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Department of Transport

Bureau of Air Safety Investigation

INVESTIGATION REPORT
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Douglas DC3 VH-EDC

Botany Bay
New South Wales

24 April 1994

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Not for public release.

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GLOSSARY OF TERMS AND ABBREVIATIONS

AAC	Airworthiness Advisory Circular
AD	Airworthiness Directive
AEP	Aerodrome Emergency Plan
AGL	Above Ground Level
AIP	Aeronautical Information Publication
Altitude	Height above mean sea level in feet
ANZAC	Australian New Zealand Army Corps
AOC	Air Operators Certificate
ARDU	Aircraft Research and Development Unit
ARP	Aerodrome Reference Point
ATC	Air traffic controller
ATIS	Aeronautical Terminal Information Service
ATPL	Air Transport Pilot Licence
ATS	Air Traffic Services
AVR	Automatic Voice Recording
AWI	Airworthiness Inspector
BASI	Bureau of Air Safety Investigation
BOM	Bureau of Meteorology
CAA	Civil Aviation Authority
CAAP	Civil Aviation Advisory Publication
CAO	Civil Aviation Orders
CAR	Civil Aviation Regulation
CAVOK	CAVOK is given in lieu of the standard information on visibility, weather and cloud, when the following conditions are observed to occur simultaneously at the time of the observation: (a) visibility 10 km or more; (b) no cloud below 5,000 ft, or below the highest minimum sector altitude, whichever is the greater, and no cumulonimbus; and (c) no precipitation, thunderstorm, shallow fog, fog patches, fog at a distance, low drifting snow or dust devils.
CCC	Common Crash Call
CG	Centre of Gravity
COORD	Air Traffic Control Coordinator

CRM	Crew resource management
DAM	District Airworthiness Manager
DFOM	District Flight Operations Manager
DVR	Disaster Victim Registration
EFATO	Engine Failure After Takeoff
ELT	Emergency Locator Transmitter
EROPS	Extended Range Operations
EST	Eastern Standard Time.
FAC	Federal Airports Corporation
FIS	Flight Information Service
FOI	Flight Operations Inspector
Height	Vertical distance in feet above a fixed point
Hg	Mercury
hPa	Hectopascals
IAS	Indicated airspeed
ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules
kt(s)	Knot(s)
KIAS	Knots - indicated airspeed
LAME	Licensed Aircraft Maintenance Engineer
MAOC	Manual of Air Operator Certification
MCM	Maintenance Control Manual
ME	Multi Engine
MOU	Memorandum Of Understanding
MTOW	The maximum permissible take-off weight of an aircraft as specified in its Certificate of Airworthiness
NASS	National Airworthiness Surveillance System
NM	Nautical mile
Octa	Cloud amount expressed in eighths.
POB	Persons on board
QNH	An altimeter sub-scale setting to show height above sea level
PNG	Papua New Guinea
P&W	Pratt and Whitney
RAAF	Royal Australian Air Force
RFFS	Rescue Fire-fighting Service
RPM	Revolutions Per Minute

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RPT	Regular Public Transport
SPA MSB	Sydney Port Authority Maritime Services Board
SAR	Search and Rescue
SOAP	Spectrographic Oil Analysis Program
SR&S	Safety Regulation and Standards
TAA	Trans Australia Airlines
TBO	Time Between Overhauls
TSO	Time Since Overhaul
TWR	ATC responsible for aerodrome control
V_1	Decision speed. The critical engine failure speed, at which the pilot may either reject, or continue the takeoff.
V_2	Takeoff safety speed. (At weights up to and including MTOW, both the V_1 and V_2 for VH-EDC equal 81 kts IAS.)

Note 1 — 'Ground effect' refers to the decrease in induced drag and increase in lift resulting from the alteration of the wing airflow downwash characteristics when the aircraft is operated close to the ground.

Note 2 — 'CAA Bankstown' and 'CAA Moorabbin' refer to the CAA District Offices located at Bankstown and Moorabbin Airports.

Note 3 — All bearings are in degrees magnetic unless otherwise indicated.

Note 4 — All times are Australian Eastern Standard Time (Co-ordinated Universal Time + 10 hours) unless otherwise stated.

SYNOPSIS

On Sunday 24 April 1994, at about 0910 EST, Douglas DC3 aircraft VH-EDC took off from runway 16 at Sydney (Kingsford-Smith) Airport. The crew reported an engine malfunction during the initial climb and subsequently ditched the aircraft into Botany Bay. The DC3 was on a charter flight to convey a group of college students and their band equipment from Sydney to Norfolk Island and return as part of ANZAC Day celebrations on the island. All 25 occupants, including the four crew, successfully evacuated the aircraft before it sank.

The investigation found that the circumstances of the accident were consistent with the left engine having suffered a substantial power loss when an inlet valve stuck in the open position. The inability of the handling pilot to obtain optimum asymmetric performance from the aircraft was the culminating factor in a combination of local and organisational factors that led to this accident. Contributing factors included the overweight condition of the aircraft, an engine overhaul or maintenance error, non-adherence to operating procedures and lack of skill of the handling pilot.

Organisational factors relating to the company included:
- inadequate communications between the operator and the AOC holder;
- inadequate maintenance management;
- poor operational procedures; and
- inadequate training.

Organisational factors relating to the regulator included:
- inadequate communications between CAA offices, and between the CAA and the AOC holder/operator;
- poor operational and airworthiness control procedures;
- inadequate control and monitoring of the operator;
- inadequate regulation; and
- poor training of staff.

During the investigation, a number of interim safety recommendations were issued by the Bureau. These recommendations, and the CAA's responses to them, are included in this report.

CONTENTS

INTRODUCTION

The main purpose for investigating air safety occurrences is to prevent aircraft accidents by establishing what, how and why the occurrence took place, and determining what the occurrence reveals about the safety health of the aviation system. Such information is used to make recommendations aimed at reducing or eliminating the probability of a repetition of the same type of occurrence, and where appropriate, to increase the safety of the overall system.

To produce effective recommendations, the information collected and the conclusions reached must be analysed in a way that reveals the relationships between the individuals involved in the occurrence, and the design and characteristics of the systems within which those individuals operate.

This investigation was conducted with reference to the general principles of the analytical model developed by James Reason of the University of Manchester (see Reason, *Human Error* (1990)).

According to Reason, common elements in any occurrence are:

- *organisational failures* arising from managerial policies and actions within one or more organisations (these may lie dormant for a considerable time);
- *local factors*, including such things as environmental conditions, equipment deficiencies and inadequate procedures;
- *active failures* such as errors or violations having a direct adverse effect (generally associated with operational personnel); and
- *inadequate* or *absent defences* and consequent failures to identify and protect against technical and human failures arising from the three previous elements.

Experience has shown that occurrences are rarely the result of a simple error or violation but are more likely to be due to a combination of a number of factors, any one of which by itself was insufficient to cause a breakdown of the safety system. Such factors often lie hidden within the system for a considerable time before the occurrence and can be described as *latent failures*. However, when combined with local events and human failures, the resulting sequence of factors may be sufficient to result in a safety hazard. Should the safety defences be inadequate, a safety occurrence is inevitable.

An insight into the safety health of an organisation can be gained by an examination of its safety history and of the environment within which it operates. A series of apparently unrelated safety events may be regarded as *tokens* of an underlying systemic failure of the overall safety system.

1. FACTUAL INFORMATION

1.1 History of the flight

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The aircraft had been chartered to convey college students and their band equipment from Sydney to Norfolk Island to participate in ANZAC Day celebrations on the island. A flight plan, submitted by the pilot in command, indicated that the aircraft was to proceed from Sydney (Kingsford-Smith) Airport to Norfolk Island, with an intermediate landing at Lord Howe Island to refuel. The flight was to be conducted in accordance with IFR procedures, with a departure time from Sydney of 0900. The aircraft, which was carrying 21 passengers, was crewed by two pilots, a supernumerary pilot and a flight attendant.

Preparations for departure were completed shortly before 0900, and the aircraft was cleared to taxi for runway 16 via taxiway Bravo Three. The pilot in command occupied the left control position. The co-pilot was the handling pilot for the departure. The aircraft was cleared for takeoff at 0907:53. The crew reported that all engine indications were normal during the take-off roll and that the aircraft was flown off the runway at 81 kts. During the initial climb, at approximately 200 ft, and with the landing gear retracting, the crew heard a series of popping sounds above the engine noise. Almost immediately, the aircraft began to yaw left and at 0909:04 the pilot in command advised the TWR that the aircraft had a problem.

The co-pilot identified that the left engine was running erratically. The crew subsequently recalled that the aircraft speed at this time had increased to at least 100 kts. The pilot in command, having verified that the left engine was malfunctioning, closed the left throttle and initiated propeller feathering action. During this period, full power (48 in Hg and 2,700 RPM) was maintained on the right engine. However, the airspeed began to decay. The handling pilot reported that he had attempted to maintain 81 KIAS but was unable to do so. The aircraft diverged to the left of the runway centreline.

The co-pilot and the supernumerary pilot reported that almost full right aileron was used to control the aircraft. They could not recall the skidball indication or how much rudder was being used.

When he first became aware of the engine malfunction, the pilot in command assessed that, although a landing back on the runway may have been possible, the aircraft was capable of climbing safely on one engine. However, when he saw that the aircraft was not climbing, and that the airspeed had reduced below 81 kts, the pilot in command took control, and at 0909:38 advised the TWR that he was ditching the aircraft. He manoeuvred the aircraft as close as possible to the southern end of the partially constructed runway 16L.

The aircraft was ditched approximately 46 seconds after the pilot in command first advised the TWR of the problem.

Figure 1.

Locality map showing the accident site in relation to Sydney Airport.

The four crew and 21 passengers successfully evacuated the aircraft before it sank. They were taken on board pleasure craft and transferred to shore. After initial assessment, the survivors were transported to various hospitals. All were discharged by 1430 that afternoon, with the exception of the flight attendant, who had suffered serious injuries.

Immediately following the pilot in command's call that the aircraft was ditching, the COORD in Sydney TWR raised the crash alarm. He then activated the AEP 'Crash in the Vicinity of Sydney Airport (including Botany Bay)' checklist. The COORD notified the RFFS fire control centre at 0909:55. At 0910:00 he activated the CCC and contacted the Police, Ambulance, FAC and NSW Fire Brigade.

Remove & place on P 12

A ground witness, located on taxiway C parallel to runway 16, south of runway 07/25, observed the aircraft take off, and reported hearing the sound of engine misfiring as the aircraft lifted off. He estimated that the aircraft climbed to approximately 200 ft before it began to veer left and descend. The witness commented that the aircraft's attitude remained significantly nose-high until the commencement of descent to the ditching.

1.2 Injuries to persons

	Crew	Passengers	Other	Total
Fatal	-	-	-	-
Serious	1	-	-	1
Minor	2	-	-	2
None	1	21	-	22

1.3 Damage to aircraft

During the ditching the aircraft sustained substantial damage from impact forces. Additional damage occurred during the subsequent recovery operations, and as a consequence of salt-water immersion.

1.4 Other damage

No other damage was reported.

1.5 Personnel

Technical crew

	Pilot in command	Co-pilot	Supernumerary pilot
Licence category	ATPL (1st class)	Commercial	ATPL (1st class)
Medical certificate	Class 1	Class 1	Class 1
Instrument rating	M.E. command	M.E. command	M.E. command
Total hours	9,186	500	2,741
Total on type	927	250	22
Total last 90 days	30.1	25	70
Total on type last 30 days	1.2	5	1
Total last 24 hours	0	0	2
Last flight check	22 June1993.	9 Jan. 1994	26 Jan. 94
Aircraft endorsement	DC3 command	DC3 command	DC3 co-pilot

Cabin crew

Proficiency status	Received initial training on 25 Sept. 1993
Experience	Approximately ten flights
Last proficiency test	25 Sept. 1993
Last check	Ground check (23 Apr. 1994)

Previous 72 hours history

Pilot in command. During the two days prior to the accident, the pilot in command planned the flight and refamiliarised the flight attendant with emergency duties on over water flights. He reported that he had a normal sleep period prior to commencing duty on the day of the accident.

Co-pilot. The co-pilot advised that he was unable to remember his activities during the 72 hours prior to the accident.

Supernumerary pilot. The supernumerary pilot reported that his sleep pattern had been normal for the 72 hours prior to the accident.

Cabin crew. The flight attendant advised that her sleep pattern had been normal for the 72 hours prior to the accident.

Recent operational experience

Pilot in command. The pilot in command had flown a total of 2.9 hours (including 1.2 hours on DC3 type) in the previous 30 days and a total of 30.1 hours (26.8 hours on DC3 type) in the previous 90 days. He had completed his initial endorsement on the DC3 type in 1979 and had recommenced flying the type in November 1992.

No evidence was found to indicate that he had any recent experience with asymmetric operations in DC3 aircraft at high gross weights, nor was this a requirement.

In January 1993, the pilot in command had been approved by the CAA to act as the operator's DC3 flight captain, and had been granted check-and-training approval for the DC3 in May 1993. His most recent formal check flight was carried out by a CAA FOI in June 1993.

Co-pilot. The co-pilot, who was also the aircraft owner, had flown 5 hours total in the last 30 days and a total of 25 hours in the last 90 days, all on DC3 aircraft. He had been granted a commercial pilot's certificate in the USA on 16 January 1992. On 13 August 1992, he was issued an Australian CAA certificate of validation for the purpose of acting as flight crew of an Australian registered aircraft at 'unrestricted pilot standard' for day VFR operations. This was valid until 13 November 1992. The co-pilot had advised the CAA that he had completed DC3 command endorsement training in the USA on 5 April 1992, and on the basis of this advice, his certificate of validation was annotated with a DC3 type rating. He was issued with an Australian commercial pilot licence on 20 September 1993. The co-pilot's most recent formal check was for the renewal of his command instrument rating on 9 January 1994.

Supernumerary pilot. The supernumerary pilot had flown a total of 25 hours (including one hour on DC3 type aircraft) in the previous 30 days and 70 hours (including 10 hours DC3) in the previous 90 days. He was normally employed as a flying instructor and had completed a DC3 co-pilot endorsement in January 1994. He was employed by the operator in a part-time capacity and was on this flight to gain further DC3 experience.

Cabin crew. The flight attendant held a certificate of competency issued in September 1993 by the operator, and had undergone refresher training on the day prior to the accident.

1.6 Aircraft information

1.6.1 Significant particulars

First registered	17 November 1949 VH-JVF
Registration	VH-EDC (formerly VH-JVF and VH-CAR)
Manufacturer	Douglas Aircraft Company
Model	DC-3C-S1C3G (formerly C47A)
Common name	DC3
Manufacturer serial number	12874
Country of manufacture	USA
Year of manufacture	1944

Engines	2 Pratt & Whitney R1830-92
Engine type	Radial/piston
TTIS	40,195:05 hours
Certificate of registration	
Number	1680
Issued	30 July 1992
Certificate of airworthiness	
Number	1680
Issued	3 October 1980
Category	Transport
Maintenance release	
Number	202756
Issued	6 March 1994 at 40,191:15 hours
Valid to	40,291:15 hours

Additional engine and propeller data

- Left engine: Pratt & Whitney R1830-92, Serial Number CP329666. Time since overhaul: 1,027:56 hours.
- Right engine: Pratt & Whitney R1830-92, Serial Number BP463388. Time since overhaul: 1,085:53 hours.
- Left propeller: Hamilton Standard 3 blade, Model 23E50473, Serial Number 1G1B14. Time since overhaul: 550:25 hours.
- Right propeller: Hamilton Standard 3 blade, Model 23E50473, Serial Number FA 5612. Time since overhaul: 830:48 hours.

At the time of the accident, both engines were operating on CAA-approved concessions to overrun the published TBO of 1,000 hours.

1.6.2 Weight and balance

On the day prior to the accident, the pilot in command completed a weight and balance calculation based on anticipated weights. These calculations were as follows:

Weight as calculated by the pilot in command

	Weight (kg)
Aircraft operating weight	**8,569**
Supernumerary pilot	77
Adjusted operating weight	**8,646**
Catering (70 kg included in operating weight. Because 30 kg required, reduce operating weight by 40 kg)	-40
Remove 2 seats (11 kg each)	-22
Adjusted operating weight	**8,584**
16 male adolescents (63 kg each)	1,008
4 male adults (84 kg each)	336
1 female adult (69 kg)	69
Total passenger weight	**1,413**
Life rafts	70
Forward locker (baggage)	350
Fuel (430 gal (imp))	1,363
Ramp (taxi) weight	**11,780**
Subtract taxi/runup fuel (23 kg)	-23
Take-off weight	**11,757**
MTOW	**11,884**

Weight as calculated during the investigation

A weight-and-balance summary was compiled from known and estimated data gathered during the investigation. Using the operational weight for the 24-seat configuration adjusted by 22 kg for the removal of two seats, the weight calculation was completed as follows:

Adjusted operating weight	**8,584**
Passenger weight (as reported by the passengers)	1,634
Baggage (actual)	483
Life rafts (actual)	92
Toolbox, oil drums & spare parts (actual)	230
Fuel (456 gal (imp)—168 + 168 + 120 (estimated))	1,446
Taxi weight	**12,469**
Subtract taxi/ runup fuel	23
Take-off weight	**12,446**
MTOW	**11,884**

The aircraft weight at takeoff was therefore 562 kg or 4.7% above the MTOW.

