YF-12A
MACH 3+ INTERCEPTOR

Paul Crickmore recounts the story of the Lockheed YF-12A programme.

During the late 1950s a specification was drawn up to provide a missile and fire-control system (FCS) for the North American F-108 Rapier interceptor. This so-called Improved Manned Interceptor (IMI) was to be Mach 3.0 capable and its ASG-18 pulse-Doppler radar system, developed in parallel with the GAR-9 missile by Hughes, would have a look-down/shoot-down capability for head-on attacks.

Furthermore, the system considerably advanced the maximum range of contemporary airborne intercept mono-pulse systems then in use from 40 miles (64km) to 120 miles (193km).

As development of both aircraft and avionics progressed, a Convair B-58 Hustler (55-665) was lent to Hughes to act as a systems test-bed. Delivered to Hughes' main plant at Culver City, California, it was on the ground for at least a year while reconfiguration work prepared it for the missile and FCS flight test programme.

While this was being undertaken, Hughes engineers were using high-speed film techniques and a 9ft (2.7m) deep pit, filled with foam to analyse separation and pitch characteristics of the 818lb missile. Missile/vehicle separation was provided by two thrusters, one located at each end of the missile. On firing, these propulsive charges unlocked the missile from its rail then forced the missile down, clear of the aircraft. At a finite time, its rocket motor ignited and the GAR-9 sped away.

In 1961, and with work progressing well, Hughes appointed James 'Jim' D Eastham as project test pilot on the YB-58 ASG-18/GAR-9 programme. Hughes also provided the Fire-control Operators (FCO), two of whom would occupy the tandem positions behind Eastham. Their task was to monitor the entire system and fire the GAR-9.

AN/ASG-18 AND GAR-9

The AN/ASG-18 employed a high average-power, liquid-cooled, travelling wave tube transmitter chain. This consisted of two travelling wave tube amplifiers set in tandem to provide the desired gain and analogue circuitry for generating and processing a coherent high pulse repetition frequency (PRF) wave form.

This entire package included a solid-state digital computer for navigation and attack, a built-in test (BIT) circuit; integrated controls and displays and an infrared (IR) search and track set capable of co-operative use with the radar.

The effective range of the IR system depended upon the point where either it traversed over the horizon or nothing came between the target and the system. All early IR systems used an un-cooled lead sulphide sensor cell and operated in the short wavelength of 2.0-2.5 microns. But this generated countless discrimination problems.

So Hughes continued development work in this field and eventually produced a long wavelength sensor cell utilising an indium antimide cell, cooled by liquid argon. This worked in the 3-5 micron range and had an outstanding discrimination capability. The IR system installed in the YB-58 and YF-12A was yet another development and it utilised a lead selenide cell that was cooled by liquid nitrogen, but extensive testing of this system would never be carried out.

On completion of modifications to the YB-58, the programme was moved to the Hughes facility on Contractors Row at Edwards AFB, California. Despite the cancellation of the F-108 programme on September 23, 1959, Department of Defense officials decided the outstanding FCS and missile development programme should continue on a 'stand-alone' basis.

KEDLOCK

Spurred on by the earlier success of his A-12 design for the CIA, Clarence L 'Kelly' Johnson, discussed the possibility of building a long-range interceptor version for the US Air Force, during a meeting over March 16/17, 1960, with Gen Hal Estes of Air Force Systems Command and Dr Courtland Perkins, the Air Force Secretary for Research and Development. Referred to as the AF-12, the idea was keenly received and subsequently forwarded to Gen Martin Demler, at Wright-Patterson AFB, Ohio, for ▶

Main photo: **The cut-back chine modification, made to accommodate the radome, is nicely portrayed in this shot of article 1003, serial 60-6936 over the Rockies.** Lockheed Martin via Tony Landis

Above: **Jim Eastham touches down at Area 51 following the satisfactory completion of the YF-12A's first flight on August 8, 1963 – he was chased by another Lockheed test pilot in an F-104 Starfighter.** Lockheed Martin

Prototype article 1001, serial 60-6934 with its centreline folding ventral fin extended to improve longitudinal stability. This picture was taken early on in its test flight career, before it was given an overall black colour scheme to reduce the effects of thermodynamic heating encountered at its design cruise speed of Mach 3.2. Lockheed Martin

further discussion and analysis.

