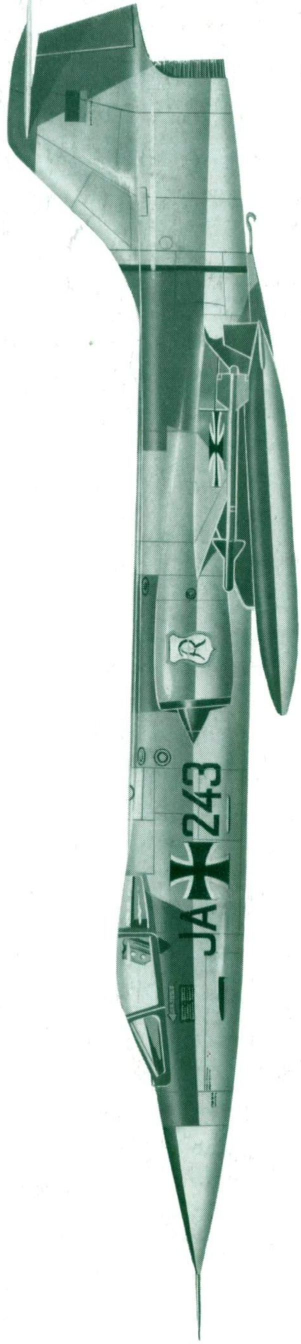
PROFILE PUBLICATIONS

The Lockheed F-104G/CF-104



NUMBER 131

RETAIL PRICE
UNITED KINGDOM TWO SHILLINGS
UNITED STATES & CANADA 50 CENTS

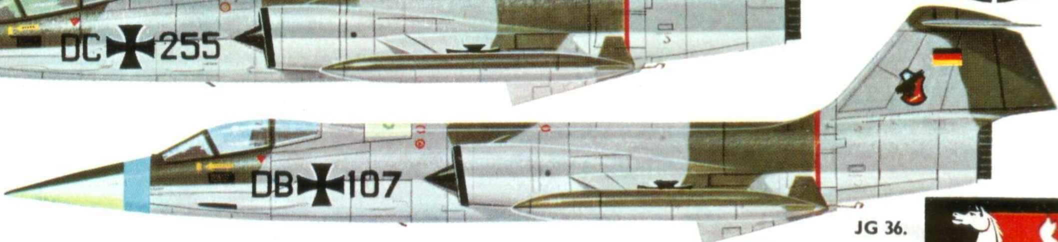
JG 74.

F-104G of JG 74, Federal German Air Force, Neuburg.

JG 33.

JG 34.

F-104G of JG 33, Federal German Air Force, Buschel.



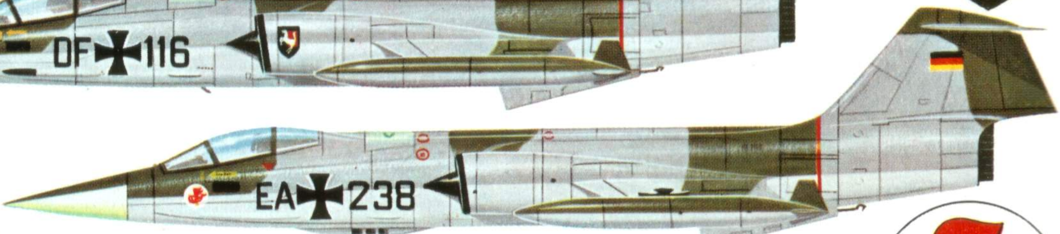
F-104G of JG 32, Federal German Air Force, Lechfeld.

JG 32.

JG 36.

F-104G of JG 36, Federal German Air Force.

No. 306 Sqdn.

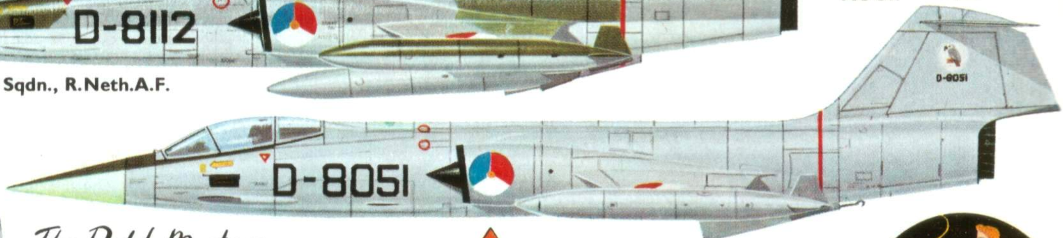


RF-104G of AG 51, Federal German Air Force, Manching.

AG 51.

F-104G of No. 306 Sqdn., Royal Netherlands Air Force.

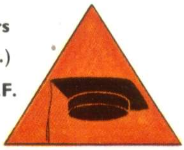
F-104G of No. 322 Sqdn., R.Neth.A.F.



No. 322 Sqdn.

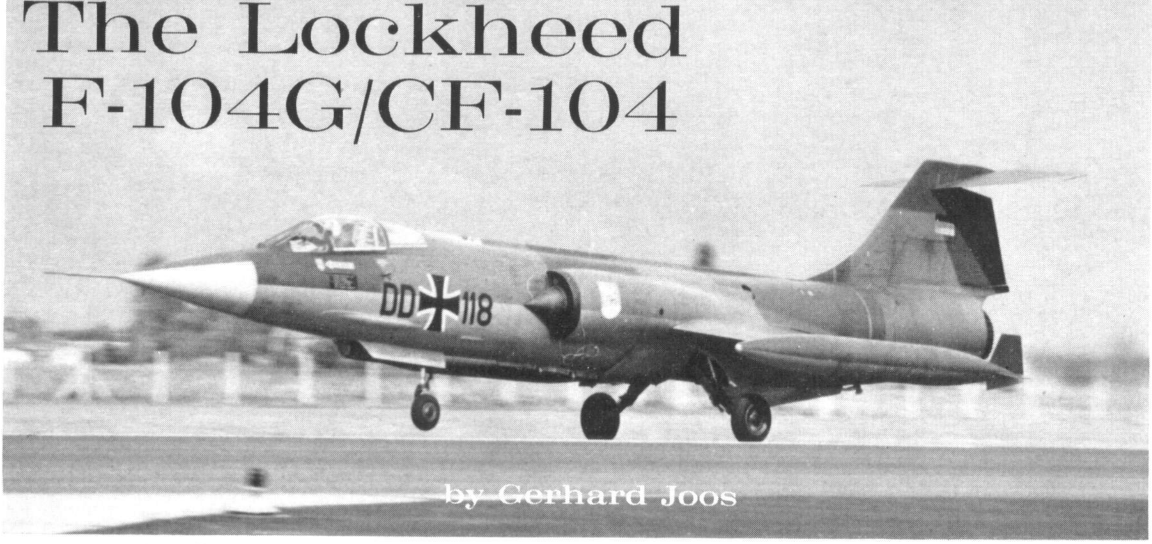
The Dutch Masters (Script appears under a/c number, under triangle.)

TF-104G of "The Dutch Masters" R.Neth.A.F. Conversion Flight, Twenthe.



No. 325 Sqdn., R.Neth.A.F.
Code D-6657, overall grey scheme.

The Lockheed F-104G/CF-104



by Gerhard Joos

An F-104G of the Luftwaffe's Jagdbombergeschwader 34 *takes off from its Memmingen base. The unit emblem is visible on the intake.* (Photo: Stephen Peltz.)

During the past four years the European people have had to familiarize themselves with a new sound in their skies which differed distinctively from the noises made by other jet aircraft: the howl of the engine of the most discussed fighter aircraft since the end of World War II, the Lockheed F-104G "Super Starfighter", now the strongest weapon of most NATO Air Forces.

The story of this spectacular airplane began with the re-forming of the *Luftwaffe*. It was already clear at the initial stage, that the then subsonic equipment (Sabre 6, F/RF-84F, Sea Hawk) would have to be replaced by a modern supersonic weapon system as soon as sufficient jet pilots and qualified ground crews were available. The airplane the *Luftwaffe* was searching for had not only to be an interceptor, but had to be able to fulfil also fighter bomber and reconnaissance duties on equal terms. Many modern designs, most of which were only flying as prototypes, were under study, and—to make a very long story short—the end came with the signing of the development contract for the Lockheed F-104G by West Germany on 18th March 1959. It was intended to build the aircraft under licence, and a contract with Lockheed covering this aspect was also signed at the same date.

The German search for a modern weapon system was closely watched by other NATO nations, and after the German government had made its decision it was followed by Canada, Japan, the Netherlands, Belgium, and finally, in March 1961, by Italy. This led to probably the greatest example of international cooperation on a technical level in history, as all nations decided to participate in the licence production of the F-104G (Japan was building its own version, the F-104J).

