MARCONI-ELLIOTT AVIONICS

with SFENA

Automatic Flight Control System for SNIAS-BAC Concorde

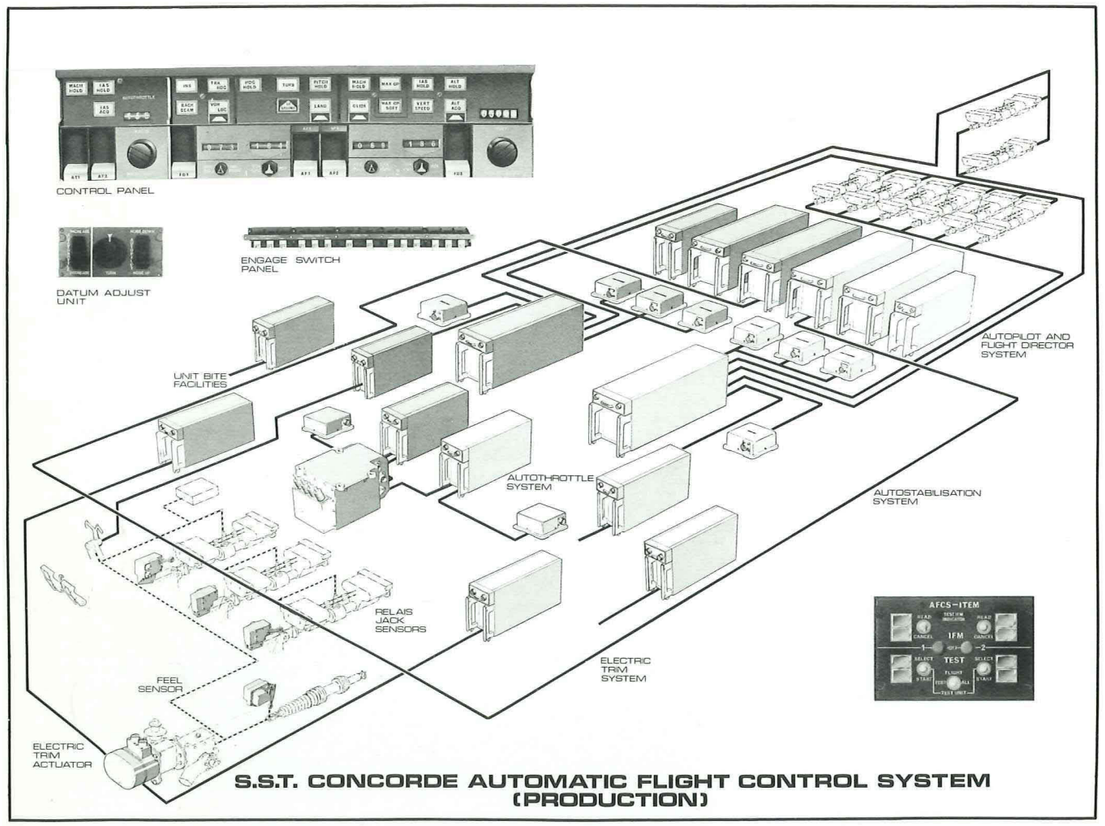
Introduction

The Automatic Flight Control System (AFCS) has been jointly developed by Elliott and SFENA for the production Concorde aircraft. Elliott carries overall design responsibility and the equipment will be supported in the field by both Elliott and SFENA.

The brochure provides a concise description of the AFCS to familiarise aircraft operators with the system, in order to formulate a maintenance and support plan.

The AFCS comprises the following sub-systems:

- **Autopilot and Flight Director**
- **Electric Trim**
- **Three Axis Autostabilisation**
- **Safety Flight Control**
- **Autothrottle**
- **Integrated Test and Maintenance**



S.S.T. CONCORDE AUTOMATIC FLIGHT CONTROL SYSTEM (PRODUCTION)

Autopilot & Flight Director

The integrated Autopilot and Flight Director employs common computing and mode selection facilities. The autopilot function provides automatic control from initial climb, through cruise to automatic landing. Monitoring techniques ensure 'fail soft' operation in all modes with automatic failure survival to a standby channel during final approach and automatic landing. Flight director commands enable the pilot to monitor autopilot demands against basic instruments and permit flight director control in all modes of cruise and approach flying. The system incorporates a landing display which consolidates the performance and system serviceability information needed by the pilot to assess the fitness of the AFCS to proceed under automatic control to touchdown. An automatic go-around facility is provided.