During late October 1960, Lockheed received a letter of intent for $1m and was directed to "go forward with Plan 3A" and produce an interceptor version of the A-12. Furthermore, it was stipulated that the aircraft was to be equipped with the Hughes ASG-18 FCS and the GAR-9 missile system. Accorded the classified cryptonym Kedlock, Johnson appointed Rus Daniell as the project engineer and the seventh A-12 was nominated to become the AF-12 prototype.

In December 1960, a second project group was organised at Lockheed's Skunk Works and to maintain security, operated independently of the A-12, Oxcart team.

A considerable amount of work was necessary to convert the reconnaissance platform into an interceptor – although it's fair to say that most of this was focused around the forebody, forward from fuselage station (FS) 715, a point perpendicular to where the inboard wing section meets the fuselage.

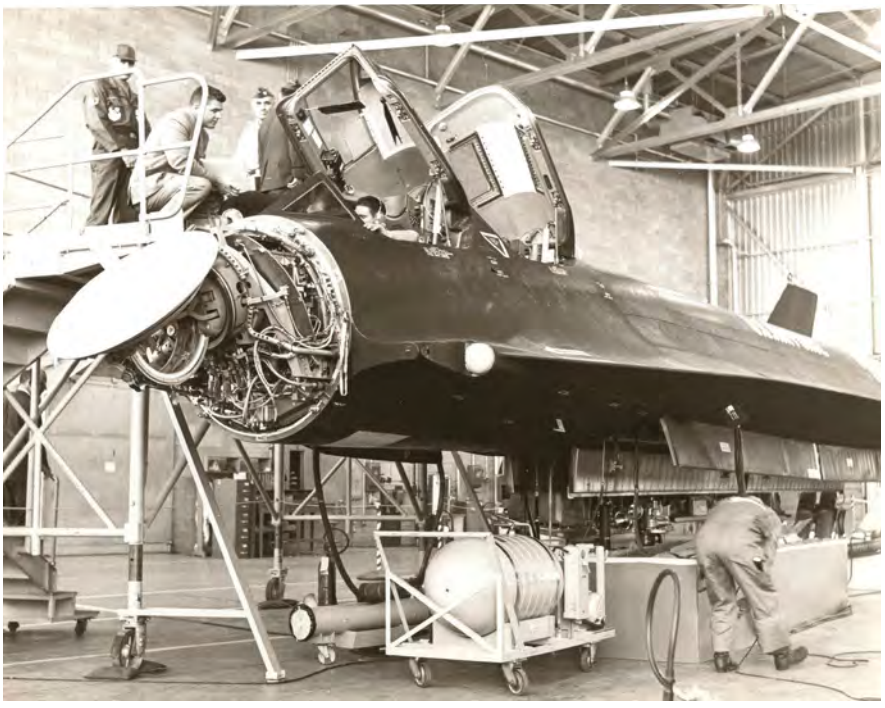
These external changes included the creation of a second cockpit in what was the A-12's Q-bay (where its camera system was located). The fuselage 'chines' were cut back to incorporate a radome to house a 40in scanning dish, and four weapons bays were added, cut into the underside of the 'chines'. These housed the FCS – in the right, forward bay – and three GAR-9 missiles – two in the left bays, and the third in the right rear bay.

On January 23/24, 1961, the first meetings with the USAF's weapon system project team took place at Burbank, California, and they were briefed on Skunk Works design and development philosophy.

