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BOARD OF TRADE

CIVIL AIRCRAFT ACCIDENT

Report on the Accident to Ambassador AS.57 Series 2 G - AMAD at Heathrow Airport, London on 3rd July 1968

LONDON: HER MAJESTY'S STATIONERY OFFICE

FOUR SHILLINGS NET

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to Ambassador AS.57 Series 2 G-AMAD

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1969

Board of Trade
Accidents Investigation Branch
Shell Mex House
Strand
London WC2

March 1969

To the Rt. Hon. Anthony Crossland, M.P.,
President of the Board of Trade

Sir,

I have the honour to submit the report by Mr. N. S. Head, an Inspector of Accidents, on the circumstances of the accident to the Ambassador AS.57, Series 2, G-AMAD, which occurred at Heathrow Airport, London, on 3rd July 1968.

I have the honour to be

Sir,

Your obedient Servant,

V. A. M. Hunt
Chief Inspector of Accidents

SBN 11 510252 3

ACCIDENTS INVESTIGATION BRANCH

Accident Report No. EW/C/0214

Aircraft:	Ambassador As.57 Series 2, G-AMAD
Engines:	Two Bristol Centaurus 661
Owner and Operators:	B.K.S. Air Transport Limited
Crew:	Commander - Captain E.A. Hand - killed Co-pilot - Second Officer P.J. Burchell - killed Engineer - Mr. J.C. Moody - killed
Passengers:	5 - 3 killed - 2 seriously injured
Other Persons:	27 - slightly injured 2 - seriously injured
Freight:	8 horses - 7 killed - 1 destroyed
Place of Accident:	Heathrow Airport, London
Date and Time:	3rd July 1968 at 1628 hrs. All times in this report are GMT

Summary

The aircraft was on a flight from Deauville to Heathrow Airport, London, carrying eight horses and five grooms. The approach to land at London was normal until the aircraft reached the threshold of the runway when it started to bank steeply to the left. The bank increased and the aircraft turned through about 30° and finally crashed into aircraft parked at the new No.1 terminal building under construction at the central area of the airport.

The investigation has shown that the accident was caused by a fatigue failure of a flap operating rod which permitted the port flaps to retract whilst the starboard increased their extension from 40° to 50°. This resulted in a rolling moment to port which could not be controlled.

1. Investigation

1.1 History of the flight

The aircraft left Deauville at 1535 hrs., on flight No. C.6845, and made an uneventful flight to London at flight level 70. It was cleared to land on runway 28 Right and at 1624 hrs. reported passing the outer marker inbound. The approach proceeded normally and the aircraft came into the view of air traffic control personnel in the tower when it was about 200 feet, and close to the airport boundary. It was then in a normal approach attitude. However, at a position near the threshold of runway 28 Right the port wing was seen to drop and the aircraft turned slowly to the left off the runway centre-line. The bank increased and the port wing tip, followed by the port main wheels, touched the grass surface of the aerodrome. Witnesses near to the runway threshold heard engine power applied as if for an overshoot and the aircraft then became airborne again and with the bank further increasing, it flew towards the partly constructed No.1 terminal building on the northeast side of the airport central area. Whilst still steeply banked it struck two British European Airways Trident aircraft, which were parked at a pier of the terminal building, and burst into flames. The aircraft then rolled on to its back and after demolishing a twelve foot high metal blast barrier came to rest against the ground floor of the terminal building between two of the embarkation piers. 27 people on the ground in the area received slight injuries, 2 people were seriously injured.

1.2 Injuries to persons

Injuries	*Crew*	*Passengers*	*Others*
Fatal	3	3	-
Non-fatal	-	2	29
None	-	-	

1.3 Damage to aircraft

The aircraft was destroyed by the crash and subsequent fire.

1.4 Other damage

Three BEA aircraft, which were parked nose-in to one of the piers of the terminal building, suffered damage as follows:

Trident G-ARPT was destroyed. It was severed forward of the rear toilets, the entire after part including the engines became detached and were thrown about 30 feet away.

Trident G-ARPI was severely damaged. The fin and tailplane was severed at the line of junction with the fuselage.