Several production groups were formed to meet the challenge. These were, in Southern Germany, the South Group consisting of Dornier, Heinkel, Messerschmitt and Siebel; the North Group included Focke-Wulf, Hamburger Flugzeugbau, Weserflug and (in Holland) Fokker and Aviolanda; the West Group was formed by S.A.B.C.A. and Avions Fairey in Belgium, joined by Fiat and other Italian companies, whereas Italy itself became the fourth entity. Prime contractor was Fiat assisted by virtually all resources of the Italian aircraft industry. The head office and coordinator was the NATO Starfighter Management Office (NASMO) located in Koblenz, Germany.

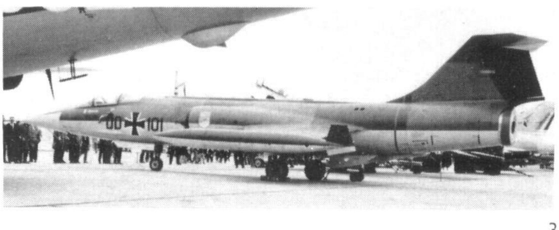
The initial production schedule called for 210 aircraft built by the South Group, 350 by the North Group, 188 by the West Group, and 199 by Fiat; and Canada was to build 248 examples. Lockheed was to build 182 aircraft. Cross flow of parts, assemblies and complete airplanes were common and most notable in the case of Germany, whose Air Force received 700 single-seaters from five different nations. Initial orders for other nations were 120 for Holland, 100 for Belgium, 125 for Italy, 200 for Canada and 120 for MAP countries (this figure also includes a number of two-seaters) which were built by Lockheed and Canadair. To assure early service introduction and training, some outright purchases were made from Lockheed which delivered 96 single-seaters to Germany, one to Belgium and one to Italy plus a number of two-seaters.

DESIGN BACKGROUND

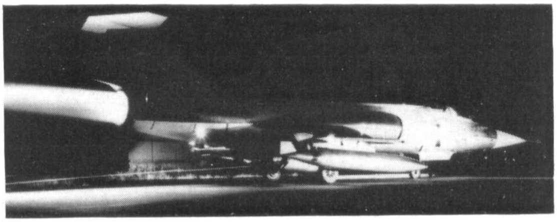
The F-104 was originated in 1952, when the U.S. Air Force called for a pure day superiority fighter. Lockheed designers tried scores of new ideas, and the outcome was a startling new design which barely resembled an aircraft. It looked much more like a manned missile and was often referred to as the last combat airplane flown by a pilot.

It had a trapezoid-shaped wing of only $7\frac{1}{2}$ feet span with 10 degree anhedral (necessary to counteract a roll tendency induced by the fin) with knife-edge sharp leading edges which have protective covers when the airplane is parked, to prevent injuries of ground personnel. The first XF-104 took to the air in February 1954. During the following four years major modifications were introduced, and the first

DD+101 was the first Super Starfighter delivered to Jabo G 34. (Photo: the author.)



JD+101 of JG 74 *at take-off; and* (below, right) *night engine testing of a* Luftwaffe *machine produces a spectacular display o pyro-technics.* (Photos: Stephen Peltz and German Air Force.)

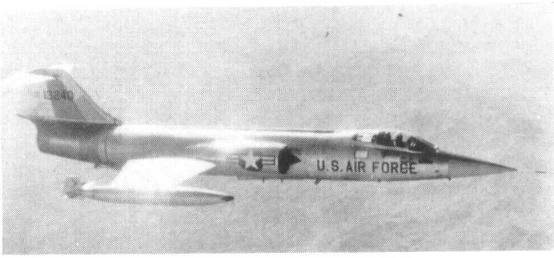


production F-104A's were put into operational service in January 1958. The F-104A was followed by the first two-seat version, the F-104B. These models were replaced by new versions, the F-104C and its two-seat counterpart, the F-104D, and the first F-104C was delivered to the Tactical Air Command on 16th October 1958.

When the German Air Staff decided to purchase the F-104 for its young *Luftwaffe*, it was with a version in mind which had yet to be developed, the F-104G—G for Germany. Since the U.S.A.F. F-104 versions were strictly day fighters they did not meet the requirement for a fighter bomber and reconnaissance fighter. Lockheed assured the German High Command however, that a new version suitable for these tasks would be built within a short time.

F-104G MODIFICATIONS

The first F-104G (number 1078) which emerged from the assembly line and which made its first flight on the 7th June 1960, 15 months after the contract was signed, was externally similar to the F-104C apart from an enlarged vertical fin (about 25 per cent), first introduced on the F-104B, giving a considerable improvement in longitudinal stability. Irriversible hydraulic power was incorporated for the rudder, and power for the horizontal stabilizer



A German F-104G in U.S.A.F. markings. This is one of the aircraft based at Luke A.F.B.; they are German machines used in the training of German pilots. (Photo: the author)

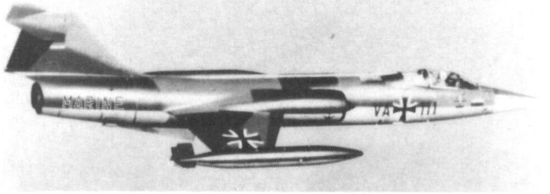
DB + 252 carries the emblem of Jabo G 32 *on the fin; this unit is based at Lechfeld.* (Photo: Stephen Peltz.)

control system booster was increased. The heavier gross weights and low level operations also demanded a redesign and strengthening of 36 new forgings for the fuselage main frames, wing fittings and beams, fuselage longerons and joints, tail frames, empennage beams and ribs and fuselage skin. Braking efficiency was improved by adding fully powered brakes combined with an anti-skid system energized by the sensing units in the wheel axles, and the drag chute's diameter was increased by two feet to 18 feet. To prevent intake icing British Spraymat electro-thermal units have been applied. Another major modification was the addition of a highly complex electronic system to give the Super Starfighter all-weather capability.

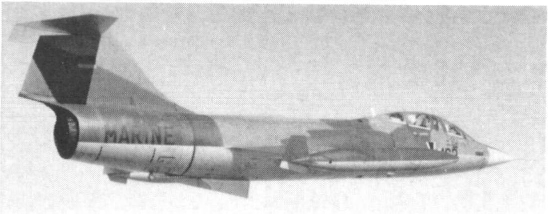
While the parent company was busy with the design and construction of the first prototype things were also pushed forward in Europe to start licence production as soon as possible, and the first flights of European Super Starfighters were not far behind their American predecessor. Here are the dates: Germany, 5th October 1960; Belgium, 3rd August 1961; Holland, 11th November 1961; Italy, 9th June 1962. To help in the initial phase of licence production Lockheed delivered parts and components, and the first aircraft to fly in Europe were often assembled with the use of such parts.

THE AIRCRAFT DESCRIBED

The F-104G has aesthetic beauty, with a long slim fuselage which carries virtually all systems incorporated into the plane. The fuselage is of all-metal, semi-monocoque construction and is built in three sections of mixed steel, aluminium and titanium structure. The front section contains the cockpit with the Lockheed-built C-2 ejection seat, electronic systems, the Vulcan 20 mm. cannon and the nose-wheel support structure. It is built in halves, and functional systems are installed, then the halves are mated before final assembly. The mid-fuselage houses the five bladder-type fuel cells, the multi-shock air intake ducts, the power plant and the main undercarriage. It is built on five heavy aluminium forged frames tied into a forged keel on assembly which supports landing gear loads. It is also com-



An F-104G of the German Navy's Marinefliegergeschwader 1, *with anchor symbol on the intake; and a Naval TF-104G trainer.*
(Photos: MFG 1 and the author.)



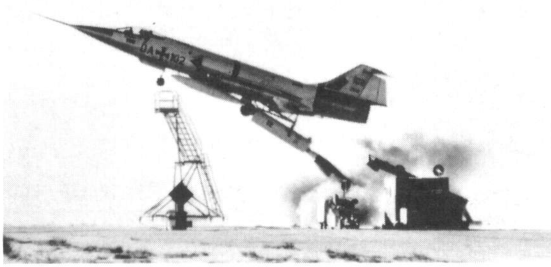
pleted in halves for ease of systems installation prior to final assembly.

The aft section is skinned with stainless steel and titanium. It houses the afterburner and tailpipe and carries tail loads into the mid-fuselage. The drag 'chute compartment is located on the fuselage bottom just aft of the mid-to-aft fuselage joint and opens downward when the chute is actuated. A ventral fin is installed on the fuselage lower centre line. This acts as a large vortex generator. It spoils circular air flow around the fuselage thus increasing directional stability through the supersonic speed range. Just beside the ventral fin on the starboard side the arrestor hook is installed; this can be released by the pilot to engage a cable-type barrier if the airplane cannot be stopped on the runway. Early production aircraft did not possess this safety device but were all subsequently modified.