All seemed to be progressing well, however by June, wind-tunnel tests revealed serious directional stability problems resulting from the reconfigured nose section and the slightly raised second cockpit position. To alleviate the issue, further external modifications were necessary to the rear of the aircraft. Two fixed ventral fins were installed on the underside of each engine nacelle, and in addition a large, folding fin was mounted on the underside centreline of the aircraft's rear fuselage. Retraction and extension of the folding ventral fin worked out of phase with the cycling of the landing gear – in short, when the gear was retracted, the fin extended and vice versa.

Eastham was recruited into Kedlock, becoming its chief test pilot, but also continued working for Hughes on the YB-58/ASG-18 programme. Once an extensive security check had been completed, Eastham began spending time with Skunk Works' engineers at Burbank, familiarising himself with the location of switches and other specialist equipment in the AF-12 mock-up.

By August 2, 1962 USAF funding had been increased to allow for the modification of three A-12s and the major elements of the prototype, assigned the Lockheed Article number 1001, and Air Force serial 60-6934, were in the jig at the Skunk Works. As the manufacturing effort continued from December 1962 through to the spring, reservations were muted in some quarters about the security of both the Oxcart and Kedlock projects, particularly in relation to the latter's fast approaching flight test programme.

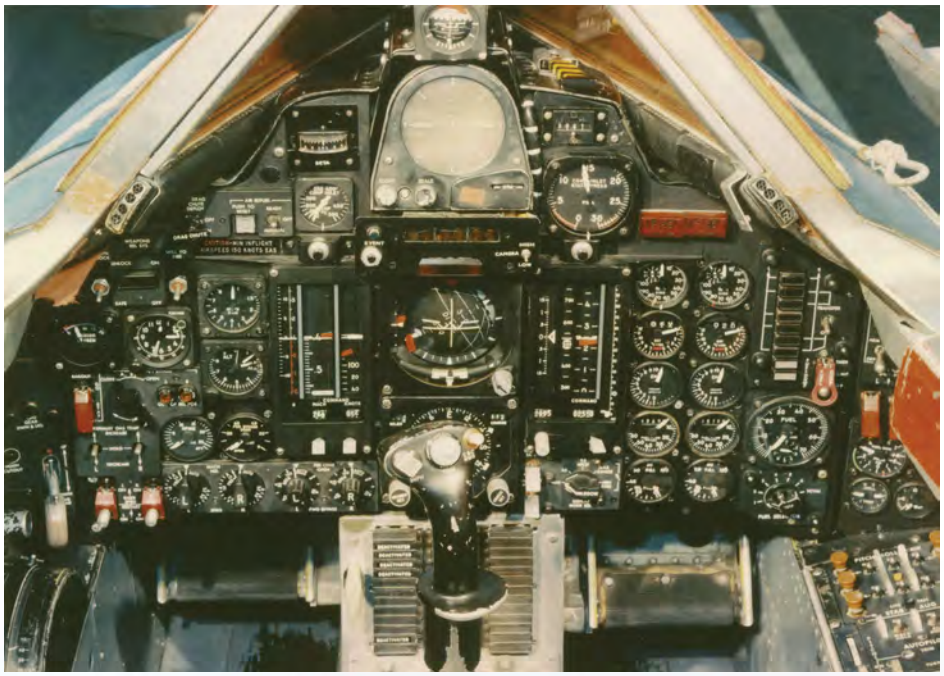


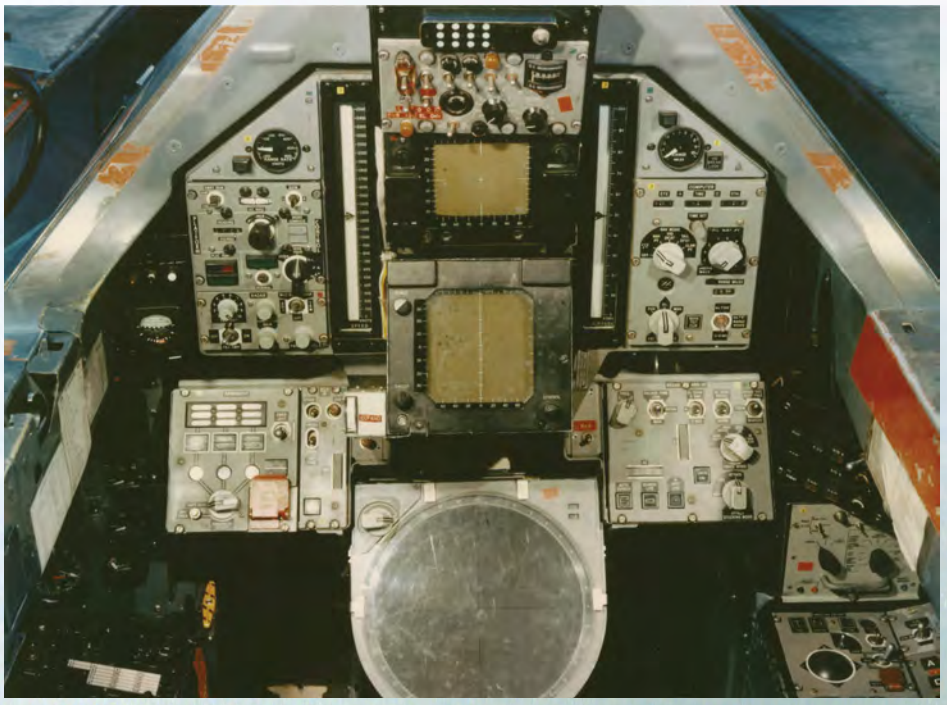
The Hughes AN/ASG-18 fire-control system utilised a massive 40in scanning dish. Also note the IR sensor mounted in the shoulder of the cut-back chine, the AIM-47 missile just visible behind the screen intended to hide it from view and the camera located on the right of the raised cockpit, used to photograph cockpit instrumentation for later analysis. Lockheed Martin