Viscount G-APKF was damaged. A propeller and reduction gear from the Ambassador struck a catering vehicle which was positioned near to this aircraft, driving the vehicle against the fuselage thus damaging the skin and underlying members.

Three motor vehicles, a blast barrier and part of the new No. 1 terminal building were also damaged.

1.5 Crew information

Captain Ernest Arthur Hand, aged 48, was the holder of an airline transport pilot's licence, endorsed in Part 1 for Ambassador AS.57 aircraft. His last competency check on this aircraft type was completed on 21st February 1968; he was assessed fit at his last medical examination on 23rd January 1968. Captain Hand had been employed as a pilot in commercial aviation since 1947 and joined B.K.S. Air Transport Limited in 1953. He was a check and training captain on Ambassador aircraft and had flown a total of 15,338 hours as pilot of which 4,450 hours were on Ambassadors. He had flown 53 hours in the last twenty-eight consecutive days and had 36 hours rest before reporting for duty at 0430 hrs. on the day of the accident.

Second Officer Peter John Burchell, aged 29, was the holder of a valid commercial pilot's licence, endorsed in Part 1 for Ambassador AS.57 aircraft. His competency check on this aircraft type was carried out on 3rd February 1968 after the completion of an Ambassador conversion course. His instrument rating was renewed on 21st June 1968 and he was assessed fit at his last medical examination on 24th May 1968. Mr. Burchell first obtained a commercial pilot's licence in May 1967 and had been employed by B.K.S. Air Transport Limited since the 1st January 1968. He had flown a total of 609 hours of which 142 hours were in Ambassadors. He had flown 13 hours in the twenty-eight days prior to the accident and had 12 hours 40 minutes rest before reporting for duty at 0430 hrs. on the day of the accident. This period of rest was in excess of the minimum required by the Regulations.

Mr. John Cullen Moody, aged 43, was an aircraft engine and airframe fitter and had been flying with B.K.S. Air Transport Limited since 1960. His duties included the inspection of

the aircraft when it was away from base and he was also responsible for its loading. He had no flight duties apart from supervising the grooms in case of an emergency.

1.6 Aircraft information

The aircraft was manufactured in 1950 by Airspeed Limited. After service with British European Airways it was purchased by B.K.S. Air Transport Limited in July 1957 and used initially for passenger transport. At the time of the accident the aircraft had a valid certificate of airworthiness and examination of records showed that it had been regularly maintained in accordance with an approved maintenance schedule. The certificate of maintenance issued on 10th June 1968 was current.

It has been established that the weight and centre of gravity of the aircraft were within the prescribed limits. The type of fuel used was 100/130 octane avgas.

Between February 1967 and June 1968 the aircraft underwent a complete overhaul and was converted to an air freighter to carry race horses. Four pairs of horse boxes were positioned along the centre line of the fuselage, with eight passenger seats, four each side, positioned so that a groom could sit at the head of each horse. The conversion was approved by the Air Registration Board.

The aircraft had flown for a total of 22,290 hours since new, including 127 hours since the last check 4 inspection on 10th June 1968. During this inspection both flap systems were removed. The bolted fittings at the jack end of each flap rod were dismantled and the rods inspected visually for cracks. None were found.

Brief description of the flap system

The Ambassador's flaps are of the split type. The port and starboard sets are each actuated by hydraulic jacks fixed in the corresponding wing roots. The fork end of each jack piston rod is coupled to an 'I' section operating rod made from extruded aluminium alloy (Spec. DTD.683). The push-pull action of the rods is transmitted to the flaps through a number of toggle links and the flaps are lowered when the hydraulic jack pulls the operating rods inboard. Both jacks are synchronised by steel cables routed across the fuselage. The purpose of these cables is to ensure that in the event of variations of hydraulic pressure between one side and the other, an asymmetric flap condition will not occur.

The flaps are electro-hydraulically controlled. The flap selector lever on the right hand side of the pilots control pedestal is a four-positioned selector switch. The positions that can be selected are UP, 10^{o}, 30^{o} and 40^{o}. 10^{o} is normally used for take-off and overshoot. 40^{o} is the normal landing setting. The pilot's selector is connected electrically to a drum switch mounted in the port wing which actuates the appropriate control valve solenoid.

