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SPECIAL INVESTIGATION REPORT 72-2

Air Safety Investigation Branch

Department of Civil Aviation
Australia

ACCIDENT INVESTIGATION REPORT

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**Beech 65-80 Queenair Aircraft
VH-CMI near Alice Springs on
20 January, 1972.**

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**Connair Pty. Ltd. Beech 65-80
Queenair Aircraft VH-CMI near
Alice Springs on 20 January, 1972.**

The investigation of this aircraft accident was authorised by the Director-General of Civil Aviation pursuant to the powers conferred by Air Navigation Regulation 278.

Prepared by:
Air Safety Investigation Branch Melbourne

September, 1972

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THE ACCIDENT

At approximately 0745 hours Central Standard Time on 20 January 1972, there was an in-flight fire in a Beech 65-80 Queenair aircraft, registered VH-CMI, which resulted in the separation of the starboard engine and the starboard outer wing. The aircraft subsequently struck the ground some seven miles south-west of Alice Springs Airport in the Northern Territory. At the time of the accident, the aircraft was engaged in operating a charter flight for the purpose of carrying passengers, mail and freight from Alice Springs to Ayers Rock. The aircraft was destroyed by fire and impact forces and the pilot and the six passengers were killed.

1- Investigation

1.1 HISTORY OF THE FLIGHT

Beech 65-80 aircraft, VH-CMI, was assigned to operate a charter flight departing Alice Springs for Ayers Rock at 0730 hours on 20 January 1972. The aircraft was owned by Connellan Airways Pty. Ltd. and operated by Connair Pty. Ltd. who hold an appropriate charter licence issued by the Director-General of Civil Aviation. The aircraft was registered for regular public transport operations.

Before boarding the aircraft the pilot attended at the self briefing facility at Alice Springs Airport and compiled a visual flight rules (VFR) flight plan covering two return flights to Ayers Rock. This flight plan, which was lodged with the flight service officer on duty, indicated that the aircraft would proceed to Ayers Rock on the direct track of 235 degrees magnetic at a cruising altitude of 6,000 feet and that the estimated flight time was 64 minutes.

At 0733:06 hours, the pilot called Alice Springs Tower by radio and requested a clearance to taxi. The aircraft was cleared to taxi for take-off on Runway 12, (i.e. the runway which is aligned 116 degrees magnetic). While taxiing the pilot received and acknowledged an airways clearance which was in accord with his flight plan and, at 0735:23 hours, the aircraft was cleared to take off and make a right turn for the purpose of joining the departure track. The aircraft carried

out an apparently normal take-off which was watched by the aerodrome controller on duty in the control tower until such time as the aircraft had commenced its turn to the right.

At 0740:06 hours the pilot reported that the aircraft's departure time was 0739. He was given the area altimeter setting and instructed to change from the tower frequency to the flight service frequency. Note : Aeronautical Information Publication requires that a pilot shall report his departure time when established on the departure track at no further distance from the aerodrome than five miles. The departure time shall be the current time less an adjustment for the distance from the aerodrome.

At 0740:25 hours the pilot made a normal contact with Flight Service and this call was acknowledged. The next radio transmission from the aircraft was recorded at 0741:40 hours and consisted of a one-second transmission on the flight service frequency. No message was passed, the only modulation being a background of engine noise with a "beep-beep" sound superimposed upon it. At 0742:20 hours, 40 seconds after the previous transmission, the pilot reported on tower frequency : "we are returning to the field I have, er, a asymmetric condition, er, a fire in the starboard engine." Throughout this transmission there was a continual "beep-beep" sound in the background. The tower controller immediately cleared the aircraft to return for landing on Runway 12 and requested it to report on final approach. This instruction was not acknowledged from the aircraft but a muffled clicking noise, similar to a microphone switch being operated or a sudden break in an unmodulated radio transmission was detectable at this time on the record of radio communications. There was no further radio contact with the aircraft and at 0742:52 hours the aerodrome controller observed a puff of black smoke in the sky to the south-west of the aerodrome.

The only person who saw the aircraft after its departure from the immediate vicinity of the aerodrome was Mr. B. L. Parsons who, at the time, was located some 5 miles south-west of the airport driving an item of road construction equipment in a south-westerly direction. He reports that he first observed the aircraft flying diagonally across the road ahead of him from left to right and that it appeared and sounded normal at that time. The witness, some time later, saw a cloud of black smoke to his left and at the same time saw an aircraft, beneath the cloud, diving steeply towards the ground. It appeared to make one complete

revolution about its longitudinal axis before disappearing behind trees and no smoke arose from the position where the aircraft disappeared. The witness was unable to recall, with any degree of accuracy, the time interval between the two sightings.

1.2 INJURIES TO PERSONS

Injuries	Crew	Passengers	Others
Fatal	1	6	—
Non-fatal	—	—	—
None	—	—	—

1.3 DAMAGE TO THE AIRCRAFT

The starboard outer wing and the starboard engine with its associated cowls, mounting structure and propeller became detached from the aircraft in flight and were substantially damaged when they fell to the ground. The remainder of the aircraft was destroyed by impact forces when it subsequently dived to the ground.

1.4 OTHER DAMAGE

There was no damage to property except that which was carried in the aircraft.

1.5 CREW INFORMATION

The pilot-in-command of the aircraft, Nigel Clifford Halsey, aged 25 years, was the sole crew member and held a valid commercial pilot licence endorsed for the aircraft type. His total flying experience amounted to 1,558 hours of which 481 hours had been gained in multi-engined aircraft, including 55 hours in Beech 65-80 aircraft. Mr. Halsey had passed the necessary theoretical examination for a senior commercial pilot licence but he had not accumulated the flying experience necessary to qualify for the issue of this class of licence.

