The Lockheed F-104G and Canadair CF-104 will soon become a familiar sight in every part of Western Europe. The majority will wear the black-and-white of the Luftwaffe

LARGEST AIRCRAFT-PRODUCTION PROGRAMME IN THE WORLD

Super Starfighter

IN many respects, the Lockheed F-104 Starfighter surpasses every other type of aeroplane. In speed, ceiling, rate of climb, acceleration, and most other aspects of pure performance it has few rivals. Perhaps no other military aeroplane can touch it for sheer glamour. Apart from research machines, it is generally regarded as being the "hottest" vehicle which pilots have ever been asked to handle, and arguments regarding its safety—and effectiveness—have waxed loud and long. Today this neatly engineered, razor-edged storm centre has become the subject of the biggest aircraft-manufacturing programme in the world, and probably the greatest example of international co-operation on a technical level that the world has yet seen. In fact, it is doubtful if any manufactured article has ever been the subject of so much effort in so many countries.

This journal examined the genesis and design of the F-104 on April 20, 1956, and again on May 30, 1958, when we presented the first detailed cutaway drawing of the F-104A ever published. In this issue, in which the keynote is the resurgence of the Federal Republic of Germany as a leader in aircraft manufacture, we offer an appraisal of the aeroplane which is costing that country more money than all other types put together. The F-104G Super Starfighter differs considerably from the less-capable earlier versions, and this article traces its development, and outlines the world-wide network of manufacturers who are helping each other to make it.

Outwardly, the Super Starfighter differs only slightly from its predecessors, giving little clue to its very great increase in operational effectiveness and versatility. In contrast, the original design team at the California Division of Lockheed Aircraft examined a remarkable diversity of studies when the project began during the Korean war. Shortcomings of the first generation of US Air Force jet fighters led to a requirement for a "day superiority fighter," in which everything was subordinated to flight performance. Arranged in strips on these pages may be seen a selection of the ideas which "Kelly" Johnson's men thought might provide the answer.

In March 1952 work began on the model 227-0-6, with sliding intake centrebody, and on the 227-0-11. The latter was the true ancestor of the F-104, but the delta wing and flush cockpit were soon abandoned. In April the design grew to 30,000lb, but by July the 227-16-2 reversed the trend. This aircraft weighed only 8,000lb, and it introduced an amazing unswept wing, of only 16ft 9in span and a t/c ratio of only 3.6 per cent, which became standard for all subsequent projects. Apart, that is, from the 227-14-1, with tail booms mounted at the tips of the wing. A strange idea in August was the tiny (15ft 8in span), rocket-propelled 227-15-3, which suffered from inadequate range. In contrast, the 227-13-1 was the result of a vicious circle which raised the weight to approximately 50,000lb.

By October a real effort had been made to reduce size and weight, and the smaller engine of the 227-20-1 reduced the weight to 25,000lb without affecting range and performance. Lockheed went further, and the 242-19-1 represented an unsuccessful attempt to slash the weight to 9,000lb (at the same time introducing a vee windshield and low tailplane, together with elementary area ruling). The 242-23-1 represented an attempt to 'reduce frontal area by hiding fuel and landing gear behind the air ducts, but its performance was poor at speeds above the transonic regime. A much more successful approach was the 246-1-1, of 22ft 1in span. Lockheed still did not like the vee windshield (feeling that a flat screen was necessary for gun-sighting); the intakes had to be changed, and the horizontal tail was raised to the top of the fin to eliminate inertia coupling. The 242-1-27 was an attempt at reducing length by retracting the main gears into nacelles, but this had many disadvantages. The final drawing on page 623 represents an empty weight of about 12,000lb, and is almost the XF-104 which was finally built.

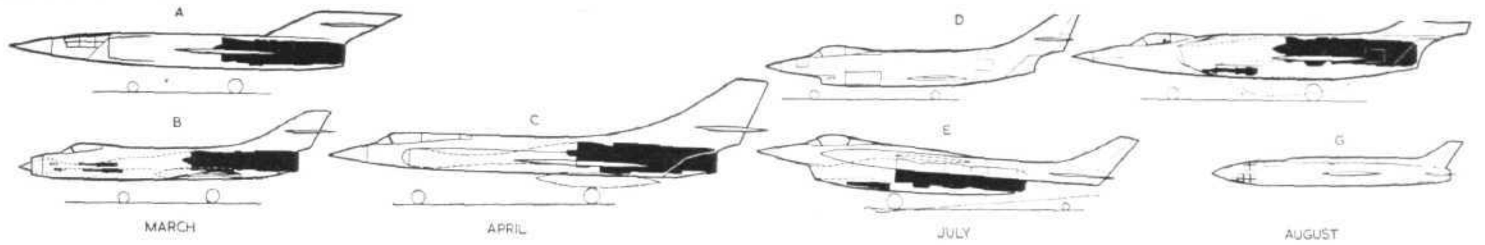
After further refinement, the XF-104 was then designed, built and flown in less than a year. Development then continued, and the production F-104A differed in having a larger engine (General Electric J79 with afterburner) fed by a fixed-geometry, multi-shock intake with cleverly arranged bleed systems to match airflow requirements to the flight regime. To accommodate the larger engine and increased fuel capacity the fuselage was lengthened by several feet, and other major changes included a switch to an a.c. electrical system of much enhanced capacity, and the addition of a search and track radar system, armament and a ventral fin.

Lockheed manufactured fewer than 300 F-104 Starfighters for the US Air Force. The first production machine was the single-seat F-104A day fighter for Air Defense Command, which entered operational service in January 1958. The F-104B is a tandem-seat trainer/air-defence model for the same command, the F-104C is a single-seat attack/ground-support version for Tactical Air Command, and the F-104D is a tandem-seat trainer/local-defence variant for Tactical Air Command. Squadrons equipped with the F-104A found that the good qualities of the aircraft were marred both by limited operational effectiveness and by a safety record which compared unfavourably with that of other "Century-series" aircraft. Today this version of the Starfighter is no longer in US service, except as the QF-104 target drone. The F-104C incorporates such major improvements as flap-blowing, a retractable flight-refuelling probe and provision for carrying a range of stores externally. Several more advanced versions have since been offered to the US Air Force, but none has been accepted.

In 1958 Lockheed prepared proposals for three advanced versions embodying improvements to the structure, systems and equipment, under the company designations F-104-7 (TAC fighter/bomber), -9 (NATO/US air superiority) and -11 (ADC advanced air superiority). The company appreciated that they would have to conduct an extensive redesign in order to produce a multi-mission aircraft capable of competing successfully with the many other aircraft then becoming available in the same category. Moreover, they began to look increasingly outside the United States to find a market.