Jim Eastham (left) and FCO Ray Scalise wearing David Clark S-901 full pressure suits required for high-altitude flight. Like all pilots involved in the A-12 Oxcart or YF-12 Kedlock programmes, each had a personal callsign beginning Dutch, followed by two digits – Eastham's was Dutch 52. Jim Eastham Collection

Right: **The YF-12A's unique strip-type instrumentation for airspeed and altitude was one of the distinguishing features of the front cockpit.** Lockheed Martin

Below right: **The FCO's cockpit instrumentation was dedicated to the control of the YF-12's formidable weapons system. Three displays provided target, ranging and position data, with radar control panels to the left of the square displays, armament controls below these, radar and IR controls opposite to their right and computer controls above (centre). The FCO was also provided with airspeed (on the left) and altitude information (on the right) via the vertical tapes.** Lockheed Martin





Edwards AFB, California, certainly appeared to offer the best option, however in the event 1001 was crated up and trucked to Area 51.

OUTLINE DESCRIPTION

For the test phase the designation YF-12A was used. The aircraft was 101ft 8in (31m) long, stood 18ft 6in (5.6m) high, had a wingspan of 55ft 7in (17m) and a wing area of 1,605sq ft (149m^2). The wing featured a leading edge sweepback of 61.25°, with no dihedral and its angle of incidence was 1° 2'.

Empty gross weight of the prototype – Article 1001 – was 60,730lb (27,547kg), the specification being 59,422lb (26,953kg) and the maximum take-off weight; again for the prototype was 127,000lb (57,606kg), the specification was 124,491lb (56,468kg). While on the ground, the aircraft was supported by a tri-cycle undercarriage, which had a main wheelbase of 37.8ft (11.5m). The aircraft's centre of gravity limits (CG limits), were between 16 and 29% of the mean aerodynamic chord (MAC) and the G limits were -1 to +3.6. Interestingly, the aircraft's maximum allowable airspeed and its design speed were one and the same, 450 knots equivalent airspeed (KEAS).

