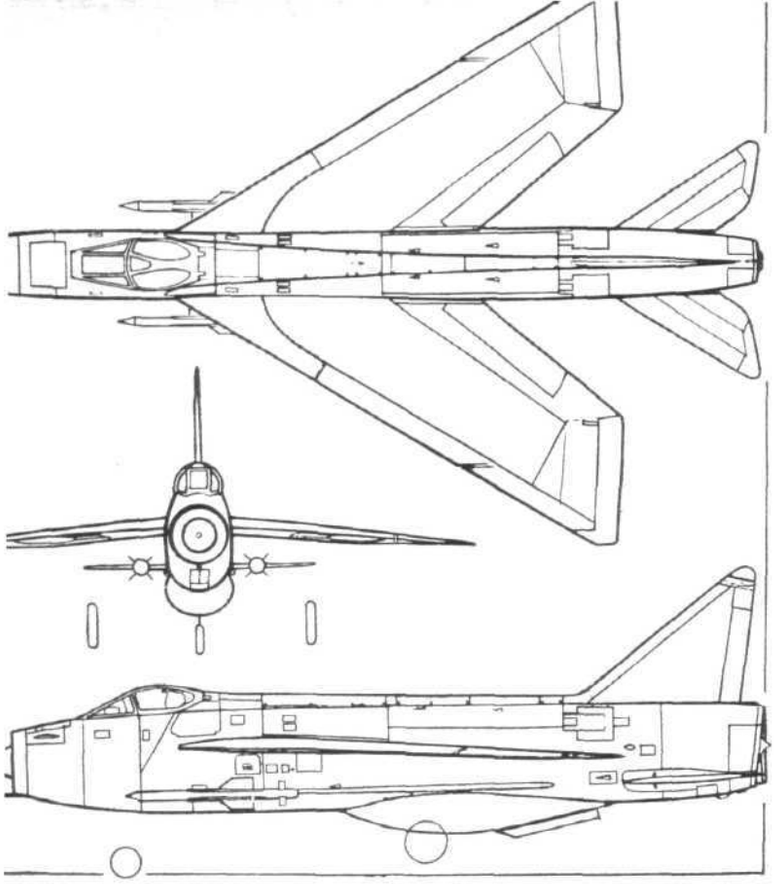

ENGLISH ELECTRIC LIGHTNING F. Mk 1A

Two Rolls-Royce Avon turbojets with variable reheat. Span, 34ft 10in; length, overall, 55ft 3in; height, 19ft 7in; tailplane span, 14ft 6in; track, 12ft 9·3in; net wing area, 380·1 sq ft; sweep angles, leading edge 60°, trailing edge 52°; maximum speed, approximately 1,500 m.p.h. (M2.27); service ceiling, well over 60,000ft

LIGHTNING...

supplied by an air-turbine-driven pump for each powerplant, and separate igniters are employed to ensure immediate combustion of the reheat fuel at all altitudes. Area of the propelling nozzle is varied by 12 hinged segments coupled to a sliding ring positioned by a bleed-air motor.

Flying controls The basic system is completely conventional for an aircraft of this character, the ailerons, tailplanes and rudder all being irreversibly driven by Hobson hydraulic power units. All three sets of services are powered by two independent hydraulic systems, the ailerons having separate linear jacks, the rudder a tandem-piston unit and the horizontal tail being positioned by screwjacks driven through a gearbox by independent hydraulic motors. Linkages to the cockpit are simple push/pull tubes and levers; the hydraulic systems are discussed later.

An Elliott Bros (London) Ltd autopilot is fitted, providing largely automatic control in any of a variety of flight modes. The details of the system are classified; but in this journal's report of the 1960 SBAC show, we wrote:[14]

"More significant were certain components of two military autopilots being developed by Elliott for a supersonic fighter aircraft now entering service. A feature of the control panel of one of them was the use of mechanical interlocks between mode selectors to save panel space. A climb setting covers optimum climb performance under autopilot control and the inclusion of "track" and "glide" switches indicates automatic or near-automatic landing. Automatic throttle control is included. The main hand control is designed for use with the right hand outside the field of vision. Airpass has a controller for the left hand. It was stated that the autopilot hand controller could govern either extent or rate of turn, according to the mode in use. The barometric height lock is monitored, especially at low altitudes, by a radio altimeter to avoid excessive pitch demands."

Another logical assumption is that the Elliott autopilot is also linked to the radar fire-control, to fly the Lightning on the correct trajectory to effect the most economical interception. All signals from the system are passed as demands to the autostabilizer actuators inserted in each control circuit. All four autostabilizer actuators (there are two in the aileron circuit, one in each wing) are Hobson electrically signalled, rotary hydraulic motors, with a linear output connected to the appropriate control system in such a manner that it moves the surface but not the cockpit control.