From 1956 Lockheed and the US Air Force subjected the F-104 to a test programme involving 52 test aircraft flying approximately 8,000 missions for a programme cost somewhat in excess of $30m. One of the many conclusions drawn was that the airframe would have to be redesigned if the role of the aircraft were to be changed from day superiority fighter to all-weather fighter/bomber. But Lockheed knew there would be little chance of selling a purely defensive aircraft, and accordingly the company themselves undertook the development of what is virtually a new aeroplane.

The entire structure was re-stressed to meet fighter/bomber strength requirements with full external loads, and to permit ground-support and penetration missions to be accomplished at low altitudes with no placard restrictions. A total of 36 new forgings was introduced for such major components as wing fittings and spars, fuselage frames, longerons and joint-members, and spars and



Stages in the evolution of the F-104: A, Model 227-0-11; B, 227-0-6; C, 227-8-1; D, 227-16-2; E, 227-14-1; F, 227-13-1; G, 227-15-3. All drawings on this page have been prepared to the same scale, emphasizing the variation in size between projects. For dates, see text

ribs in the tail unit. Approximately 60 lesser forgings are of the zero-draught close-tolerance variety, which the company estimates has saved approximately 40 per cent of the cost of conventional machined parts.

To provide the increased control power required for operations at low altitudes and increased gross weights, modifications were made to the tail unit. The principal change represents a refinement of the enlarged vertical tail originally developed to counteract the increased side area of the tandem-seat nose of the F-104B. Lockheed extended the leading edge of the fin forwards, incorporated irreversible hydraulic power to drive the rudder and eliminated the separate yaw-damper tab previously fitted. At the same time, the hydraulic boost system for the horizontal tail was appreciably increased in power.

Modifications were made to improve the performance of the wing. Chief among these is an alteration to the control system governing the trailing-edge flaps, to enable the latter to be employed as manœuvring flaps. Lockheed claim that their use "results in as much as 33 per cent reduction in airplane turn radius at an altitude of 5,000ft." These flaps are fully blown, and for take-off and landing are supplemented by the full-span leading-edge flap. The latter is machined from a slab of 7075-T6, and the leading-edge radius is so sharp (0.016in) that felt protective guards are frequently employed during maintenance operations. The ailerons are hung on 90-ton-steel piano hinges and driven by hydraulic manifolds serving ten parallel actuating rods.

Logical modifications to the landing gear included fully powered brakes with an anti-skid system energized by sensing units in the axle of each wheel. At the same time, the diameter of the braking parachute was increased from 16ft to 18ft, and Lockheed briefly investigated the practicability of fitting an arrester hook. It was decided to add electro-thermal de-icing elements to the engine intakes, and the choice fell upon the British Spraymat, produced under Napier licence by Pacific Airmotive Corporation. To increase range during purely offensive operations, provision was made to replace the six-barrel M61 gun and ammunition bay by an aluminium fuel tank with a capacity of 120 US gal.

What the F-104G Can Carry

Modifications of this nature were all largely decreed by the decision to turn the aircraft into an attack vehicle with the ability to carry a wide range of external stores. Most important of these are the "Special Weapons"—the euphemistic term for nuclear bombs—many types of which can be hung from Station 3 on the aircraft centreline. Ten feet away, the wing-tip shoe can carry a Sidewinder air-to-air missile or a tank with a capacity of 170 US gal (see photograph, page 622). Stations 2 and 4, beneath the wings, can each carry a 195 US gal tank, an air-to-surface missile (the F-104 has yet to be seen with such a weapon, but the Bullpup and possibly a modified Nord AS.30 come to mind as possible loads), and a great variety of other stores up to a unit weight of 1,000lb. A similar range of stores, as well as a pair of Sidewinders or a 225 US-gal tank, can be hung on Station 3 already mentioned.

In parallel with these extensive airframe modifications Lockheed sketched a very complete system for internal and external armament. The only internal armament of the earlier models was the General Electric M61 "Vulcan" six-barrel gun, with a single-belt feed, installed in the lower port side of the forward fuselage. This was retained, but modified in detail to increase rate of fire to the theoretical 6,000 rds/min: and electric drive was standardized.

The question of all-weather radar, fire control, weapon-delivery systems, navigation and instrumentation was far more complex. Lockheed were fortunate in that a major nation, with a potential requirement for a very large number of aircraft, had since mid-1957 been giving the Lockheed proposals far more than a cursory examination. This nation was the Federal Republic of Germany.

During 1958 German engineers co-operated with Lockheed in developing a model appropriately called the F-104G. If anything, this was to be an even more advanced aeroplane than the F-104-7 already planned. It was soon clear that its operational equipment and maximum external load would raise the overload weight to at least 20,000lb, and it is a remarkable fact that the resulting aircraft has the same wing and powerplant as the earlier versions.

After an evaluation of "nearly two dozen of the world's top fighter aircraft," the Federal Government in Bonn announced their choice of the F-104G as their future standard tactical aircraft in February 1959. Lockheed have described how the painstaking and protracted evaluation of the large team from the Luftwaffe and Herr Strauss's Defence Ministry gradually narrowed the list of US designs down to two aircraft. The other machine was clearly the Grumman G-98 Super Tiger, powered by the same engine as the F-104. It had the advantage of being a *fait accompli*, whereas the F-104G was then almost two years distant. But Lockheed claim to have eliminated their rival by a series of competitive performance trials, using an existing F-104C.

Still in the race were one or two European aircraft—in particular, the Mirage III. In retrospect, there are strong grounds for feeling that this aircraft would have met the requirements of the Luftwaffe fully as well as the F-104, but it succumbed to Lockheed's brilliant salesmanship. At that time neither aircraft existed as a developed weapon, but Lockheed were more convincing in describing the equipment which they were going to fit. It is probably fair to suggest that something also depended upon the image created by the respective companies: Lockheed presented a bold, confident and united front; Dassault were a much smaller team, with practically no experience of making presentations of such a character. Moreover, the French company's cause can hardly have been assisted by reluctance on Dassault's part to turn their sleek intercepter into a pylon-festooned attack aircraft.

Long before the deal was clinched, Lockheed had evolved a comprehensive specification, and it is appropriate to outline the operational equipment specified for the F-104G before going on to analyse its remarkable success. Many details remain classified, but the basic principles have already been outlined by Lockheed.