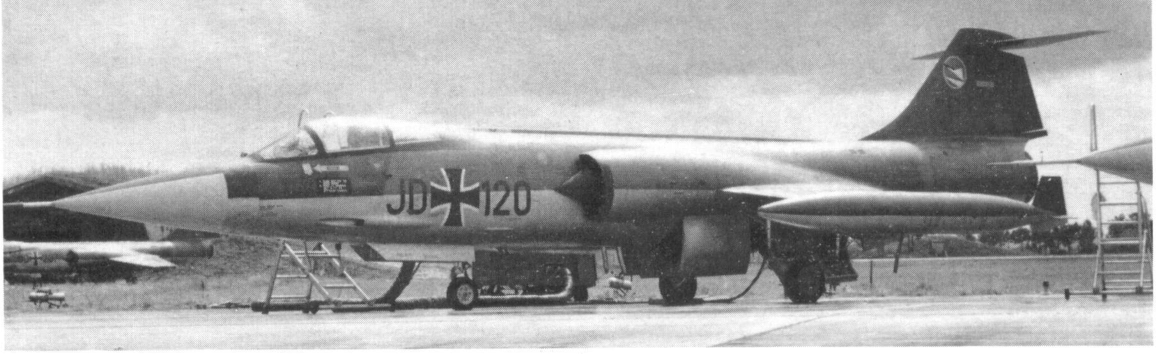
The cockpit canopy is hinged on the left-hand side and is normally operated manually. For ejection, hold-down hooks are released automatically on each side to assure symmetrical operation. It can be jettisoned three ways: pulling a handle on the forward cockpit console, working the seat escape handle, and —on the ground—from the exterior by rescue crews.

The three hydraulically operated units of the landing gear are all forward retracting. Each main leg consists of a forging pivoted at its upper end and sprung by a single Liquid Spring strut (Dowty patent). On retraction of the main gear, the wheel is pivoted inwards so that when fully retracted the whole assembly lies flush with the fuselage within the main landing gear wheel well. It is enclosed by two pairs of doors. After extension the forward doors return to a nearly closed position. The nose gear consists of a single oleo pneumatic strut incorporating a cantilever fork and axle, a static ground and a steering unit. The steering actuator is hydraulically operated through the action of a control valve linked to the rudder pedals. A push-button on the control column activates the steering system which will provide an angular travel of 50 degrees. Emergency extension of main and nose gear is effected by gravity and air stream after manual release of the locks.

After extensive tests comparing lift/drag ratios of many airfoils the thin straight wing was chosen. Its thickness ratio is only 3·26 per cent. The maximum thickness of 4·2 inches adjacent to the fuselage decreases to 1·96 inches on the wing tip. The wing tip chord is approximately 38 per cent. of theoretical root chord and leading edge sweep back is approximately 26 degrees. The trailing edge has a smaller sweep forward. Each wing structure consists of one-piece machined upper and lower skins attached to the forward and rear spar. Within this torsion box, enclosed by root and tip forgings, are 13 spanwise intermediate channels riveted to the skins. The wings are attached to the fuselage by precision forgings. They have a boundary layer control system which provides increased lift and lower landing speeds. It operates in connection with the flaps. When these pass the 15-degree mark, the bleed air valve commences to open, and it is fully open when the flaps are at full down 45 degree position. Highly compressed air from the 17th compressor stage is thus ducted into the wing and over the upper flap surfaces out of 55 slots 0·9 inches apart along the trailing edge flap hinge line. It reduces turbulence in



A Luftwaffe *TF-104G and (above) a ZELL take-off during tests by Lockheed at Edwards A.F.B., California.*
(Photos: Stephen Peltz and the author.)



Jadgeschwader 74 *operate F-104G's from Neuburg; the aircraft normally carry Sidewinder missiles on wing-tip rails.* (Photo: Stephen Peltz)

the boundary layer due to flow separation thus reducing the stalling speed. Full leading edge flaps, used in conjunction with the trailing edge flaps for take-off, landing and low-speed manoeuvring, are attached to the wings by piano-type hinges and are actuated by rotary electromechanical actuators in the wing root fillets. The trailing edge flaps, also attached by piano-type hinges, are actuated in a similar manner.

Each aileron is hung by a piano-type hinge and actuated by 10 hydraulic jacks which are fed by an irreversible aileron boost control unit through a spanwise manifold. The aileron system is interconnected with the flap system so that when the flaps are fully up, aileron travel is limited to approximately 65 per cent. Power is provided by two independent hydraulic systems, and either one is fully capable of taking over should one system fail.

On uncamouflaged aircraft the wings are coated with a special high gloss white paint to guarantee an absolutely smooth air flow.

The entire horizontal stabilizer is pivoted aft of the fin mid-chord line, and moves as one unit. It has no elevator. It measures 3·6 inches at the centre and 0·6 inches at the tip and is made with a single spar (which is also the hinge line) covered with skin panels. All empennage control surfaces are actuated by irreversible hydraulic systems with the dual servo units housed in the fin. Electrically controlled hydraulic actuators are used to operate the speed brakes which are located at the sides of the aft fuselage section.

An automatic pitch control system is installed to provide warning of an impending stall. As the stall approaches, the system energizes a stick shaker and then, should the pilot persist in maintaining the aircraft atitude, applies a forward stick force. An automatic Flight Control System is also installed which moves the control surfaces to maintain desired pitch and roll attitudes and Mach numbers.

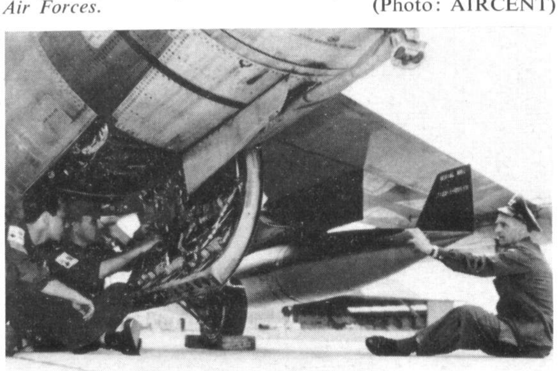
The cockpit and instrument panel are designed to be easily read and interpreted. Among other features the instrument panel—besides the usual flight and engine instruments, radar display, etc.—holds a master caution light which is monitoring all warning lights. After it is activated in case of trouble it can be reset to operate for other parts of the warning system. The instruments are on four vertically mounted panels. Individual instruments are face-lighted. Printed placards are edge-lighted. More indicators and gauges are held by a T-shaped lower panel, and other instruments, levers, controls, buttons, circuit breakers, etc. are mounted on consoles extending along the cockpit walls.

POWER PLANT

The F-104G Super Starfighter is powered by the General Electric J-79-11A turbojet engine. It delivers 9,700 lb. normal thrust, 10,000 lb. military thrust, 12,300 lb. with minimum reheat and 15,800 lb. with full reheat. Weighing only 3,500 lb. it has an excellent thrust-to-weight ratio which is the result of a variable-stator design concept with a converging-diverging jet nozzle. It was developed in cooperation with the U.S. Air Force and was the first production engine capable of powering aircraft twice the speed of sound. Major components and related structural and hot static parts are of lightweight fabricated sheet-steel construction resulting in substantial weight saving and increased engine durability. It has a 17-stage, axial-flow, single rotor compressor with the first six stator stages and inlet guide vanes variable to reduce stall problems at low engine operating speeds and to obtain maximum compressor efficiency throughout the flight envelope. The wheels of the three-stage turbine are coupled to the compressor rotor by a conical shaft for low weight and high strength.

The high speeds of the F-104 rendered necessary a sophisticated intake and exhaust system. Excess air (secondary flow) is bypassed around the engine and ejected at the nozzles for cooling and better propulsion efficiency. Half-conical wedges in the intake scoops "guide" a shock wave which at Mach 2 hits the intake lip. Within the intake another shock wave forms, perpendicular to the air flow, thus reducing its speed further to about Mach ·95 and simultaneously increasing the air pressure before it enters the engine. By varying the diameter of the exhaust nozzles (primary flow and secondary flow) the speed of the exhaust gases can be controlled to obtain constant maximum thrust. The exhaust nozzles

Luftwaffe *maintenance N.C.O.'s examining the lowered main hydraulic panel of a Super Starfighter. Note the shoulder patches of the two men on the left; indicating the European alliance, they carry the symbols of the Italian, Belgian, German and Dutch Air Forces.* (Photo: AIRCENT)



Fine take-off study of CF-104 (12739) of the R.C.A.F.'s No. 3 Wing; note emblem of 4th A.T.A.F. on intake, and training weapons container on centreline station.
(Photo: Peter Doll Collection.)

represent an advanced design with their multiple segments which are operated by hydraulic actuators. An emergency device is provided to close the nozzles should they fail in the open position. Compressor discharge air guards against inlet guide vanes and struts icing.