Three Axis Autostabilisation

The Three Axis Autostabilisation system provides augmentation of the natural handling qualities and improves passenger comfort. The system operates directly into the elevon and rudder control surfaces, without moving the pilots controls. This is achieved by electrically limited outputs into electrical signalling "fly-by-wire" amplifiers which are housed in the autostabilisation computer. Automatic rudder demands limit aircraft sideslip during engine failure. Two channels are provided for each axis to meet the reliability requirements. The self monitoring of these channels also incorporates autochangeover to give smooth automatic failure survival.

Autothrottle

The Autothrottle system operates the pilots throttle levers to control thrust according to Indicated Air Speed or Mach Number, self-monitoring techniques and channel redundancy give automatic failure survival in approach and cruise flight cases.

Electric Trim

The Electric Trim system provides pilot operated pitch trim in manual flying. During automatic pilot control the auto-trim facility reduces the aircraft transient on autopilot disengagement. In addition, open loop trim commands are utilised to augment static stability (e.g. Mach trim). Dual channel redundancy is provided with self-monitoring to give automatic failure survival.

Safety Flight Control

The Safety Flight Control System initiates warning signals and active surface demands to limit the effect of inadvertent high incidence flight. Two channels are provided to meet the reliability requirements.

Integrated Test & Maintenance

ITEM is a simple digital system which automates the process of maintenance of the Automatic Flight Control System, (AFCS). It organizes Built-In Test Equipment, (BITE), already located in the AFCS and enables the complete avionics system to be tested from a Control Panel, situated on the flight deck.

During flight, an In-Flight Monitor (IFM) mode enables the AFCS serviceability to be continuously surveyed. Any maintenance action needed is stored for use after the aircraft has landed.

Both IFM and BITE modes locate maintenance action to Line Replaceable Unit (LRU) level thus avoiding the need for special skills in operating and maintaining the avionic systems.

Computing

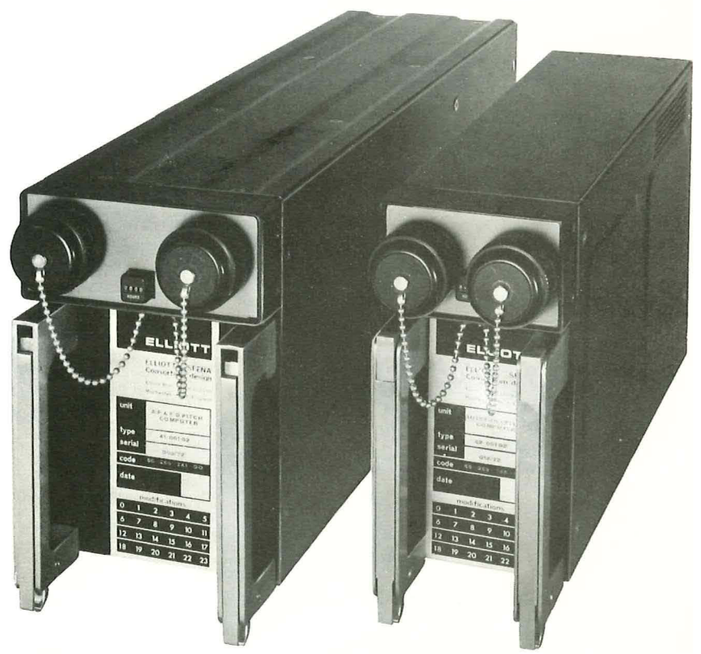
Computing circuits and power packs which constitute the automatic flight control system are packed into eight basic computers (2 off each) namely:

- **Autopilot and Flight Director Pitch Computer**
- **Autopilot and Flight Director Azimuth Computer**
- **Autostabiliser Computer**
- **Autothrottle Computer**
- **Electric Pitch Trim Computer**
- **Warning and Landing Display Computer**
- **Safety Flight Control Computer**
- **Item Computer**

The computing circuits are split into modules which are arranged in stacks either side of the chassis assembly. These stacks are located together by plugs which also provide a means of inter-connecting the individual modules and connecting the modules to a mother-board mounted on the chassis. These mother-boards are connected to the cableforms which run to the rear aircraft connectors and front test connectors.

The box is physically segregated into "command" and "monitor" computing areas to preclude common failures. The solid state logic switching circuitry is incorporated in the centre segregation spline.

The electronic implementation is based on standardised micro-electronic linear computing elements with external components to set gain and transfer functions. Electromechanical integrators have been eliminated and digital integration is used when long term storage of datums is required. All switching is solid state except where



Controls

The control of the AFCS is divided into three natural groups:

a) engagement of systems required throughout the flight
b) engagement and mode selection of pilot aids which are frequently switched in flight.
c) autopilot manoeuvring controls.