On the day prior to the accident the Senior Regional Pilot of the company conducted a progress and base check on Mr. Halsey in conjunction with a flight to Mt. Isa and return in VH-CMI. The base check, which was carried out at Mt. Isa, included a simulated failure of the starboard engine followed by an asymmetric go-around and landing. The progress and base checks were both carried out satisfactorily.

Mr. Halsey's most recent medical examination was carried out on 23 September 1971 when he met the medical requirements for a commercial

licence. There was no evidence from his previous medical history, his activities on the evening preceding the accident, or from the post-mortem examination that pilot incapacitation contributed in any way to the accident.

1.6 AIRCRAFT INFORMATION

History Beech 65-80 aircraft, Serial No. LD-12, was constructed in the United States of America and imported to Australia in 1962 as a used aircraft. At that time its total time in service amounted to 310 hours. The aircraft passed through the hands of a number of owners before being acquired by Connellan Airways Pty. Ltd. The certificate of registration was transferred to that company on 20 May 1970 and was valid until 19 May 1979.

There was a current certificate of airworthiness for the aircraft which was valid until 10 December 1973 and the records indicate that, prior to this accident, the aircraft had flown a total of 4,017 hours since new and 555 hours since its last major inspection. The port engine had completed 2,138 hours in service, including 168 hours since its last overhaul, whilst the starboard engine had completed 2,299 hours in service including 716 hours since its last overhaul. All of these operating periods were within the maximum hours between overhauls specified in the maintenance manual and approved by the Director-General.

A Check 3 inspection was carried out on the aircraft on 13 January 1972 and, with the exception of a minor discrepancy in respect of radio, the worksheets were appropriately certified by licensed engineers. Maintenance Release No. 1142 was issued on the morning of 20 January 1972, on the completion of the daily inspection and no defects were recorded.

In the three-week period preceding the accident a recurring defect had been reported by a number of pilots. This defect consisted of an intermittent fluctuation of 10 to 20 lb per hour in the starboard flowmeter indications during cruising flight. In an effort to rectify this defect, filters and lines were cleaned and all of the major fuel system components were replaced. Although this action effected some improvement it seems likely that this defect was present to a reduced extent at the time of the accident.

Loading Prior to the aircraft's departure from Alice Springs, a load statement was prepared and a copy of this statement was handed to the pilot.

The passenger list and seating plan are shown at Appendix A. Although the two seats used by Mr. and Mrs. Kneipp are known it has not been possible to establish the particular seat which each occupied. In addition to the six passengers who were carried, 27 lb of baggage, 60 lb of freight and 27 lb of mail were stowed in the rear locker.

The gross weight of the aircraft at the time of take-off has been calculated to have been 7,342 lb which is less than the maximum permissible gross take-off weight of 8,000 lb. The load distribution was such that the centre-of-gravity of the aircraft was within designated limits.

1.7 METEOROLOGICAL INFORMATION

Prior to completing the flight plan for the flight the pilot was provided with the terminal forecast for Ayers Rock and details of the appropriate area forecast. These forecasts indicated that the weather would be fine with a visibility of 15 to 20 miles, there would be 1/8 of cloud at the aircraft's operating altitude of 6,000 feet, and the wind at that altitude was forecast to be variable at 8 knots. The surface wind at Alice Springs, given to the aircraft by the tower shortly before take-off, was light and variable tending north-easterly and the surface temperature at the time was 27°C. An upper wind observation, made at 0900 hours at Alice Springs Airport, recorded the 3,000 foot wind as 055 degrees 10 knots and the 5,000 foot wind as 320 degrees 8 knots.

1.8 AIDS TO NAVIGATION

The availability or serviceability of radio navigation aids was not a factor in this accident.

1.9 COMMUNICATIONS

During the flight all communications between the aircraft and ground were carried out on Very High Frequency radio channels. These communications were recorded on magnetic tape and a transcript of the relevant portion of this tape appears at Appendix B. There is no evidence of any deficiency in the provision of communication facilities.

1.10 AERODROME AND GROUND FACILITIES

The availability of these facilities was not a factor in this accident.

1.11 FLIGHT RECORDERS

The aircraft was not fitted with either cockpit audio or flight data recorders and there is no requirement for Australian registered aircraft of this category to be so equipped.

1.12 WRECKAGE

Wreckage Trail The accident site was located in relatively flat featureless country some seven miles south-west of Alice Springs Airport. The area is sparsely covered by stunted eucalypt scrub and there is no nearby habitation.

The wreckage trail extended for a distance of some 5,000 feet. Some 4,650 feet of the trail preceded the main impact point whilst debris resulting from the main impact was thrown forward a further 350 feet.

The following major components of the aircraft were located along the wreckage trail at the indicated distances preceding the main impact point:

Starboard main landing gear	500 feet
Starboard engine and propeller	640 feet
Starboard engine augments (inboard)	1,100 feet
Starboard outer wing	1,200 feet
Starboard engine augments (outboard)	1,700 feet

The nature of these components and their distances from the main impact point clearly indicated that the aircraft had sustained a major structural failure in flight.

The earliest part of the wreckage trail consisted of flakes of heat-blistered paint and droplets of molten metal. Closer to the main impact point and through the area of the major components listed above, a large number of lesser components and pieces of the aircraft structure were located.

The main wreckage, comprising the complete fuselage, the empennage, the port wing, the port engine and the inboard section of the starboard wing, struck the ground at high speed in a steep nose-down attitude at an angle of about 70 degrees to the horizontal. The impact resulted in disintegration of most of the structure.

There was abundant evidence from the starboard centre wing, the inboard end of the starboard outer wing and the structure and components at the rear of the starboard engine firewall, that an intense fire had occurred in the nacelle area behind the firewall. It was also apparent that the wing separation had occurred because the heat

to which the wing spars had been subjected had substantially reduced their load-carrying capacity.

