AAIB Bulletin No: 3/95 **Ref: EW/C94/7/5** **Category: 1.1**

Aircraft Type and Registration:	Airbus A300-B4, OO-ING
No & Type of Engines:	2 CF6 turbofan engines
Year of Manufacture:	1977
Date & Time (UTC):	23 July 1994 at 0115 hrs
Location:	Stand 23, London Gatwick Airport
Type of Flight:	Public Transport
Persons on Board:	Crew - 11 Passengers - None
Injuries:	Crew - None Passengers - N/A Ramp personnel - 1 Minor injury
Nature of Damage:	Front pressure bulkhead and raydome damaged beyond repair; damage to forward upper fuselage and forward floor beams
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	56 years
Commander's Flying Experience:	14,000 hours (of which 304 were on type) Last 90 days - 222 hours Last 28 days - 54 hours
Information Source:	AAIB Field Investigation

History of the flight

The plan was to fly from Amsterdam to London Gatwick, with only the crew on board, to position for a series of non-schedule flights the following day. The aircraft had a history of technical problems with the brake system and, on a previous sector that evening, there had been a build-up of pressure in the Yellow brake system; this manifested itself as a pressure indication on the right side of the dual brake pressure indicator and a hardening of the feel of the right brake pedal. The commander considered the commercial and technical ramifications of declaring the aircraft unserviceable at Amsterdam and decided, as no passengers were involved, to continue with the positioning flight to Gatwick. Contrary to the requirements of the minimum equipment list, he elected to take off with the Yellow hydraulic system depressurised and briefed the crew, at some length, on the consequences of this; included in the briefing was the need to increase required runway distances with inoperative ground spoilers and the requirement for the flight engineer to be ready to reinstate the Yellow hydraulic system immediately should it be needed for alternate braking. The aircraft left Amsterdam at 0005 hrs with the first officer as the handling pilot.

The flight was uneventful and the aircraft landed at Gatwick at 0110 hrs; the first officer noted that the right brake pedal was difficult to depress and, using the tiller, it seemed to require more effort to turn the aircraft to the right than to the left. The consequences of parking with the Yellow system depressurised were not discussed as the aircraft approached the stand and there was no evidence to suggest that this aspect had been considered previously. The first officer brought the aircraft to a halt on Stand 23 using normal braking; the APU had been started. The commander stated that he then waited, with the engines still running, for the ramp engineer to plug in the external power and to chock the wheels. The ramp engineer, standing on steps, moved to plug in the external power connector, however, chocks were not placed under the mainwheels because, for safety reasons, it was not the normal procedure to do this until the engines had been shut down.

The commander, assumed that the chocks were in place and, after a brief discussion with the flight engineer, he applied the parking brake. Meanwhile, the flight engineer used the push button, on the left side of the overhead panel, to activate the AC electric pump and pressurise the Yellow system accumulators. The action of pulling the parking brake lever de-activated the normal braking system, however, there was insufficient pressure in the Yellow system to activate the brakes and, as the ramp had a down slope and the engines were still running, the aircraft started to roll forward. The ramp engineer dropped the power connector, jumped from the steps and vacated the immediate area; he sustained minor injuries.

The commander was immediately aware that the aircraft had started to move and his first action was to recycle the parking brake lever. This had no apparent effect and so he returned it to the off position in order to re-instate the normal braking system; both the commander and the first officer applied pressure to the foot pedals. This was probably coincident with the flight engineer's decision to select the alternate brake system using the switch to the left of the AC pump push button. As there was still insufficient pressure in the Yellow system, the foot pedals were now ineffective and the aircraft continued to move forward. The commander ordered both engines to be shut down. The flight engineer reselected normal braking and there was some evidence to suggest that, although the crew were not aware of it, a short period of braking did occur. It was, however, too late to prevent the aircraft impacting the terminal building.

Crew training and experience

The flight crew members had all been trained by the same agency in Greece and there was no evidence to suggest that the basic training was other than satisfactory; the crew themselves had no complaint about it. They had received no formal crew resource management (CRM) training.