The switches in group (a) have been located in the roof panel to reduce the risk of confusion with those in group (b). The controls in group (b) have been mounted on a panel in the centre of the flight deck immediately below the glare shield. This location provides ease of control for both pilots and a clear indication of the engagement and mode selection state of the autopilot to all members of the flight deck crew.

Pilot's Control Unit

Datum Adjust Unit

Engage Switch Panel

Pilot's Control Unit

The Pilot's Control Unit is designed to enable both pilots to control the aircraft through either of the two autopilot/flight directors and autothrottles.

The control unit contains the following:

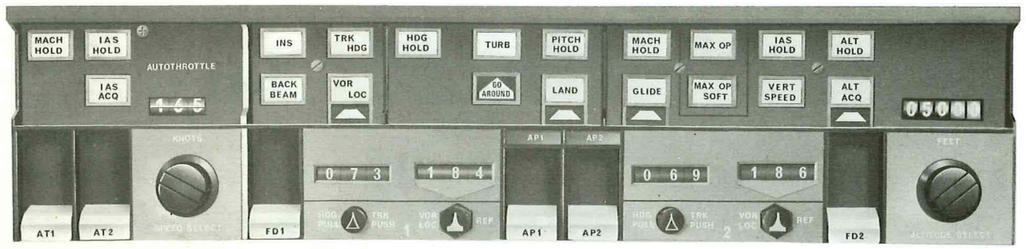
System Engage Switches for Autothrottle, Flight Director and Autopilot

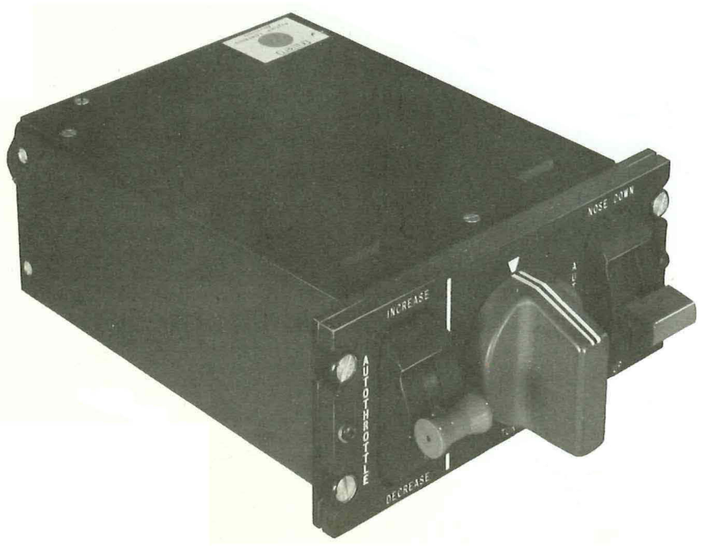
Mode Selector Push Buttons

Heading/Track VOR Course Selector

Altitude Selector for Altitude Acquire and Altitude Alert

IAS Selector for Autothrottle.



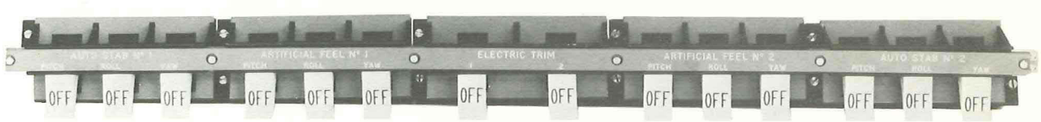


Datum Adjust Unit

The Datum Adjust Unit comprises the control facilities used by the pilot to manoeuvre the aircraft through the autopilot and autothrottle. The unit has been located on the centre pedestal, remote from the AFCS control unit, to provide excellent ergonomics should the pilot require to control the aircraft through adjustment of the 'pitch hold' and 'heading hold' modes over long periods. This location also facilitates accurate setting of pitch attitude in turbulent conditions.

The unit contains the following controls:

a) Autopilot/Flight Director Datum Adjust, which demands:
   i) changes in pitch attitude in the pitch attitude hold mode, (including full provision for turbulence mode)
   ii) changes in the engaged datum of the manometric hold modes.
   iii) changes in the position of the VSI datum.
b) Autopilot Turn Control provides a bank angle demand facility enabling changes of heading to be made at bank angles below the autopilot internal limit.
c) Autothrottle Datum Adjust for manometric hold datum.