During the on-site investigation, all of the significant items of wreckage were identified, photographed, and initially examined. A survey plan (see Fig. 1) was also made of the locations of all components, after which they were collected and transported to a vacant hangar at Alice Springs Airport. Here a detailed examination of the wreckage and a re-assembly of the starboard nacelle area was carried out. Subsequently a number of components were transported to Melbourne for further specialist examination.

Powerplant Layout Each engine nacelle in this aircraft is divided into two compartments by a stainless steel firewall. The engine and its ancillaries are mounted forward of the firewall and enclosed in cowlings which include side panels which may be opened to provide access to the engine for maintenance purposes. The rear nacelle compartment behind the firewall contains the main landing gear wheel-well, the oil tank (which is mounted on the upper rear side of the firewall), numerous fuel and oil lines and a number of electrical cables. The wing spars pass through this compartment.

A separate exhaust system is provided for the three cylinders on each side of each engine. Three short exhaust pipes, one from each cylinder, lead rearwards and are clamped together near their aft extremities where they are directed into a short length of stainless steel ducting called the first-stage augments. The output of each first-stage augments is then directed into a main augments. The main augments are larger insulated ducts clamped to cut-outs on each side of the firewall and exhausting rearwards from each side of the rear nacelle; they vent the engine cooling airflow with the entrained exhaust gases to atmosphere. The main augments are positioned close to the wheel-well walls and the nacelle external skin includes a fairing covering each augments except for the discharge orifices.

Powerplant Examination Both propellers were stripped and examined. The examination showed that the starboard propeller had been feathered and was not rotating at the time of ground impact. The port propeller was found to have been operating within the constant-speeding range at the time that the main wreckage struck the ground and the damage to the propeller blades, clamps and locating tubes was consistent with the propeller having been abruptly stopped from a rotating condition.

The strip examination of the port engine revealed no evidence to suggest that it was not capable of normal operation prior to being severely damaged by ground impact.

The starboard powerplant, with the engine cowlings and about 18 inches of nacelle structure aft of the firewall, struck the ground heavily in an inverted attitude. The impact resulted in fracturing of the crankcase, and the engine-driven accessories were broken from their mounting pads. The cylinders, exhaust pipes and the first-stage augments remained in approximately their correct relative positions, but the main augments fell separately. All engine components were retained within the cowls although impact distortion caused the side cowl panels to burst open.

The strip examination of the starboard engine revealed that the shells of No. 2 main bearing had sheared the dowels which locate them in their housing and that they had rotated within the housing and had also been displaced axially. The loss of restraint of this bearing had been of a progressive nature, involving fretting away of the tangs on each bearing half, followed by progressive failure of the stepped dowels eventually leading to complete freedom of the bearing to rotate and move axially on the journal. The spin and axial displacement would have had the effect of depriving the No. 2 main bearing and the Nos. 3 and 4 big-end bearings of lubrication. The No. 2 main bearing had lost all bearing metal and its bronze backing, leaving only the steel shell, and the No. 3 big-end bearing shells had completely disintegrated, leaving the connecting rod and the crankshaft journal in a scorched and blackened condition. The No. 4 big-end bearing also showed the effects of lack of lubrication.

The disintegration of the No. 3 big-end bearing had resulted in a gross increase in bearing clearance with a consequent over-travel of the piston. As the piston passed bottom dead centre its skirt was pounded by the crankshaft counterweights and ultimately the No. 3 connecting rod failed at about its mid-point. The piston and the upper half of the connecting rod lodged in the upper part of the cylinder, but the lower half of the connecting rod remained attached to the crankshaft. The flailing action of this part of the connecting rod, whilst the engine continued to rotate, punched a hole some eight inches square in the top of the crankcase, penetrated the induction manifold at the bottom of the crankcase, breached the oil gallery, and removed a three-inch section of the camshaft, thus stopping valve operation on Nos. 1, 2, 3 and 4 cylinders. Both the supply and

scavenge sides of the oil system for this engine were found to be heavily contaminated with metal particles, and all bearings showed evidence of having been lubricated with metal-contaminated oil.

The engine was found to have had Avco Lycoming Service Instruction 1112C incorporated at the crankcase bearings. This repair scheme involved the removal of fretted material from the area of the through-studs at Nos. 2 and 3 main bearings and the insertion of selected spacers to retain the correct bearing housing diameter when the crankcase halves were bolted together. Evidence was found of fretting of the mating crankcase surfaces at Nos. 1, 3 and 4 bearing housings, but not at the No. 2 location.

System examination The aircraft's electrical, fuel, oil, instrument, flight control and engine control systems were subjected to the most detailed examination possible having regard to the severe fire and impact damage which had occurred.

The insulation had been almost completely burnt away from the electrical looms in the starboard nacelle area and a number of areas of electrical arcing were present on some of the wires. The grouping and location of these arcing indications, and the fact that they were associated with mechanical damage to the cables, indicated that the arcing had occurred at the time of wing separation. The fire damage to the main electrical loom was only moderate at the connector on the right hand side of the firewall, being most intense at a point some 13 inches aft of the firewall.

The starboard wing fuel system was re-assembled and it was found that several sections of fuel line were missing. The missing sections were all on or near the inboard side of the landing gear bay and comprised:

- (a) virtually the whole of the vapour return line;
- (b) those sections of the main tank vent line within the landing gear bay; and
- (c) sections of the main tank supply line, the engine supply line, and the crossfeed line.

The remaining portions of fuel line were subjected to metallurgical examination as described in Section 1.16 of this report. The fuel tank selector in the starboard nacelle was found selected to the main tank. The cables which operate the fuel tank selector were heat-affected and broken. The evidence suggests that breakage occurred at the time of wing separation.

The four-gallon capacity oil tank for the starboard engine, which is mounted on the upper rear face of the firewall, was partially burned away and fire had been present inside the tank.

The examination of the aircraft systems revealed no evidence of any defect or malfunction having been present prior to the engine failure and fire.