The engines' fuel systems—main and afterburner—are both flow controlling units, hydro-mechanically operated. An integral part of the basic engine, controls have electrical trim, with both hydraulic and electric power. Overall, the system serves main fuel, afterburner fuel, nozzle area and variable stator controls (integrated with main fuel controls).

OTHER SYSTEMS

Fuel is contained in four main and one auxiliary bladder-type tanks contoured to the fuselage shape and located above the centre section area. The aft main and the saddle tanks gravity feed the forward collector tank. Additional auxiliary tanks can be fitted in the gun bay, the ammunition and the ejector case compartments. Feed from these tanks to the collector tank is accomplished by means of a fuel transfer pump. Provisions are also made for the alternate installation of two tip tanks and two under-wing pylon tanks. The external tanks are pressurized with engine bleed air and can be jettisoned. Normal refuelling of both internal and external tanks is accomplished through a single-point pressure system which can also be used with an aerial refuelling probe. When installed, the probe is located on the port side of the aircraft, level with the cockpit.

The F-104G has two independent hydraulic systems working from engine-driven variable displacement pumps, both operating at 3,000 PSI. A flamed-out but windmilling engine gives adequate hydraulic power to operate the flight controls. In case of hydraulic failure a ram-air turbine can be extended from the starboard fuselage side into the slipstream. It enables the primary system to work normally and allows moderate manoeuvres. The ram-air turbine also delivers emergency electrical power. Normally electric power is delivered by two engine-driven variable frequency generators, a fixed frequency unit driven by a hydraulic motor, and two batteries. The emergency system is capable of operating all vital functions for a dead stick landing including radio, cockpit lights, windshield defogging and the flaps.

ELECTRONICS

Never before in the history of aviation has an aircraft of the F-104G's size carried such a compact load of electronics. And it is the electronic equipment which (aside from the structural changes) makes the big difference between the F-104G/CF-104 and earlier American models of the F-104.

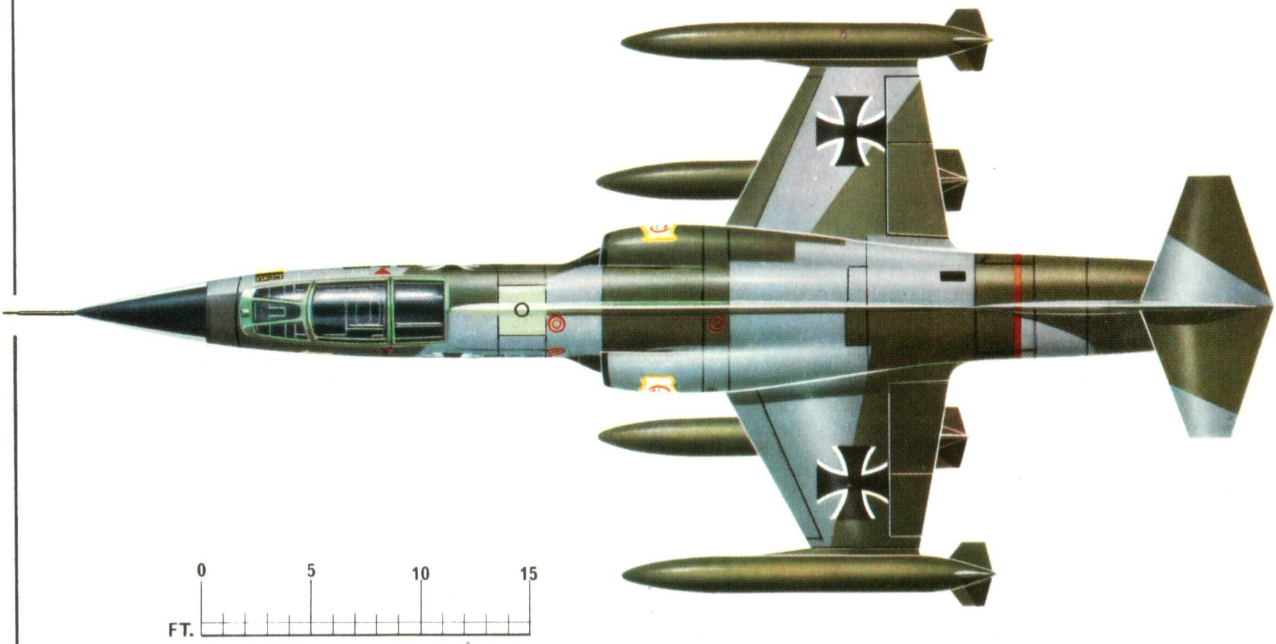
The North American Search and Ranging Radar (NASARR) forms the centre part of the F-104G's fire control system by providing the pilot with range information for visual bombing, ground mapping for all-weather bombing and navigation, contour mapping for navigation, and terrain avoidance for low-level operations. With a fire control computer, the NASARR (F15A-41B) system provides radar search in air-to-air missions, figures lead angle of attack for automatic missile release and acts in conjunction with the director-type gunsight for the M-61 Vulcan gun. This director gunsight gives the pilot an optical line-of-sight indication, after NASARR has computed the proper lead angle for firing the gun. The caged sight is also used as aiming reference for visual dive bombing. A Lockheed-developed infra-red sight is integrated with the director sight. It picks up emissions of infra-red rays from heat sources and can be used by day and night. An air data computer receives electrical analogs of air temperature and angle of attack from transducers and transforms these into functions of true altitude, true air speed, true Mach number and angle of attack as required by other systems. A bombing computer is also installed for four types of bomb delivery, and the appropriate data are fed into it by the air data computer.

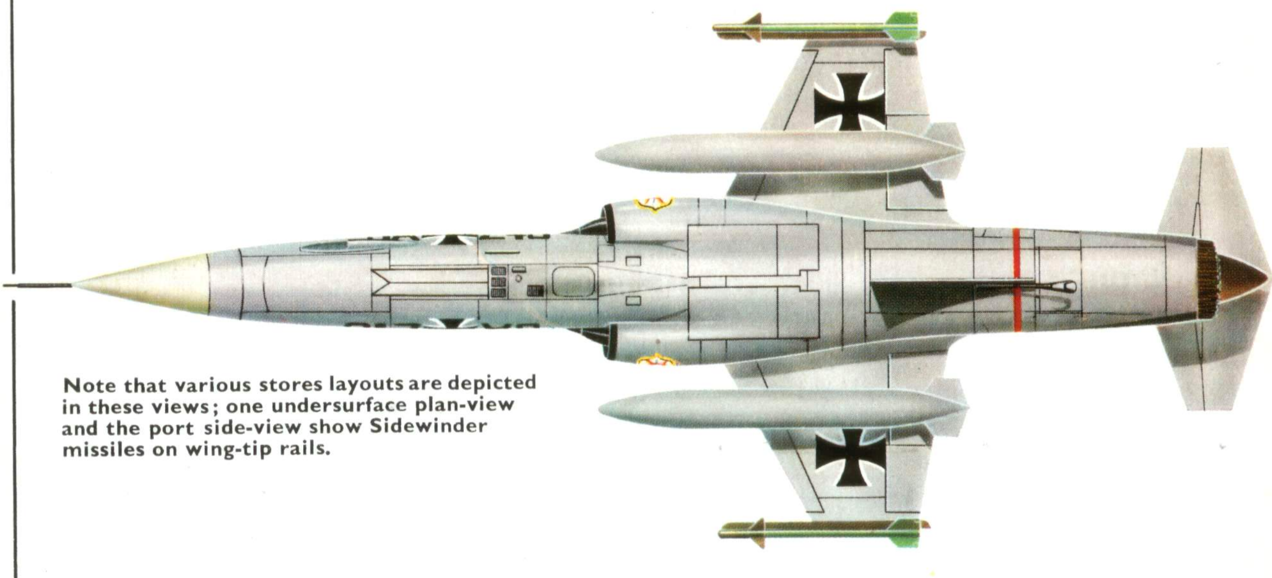
A PHI (Position and Homing Indicator), developed by Computing Devices of Canada, is used for automatic dead-reckoning navigation. It figures the airplane's position in relation to coordinates and gives immediate indication to pre-selected checkpoints. It records all changes of course and speed. The PHI-indicator also serves for the inertial navigator, the C2G compass and for the TACAN system.