Two solenoid valves in the control valve unit, one for raising and another for lowering the flaps, link the main hydraulic supply and return lines to the appropriate ends of the jacks, dependent upon the flap position selected. When the selected position is reached the drum switch, which is mechanically linked to the port flaps only, automatically closes the control valve to lock the flaps hydraulically in the selected position. A Desynn transmitter, also mechanically linked with the port flaps, causes the position to be shown on an indicator mounted on the pilot's centre instrument panel.

1.7 Meteorological information

A special weather observation taken at Heathrow Airport, London at the time of the accident was as follows:

Surface wind:	260^{o}/15 knots, variable 230^{o} to 300^{o}
Visibility:	60 kilometres
Weather:	Nil
Cloud:	$\frac{2}{8}$ at 5,000 feet
Remarks:	Gust to 27 knots at approximately 1625 hrs.

1.8 Aids to navigation

The ILS (instrument landing system) for runway 28R and the locator beacon "OE" serving the runway were available. These aids were checked after the accident and found to be working within their permitted tolerances.

1.9 Communications

VHF radio communications between the aircraft and London Airways, London Approach and London Tower were normal, the final call from the aircraft was on passing the outer marker inbound.

1.10 Aerodrome and ground facilities

Heathrow Airport, London and its facilities were serviceable at the time of the accident.

1.11 Flight recorders

No flight recorder was fitted. The carriage of a flight recorder is not required in the case of piston engines aircraft with a maximum total weight authorised under 60,000 lb.

1.12 Wreckage

Inspection at the scene of the accident showed that whilst steeply banked to port the Ambassador had struck two aircraft parked at a pier of the No.1 terminal building. It had burst into flames on impact and then crashed inverted against the terminal building.

During the examination of the wreckage at the accident site, the flap operating rods were located. Examination of the rods revealed a fracture on the port rod just outboard of its connection to the flap jack piston rod. These components were removed for detailed laboratory examination. This examination revealed that the port operating rod had failed due to fatigue. (See Appendix A). There was no evidence of incorrect assembly or corrosion. There was no failure or fatigue on the starboard operating rod.

Further examination of the wreckage at the site showed that the flap selector lever in the cockpit was firmly gated in the takeoff position. Marks on the flaps showed that at impact the port flaps were up whilst the starboard fully down. The undercarriage was down and locked.

Examination of the flying controls and their locking mechanisms revealed no evidence of pre-crash defect or failure. Both engines had been torn out of their mountings by the impact and the condition of the propellers was consistent with them being under power when the crash impact occurred.

A strip examination of the engines revealed satisfactory lubrication and no evidence of pre-impact failure. It is considered that this examination indicated that both engines were capable of giving full power and were giving power at the time of impact.

There was no evidence that the horses had broken loose from their boxes or interfered with the control of the aircraft in any way.

1.13 Fire

The port main fuel tank of the aircraft burst on impact with the parked aircraft. Fuel, which was sprayed from this tank, ignited immediately.

The Airport Fire Services were notified at 1628 hrs. and arrived at the scene of the accident two minutes later. Two fires had occurred in the area of the wrecked fuselage of the Ambassador and a less severe fire developed in the vicinity of one of the engines embedded in the wall of the terminal building. Fire had also occurred in each of the two Trident aircraft. All fires were promptly deal with by seven fire fighting appliances using foam and carbon dioxide, and by 1641 hrs. the fire was under control. The London Fire Brigade, which had also arrived, provided back-up facilities.

1.14 Survival aspects

The Airport Fire Services immediately commenced rescue operations when they arrived at the accident site. Within a very short period of time the six people who died were removed from the wreckage. A number of construction workers and BEA personnel, who were in the immediate area, assisted in the rescue work; one of the injured grooms, who was trapped by his foot, was rescued from the burning aircraft by two people from this group. The other injured groom was found pinned in the forward section of the fuselage and because of extremely difficult circumstances it took one and a half hours to cut him free; fortunately the fire had been quickly extinguished which eliminated the possibility of it spreading into this part of the wreckage.

The flight plan filed prior to the departure of this flight from Deauville did not contain the number of persons on the aircraft. This meant that the rescue personnel had to continue to search the wreckage after all the occupants had, in fact, been removed.