The commander's experience was commensurate with his position, however, he only gained his A300 rating in March 1994 and had relatively little experience on type; it was noted that his previous experience had been on the MD83. The first officer, aged 23 years, had flown a total of 947 hrs, of which 646 were on the A300; she gained her rating in December 1992. Her previous experience was on single engine aircraft less than 5,700 kg. The flight engineer, aged 29 years, also gained his rating in December 1992 and had flown 1,067 hrs, of which 868 were on the A300.

Belgian CAA action

The licences of both commander and the flight engineer were suspended following the accident. The commander was required to undergo a simulator check; this he did successfully and his licence was re-instated. The flight engineer was required to undergo further ground training followed by a simulator check; these items he completed successfully and his licence was re-instated. The company was required to ensure that all aircrew employed by them received formal CRM training.

The Belgian CAA Flight Operations Department carried out an inspection of the company on 27 January 1995.

Flight recorders

The flight recorders were removed and replayed satisfactorily. The Cockpit Voice Recorder covered the period from final approach to after the impact, and showed the time from the call for the application of the parking brake to the impact was approximately 20 seconds.

Description of the brake system (Figures 1 & 2)

Braking control is ensured through the rudder pedals (CM1 or CM2) except for the PARKING BRAKE which is manually controlled through the PARKING BRAKE handle.

The eight wheels of the main landing gear are provided with a multi disc brake system. Each brake assembly is fitted with two separate sets of pistons, one set for the NORMAL system powered by the Green hydraulic system and the other set for ALTERNATE/EMERGENCY/PARKING system powered by the Yellow hydraulic system.

The braking system provides four braking capabilities (Figure 2) using hydraulic pressure delivered by the Green system, the Yellow system or the Yellow accumulator.

1 NORMAL braking uses Green hydraulic pressure and includes an antiskid system. It is electrically controlled by the Brake Pedal Transmitter which in turn is operated, via a mechanical link by the brake pedals, which are an integral part of the rudder pedals. When

there is no brake pedal deflection, with the braking system selected to NORMAL the Automatic Selector Valve automatically provides Yellow system hydraulic pressure to the Alternate and Emergency braking system. The Yellow hydraulic pressure is on stand-by at the Emergency Brake Dual Distribution Valve (BDDV) (see Note 1). There is no indication of the Green system brake pressure within the cockpit.

2 ALTERNATE braking uses Yellow hydraulic pressure and also includes the antiskid system. It is selected automatically through the Automatic Selector Valve when Green hydraulic pressure fails or when the Green system is not in operation or when selected manually. It is mechanically/hydraulically controlled through a mechanical link from the brake pedals to two footmotors which provide low pressure hydraulic pressure to the BDDV.

3 EMERGENCY braking uses the same hydraulic lines as the ALTERNATE system. It is automatically selected should both Green and Yellow hydraulic systems fail, or if the ANTISKID switch is moved to OFF. In the first case power is supplied by two accumulators in the Yellow system which are charged by an AC electric pump and contain sufficient fluid for seven full brake applications; the antiskid system is not available. In the second case normal Yellow system pressure is utilised, backed-up by the accumulators.

4 The PARKING BRAKE uses Yellow hydraulic pressure or Yellow accumulator pressure. When the PARKING BRAKE handle is pulled, it de-activates the NORMAL or ALTERNATE braking and reduced Yellow system pressure is applied (110 bar/1595 psi).

5 Braking is applied during gear retraction. The nosewheels are braked by rubbing pads located in the nose gear bay. The main gear wheels are braked automatically, through the brake system control box (ANTISKID selector being in NORM position) when the landing gear lever is selected to UP, hydraulic braking being initiated electrically when the gear doors open.

Note 1 The BDDV was in some previous documents referred to as the Emergency Brake Distribution Valve (EBDV) but Airbus Industrie have stated that it is now called the Emergency Brake Dual Distribution Valve (BDDV). The abbreviation BDDV is used throughout the remainder of this Bulletin.