This expression KEAS, was used throughout the A-12/YF-12 and SR-71 programmes when speed criteria needed to be followed, because aircraft are designed structurally utilising KEAS and it also enabled one airspeed limit to be specified for all altitudes. Prohibited manoeuvres were spins and roll rates in excess of 120° per second and take-off rotation had to be limited to less than 14°, or the engine nacelle ventral fins would make contact with the runway.

PREPARATIONS FOR FLIGHT

Once Article 1001 had arrived at Area 51, several weeks were spent reassembling the aircraft, equipping it with twin Pratt & Whitney J58 engines and completing a high-speed taxi test to near take-off speed.

On August 7, 1963 Eastham climbed aboard 60-6934 for a first flight, which he later modestly characterised as a typical production test flight, chased by Lou Schalk flying an F-104 Starfighter (Schalk was the Lockheed A-12 chief test pilot).

Aircraft '935 during a test flight from Edwards AFB. Note the AFSC shield and the outstanding unit ribbon on the vertical stabiliser. AFFTC History Office via Tony Landis

YF-12As 60-6934 and 60-6936 were both due to fly to set world speed and altitude records on May 1, 1965, however due to a maintenance problem, all four records were gained using '936. The large white cross was applied to the underside of both aircraft to enable powerful ground-based cameras to accurately track them during the record attempts. Lockheed Martin via Tony Landis

Johnson would later note in his AF-12 log: "It is the first airplane I've ever worked on where the fire-control system was checked out prior to the first flight."

Having completed its maiden flight with flying colours, there was little urgency in getting the YF-12A out to its design speed of Mach 3.2, since the full speed envelope had already been achieved with Oxcart. Time was instead spent installing the FCS, ensuring that it integrated into the YF-12, and testing the inertial navigation system.

GOING PUBLIC

With the Oxcart flight test programme now in full swing at Area 51, the increase in test and training sorties brought with it an increase in the number of sightings made by airliner crews and others outside the programme.

This inevitably led to questions being raised as to how much longer the project could remain hidden. On November 29, 1963, one week after the assassination of President John F Kennedy, the new President, Lyndon B Johnson, convened a meeting of the National Security Council, the main question on the agenda being whether to, or how to 'surface' the technological triumph of Oxcart.

In the event, it was decided to keep the programme secret until the run up to the 1964 elections. However, after the Republicans accused the Democrats of failing to sponsor new aircraft projects, President Johnson directed his advisers to prepare a formal announcement about the hitherto 'black' project.

Kelly Johnson was asked to work on the draft and he proposed that the terminology 'A-11' be used in the statement as, "it was the non-anti-radar version" – which didn't get built. President Johnson announced the existence of the A-12 on February 29, 1964, using the 'A-11' designation in his speech as recommended by Kelly Johnson.

To give credence to the President's announcement and divert attention away from the CIA's A-12 Oxcart programme, Kedlock was nudged a little into the 'white world' just a few hours prior to the President going on-air. Two YF-12A aircraft, 60-6934 and 60-6935, were repositioned to Edwards AFB by Schalk and Bob Gilliland (Gilliland would become chief test pilot of the SR-71).

The event was witnessed by just a few dozen maintenance staff who happened to be at work that Saturday morning. Schalk remembers taxiing to the assigned hangar as eyes bulged and heads nodded in utter disbelief at the sight of the two sleek aircraft. Their like hadn't been seen before by anyone outside the programme, with the possible exception of a few desert dwellers and incredulous airline crews.

Schalk continued: "Our supposed low-key positioning flight lost a touch of elegance when, to aid push-back into the hangar, we turned the aircraft through 180° at the entrance. This turn-around manoeuvre sent hot engine exhaust gasses into the hangar that caused the overhead fire extinguisher valves to open. These valves were big – like the flood valves on the hangar decks of aircraft carriers – the desert hadn't seen so much water since Noah's embarkation."