The heart of the navigation system is the Litton LN-3 inertial navigator. It was developed as an advanced navigational aid to provide the pilot

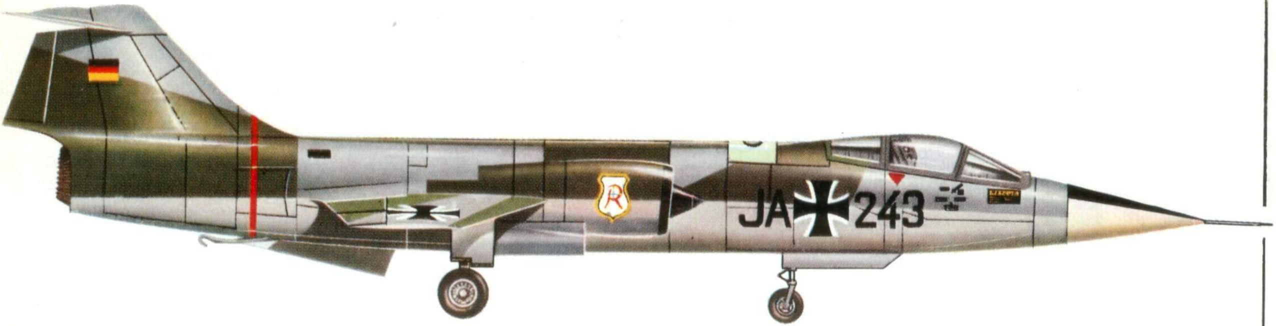
(*continued on page 10*)

Detail of the externally-mounted Vicon reconnaissance pod carried by CF-104 (12854) of No. 441 Squadron, No. 1 (F) Wing, R.C.A.F.; and (right) *nose details of this aircraft.*
(Photos: the author)

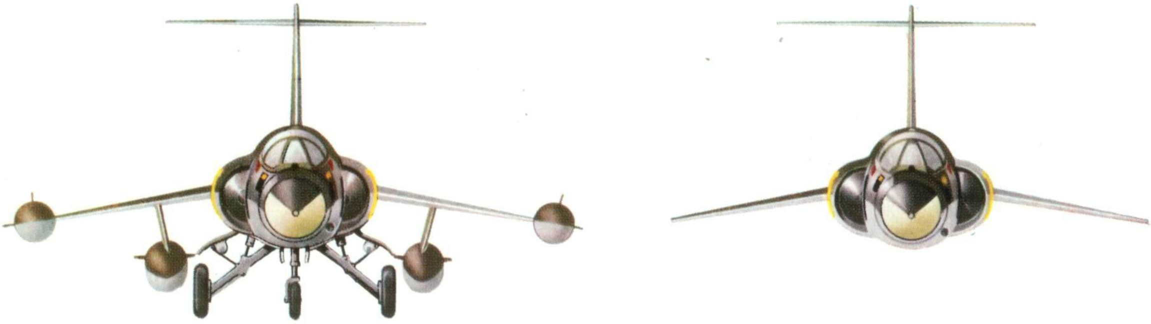




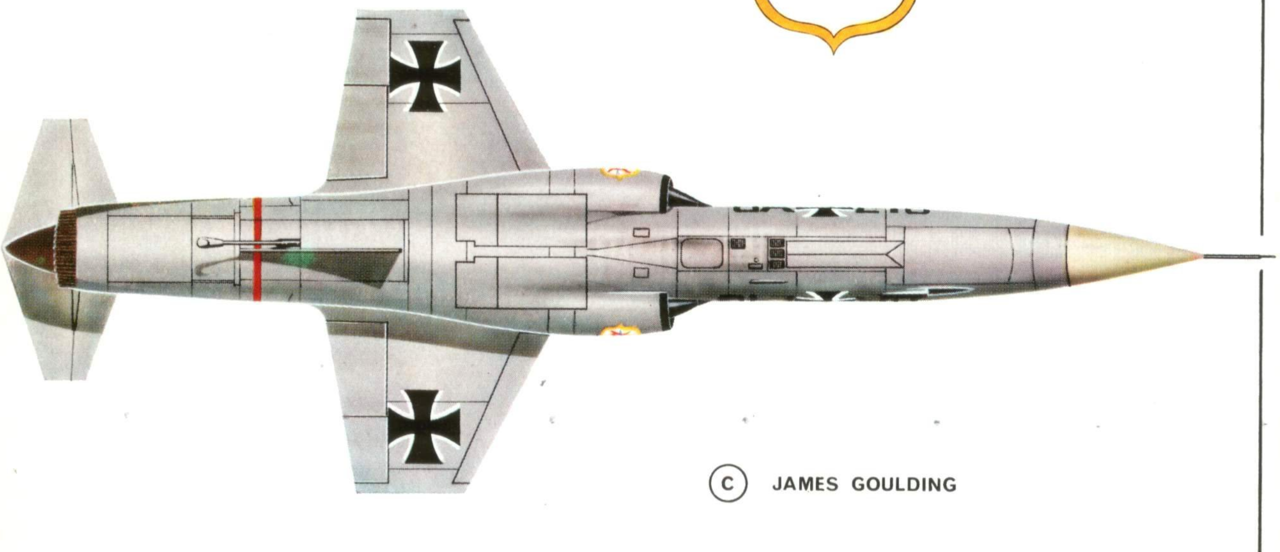
Note that various stores layouts are depicted in these views; one undersurface plan-view and the port side-view show Sidewinder missiles on wing-tip rails.

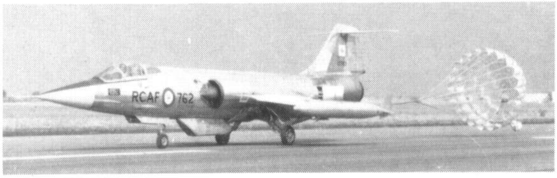


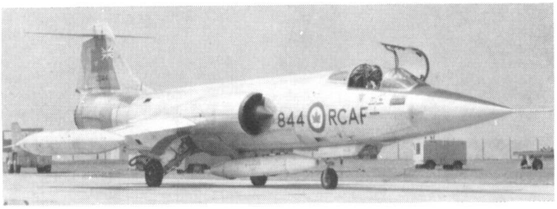
LOCKHEED F-104G SUPER STARFIGHTER, *of Jagdgeschwader 71* **"Richthofen", Federal German Air Force** ***(Luftwaffe)*****, 1966.**



Insignia of JG 71 "Richthofen"; the traditional R-shield design carried by units bearing that honour-title since the late 1930's, with the N.A.T.O. "star" superimposed.







continuously with optical indication of direction and distance to a preselected target or other reference points, regardless of wind, but prevents detection by ground stations since the system does not transmit any kind of energy. At the present time it is the most developed system in size, cost and weight. Its primary advantage is the complete independence from ground stations, and it cannot be influenced by enemy counter-electronic action. It also provides data about heading, pitch and roll for other electronic systems. For normal radio navigation the Super Starfighter is equipped with TACAN, and for voice communication an improved UHF command set is installed.

All "Black Boxes" are located in the "E" (for Electronics) bay beneath the aft section of the cockpit canopy apart from the radar antenna which is carried in the nose. Access to the electronics compartment is provided by a hinged door on top of the fuselage. Boxes are interchangeable and standardized in height and depth, and all units have self-test points and adjustments permitting quick checkout before or between sorties.

As for electronics, the F-104G was designed with easy and quick maintenance in mind. It has 165 interchangeable parts which can be switched or replaced with tools from an average man's height. All major compartments can be reached from the ground, i.e. the circuit breakers and load carriers are located in service bays on the forward sides of the fuselage. Most of the hydraulic system is mounted on a panel built into the lower side of the fuselage and can easily be lowered for servicing. The cockpit bottom hatch can be removed, the entire seat installation taken out, thus providing inside stand-up room for a technician.

There are also provisions for all types of external stores on a centreline pylon, two under-wing pylons and the wing tips.

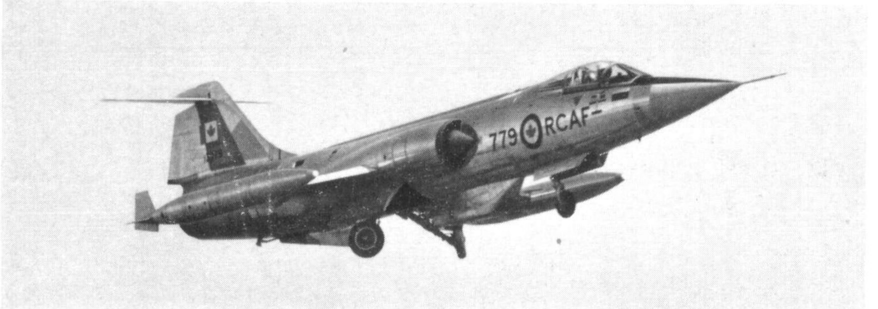
CANADIAN MACHINES

Not all Super Starfighters seen in European skies stem from continental production lines; some were assembled by Canadair. These are the CF-104's (Canadair designation CL-90 and original R.C.A.F.-designation CF-111) in service with the R.C.A.F.'s No. 1 Air Division in Europe; and F-104G's operated by some smaller Air Forces. The decision to adopt the F-104 as replacement for the Sabre Mk. 6 was announced by the Canadian government on 2nd July, 1959, and the licence production contract was signed on 17th September of the same year. Meanwhile, on 14th August, it was announced that Canadair had been selected to manufacture 200 aircraft for the R.C.A.F. plus wings, tail assemblies and rear fuselage sections for sixty-six aircraft for the *Luftwaffe*, built by Lockheed.