2 A Dual Brake Pressure Indicator located on the centre panel within the cockpit shows the Yellow brake system pressure on the left and right sides. An AC electric pump, activated by a manually operated button on the overhead brake control panel in the cockpit pressurises the Yellow brake accumulators.

Examination of the brake system

Because of the damage to the aircraft it was not possible, initially, to test the aircraft's braking system as a complete system. When the front of the right-hand main landing gear truck was raised clear of the ground it was found that the numbers 3 and 4 wheels could not be rotated by hand. Static tests revealed an apparent fault with the right-hand footmotor, part number 746078-102, which had been fitted to the aircraft ten days prior to the accident. During the removal of the right-hand footmotor it was noted that the top retaining bolt, the first of the two retaining bolts to be removed, was extremely tight within its locating holes and that as the top of the footmotor was moved away from its top fitting point it expanded in length. When refitted it had to be compressed to allow the second of the two retaining bolts to be fitted. A pencil line was drawn on the footmotor body to mark its compressed position when fitted in the aircraft. The difference between the compressed fitted length and the relaxed length of the footmotor was found to be approximately 0.65 mm.

The footmotor was removed from the aircraft and hydraulic pressure was applied to its output port. With the footmotor in its relaxed position there was fluid flow through the unit. With the footmotor compressed to the pencil line, the position of the footmotor when fitted within the aircraft, there was no fluid flow through the unit. This indicated that, when the unit was fitted to the aircraft, any pressure in the hydraulic line between the BDDV and the footmotor would be trapped and would not be allowed to bleed back to the footmotor reservoir when the right brake pedal was in the relaxed (brake OFF) position. The pipeline from the footmotor to the BDDV was routed under the cockpit and cabin floor through the main avionics bay and cargo bays to the main landing gear bay where the BDDV was located. It is felt that the thermal expansion of the hydraulic fluid within this pipe was, under certain operating conditions, enough to raise the pressure within the line to that required to operate the BDDV. This would allow Yellow system pressure to activate the Alternate brake system and produce a hard feel to the right brake pedal over a relatively short distance of travel. With the Yellow system depressurised and aircraft braking taking place using the Green system then the braking action would be asymmetric between the right and left brakes due to the right brake pedal travel being restricted.

No faults were found in the left-hand footmotor installation.

Examination and testing of components by the manufacturer

A number of components from the aircraft's Yellow braking system, including the right-hand footmotor, were examined and tested by the component manufacturer. When the right-hand footmotor was bench tested it was found that the dead travel, that is the amount of compression required to close the Internal Relief Valve (Figure 3), was 0.5 mm which was within the unit's specification. This supported the view that, when installed, the compression of 0.65 mm would have been sufficient to close the Internal Relief Valve.

Overall measurement of the footmotor was 171.5 mm whereas the specified length was 170 mm +0.05 mm to +0.1 mm. Strip examination of the unit revealed that the Threaded Ring, part number A82976 was not correctly installed in that it had not been tightened sufficiently into the body, part number A82974. Further disassembly revealed witness marks on the two halves of the Two-piece Stop, part number A82975, which strongly suggested that on assembly at overhaul one half of the Stop had been allowed to be partially lying on top of the other half. The unit was then reassembled correctly using all the original parts and found to functioned satisfactorily.

Three other brake system components that were bench tested were found to have minor faults. The Parking Brake Selector, part number 746161-101 had a very small internal leak between the input and return ports when the parking brake was selected ON. This would allow a very slow decay of the parking brake pressure and a very slight increase in the time required to pressurise the Yellow accumulators when using the AC electric pump when the park brake was applied. This fault was due to normal inservice wear within the valve.