Aircraft 60-6936 joined its two stablemates

Serial 60-6936 was the only YF-12 to have launched three AIM-47s as seen by the 'mission strikes' beneath the cockpit canopy. The AIM-47 on the trolley never entered operational service, however it provided much of the technology within the legendary AIM-54 Phoenix developed for the F-14 Tomcat. Lockheed Martin

Col Robert L 'Fox' Stephens and FCO Lt Col Daniel Andre established new world speed records for both speed over a straight course and altitude on May 1, 1965. USAF

Left: **YF-12A, 60-06934, in the type's early scheme.** Lockheed Martin

at Edwards a few weeks after their arrival following the completion of some essential rewiring work. Once at Edwards it became apparent that the number of people assigned to Kedlock had ballooned to include personnel from Air Force Systems Command (AFSC) and Air Defense Command (ADC). Not officially named the SR-71/YF-12 Test Force until mid-1965, work at the new base wasn't without its difficulties as most of the expertise remained at Area 51 with the A-12. Notwithstanding, once a new electrically controlled air inlet system had been installed to reliably control air flow within the aircraft's air inlets, it took Eastham just three months to complete the YF-12's envelope extension programme. All these flights were conducted in the Lockheed operated prototype, 60-6934.

In April 1965, Eastham flew a number of profile-proving sorties that later enabled USAF crews to fly the YF-12A into the record books. It was by no means a coincidence that the date chosen to establish these new speed and altitude records was May 1, 1965. Five years to the day after CIA pilot, Francis Gary Powers had been shot down by a Soviet SA-2 missile while flying a Lockheed U-2 on a clandestine reconnaissance-gathering mission. It was a very public way of letting the Soviet Union know that the United States was still ahead of the game (see table on the next page for details).

With much of the 'pick and shovel work' completed in the B-58, the AN/ASG-18 and the GAR-9 (now redesignated the AIM-47 Air Intercept Missile) were quickly integrated into the YF-12A, where the system transcended its predicted performance figures. Once in operational service, three AIM-47s were to be hauled aloft, however, the highly instrumented test aircraft never carried the planned full missile load.

During the first missile separation test, onboard cameras showed the missile to be incorrectly aligned. Had the rocket motor ignited, the missile would probably have ended up in the front cockpit. Adjustments were made and the remainder of the test programme proceeded extremely well. In all, 12 live missile firings were made from the YF-12A, seven flown by Eastham, the remainder by USAF crews (see table for details).

An indication of the system's operational potential can be gauged from a test flight flown on April 25, 1966 in '934, from Eglin AFB, Florida, over the Gulf of Mexico, as Eastham recalls: "Following take off, we accelerated in a generally south west direction and made a right turn on to an east bound heading for the 'hot-run'. George Parsons my FCO acquired the target, which was at about 1,000ft, Mach 0.6 and heading west at a range of 130nm [241km]. At that time, we were at Mach 3.2 and 75,000ft. Even though we were being vectored, we also ran the mission utilising a modified close-control feature of the ASG-18 weapon system and tracked the target at the exact 12 o'clock position. Our closure rate was Mach 3.8 and essentially we had an altitude differential of 75,000ft. We went through the mission prep stage and the launch was made at approximately 53nm [98km]. The missile guided to impact on the left horizontal stabiliser of the QB-47. At the time of impact we were looking down 73° at the target."