The aircraft was equipped with an engine fire detection system and a one-shot fire suppression system covering the area forward of each engine firewall. It was not possible to determine from the wreckage examination whether the fire warning system had operated. The fire extinguisher bottle from the starboard nacelle had been damaged by the nacelle fire and its contents had been discharged. It was established that the explosive charge in this extinguisher had been fired by electrical detonation rather than by the effects of heat.

Structural Examination The examination of the aircraft structure revealed that, with the exception of the starboard engine nacelle and its adjacent structure, all of the structural damage which occurred was consistent with impact with the ground. There were large areas of severe paint blistering on the rear fuselage and the empennage as a result of the nacelle fire, but no structural damage occurred in these areas from this source.

All identifiable parts of the nacelle structure, the adjacent centre wing and outer wing structure, the firewall and the engine cowlings, landing gear components and doors were re-assembled to more clearly assess the fire path and structural damage.

An intense fire had been present in the rear nacelle and the resultant structural damage had been largely confined between the main wing ribs which form the side walls of the landing gear bay. This bay is 20 inches wide.

The front wing spar failed in upward bending, the lower spar cap failing some six inches from the inboard rib and the upper cap at two points, two inches and eleven inches respectively from the inboard rib. The outboard failure of the upper cap was consistent with an in-flight bending failure, while the inboard failure appeared to have resulted from ground impact. A section of spar web in the region of the failure was missing. The rear wing spar, which forms the rear wall of the landing gear bay, also failed in upward bending, the upper spar cap failure being adjacent to the inboard rib and the lower cap failure some four inches further outboard. Most of the inboard section of spar web was missing and the remainder

was severely heat affected and partly burnt away. The spar caps were subjected to a metallurgical examination as described in Section 1.16 of this report.

The remainder of the aircraft structure in the landing gear bay area was affected by fire to varying degrees ranging from slight staining to complete consumption. The general pattern of fire damage forward of the wing front spar was fairly uniform over the width of the wheel bay. Aft of the front spar the fire damage was concentrated more on the inboard side of the landing gear bay as evidenced by the destruction of the lower portion of the inboard side rib, the concentration of fire damage on the rear spar close to that rib, and the pattern of burning of the upper wing skin.

The outboard side rib was virtually undamaged by fire aft of the front spar, but forward of the spar there was evidence of a severe fire zone in the lower half of the wheel bay on the outboard side. A large section of the rib had been consumed by fire in the region adjacent to the main augmentor. The maximum intensity of fire damage had occurred about 15 inches aft of the firewall, where the entire lower panel of the rib had been burnt away.

The landing gear actuator and its support structure, on the forward face of the front spar, were very severely fire-damaged. All other components of the landing gear were also fire-damaged and the nature of the damage showed that the right main gear had extended during the course of the fire, this having occurred because of the failure of the actuator support structure. That portion of the tyre which is normally contained within the nacelle was severely scorched by fire, and the tyre was found to be deflated. The landing gear doors were both damaged by the fire within the landing gear bay.

The starboard wing flap, which was broken into two pieces, was severely damaged by fire on its lower surface in line with the inboard half of the landing gear bay. The nacelle fairing which is attached to the lower surface was almost completely burnt away. The nature of the damage showed that the flap had been in the retracted position during the course of the fire and at the time of wing failure.

The outboard main augmentor fairing was severely affected by fire and nearly all paint was burnt from its lower half. A section of the fairing was burnt away at its lower forward corner where it attaches to the firewall and an adjoining section of the lower edge of the engine side cowl panel

was missing. The paint on this cowl panel was blistered over its lower half by heat of internal origin, and the forward part of the blistering pattern corresponded in shape to the exhaust pipes of cylinders Nos. 3 and 5. The paint was completely burnt away in the area adjacent to the outboard first-stage augmentor, which itself showed indications of abnormally high temperatures. There were no similar heat effects on the inboard first-stage augmentor or on the inboard side cowl panel.

The firewall was extensively crushed and distorted by impact of the power-plant with the ground in an inverted attitude. In addition, the lower section of the firewall was bent rearwards along a line passing through the two augmentor cut-outs and the pattern of soot deposits in the buckled areas showed that fire had been present after this rearward deformation had taken place. The most severe area of fire damage on the rear face of the firewall was at its mid-depth between the wheel bay side ribs. The forward face of the firewall showed no indications of fire, but there was a pattern of smoke staining through the outboard augmentor cut-out.

The rear clamps on the main augmentors remained attached to them, but the clamp brackets had been burnt away from their supporting structure. The forward clamps remained in position around the firewall cut-outs after the main augmentors became detached. In both cases the outer bolt through the clamp halves had been tightened such that the faces were tightly clamped together whereas there was a considerable gap between the clamping faces at the inner side of each clamp. There was evidence of good clamping action in the form of numerous areas of contact between the clamps and the lips on the forward end of each main augmentor. In the case of the outboard augmentor, however, these areas had been heavily sooted over in a manner which indicated that fire had been present after the augmentor had been displaced from its forward clamp.

1.13 MEDICAL AND PATHOLOGICAL INFORMATION

Post mortem examinations were carried out on all of the victims and no condition was found which could have contributed to the accident.

1.14 FIRE

The details of the in-flight fire have been covered in the preceding section of this report.

There was no significant ground fire. When the aircraft had not been sighted eight minutes after receipt of the message that it was returning, fire-fighting vehicles were despatched in the direction from which the aircraft had been expected to arrive. Due to difficulty in locating the position of the wreckage, they did not reach the accident site until 58 minutes later but this was of no consequence in the particular circumstances.

1.15 SURVIVAL ASPECTS

This was not a survivable accident.

1.16 TESTS AND RESEARCH

A metallurgical examination was made of a number of structural components and fuel lines from the starboard nacelle area to determine the mode of failure, the maximum temperature, the duration of heating and the presence of any pre-existing damage.