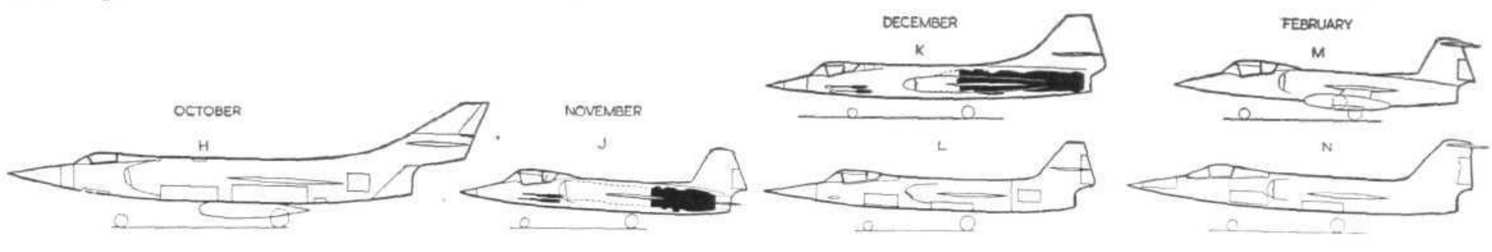
It is in its electronic features that the F-104G differs principally from the versions of the F-104 ordered by the US Air Force. For the USAF the F-104 is an air-superiority weapon, whereas for European military requirements it needs to perform as an all-weather intercepter, fighter/bomber or reconnaissance aircraft.

One of the most important new electronic systems is the multi-purpose NASARR F-15A radar, by NAA Autonetics Division. Consisting of a radar set and a fire-control computer, the equipment operates in two basic modes—air-to-ground for bombing and navigation, and air-to-air for target interception—and is capable of providing data-link information read-out. For air-to-ground operation it provides ranging information for bombing computation in visual bombing modes, ground mapping for all-weather bombing, contour mapping for navigation and terrain avoidance. In air-to-air use it provides increased power for radar search, acquisition and automatic tracking of air targets to achieve the capability for: lead-collision attack for automatic release of rockets; lead-pursuit attacks using the M61 gun, with information supplied to director-type gunsight; and pursuit attack with Sidewinder guided weapons.

Another important "black-box" is the air-data computer, which

(Continued on page 626, after double-page drawing)

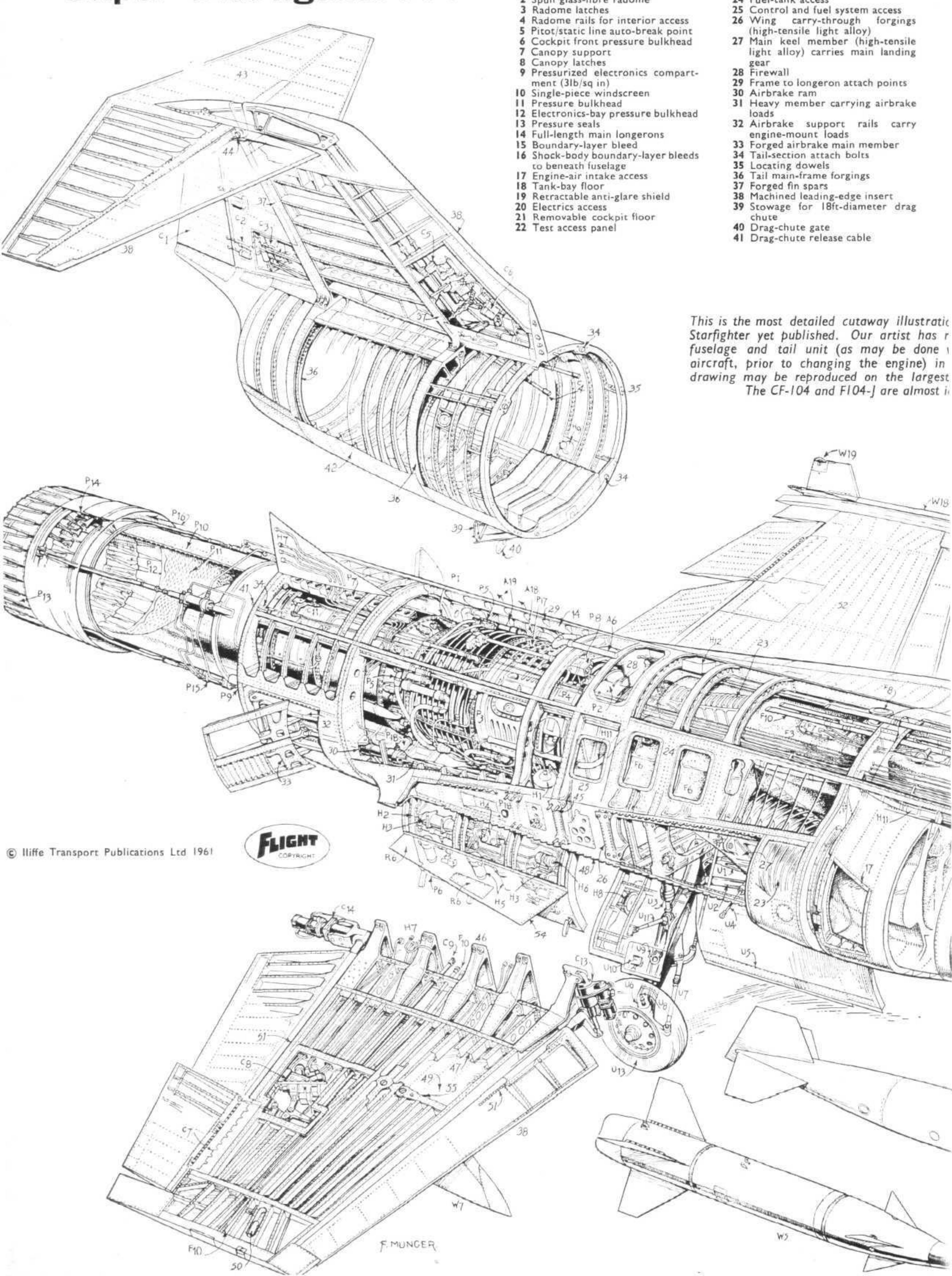
Final stages in the evolution of the design: H, 227-20-1; J, 242-19-1; K, 242-23-1; L, 246-1-1; M, 242-27-1; N, a design which is virtually the XF-104



Super Starfighter . . .

Structure
1 Pitot/static probe
2 Spun glass-fibre radome
3 Radome latches
4 Radome rails for interior access
5 Pitot/static line auto-break point
6 Cockpit front pressure bulkhead
7 Canopy support
8 Canopy latches
9 Pressurized electronics compartment (3lb/sq in)
10 Single-piece windscreen
11 Pressure bulkhead
12 Electronics-bay pressure bulkhead
13 Pressure seals
14 Full-length main longerons
15 Boundary-layer bleed
16 Shock-body boundary-layer bleeds to beneath fuselage
17 Engine-air intake access
18 Tank-bay floor
19 Retractable anti-glare shield
20 Electrics access
21 Removable cockpit floor
22 Test access panel
23 Extruded light-alloy engine air duct
24 Fuel-tank access
25 Control and fuel system access
26 Wing carry-through forgings (high-tensile light alloy)
27 Main keel member (high-tensile light alloy) carries main landing gear
28 Firewall
29 Frame to longeron attach points
30 Airbrake ram
31 Heavy member carrying airbrake loads
32 Airbrake support rails carry engine-mount loads
33 Forged airbrake main member
34 Tail-section attach bolts
35 Locating dowels
36 Tail main-frame forgings
37 Forged fin spars
38 Machined leading-edge insert
39 Stowage for 18ft-diameter drag chute
40 Drag-chute gate
41 Drag-chute release cable

