHF/DF control, and during this phase the excellent layout of the cockpit coupled with its simplicity and the good forward and sideways view was again noted.

Zero+18min. Descent continued through 10,000ft, 300kt/88 per cent, fuel 2,250lb; entering recovery pattern from Mojave to Rosamond Lake.

Zero+25min. 5,000ft. Rolls to right and left were carried out at 550kt in mild turbulence, and although the ailerons were responsive and powerful the lumpy breakout force resulted in over-correction and a tendency to become slightly out-of-phase with the high rates developed.

On rejoining the circuit with 1,900lb fuel, airframe buffet was experienced when reducing below 240kt in the clean configuration. This was eliminated with use of landing flap, but after lowering the undercarriage with speed steady at 220kt downwind, the stick-shaker continued to make itself felt during passage through rough air. On pulling the turn from base leg to finals at 190kt, the stick-shaker came in at approximately 1·3g and the turn was completed with this continuing.

Directional control in turbulence during final approach was quite satisfactory with an occasional tendency to lurch sideways and, provided that the correct approach speed of 180kt was maintained at 88 per cent, no difficulty was experienced in maintaining the approach to the correct hold-off point, although the aircraft felt critical at all times and aileron lumpiness was again disliked when correcting for rolling moment due to yaw in turbulence.

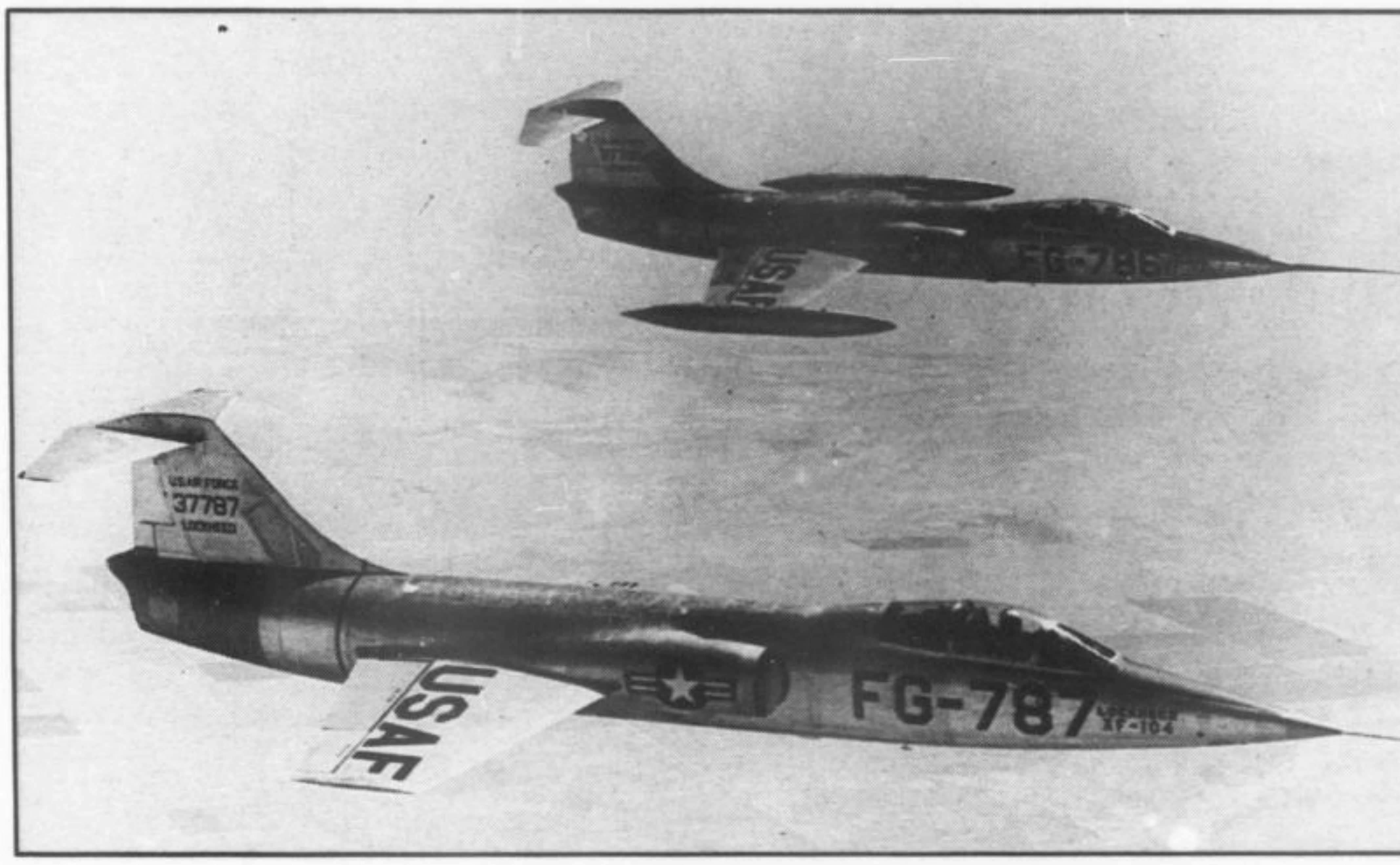
The hold-off and touchdown were straightforward provided that power was not altered from the 88 per cent set, as to do this would reduce flap-blowing and cause a high rate of descent. The soft Dowty liquid-spring system undercarriage eliminated all landing shock and assured a smooth touchdown.

After lowering the nosewheel the tail parachute handle was operated, but the parachute was not felt and it was reported by the tower that it had developed and self-jettisoned. Use of the pedal-operated wheelbrakes was smooth and decelerated the aeroplane reasonably rapidly with moderately heavy use to normal taxying speed in well under 2,000yd.

It was again pleasant to be able to lift the sideways-opening canopy for taxying in under the hot desert sun.

The F-104 had proved technically fascinating, exhilarating in performance but otherwise rather unpleasant to fly and, in the underdeveloped engine circumstances, undoubtedly rather dangerous; and it was judged more than a little controversial in its claims to be a "next generation air superiority fighter".

But now the next subject for evaluation, the F-106, which was still in experimental status, seemed likely to be a much more promising formula.



The two Starfighter prototypes, XF-104s 53-7786 and 53-7787, in formation. The second aircraft was lost during gun firing trials in April 1955.