The Automatic Selector Valve, part number A25461-103 was found to have an internal leak between Yellow supply and Yellow return when there was no Green input pressure; this would occur when the Green system was OFF, or the brake system was not selected to NORMAL, or the brake pedals were not being applied or the parking brake was ON. The leak only occurred when the Yellow pressure was below 23 bar. This would have increased the time required to pressurise the Yellow accumulators from below 23 bar using the AC electric pump. This unit was fitted to the aircraft as an overhauled item eight days prior to the accident.

The BDDV, part number A25434, was found to have a leak rate between the Yellow pressure input and the Yellow return one third in excess of the maximum allowable. This would allow the Yellow system pressure, when supplied only by the Yellow accumulators to bleed away quicker than normal. This would not occur when the Park Brake was selected ON because of the operation of the Parking Brake Hydraulically Operated Valve (not shown in Figure 1).

An hydraulic pressure of 5 bar was required in the low pressure hydraulic line from the footmotors to activate the BDDV, which was slightly higher than the maximum specified. This would require the brake pedals to be depressed with slightly more force to activate the brakes when the brake system was selected to ALTERNATE or EMERGENCY.

Testing of the aircraft brake and nosewheel steering systems

Following the repair of the aircraft, which included the replacement of many of the brake system components, extensive testing of the complete brake system and nosewheel steering was carried out. This testing did not show any faults in either system that were relevant to this accident. An aircraft taxi test was conducted on a flat area of taxiway, with both engines at ground idle, the Yellow Engine

Driven Hydraulic Pump selected OFF, the Yellow accumulators depressurised and the parking Brake selected ON. As the aircraft began to roll forward the Yellow accumulators AC electric pump was selected ON and the time measured to stop the aircraft was 12.5 seconds.

Maintenance

The aircraft's Maintenance Manual, Chapter 32-43-12, details the procedure for the removal and installation of the left-hand and right-hand footmotors. Following installation of the footmotor there is a requirement to bleed the emergency brake distribution dual valve control system and then perform a functional test on the emergency brake system.

Between 7 and 21 July 1994 the aircraft's Technical Log recorded 20 entries relating to the braking, antiskid and hydraulic systems. The right footmotor was changed on the 13 July following which the engineer recorded in the Technical Log that the operation of the unit was satisfactory. The engineer who signed the Technical Log for this task said that the procedure as detailed in Chapter 32-43-12 of the Maintenance Manual was complied with in its entirety.