1.6.3 DC3 asymmetric performance—general

From October 1947 to December 1948, the RAAF carried out asymmetric handling and performance flight tests of Dakota C47B aircraft. The test schedule was performed by ARDU, with the intention of producing a report for the information of airline operators and the Department of Civil Aviation. At a weight of 11,884 kg (26,200 lb), the tests showed that with the left engine failed at 86 kts, the landing gear down, and the left propeller windmilling, a climb of 63 ft/min could be obtained. The rate of climb reduced to zero if the speed was increased to 94 kts or reduced to 78 kts.

In 1953, further tests were carried out by ARDU to investigate the possibility of raising the maximum all-up weight of the Dakota aircraft from 11,884 kg to above 12,700 kg. Comprehensive measurements of the rate of climb with one engine inoperative and the propeller windmilling were made for the weights listed below:

Weight (kg (lb))	Rate of climb (ft/min)
11,794 (26,000)	100
12,700 (28,000)	0
13,608 (30,000)	-90

One takeoff was made at 12,928 kg (28,500 lb) with a simulated left engine failure at 88 kts. The aircraft was able to maintain height only while flown in ground effect.

In 1954, TAA investigated the approved take-off speeds for the DC3. A series of takeoffs with simulated engine failure at the take-off safety speed of 75.5 KIAS showed that at a weight of 11,884 kg (26,200 lb) the aircraft would not climb at this speed. It was then decided to determine the speed at which the asymmetric performance was satisfactory at 11,884 kg for passenger aircraft, and 12,202 kg (26,900 lb) for freight aircraft. The tests showed that the best climbing speed with the landing gear down, one propeller windmilling and take-off power on the other engine, was between 80 kts and 85 kts. With the landing gear retracted, one propeller windmilling and take-off power on the other engine, the best climb speed was 90 kts.

On 14 May 1955, the following information concerning asymmetric take-off tests was printed in a TAA Supplement to Aircrew Bulletin:

> Satisfactory asymmetric take-offs were performed at 26200 pounds with the engine failing at 81 knots, and at 27000 pounds with the engine failing at 86 knots. Previous tests had shown that at 26900 pounds with the engine failing at 80 knots the aircraft lost airspeed as the climb was started and fell back onto the runway. It is felt that the extra 5 knots is required at this weight to allow for the drop in airspeed when the aircraft attitude is changed on beginning the climb. It was suggested that the takeoff safety speed be 81 knots for weights of 26200 and below, increasing linearly to 86 knots at 26900 pounds.

The TAA report stated that the success of an asymmetric takeoff was greatly dependent on the flying technique adopted after the engine failure. Sudden changes of attitude were accompanied by loss of airspeed and a consequent inability to climb away. It was recommended that on the failure of an engine at the critical engine failure speed, the aircraft should be held at this speed while the undercarriage was being retracted, and the speed then increased to 90 kts while the propeller was being feathered.

1.6.4 VH-EDC performance and handling

Examination of the data obtained from the performance testing of the DC3 demonstrated that only minimal climb performance is available after engine failure at V_1/V_2 (81 kts) during takeoff at the MTOW of 11,884 kg or 26,200 lb. At higher weights, the aircraft will not achieve any climb performance unless the take-off safety speed is increased linearly with the increase in aircraft weight. At weights above 12,202 kg or 26,900 lb it is unlikely that the aircraft will achieve any climb performance unless all parameters are within their optimum ranges.

The crew flew VH-EDC off at 81 kts and subsequently reported that the aircraft accelerated to at least 100 kts before they shut down the left engine. Despite engine instrument indications that full power was being obtained from the right engine, the crew were unable to prevent the speed reducing below the takeoff safety speed of 81 kts.

The following is an extract from the operator's operations manual for VH-EDC:

CRITICAL ENGINE AND MINIMUM SPEEDS AT MAXIMUM AUW

The PORT engine is the critical engine. Minimum speeds vary from an absolute minimum of 68 knots IAS with the port engine feathered and power settings of 42 inches manifold pressure and 2250 on the starboard engine to 76 knots IAS with the port airscrew windmilling in full fine pitch and full power of 48 inches manifold pressure and 2700 RPM on the starboard engine. The limiting factor V_{MCA} of 180 pounds foot pressure is reached at approximately 73 knots. It is preferable to keep straight by use of rudder alone, rather than using the aileron. The foot load is within the capabilities of all pilots, but there is a danger of the foot slipping up on the brake pedal unless the rudder pedals are adjusted before takeoff so that full rudder can be applied with the heel. For long legged pilots, this makes for a rather uncomfortable seat position, with the control column fouling the knees.

The DC3 aircraft at all-up weight has a marginal performance at V_2 speed (81 knots) on one engine, and this requires concentration on the part of the pilot to see that the best performance is obtained. It is of vital importance that the climb performance of the DC3 in the asymmetric condition is fully understood.

1.6.5 Single engine performance VH-EDC

Factors which may have affected the single engine performance of the aircraft were:

- configuration;
- temperature;
- weight and CG position;
- atmospheric turbulence;
- ground effect; and
- pilot technique.

Configuration

The engine malfunction occurred when VH-EDC was in the take-off configuration, with the landing gear extended, the wing flaps retracted, and full power on both engines. The pilots expressed differing views on exactly when, after the takeoff, the malfunction occurred. With the progress of the emergency, the configuration changed as the landing gear was retracted, and the left propeller moved toward the feathered position. Although the aerodynamic drag acting on the aircraft was substantially reduced by these actions, additional significant drag was induced when the co-pilot, having applied right rudder control, also applied substantial right wing down aileron control, in response to the aircraft continuing to yaw to the left.

The pilot in command indicated that the malfunction occurred after the landing gear was selected up, and at a height of approximately 200 ft with the airspeed in excess of 100 kts and probably close to the normal climb speed of 113 kts. He also indicated that despite an initial airspeed in excess of 100 KIAS and power indications on the right engine of 48 in Hg and 2,700 RPM, the aircraft would not climb or maintain altitude.

The co-pilot stated that he thought the aircraft may have been at 200 ft with the landing gear retracting when the failure occurred, and could remember maintaining 81 kts after the malfunction. He was not clear as to the speed at which the malfunction occurred. The supernumerary pilot said he was not paying close attention to the instruments. However, he

Was the ground witness a person experienced in, or whom you would expect to experienced in estimating vertical distance - as this is actually a very difficult estimation activity for the uninitiated. Also, ? the need for this further verification?

did hear the sound of the engine malfunction, and was aware that the aileron control was held at about 90° from the neutral position.

The landing gear was observed by witnesses located under the flight path to be retracted prior to the aircraft being ditched.

A ground witness indicated that the engine malfunction was evident from early in the takeoff, and the aircraft had accelerated and climbed to approximately 200 ft before it began to veer to the left and descend.

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why is this included in config section?

Temperature

The temperature recorded on the ATIS at the time of the accident was 16°C.

Weight and centre of gravity

The pilot in command had completed a weight and balance document (trim sheet) on 24 April 1994. The trim sheet showed the take-off weight as 11,757 kg with the CG position within the CG envelope.

The actual take-off weight calculated during the investigation was 12,446 kg, which was 562 kg in excess of the MTOW.

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Atmospheric turbulence

At the time of the accident, the wind was light and variable, with no reports of turbulence.

Ground effect

The company operations manual recognised the benefit that may be obtained by utilising ground effect during a single engine takeoff. The manual indicates that, in the most critical take-off condition with the left engine failed, at 81 kts, the propeller windmilling in fine pitch, and with the landing gear down, the aircraft will accelerate to a speed of 95 KIAS if held close to the ground.

Pilot technique

The operator's operations manual for VH-EDC comprehensively described the procedures and techniques to be adopted in the event of an engine failure after V_1/V_2. However, it contained conflicting information about the actions of individual technical crew members in the event of an emergency during the take-off phase.

Section B1.6 (page 10) of the manual indicated that when the co-pilot is the handling pilot for the takeoff, the pilot in command should follow through on the controls and take over immediately a malfunction occurs. However, section B1.3 (page 8) indicated that the pilot flying should continue to fly the aircraft in the event of an emergency, and the non-flying pilot should provide assistance to the pilot flying. The pilot in command advised that he used the latter procedure because he believed the co-pilot held a command endorsement on the DC3 and was capable of flying the aircraft correctly in any emergency situation.

The operations manual contained instructions describing the actions that needed to be taken by the crew to ensure that optimum single engine performance at MTOW was achieved. These included accurate airspeed control (minimum 81 kts), directional control using rudder alone, full power on the remaining engine, landing gear and flaps retracted and, if necessary, the use of ground effect. Once the propeller had feathered, the speed was to be increased to 91 kts. Operations at weights above MTOW were not permitted and therefore were not addressed in the operations manual.

The take-off emergency response briefing was conducted by the co-pilot and was general in nature. It included the take-off safety speed of 81 kts, and a return for a landing in the event of an engine failure.

1.7 Meteorological information

The current ATIS information was: wind light and variable; QNH 1026; temperature 16°C; CAVOK.

The BOM assessed the conditions in the vicinity of the crash site as:

surface wind calm; visibility greater than 10 km; weather hazy; sky clear; QNH 1026; temperature 18°C; dew point 14°C; and relative humidity 77%.

1.8 Aids to navigation

Not relevant.

1.9 Communications

Communications on Sydney ground and aerodrome control frequencies were normal until the time at which the crew first advised Sydney TWR of the problem. Following this, the aircraft's microphone became stuck intermittently in the 'transmit' position.

1.10 Aerodrome information

Sydney (Kingsford-Smith) Airport is located on the shore of Botany Bay. Runway 16, the runway in use at the time of the accident, extends approximately 1,800 m into the bay. The parallel runway is to the left of runway 16, and extends approximately 2,500 m into Botany Bay. At the time of the accident, this runway was still under construction. The distance from taxiway Bravo Three to the end of runway 16 is 3,330 m.

1.11 Recorded information

The aircraft was not equipped with a flight data recorder or cockpit voice recorder, nor were these required by regulation.

Recorded radar data were analysed. Due to the proximity of the aircraft to the radar head, the flight path and airspeed information was considered to be of insufficient accuracy. However, the performance trend was evident. Altitude information was not available due to garbled transponder mode-C responses from the aircraft.

Analysis of the AVR data provided additional information regarding the timing of the sequence of events.

1.12 Wreckage and impact information.

1.12.1 Accident site description

The aircraft sank adjacent to the end of runway 16L, 100 m from the sea wall and in approximately 16 m of water. The geographical co-ordinates of the accident site were 33° 58' 33.94 S, 151° 11' 33.89 E.

1.12.2 Aircraft recovery

The aircraft was floated to the surface using inflatable air bags, and then transferred to an aircraft hangar for examination. It was intact, except for the right engine and propeller assembly, which was recovered later.

12.3 Technical examination of the wreckage

1.12.3.1 Structure

The aircraft damage was consistent with collision with the water during the ditching and the effects of the subsequent recovery operation.

1.12.3.2 Flight controls

No evidence was found of any pre-existing defect or malfunction of any part of the flight control system. It was determined that the wing flaps were extended approximately 20–22°.

1.12.3.3 Powerplants

Left engine

During dismantling of the left engine the following abnormalities were noted:

1. On removal of the no. 3 cylinder inlet valve pushrod cover, pushrod and tube, excessive wear of the pushrod and of the cylinder where the pushrod enters the valve rocker housing was apparent. Further inspection revealed that one of the thrust washers which are fitted

either side of the rocker arm on the rocker shaft, was not fitted to the shaft. The thrust washer subsequently fell out of the valve rocker housing. The loose washer was oval in shape, having sustained impact damage during engine operation. At the last time of fitting, the shaft was installed but failed to engage the washer which subsequently was left within the rocker housing. The housing, through which the cover tube is located and through which the pushrod operates, was damaged at the point coincident with the damage on the pushrod.

(A review of the CAA major defect reporting system for P&W 1830 series engines, and the BASI accident and incident summary reports for DC3 aircraft, did not identify any previous reports relating to the misassembly of cylinders, valves, rockers, shafts or thrust washers.)

The cylinder, complete with inlet and exhaust valve assemblies, inlet valve pushrod and cover and the damaged washer, was examined. The aim was to determine when and how the washer was damaged, and the likelihood of this loose component jamming the inlet valve in the open position. The rocker arm end of the pushrod contained heavy rub marks which penetrated the pushrod to about 25% of the wall thickness. The curved edges of these wear marks matched the deformed washer. There was also a curved depression within the rocker housing, adjacent to the inlet pushrod tube, which matched the shape of the deformed washer. Plastic deformation of the cylinder head material into this depression indicated the nature of the compressive loads applied to the pushrod. The amount of material rolled inside the depression mark suggested that the washer had been in this position for a considerable period. With the washer located in the depression, it could become jammed between the cylinder head and the pushrod, thus preventing the inlet valve from closing. The amount of valve lift provided by the jammed pushrod was approximately 4 mm.

Figure 2.

The deformed thrust washer and the deep rub marks on the push rod.

Figure 3.

A) The mark on the edge of the cylinder head rocker assembly housing. Its shape matched the shape of the thrust washer.

B) The thrust washer with one side forced against the rocker assembly housing, while the opposite side is jammed between the rocker arm and the push rod upper end. To facilitate this demonstration, an adhesive was used to hold the washer in position.

The firing of the spark plugs on the cylinder while the inlet valve was jammed open would cause the fuel-air mixture in the common induction system to ignite. In addition to the loss of power from the no. 3 cylinder, the resultant disruption of the fuel-air mixture to the remaining cylinders would cause irregular engine operation and a reduction in power. The engine manufacturer has advised that a power loss of up to 50% could result, accompanied by backfiring through the intake manifold and carburettor. Fire residues and soot deposits were found in the no. 3 cylinder intake cavity and the adjacent intake manifold. Examination of the air intake assembly revealed deposits of black soot within the carburettor air intake and on the debris screen, indicative of backfiring, and possible intake fire.

2. The left magneto was found to have been secured at the fully anticlockwise timing adjustment position. Subsequent removal of the magneto revealed that the splines of the accessories driving gear were worn well beyond service limits and that failure of positive drive to the magneto was imminent. Detailed examination revealed that the driving gear material did not meet the required hardness standard. The left magneto had a different serial number to that recorded in the engine logbook as having been fitted when the engine was last overhauled in 1987. Since the overhaul, 1,025 hours of engine operation had been recorded. However, because there were no certifications as to when the magneto was changed, it could not be determined when the driving gear splines were last inspected. The crew reported that pre-flight magneto RPM drop checks were satisfactorily completed.

3. The propeller governor pitch control cable 90° pulley block securing bolt was excessively worn. There was a certification on the periodic inspection worksheets at the time of issue of the current maintenance release on 25 February 1994, some 6–8 operating hours prior to the accident, that the assembly had been renewed.

Figure 4.

The worn pulley block securing bolt.

4. During removal of the no. 12 cylinder, two of the 16 cylinder base studs were found to be sheared and missing. Light loosening pressure applied to the nut of a stud adjacent to these two, resulted in that stud breaking also. Removal of the cylinder revealed an area of galling/fretting in the vicinity of the broken studs, indicating cylinder movement on its mounting pad. Examination revealed that the recovered broken stud had failed in fatigue, initiating from multiple origins around the stud circumference. It is a maintenance requirement for the cylinder base attachment studs to be inspected at each periodic inspection. Records of the periodic inspection conducted 6–8 operating hours before the accident contained no reference to the failures despite there being a blackened area adjacent to the broken studs.

5. On removal of the spark plugs from the engines it was found that the electrode 'gap' settings were inconsistent between plugs, and that the majority of plugs showed evidence of electrode wear beyond normal life. After cleaning and re-gapping, the spark plugs were examined and tested. On test some plugs were found to be electrically breaking down. The condition of the spark plugs was not considered consistent with certification for maintenance release issue some 6–8 operating hours prior to the accident.

Right engine

This engine was subjected to strip examination, and with the exception of the propeller governor, no pre-existing abnormalities were found.

Right engine propeller governor

When initially fitted to the test rig, the governor failed the test specifications. However, when correctly adjusted, the unit met the manufacturer's specifications. Examination found that the hexagonal mounting hole in the alloy pulley, which mates to the hexagonal rack shaft in the governor, was excessively worn. Additionally, the locked castellated nut securing the pulley to the shaft was found to be loose. It is likely that the excessive wear had permitted the pulley to rotate into the out-of-rigging position when the operating cables were subjected to substantial loads as the engine separated at impact.