The unarmed missile hit and destroyed approximately 4ft of the B-47's horizontal stabiliser. It seems that all but one of the seven launches made by the Lockheed crew were deemed a success – the failure of ▶

YF-12A/AIM-47 MISSILE FIRING RECORD

Date	Mission Number	YF-12A	Speed	Altitude	Target	Target Altitude
March 18,1965	G-11	'935	M2.2	65,000ft	Q-2C	40,000ft
May 19,1965	G-13	'935	M2.3	65,000ft	Q-2C	20,000ft
September 28,1965	G-15	'934	M3.2	75,000ft	Q-2C	20,000ft
March 22,1966	G-18	'936	M3.15	74,500ft	Q-2C	1,500ft
April 25,1966	G-19	'934	M3.2	75,000ft	QB-47	1,500ft
May 13,1966	G-16	'936	M3.17	74,000ft	Q-2C	20,000ft
September 21,1966	G-20	'936	M3.2	74,000ft	QB-47	At sea level

Below: **Article 1002, serial 60-6935, the second YF-12A to have been built, approaches Edwards AFB. Note the ADC patch on the vertical tail and the folded ventral fin.** AFFTC History Office via Tony Landis

Left: **An AIM-47 missile is loaded.** USAF

one of the sorties was attributed to a missile gyro system failure. Perhaps not surprisingly, the USAF was extremely impressed. ADC calculated that it required 96 production versions of the big fighter – designated F-12B – to replace its ageing fleet of F-102 and F-106 interceptors. With a force this size, officials were confident that they could provide protection to the entire United States against incoming high-speed, low-level bombers by stationing three squadrons of 16 aircraft each on the east coast at Otis AFB, Maryland and another three squadrons at Paine AFB, Washington State to protect the west coast.

Another important facet of the F-12B was its pre-attack speed, which was much faster than the Convair F-106, which required double the time to reposition itself on a subsonic bomber compared with the F-12. In the case of a supersonic bomber, the F-106's time requirement was four times greater. But in truth, Defense Secretary Robert McNamara preferred the so-called F-106X proposal (which would metamorphosis into the F-15 Eagle), after a national intelligence estimate showed it to be the most cost-effective answer to the predicted Soviet bomber threat.

As a result, on three separate occasions over three years, he denied the USAF access to $90m of funds that had been appropriated by Congress to begin F-12B production. Consequently, in July 1966, Kelly Johnson was directed to give up further flying of the YF-12As. The situation continued to deteriorate and on August 5, 1966 Johnson noted in his log: "We have laid off half of our test crew on the YF-12A and are maintaining only enough people to store the airplane or send it to Burbank. We are very near the end of this program."

Finally, on January 5, 1968 the Skunk Works received official notification from the USAF, closing down the F-12B. The YF-12A programme formally ended on February 1. This was followed four days later by a letter from the USAF instructing Lockheed to destroy all A-12/F-12 and SR-71 tooling. In compliance, the large jigs were cut up and sold for scrap and Johnson noted in his log: "Ten years from now the country will be very sorry for taking this decision of stopping production on the whole Mach 3 series of aircraft in the USA." AN

Below: **NASA pilot Fitz Fulton and flight test engineer Ray Young fly'935 in loose formation with NASA Northrop T-38 Talon chase aircraft N923NA. When Kedlock was cancelled NASA were lent two YF-12As for a brief joint test programme with the USAF. In addition to the camera pod on the underside of '935, there's a pod covered in white ceramic material for a cold-wall, heat transfer experiment.** NASA

YF-12A WORLD SPEED AND ALTITUDE RECORDS (ALL SET MAY 1, 1965)

Record: Absolute Altitude, 80,257.86ft
Crew: Pilot Col Robert L 'Fox' Stephens, Fire-control Officer (FCO) Lt Col Daniel Andre

Record: Absolute Speed over a straight course, 2,070.101mph
Crew: Pilot Col Robert L 'Fox' Stephens, FCO Lt Col Daniel Andre

Record: Absolute Speed over a 500km closed course, 1,688.889mph
Crew: Lt Col Walter F Daniel, FCO Maj James P Cooney

Record: Absolute Speed over a 1,000km closed course, 1,643.041mph
Crew: Pilot Lt Col Walter F Daniel, FCO Maj Noel T Warner
All records were set using YF-12A, 60-6936