Engage Switch Panel

The Engage Switch Panel which houses the pilot operated engage switches associated with the autostabilisation, electric pitch trim and artificial feel systems is located within the cockpit roof panel.

The Engage Switch Panel comprises the following units:

Autostabiliser Engage Switch Unit
Electric Trim Engage Switch Unit
Artificial Feel Engage Switch Unit

These switches are engaged before take-off and, except in the event of a failure, require no further pilot action until after landing.

The switches are solenoid held and the pilot can detect the exact sub-system failure by observing which switch has disengaged. The novel design of the switch handle and the bridge lighting enables the pilot to readily identify the sub-system which is in the abnormal condition.

Components

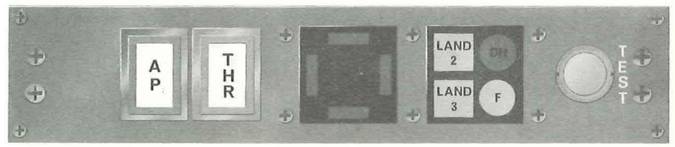
Warning & Landing Display

This Indicator consolidates the information required by the pilot to assess the system capability aspects of the decision to carry out a low minima approach or landing.

The information is of two types: performance and system serviceability. The performance indicator is a simple ILS "window".

If the aircraft is outside the window it can be assumed that there is a freak environment or performance condition which, provided the aircraft is within the operational limitation of wind and turbulence would mean that the probability of inadequate performance below the minima go-around height is unacceptable.

The system capability indication consists of bringing together in one indication the serviceability of all redundant systems required for automatic failure survival between the minimum go-around altitude and touchdown. If all necessary redundancy is present the indicator shows the capability as LAND 2 and LAND 3. If there is insufficient redundancy for automatic failure survival in all systems the indicator shows LAND 2 only. (This does not preclude the pilot carrying on to land with only one system operative in clear weather, the indicator only showing the pilot the system capability).



During an approach, the indicator warns the pilot of any loss of system redundancy and should there be complete loss of a facility, e.g. autopilot or autothrottle, the pilot is given a visual warning and an audio warning.

The display is provided with a confidence facility for use at the start of an approach and an alarm cancel button.

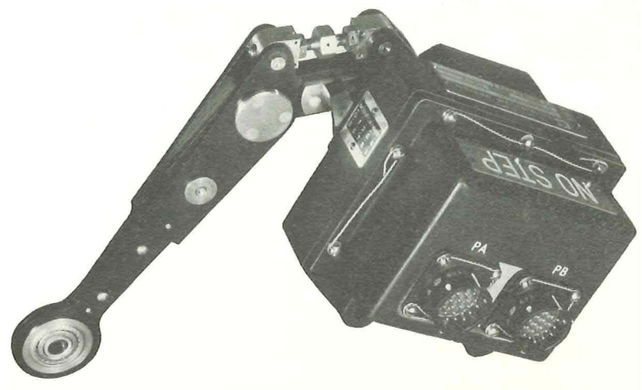
Relais Jack Sensors

The position transmitters on the flying control hydraulic booster jack are known as "relais" jack sensors. These produce two-wire synchro information on stick position for the autostabiliser and autopilot.

There is a separate unit for each axis of flying control movement i.e. pitch, roll and yaw.

Each unit carries the necessary synchros for channels 1 and 2 and command and monitor computing.

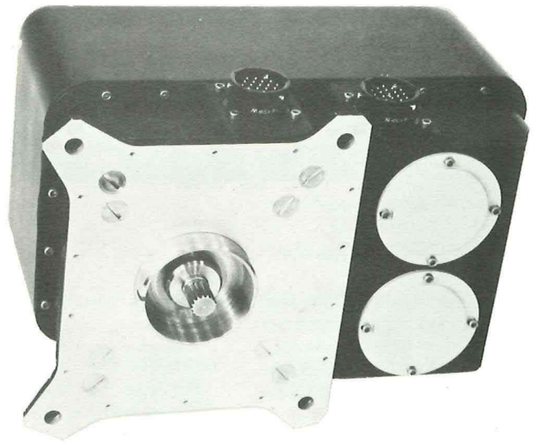
The units are mounted on the auxiliary hydraulic servo unit earth point and auxiliary servo extension is transmitted via a trailing link to the sensor input arm.



Electric Trim Actuator

The Electric Trim Actuator is an electromechanical unit with a single mechanical output connected to the aircraft pitch elevon trim gearbox.