1.12.3.4 Propellers

Left propeller

Inspection confirmed that the left propeller was at 65–66° of pitch instead of the 88° pitch of the fully feathered position. There were no visual indications of abnormal wear on any part of the pitch change mechanism, or of other anomalies that would inhibit the normal functioning of the propeller system. Further propeller examination was conducted to establish the reason for the propeller not being in the fully feathered position. This examination revealed the following:

DRAFT

1. Torque to turn individual blades within the hub was found to be approximately 55, 40 and 25 ft lb respectively. This compared with the manufacturer's specified torque value of 30–40 ft lb.

2. Each blade butt had been fitted with a plastic sleeve during hub assembly to prevent water ingress. The sleeve of the blade which required 55 ft lb to turn, was dislodged from its position. ~~It is~~ likely that, at some time prior to the accident, the sleeve became dislodged, permitting water penetration and consequent corrosion. The higher torque required to turn this blade was probably due to the presence of corrosion by-products and corrosion-related pitting at the bearing area. However, it is unlikely that the higher torque required would have prevented the propeller from moving to the fully feathered position.

An engineering investigation concluded ~~that~~ it was ... || X

HA This conclusion seems unsupported particularly to deal with why it didn't happen as a result of this accident. ✓

3. Once removed from the dome, the cam assembly with the piston attached remained in the 'as found' position and did not respond to a force applied to move it towards the fine or feathered pitch positions. (Correctly assembled cams with the piston attached move freely throughout the range when being propelled by their own weight and without any outside forces being applied.)

4. Disassembly of the cam/roller mechanism revealed that both the internal and the external cams contained heavily polished roller contact marks and grooving wear over a distance equivalent to that of the propeller mechanism moving in the operating range. There were lightly polished areas on the cams indicating that the rollers had at some time been operating through to the fully feathered position. All four roller assemblies rotated freely and contained no flat spots.

5. Despite the cam profile in-service wear, when the cam assembly pre-load nut was released by about 40°, the mechanism achieved unrestricted movement of both cams throughout their range, driven by their own weight, and without any application of an external force.

6. There was no damage or abnormal wear to any of the blades or blade operating mechanism within the hub which would have prevented the blades from reaching the fully feathered position had the cam assembly pre-load nut been correctly tightened.

7. Subsequent testing of the feathering pump and propeller governor/pressure switch assembly revealed no operational abnormalities.

Nominate actual AD

do we normally not identify these any more precisely

Yes!

8. There were no certifications to indicate that the left propeller had been 'desludged'. An airworthiness directive requires that this should be accomplished at each 500 hours time in service.

is this a well known technical requirement?

Yes!

The co-pilot advised that he considered that the engine was slow to stop rotating after feathering action was initiated.

Consideration was given to reports that the blades on this propeller had moved from the fully feathered position during aircraft recovery operations. However, the specialist examination concluded that the propeller had not been able to operate to the full feather position for some period of time preceding the accident.

Right propeller

On recovery, the right propeller was still attached to the engine. The three blades were bent symmetrically rearwards at the mid position. Examination found the blades in the fine pitch operating range, consistent with the power setting at the time of the ditching. No pre-existing defects or malfunctions likely to affect normal operation of the propeller were found.

1.12.3.5 Landing gear and hydraulic system

Examination of impact damage to the main landing gear indicated that it was in the retracted position at water impact.

The hydraulic system was found to be capable of normal operation. The cockpit hydraulic selector was found in the rear position (normal for takeoff) and the landing gear selector and lever lock were selected to the landing gear retract position.

1.12.3.6 Fuel system

A number of fuel samples were taken from various parts of the aircraft's fuel system and from the source from which the aircraft was refuelled. Analysis of those samples confirmed that the fuel met the required specifications.

Examination of the engine fuel system did not detect any pre-existing defect which would have prevented normal operation. The airframe fuel system was also found to be capable of normal operation. However, anomalies were found with some fuel tank drain valves which suggest that it may not have been possible during the pre-flight check to ensure that the fuel was not contaminated.

On this aircraft, two drain valves, of either the 'push to drain' or 'screw

65

to drain' type, were fitted to each main and each auxiliary fuel tank. The drain valve fitted to the outboard position of the right auxiliary tank was rendered virtually inaccessible due to misalignment of the valve with the wing skin cutout. Of the two screw type valves in the left main tank, the swaged turning handle of the inboard valve rotated freely about the shaft. The left main tank outboard valve had been tightened, such that extreme force was required to open the valve.

There was no damage evident, proximate to the valves, to suggest that they became unserviceable as a result of impact forces or by damage sustained during recovery.

1.12.3.7 Instruments

The aircraft instruments had been subjected to salt water corrosion and could not undergo calibration testing. There were no reported pre-existing instrument defects.

1.12.3.8 Aircraft records

Aircraft category

The certificate of airworthiness for the aircraft was issued in the transport category, a condition of which was that the aircraft be maintained to the class-A requirements. Advice confirming that the aircraft was in the transport category was passed to the operator by the CAA Bankstown Office on 5 February 1993. However, the aircraft continued to be maintained as a class-B aircraft. The class-A system of maintenance is more structured and accountable for quality assurance of continuing airworthiness than is the class-B system.

CAO Section 100.2.3 - Categories, Note 1 states, in part:

> A Certificate of Airworthiness for an aeroplane, which is not commuter category, of maximum takeoff weight greater than 5700 kg, will normally be issued only in the transport category.

The investigation found that, within the CAA, there was documentation which gave conflicting information as to whether this and other DC3 aircraft were classified as transport or normal-category aircraft, and therefore subject to class-A or class-B maintenance respectively. This resulted in some confusion among those administering the system.

Use of the CAA aircraft register computer as the sole data reference for the production of certificates of airworthiness had not been authorised by the CAA management because the data had not been audited. However, CAA Moorabbin, when assessing this aircraft and operator for inclusion on an existing AOC, used the computer system as the sole source of data to produce a copy of the certificate of airworthiness. The aircraft history file was with CAA Bankstown when the replacement certificate was prepared. Consequently, a duplicate certificate of airworthiness for VH-EDC was printed, on which the aircraft was incorrectly identified as being in the normal category. (The CAA has subsequently confirmed that, at the time of the accident, all DC3 aircraft on the register with a current certificate of airworthiness were in the transport category and, with the exception of VH-EDC, were being maintained as class-A aircraft.)

Aircraft logbooks

The logbooks which were being used for the certification and recording of the maintenance history of this aircraft and its major components, were superseded versions of the old-style book format. Logbooks of this type were suitable for use for normal-category aircraft, but more suitable recording systems are available for the more complex requirements of transport category aircraft.

Operators continue to use similar logbooks which, having been superseded, possibly several times, may contain invalid instructions, and which are less able to provide an adequate aircraft maintenance history and audit trail.

The operator was unable to substantiate the aircraft maintenance history for the period between June 1977 and May 1988, which covered 12,565 hours of aircraft operation. Maintenance during this period had been recorded on an alternate system. However, the investigation was unable to confirm that the records still existed. Consequently, the AD compliance status of the aircraft could not be established, e.g. AD/DC3/26B and 29B, which refer to the requirement for wing modifications, and inspections using radiographic/x-ray techniques.

AAC 6-12 dated 13 June 1991 advised of the availability of a new aircraft logbook. The new logbook incorporates the loose-leaf concept, and each section is provided with specific instructions to users.

An aviation regulatory proposal (ARP) circulated for comment on the proposed introduction of the new logbook received adverse industry comment. Consequently, the CAA has not mandated its use. However, the use, throughout the life of VH-EDC, of a similarly comprehensive system, could have provided the necessary aircraft maintenance history and audit trail.

Engine TBO concessions

Right engine

On 28 June 1993, the operator submitted to CAA Bankstown an application for a concession to exceed the published engine TBO period for the right engine. It included two oil sample analysis reports and a compression/ground run test report. The CAA approved a TBO extension of 100 hours, and the operator was notified accordingly on 6 July 1993.

Left engine

On 24 December 1993, the operator submitted to CAA Bankstown an application for the left engine to exceed the TBO period. Two oil sample analysis reports and a compression/ground run test report were included. The application was approved by the CAA on 1 February 1994 for 100 hours over-run, and the operator was notified of this on 4 February 1994.

The AWI assigned to the operator had been verbally advised by the operator on 26 April 1994 that the right engine had been changed on VH-EDC. The AWI expressed the opinion that both engines should not operate on the same aircraft in the over-run period at the same time. However, the CAA did not have a policy to this effect. When the left engine was retain.

you say this because that is what he told you?

~~as advised by the operator~~

granted over-run approval, the AWI assumed that the right engine had been changed. There was an entry dated 24 April 94 in the VH-EDC aircraft logbook that the right engine Serial Number BP463388 had been removed and Serial Number 667 installed. This entry had subsequently been crossed out and noted as an 'Incorrect entry.'

At the time the operator commenced operating the aircraft, the left engine TSO was 840:43 hours. Oil samples to support the concession application for over-run of the engine TBO were taken for analysis at 949 and 996 hours. The analysis reports from both these samples indicated abnormally high wear metals of iron, lead and aluminium. The reports recommended that the oil be resampled after a further 100 hours. However, without a previous trend to compare them against, the samples were not valid indicators of engine health. Furthermore, they represented only about 150 hours of engine operation by this operator (47 hours between samples) and were not indicative of either operating technique or type of operation.

On receipt of the application, the CAA Bankstown Office forwarded it to CAA Central Office for approval. Despite the indications that the engine was suffering mechanical distress together with marginal cylinder compression recordings, further information prior to approval was not sought by either CAA Bankstown Office or CAA Central Office.

The concession was approved, and the operator was advised on 4 February 1994. However, the operator had pre-empted the approval by operating the engine past the TBO period for approximately 15 hours. During the 15 hours TBO overrun, flight crews were not alerted to the engine TBO expiry, as an entry to identify the engine maintenance requirement had not been made on the aircraft maintenance release.

1.13 Medical information

There was no evidence to suggest that any crew member suffered from any pre-existing condition which might have contributed to the occurrence.

1.14 Fire

There was no evidence of pre- or post-impact fire, except for some burning which was contained within the left-engine induction system.

1.15 Survival aspects

1.15.1 Seats and seating configuration

The cockpit of VH-EDC was equipped with two flight crew seats and an additional forward facing jump seat which was positioned in the aisle at the cockpit bulkhead. The flight crew each had a four-strap/three-point harness with each shoulder harness attached to an inertia reel. The jump seat was fitted with a lap belt only.

Figure 5.

Diagram showing the internal layout of VH-EDC.

At the time of the accident, the cabin contained 22 passenger seats and one flight attendant seat. There were five rows of four seats and one row of two seats, with a central aisle. The final seat row on the left side of the aircraft contained two seats. Each seat was fitted with a lap belt. The flight attendant's seat was located at the rear of the passenger cabin near the rear main door. Because the seat was not adjacent to a window, the flight attendant when seated was unable to see the aircraft outside the cabin. A shoulder harness was fitted to the seat, but without an inertia reel.

The operating crew reconfigured the seating layout on the day prior to the accident. It is a regulatory requirement that a seating reconfiguration on a class-A aircraft be certified by an approved person. However, seat reconfiguration on a class-B aircraft can be performed by any person.

1.15.2 General

The rapid onset of the emergency and the resulting cockpit workload left no time for the flight crew to brief the passengers or the flight attendant. The supernumerary crew member attempted to indicate by hand signal to the flight attendant that there was a problem. The flight attendant was later unable to recall having seen the gesture, or to recall any aspect of the ditching. At no time was any signal given to indicate that it was safe for the flight attendant to leave her seat.

Cockpit

The seats of the pilot in command and the co-pilot were each fitted with shoulder restraints incorporating an inertia reel. However, neither pilot was wearing a shoulder restraint. The pilots reported that the operation of the inertia reels interfered with their ability to carry out their duties. On impact, the pilot and co-pilot were thrown forward against the windscreen, receiving minor injuries. There were no failures of the lap belts or seat structures.

The flight crew encountered no difficulty in leaving their seats. The pilot in command and the supernumerary pilot entered the passenger cabin to facilitate the evacuation of the passengers. The co-pilot egressed through the cockpit escape hatch.

Cabin

Prior to takeoff, the flight attendant had briefed the passengers, checked that all seat belts were fastened and advised the flight crew that the cabin was secure. On returning to her seat, she had fastened the lap belt, but not the shoulder restraint.

Passengers reported that during the ditching, the flight attendant was projected over the last passenger seat row and onto the next seat row. She was assisted from the aircraft to a life raft by passengers, to whom she had appeared to be concussed and confused. Consequently, she was unable to perform her passenger safety function during the evacuation.

The flight attendant had no recollections of the ditching. Her injuries were the result of colliding with the passenger seats located on the left side of the aircraft. The injuries were not consistent with those which could be expected had she been restrained by either the lap belt or by the full harness. Examination of her seat and its harness did not disclose any pre-existing defects.

Passenger seats and seat belts

At impact, one seat belt detached from seat 3D, and seat rows 1C/D, 5A/B and 6A/B separated from the seat rail on the outboard side. Examination of these seats indicated that the three outboard feet of seat rows 5 and 6 were not in the seat rail. The positioning pins were operational and there was no damage to either the seat rail or the feet of the seat. The rear two outboard feet of row one were not in position. No damage had occurred to either the seat rail or feet and the positioning pin was stowed, with the adjusting mechanism absent.

Figure 6.

A) The lower arm of the seat structure showing the two rear locating feet.

B) The Douglas track floor rail into which the feet of the passenger seat locate, under the rail tongue. The seat is retained in position by a spring loaded locating pin which engages in the rail recess.

C) A schematic diagram of the locating pin mechanism.

In addition to the seat belt which detached from a seat, three further seat belt fixtures were found to be deficient. The outboard half of the 3D seat strap was dislodged, and the spring loaded gate which secures the fitting to the seat structure was found to be jammed in the open position. The gate was also jammed open on the inboard side of 3D. Both springs were absent, as they also were on the outboard side of the belt for seat 2C. The gate itself was deformed and was partially open. The spring was present on the outboard seat attachment for seat 5C; however, the gate was deformed and partially open. Examination of the belts and their fittings did not indicate any pre-existing fault.

Figure 7.

A) The seat 3D belt straps as found, with the attachment gates jammed in the open position. The seat 3C strap is shown to demonstrate the position of a correctly functioning gate.

B) Detail showing the orientation of the spring within the gate mechanism.

Life jackets and rafts

The aircraft carried life rafts and life jackets sufficient for all passengers and crew. The crew reported that three types of life jackets were carried. However, five different types were recovered, all of which differed in various ways, including colour, packaging and the manner in which they were secured or fitted. There were eight life jackets of the type demonstrated by the flight attendant during her pre-takeoff briefing of the passengers. The location and fitting of the life jacket shown on the passenger safety card also differed to that of the life jacket demonstrated during the safety briefing.

Many life jackets were displaced during the impact sequence; eight passengers reported that life jackets had moved forward within the luggage racks or the cabin. Twelve passengers encountered difficulty in locating a life jacket, and nine passengers experienced some difficulty in fitting the jacket. Eleven reported that the instructions provided by the flight attendant were inappropriate to the jacket provided at their location. With the exception of all crew members and one passenger, all occupants donned a life jacket prior to leaving the aircraft.

Evacuation

The passengers, one of whom opened the rear main door, began the evacuation in an orderly manner. A life raft was deployed, and it was used to transfer two passengers and the flight attendant to two pleasure craft. By the time this initial transfer had been completed, water had already begun to enter the aircraft through the forward fuselage. The pilot in command therefore instructed the passengers to expedite their evacuation. When the remaining passengers had egressed, the pilot in command and the supernumerary pilot left the aircraft through the rear exit.

Figure 8.

Use of emergency exits during evacuation from a ditched aircraft.

1.15.3 Emergency response

Following receipt of the call from the pilot in command advising that the aircraft was ditching, the ATC COORD activated the crash alarm. This occurred at 0909:38. The 'Crash in the Vicinity of Sydney Airport (including Botany Bay)' checklist was then activated. The RFFS control centre was notified at 0909:55 and the Police, Ambulance, FAC and NSW Fire Brigade were informed by the CCC that a DC3 aircraft had crashed off the end of runway 16. These agencies were informed that the emergency involved a 'level 2' aircraft. This classification refers to aircraft seating between 19 and 150 persons.

Tower personnel contacted Melbourne SAR at 0915, after a delay caused by the telephone number for SAR no longer being available on the tower telephone. There was some confusion regarding the number of POB. The flight plan indicated 25 passengers and crew. However, the pilot in command advised police at the accident site that there were 24 POB. He had been advised of a late cancellation by one passenger, but was not aware that another passenger had then been included on the flight. The passenger manifest listed 21 passengers and four crew. It took approximately one hour to confirm that all persons had safely exited the aircraft.

The FAC, CAA RFFS, NSW Police including Water Police and Air Wing, NSW Fire Brigade, NSW Ambulance and Airborne Medical Services all responded to the emergency in accordance with the AEP. SPA MSB and the Volunteer Coast Guard also responded. The Coast Guard vessel was in the vicinity when the aircraft ditched, while the SPA were informed by the ATC

COORD.