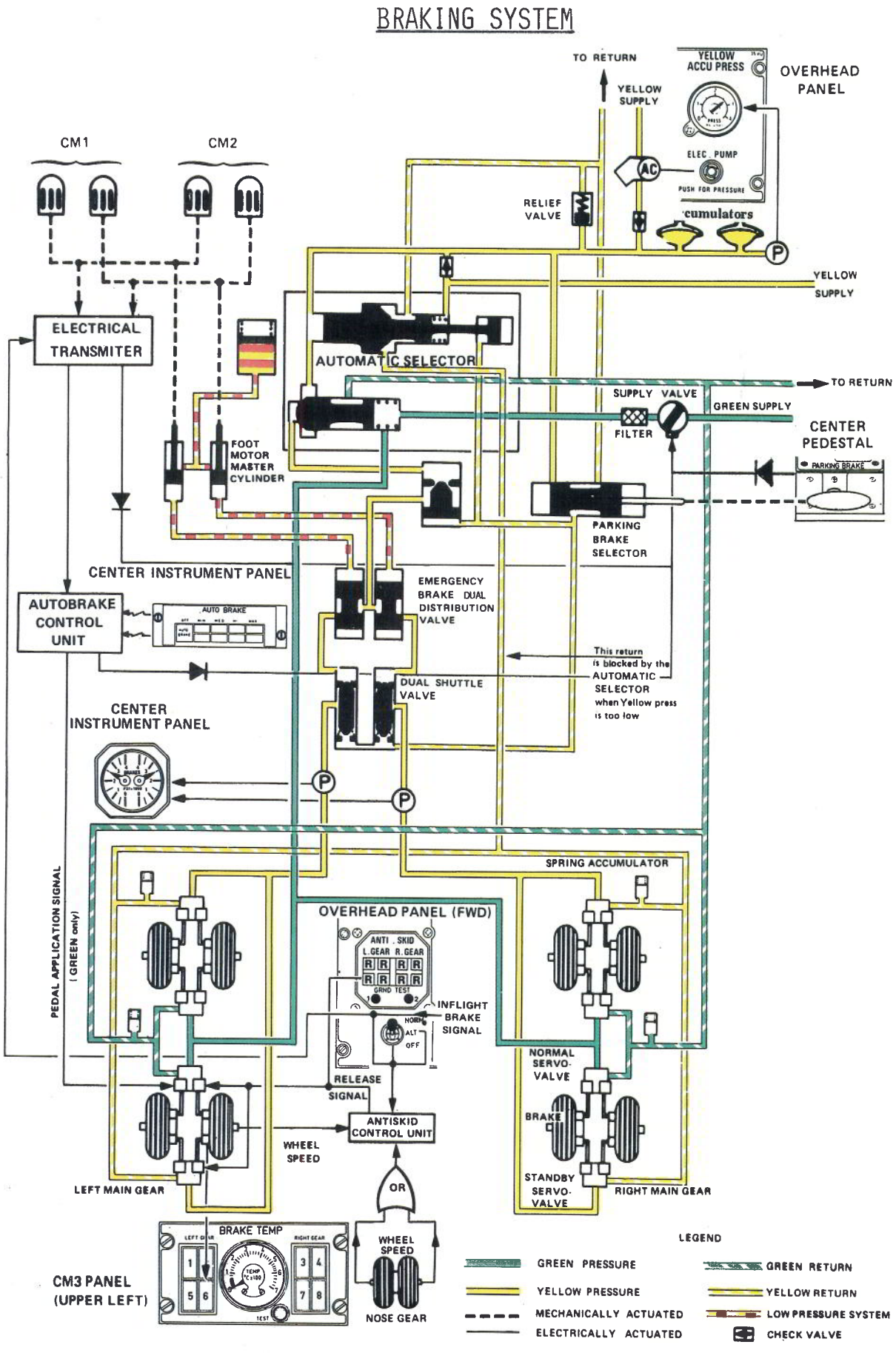
Following the right footmotor change on the 13 July there were three occurrences, over a two day period, of pressure build-up in right-hand Yellow brake system with the brake system selected to NORMAL (Green system). After each occasion rectification work was carried out culminating in a 'troubleshooting' exercise after the third occurrence. Following this 'troubleshooting' exercise the problem did not recur until 20 July 1994 when it was reported that the left (*Yellow*) brake pressure indicated 3,000 psi. As no faults were found with the left-hand brake system, it is felt, retrospectively, that the side on which the problem occurred was misidentified. The Technical Log does not indicate any further occurrences of this specific problem until the day of the accident.

Examination of the documentation held by the maintenance organisation that had fitted the footmotor showed that the unit had been supplied directly, on the 11 July 1994, by an approved overhaul agency following a repair which involved the replacement of four items within the footmotor. It was also noted that the Automatic Selector Valve, which was fitted to the aircraft on the 15 July 1994 was also supplied directly, on the 15 July by the same approved overhaul agency that had supplied the footmotor. The Automatic Selector Valve had undergone repair work prior to its release to the maintenance organisation.

Safety Recommendation

95-4 It is recommended that the DGAC reviews, and revises where necessary, the overhaul and quality assurance procedures of the overhaul agency to ensure that, in future, it releases only components which are fully serviceable.