The actuator comprises two separate drive mechanisms consisting of an electric motor, electric engage clutch and a reduction gear train driving a common splined output shaft which transmits the output drive via an internal friction clutch.



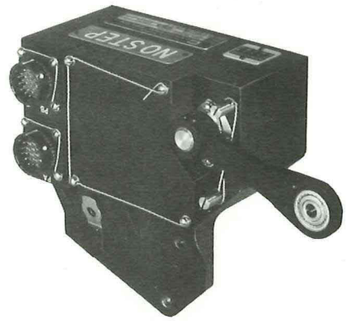
Accelerometer

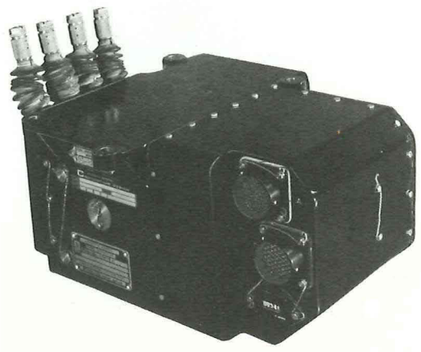
The Accelerometer is associated with the yaw axis autostabiliser and the autothrottle. The unit is of the mechanically sprung type with two separate indication pick-offs for command and monitor computing lanes. A torque coil is also provided to displace the system during testing.

Feel Sensors

The Feel Sensor produces a two-wire synchro signal as a function of the feel displacement from the zero feel force position for use in the electric trim system when the autopilot is operative. The unit is mounted on the artificial feel chassis.

The sensors carry synchros for channels 1 and 2 and command and monitor computing lanes.



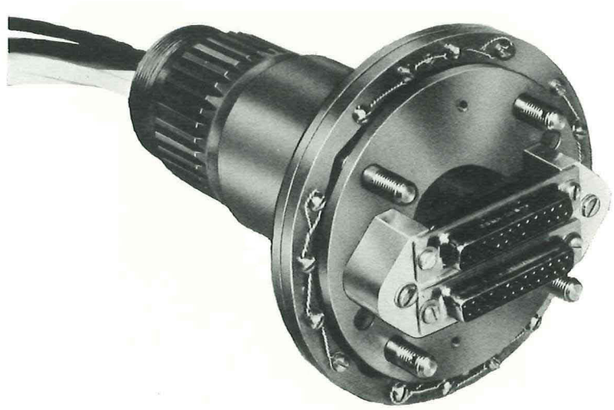


Autothrottle Actuator

The Autothrottle Actuator is an electromechanical unit which operates the pilot's throttle levers in response to electrical thrust demand signals from the autothrottle computers. The actuator assembly houses two segregated servo systems, each being connected to a final output drive mechanism via channel isolation clutches. The final drive mechanism incorporates a separate output isolation clutch, a final reduction gear, a slip clutch and position feedback sensors for each throttle lever.

Rate Gyroscope

The Rate Gyroscopes are mechanically sprung with two separate inductive pick-offs one each for command and monitor computing lanes. A wheel speed monitor is also provided. A torque motor allows the gimbal to be displaced for system testing.



SFC Sensor

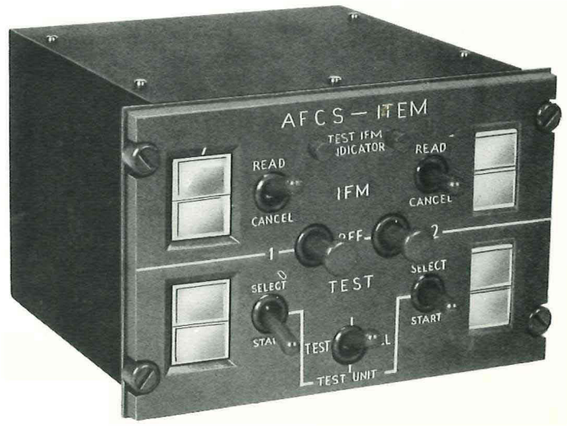
One such unit is mounted in the head of each pilot's control column. Pilot stick loads are translated into electrical signals using piezo-electric strain gauges, so providing an alternative method of applying pilot's demands to the control surfaces in the unlikely event of a mechanical jam of the control column.

Control Indicator Unit - Item

The unit, which is flight deck mounted, provides the control and display facilities for both the BITE and IFM functions of ITEM.

Each of the eight indicators on the panel can display up to eleven independent pieces of information. This enables areas requiring maintenance action to be identified according to LRU, subsystem, associated sensors, etc.

The BITE function may be applied to either the full AFCS or to any selected LRU.



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