This is the most detailed cutaway illustratic Starfighter yet published. Our artist has r fuselage and tail unit (as may be done \ aircraft, prior to changing the engine) in drawing may be reproduced on the largest The CF-104 and F104-J are almost i



42 Steel and titanium skin on tail section
43 Tailplane, 3.6in thick root, 0.6in thick tip
44 Tailplane hinge-pin
45 Wing-root attach bolts
46 Wing-root forgings
47 Channel-section stiffeners
48 Root-fairing attachment
49 Machined skin 0.25in root, 0.125in tip
50 Tip-tank latch and solenoid
51 Piano hinge on underside
52 Wing, 3.6 per cent thick, 10° anhedral
53 Missile mounting shoe
54 Ventral fin
55 Stores-pylon mounting rib

A Air systems
A1 Liquid-oxygen converter (5-litre)
A2 Ram-air intake (refrigeration system, and electronics emergency cooling)
A3 Ram-air to refrigeration system
A4 Water boiler
A5 Cold-air unit
A6 Engine bleed air from primary heat-exchanger (213°C, 250lb/sq in)
A7 Secondary heat exchanger
A8 Defrosting-air delivery
A9 Cabin-air delivery
A10 Fan exhaust to gun-bay purging
A11 Venturi
A12 Flow-control valve
A13 Mixing chamber
A14 Pressure-altitude switch
A15 Hot-air exhaust
A16 Water separator
A17 Temperature-control valve
A18 Primary heat-exchanger
A19 Primary heat-exchanger air outlet
A20 Conditioned-air outlet to cockpit (−4°C)
A21 Defrosting-air ducts
A22 Radar-cooling air outlet

C Controls
C1 Rudder piano-hinge on port side
C2 Rudder power units
C3 Rudder power-unit control valves
C4 Rudder and elevator control rods
C5 Tailplane power unit
C6 Tailplane power-unit control valves
C7 Aileron 10-cylinder power unit
C8 Aileron power-unit control valves
C9 Aileron control rod
C10 Control cable runs port and starboard
C11 Control lever, cable to rod, to C4
C12 Control-cable duct
C13 Leading-edge-flap actuator
C14 Main-flap actuator
C15 Power-control lever
C16 Control column
C17 Column pivot on aileron torque-tube
C18 Elevator push/pull rod
C19 Elevator torque-tube and levers
C20 Toe-brake linkage
C21 Port and starboard consoles, provision for changeable panels
C22 Controls support and centring device
C23 Elevator cables
C24 Bell-crank group port and starboard
C25 Control rigging-pin access
C26 Angle-of-attack vane

E Emergency
E1 Canopy jettison hinge/latches
E2 Martin-Baker Mk Q5 ejection seat
E3 Ejector firing handles
E4 Canopy external release
E5 Emergency cold air inlet
E6 Ram-air turbine
E7 Alternator (5kVA)
E8 Hydraulic pump
E9 Spraymat anti-icing

F Fuel
F1 Auxiliary tank
F2 Forward main tank
F3 Aft main tank
F4 100 gal drop tank (fuel fed by air pressure)
F5 3-phase, high-voltage boost pumps (4 off)
F6 Saddle tanks
F7 Inspection plate and tank anchorage
F8 Fillers (standard total cap with tip tanks 1,400 gal +)
F9 Optional flight-refuelling probe
F10 Vent and feed pipes

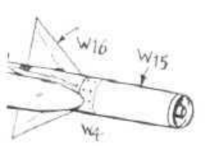
H Hydraulic and electric power
H1 Hydraulic reservoir
H2 Hydraulic servicing panel on door
H3 Hydraulic accumulators (two 3,000lb systems)
H4 Pressure gauges
H5 Pressure filters
H6 Pressure transmitters
H7 Hydraulic pipe runs to actuators
H8 Taxi lamp
H9 Navigation lights
H10 High-voltage electrics bay
H11 Cable duct (port and starboard)
H12 Junction box
H13 Circuit breakers
H14 Batteries (2-28V)

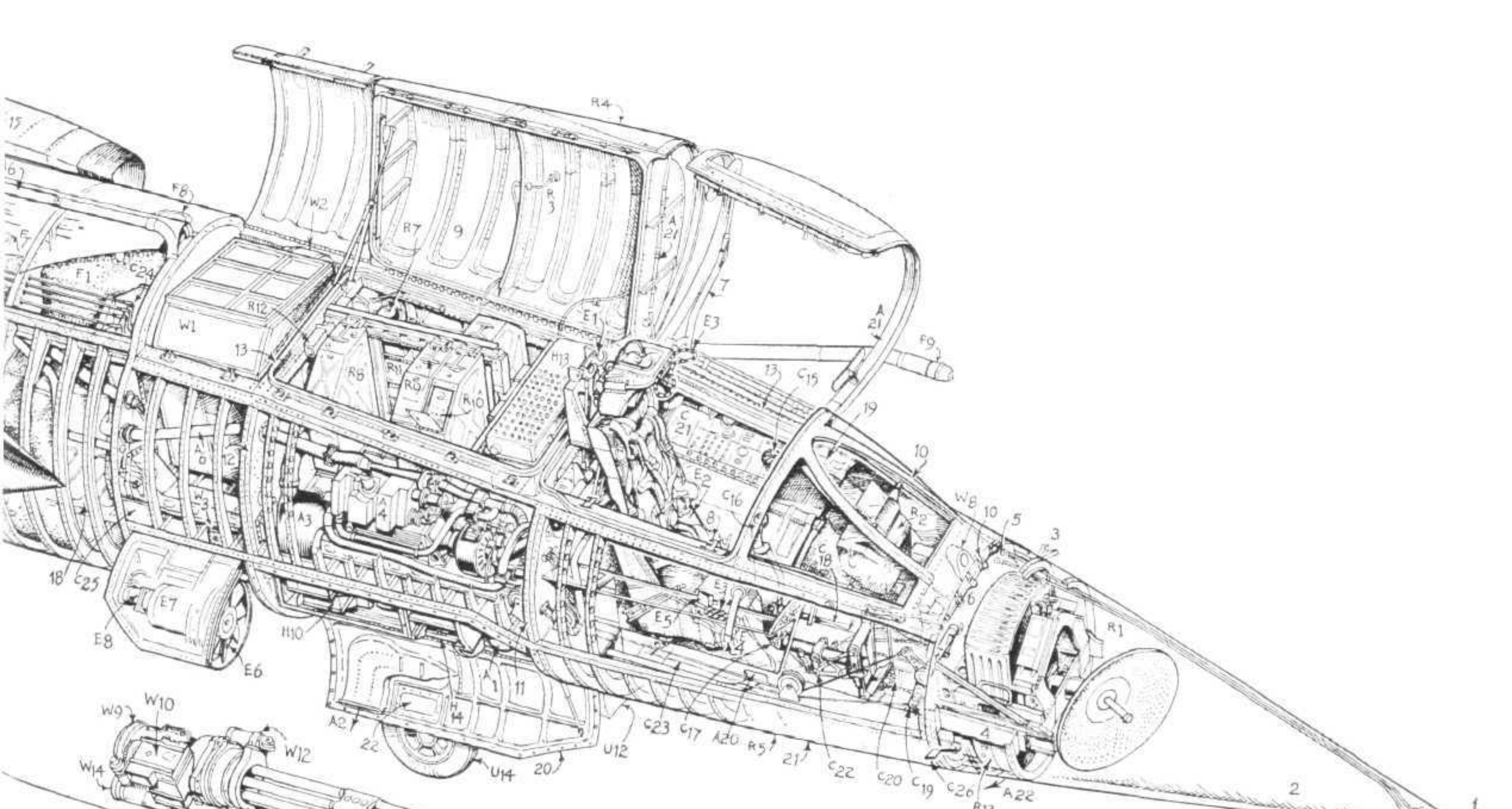
P Powerplant
P1 General Electric J79 GE-7 engine
P2 Engine-air bypass bleed flaps
P3 Oil tank
P4 High-energy ignition units
P5 Oil coolers
P6 Main engine access door
P7 Engine loading rail
P8 Engine front mount rollers
P9 Engine thrust mounting on rear of frame
P10 Afterburner unit
P11 Resonance baffle
P12 Inner variable nozzle
P13 Outer variable nozzle
P14 Nozzle linkage
P15 Variable nozzle actuator
P16 Bleed air flow from P2
P17 Variable compressor stators
P18 Compressor bleed to flap blowing