Artificial feel is provided about all three axes. In the aileron circuit a simple torsion bar is inserted between the control column and the (normally fixed) aileron-trim drive, to provide feel directly proportional to stick deflection. In the rudder and tailplane systems, any control movement is resisted by a separate feel unit, in which deflection from neutral pushes a piston against hydraulic pressure governed by the feel simulator according to q (dynamic head) pressure, which varies with airspeed and altitude. These hydraulic feel units may be cancelled by a cockpit switch, and are automatically disengaged by a landing-gear DOWN selection. Further centring forces are provided by coil springs in each feel unit, which remain operative in the event of loss of hydraulic pressure or pitot/static differential, and a non-linear spring unit in the rudder circuit applies additional centring force and feel to the pedals.

Trimming is effected from cockpit switches, the rudder having a double switch on the port console and the other surfaces a four-way thumb switch on the control column. Each switch controls an electric actuator with a linear output which displaces the complete control run; the aileron trimmer is attached to the control-column torsion bar and the other units are linked to the autostabilizer/feel assemblies in the rear fuselage.

Fuel system It has long been known that the Lightning F.1A has an integral-tank wing, and that additional fuel is carried in the flaps and belly tank; but no indication may be given of the capacities of these tanks. The complete system is pressure-fuelled from a fuselage adaptor beneath the port wing trailing edge; and, for ferrying purposes, a Flight Refuelling probe may be attached beneath the port wing.

Fuel is transferred to the wing collector boxes and thence fed by SPE electric booster pumps to the engines. Reheat fuel is supplied by a separate Lucas bleed-air turbopump for each engine. Large recuperators in the main tank provide a limited supply of fuel for inverted or negative-g flight. The ventral tank is a stressed-skin box secured to the fuselage at a single point; it is not regarded as expendable, but can be jettisoned in emergency.

Hydraulics The Lightning hydraulic system is energized by four Integral gear/radial-piston pumps, one pair being mounted directly on the external wheelcase of each engine. Fluid specified is mineral-based OM-15, and ruling system pressure is 3,000lb/sq in. The system is divided into three completely independent subsystems: No 1 Controls System serves the outboard aileron power units, port tailplane motor, one half of the rudder power unit, braking-parachute doors and emergency gear extension; No 2 Controls System serves the other halves of the flying-control power units; and the Services System handles all other functions, namely, landing gear retraction, wheel and air brakes, flaps, nosewheel centring, autostabilization and feel, canopy operation and supplies to the various types of armament pack.

The forward pump on each Avon powers the services system, while the rear pumps independently serve the two controls systems. It is noteworthy that the two latter systems are separate in space as well as in drive, and there has never been a case of a Lightning losing all control power. No emergency ram-air turbine is fitted, for adequate control power remains even with both engines windmilling—and the odds are roughly a million to one against losing both engines. Each flying control is served by a nitrogen-charged accumulator for emergency use and to provide extra power for very high rates of operation. Hydraulic filters are by Palmer.

Electrics All electric power generated on board is obtained from a large Dowty-Rotol package, supported off the port side of frames 54 and 55, containing a radial-inflow turbine running on 15th-stage compressor bleed air. The unit can operate with either engine shut down, and is self-governing. On it are mounted a 20kVA alternator supplying three-phase, 400 c/s current at 200V, and a 28V d.c. generator. The latter can maintain essential services in the event of generator failure, and both service and emergency batteries are provided to serve critical loads in the absence of any power generation. A ram intake in the leading edge of the fin leads cooling air to the alternator, generator and gearbox oil cooler.

Air systems The two powerplants are bled of air at the 8th and 15th stages to serve a wide range of essential services. The biggest mass-flow is that required to drive the electrical turbine pack already described, but major components throughout the aircraft are served with air—some very hot and carried in lagged stainless-steel ducts with Avica-Flex gimbal joints, and some cooling air taken in from a variety of ram intakes. Apart from cabin conditioning, the major parts of the air system are those which drive the reheat fuel pumps, jetpipe nozzle rams and accessories pack; suitable airflows are provided for the various parts of the radio and radar systems, armament pack, fuel system, hydraulic reservoirs and other services. Special supplies are provided for intake de-icing, de-misting and rain dispersal.

Ducts from the main air systems lead to units which provide conditioned air to the cockpit, radar bullet and to the pilot's anti-g trousers and air-ventilated suit (and partial-pressure helmet). Broadly, the hot bleed air passes first through a Marston Excelsior air/air heat exchanger, then through a closed-circuit water boiler system (likewise a Marston unit, filled with distilled water plus anti-freeze, and having a steam vent to atmosphere in all positive-g conditions) and finally through a de Havilland cold-air unit. The cockpit supply is a mixture of this refrigerated flow and hot bleed air, passed through a water extractor. A heat exchanger in the final