All of the pieces of fuel line which were recovered were examined, and some of them were found to contain holes or splits similar in appearance to pressure bursts. It was found that in each case of fracture or bursting the failure had occurred while the particular section of pipe had been at an elevated temperature in the range 400-600°C, the bursts all showing evidence of temperatures close to 600°C. In some cases the fracture surface was bright, which was indicative of the fracture occurring at wing separation with rapid removal of the fracture surface from the fire zone, whereas in others the fracture was sooted and heat stained which indicated that the fractured pipe had remained in the fire zone for some period after failure. In all cases the bursts occurred due to internal pressure whilst the pipe was weakened by heat, and fuel was probably added to the fire as a result of these breaches. There was no evidence of any pre-existing defect, in any of the fuel lines recovered, which could have initiated or contributed to the nacelle fire.

The examination of the spar caps close to the positions of failure indicated that a gradient of hardness (and maximum temperature reached) existed through the cap sections. Experiments were carried out on unaffected samples of the actual front spar lower cap in an air-recirculation furnace in an endeavour to establish the duration of heating of the failed spar caps. Equipment limitations precluded the development of temperatures beyond 900°C and the observed internal hardness/temperature gradients could not be

achieved at this temperature. From a plot of furnace temperature against the time of heating required for the centre of the cap to reach the appropriate temperature it was clear that the actual flame temperatures must have been in excess of 900°C and that the duration of heating must have been of the order of one minute.

From the observed hardness figures it was also estimated that the load carrying capacity of the spar caps was reduced by more than 80 per cent in the period of maximum heating.

A chemical analysis was made of soot deposits on the internal structure of the starboard wing in an effort to establish whether they had resulted from the combustion of Avgas or engine oil. The results were inconclusive.

2 - Analysis

The analysis of this accident is primarily concerned with the origin and progress of the intense fire in the starboard engine nacelle which resulted in the separation of the starboard outer wing. Beyond the point in time at which wing separation occurred no action was available to the pilot which could possibly have influenced the subsequent course of events and consequently the analysis of the operational aspects of the accident is confined to the period prior to wing separation.

There was no evidence that the start-up, taxi and take-off were other than normal and at 0740:25 hours, some five minutes after being cleared to take off, the pilot made a normal radio contact on flight service frequency. The contents of this transmission, which terminated at 0740:31 hours (see Appendix B), clearly indicate that he was not aware at that time of any abnormal operation. The next transmission from the aircraft, 69 seconds later at 0741:40 hours, obviously was made after an engine had failed since it consists of a recognisable landing gear warning horn signal. This horn would only be operating if one or both throttles were retarded whilst the landing gear was not locked down. Since there is evidence that, prior to the accident, the aircraft sustained a failure of the starboard engine, it is reasonable to assume that this event took place during the 69 second period between these transmissions and that, at the time of the second transmission, the pilot had probably completed and certainly commenced initial feathering action. In the next transmission, a further 40 seconds later, the sound of the landing gear warning horn was still present

and the pilot reported that he had an asymmetric condition and a fire in the starboard engine. The evidence that the starboard engine fire extinguisher was discharged electrically indicates that, on becoming aware of the fire, the pilot carried out the necessary emergency procedures.

There is little doubt that the black smoke puff observed by the tower controller was the result of the separation of the starboard wing and engine. It is known to have been visible at 0742:52 hours, some 22 seconds after the last transmission from the aircraft was completed, and it obviously appeared some time prior to this. The recording of the ground/air communications provides valuable evidence of the time scale of the events and indicates that the maximum period between the pilot becoming aware of an abnormal operating condition and the in-flight break-up of the aircraft was something less than 2 minutes and 21 seconds.

Based on the aircraft's performance and the elapsed time from take-off it is probable that a height of between 2,500 and 3,000 feet above ground level had been reached at the time that the emergency occurred. At the time of wing failure the aircraft had completed a turn on to a reciprocal heading and was returning to the airport. Calculations made from witness observations of the black smoke puff, together with a trajectory plot of selected items of wreckage, indicate that the aircraft broke up at a height of about 2,000 feet above ground level.

In assessing the engineering evidence summarised in Sections 1.12 and 1.16 of this report, consideration must first be given to the sequence of the two major events – the failure of the engine and the occurrence of a fire.

Had a fire existed behind the firewall for long enough to burn through the oil tank and consume its contents or cause them to be lost, it is possible that an engine failure could have occurred as a result of loss of oil supply.

There are several sources of combustible material aft of the firewall, but no evidence of a leakage of any sort was found. However, several sections of fuel line were not recovered, including the whole of the vapour return system aft of the firewall, and an undetected rupture or leak in one of these areas must be considered a potential source of fuel. In addition, the starboard engine had a history of fluctuations of fuel flow, exhaust gas temperature and cylinder head temperature during cruising flight. Such fluctuations could possibly be attributed to air leaking into the fuel supply line under the suction head produced by

the engine-driven fuel pump when operating with the electrically-driven boost pumps off. A corollary to this proposition is that a fuel leak could have existed with boost pumps on, during the take-off and climb segments of the flight. The main evidence against the existence of such a fuel leak is that, during the course of the attempts to trace the cause of the flowmeter fluctuations a prolonged ground inspection of the starboard nacelle had been carried out with the main boost pump running to pressurise the engine supply lines and no leaks were found.

Even if it is assumed that some leakage of combustible material had occurred behind the firewall there is other evidence that a fire in this area did not precede and cause the engine failure. Firstly, the No. 2 main bearing failure, which is known to have been the first step in the engine failure sequence, was of a progressive nature. Its deterioration probably extended over some hours of engine operation, and bearing material was widely distributed throughout the engine oil system. This indicates that an oil supply had been available to and was circulating through the engine during the bearing failure process. Secondly, if a fire behind the firewall had preceded and caused the engine failure the time involved from the start of the fire to failure of the wing would be inconsistent with the evidence regarding the time of heat exposure of the spar caps. Section 1.16 of this report shows that the spar had been subjected to high temperatures for about one minute. It is known from the communications record that the engine had failed at some time prior to 0741:40 hours and that the aircraft was still intact during the last transmission which terminated at 0742:30 hours. Thus the shortest possible time from engine failure to wing failure is 50 seconds and this, in itself, is close to the one-minute spar exposure time. If a substantial fire had existed in the rear nacelle for long enough to burn through the oil tank, consume its contents, and finally cause a bearing failure, the total time of spar cap heat exposure would have been for too long to be consistent with the metallurgical evidence.