An examination of the safety belts of the groom's seats showed that they were unfastened at the time of the accident. According to the evidence of one of the grooms who had survived the accident, it is customary for them to stand with the horses during take-offs and landings; both survivors, who were located in the two rear starboard seats, were standing in this manner at the time of the accident.

1.15 Tests and research

Following the discovery of the fatigue fracture in the port flap rod, all flap rods in the remaining Ambassador aircraft were inspected. In addition, a number of rods were removed and tested. The starboard rod from the accident aircraft was pulled to destruction in a tensile test machine to check its strength. This rod sustained more than its design ultimate strength. A subsequent examination of this rod revealed no evidence of fatigue.

A number of rods removed from other Ambassador aircraft, including those which had achieved lives greater than 13,000 hours were also examined and tested. The examination revealed fatigue cracks emanating from the 2 BA bolt holes in a number of these rods. In this respect, the appearance and position of the fatigue cracks was similar to that of the rod in the accident aircraft. When tested in a tensile machine the position and mode of failure also proved to be similar.

Prior to the accident there was no laid down fatigue life for the flap operating rods. However, immediately following the accident the Air Registration Board, in conjunction with Hawker Siddeley Aviation Limited, introduced a scheme to reinforce the rods with steel plates. Tests with these

strengthened rods has confirmed a safe fatigue life of 37,000 flying hours. In addition, a design re-appraisal has led to the introduction of a safe fatigue life for other parts of the flap system, and additional mandatory inspections of certain items has now been incorporated in aircraft operators' approved maintenance schedules.

1.16 Discussion on the flap system

With regard to the flap system, the steel cables, referred to in the description of the flap system in paragraph 1.6, were designed to ensure synchronisation of the port and starboard flaps in the event of variation in hydraulic pressure between the two operating jacks. It was not designed as a safeguard for the failure of a flap operating rod as prior to the accident such an eventuality was considered extremely remote. Unfortunately, on the occasion of the accident, the failure of the port operating rod occurred at a position about 3 inches outboard of the cable connection. This permitted the port flaps to blow up to a trail position but left the rest of the flap system, and the compensating mechanism intact.

For the flaps to work correctly and lock at the selected position, the flap position drum switch must be in phase with the pilot's selector. As the drum switch is connected to the port flaps only, it follows that when the failure to the rod occurred, and the port flaps blew up, they would take the flap position drum switch to the "UP" position. The effect of the pilot's selector being at "DOWN" (40^{o}) would cause the hydraulic valve to the jack to open and hydraulic pressure would be directed to both jacks to extend the flaps. Because of the design of the system they would then travel a further 10^{o} beyond the normal maximum extension of 40^{o}. As the port flaps were disconnected by the failure of the operating rod, only the starboard flaps would move and consequently the degree of asymmetry increased from 40^{o} to 50^{o}. At this time the flap position indicator on the flight deck (also connected to the port flaps) would indicate "flaps up".

The evidence indicates that the pilot attempted to overshoot when the flap asymmetry occurred. The flaps were selected upwards from the landing setting to the take-off position (10^{o}) which is correct for an overshoot, but at this selected setting the drum flap position switch at flaps fully "UP" would still be out of phase with the selector. Therefore, the hydraulic pressure would still be applied to the jacks to put the flaps down. Only if the selector was moved to the fully "UP" position would the selector and drum switch be in phase and the starboard flaps would then retract. Even then, retraction would take approximately 25 seconds.

2. Analysis and Conclusions

2.1 Analysis

Examination of the wreckage of the aircraft revealed no pre-crash defect other than that to the port flap operating rod. Therefore, with the evidence of the witnesses who saw the accident and a cine film taken by one of them it is clear that the accident resulted from this failure which most probably occurred when the flaps were extended from the approach (30^{o}) to the landing setting. The degree of asymmetry that occurred would result in a strong rolling moment to port and the application of full starboard aileron would be insufficient to return the aircraft to level flight.

The immediate effect of the bank to port was to turn the aircraft off the heading of the runway towards the central terminal area. In these circumstances it would be a normal reaction for the pilot to overshoot in order to gain time and space in which to analyse and correct the behaviour of the aircraft and the evidence indicates this was attempted. Engine power was applied and the flaps selected up to the correct position for an overshoot. It is clear that the pilot made a valiant effort to regain control of the aircraft but the effect of the steep angle of bank was to induce a sideslip to the left and also decrease the lift from the wing so that an effective climb was not possible.