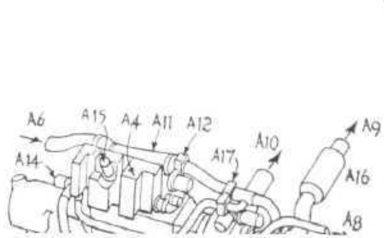
R Radar and electronics
R1 NASARR type R22-A radar (range and lead, for gunsight, missile computer and fire-control computer, target information and ground mapping)
R2 Infra-red optical sight
R3 Aerial lead-in
R4 Aerial in canopy moulding
R5 UHF/ADF aerial in cockpit floor
R6 Aerials
R7 Compass, inertial navigation and fire control, on port side
R8 Interchangeable "jeep can" electronics packages
R9 "Jeep can" latches
R10 Individual test panels
R11 Cooling air supply through rack
R12 Flexible rack-mounting
R13 Radar test panel

U Undercarriage
U1 Link, supporting jack end
U2 Retraction jack
U3 Dowty Liquid Spring unit
U4 Preclosing door jack
U5 Preclosing doors
U6 Wheel-swivel joint
U7 Wheel-swivel linkage
U8 Brake pipe
U9 Towing point
U10 Up latch
U11 Door link
U12 Nose-gear door
U13 High pressure mainwheel tyres
U14 Forward-retracting nose-gear

W Weapons
W1 Ammunition pack
W2 Feed to gun
W3 Ammunition hoist pick-up
W4 Sidewinder air-to-air missile
W5 Bullpup air-to-ground missile
W6 External stores rack under fuselage
W7 Wing stores pylon
W8 Camera port
W9 M61 20mm gun, 6,000 rounds per min (installed to port)
W10 Shell feed
W11 Case ejection
W12 Recoil mounts
W13 Revolving barrels
W14 Drive motor
W15 Infra-red homing head
W16 Control surfaces
W17 Warhead
W18 Motor tube
W19 Air-driven gyros
W20 Proximity fuse







Super Starfighter . . .

receives electrical analogues of pitot and static pressure, air temperature. and angle of attack from remotely located transducers. It transforms this information into the various functions of altitude, airspeed, Mach number, rates of change, and angle of attack required by other computers in the aircraft.

Navigation is assisted by a lightweight Litton inertial system, which measures actual ground distance and track, and is in no way dependent upon forecast or computed winds. It has a high degree of accuracy, and continuously presents to the pilot position by latitude and longitude. Presentation is made through the PHI (Position and Homing Indicator), a miniature automatic navigator which works on the principle of dead-reckoning. Developed by Computing Devices of Canada, the PHI computes by remembering where it started and keeping track of all course changes and speeds. The pilot has a choice of five pushbuttons, each marked with the name of a target or destination. Pushing any button causes the pilot's indicator to show him the heading to fly to reach that destination, and the distance to go in nautical miles.

The F-104G's bombing computer, which ties in with the inertial navigator, air-data computer and NASARR systems, mechanizes the relationship between the bomb trajectory and the aircraft in space. As a result of this mechanization, bomb release takes place at the proper point in space to impact on the target. There are four basic bomb delivery modes: dive-toss, LABS (low-altitude bombing system), over-the-shoulder and level release.

Complete provisions are made for installation of a data line-time division set. This equipment provides a means of receiving course direction (automatically computed at the ground environment) towards an enemy aircraft until acquisition is made by airborne radar. It has many advantages; it provides back-up voice service to the primary u.h.f. command set; can be used in either an air-defence or ground-support environment; gives the pilot a visual display of the intercept situation; allows full utilization of the autopilot; provides for a "return to base" operation; eliminates language barriers which normally accompany voice operation; provides for memory of the latest received information; permits selective addressing; is nearly invulnerable to jamming; and pinpoints target information on the NASARR indicator.

TACAN is standard in the F-104G. This is a radio air-navigation system of the polar co-ordinate type, which provides the aircraft with instantaneous and continuous information on distance (in n.m.) and direction (in degrees of bearing) from a ground station.