By the time the Water Police and the MSB were in the vicinity of the aircraft, the majority of the passengers and crew had been taken on board pleasure craft. Eight boats were used to transfer the passengers and crew to shore.

After medical assessment of the passengers, and consultation with the various hospitals by the Ambulance Co-ordination Centre, five persons were taken to Prince of Wales Hospital, six to St George Hospital and 14 to Prince Henry Hospital. All arrived between 1030 and 1040. With the exception of the flight attendant, all were discharged by 1430 that afternoon.

1.15.4 Emergency locator transmitter (ELT)

The ELT fitted to this aircraft was a NARCO ELT Model 10, Serial Number A 22782. The battery showed a 'replace by' date of 28 July 1992, 21 months prior to the accident. The operator advised that the battery had been changed at the 100-hourly period inspection which was completed in March 94. (The certification records of the inspection do not reflect this.) Inspection of the ELT confirmed that the g-switch had not activated and that the battery pack had not been recently renewed.

1.16 Tests and research

Not relevant.

1.17 Management and organisational information

1.17.1 Overview

At the time of the accident, In accordance with the provisions of section 27 of the Civil Aviation Act, the CAA could issue an AOC to authorise flying or operation of an aircraft within Australian territory for commercial purposes, subject to conditions specified by the Authority. An AOC would be issued unless the applicant had not complied with, or had not established the capability to comply with, the provisions of the regulations relating to safety,

[you may need a foot-note to explain references to legislation as in force at the relevant time as it is now of course CASA]

Not agreed with

including provisions relating to the competence of persons to conduct operations of the kind to which the application relates.

The effect of the requirements of the Civil Aviation Act and CARs concerning the certification and surveillance of air operators was contained in the MAOC. Volume 1 part A chapter 9 stated:

> The issue of an AOC certifies that the standard of personnel, aircraft, documentation and facilities of an operator were adequate at the time of issue to ensure that the air services of that operator could be conducted safely and in accordance with the regulations.

Volume 2 part A chapter 3 of the MAOC addressed the variation of an AOC for the purpose of addition of a new aircraft type. Section 3.3 stated:

> An operator is required to submit an application to include an additional aircraft type on his AOC in reasonable time for the Authority to assess the operator's competence to utilise that type.
>
> Based upon his knowledge of the operator's current fleet, the Inspector normally assigned to the operator will assess the need for further inspection of the operator's facilities, training and checking organisation, maintenance organisation and aircraft. If it is determined that these are necessary, the operator should be asked to provide details of when the facilities and aircraft will be available for inspection. The operator must also provide appropriate operations manual and training and checking manual amendments and if one is not available from airworthiness records, the aircraft flight manual.
>
> Addition of the new aircraft type is to be conditional upon the approval of the assigned inspector, who will be responsible for document evaluation and any required inspections.

The MAOC described the subsequent program of surveillance and inspections by the CAA necessary to ensure that the ongoing operation continued to meet the required standards. The surveillance and inspections were intended to include the conduct of annual/periodic aircraft, training, facilities, document and records inspections. Details of specific inspections were also provided in the MAOC, and included information on the purpose, frequency, methods, conduct, reporting and follow-up requirements of inspections. The MAOC provided checklists to facilitate those inspections. The target level of coverage for each inspection activity was also listed in the manual.

Airworthiness surveillance of approved organisations was required by the CAA to be conducted in accordance with the policies, procedures, planning and instruction guidelines of the NASS. Instructions for NASS users were contained in the 'Policy and Procedures' and 'Planning System User and Training' manuals. Section 1.1 of the former stated:

> The purpose of this manual is to document standardised practices and procedures by which Airworthiness Officers engaged in airworthiness surveillance activities will be able to plan, conduct, record and report those activities in an effective and efficient manner. This will ensure that safety regulation of the aviation industry is conducted in an equitable manner whilst at the same time providing the Authority with a means to effectively control its surveillance activities.

At the time of the accident, a CAA SR&S district office for the area in which an operator maintained its main base normally had responsibility for the flight operations and airworthiness surveillance of that operator. The MAOC stated:

> When planning individual work schedules, senior examiners and surveyors should ensure that inspections and surveillance are given the necessary priority. If, during the year, it becomes apparent that the minimum level of surveillance may not be achieved in some area, the senior examiner/surveyor should take immediate steps to have resources allocated to the area in question.

In addition to the provisions of NASS, procedures for the airworthiness surveillance of operators by the CAA were promulgated in the MAOC. Airworthiness surveillance of an operator's aircraft, which could be carried out at any time, was to concentrate mainly upon ramp inspections and line aircraft inspections. If the holder of the AOC was also an approved aircraft maintenance organisation, then the surveillance was to cover all activities specified in the certificate of approval.

1.17.2 VH-EDC air operator certification and surveillance

The company which owned and operated VH-EDC was located at Camden, NSW. A principal of the operator was also a partner in a company based at Moorabbin, Victoria, which had been issued an AOC for the operation of normal-category aircraft. The principal was employed at an overseas location by a major international airline as a technical operations manager. He was an experienced LAME and had worked with the manufacturer on aspects of its DC3 aging aircraft program.

To enable the commercial operation of VH-EDC, CAA Moorabbin was requested by the AOC holder to vary their AOC to include DC3 aircraft. This was completed on 8 February 1993. CAA Moorabbin was responsible for surveillance of the DC3 operation.

The AOC holder's chief pilot had limited multi-engine experience and no DC3 experience. Consequently, CAA Moorabbin agreed that a DC3 flight captain, based at Camden, could be appointed to exercise some of the chief pilot's responsibilities. This function was delegated to the pilot in command of the accident flight. In May 1993, the pilot in command was also approved as check-and-training captain. However, overall supervision of the operation of the aircraft remained the responsibility of the chief pilot, who was based at Moorabbin.

When assessing an operator for approval of an AOC or for the addition of a new aircraft type to an existing AOC, the MAOC intended that compliance with both operation and airworthiness regulatory requirements be assessed. These requirements included a system of maintenance, appropriate facilities, equipment and documentation. The variation to the AOC to include the DC3 was approved by CAA Moorabbin, without surveillance being conducted to ensure that the airworthiness requirements were met.

Surveillance of the AOC holder was controlled by CAA Moorabbin. However, as the aircraft and its operator were based at Camden, the Bankstown Office, at the request of the Moorabbin Office, accepted airworthiness surveillance responsibility, and the conduct of specific operational surveillance on request from the Moorabbin Office. The MOAC-recommended mechanism—the MOU by which surveillance and audit responsibilities should be delegated between CAA offices—was not used.

The intended level of CAA flight operations and airworthiness surveillance activity for this operator was a total of three days per year. Most of the CAA involvement with the operator during the period leading up to the accident focused on the DC3 flight captain and check-and-training approval process. Airworthiness surveillance actually conducted was limited to one 'opportunity' inspection in March 1994, by CAA Bankstown, when the aircraft was flown to Bankstown for radio maintenance. No formal flight operations surveillance, responsibility for which had been retained by CAA Moorabbin, was conducted. However, implicit in the DC3 flight captain and check-and-training approval process was an element of flight operations surveillance.

No evidence was found to indicate that the chief pilot had fulfilled his supervisory responsibilities with regard to the DC3 operations. However, there was evidence that the pilot in command, as DC3 flight captain, advised the chief pilot of all commercial operations. All ongoing supervision of both general operations and check and training was left to the pilot in command.

1.17.3 Task planning

Performance charts

Aircraft performance charts relevant to the accident were as follows:

Chart DCA PK16.1/1 (take-off weight chart) and DCA PK16.1/2 (landing weight chart) were developmental services charts used during operations in PNG and were not approved for use in Australia. However, they were included in the operations manual accepted by the CAA.

Chart TAA P19 Issue 1 (take-off chart) and TAA P20 Issue 1 (landing weight chart) were originally produced to permit operations up to a MTOW of 12,202 kg (26,900 lb). At the time of the accident these charts were valid for use up to the CAA-approved MTOW of 11,884 kg (26,200 lb).

The operations manual required that charts P19 Issue 1 and P20 Issue 1 be used for all normal operations, but gave the pilot in command discretion to use PK16.1/1 and PK16.1/2. However, the circumstances in which the pilot in command might exercise such discretion were not identified. Use of Chart P19 Issue 1 would have precluded takeoff from Lord Howe Island, whereas use of PK16.1/1 allowed the operation, with the caution that the accelerate/stop distance would not always be available when using that chart.

Prior to the accident flight, the pilot in command had been advised, both orally and in writing by CAA Bankstown, of the requirement to include only the approved performance charts in the operations manual. Although he amended Chart P19 Issue 1 to reflect a maximum take-off weight of 26,200 lb (11,884 kg), the pilot in command did not remove Chart PK16.1/1 or Chart PK16.1/2 from the manual as he had been advised to do by the CAA. The chief pilot was not aware of the incorrect charts as he was not included in the meeting with the CAA at Bankstown nor did he receive their written advice.

The operator carried out initial task planning some time prior to the accident flight and provided the charterer with a load availability of 2,160 kg. The load availability figure was derived from the normal basic weight of the aircraft, adjusted for seat removal and fuel to be carried. However, it did not take into account the weight of life rafts, additional drums of oil, or aircraft spare parts and tools, that were to be carried. Additionally, no provision was made in the calculations for inclusion of the supernumerary crew member. Thus, the load availability given by the operator to the charterer exceeded what was actually available on the accident flight by approximately 600 kg.

Performance calculations using Chart PK16.1/1 were made by the pilot in command despite knowledge that the chart was invalid. To be able to complete the accident flight task, two departures from Lord Howe Island at MTOW would have been required. A commercial advantage was achieved when the operator was awarded the charter contract on that basis.

Aircraft loading

The pilot in command prepared a load sheet prior to his arrival at the airfield. This indicated that the aircraft's weight would be 11,757 kg at takeoff, or 127 kg below the MTOW. He used the CAAP suggested weights for the passengers, and estimated the weight of the freight, including the life rafts. He calculated the load as 1,833 kg, although the charterer had been advised that the availability would be 2,160 kg. The charterer did not advise the operator of the actual weights.

The volume of freight (band instruments) delivered had concerned both the pilot in command and the co-pilot. The pilot in command indicated that

50

although he assessed that the weight was in excess of what he had expected, he considered that the additional weight would not exceed the 127 kg he had already calculated was still available. He did not attempt to check the weights despite an operations manual requirement that the pilot in command confirm the actual weights in the event of any concern about their accuracy. The investigation team determined that the load delivered by the charterer actually weighed 2,117 kg.

The result was that the aircraft began the takeoff approximately 562 kg in excess of the MTOW. (The various weight and balance calculations are set out in section 1.6.2.)

1.17.4 Training and checking

General

Apart from flight attendant training, no formal check-and-training records, as required by the operations manual, were available. There was no evidence available to indicate that the co-pilot had operated the aircraft type at representative weights following an engine failure on takeoff. The pilot in command, as the operator's DC3 check-and-training captain, had not checked the co-pilot's ability in such situations. At the time of the accident, the CAA CARs and CAOs did not specify a required aircraft load status for the conduct of asymmetric training or checking.

The crew had not received any CRM training, nor was such training required by the CAA.

Pilot in command

The pilot in command was responsible for operational standards and training. He accepted the co-pilot's DC3 credentials (type rating) without checking that person's proficiency on the aircraft with regard to emergency procedures.

Is he under any obligation to do so as a matter of law, convention, industry practice? He simply did not check!

The investigation did not find any evidence that the chief pilot, or the CAA ~~surveillance system~~, attempted to ensure that the pilot in command was complying with the operations manual check-and-training requirements.

Is there a legal / or / other requirement to do so? Yes!

Co-pilot

The co-pilot's licence was endorsed with a DC3 type rating, following his representation to the CAA that he had completed DC3 pilot in command endorsement training. The investigation found no evidence to establish that the co-pilot had actually completed the required training.

The flying hours recorded in the co-pilot's logbook, which were used to substantiate the application for the DC3 type rating, were insufficient to qualify the pilot for the rating.

The US pilot who provided the training advised the investigation team that its purpose was to familiarise the trainee with the co-pilot duties. The trainee was not given instruction or a flight check to enable him to fly as pilot in command.

There was no indication that the co-pilot's logbook entries had been checked by the pilot in command prior to allowing the co-pilot to fly as crew in a DC3. There was also no record of a check of his ability to handle the aircraft from the right control position during abnormal or emergency situations.

During the accident investigation, the co-pilot produced an instrument rating test form to show that he had completed a command instrument rating renewal at Cairns, Queensland on 9 January 1994. The form indicated that the test was conducted in a DC3. However, the test results had not been submitted as required to the CAA.

The co-pilot's logbook showed that he had been flying VH-EDC as a flight crew member since 13 August 1992, and that he first flew the aircraft as pilot in command on 25 November 1992. The pilot was not qualified to fly as a crew member on commercial flights before 20 September 1993, when he gained the commercial pilot licence. Consequently, he was subject to the operations manual check requirements only from September 1993. No evidence was found to indicate that the co-pilot had undergone initial checking or training on commencement of commercial operations. The operations manual requirement was that two checks per year be conducted at intervals of at least four months. However, the instrument rating renewal met the requirements for the intermediate check.

Flight attendant

Company records indicated that the flight attendant was trained and checked proficient in accordance with the operations manual on 25 September 1993. This consisted of approximately two hours of training during which the operation of exits, therapeutic oxygen, fire extinguishers and seat belts was explained. She was also informed of cabin safety procedures such as checking that passenger seat belts were fastened, and determining from the signal from the cockpit when it was safe to commence cabin service. Evacuation procedures were also discussed, including the use of exits away from the fire or problem. The training was undertaken by the pilot in command.

On the day prior to the accident, the pilot in command spent approximately two hours training the flight attendant in the emergency procedures associated with a ditching.

1.17.5 Aircraft operations manual

The AOC holder produced an operations manual for the DC3, which included a check-and-training section. The manual was not approved, but was assessed as acceptable by CAA Moorabbin. However, the investigation found that the manual contained invalid take-off and landing performance charts. The manual was also found to contain two different instructions for crew procedures during takeoff when the co-pilot was the handling pilot.

CARs required that all aircraft have a CAA-approved flight manual. However, an official Australian flight manual for DC3 type aircraft was never produced. Information normally available in the flight manual was required to be included in the operations manual. Consequently, data which would normally be subjected to an approval process by the CAA were accepted only as part of the operations manual. Such data included take-off and landing performance charts, limit and critical airspeeds, weight and CG information, etc.

The investigation team was advised by the CAA Airworthiness Branch that a single set of official Australian DC3 performance charts had never been produced. In the past, when the major airlines operated DC3 aircraft, they produced their own performance charts; consequently, there are numerous such charts in use. However, the charts PK-16.1/1 and PK-16.1/2, which were retained in the operations manual for VH-EDC and used by the pilot in command when planning the flight, were not approved by the CAA.

The inclusion in the operations manual of the invalid take-off and landing performance charts was identified by CAA Bankstown in December 1993. Replacement performance charts were dispatched to the operating company by CAA Bankstown that month. However, the operator did not include the replacement charts in the manual, nor were the invalid charts discarded. A copy of the letter which accompanied the replacement charts was sent from CAA Bankstown to the CAA Moorabbin DC3 type specialist, but not to the Moorabbin FOI overseeing the DC3 operation or to the chief pilot.

A meeting was held at Bankstown between the operator and the CAA one month prior to the accident to discuss weight control of the aircraft. At this meeting the pilot in command was informed as to which take-off performance chart was to be used. The chief pilot was not included in these discussions. The pilot in command subsequently completed performance planning for the flight, aware that the take-off performance chart he was using was not valid. ~~valid~~ not approved?

It was the chief pilot's responsibility to ensure compliance with the operations manual. The AOC holder did not retain a copy of the manual, to be used as a reference by the chief pilot, and the investigation found that the chief pilot was not aware of all aspects of the DC3's operations. No evidence was found to indicate that the chief pilot had conducted any direct supervision of the Camden operation. Nor was it established that CAA Moorabbin was aware of the lack of an operations manual in the AOC holder's office or of the chief pilot's lack of supervision.

This is a very broad conclusion unsupported by any direct evidence here or by eg. of what he was not aware of.

The operations manual included procedures to be adopted in the event of a number of abnormal situations, including forced landing and ditching. The manual indicated the duties to be undertaken by both the pilot in command and co-pilot. However, the duties of the flight attendant in such situations were not included. Further, in the case of premeditated forced landing or ditching procedures, there was no reference to passenger briefings or to the evacuation of passengers.

1.17.6 Aircraft handling

Neither the CAOs nor the company operations manual set out the minimum experience and training required before a co-pilot was permitted to conduct a takeoff from the right control position. The operations manual contained two different instructions regarding crew actions when the co-pilot was conducting the takeoff. One instruction required the pilot in command to follow through on the controls during takeoff and to resume control immediately on recognition of a problem. The other required that the co-pilot continue to fly the aircraft while the pilot in command provided support. The latter procedure did not address the implications of the limitations imposed by the lack of flight attitude instruments located at the right side control position.