It can thus be concluded that the engine failure preceded the development of a fire aft of the firewall and it appears certain that the engine failure was the direct cause of the fire. The problem which remains is to determine where the fire started and to trace the course of its development to the point of causing a catastrophic structural failure.

Looking firstly at the engine failure, it is evident that the failure resulted in a large hole in

the crankcase, a breaching of the oil gallery, penetration of the induction manifold, and a camshaft failure which stopped valve operation of cylinders 1, 2, 3 and 4. As long as the engine continued to rotate there would have been a release of combustible material into the engine compartment by virtue of oil being sprayed from the crankcase failure and an Avgas/air mixture being forced out of the broken induction manifold by supercharger action. It is not known how long the engine continued to rotate after failure of the connecting rod, but the nature of the damage to the various components and the presence of a large quantity of oil in the engine compartment show that it did so for a significant time interval.

Several ignition sources would have been available inside the engine compartment. The mixture of oil, Avgas and air entrained by the augmentser system could have been ignited by the exhaust gases from Nos. 5 and 6 cylinders which would still have been functioning prior to engine shutdown. Other possibilities are, arcing from a damaged high-tension lead, ignition of the fuel/air mixture in the induction manifold if the forward end of the camshaft had stopped in a position which left one of the inlet valves open, or auto-ignition of the engine oil on a still-hot exhaust pipe. The latter appears to be a very likely possibility because the paint blistering on the outside of the outboard side cowl shows a distinct pattern suggesting that a fire was at some stage burning on the outside of Nos. 3 and 5 exhaust pipes.

The fire around the forward sections of these exhaust pipes was apparently not very intense. There was no observable fire damage to the engine or its mountings nor to any of the components or systems forward of the firewall. The cowl panels showed no internal evidence of heat except in the area immediately adjacent to the first-stage augmentser. Here there were very pronounced heat effects and the augmentser itself showed evidence of abnormally high temperatures, indicating that an intense fire had been burning in and around the first-stage augmentser.

It therefore appears reasonable to conclude that the fire resulted from the release of a considerable volume of combustible material following the crankcase failure, this being ignited either by contact with hot exhaust pipes or with exhaust gases, and being almost completely entrained within the outboard augmentser system.

It now becomes necessary to consider the means by which this fire, apparently contained within the normal exhaust system, was able to penetrate into the nacelle area behind the firewall.

A number of possibilities exist. One is that the engine compartment fire burned through the side cowl and the flames passed externally rearwards and toward the bottom of the nacelle, entering the wheel bay through the wheel cut-out in the landing gear doors. However, the hole in the cowl panels at the rear lower corner of the side panel, adjacent to the firewall, was a fairly small one and showed little evidence of local melting around its edges, suggesting that the missing pieces had been broken away rather than burnt away. Nor was there any evidence of a streaming pattern in the paint blistering aft of this hole — the pattern of paint blistering in this area was in fact much more suggestive of having been caused by fire within the nacelle. Finally, the forward extremities of the landing gear doors were not significantly blistered on the external surfaces as would have been the case if flames had entered the wheel cut-out from such an external source.

Another possibility arises from the fact that the burning which occurred in the augmentser system would probably have produced a considerable torching effect aft of the main augmentser outlet. The possibility was considered that such a flame had entered the nacelle by burning through the lower nacelle skin. There was certainly evidence of much exterior paint blistering aft of the augmentser, and the rear nacelle skin had been completely burnt away on the lower surface aft of the landing gear doors. However, the paint damage showed no clear streaming pattern aft of the augmentser outlet, and at the rear of the nacelle the structural fire damage was strongly indicative of having been of internal origin. The main pointer to this was the fact that the destruction of the lower nacelle structure extended directly rearwards in line with the landing gear bay side rib, suggesting that it had been caused by a fire burning within the confines of the bay after the landing gear doors had opened. In addition, a flame torching rearwards from the augmentser would have been directed along a path lying just outboard of the side rib at Wing Station 88 and there was no sign of any penetration of the skin in this area.

Another possible mode of entry of fire into the landing gear bay area would be the leakage of a substantial quantity of avgas or oil behind the firewall at the time of engine failure, this being ignited externally by the torching with a subsequent flash back into the nacelle. A coincident long-term leakage is not considered likely for reasons discussed earlier and there is no evidence of a defect in the fuel system which could have

produced a fuel leak in the early stages of this particular flight. However, the severe vibration which would have occurred whilst the engine continued to rotate after failure could conceivably have caused some disruption of the fuel or oil systems aft of the firewall. All of the fuel line nuts appeared to have been tight at the time of the fire, with no evidence of straining, nor was there any evidence of a pre-existing fuel line defect which could have been aggravated by vibration to produce a sizeable leak. However, a number of sections of fuel line were consumed in the fire and it is not possible to exclude any of these sections as the source of such a fuel leak. The only relevant evidence in this respect is that the fractures remaining were all high-temperature overload failures, indicating that at least the ends of the missing sections had failed as a result of the fire and the subsequent structural break-up.

Consideration has also been given to the possibility that the engine vibration induced a partial collapse of the nacelle structure, which could very readily have produced a fuel or oil line failure aft of the firewall. There is certainly evidence that the nacelle had drooped to some extent prior to the final structural failure, but there was no evidence that this was induced by vibration. In fact, the compression failure of the lower nacelle skin panel aft of the firewall showed evidence of failure at high temperature, indicating that it had occurred well after the development of the internal fire and probably as a result of the weakening of the panel by that fire.

