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FLIGHT INSTRUMENTS

CHAPTER 7 – AIR DATA SYSTEMS

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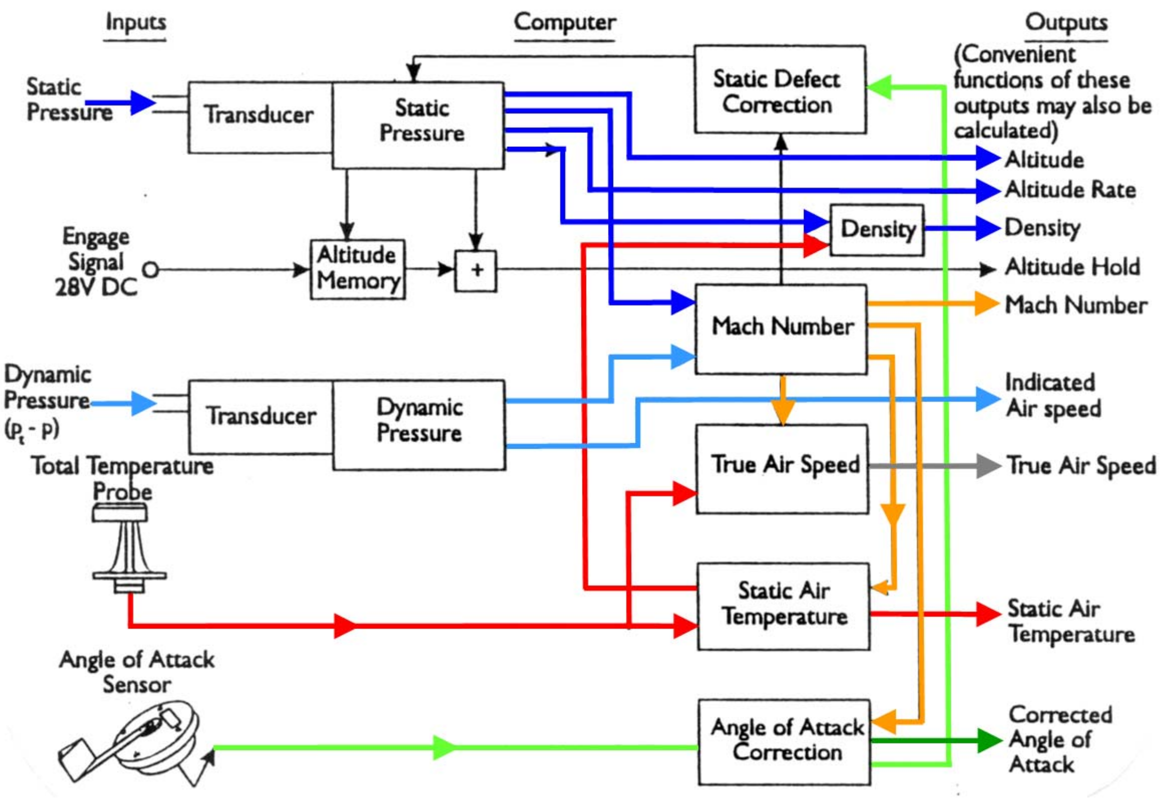
AIR DATA SYSTEMS