The pilot in command indicated that it was his policy that the handling pilot should continue to fly the aircraft and deal with the emergency while the non-handling pilot provided support.

During the accident sequence, when the co-pilot called an engine failure on the left engine, the pilot in command performed the phase-1 engine failure checklist. There is no evidence that the crew referred to the engine instrument indications to verify power availability. The pilot in command feathered the propeller on confirmation by the co-pilot of correct identification, and shut down the engine, while the co-pilot continued to fly the aircraft. The pilot in command took control of the aircraft when it became apparent to him that, despite the right engine being selected to, and indicating, full power, the aircraft performance had deteriorated and the co-pilot was unable to fly the aircraft safely.

No attempt was made to land on the remaining runway ahead of the aircraft, as the available distance appeared to the pilot in command to be marginal. The operations manual procedure for the aircraft, at the reported speed at which the malfunction occurred, required that the pilot proceed with the takeoff.

Evidence of the operation of the aircraft during the emergency was obtained from the open microphone transmissions recorded by the AVR facility. Following the engine shutdown, the co-pilot attempted to maintain 81 kts (the take-off safety speed for MTOW, as prescribed in the operations manual). However, within 20 seconds after the pilot in command had advised ATC that the engine was shut down, the aircraft's speed decayed to the degree that the decision was made by the pilot in command to ditch the aircraft.

1.17.7 Licensing of the co-pilot

The co-pilot claimed to have completed DC3 endorsement training in the USA. A check with the FAA revealed that the co-pilot had not applied for, nor had he been granted, a DC3 type endorsement by the FAA.

In August 1992, the co-pilot submitted his FAA commercial pilot licence to CAA Bankstown, seeking Australian validation. He also produced his pilot logbook and identified an entry which he claimed to be verification of the required training for the issue of a DC3 type rating.

The CAA's intention was to validate the licence to the Australian unrestricted private pilot licence standard. However, the certificate of validation issued by the CAA stated that the FAA licence had been validated to unrestricted pilot standard. The CAA also included a DC3 type rating, without requiring substantiation beyond the logbook entry of completion of the required training. CAA policy required that a rating should not be issued for foreign training unless the type was endorsed on the applicant's overseas licence by the relevant authority.

In September 1993, the pilot was issued an Australian commercial pilot licence, which again included the DC3 type rating.

Inquiries conducted following the accident indicated that the pilot had not completed the required DC3 endorsement training.

1.17.8 CAA airworthiness surveillance

The operator acquired VH-EDC on 24 June 1992 and was maintaining the aircraft at its Camden NSW base. The AOC holder's maintenance certificate of approval, which was limited to normal-category aircraft, was amended on 16 October 1992 to include the DC3 aircraft type. The duplicate certificate of airworthiness, produced by CAA Moorabbin, incorrectly identified the DC3 as a normal-category aircraft. Surveillance of the maintenance of VH-EDC was to be controlled by CAA Moorabbin.

CAA Moorabbin did not inspect the aircraft file, the aircraft, or the aircraft's logbooks before allowing VH-EDC, which had been out of service for the previous two years, to enter service on commercial charter operations.

CAA Moorabbin drew up a functional line reporting diagram for the maintenance management of the aircraft which showed the engineering manager of the AOC holder as the chief engineer, responsible for the management of the DC3 maintenance. However, the engineering manager indicated that he was not aware of the type of maintenance required, and was not directly involved in the planning or introduction of the DC3 into commercial service. In addition, he was unaware of the maintenance management plan and did not exercise any control over maintenance at Camden, nor did he believe it was his responsibility. He left the employment of the AOC holder in February 1993, at about the time that VH-EDC entered service, and was not replaced. Consequently, the AOC holder did not exercise management control of the DC3 maintenance.

Airworthiness surveillance by CAA Moorabbin between February and May 1993 did not disclose that the AOC holder's engineering manager position was vacant, and therefore the maintenance management plan was no longer valid. When CAA Moorabbin transferred airworthiness surveillance of the aircraft to Bankstown, they passed on the functional diagram which indicated that the LAME at Camden would report to the engineering manager of the AOC holder.

The operator submitted an aircraft logbook statement to CAA Bankstown on 4 August 1992, seeking approval to maintain VH-EDC as a class-B aircraft. Approval was denied and the operator was advised accordingly on 14 August 1992.

On 5 February 1993, CAA Bankstown wrote to the operator advising that the certificate of airworthiness classified the aircraft as transport category and that the logbook statement, which referred to maintenance of the aircraft in accordance with 'schedule five', was not applicable to class-A aircraft. Furthermore, there was a requirement to submit a 'system of maintenance' for approval with a maintenance control manual and the nomination of a maintenance controller. The operator contacted the CAA officer by telephone on 10 February 1993, and advised that he would submit a maintenance control manual. This was before CAA Bankstown was officially asked by CAA Moorabbin to undertake the AOC (Camden) airworthiness surveillance role.

CAA Moorabbin wrote to CAA Bankstown on 28 May 1993 requesting that, as VH-EDC was to be maintained at Camden, Bankstown arrange the required local audit and surveillance activities. This request was accepted. However, the only surveillance undertaken by CAA Bankstown after that date was a NASS-10 survey of the aircraft at Bankstown on 2 March 1994. This was an opportunity surveillance activity, and not part of a planned program of surveillance.

There was no plan formulated in accordance with NASS procedures for surveillance of the operator by the Bankstown-assigned AWI. However, the assigned AWI advised that attempts to contact the company to arrange a meeting when the aircraft and its maintenance documents were together had been unsuccessful. There were no formal, documented attempts by the CAA requesting that the management personnel of the operator make themselves, the Camden facility, the aircraft, or its documentation available to initiate the surveillance process.

Up to the time of the accident, the operator had neither submitted a maintenance control manual for approval, nor nominated a maintenance controller. Furthermore, 100-hourly periodic inspections had continued to be conducted by the operator in accordance with the CAR Inspection Schedule 5, which is not an approved schedule for the maintenance of class-A aircraft.

1.18 EROPS

The planned flight involved overwater operations, which necessitated consideration of compliance with requirements for extended range operations.

CAO 20.7.1B Issue 2 and CAO 105 AD/General/69 Amdt 1, 3/90, set out the requirements for EROPS for twin engine aircraft. CAO 20.7.1B, para. 2, 'Application', indicated that the order was only applicable to all new types of piston engine aircraft having a maximum permissible all-up weight in excess of 5,700 kg, which were first registered after 1 June 1963. The DC3 would therefore not appear to be subject to EROPS requirements. However, this was contradicted by para. 13.4 of the same order, which identified its applicability to twin-engine aeroplanes of a type first registered in Australia on or before 28 October 1985.

CAO 105 AD/General/69 Amdt 1, 'Applicability', identified that the DC3 aircraft type was required to satisfy the EROPS requirements:

> Applicability:
>
> All passenger-carrying twin-engined aeroplanes certificated for 20 passengers or more intended to be operated on extended range operations except as indicated in Note 1.
>
> Note 1: This Directive is not applicable to aeroplanes of an airframe/engine combination first registered in Australia on or before 28 October 1985 operated by the same operator as on 30 November 1989 under the provisions of CAO 20.7.1B Subsection 13 Paragraph 13.4.
>
> Note 2: For the purpose of this Directive, Extended Range Operations means a distance in excess of 60 minutes flight time from an adequate aerodrome calculated at single engine cruise speed.
>
> Note 3: In addition to the Requirement of this Directive, operational requirements as specified in CAO 20.7.1B subsection 13 shall be complied with before specific extended range operation is approved.

Under the provision of this directive, the operator was required to obtain CAA EROPS approval to conduct the flight using VH-EDC.

During planning for an EROPS flight, an operator would be expected to

by law? custom? common sense?

reference operational CAOs, in particular CAO 20.7.1B. However, CAO 20.7.1B did not cross reference to AD/General/69 Amdt 1. The investigation team was made aware that other operators, and some operational staff of the CAA, did not properly understand these orders and directives. Had the intention of these orders and directives been recognised and complied with, VH-EDC would not have been used for the task on which the accident occurred.

1.20 Additional information

Passenger behaviour

Despite the lack of direction from the flight attendant due to her incapacitation, the passengers were calm and composed during the ditching and subsequent evacuation. Significant features of the evacuation were that:

(a) the passengers perceived that their survival was not threatened, which was due, in the main, to the calm weather and sea conditions, proximity to the shore, the number of pleasure craft in the vicinity, and the initial buoyancy of the aircraft;

(b) one passenger essentially took control of the evacuation process;

(c) the life rafts were highly visible to all the passengers; and

(d) the majority of the passengers knew each other, which facilitated their cooperation during the evacuation.

Passenger briefing

None of the passengers braced prior to the impact, despite 17 passengers having referred to the safety briefing card which provided details of the brace position. Prior to impact, the passengers were not directed to adopt the brace position, nor had they been instructed to do so, during the pre-takeoff briefing.

2 ANALYSIS

2.1 Introduction

The investigation has established that the left engine of VH-EDC lost power shortly after takeoff. The aircraft was unable to maintain altitude and the crew elected to ditch it in Botany Bay near the end of the partially completed runway 16L. ~~The fortunate outcome, in~~ that few injuries were sustained, primarily reflects the favourable position of the aircraft, and the pilot in command's handling of the ditching.

Indications of a possible engine defect were available to the operator and the CAA prior to the accident flight. The significance of the engine condition information provided by the operator was apparently not recognised when the CAA approved an extension of the engine TBO.

Engineering examination of the left engine has indicated that the malfunction of the engine was most likely attributable to the jamming open of the no. 3 cylinder inlet valve. The effect on the engine operation of an inlet valve jammed open is consistent with the reported circumstances of the engine malfunction.

That the engine malfunction resulted in an accident, indicated that other aspects of the aircraft operation were deficient. These deficiencies included aircraft maintenance, aircraft loading, pilot competence, and flight crew procedures.

The use of VH-EDC for the planned flight was inappropriate. The circumstances in which the operator was able to justify its use, together with the procedures adopted by the CAA when approving the addition of the DC3 operation to an existing AOC have been the principal matters in this analysis.

The analysis of this occurrence indicates that there were latent failures in the aviation system which contributed to the accident, in addition to active failures involving the flight crew and others which contributed to system defences being breached or bypassed.

2.2 Defences

Complex socio-technical systems, such as the civil aviation system, normally incorporate defences (sometimes called the safety net) which are designed to detect and provide protection from hazards resulting from human or technical failures, and to eliminate or reduce their possible effects. When an accident occurs, an important first step in determining why it occurred is to identify what aspects of the system defences were absent, had failed, or were circumvented.

Investigation of this accident revealed that there were defences in the system which, had they not failed or been circumvented, should have prevented the accident. The principal defences relevant to the mechanical malfunction of the engine and to the flight and crews' handling of the subsequent emergency are discussed below.

2.2.1 Failed defences

(a) Engine overhaul/maintenance procedures

Engine maintenance manuals and procedures documentation have been available since the introduction into service of the engine type. The use of this information by operators and maintenance personnel, and compliance with the appropriate CAA maintenance requirements, are intended to prevent incorrect engine component assembly. However, this occurrence involved the incorrect installation of an engine component which could subsequently have caused the left engine to lose power at a critical phase of flight. Thus the defence provided by the established overhaul and maintenance procedures failed.

(b) System for extension of engine TBO

The CAA had in place a system for granting approval to operate engines beyond their specified TBO. This system, if properly applied, should have acted as a defence against engines in poor condition being allowed to continue in service beyond their specified TBO. However, in this instance the system failed. Despite having been provided with oil samples and records of compression tests which indicated that the left engine probably was in poor condition, the CAA granted an extension allowing the operator to continue operating the engine beyond its TBO.

(c) Crew qualification system

This defence comprised, in part, standards and procedures for crew licensing and for check and training of licensed crews to ensure that they were qualified to perform tasks appropriate to their roles. Responsibility for the effectiveness of these defences was shared between the CAA and operators. Despite the CAA having established standards and procedures covering both licensing and check and training, the defence intended by these standards and procedures failed. This was evidenced by the co-pilot in this accident holding an aircraft rating, the qualifications for which could not be substantiated, and there being no record of the operator having ensured that flight crew members had completed the check and training required by the CAA standards.

(d) Operations manual procedures

In producing an operations manual, the operator sets out the instructions, procedures and practices which its operations personnel must follow in order to ensure that they carry out their tasks safely and in accordance with the appropriate provisions of the Civil Aviation Act and Regulations. The operations manual acts as a system defence in that it provides standardised and proven ways of dealing with matters such as the in-flight emergency involved in this accident. Its effectiveness in providing such a defence is contingent upon it being complete and accurate.

Operations manuals were required to be approved by the CAA. However, when this operator's manual was submitted in support of the application for the variation to the AOC, the manual was 'accepted' only, by the Authority. As a consequence, the defence inherent in an operator having, and following, sound operations manual procedures failed. This was evidenced by the manual containing erroneous and potentially misleading information which had not been identified during the operations manual 'acceptance' process.

2.2.2 Circumvented defences

(a) MAOC procedures

The MAOC procedures were intended to give effect to CARs and CAOs, by providing guidance to CAA personnel on the issue, control and monitoring of an AOC. The guidance was to ensure that CAA officers adequately assessed the establishment and operation of commercial aircraft services. The MAOC procedures should, if applied correctly, act as a system defence by preventing operators, who do not meet the relevant standards, from being issued with an AOC. That this defence was circumvented is evidenced by the CAA having approved the addition of DC3 aircraft to an existing AOC, and the operator having commenced commercial passenger-carrying operations without the CAA having conducted any surveillance on the DC3 operation.

(b) Flight manual

An approved flight manual was required by the CAA for most aircraft. The flight manual acted as a system defence in that it served to ensure that essential aircraft information, assessed and approved by the CAA, was available to the operating crew. Included in that information were the take-off and landing performance charts.

The defence provided by the provision of an approved flight manual was circumvented when the DC3 aircraft type was exempted by the CAA from the requirement to have a flight manual. Information normally contained in the flight manual was intended to be included in the operations manual. However, because the operations manual was not 'approved' by the CAA, the inclusion of incorrect information was not recognised, and that incorrect information remained available to the crew at the time of the accident.

where is this covered in Pa1? 1.17.5.

2.3 Active failures

Active failures are unsafe acts which may be classified as either errors or violations. These failures are typically associated with operational personnel such as pilots, air traffic controllers, maintenance staff, etc.

2.3.1 Engine malfunction

(a) Incorrect assembly of components

An inlet valve rocker shaft thrust washer in the no. 3 cylinder was not installed correctly. This could cause the valve to jam open and result in a loss of power.

The left propeller was found to have an over-torqued pitch change mechanism nut which probably caused the failure of the propeller to feather fully.

(b) Approval of TBO extension

CAA officers approved the extension to the left engine TBO, despite a SOAP analysis indicating possible engine internal distress. Cylinder compression test results also did not appear to support the engine extension. The application could either have been rejected or further examination required before the CAA approved the extension.

2.3.2 Aircraft operation

(a) Pilot in command's response to the engine malfunction

The pilot in command, who was not aware of the degree to which the aircraft was overloaded, had assumed that the co-pilot should have been capable of safely operating the aircraft, despite the engine malfunction. Consequently, he did not initially respond to the incorrect aircraft handling by the co-pilot. The deterioration in aircraft performance was such that when he did take control, there was little option other than to ditch the aircraft.

It is possible that the malfunction did not result in a total loss of power from the left engine. The ground witness evidence indicated that the engine may have been malfunctioning throughout the climb, suggesting only a partial loss of power. The engine instrument indications were not referenced to confirm the degree of power loss. However, the co-pilot assessed that the engine should be shut down and the propeller feathered, and the pilot in command complied.

(b) Co-pilot's response to engine malfunction

Following the engine malfunction, the co-pilot attempted to maintain the take-off safety speed required by the operations manual for weights up to and including MTOW. However, as the aircraft weight exceeded MTOW, that speed was inappropriate, and resulted in a reduction in the single engine performance capability of the aircraft.

The aircraft performance was further eroded when the co-pilot applied excessive aileron control in an attempt to maintain directional control.

2.3.3 Check and training

The pilot in command, as the DC3 flight captain, did not establish a check-and-training records system as required by the operations manual. Nor was a check-and-training program implemented. Consequently, flight crew employed by the operator may have operated the aircraft when not qualified to do so.

I thought we had evidence that some of them were unqualified & untrained So why "may"?

No documentary evidence of check and training conducted by the pilot in command was made available to the investigation, other than the co-pilot's instrument rating renewal test form. Prior to conducting takeoffs on commercial flights, the co-pilot was not formally assessed by the pilot in command for competence in EFATO with the aircraft at high gross weights.

2.3.4 Violations

Violations involve deliberate deviations from a regulated practice or prescribed procedure. The evidence obtained during the investigation suggests that active failures in this category contributed to the breaching of system defences in the ways shown in the following analysis.