The final possible entry path to be considered is via the wheel bay side rib adjacent to the outboard augments. Both main augmenters were found in the wreckage trail and they had both left their forward clamps still attached to the firewall. Although the forward lips of both augmenters and their respective clamps showed evidence of good clamping contact, the presence of substantial soot deposits over these clamping areas in the case of the outboard augments showed that fire had been present subsequent to its detachment.

The indications were quite consistent with the displacement of the outboard main augments as a result of severe engine vibration and the consequent entry of the intense first-stage augments fire into the space between the main augments and the wheel bay side wall. In the absence of any significant cooling airflow on the inboard side of this rib, penetration could be expected to occur in a very short time. Once having entered the wheel bay area, several sources of additional fuel for the fire would become available by way of the fuel

lines and the oil tank, which would probably still have contained a quantity of oil after the engine ceased rotation. The vapour return line and those fuel lines in which fuel was not flowing would have been particularly susceptible to rapid breaching by the fire. It should also be noted that the heat-induced bursting failures of the main and auxiliary tank supply lines were at comparatively low points in the system and would have allowed a substantial discharge of fuel even with the boost pumps not running.

The overall pattern of fire damage is consistent with the above hypothesis; particular points being the almost complete destruction by fire of the side rib in the area immediately adjacent to the outboard main augments and the evidence of high internal temperatures surrounding the main augments as shown by the complete removal of paint from the lower nacelle panel outboard of the side rib.

The adequacy of the clamping action on the forward end of the outboard augments could not be accurately assessed. However, it was noted that there was a gap between the clamp halves of the inner bolt, whereas the outer clamps faces were tightly bolted together. To ensure maximum clamping efficiency a gap should be present between the clamp halves at both the inner and outer faces with both bolts correctly torqued.

Although other possibilities cannot be completely excluded, the available evidence supports a probability that the last-mentioned hypothesis represents the actual mode of entry of the fire into the landing gear bay area.

Thus the probable sequence of events may be summarised as follows:

- (1) An engine failure which involved rupture of the crankcase, the induction manifold and the oil gallery occurred as a result of a progressive loss of restraint of the Number 2 main bearing shell.
- (2) The engine failure allowed the release of a large quantity of flammable fluids into the engine compartment.
- (3) The flammable mixture, consisting mainly of engine oil, was ignited by contact with exhaust gases or with the hot exhaust pipes and resulted in an intense fire burning in and around the outboard first-stage augments.

- (4) Engine vibration subsequent to the failure and prior to the cessation of engine rotation resulted in the displacement of the forward end of the outboard augments from its firewall clamp and allowed the fire to enter the space adjacent to the landing gear bay side rib at Wing Station 88.
- (5) The fire penetrated the rib and entered the landing gear bay.
- (6) The resultant internal fire forward of the wing front spar destroyed the landing gear actuator support structure, allowing the landing gear to extend.
- (7) Additional fuel was added to the fire by the breaching of fuel lines and the burning away of the rear face of the oil tank.
- (8) The fire spread rearwards through the landing gear bay area, rapidly weakening the wing spars to the extent that wing failure occurred, this being preceded by a downward collapse of the engine support structure.

The final aspect to be considered is the reason for the loss of bearing restraint which initiated the above sequence of events. There are three design features which can contribute to the restraint of the main bearing shells. The primary means of restraint against the tendency of the bearing shells to rotate is by the clamping action or "nip" of the bearing housings on the shells when the two crankcase halves are bolted together. Additional restraint against rotation and also against any axial movement of the shells is provided by the small tangs on the outer faces of the shells, which engage in appropriate recesses in the crankcase housings, and by the dowels which are fitted in the housing and engage in slots in the bearing shells.

It is known that fretting of the mating crankcase surfaces at the Number 2 and 3 main bearing saddles can occur in service, and that the resulting loss of metal can change the size of the bearing saddles sufficiently to cause loose through-bolts or excessively tight crankshaft bearing fits. Avco Lycoming Service Instruction No. 1112C was introduced to deal with this problem by removal of fretted material and the installation of selectively fitted spacers to maintain the correct

housing diameter when the crankcase halves are bolted together.

The failed engine was found to have had this repair procedure incorporated, but it was not possible to determine when or where it was carried out. There was no relevant Log Book entry and the overhaul agency had no record of such work having been done.

There is evidence that, subsequent to the repair being incorporated, further fretting had occurred in the bearing saddle areas, but it is clear that such fretting played no part in the bearing failure process. In fact, fretting was apparent at main bearing positions 1, 3 and 4, but not at the failed Number 2 bearing location. This suggests that the Number 2 bearing saddle was less susceptible to fretting by virtue of having been more tightly clamped together than the others, and this in turn implies that there may have been significantly less "nip" on this particular main bearing shell. The existence of such a condition could explain why the Number 2 bearing sustained the type of failure observed, but it must be remembered that the engine had achieved a total of 716 hours operation since the last overhaul and it appears most unlikely that any gross error in assembly tolerances could have existed for such a long time before resulting in a failure. The crankcase failure was so extensive around the Number 2 bearing area that it was not possible to make any measurement of the housing diameter.

In considering the causal areas for this accident it seems clear that the sequence of events commenced when loss of restraint of the Number 2 bearing shell resulted in an extensive failure of the engine structure. Engine failures of this magnitude, however, have occurred previously on frequent occasions and the purpose of the firewall is to contain, within the engine compartment, any fire which may result from such occurrences. The availability of combustible fluids within the engine compartment is limited by design requirements and this factor provides a further restriction on the intensity and duration of any engine compartment fire. On this occasion, probably as a result of the displacement of the forward end of the outboard augments from its clamp, the firewall did not fulfil its intended function and the engine compartment fire entered an area where combustible fluids were readily available.