If the Captain had fully retracted the flaps, as can be seen from the discussion on the flap system at paragraph 1.16, the starboard flaps would have retracted and thereby decreased the amount of asymmetry. However, this would be incorrect for an overshoot and the resulting reduction in lift would create other problems at a low altitude. In addition, it is unreasonable to expect a pilot to diagnose this as the best remedial action in the very short time available. Even if he had selected the flaps fully up, by reason of their low rate of retraction, it is very doubtful that an accident could have been avoided.

The flap operating rods on this aircraft are composed of an alloy containing aluminium, zinc and magnesium (Spec. DTD.683). At the time this aircraft was manufactured this material was widely used for components where maximum strength was required. Although the past history of DTD.683 has shown a susceptibility to stress corrosion, it must be

emphasised that the failure on this occasion was due to fatigue. The fatigue properties of this material are not inferior to other suitable alloys.

The post mortem examination of two of the grooms showed that they had sustained injuries consistent with them having been thrown about inside the aircraft. It must be recognised that with the carriage of highly strung horses a groom will wish to stand at the head of his charge, especially during take-off and landing when they may be restive because of the noise and acceleration experienced. It is suggested some thought should be given to seeing whether a form of safety harness could be provided which would reduce the risk involved but permit them to remain close to their charges.

Prompt and efficient action by the Airport Fire Services, and by personnel near to the accident site who entered the burning aircraft were the main factors which led to the rescue of the two surviving grooms.

2.2 Conclusions

(a) *Findings*

(i) The crew was properly licensed.

(ii) The documentation of the aircraft was in order and it had been maintained in accordance with an approved maintenance schedule.

(iii) During the final stage of an approach to land, the port flap operating rod failed because of fatigue. The port flaps then retracted.

(iv) Because of the design of the flap system, the starboard flaps extended a further 10^{o} after the retraction of the port flaps.

(v) The degree of flap asymmetry produced a rolling moment to port which could not be controlled.

(vi) An attempt was made to overshoot but because of the difficulty in controlling the aircraft it was not possible to clear obstructions in the flight path.

(b) *Cause*

Failure of the port flap operating rod by fatigue permitted the port flaps to retract. This resulted in a rolling moment to port which could not be controlled.