(a) Co-pilot qualifications

At the time of the accident the co-pilot held a valid Australian commercial pilot licence with a DC3 type rating. However, the pilot was not able to validate his claimed training for the DC3 rating. The CAA had endorsed his licence without ensuring that he had completed the required training. Consequently, the co-pilot was probably ~~not qualified~~ inadequately trained to perform DC3 co-pilot or pilot in command duties.

why do you qualify this?

(b) Aircraft overloading

The pilot in command did not ensure that the aircraft weight did not exceed the MTOW. Although he had some doubts concerning the total load, he did not obtain a load sheet, and the freight and passengers were not weighed. The weight of the spare parts, tools and drums of oil was not included when calculating the aircraft take-off weight. Consequently, he was not aware of the degree to which the aircraft was overloaded

2.4 Preconditions (local factors)

Preconditions are task, situational or environmental factors which may promote the occurrence of active failures.

2.4.1 CAA environment

CAA Moorabbin expedited the commencement of the operation of VH-EDC by permitting operations before a check-and-training organisation had been approved, and sanctioning the operational and maintenance supervision by a chief pilot and an engineering manager, each of whom had little experience relevant to the operation of DC-3 charter services.

The manner in which the AOC variation approval was granted (particularly with respect to the AOC holder having little relevant experience), the lack of surveillance, minimal co-ordination between the Moorabbin and Bankstown CAA offices, and the provision of an FOI for the operator's check-and-training function, suggest that the CAA's focus may have been towards minimising delay in the commencement of operations rather than ensuring that the operation met, and would continue to meet, safety

Also, this is the first time the issue of minimising the process has arisen. & there is no evidence that CAA actions that did reduce time.

Analysis. ? why would you draw this conclusion - clear(?) failure to comply with a variety of requirements etc etc. - is it worth going beyond that?

Later.

requirements.

2.4.2 CAA manuals and procedures

The MAOC procedures did not provide adequate guidance for CAA officers when dealing with the proposed commercial operation of a single, transport category aircraft, based and maintained remote from the AOC holder. Consequently, CAA Moorabbin officers applied a measure of 'discretion' when assessing the surveillance requirements. However, the procedures used did not ensure that the operation of the aircraft complied with the intent of the MAOC. This is evidenced by the lack of CAA awareness of discrepancies in both maintenance and operational aspects of the DC3 operation. The failure by CAA officers to conduct surveillance of either operational or airworthiness aspects of the proposed new operation indicates a lack of appreciation of the MAOC guidance in the application of discretion. Section 1.5 of the MAOC (General Information) stated in part:

> Situations may arise where the certification process can be expedited, based on the past experience of the applicant's personnel, type and scope of operation, and organisational capacities.
>
> However, the applicant must not be certificated under any circumstances, until the CAA is assured that the prospective certificate holder is fully capable of meeting the responsibility for safe operations, and that the company will comply with the Civil Aviation Regulations in a proper and continuing manner.

Inadequate communication and co-ordination within the CAA during development of the requirements for EROPS led to an unclear, conflicting, and poorly cross-referenced CAO and AD. The deficiencies in the presentation of the requirements for EROPS were such that both the operator and an FOI responsible for aspects of the oversight of the DC3 operation were satisfied that the aircraft was not required to comply. Consequently, the aircraft was committed to a flight to which EROPS regulations applied and for which it was not approved.

2.4.3 Knowledge, skills and experience of CAA officers

(a) AOC assessment

The CAA Moorabbin officers involved in the approval of the variation to the AOC did not show sufficient awareness of the MAOC guidelines. They also appeared to lack knowledge of the requirements for the operation of the DC3 aircraft type and for aircraft based remote from the AOC holder. This is evidenced by their acceptance of the proposed operation without surveillance of either the aircraft, the aircraft documentation, or the Camden facilities. The incorrect identification of the DC3 as a 'normal' category aircraft influenced the approach taken by the CAA in approving the variation to the AOC. However, this is an indication of the lack of appreciation by CAA Moorabbin of the safety implications of the operation of an aircraft of the capacity of the DC3.

(b) Operations manual

The CAA Moorabbin's acceptance process for the operations manual did not identify the incorrect inclusions, specifically the incorrect performance charts and the contradictory crew procedures instructions. It is likely that the 'acceptance' of the manual rather than 'approval', led to a situation where CAA officers did not recognise the need for verification of the detail of the manual.

CAA Bankstown officers were aware that the operator was using incorrect performance charts and incorrect maintenance procedures. They instructed the operator to correct the discrepancies, but this instruction was not complied with. Having given that instruction, the CAA officers did not meet their responsibility to take action to ensure that the operator did comply.

(c) Surveillance and monitoring

When assessing the level of surveillance required, it is likely that the CAA officers were influenced by the extensive aircraft maintenance management experience of the principal of the operator. They were also aware that he was involved in the development of the manufacturer's DC3 aging aircraft program.

did their systems provide them with readily accessible information about the movements of the principal? No.

However, the CAA may not have recognised that the principal was frequently absent from Australia.

(d) Regulation and policy

The AWI assigned to the operator advised the operator that CAA policy precluded the granting of approval for the simultaneous operation, beyond the standard TBO, of both engines of a twin-engine aircraft. However, the CAA did not formally have such a policy, and had not published relevant information for the guidance of either their own staff or the industry.

CAA officers, including an FOI responsible for aspects of the oversight of the DC3 operation, incorrectly interpreted the intent of a CAO relating to requirements for EROPS. The CAO was misleading, and failed to cross-reference the applicable AD. However, the misinterpretation of the CAO by CAA inspectors indicated a deficiency in the knowledge and experience of CAA staff. A lack of communication between management and operational areas of the Authority was also possibly indicated. How? delete

When assessing the application for extension of the TBO for the left engine, senior CAA staff advised that the TBO for an R1830 engine should not be increased. The results of the SOAP analysis were also not supportive of extension of the TBO. However, CAA Central office approved the application. The evidence indicated that this decision was based on an inadequate assessment of the supporting documentation.
What evidence? as above.

2.4.4 Checking and supervision by the CAA

Although the CAA was asked to vary an existing AOC rather than to approve an additional AOC, the proposal was for the commencement of a new operation, with an aircraft type and certification category new to the AOC holder. This necessitated operational and maintenance procedures beyond the experience of the AOC holder.

The CAA had no relevant prior experience with the operator upon which to assess that operator's capacity to meet the requirements for the approval of the variation to the AOC, or for continuing compliance. The AOC holder was also unable to demonstrate prior competence in the management of commercial operations of aircraft which weighed in excess of 5,700 kg. Further, the proposed DC3 flight captain, although an experienced pilot generally, had only recently recommenced flying the DC3 type after a break of about 13 years and required additional training to satisfy the requirements for approval as check-and-training captain. However, CAA Moorabbin did not consider that surveillance of the aircraft, its documentation, or the operational base was required prior to approval of the variation to the AOC.

Attempts reportedly made by CAA Bankstown officers to liaise with the operator, in order to conduct surveillance on the aircraft and the Camden facility, were unsuccessful. However, these attempts were made only on the basis of telephone calls rather than formally addressed correspondence. Further, there is no indication that CAA Bankstown attempted to co-ordinate contact with the operator through the AOC holder.

2.4.5 Knowledge, skills and experience of the AOC holder and the operator

(a) AOC holder

The AOC holder was responsible under the regulations for the safety of the DC3 operation. The CAA established with the AOC holder and the operator, systems for operational and maintenance management. These systems were intended to compensate for the AOC holder's lack of knowledge and experience in the operation and maintenance of aircraft weighing in excess of 5,700 kg, while ensuring compliance with the terms of the AOC. However, neither the AOC holder nor the operator ensured that the systems functioned as intended.

(b) Operator

The operator applied for a time extension beyond the TBO for the left engine using information which indicated that the engine was operating in a distressed condition. The application suggests that the operator had not recognised the risk involved with the continued engine operation. This lack of understanding was further demonstrated when the operator indicated in correspondence to the CAA in March 1994 an intention to seek to have the TBO extended to 1,600 hours.

(c) Chief pilot

The monitoring of the DC3 operation by the chief pilot was limited to him being advised by the DC3 flight captain of intended tasks. His location, remote from the aircraft's operational base, and his exclusion from advice by CAA Bankstown concerning regulatory deficiencies, contributed to the chief pilot's lack of awareness of the DC3's operating environment. He did not maintain a copy of the DC3 operations manual at his base and, as a consequence, was unable to become sufficiently familiar with the DC3 operational procedures. This evidence indicates that the chief pilot did not recognise that, although a DC3 flight captain had been appointed to accept some operational responsibility, the ultimate responsibility for the safe operation of the DC3 remained with the chief pilot.

(d) Chief engineer

The engineering manager of the AOC holder was not familiar with the maintenance requirements of DC3 aircraft. He was neither included in the planning, nor made aware of the reporting procedure for the maintenance, of VH-EDC. Consequently, he did not exercise any control or monitoring of maintenance of the aircraft.

(e) Flight crew

The co-pilot's mishandling of the aircraft's flight controls after the engine was shut down is probably directly attributable to his lack of experience and training in similar situations. The pilot in command functioned only as support pilot, in accordance with one of the two available crew take-off procedures contained in the operations manual. However, the pilot in command had not ensured that the co-pilot was competent to operate the aircraft at high gross weights from the right control position. The appropriateness of the particular procedure adopted should therefore have been conditional upon the circumstances existing at the time.

The reason for the acceptance of the co-pilot's claimed endorsement training by the pilot in command in his role as DC3 flight captain ~~may~~ probably ~~have~~ resulted from his perception of an apparently credible existing situation. The co-pilot, as the owner of VH-EDC, had been involved in the operation of the aircraft from the time of its purchase. He had flown the aircraft as pilot in command before the DC3 flight captain became involved. This may have given the impression that he was qualified to fly the DC3 as either the co-pilot or as the pilot in command.

Did we ask him this?

The crew indicated that they had not received any CRM training. Appropriate CRM during the engine malfunction should have led to a more effective response to the malfunction by ensuring the best use of available resources. The use of the operations manual's alternative procedure during takeoff would have enabled the pilot in command to optimise the aircraft's performance, possibly avoiding the need to ditch the aircraft.

The crew displayed a lack of understanding of the link between aircraft weight increase beyond MTOW and increase in the required take-off safety speed. It could be expected that knowledge of this factor would have led the crew to confirm the actual aircraft weight. They would then have been able to properly assess the implications of operating the aircraft with a known overload.

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(f) Flight attendant

The flight attendant had not fastened her shoulder harness, and was unable to recall the circumstances in which she had released her lap belt. She had received training which should have been sufficient to enable her to manage the situation with which she was faced. However the flight attendant had not fully recognised the need to first ensure her own safety in order to be able to fulfil her passenger safety function.

2.4.6 Checking and supervision by the AOC holder and operator

The AOC holder had been assessed by the CAA to be competent to ensure the continuing compliance by the operator with operational and maintenance requirements. However, there is no indication that the AOC holder recognised that under the terms of both the AOC and the maintenance certificate of approval, the AOC holder was ultimately responsible for safety compliance.

The evidence suggests that the AOC holder considered that the operator's considerable aviation experience was such that monitoring of the operation was not warranted.

The oversight of maintenance management by the AOC holder did not eventuate, and the chief pilot's involvement in the management of the DC3 operation was limited to administrative functions. The AOC holder did not advise the CAA that the maintenance manager had resigned. Consequently, CAA Moorabbin was not aware that the maintenance management plan was no longer valid.

The use of the existing AOC was probably seen by the operator as a convenient and expeditious means of commencing the DC3 operation. There was no evidence of a commitment by the operator to ensure that safety monitoring by the AOC holder was enabled through proper communication and documentation. Consequently, the chief pilot may have gained the impression that he was not expected to assume responsibility for the operation. This is evident from the lack of involvement by the chief pilot in the management of the DC3 operation, despite being the responsible person designated by the CAA.

The lack of monitoring of the DC3 operation by the AOC holder was compounded by the lack of CAA surveillance. Consequently, the CAA was not aware that there was no effective supervision of the DC3 operation.

2.4.7 Record keeping by the operator

The AOC holder had not ensured that the DC3 flight captain had established a formal recording system for DC3 flight crew qualifications and check and training. Consequently, the investigation could not determine if the DC3 flight captain established the credentials of pilots used by the operator. There was no evidence available to indicate that he verified the co-pilot's licences or endorsements, or his ability to operate a DC3 on one engine at representative weights following an engine failure on takeoff. Neither the operator nor the co-pilot provided documentary records to substantiate that the co-pilot had completed the training necessary to qualify as a DC3 co-pilot or as a pilot in command.

The operator was operating the aircraft without ensuring that the aircraft maintenance history records were complete and accurate. Consequently, the investigation was unable to identify maintenance performed, or ADs and other requirements complied with during a period of more than 12,000 hours flight time. The available records reflected a lack of diligence in accurately recording maintenance required and maintenance performed.

2.4.8 Operator's manuals and procedures

The failure by the CAA to ensure that the operator's operations manual was properly assessed for relevance and accuracy provided the opportunity for erroneous material to be used to justify operations of an unsafe nature and for conflicting information to remain in the manual. This is evidenced by the retention in the manual, up to the time of the accident, of non-approved take-off and landing performance charts, and the inclusion of conflicting instructions relating to flight crew procedures when the co-pilot is conducting the takeoff. The use of the approved performance charts would have shown that the proposed charter flight could not comply with either the landing weight or take-off weight requirements at Lord Howe Island.

The inclusion in the operations manual of the procedure adopted by the pilot in command, which permitted the co-pilot to continue to handle the aircraft while the pilot in command performed the support function, was inappropriate. The right control position instrument panel was not provided with flight attitude instruments. Consequently, accurate control of the aircraft in all circumstances when flown from the right control position could not be assured. The pilot in command's use of the procedure on this occasion was also inappropriate, as he had not confirmed that the co-pilot was capable of correctly handling the aircraft from the right control position following engine failure on takeoff, with the aircraft at high gross weight.

A proper appraisal of the operations manual should have identified and resolved the conflicting flight crew procedures. The pilot in command would then have been better placed to assess the effect of the engine malfunction on the aircraft performance.

2.4.9 Task performance by the operator

The use of the DC3 for the charter flight was inappropriate. Had the hirer been quoted a correct load capability, the task should not have been awarded. Use of the correct take-off performance chart clearly precluded operations at Lord Howe Island. However, invalid performance charts were used to justify the operation. In addition, the aircraft did not comply with EROPS requirements.

The load capability quoted by the operator for the flight was significantly overstated. As well as not including the weight of operator equipment, it also did not include the weights of required emergency equipment, including life rafts. The omission of these items from the aircraft load calculations may have been an oversight. It is also possible that the declared load capability was intentionally overstated.

The operations manual required that the pilot in command should review the weight of any item if there was doubt about the accuracy of the declared weight. Both pilots expressed concern when the passengers and their equipment arrived, and, although a load manifest was not provided, they did not attempt to confirm the weight of the load.

The flight crew may not have been aware of the extent to which the aircraft weight exceeded the MTOW. This is evidenced by their lack of recognition of the need to confirm the aircraft weight or to change their operating procedures during the takeoff. Apparently unaware of the need to increase the take-off safety speed linearly with increase in aircraft weight beyond MTOW, the crew did not recognise that confirmation of the actual aircraft weight was critical. Consequently, the standard take-off safety speed of 81 kts adopted by the crew was not appropriate for the overloaded condition of the aircraft.

The pre-takeoff briefing was general in nature, again indicating that the crew were not aware of the need for an emphasis on particular procedures relating to the effect of high gross weight on aircraft performance.

The non-compliance with EROPS requirements is also consistent with other aspects of the company approach to the planning of the charter flight. The investigation team was unable to determine whether the operator attempted to clarify the intent of the applicable CAO and AD.

2.5 Organisational factors

Organisational factors are weaknesses or inadequacies which are not readily apparent, and which may remain dormant in organisations for extended periods. These latent failures become apparent when combined with active failures, resulting in a breakdown of safety.

2.5.1 CAA procedures (operations and airworthiness)

When assessing operators for approval of variations to AOCs and to certificates of approval, CAA officers were permitted to apply discretionary judgement, and were expected to 'act in a reasonably flexible manner' when considering the extent to which the MAOC guidelines should be complied with. CAA Moorabbin established procedures which were intended to ensure that the DC3 operation complied with regulatory requirements. However, as the officers were not sufficiently familiar with the regulatory requirements for the operation of DC3 type aircraft, the approach adopted was inadequate.

The CAA management's monitoring of the performance of officers in the exercise of their regulatory responsibilities was inadequate. CAA management did not ensure that the discretionary powers were appropriately applied and that the intent of the MAOC was achieved.

The CAA failed to restrict use of the information contained on the computerised aircraft register until that information had been audited. Consequently, there was no procedure in place to prevent the CAA

Moorabbin Office from producing an incorrect duplicate certificate of airworthiness for VH-EDC.

The operator submitted, and the CAA 'accepted', an operations manual which contained significant errors. These included omissions, inappropriate inclusions (notably aircraft performance charts), and potentially misleading duplications. These deficiencies were either directly related to the justification for the planning of the flight, or were critical to the circumstances of the response to the emergency. At the time of accepting the manual, however, the CAA did not identify these errors.