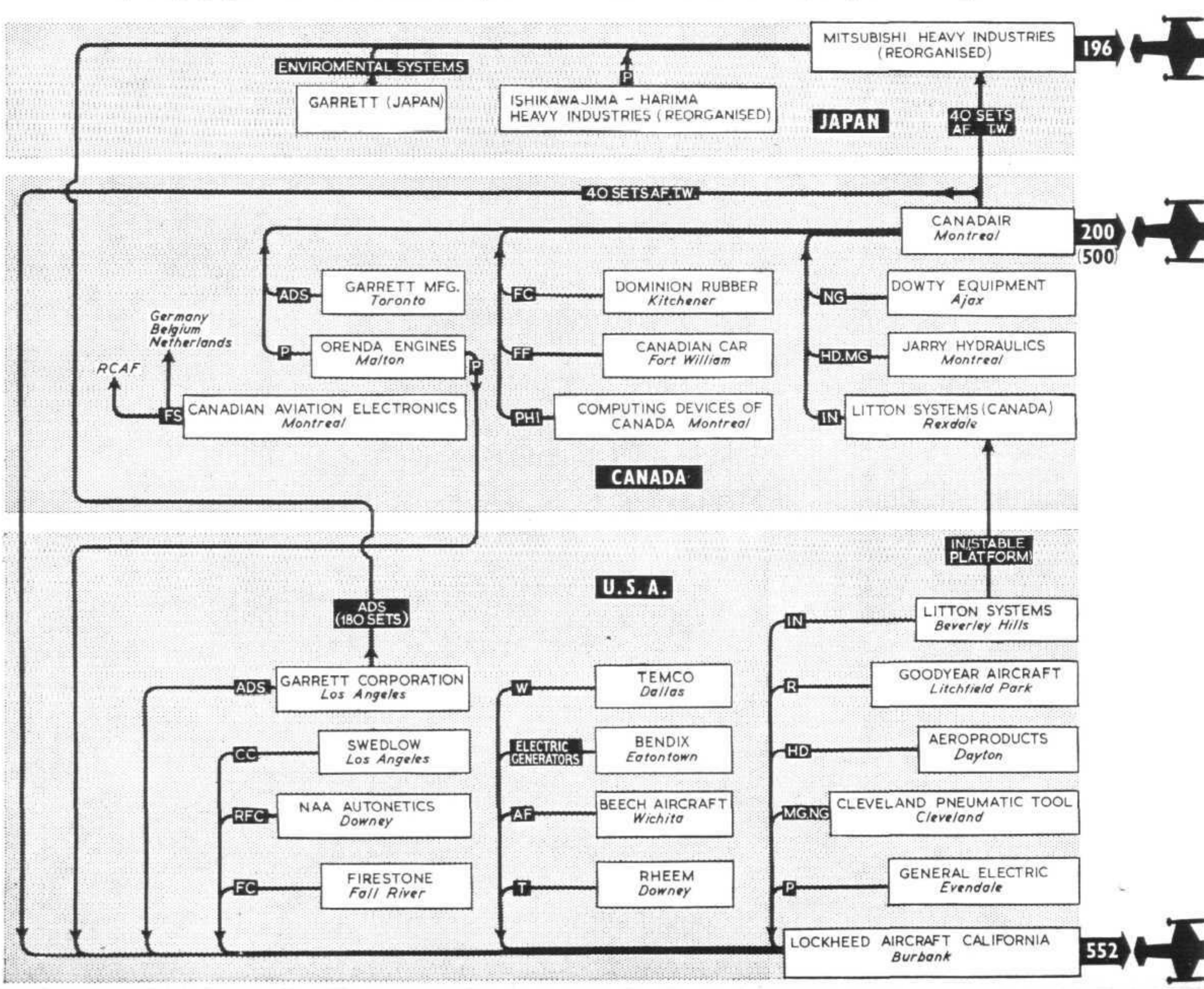
The European F-104G has a director-type gunsight. This presents to the pilot an optical indication of the line of sight with the proper lead angle for firing the M61 gun. When caged, the sight is used as an aiming reference for firing Sidewinders in a pursuit attack. When used with an infra-red sight these capabilities may be accomplished at night, as well as during daylight hours. Additionally, the caged sight reticule may be used as an aiming reference for visual dive-bombing.

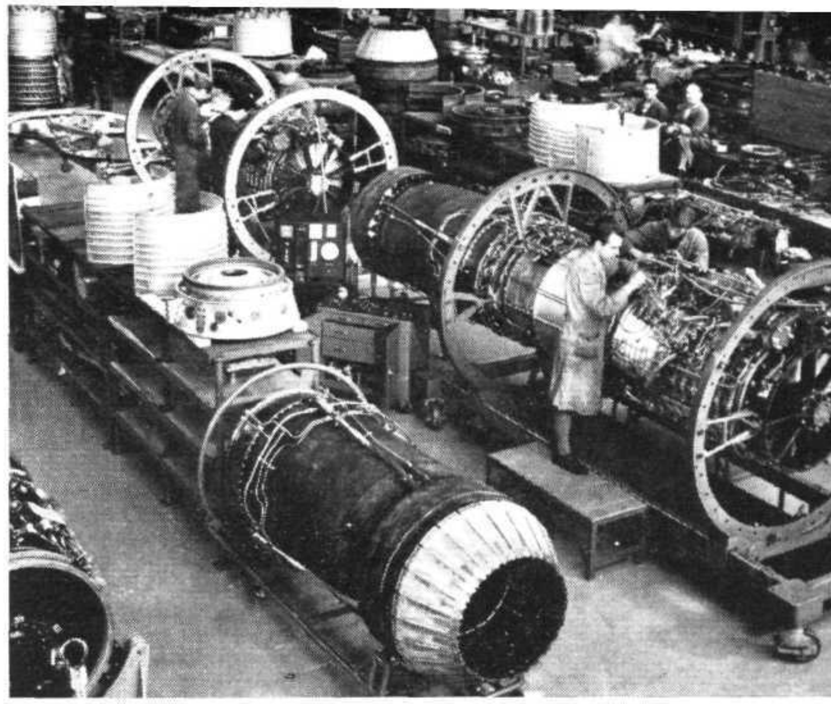
Advantages of the director sight (over the disturbed-reticle sight fitted to USAF F-104s) include: smaller sight head, resulting in better pilot visibility through the windshield; improved tracking; lighter weight; no separate computer required in electronics compartment, thereby permitting installation of other necessary electronic equipment; and easier installation and maintenance. For compatibility with the director-type sight, the new infra-red sight will offer daytime capability and improved detection range. It will be integrated with the director sight, and utilizes a common optical system.

Key to Components Symbols in Diagrams Below

A, autopilot; AB, airbrake; AD, air ducts; ADS, air-data system; AF, aft fuselage; AI, air intakes; AID, air-intake de-icing; CC, cockpit canopy; DF, dorsal fairing; EH, electronics hatches; ES, ejection seat; FB, fuselage bulkheads; FC, fuel cells; FF, forward fuselage; FH, fuel tank hatches; FS, flight simulator; HD, hydraulics door; IN, inertial navigation system; IS, infra-red sight; K, keel pieces; LE, loose equipment; LO, liquid-oxygen system; MF, mid-fuselage; MG, main landing gear; MGD, main-gear doors; N, nose; NG, nose gear; NGD, nose-gear doors; O, optical sight; P, power-plant; R, radome; RC, range computer; RFC, radar fire control; T, tail unit; TN, Tacan navigation system; TT, tip tanks; UT, underwing tanks; W, wings; WS, windscreen.