N. S. HEAD
Inspector of Accidents

Accidents Investigation Branch
March 1969

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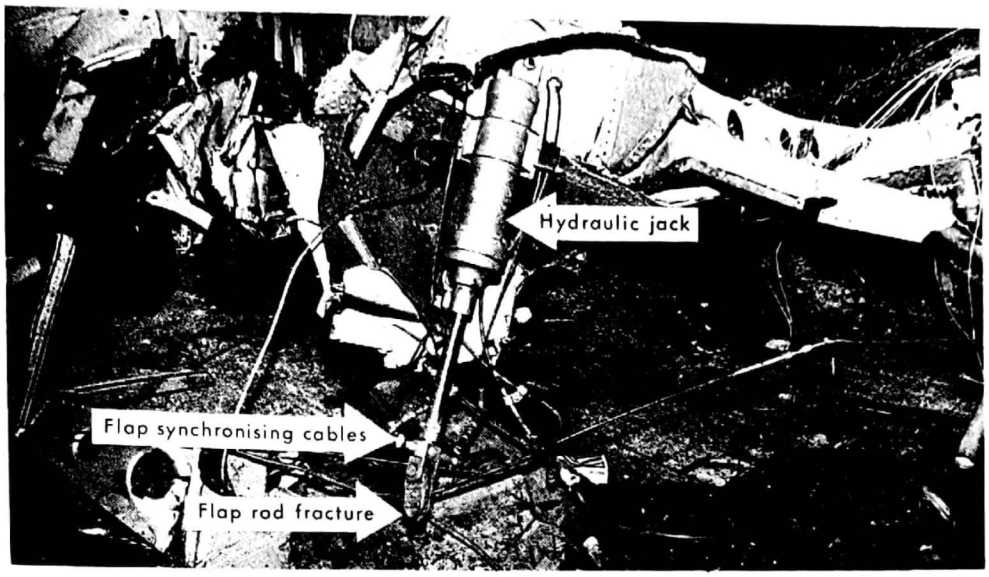
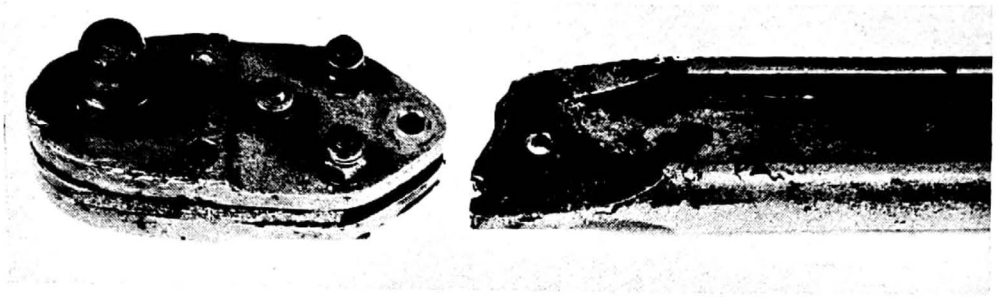
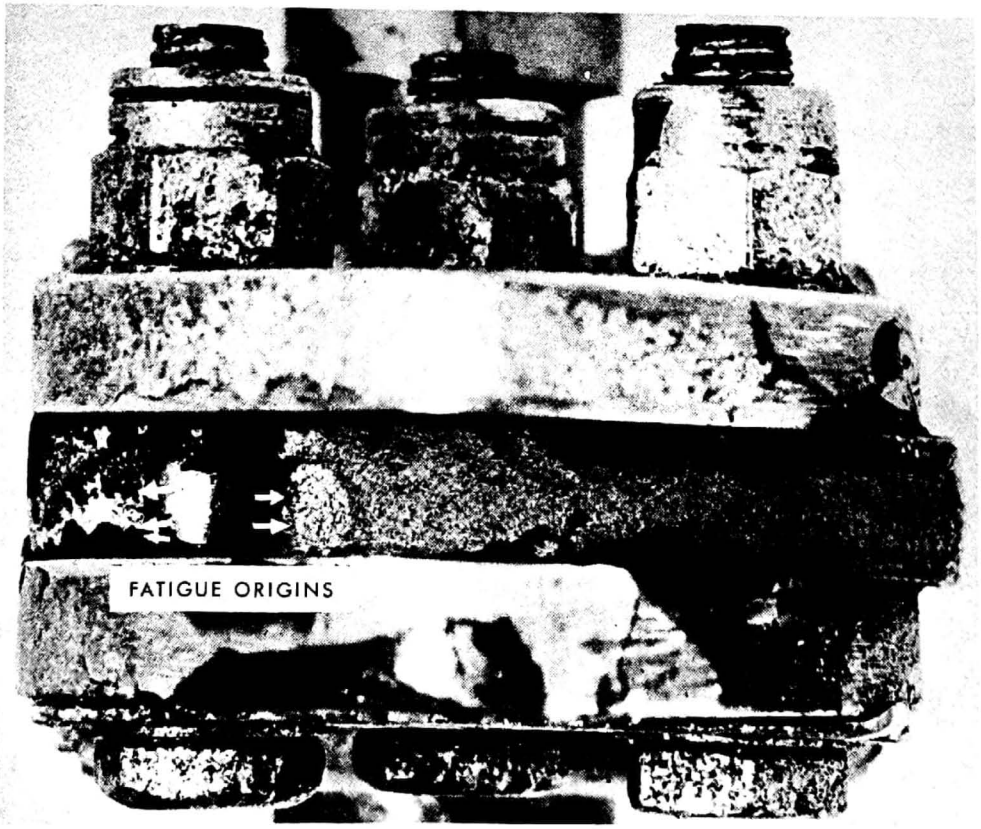


PORT FLAP JACK AND FRACTURED FLAP ROD



FRACTURED PORT FLAP ROD



ENLARGED VIEW SHOWING FATIGUE FRACTURE

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