The CAA procedures or standards for the approval of overhaul time extension of this type of engine were inadequate to ensure that engines approved to continue in service were in fact safe to do so. This is evident by the failure of the CAA to recognise the implications for engine integrity of the SOAP analysis information supplied by the operator, and the limited operational period during which the operator had been monitoring the engine.

2.5.2 Control and monitoring of the AOC holder and operator

Prior to approval of the addition of the DC3 type aircraft to the AOC, the CAA was required to establish that the operator had the capability to maintain an acceptable standard of compliance with the regulatory requirements. The MAOC-recommended inspections were not conducted, nor was the NASS applied to the operation to ensure the operator's continuing compliance with required airworthiness standards.

Consequently, CAA Moorabbin did not recognise that the proposed operator/AOC holder structure and facilities were not appropriate for the DC3 operation. The requirement to ensure that the operator was capable of operating and maintaining the aircraft in the transport category was therefore not met.

The surveillance procedures established by CAA Moorabbin were dependent upon the chief pilot and the engineering manager of the AOC holder being responsible to the CAA for the operational and maintenance management, although neither had experience relevant to this category of aircraft. These procedures failed when the CAA was not advised that the engineering manager had resigned, and when it remained unaware that the chief pilot was not involved by the operator in other than an administrative capacity.

The low priority afforded by the CAA for surveillance of the operation of VH-EDC was due, at least in part, to there being only one operational aircraft. However, the investigation has been unable to determine why CAA Bankstown, over a period of about 13 months following acceptance of responsibility for airworthiness surveillance, failed to plan any surveillance of the operator's base, even though it was aware of operational and maintenance discrepancies.

The MAOC-recommended surveillance of the operator/AOC holder prior to approval of the variation to the AOC would have enabled CAA officers to be sufficiently aware of the proposed operation. This awareness should have identified deficiencies both in the proposed maintenance management structure and in operational aspects. The lack of a surveillance program suggests that CAA management had not ensured that officers recognised the level of responsibility associated with the exercise of discretionary powers.

2.5.3 Communications

(a) Communication and co-ordination between the CAA offices and between the CAA functional branches

This was not effective. This is evidenced by the following:

- CAA Central Office did not ensure that all staff were fully aware of limitations on the use of the aircraft register until after an audit could be conducted to qualify and validate the data. They were not aware of the extent to which staff were accessing and applying the unaudited data.

- The CAA had implemented systems and protocols, including the MAOC. However, these systems were not always provided with the means necessary to ensure their effectiveness. This is evidenced by the failure of the officers concerned, and their management, to recognise the potential consequences resulting from the lack of a MOU between the Moorabbin and Bankstown offices.

- There is no record of CAA Bankstown being consulted by CAA Moorabbin concerning the request for the DC3 Camden-based operation to be included on the AOC of a Melbourne-based company. This was despite the aircraft file being held at Bankstown. Had this information been provided, CAA Bankstown should have advised CAA Moorabbin of its contact with the operator regarding the maintenance management classification of the aircraft.

- There was a lack of co-ordination between the CAA airworthiness and CAA operational areas when developing or modifying CAOs. This is evidenced by the inadequate cross referencing between CAO 20.7.1B Issue 2 and AD /Gen /69 Amdt 1, 3/90, relating to EROPS, current at the time of the accident. This lack of cross-referencing suggests that there was inadequate communication between the CAA branches during development or modification of operational and airworthiness requirements.

(b) <u>Communications between the CAA and the AOC holder</u>

- The CAA was not aware of the departure of the AOC holder's engineering manager, without whom the CAA's required DC3 maintenance management structure was not functional.

- When advising the operator concerning the requirement to use the correct performance charts and maintenance procedures, the CAA did not ensure that the AOC holder was also advised of the requirements.

- CAA Bankstown experienced difficulty when attempting to co-ordinate, with the operator, surveillance of the Camden facility. This was due, in part, to an inability to communicate with the principal of the operator, who was frequently engaged in aircraft maintenance management commitments overseas. However, there was no record of any formalised communication procedure, or of any attempts by CAA district offices to communicate with the AOC holder to facilitate access to the operator.

(c) Communications between the AOC holder and the operator

The AOC holder was unable to meet its responsibilities to the CAA due to an inadequate level of communication with the operator.

- The operator did not advise the chief pilot concerning the CAA requirement to remove the invalid performance charts from the operations manual and to use only the correct charts. Also, the AOC holder was not aware that the CAA had required that the operator should maintain the aircraft to the transport category standard.

2.5.4 Training of CAA staff

There are no details here of the training which was provided. Was there any - why was it inadequate?

Inadequate training of staff had led to differences in the understanding of, and approach by, CAA officers to industry situations. Consequently, the degree of discretion in the conduct of their duties afforded officers by the Authority, had led to variations in the safety standards applied to industry.

- A lack of familiarity by CAA staff with requirements both for the commercial operation of DC3 aircraft and the AOC approval procedures in general, was evident. CAA Moorabbin staff were not sufficiently familiar with the definition and implications of transport-category and normal-category aircraft.

How should they/could they have done so?

- The CAA had not ensured that staff were adequately trained in the use of the computerised aircraft register database before it became possible to produce documentation from the database. They did not ensure!

- CAA staff did not recognise the need to refer to available information regarding the aircraft, the facilities, and the operator during the certificate of approval and AOC approval processes.

- The approval process for the variation to the AOC, and the subsequent inadequate monitoring of the operation, suggested that management had not ensured that staff recognised the critical safety function of surveillance.

- The failure to recognise the safety implications of the left engine SOAP analysis report when approving the engine for a TBO extension, suggested that the CAA staff concerned were not ~~sufficiently~~ appropriately ~~qualified~~ experienced. Alternatively they didn't read it!

- Individual CAA officers were attempting to apply a more stringent interpretation of CAA policy in the absence of clear guidelines. An example was the lack of guidance on the granting of concessions to concurrently exceed the TBO of both engines on an aircraft.

  How does this relate to training? Inconsistency

- CAA Bankstown staff were inadequately trained to assess pilots' qualifications for issue of aircraft ratings. This is evidenced by the issue of a DC3 type rating to the co-pilot without his production of adequate substantiation of the required training.

2.5.5 CAA regulation and standard setting

- Although the intent of CAO 20.11 5.1.1 may be that only one type of life jacket should be used, this was not specified by the CAO. By not ensuring clarity of intent in the CAO, the CAA had apparently not recognised the potential consequences for passenger safety.

- The published CAA requirements for EROPS, applicable to DC3 type aircraft, were inadequately presented. This was evidenced by the confusion experienced by both operators and CAA staff in attempting to determine their applicability to the DC3.

- Acceptance by the CAA of the operations manual failed to identify the incorrect and invalid data and instructions included in the manual. Further, the inclusion in the operations manual, without CAA 'approval', of the flight manual requirements which are normally subject to a CAA 'approval' process, could have directly contributed to the use by the operator of invalid performance charts to plan the flight.

  or 'not approved.' — Non approved

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There seems to be a confusion here as to whether the problem was because the manuals/procedures/rules didn't accord the SOAP analysis the importance it needs/ or whether they did, but the officers didn't understand the rules

Were these specified somewhere? Did the CAA office have the criteria? Did the criteria include SOAP report/analysis.

- The criteria by which the CAA required that applications for engine TBO extension be assessed were deficient. This was evidenced by the apparent lack of recognition by the CAA of the importance of the SOAP report, and of the limited time during which the operator had been monitoring the engine.

2.5.6 Operator's training

The operator did not maintain adequate check-and-training records. Consequently, the actual training conducted could not be verified.

Since becoming a DC3 crew member, the co-pilot had not been required by the pilot in command, as DC3 flight captain, to demonstrate aircraft handling ability other than during a command instrument rating test, reported to have been conducted about four months prior to the accident. There was no evidence that the co-pilot had previously experienced asymmetric operations in DC3 aircraft at high gross weight, or when operating the aircraft from the right control position.

Following the engine malfunction, the co-pilot handled the aircraft controls inappropriately, suggesting a misunderstanding of basic aircraft asymmetric handling technique. He was unable to substantiate completion of the training required by the CAA to qualify for issue of a DC3 rating.

2.5.7 Operator's maintenance management

When the CAA planned maintenance management structure failed, no apparent attempt was made by either the operator or the AOC holder to rectify the deficiency.

The operator's procedures were inadequate to ensure that maintenance records were correctly annotated and maintained. The aircraft logbooks did not adequately reflect the maintenance status of the aircraft. The logbooks contained certifications for procedures which had not been completed, and some maintenance procedures reported by the operator to have been performed were not recorded. Further, the operator had not ensured that the aircraft maintenance history was properly verified, as it was unable to substantiate maintenance certification for the period June

1977 to May 1988.

The overrun of the left engine TBO also reflected the operator's inadequate maintenance management procedures. The current maintenance release was not annotated to indicate to flight crew the aircraft hours to which the engine was life limited. Consequently, the flight crew were not alerted as to when the engine had reached its approved life.

The identified deficiencies in the maintenance and installation of seat belts and seat fittings indicated inadequate qualified supervision by both the operator and the AOC holder. The failure of the maintenance management structure and the lack of maintenance supervision by the AOC holder suggested that the AOC holder considered that all it was expected to do was to facilitate the CAA approval of the DC3 operation.

2.5.8 Operator's procedures (operations and maintenance)

The AOC holder may not have fully understood the implications for the management of a commercial DC3 operation remote from its main base. The holder did not implement procedures to ensure that the nominated managers, despite lacking DC3 experience, could exercise an effective monitoring role. That this did not occur is evident by the virtual isolation of the AOC holder's nominated managers from the operational and maintenance control of the DC3 operation.

The lack of an effective DC3 operational safety and supervisory structure within the AOC holder was responsible for a number of the operational failures identified by the investigation. The appointment of a DC3 flight and check-and-training captain, of itself, was not sufficient. The chief pilot, in order to meet his responsibilities, needed to be more closely involved in the operational planning for the DC3. Similarly, the CAA-approved maintenance management structure was not recognised by the AOC holder to be essential to meeting its maintenance management responsibilities.

The operator was aware that the aircraft maintenance procedures were required to comply with transport category standards. It was also aware that the operations manual contained invalid data. However, the operator had not corrected either concern prior to the accident.

The adoption by the pilot in command of the operations manual procedure which permitted the co-pilot to continue as the handling pilot following an engine failure during takeoff, was not sound. The pilot in command was significantly more experienced than the co-pilot, and the right control position was not equipped with flight attitude instruments. The alternative procedure ensured the best use of available crew resources and was therefore more appropriate to the circumstances of the takeoff on the accident flight.

2.6 Summary

The flight crew were aware that the aircraft performance charts used to bid for and plan the flight were not valid. However, they were also aware that the use of the correct charts would preclude the flight.

The origin of the defect determined to have most likely caused the left engine malfunction could not be established. However, an appropriate response by the CAA to the left engine condition information should have prevented further operation of the engine.

The pilot in command recognised that the aircraft was heavily loaded. He had the option of conducting the takeoff himself to ensure that the aircraft performance was maximised. However, he not only permitted the inexperienced co-pilot to conduct the takeoff but also chose not to follow through on the controls. Consequently, when the engine malfunction occurred, the pilot in command did not take over control of the aircraft, but complied with the assessment by the co-pilot that the engine should be shut down. Further, following the engine shutdown, the pilot in command did not respond to the inadequate aircraft handling by the co-pilot until the only option available was to ditch the aircraft.

The success of the subsequent ditching resulted in minimal injuries to the passengers and crew. Preventable injuries were sustained by some crew members who chose to not use the full restraint harnesses provided.

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The timely rescue of the aircraft occupants was facilitated by the calm waters of the bay and the presence nearby of a number of small pleasure craft and a volunteer coastal patrol vessel.

3. CONCLUSIONS

3.1 Findings

1. The pilot in command was correctly licensed and endorsed.

2. The aircraft owner/co-pilot applied for and was granted a DC3 type rating, despite not being able to substantiate completion of the required training.

3. The pilot in command, as check-and-training captain, had not adequately confirmed the status or capabilities of the co-pilot in the response to an EFATO at high weights or as the pilot flying from the right control position.

4. The chief pilot did not adequately supervise the DC3 operation.

5. The DC3 operations manual contained conflicting instructions relating to crew procedures when the co-pilot was the handling pilot during takeoff.

6. The operator was aware that the operations manual contained an ~~invalid~~ performance chart. Although directed to by the CAA, the operator had not removed the chart. (not approved?)

7. The invalid take-off performance chart was used by the operator to bid for and be awarded a task which was beyond its capability to perform safely. ~~the aircraft~~?

8. The operator provided the charterer with an incorrect load capability.

9. The pilot in command was concerned that the load delivered was greater than had been anticipated, but did not require verification to prevent the aircraft being overloaded.

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10. The flight crew were not aware that if the aircraft weight exceeded the MTOW, the take-off safety speed would need to be increased.

11. The pilot in command did not initially take over the controls following the engine malfunction.

12. The co-pilot was inadequately trained to respond appropriately to the loss of aircraft performance following the engine malfunction.

13. The left propeller did not fully feather; however, the blade angle achieved was sufficient to stop rotation of the engine.

14. Degradation of the aircraft's performance was consistent with the overloaded condition of the aircraft, mishandling of the flight controls, and the inability of the propeller to feather fully.

15. The pilot in command resumed control and ditched the aircraft adjacent to the southern end of the third runway.

16. The CAA documentation on EROPS was unclear and ambiguous.

17. The CAA did not ensure that the aircraft was maintained in accordance with the requirements of the transport category.

18. The left engine malfunction was most likely due to the incorrect assembly of the no. 3 cylinder inlet valve rocker mechanism which allowed a thrust washer to jam the valve open.

19. The metal found in the oil samples taken from the left engine at the time of the application for the TBO extension could be attributed to the incorrectly fitted inlet valve rocker mechanism and a worn magneto drive shaft spline.

20. The operator applied for, and was granted, an extension of the TBO for the left engine based, in part, on test results that indicated that further engine inspection was warranted.

21. The flight attendant was qualified as an aircrew member.

There don't seem to be any findings about the maintenance of the aircraft or the chief engineer's departure - or are these not relevant to the finding at #18.

Not possible to tie that to a particular event -

22. At the time of impact, the flight attendant was not wearing a restraint harness, and the pilot in command and co-pilot were not wearing shoulder restraints.

23. The flight attendant was unable to direct the evacuation of the aircraft due to the severity of her injuries.

24. All three flight crew members received minor head injuries.

25. Three seat rows detached from the outboard seat rail during the impact. All were inadequately secured prior to the flight.

26. One seat belt detached from the seat structure and three further belts were not correctly secured.

27. Five different types of life jacket were carried on the aircraft.

28. With the exception of the co-pilot, all occupants egressed through the main rear door.

29. The operations manual did not detail the duties to be undertaken by the flight attendant in an emergency and did not adequately address the evacuation of passengers.

30. The ATC, RFFS, FAC, NSW Ambulance, NSW Fire Brigade and NSW Police response was satisfactory and in accordance with the AEP.

31. Passengers and crew were transferred to two separate locations on land by some of the many pleasure craft using Botany Bay at the time of the accident.

32. Following the accident, confirmation of the actual number of persons on board the aircraft took approximately one hour.

33. State and local medical disaster plans were not activated, nor were they required to be.

34. Transfer of passengers from the site to hospitals was performed in a satisfactory manner.

35. Hospital processing of the victims was prompt and efficient.

36. There is no national body with emergency service expertise that has legislative power to investigate emergency service responses.

3.2 Significant factors

The following factors were considered significant in the accident sequence.

1. The use of, and compliance with, the correct performance charts would have precluded the flight.

2. Clear and unambiguous presentation of CAA EROPs documentation should have precluded the flight.

3. The aircraft weight at takeoff exceeded the MTOW, the extent of which was unknown to the crew.

4. An engine malfunction and resultant loss of performance occurred soon after takeoff.
5. The recommended take-off safety speed used by the crew was inappropriate for the overloaded condition of the aircraft.

6. The available single engine aircraft performance was degraded when the co-pilot mishandled the aircraft controls.

7. The pilot in command delayed taking over control of the aircraft until the only remaining option was to conduct a controlled ditching.

8. There were organisational deficiencies in the management and operation of the DC3 involving both the AOC holder and the operator.

9. There were organisational deficiencies in the safety regulation of both the AOC holder and the operator by the CAA district offices at Moorabbin and Bankstown.

10. There were organisational deficiencies relating to safety regulation of EROPS by the CAA.

4. SAFETY ACTIONS

Classification of responses

The Civil Aviation Safety Authority and Airservices Australia respond to the Bureau's formal recommendations in accordance with a memorandum of understanding. Although no formal procedures are in place for other respondents to Bureau recommendations, the expectation is that responses will be received from all recipients.