The family tree below is inevitably incomplete, particularly in respect of Japanese production; but it is the best that can at present be achieved. The flow of components from Lockheed and Canadair will be noted, but it is impossible to show the huge quantities of drawings, jigs and such items as special forgings or instruments which are not yet available outside North America. A key to symbols used appears above





Powerplant of the F-104G is the 15,800lb-thrust J79-11A, designed by General Electric's Large Jet Engine Department near Cincinnati. These examples are in the BMW factory at Munich, and other engines are being made by FN, Alfa Romeo and Ishikawajima-Harima

F-104 WORLD-WIDE

THE remainder of this account is a condensed survey of the countries associated with the F-104, arranged in alphabetical order.

Belgium Less prosperous than West Germany, Belgium is said to have chosen the F-104 largely on economic grounds. She is a member of the Western industrial group formed for F-104G manufacture, the genesis of these groups being given in the section dealing with Germany. The agreement forming the Western Group was signed by Belgium, Germany, Italy and the Netherlands in December, 1960. Despite difficult conditions created by loss of the Congo, unrest at home and severe criticism by the Socialist group in the Chamber of Representatives, Belgium's part in the programme is now firm. Avions Fairey and SABCA are establishing a joint production line and flight-test facility at Gosselies, near Charleroi, for the manufacture of 164 aircraft, and a further 30 will be erected from parts supplied by Fiat. Allocation of the aircraft is given in the table on the left. Tooling is well advanced, the first aircraft is due to be completed next September and the scheduled output of six aircraft per month should be reached by the beginning of 1963.

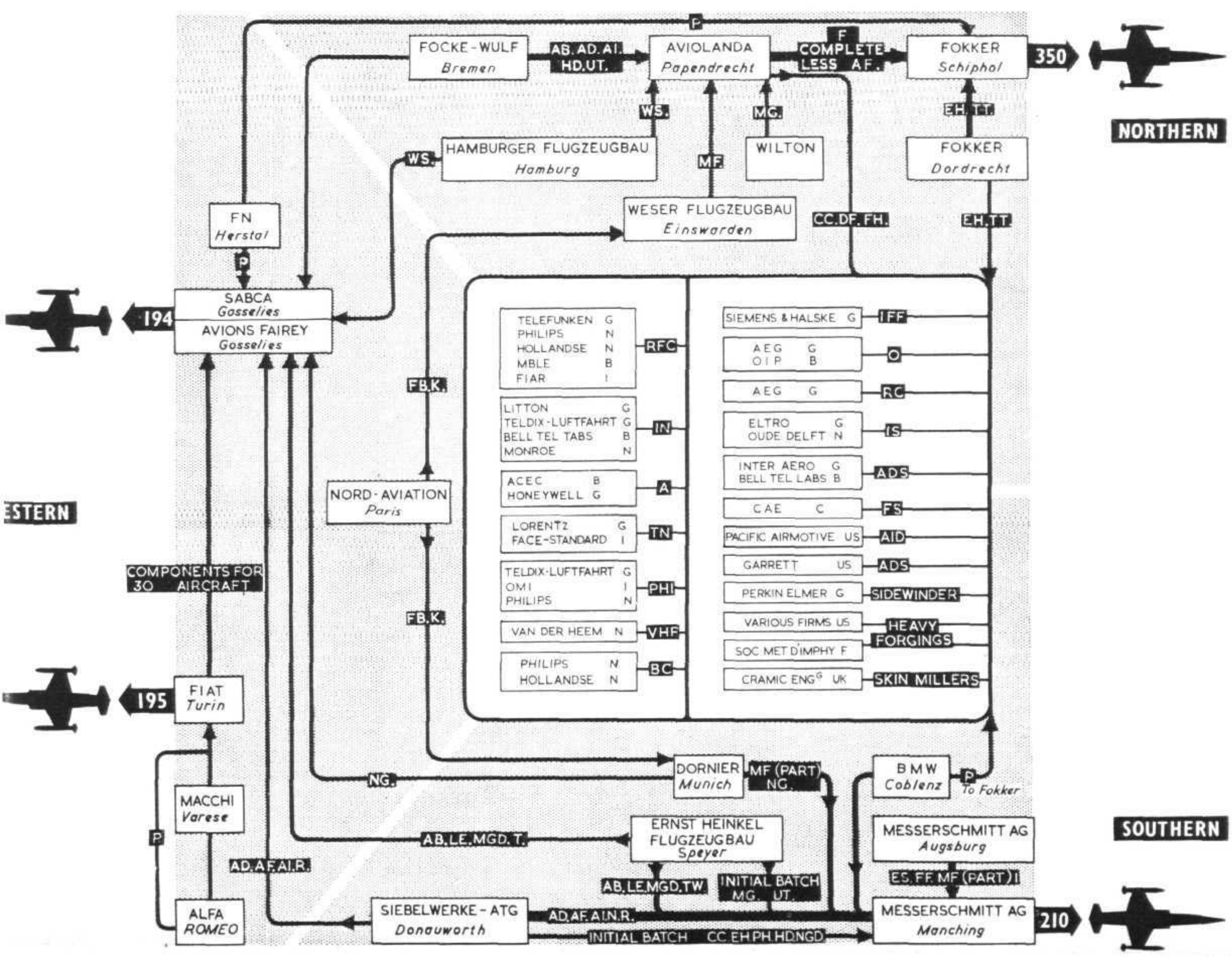
SIZE OF THE PROGRAMME

urce	USAF	Germany	Belgium	Netherlands	Italy	Canada	Japan	Other NATO	Total
ed	295 A, B, C, D	30 F, 96 G, 54 TF-G	—	20 TF-G	—	14 CF-D	3 J, 1 DJ	39 G	552
Nord	—	255 G	—	95 G	—	—	—	—	350
Sud	—	210 G	—	—	—	—	—	—	210
SABCA	—	89 G	75 G	—	—	—	—	—	164
	—	50 G	25 G	25 G	125 G	—	—	—	225
ir	—	—	—	—	—	200 CF	—	300 *	500
ishi	—	—	—	—	—	—	177 J, 19 DJ	—	196
/c	295	784	100	135	125	214	200	?	2,197
$ × 10⁶)	?	1,130	160	173	198	383	270	?	?