The first CF-104 prototype was F-104A-15-LO system number 56-0770, later renumbered 12700), modified in respect of fire control and flight control systems; it did not yet possess the strengthened airframe. This aircraft made its first flight on 1st September 1960. The next aircraft, number 12701, the first true production CF-104, was completed on 18th March 1961 and flew for the first time on 26th May, 1961 after being airlifted to Palmdale, California, for performance tests by Lockheed. It was later joined by the second production aircraft, No. 12702. The first CF-104's to fly at Montreal were the fourth and fifth Canadian Starfighters, Nos. 12703 and 12704. They both took the air on 14th August 1961. The 200th and last CF-104 (No. 12900) was completed on 4th September, 1963 and delivered to the R.C.A.F. on 10th January, 1964; early production aircraft were modified to the standard of the last production machines.

Differences between F-104G's and CF-104's externally are difficult to recognize. The main difference can be found under the skin. Whereas the F-104G is a multi-mission aircraft with its NASARR optimised in both air-to-ground and air-to-air modes, the CF-104, used primarily as a strike fighter, is equipped with R-24A NASARR optimised in the air-to-ground mode. The lead angle computer is removed

Above and Right: *A selection of views of R.C.A.F. Super Starfighters in flight, landing and "readiness" regimes.* (Photos: Stephen Peltz and (831) R.C.A.F.)



Fine study of 12779 immediately after take-off. Note the main undercarriage turning on the vertical axis for the retraction.
(Photo: Stephen Peltz.)

together with the cannon, and the director-type gun sight is replaced by a simple fixed-reticle sight. The instruments are integrally lighted. The extra space gained by removal of the cannon, ammunition and ejector case is used by installation of additional aluminium fuel tanks raising the total internal fuel capacity of the CF-104 by 101·5 Imp. gallons. The main undercarriage members were fitted with longer-stroke liquid springs and larger tyres. The CF-104 is powered by the Orenda J79-OEL-7, manufactured under licence from General Electric, delivering the same thrust as the F-104G's engine. Performance and dimensions of the CF-104 are generally similar to those of the F-104G (which appear on the last page of this *Profile*), but the weights are as follows: empty; 13,909 lb.; loaded (clean); 21,005 lb.; max.; 28,891 lb. Besides this, provisions on all CF-104's are made for installation of a Vicon photo-reconnaissance pod on the fuselage centre line behind the nose gear housing four 70 mm. Vinten cameras.

While CF-104 production was running well, the U.S.A.F. ordered 140 F-104G's to be built by Canadair for various NATO nations under the MAP programme, of which Canada was to pay a quarter of the cost. These aircraft were delivered to Norway, Denmark, Greece, Turkey and Spain. Canadair started to build F-104G's when the CF-104 production was nearing its end. The first of these MAP F-104G's (serial number 62-2302) made its maiden flight on 30th July 1963, and deliveries to NATO forces began before the end of that year.

RECONNAISSANCE AND TRAINER MODELS

A number of F-104G's were modified by Avio Diepen at Ypenburg to carry camera equipment in the fuselage. Others were built for the *Luftwaffe* and the Italian Air Force by Fiat. These are externally recognizeable by a small bump under the forward fuselage which includes part of the nose wheel doors. Three cameras are installed in tandem for vertical, left and right oblique photography. The pilot through a selective switch can operate the cameras either individually or collectively. Operation is fully automatic and is controlled by the pilot through the gun trigger on the control stick grip. For installation and removal of the cameras the nose gear has to be unlocked and rotated 90 degrees to make room for moving the camera platform. The RF-104G carries no armament.

The need to familiarize pilots with the use of NASARR and other flying requirements particularly in low level operations led to the development of the TF-104G, one of several two-seater versions of the Starfighter. Its airframe is basically similar to the F-104G, but the installation of a second cockpit rendered necessary some internal changes, such as removal of the autopilot and the Vulcan cannon and relocation of electronic equipment and fuel tanks. Partial weapons capability has been retained (despite elimination of the centreline bomb rack) by the underwing and wing tip stations. Range is reduced by the smaller internal fuel capacity of 583 Imp. gall. An externally notable feature is the de-icing equipment of the air intakes; another one (on all two seaters) is the rearward retracting nose gear. It carries however full NASARR equipment thus providing for the possibility of one pilot flying low level by use of radar while the other pilot is watching the outside airspace.

The first TF-104G was an actual production model. No prototype was built because of similarity with the F-104D. The total number of TF-104G's built to date is 208. Of these Italy received 12, Holland 18, Belgium 12, Spain 1, Denmark 4, and Germany 137 (plus 30 F-104F's). The remaining 24 were distributed among other MAP countries. At the time of writing Germany is planning to purchase some 30 additional TF-104G's which would be built by the German manufacturing group. The R.C.A.F. has procured 38 two-seaters which were originally designated CF-113 but then changed to CF-104D. This aircraft is similar to the TF-104G and differs only in equipment. The first CF-104D (number 5301) made its maiden flight on 14th June 1961.

All two-seaters completed so far were built by the parent company. In some cases however the components were shipped to the receiver country, i.e. in

An RF-104G of the Royal Netherlands Air Force; D-8112 of No. 306 Squadron.
(Photo: Stephen Peltz.)

Over the Mediterranean, two R.Neth.A.F. Super Starfighters of No. 325 Squadron formate on a machine of the Italian 4° Aerobrigata. *In the background, the coast of Capri.* (Photo: FIAT/R.Neth.A.F. via G. H. Kamphuis.)

the case of Italy, where the aircraft were reassembled and test flown by Fiat. The first Fiat-assembled TF-104G made its initial flight early 1965.

SERVICE ASSIGNMENTS

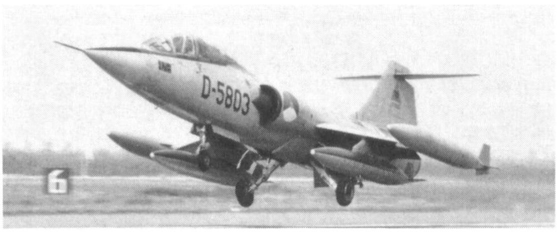
As already stated, the German *Bundeswehr* received the lion's share of 700 F-104G's single seat fighters, and they form the backbone of the *Luftwaffe* and the *Marinefliegergeschwader*. They equip five fighter bomber wings (JABO-G. 31, 32, 33, 34 and 36), two interceptor wings (JG 71 and 74), two reconnaissance wings (AG 51 and 52) and two wings of the Navy, *Marinefliegergeschwader* (or MFG) 1 and 2. Each wing is equipped with 50 aircraft including reserves. Single and two-seaters are also assigned to the *Luftwaffe's* conversion unit in Germany, WS (for *Waffenschule*) 10. Furthermore, 95 aircraft (single and two-seaters) are posted to the United States, where the *Luftwaffe* and *Marine* are now training all Starfighter pilots at Luke Air Force Base, Arizona. They are assigned to the 4512th, 4518th and 4443rd Combat Crew Training Squadrons, U.S.A.F. This training scheme was adopted because bad flying weather in Europe has severely hampered pilot training so that the *Luftwaffe* was facing difficulties in fulfilling NATO commitments. Although the aircraft at Luke are flying in U.S.A.F. markings for several reasons they are German property, and Germany is paying all the costs of this training programme.

The R.Neth.A.F. received 120 aircraft. These equip two interceptor squadrons, Nos. 322 and 323, two fighter bomber squadrons, Nos. 311 and 312, and one reconnaissance squadron, No. 306. No. 323 Sqn. was the first unit to receive the F-104G and began conversion training and operations in March 1964, and No. 322 Sqn. followed in July. Conversion training now takes place at Twenthe, where a special flight was formed and where most of the Dutch TF-104G's (named "The Dutch Masters") are based. The F-104G's used in the intercept rôle operate in conjunction with the Elliott Firebrigade Mk. 2, and the Den Helder radar station, especially established for the Super Starfighter. This combination is the best defensive set-up in NATO.