INTRODUCTION

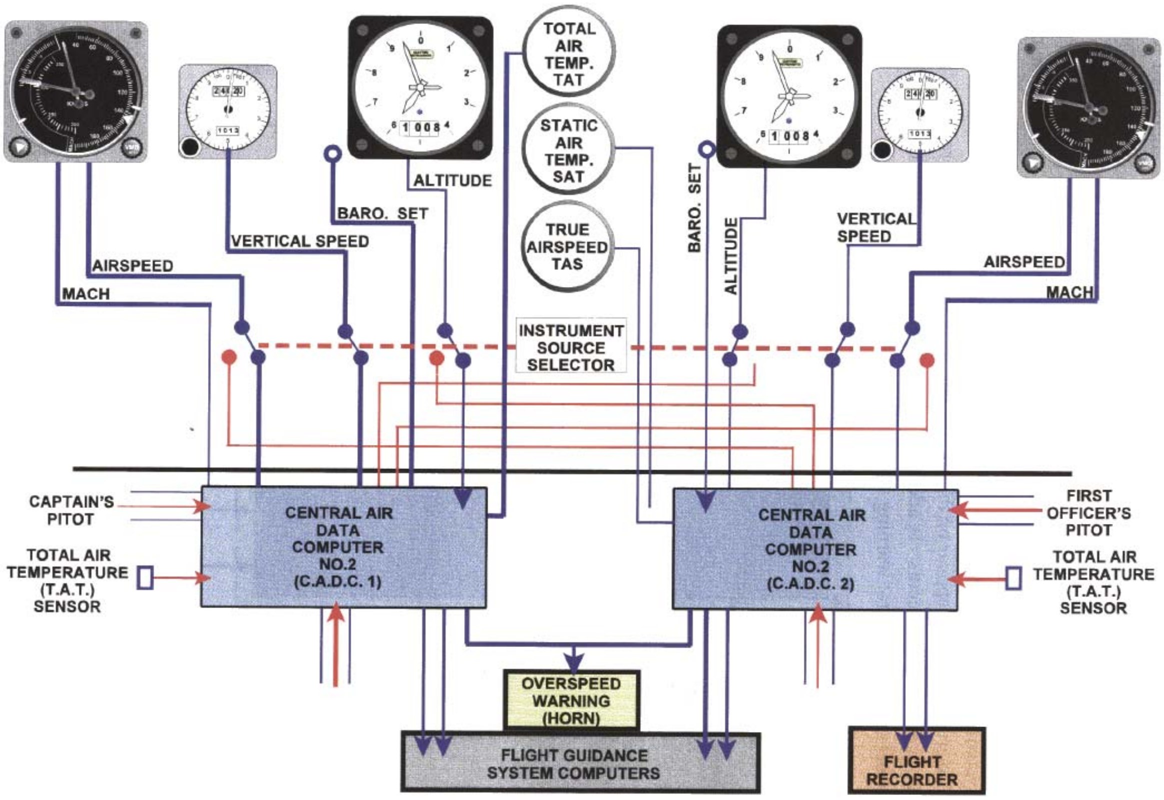
In many large aircraft currently in service, the conventional pressure instruments which show air data such as altitude, airspeed and Mach number are replaced by indicators displaying information generated by a central computer. The computer unit and displays, together with the sensors of the basic data of pitot pressure, static pressure and air temperature, and a power-pack, form the aircraft's AIR DATA SYSTEM. Whilst such a system is self- contained, its outputs are essential to the operation of the aircraft's automatic flight control system (AFCS). Air Data System (ADS) outputs may also be used in the height transponder, flight recorder, navigation computer and elsewhere.

The standard ADS instruments show altitude, vertical speed, airspeed and Mach No. Additional instruments can display Total Air Temperature (TAT), Static Air Temperature (SAT) and TAS. The ADC outputs required for other systems are various and may include TAS, Altitude, Log Mach No, Reciprocal Mach No and Log Vertical Speed. The ADC fitted to Concorde computes Angle of Attack and Side-slip as well as more standard data. A schematic diagram of an ADS is shown in Fig 1.



PITOT-STATIC SYSTEM

In a typical aircraft, identical sets of air data instruments are provided on the Captain's and First Officer's instrument panels. Each set of instruments is connected to one of two Air Data Computers fed from independent pitot and static sources, as shown in Fig 2. In addition to the indicators powered by the two Air Data Computers, there is a standby barometric altimeter and a standby airspeed indicator fed from pitot and static sources separate to those used for the ADC's . Each of the three independent pitot-static systems makes use of cross coupled static vents located on each side of the fuselage. This arrangement is designed to reduce error due to side-slip or yaw.