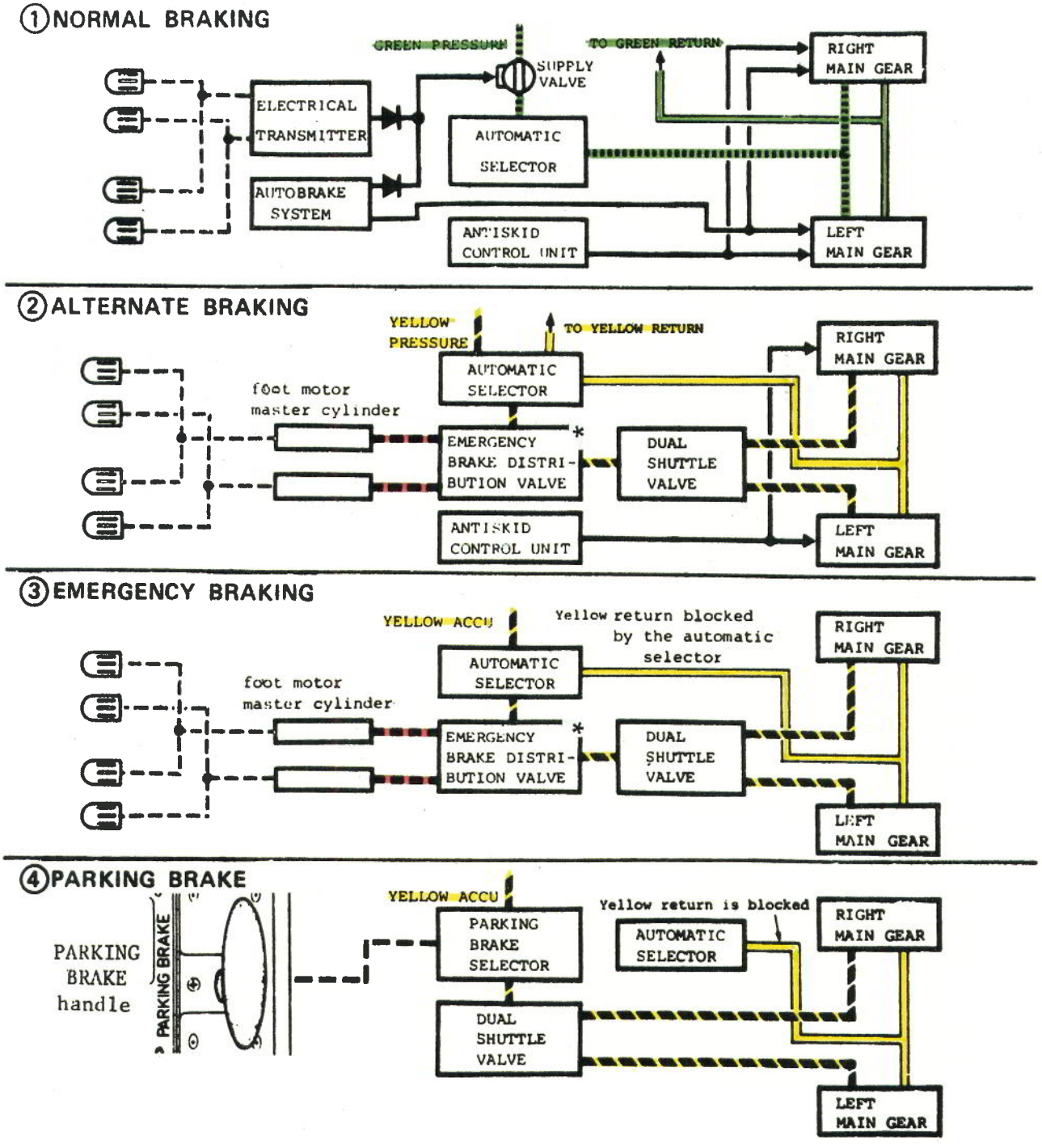
Figure 1



Adapted from an Airbus Drawing

Figure 2

BRAKING CAPABILITIES



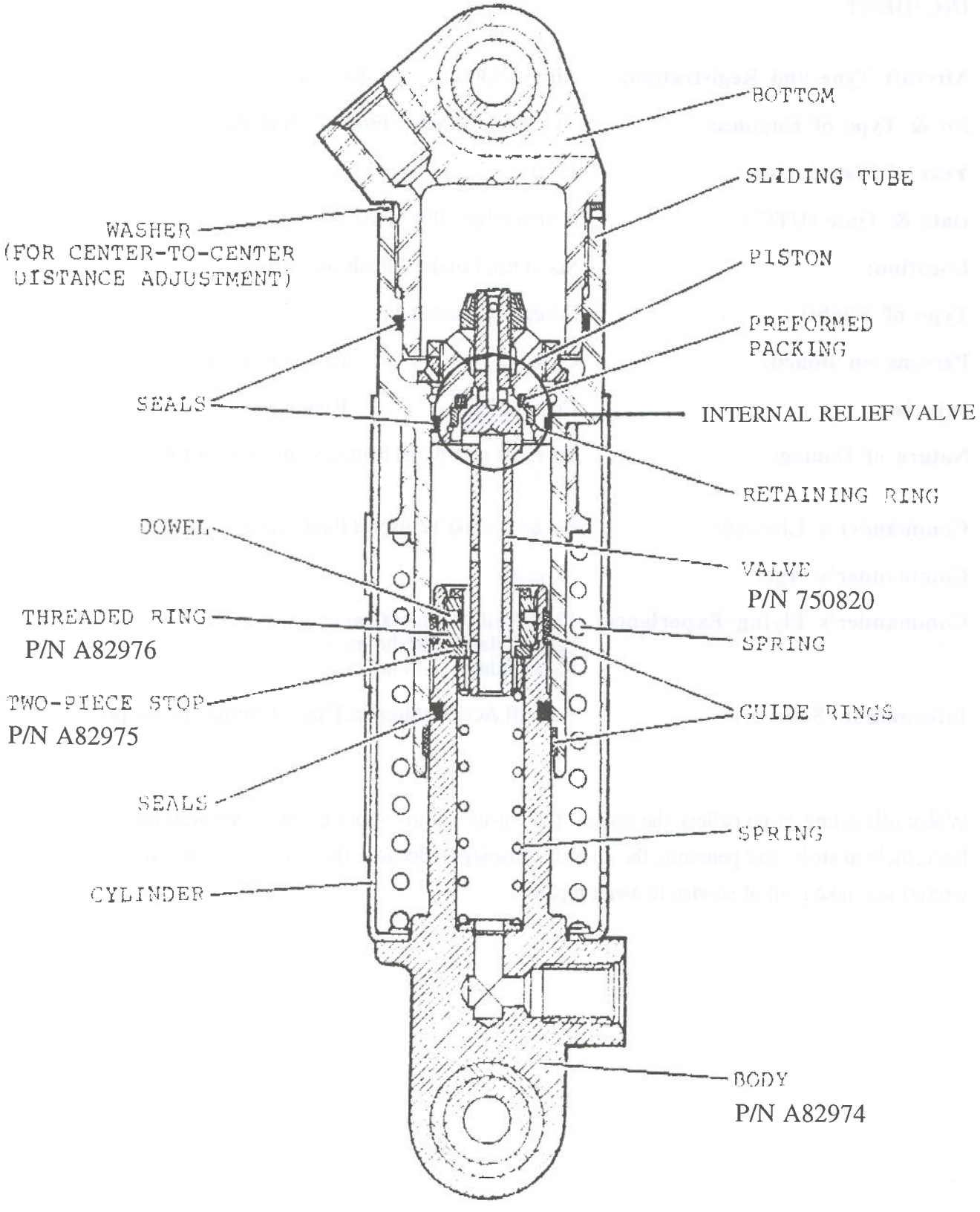
* COMPONENT NAME CHANGED TO EMERGENCY BRAKE DUAL DISTRIBUTION VALVE (BDDV)

Adapted from an Airbus Drawing

Figure 3

FOOTMOTOR

Part Number 746078



Adapted from a Messier-Hispano-Bugatti Drawing