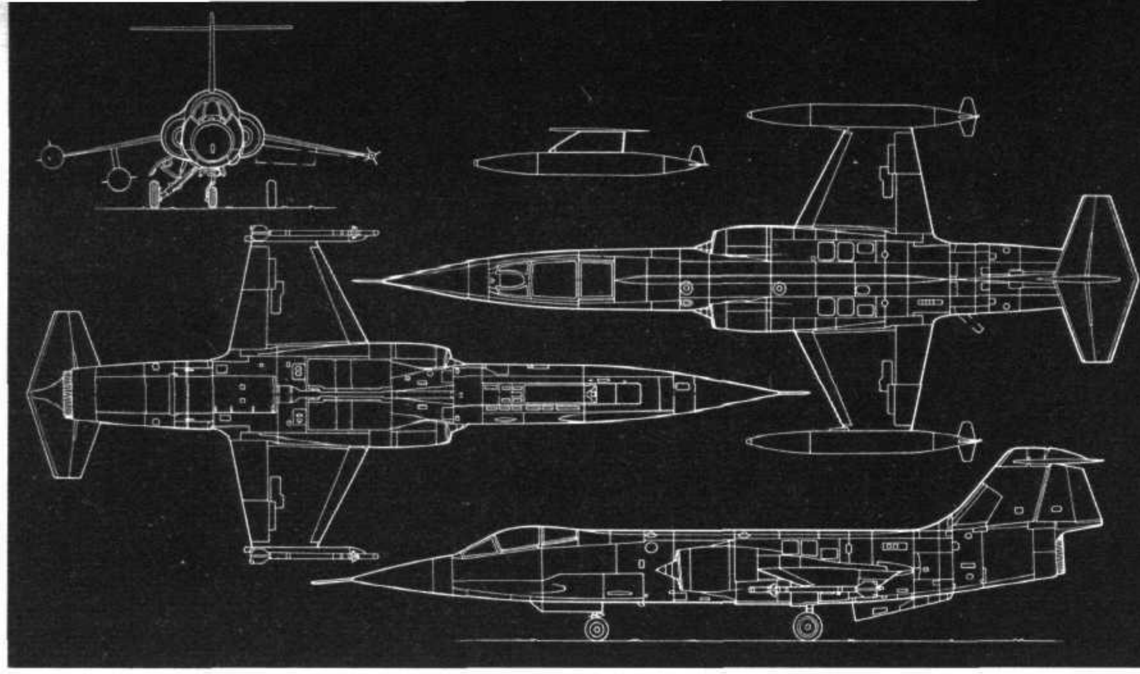
* This is the maximum size of a possible MDAP contract now being discussed.

Canada Selection of the F-104G for the RCAF Air Division assigned to NATO in Europe was announced in July 1959, and on

Below is a portrayal of the vast European programme. In the central rectangle are arranged those firms making what might be termed "systems," and a key to the lettering employed appears above. The totals of aircraft produced are those which will actually roll out from the factories concerned. Fiat will ship parts for 30 aircraft to Belgium, so that true manufacturing totals from each source are as given in the table above



Super Starfighter . . .



This drawing was prepared by Canadair Ltd. Although the subject is the CF-104, the European F-104G is externally identical. Data include: span, 21ft 11in; length, 54ft 9in; height, 13ft 6in; gross weight, 20,000lb

August 1 of that year it was stated that Canadair Ltd. would be prime contractor for the 200 aircraft necessary. The manufacturer's designation is CL-90; the RCAF nomenclature for the aircraft was originally CF-111, but this was changed to CF-104 for obvious reasons. Compared with the F-104G, the Canadian aircraft differs in minor respects, reflecting the fact that its primary mission is ground attack. It has a different optical sight, and an R-22-A or R-24-A search and ranging radar system. The first CF-104 was rolled out on schedule on March 27, and about a dozen have now flown. Canadair is shipping 121 sets of wings, aft fuselages and tails to Belgium, Germany and the Netherlands, 40 sets to Lockheed, 40 sets to Japan and large numbers of sub-assemblies to subcontractors. Moreover, political considerations may mean that a large batch (up to 300) of special MDAP aircraft for Turkey, Greece, Denmark, Spain and other NATO countries, will be manufactured by Canadair.

Germany From the outset, Germany decided that she was not going to buy aircraft but make them, and a great deal of thought went into the licence-agreement signed in March 1959 between the Federal Government and Lockheed. This licence served as a model for the five others which have since been signed, and the US magazine *Business Week* estimates that "Lockheed is getting up to 15 per cent in royalty fees." To handle production an all-German consortium was created, initially called the *Arbeitsgemeinschaft* but soon renamed the *Arbeitsgemeinschaft Sud* (South Group). The formation can be seen from the diagram on page 627, and it is gratifying to note that Arge Sud have always been responsible for the manufacture of 210 aircraft; every other European group has had its programme changed, sometimes more than once. When the Netherlands chose the F-104, Arge Nord (North Group) was formed and the total number of aircraft allocated to it has varied from 364 through 375, "400 or thereabouts" to a presumed finalized total of 350. The leader of this group is Dutch, but it includes all the major airframe companies in Northern Germany.

Italy Latest nation to join the 104 circus, Italy is using virtually the entire resources of her aircraft industry to manufacture 225 aircraft, 30 of which will be assembled in Belgium. Representatives of the many firms involved met at the Milan offices of the Associazione Industrie Aeromissilistiche last February.

Japan Having cut their teeth with the F-86F, Mitsubishi have been assigned the huge task of making 177 F-104Js, which are virtually identical to the European F-104G. The first 29 are being shipped in "knocked-down" form from Lockheed California; in fact, the first three have actually been flown at Palmdale before being dismantled for shipment. The first aircraft is due to be assembled and delivered to the Japanese Air Self Defence Force next March, and the following month supply of the 29 built from American components will begin. Next year 51 aircraft are due to be delivered, and the total of 180 fighters and 20 F-104DJ trainers —one of which will be flown by Lockheed—should have been delivered before January 31, 1965.

Netherlands Largest of the European manufacturing groups is Arge Nord, and the leader of the group is Fokker. As in the case of the other groups, work was divided on a basis of man-hours—percentages are: Fokker, 33; Aviolanda, 17; Hamburger, 23; Focke-Wulf, 9; and Weserflug, 18—and all work is on a fixed-price basis. Fokker have had to build a large nine-storey building solely to handle electronics and data-processing, together with laboratories for checking out equipment received from suppliers, a line-support section and calibration laboratory. The whole of the Arge Nord is now actually making components, although the first five aircraft are being assembled from components shipped by Lockheed or Canadair, followed by 15 aircraft supplied in the form of small components to the Arge Nord subcontractors. The first F-104G should roll out from Schiphol next month, the first aircraft wholly manufactured within the group is timed for July next year, and the scheduled rate of production from next March onwards is to be 40 aircraft per quarter.

USA Little need be added to the information given in the diagrams and tables. It is worth noting, however, that in a recent progress report to Lockheed stockholders, some interesting financial figures were given. It was stated that the nations participating in the F-104 programme would spend \$1,000m with US industry. "Out of this amount," said Lockheed, "the US Government will contribute in direct support the total of \$220m. So that, at a time when the reverse flow of US gold is of primary concern, the US balance of trade will show a net gain of \$780m." Big business indeed; but the greatest value of the programme is probably less tangible. In a world in which there is a conscious awareness of the need to erode national boundaries, no other single undertaking seems to offer such promise of speeding this end, nor to pose a sterner test.

Although the first Canadair CF-104 was shipped to Palmdale, California, for its first flight, all CF-104s are now flown at the manufacturer's plant near Montreal. This pleasing study shows the braking parachute fully deployed during a landing by a Canadair test pilot