AIR DATA COMPUTER

Early models of Air Data Computers use electro-mechanical analogue computing techniques to convert pressure and temperature data into electrical signals which are transmitted to the display instruments and to other systems. The latest air data systems employ digital techniques that make use of advances in micro-processor technology.

The relationships between TAS, Mach No, Temperature, Pitot and Static pressures can be expressed as mathematical formulae. The ADC resolves these formulae continuously to produce the required outputs from pressure and temperature inputs in the form of shaft rotations or electrical signals. In analogue computers the shaft angles of rotation proportional to static and pitot excess (pitot minus static) are provided by pressure transducers.

The PRESSURE TRANSDUCER for pitot excess is shown in Fig 4. When a change in pressure occurs the capsules respond causing a very slight deflection of the pivoted beam. The I bar is displaced relative to the E bar resulting in an out-of-balance signal in the pick-off coil. This signal is amplified and fed to a servomotor which drives the output shaft and a lead-screw. The lead-screw is connected to a precision spring so that as the screw rotates the force exerted by the spring is changed. The output shaft will rotate until the spring force balances the force from the capsule thus holding the pivoted beam in its central equilibrium position. The angle of rotation of the shaft is a measure of the capsule force and, in this case, is proportional to the difference between pitot and static pressures. In the static transducer, static is fed to one capsule while the other on the pivoted beam is evacuated and sealed.

Shaft rotations from the transducers are converted within the analogue ADC into logarithmic voltage analogues of static and pitot excess as these can be readily added or subtracted when computing outputs.

SYSTEM REDUNDANCY

Provision for blockages and/or failure of an ADC is made through change-over cocks that permit an alternative static source to be connected to the computer or by the use of electrical switching that enables the Captain's instruments to be fed from the First Officer's ADC and vice versa. These arrangements are illustrated in Figs 2 and 3.

In some aircraft the ADS is designed so that the outputs from each computer are not directed exclusively to instruments on one side of the panel. By mixing the sources of air data to each side, the possibility of an undetected malfunction is reduced.

In the event of total failure of both air data computers, due perhaps to loss of power supply, the flight can be continued by reference to the standby instruments.

ADVANTAGES OF AN AIR DATA SYSTEM

An ADS has certain advantages when compared with conventional mechanical instruments:

1. <u>Improved Displays</u> Electrical instrumentation allows the manufacturer complete freedom to design new displays that are easy to read and unambiguous. These include digital, moving tape and integrated displays including EFIS.

2. <u>Reduced Instrument and Lag Errors</u> The major cause of instrument error in conventional mechanical instruments is friction loss within the linkages. The limited response rate of such linkages gives rise to lag error. Such problems are largely overcome by ADC's as linkages are not required.

3. <u>Error Correction</u> Computation of height, airspeed and other variables within one computer permits error correction to be applied appropriate to the particular aircraft. For example, position error correction (PEC) can be calculated within the Mach No computer channel for additional use within the height and airspeed channels.

4. <u>Central Source for Other Systems</u> The ADC provides not only the conventional information displayed on the instrument panel but also air data in any form as required for other systems.

5. <u>Clean Design</u> The use of electrically-driven instruments reduces the amount of pneumatic plumbing required behind the instrument panel to only those lines connected to the standby airspeed indicator and altimeter. In addition to space saving and easier maintenance, the use of shorter pitot/static lines reduces error-producing acoustic effects.

6. <u>Failure Warning</u> A comparison monitor can be incorporated to compare the outputs of the ADC's and to give automatic warning to the pilot of malfunction. With a purely mechanical system, comparison between left-hand and right-hand instruments must be carried out visually. A warning flag will appear on the appropriate ADS instrument if there is loss of valid data or if an internal failure occurs. In addition, a light may illuminate either on the instrument warning panel or on the central warning system indicator.