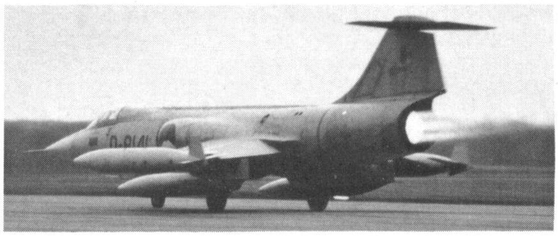
Italy operates 125 F-104G's, and among the units equipped with the type are the *4° Aerobrigata*, the *9°* and *10° Gruppi* of which fly the F-104G; the *5° Aerobrigata* with two *Gruppi* using the F-104G (one in the reconnaissance rôle); the *6° Aerobrigata* with the *154° Gruppo*; and the *51° Aerobrigata* with the *21° Gruppo*. Single and two-seaters are also assigned to the 1st Training Group and the Flying Instructors School. As a matter of interest it might be noted that the *154° Gruppo* based at Ghedi received a NATO Flight Safety Award in late 1965 after it had flown more than 5,000 hrs. on the F-104G without any accident.

Belgium received 100 F-104G's, operational with Nos. 349 and 350 Sqns. of the 1st Wing. Norway received originally 16 F-104G's (plus two TF-104G's), but at least three more F-104G's were delivered later. All single-seaters were converted to RF-104G's and are operating with one squadron, No. 331 at Bodo, in the reconnaissance rôle. Incidentally, this is the oldest fighter unit of the R.No.A.F., being formed on 21st July 1941 at Catterick, England, with Hawker Hurricanes.

The Royal Danish Air Force operates a total of 25 F-104G's and 4 TF-104G's. These are used by both No. 723 and No. 726 Sqns., based at Aalborg, as servicing has been centralized on station level.

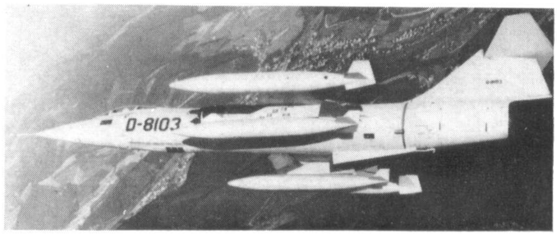


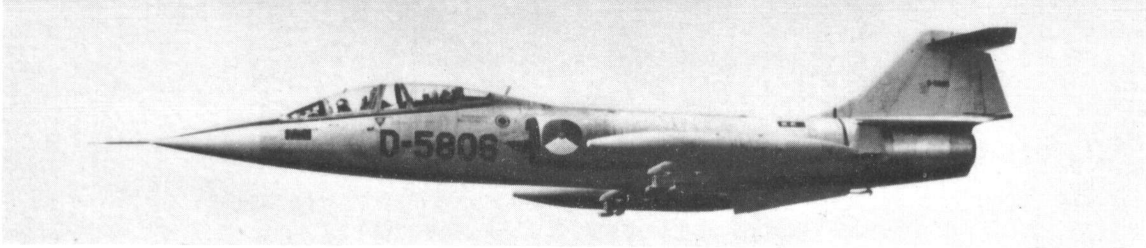
A R.Neth.A.F. trainer from the "Dutch Masters" conversion unit at Twenthe springs into the air. (Photo: Stephen Peltz)



Striking study of a 306 Squadron machine taking off from a R.Neth.A.F. base, with reheat. (Photo: Stephen Peltz.)

An RF-104G of No. 306 Squadron displays the camera equipment fairing in its belly, below the code number. (Photo: R.Neth.A.F. via G. H. Kamphuis.)



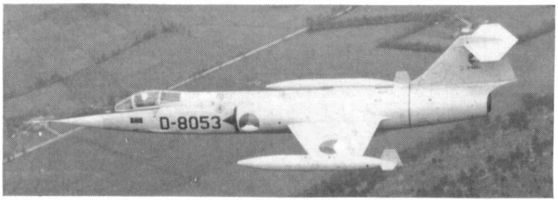


R.Neth.A.F. TF-104G, D-5806, in flight. (Photo: via G. H. Kamphuis.)

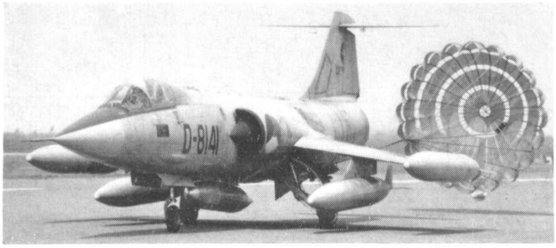
The first 8 F's and 2 TF's were delivered to Aalborg by ship on 23rd November 1964. They were followed by 8 F's and 1 TF on 19th December 1964, and 9 F's and another TF followed on 5th June 1965. Incidentally, all F-104's of the R.D.A.F. are equipped with British Martin Baker ejection seats.

Greece received 36 aircraft, and the first of these were handed over to the R.H.A.F. on 16th April, 1965 at Athens; Turkey received 38 aircraft which equip two squadrons. Spain received 20 single-seaters which are assigned to one squadron based at Torrejón. Approximately 50 F-104G's were delivered to Nationalist China, but no further details were available at the time of writing.

The Royal Canadian Air Force assigned its CF-104's to the No. 1 Air Division in Europe, comprising No. 1 Wing at Marville, France; No. 3 Wing at Zweibrücken and No. 4 Wing at Söllingen, Germany. These two wings have also adopted the squadrons from No. 2 Wing and one from No. 1 Wing, which are employed in the strike rôle, after France's ban of all foreign nuclear power on its territory. The remaining two squadrons of No. 1 Wing (Nos. 439 and 441) are employed in the photographic reconnaissance rôle but can also be used as strike fighters with conventional weapons. During 1966 these two squadrons will be stationed at Zweibrücken and Söllingen respectively (because of France's decision to abandon NATO and ban foreign units from deployment within her borders) so that by the end of 1966 the whole No.1 Air Division will be concentrated in Southwestern Germany. In Canada the CF-104 is used by No. 6 (Strike and Reconnaissance) O.T.U. at Cold Lake, Alberta for pilot training. This unit received the first production aircraft, which were later modified up to the latest production standard. The first fighter unit in Europe to convert from the Sabre 6 and CF-100 respectively to the CF-104, and thereby change its operational rôle from air fighting to nuclear strike, was No. 427 Sqn. of No. 3 Wing. This took place at Zweibrücken in December 1962, and the R.C.A.F. has operated its Super Starfighters most efficiently ever since.



306 Sqdn. Super Starfighters in flight and (below) *deploying the braking parachute during the landing run. For an idea of scale, note the size of the pilot's helmet, visible through the canopy.* Photos: the author and Stephen Peltz.)



NEW DEVELOPMENTS

Under contract with the German Air Force Lockheed started in 1962 with secret tests of a special programme called ZELL (Zero Length Launch) and SATS (Short Airfield for Tactical Support). For a ZELL take-off the aircraft is mounted on a launching platform with a huge rocket motor attached to the aircraft's underside by a cradle. This rocket delivers sufficient thrust (together with the aircraft's engine running on full power) to boost a fully laden F-104G into the air, thus permitting the aircraft to be controlled aerodynamically moments after launching. The entire cradle, which is manufactured by North American Aviation's Rocketdyne Division, is jettisoned after it is burned out, and landings are made normally. The first takeoffs were conducted at Edwards AFB, California, with Lockheed test pilot Ed Brown at the controls. Early in 1966 it was disclosed by the German Defense Ministry that further tests will be conducted in Germany at Lechfeld Air Base, and the first take-off was made there during the first days of May, again with Ed Brown at the controls. On that occasion a launching platform designed by VFW (*Vereinigte Flugtechnische Werke*) was tested. Further trials followed while German pilots took over the test programme. In combination with the launchings a series of short landings on semi-prepared surfaces are being carried out by use of a method similar to the now-standard arresting barrier; a cable spanning the runway is engaged by the extended arrestor hook, thus bringing the aircraft

Super Starfighters of No. 10 Wing, Belgian Air Force; note fin emblem. (Photo: Stephen Peltz.)

An Italian F-104G during a landing roll at Turin-Caselle air-field. The emblem of the Reparto Sperimentale di Volo *is visible on the fin.*
(Photo: the author.)

to a short stop. These tests are undertaken to enable the *Luftwaffe* to launch and recover its Super Starfighters from small clearings and sheltered areas in order to become independent from highly vulnerable runways.

The aircraft taking part in these tests are equipped with new fully automatic rocket-assisted Martin Baker Mk. GQ7 (F) ejection seats, especially designed by Martin Baker for installation in the F-104G. This seat has zero-zero capability; this means it can be used at zero altitude and zero airspeed. The g-forces acting on the pilot have been reduced to fifteen g's, and the rockets are capable of carrying the seat to greater ejection heights than has been the case with older models. The seat can be installed in the F-104G with only minor modifications in the cockpit.