There is evidence from the contact marks on the clamp and on the lips at the forward end of the augments that clamping, adequate for any normal situation, had been achieved. However, the severity of the vibration, which would certainly have been

present in an engine failure of this nature, is not known, and may have exceeded the limits of a fitting of this design. Alternatively, the clamping action, while being adequate for normal situations, may have been less than adequate for abnormal situations by virtue of the uneven distribution of the gap on each side of the clamp halves. The reason for a loss of clamping effectiveness in the circumstances of this particular engine failure cannot be positively determined.

3- Conclusions

1. The pilot was properly licenced and experienced for the flight and there was no evidence of any pilot incapacitation which may have contributed to the accident.
2. There was a current certificate of airworthiness for the aircraft and, although it is probable that the starboard engine had developed an internal defect at the time the flight was commenced, there is no evidence to show that this should have been detectable in the normal maintenance procedures.
3. Shortly after take-off, while the aircraft was climbing to cruising height, the starboard engine sustained a massive internal failure which resulted in a large quantity of oil and fuel vapour being released into the engine compartment. At the same time, probably as a result of severe vibration, the forward end of the outboard main augments became displaced from the clamp which attaches it to the firewall cut-out.

4. The combustible fluids in the engine compartment became ignited, probably by contact with outboard exhaust system components, and the resulting fire was carried by the airflow through the outboard firewall cut-out. Due to the displacement of the main augments the fire burned through the side wall of the wheel bay and entered the rear nacelle area.

5. Intensified by a further supply of fuel which was made available by heat breaching of the oil tank and fuel lines, the fire impinged on and weakened both the main and rear spars and this led to separation of the starboard outer wing and the starboard power plant.

6. The time interval between the engine failure and the separation of the starboard wing and power plant was less than 2 minutes and 21 seconds.

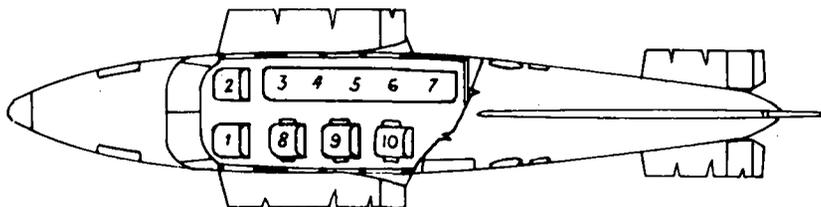
7. There is evidence that the pilot acted expeditiously to shut-down the starboard engine and that he activated the engine fire extinguishing system.

Cause The probable cause of the accident was that, following an engine failure which resulted in severe vibration and a fire in the outboard rear section of the engine compartment, the integrity of the firewall and its attached exhaust ducting was lost and structure at the rear of the engine nacelle was thereby exposed to fire.

Appendix A

LIST OF OCCUPANTS AND PROBABLE SEATING ARRANGEMENT

SEAT	OCCUPANT	APPROX. AGE	ADDRESS	INJURY
1	Nigel Clifford HALSEY	25	Alice Springs	Fatal
2	Douglas George FRIEDRICHS	39	Ayers Rock	Fatal
3	Gregory Brian CAIRNS	18	Alice Springs	Fatal
4	Michael Scott CAIRNS	1½	Alice Springs	Fatal
5	Laura Anne CAIRNS	17	Alice Springs	Fatal
6	Unoccupied			
7	Unoccupied			
8 or 9	Eleanor Short KNEIPP	51	U.S.A.	Fatal
8 or 9	Robert Frederich KNEIPP	60	U.S.A.	Fatal
10	Unoccupied			



Appendix B

TRANSCRIPT OF TAPE RECORDING
ALICE SPRINGS TOWER 20 JANUARY 1972

LEGEND

TWR Alice Springs Tower
FS Alice Springs Flight Service
FSI Flight Service position one

* This transmission was recorded on the tower tape through the flight service monitor facility

NOTE: Times of transmissions are Central Standard Time (G.M.T. + 9½ hours).
Times included in transmissions are minutes past the appropriate G.M.T. hour.

TIME	TO	FROM	
0733.06	TWR	CMI	Alice Tower good morning CMI for Ayers Rock, request taxi clearance.
.11	CMI	TWR	CMI good morning this is Alice Tower runway 12 wind light and variable, tending nor' easterly QNH1014 time 02½ line up.
.20	TWR	CMI	CMI
0735.06	TWR	CMI	CMI request airways clearance.
.08	CMI	TWR	CMI clearance track 235 cruise 6000.
.13	TWR	CMI	CMI 6000.
.21	TWR	CMI	CMI is ready.
.23	CMI	TWR	CMI, clear for take off, make right turn.
.26	TWR	CMI	CMI right turn.
0740.06	TWR	CMI	CMI departure 09.
.10	CMI	TWR	CMI area QNH 1014 call Alice Springs 122.1
.16	TWR	CMI	CMI
.18	TWR	FS	(answering intercom) FSI.
.20	FS	TWR	Departure CMI 09.
.22	TWR	FS	CMI
.25	FS	CMI	Alice Springs good morning CMI listening 122.1
.28	CMI	FS	Good morning CMI readability 5.
.31	FS	CMI	CMI
0741.40*			- BEEP - BEEP (on 122.1) with ¼ second engine noise.
0742.20	TWR	CMI	Alice Tower CMI, er we are returning to the field I have er, a asymmetric condition er a fire in the starboard engine. (Continued Beep Beep in the background.)
.31	CMI	TWR	CMI Roger right base runway 12 report on final (No acknowledgement is received to this transmission.) There is a click - phut (microphone noise?)
	TWR	FIRE	Yes we copied that mate
	FIRE	TWR	Roger can you turn out
0742.50	TWR	FIRE	How far out is he
0742.52	FIRE	TWR	You can see him there, see that smoke