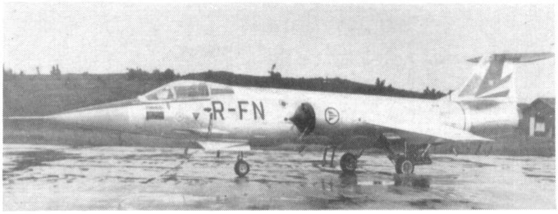
A new Lockheed development is the CL-984 fighter. This new Starfighter version is an armament-laden close support fighter patterned after the F-104G with improved performance (Mach 2·4) and weapons capability while utilizing the F-104G's airframe .It has been offered to various NATO nations and could be built with the same production facilities now existing in the European consortium. It is powered by a new General Electric J79-JIQ engine with lower specific fuel consumption delivering an afterburning thrust of 17,900 lb. which would improve overall performance at all speeds and altitudes. This new Starfighter model is capable of carrying weapons loads in excess of 7,000 pounds. In addition to the 20 mm. Vulcan cannon, it can attack with air-to-air and air-to-ground rockets, bombs up to 2,000 pounds each, and both the Sidewinder and Bullpup missiles. With the addition of a weapons pylon under the wing and as fuel station at the fuselage centreline, the CL-984 has nine external stations and can be configured to carry many combinations of fuel and weapons loads.

Two F-104G's of the Italian Air Force's 4° Aerobrigata *at altitude. Note the famous* Cavallino Rampante *emblem on the fins; this blazon has been carried by Italian Air Force fighters at regular periods since Maj. Francesco Barraca painted it on his SPAD XIII in the First World War.*
(Photo: Italian Air Force.)

Some other versions based on the F-104G's airframe have also been offered by Lockheed; these are designed to better the Super Starfighter's performance, but the only version which is going into production so far is the CL-901 or F-104S, of which the Italian Air Force is to receive 180 aircraft, and which will also be built by Fiat under licence (fifteen of these are expected to be built from spare components from the F-104G programme). This aircraft is primarily an interceptor. It is powered by the General Electric J79-GE-JIF engine offering a maximum thrust of 17,900 lb.st.t. raising placard speed to Mach 2·2, and will carry Sparrow anti-aircraft-missiles as primary armament. It will have a new flap system and overall performance will be considerably increased.

STARFIGHTER SUMMARY

Of course the history of the F-104G Super Starfighter is not yet finished. The airplane will be in the front-line inventory of Europe's air forces for many years to come. Possibly the German Air Force or Navy will be replacing a number of its aircraft at an earlier date, but within the *Luftwaffe* this will probably concern only the interceptor units. The aircraft becoming available in this case could be absorbed by the strike units or they might find their way into the air forces of some smaller nations within military



RF-104G of No. 331 Squadron, Royal Norwegian Air Force. The code letters FN first appeared on the Hawker Hurricanes flown by Free Norwegian pilots of the R.A.F.'s No. 331 Squadron in the Second World War; they have been retained ever since.
(Photo: R.No.A.F.)

A TF-104G of the Royal Danish Air Force.
(Photo: Hans Kofoed.)

6 Aerobrigata.

F-104G of 6 Aerobrigata, Italian Air Force.

F-104G of 4 Aerobrigata, Italian Air Force.

4 Aerobrigata.

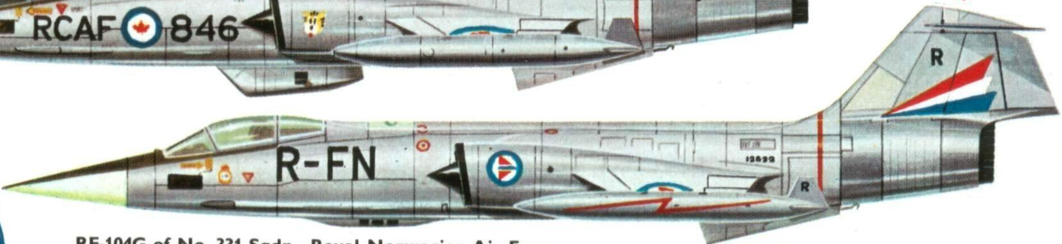
F-104G of 31 Sqdn., 10 Wing, Belgian Air Force. Note "Tiger Meet" decal on intake.

10 Wing.

Leuchars "Tiger Meet" decal.

CF-104, No. 439 Sqdn., 1 Wing, R.C.A.F. Note "Tiger Meet" decal, applied to a/c of units visiting R.A.F. Leuchars, Scotland.

R.No.A.F.



RF-104G of No. 331 Sqdn., Royal Norwegian Air Force.

R.C.A.F. fin flash.

F-104G of Royal Hellenic Air Force (Greece).

F-104G of Spanish Air Force.

R.Dan.A.F. fin flash.

F-104G of Royal Danish Air Force.

A Luftwaffe F-104G, in the markings of Jabo G 33, *being readied for a sortie on its wooded dispersal point.* (Photo: B.V.M.)

aid programmes, since there is a great demand for an advanced airplane to replace the outdated equipment of such nations.

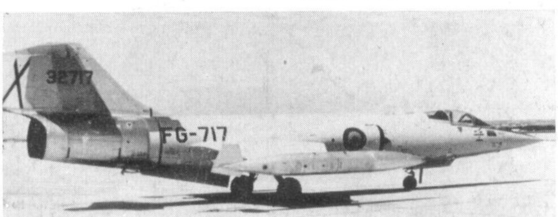
Although highly sophisticated and very advanced on a technical level the F-104G is easy to fly, provided the pilot knows how to handle it. As a very advanced weapon system it requires full attention and knowledge of its systems by the men who fly it, but in turn it has won the admiration and enthusiasm of the pilots of all nations which operate the type, especially for its excellent aerodynamic stability. This is also reflected in the many superlatives with which the F-104G was addressed, such as "dream aircraft"; and when one is closely examining its features and appearance (or even better, when one sees it in flight) one is tempted to agree. Whether it will really fulfill this reputation or not will be left to history, but one thing can be said right now: the F-104G is what it promised to be at its very beginning. An outstanding fighting machine and a modern pilot's aeroplane.

Acknowledgements: The author gratefully acknowledges the assistance in supplying information and photographs for this Profile *of the following persons and organizations:*
Mr. B. Cook of Lockheed; H. Kofoed; Fiat; the German Defense Ministry; the R.C.A.F. the R.Neth.A.F .and many others.

For the reader's interest here follows the *original* production break-down and distribution schedule which was set up when F-104G single-seat production was initiated, excluding those for MAP countries which were built by Lockheed and Canadair.

Manufacturer	**Quantity**
Germany (South Group)	210
Netherlands (North Group)	350
Belgium (West Group)	188
Italy (Fiat)	199
Canada	200
United States	134

A Canadair-built F-104G of the Spanish Air Force. (Photo: Spanish Air Force.)



Air Force	**Quantity**	**From Manufacturing Source**	
Germany	700	Germany	210
		Netherlands	255
		Belgium	89
		Italy	50
		United States	96
			700
Netherlands	120	Netherlands	95
		Italy	25
			120
Belgium	100	Belgium	99
		United States	1
			100
Italy	125	Italy	124
		United States	1
			125
Canada	200	Canada	200

F-104G SUPER STARFIGHTER SPECIFICATION

Dimensions: Span, 21 ft. 11 in.; length, 54 ft. 9 in.; height, 13 ft. 6 in.; wing area, 196·1 sq. ft.
Weights: Operational empty, 14,300 lb.; loaded (clean), 19,841 lb.; max. loaded, 25,027 lb.
Power Plant: One General Electric J79-GE-11A turbojet rated at 10,000 lb.st.t. and 15,800 lb.st.t. with full afterburning.
Performance: Short-period max. speed (clean), 1,550 m.p.h. at 40,000 ft. (Mach 2·35); max. stabilized speed, 1,320 m.p.h. at 40,000 ft. (Mach 2·0); max. low level speed, 915 m.p.h. (Mach 1·2); time to 35,000 ft., 1·5 minutes; time to 49,200 ft., 6·5 minutes; combat ceiling, 55,000 ft.; tactical radius (patrol mission with two 100 Imp. gal. and two 162 Imp. gal drop tanks), 690 miles at 610 m.p.h. (Mach ·92); max. ferry range (1,455 Imp. gal. fuel), 1,988 miles.
Armament: One 20 mm. M-61 Vulcan rotary cannon and (intercept) two or four AIM-9B Sidewinder infra-red homing AAMs or (attack) two AGM-12A Bullpup ASMs, two LAU-3 pods each with nineteen 2·75 in. rockets, two LAU-10 pods each with seven 5 in. rockets, three 700 lb. MLU-10b land-mines, three 1,000 lb. Mk. 83 general-purpose bombs, two 1,000 lb. Mk. 83 and one 2,000 lb. Mk. 84 bombs, or one 2,000 lb. nuclear store.

Total number built:		
	F-104G	1,266
	TF-104G	208
	CF-104	200
	CF-104D	38

Readers may be interested to note the following aircraft mentioned in the text which are also available as PROFILES:
Republic F- and RF-84F : Profile No. 95.
Hawker Sea Hawk : Profile No. 71.

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