Responses are considered against the occurrence report and/or the recommendation text and an assessment is made as to the acceptability of the response. These assessments do not necessarily indicate whether or not a particular recommendation has been accepted by the action agency, either fully or in part, but that the agency has:

- considered the implications of the recommendation;
- correctly recognised the recommendation's intent without misinterpretation;
- offered, if applicable, acceptable counter-arguments against implementation; or
- offered an alternate means of compliance; and
- identified, if appropriate, a timetable for implementation.

Responses are classified as follows:

(i) CLOSED - ACCEPTED. The response is accepted by the Bureau without qualification.

(ii) CLOSED - PARTIALLY ACCEPTED. The response, in part, is accepted by the Bureau. The unacceptable part is not worthy, by itself, of further correspondence.

(iii) CLOSED - NOT ACCEPTED. The unacceptable response has been closed by the Bureau as not worthy, by itself, of further correspondence.

(iv) OPEN. The response does not meet some, or all, of the criteria for acceptability to a recommendation which BASI considers safety significant and further correspondence will be entered into. Safety advisory notices do not require a response. Any received by the Bureau are published but not classified.

Safety outputs

Bureau safety outputs appear in bold. They are reproduced from original Bureau documents and may vary in textual layout.

Response text

Response text appears in italics and is reproduced as received by the Bureau.

4.1 Interim recommendations

During the course of this investigation a number of interim recommendations (IRs) were made to the then Civil Aviation Authority. The IR documents included a 'Summary of Deficiency' section in addition to the actual interim recommendation. The text of the interim recommendations are detailed below, with each IR commencing with its BASI reference number. The pertinent comments from the CAA in response to the recommendations are also reproduced.

IR940186 **The Bureau of Air Safety Investigation recommends that the CAA review its procedures with respect to the notification of people on board to ensure that the information supplied is timely, accurate and credible.**

CAA response:

The current wording of AIP OPS FPLAN-6 provides the trigger for pilots to supply amended persons on board (POB) numbers to ATS.

To modify the requirement for all flights from "should notify" to "must notify" changes to the previously supplied POB figures would impose a number of practical difficulties and workload considerations on both the industry and the Authority. Whilst it would impose an increase in workload for departures from a control zone, it would impose additional reporting and equipment requirements on VFR flights departing aerodromes outside controlled airspace who have notified details but which may or may not carry radio.

IFR flights currently have a requirement to notify ATS of their movements for traffic and SAR alerting purposes. The additional notification of POB carried by IFR operations for each flight stage would probably not have a marked effect on ATS workload.

In recognition of the Bureau's concerns regarding the notification of POB, the Authority is processing an amendment to AIP OPS FPLAN-6 to reflect the notification of POB by altering the table at paragraph 4.1 to delete (j) and to substitute alternate text in lieu as a new paragraph 3.5.

"3.5 In addition to including POB numbers with the flight notification , pilots of IFR flights operating as other than RPT must notify ATS, on first radio contact, of the number of persons on board for each flight stage.

3.5.1 Pilots of flights operating as RPT must ensure a suitable passenger manifest is held by the company, detailing POB for each flight stage. Notification of changes may be made to ATS where it is impracticable for the pilot to provide notification of amendments to the company.

3.5.2 Pilots of VFR flights must include POB when submitting flight notification or when leaving a flight note and are encouraged to notify ATS of any subsequent changes."

Response Classification: CLOSED - ACCEPTED

IR940256 **That the Civil Aviation Authority review the accuracy of the Aircraft Register computer database and the procedures for issuing duplicate**

8

Certificates of Airworthiness or other information from that source.

CAA response:

This Authority has considered the Interim Recommendation and a review of the Aircraft Register data base and procedures for issuing information will be conducted.

Response Classification: CLOSED - ACCEPTED

IR940258 That the Civil Aviation Authority ensure that the procedures of the ASSP surveillance system are specific enough to ensure that:

(a) the areas of responsibility and surveillance control between regional offices, for Certificate of Approval holders who operate interstate are defined; and

(b) the responsibilities for initiating the surveillance plan and process are conducted in a timely manner when it becomes apparent that the surveillance task for a particular Certificate of Approval holder crosses 'state or jurisdiction boundaries'.

CAA response:

I refer to BASI Interim Recommendation R940258 regarding surveillance of a "new" operator.

Under the Aviation Safety Surveillance Program (ASSP), the controlling District Office (Moorabbin) is required to ensure a surveillance program has been prepared for the Camden location by the conducting office (Bankstown).

The conducting office would have final responsibility for planning and *conducting the surveillance at the Camden location and would be required to provide a copy of their surveillance plans and a copy of their surveillance results to the controlling office.*

As part of the ongoing improvement to ASSP, the latest amendment due to be incorporated in the ASSP Manual in November 1994 will specify the requirements and responsibilities outlined above in more detail via a memorandum of understanding between the controlling and conducting office.

Response Classification: CLOSED - ACCEPTED

IR940260 That the Civil Aviation Authority:

(a) consider the mandatory, phased introduction of the loose leaf logbook to replace those older logbooks which, due to the passage of time, have become obsolete and provide inadequate records of a continuing airworthiness and history audit trail;

(b) ensure that future recipients of an aircraft coming from airline type service are required to address the issue of continuity of records, prior certifications for ADs and component changes, establish the time-in-service of lifed components and provide a compliance statement for the logbooks which can be easily verified during the surveillance process; and

(c) ensure that current owners of aircraft which were previously in airline service, or which had previously been maintained to an approved system of maintenance which did not require the use of the aircraft and component logbooks, review their maintenance records to ensure continuity and validity with respect to mandatory requirements.

CAA response:

The Authority shares your concerns regarding the record keeping and retention aspects associated with the maintenance of VH-EDC. Shortcomings in the style of logbooks for various classes of aircraft are also recognised.

It is not intended at present, however, to mandate the use of the "loose leaf" log book in that it is not suitable in all respects for all aircraft. A new light aircraft log book is being developed to be used for light aircraft.

Legislation is being developed to strengthen the requirement for better airworthiness record control which will include consideration of continuity from one type of service to another.

Response Classification: CLOSED - ACCEPTED

IR940296 **The Bureau of Air Safety Investigation recommends that the Civil Aviation Authority ensure that Company Operations Manuals, in addition to meeting the requirements of CAO 40.1.0, contain procedures which will ensure that co-pilots being tasked with flying sectors have attained a recognised proficiency level to conduct take-off and landings, including practice engine failure and handling, prior to them flying aircraft on passenger carrying operations.**

Note: This could well be addressed by review and amendment to CAO 40.1.0 such that co-pilots, prior to conducting sector flying, must comply with the training requirements of appendix 3 (d).

CAA response:

No response received to date.

IR940297 **The Bureau of Air Safety Investigation recommends**

that the Civil Aviation Authority review CAO 40.1.0 appendix III to require that asymmetric flight training, in aircraft above 5,700 kg and where a simulator is not available, include at least one takeoff, with a practice engine failure, at 90% of maximum take-off weight or equivalent simulated conditions.

CAA response:

No response received to date.

IR940298 **The Bureau of Air Safety Investigation recommends that the Civil Aviation Authority:**

(i) Review the standard of operations manuals, in respect to CRM, to ensure that aircraft operating with two crew have crew resource management procedures established, and documented, for the type of aircraft being operated and that crews receive adequate training in CRM.

Note: This is particularly relevant to older/vintage type aircraft operations.

(ii) Consider an additional training requirement to enable takeoffs and landings to be carried out safely from the right seat of aircraft in which there is limited flight instrumentation on the co-pilot side.

CAA response:

I refer to Air Safety Interim Recommendation No IR940298 regarding the accident involving VH-EDC on 24 April 1994.

In response to the Bureau's recommendation, we offer the following *comment :*

(i) Crew Resource Management (CRM) procedures and training are not mandatory requirements for any operations by Australian flight crews. Consequently, operators are not required to have CRM procedures in their operations manuals.

Except for this incident, there have been no surveillance reports to indicate that existing multi-crew operating procedures are deficient. In view of this, a widespread review of multi-crew operating procedures is not considered justified at this stage. Nevertheless, action will be taken to review multi-crew operating procedures in older/vintage aircraft.

Recent overseas studies have identified CRM as being crucial to the safe operation of multi-crew aircraft. The CAA is reviewing these studies to determine whether CRM should be a mandatory training requirement.

(ii) The CAA will also review the training requirements for multi-crew aircraft where take-offs and landings are performed from the right seat, and where there are deficiencies in aircraft instrumentation on the co-pilots side.

Response Classification: OPEN

IR 940301 The Bureau of Air Safety Investigation recommends that the Civil Aviation Authority review CAO 20.11 14.1.3 with a view to ensuring that safety briefing cards present information to passengers in the most effective manner.

CAA response:

I refer to BASI Air Safety Interim Recommendation IR940301 regarding the accident involving VH-EDC at Botany Bay on 24 April 1995.

The Bureau's recommendation that the Authority review CAO 20.11.14.1.3 in relation to the presentation of passenger briefing cards is supported.

CAO 20.11.14 is currently being reviewed and the required information and manner of presentation of the brace position on these cards will be updated to ensure that the cards provide the appropriate information to passengers.
Response Classification: CLOSED - ACCEPTED

4.2 Final recommendations

This sub-section may be required for the final report.

4.3 Safety advisory notices

The following safety advisory notices were issued:

SAN 940299 **That the Civil Aviation Authority consider the publication of information to the industry identifying:**

(i) details of this incident where abnormal wear of driving gear splines remained undetected;

(ii) the need for continued vigilance when carrying out magneto timing and synchronisation checks of P&W R1830 series engines;

(iii) the importance of magneto driving gear spline inspection and re-lubrication whenever magnetos are removed and splines exposed during in-service maintenance; and

(iv) the requirement to document and certify for component removal and replacement.

CAA response:

The Authority concurs with the suggestions contained in the Safety Advisory Notice.

Information will be issued to all operators of Pratt and Whitney R1830 engines concerning the technical aspects of the Bureau's findings as a result of the incident investigation.

A copy of this advice will be forwarded for your information.

SAN 940302 **It is apparent that the orders relating to the carriage of life jackets are open to interpretation. As a result there is a potential to degrade the level of safety afforded to passengers.**

CAA response:

It is considered that the carriage of numerous types of lifejackets in the one aircraft is undesirable and a potential safety hazard.

The Authority will review the Order relating to the carriage of lifejackets in order to rectify the problems encountered.

4.4 Safety action taken

Water rescue services

In November 1993, the CAA made the decision to introduce inflatable rubber dinghies in order to facilitate the first stage of rescue actions at RFFS services aerodromes near water. The dinghies would be used to transport life rafts to survivors within 1 km of the runway. This would allow survivors to be removed from the water in the most expeditious manner possible. The second stage of the rescue would be performed by other agencies such as the Water Police, MSB and Coast Guard.

The first airport to be provided with such facilities was Hobart. This was intended to be followed by Sydney, with two boats expected to be operational by September 1994. Brisbane, Coolangatta, Mackay and Cairns were also proposed as possible sites. The RFFS initiated a project in November 1993 to provide water rescue services within 1 km of the end of runways near water at RFFS serviced aerodromes.

BO 9401043 VH-EDC Engineering Group Report

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Accident BO9401043 - VH-EDC Botany Bay 24 April 1994
Engineering Group Report ~~AS AT 3 AUGUST 1994~~ ~~25 August 1994~~ ~~7 October 94~~ 5 May 1995

Engineering team:

s.47F(1) [redacted]

1 Aircraft recovery

(This section has been included as background information to explain the salvage process and to identify the aircraft damage which occured as the result of salvage and which was not pre-existing or sustained as a direct result of impact with the water.)

Shortly after take-off from runway 16 at Sydney Airport the aircraft was ditched into the sea adjacent to the end of the new third runway following a reported malfunction and power loss of the left engine. The decision to ditch was taken when the aircraft failed to climb after the left engine was shutdown and the propeller feathered. Prior to water impact, power on the right engine was reduced by the pilot closing the throttle. The right engine separated from the engine nacelle, at the firewall, when the aircraft impacted the water. Aircraft speed at impact was estimated to be 60 - 65 knots. The left engine and propeller remained attached to the aircraft.

After ditching (at approximately 0910 hours) the aircraft floated on the outgoing tide for a reported 12 - 15 minutes prior to sinking in approximately 16 metres of water, 100 metres from the seawall and approximately 75 metres SE of the South Cardinal Mark (Buoy).
This buoy is located at - Longitude: 151^0 11'33.89E Latitude: 33^0 58'33.94S.

During this period, whilst the aircraft was floating, unsuccessful attempts were made by one of the attendant boats to tow the aircraft closer to the seawall.

1.1 Aircraft complete with left engine/propeller:

Salvage/recovery from the sea was carried out by:- Gray Diving Services P/L, Diving and Marine contractors s.47F(1) [redacted] under the auspices of the insurance agents and organisation of s.47F(1) [redacted] of the Federal Airports Corporation (FAC). s.47F(1) [redacted] was present on the barge during the recovery salvage operation but took no active part in recovery until the aircraft was on the shore.

The aircraft was finally removed from the water in the early hours of 26 April and transported to Hangar 13 at Mascot.

Salvage was accomplished as follows:-

. A crane barge was moored above the aircraft. This barge was anchored from two fore lines adjacent to the seawall to winches on the barge deck.

. The aircraft buoyancy was adjusted using airbags attached to the nose section through the open cockpit windows and the tail section. Sufficient air was injected into the nose bags to minimise the aircraft weight on the seabed.

. Lifting slings were attached to the rear fuselage lifting eye on the top fuselage above the toilet area, between the left engine and the propeller and by a wire cable through the right main wheel axle.

. With the weight of the aircraft supported just free of the seabed by the airbags and slings, the barge was winched forward onto its anchors.

. Frequent adjustments to the crane height and jib position were made as the aircraft was dragged along the undulating seabed into shallower water.

. To enable the 200 tonne shoreside crane to be jibbed down and attached to the aircraft slings the aircraft had to be manouvred from beneath the barge. When the aircraft was at about the 5 metre depth level a launch was secured to the aircraft rear lifting attachment and, whilst the crane jib was being turned to the left side of the barge, the tail of the aircraft was dragged out free from the barge lower surface by the launch.

. Further manoeuvering with this lift brought the aircraft close enough to the seawall for the landbased crane extended jib to take over the lift to shore.

. Although the lift was a slow one, to allow the trapped water to drain, the angle of the aircraft allowed residual water which was trapped within the fuselage to accumulate in the tail section behind the cabin door.

. Before the aircraft was fully out of the water the rear fuselage lifting fitting broke free from the fuselage , dropped the tail and allowed all of the weight to be transmitted to the forward slinging points. This resulted in the left engine mountings breaking, and addition loads to be carried by the right main landing gear from which the aircraft was slung.

. The aircraft was subsequently lowered back onto the seabed alongside the seawall to enable a new slinging arrangement to be fitted. As the weight was taken off the forward slings the left engine sagged below the normal thrust line for the engine and the broken right landing gear was trapped beneath the lower wing skin causing considerable additional damage.

. Lifting bands were fitted around the leading and trailing edges at the centre wing sections and around the fuselage at the tail. Subsequent lifting and fuselage draining using this method extensively damaged the wing leading and trailing edges, flaps and the centre section lower skins.

. The aircraft was finally lifted from the water and lowered onto a flat-top low

loader for transportation to the hangar for detailed examination.
. It was necessary to remove the lower section of the right main landing gear, complete with wheel assy and broken rear drag brace strut to facilitate this action. A locking pin was inserted into the landing gear upper strut to prevent the gear collapsing when it was off-loaded in the hangar.

Investigator Comment: Much of the physical damage to the aircraft was sustained during the salvage/recovery operation. Apart from the damage to the firewall of the right nacelle when the right engine separated at water impact physical damage to the aircraft structure from water impact was minimal. Subtle secondary damage due to salt water immersion will also be extensive.

1.2 Right engine/propeller assembly:

Because the aircraft had floated on the outgoing tide after water entry, and the right engine had separated at water impact, the exact location of the separated engine and propeller were unknown. In consideration of the reports from the pilot of the aircraft and the skipper of the coastguard vessel, which was at the scene within a few minutes, a likely search area was determined. Cross referencing this area with the aircraft radar plots, the location of the South Cardinal Mark buoy, (off the end of the third runway) and the third runway site surveyor's report of the aircraft's final resting place on the seabed, we were able to target a more positive area to search.

A search of this area was conducted by s.47F(1) Hydrographic Surveys P/L, using a Klein Dual Channel Sidescan Sonar system and dual channel towfish integrated with a Trimble 4000 SST (DGPS) Global Positioning Receiver. This search identified a major object in the search area 5,7 metres deep with other sundry objects in the vicinity, as well as additional targets outside of the prime target area.

Advise of the location of these targets complete with their ISG, AMG and GPS co-ordinates were sent to the Sydney Water Police (Divers Unit). Divers from this unit were released to assist BASI in the identification and recovery of the engine and propeller assembly by diving Sergeant s.47F(1) A diving team from this unit subsequently identified and recovered minor cowling wreckage from the object No. 1 target area before they located and attached a marker buoy to the engine and propeller assembly. The engine was found sitting nose down on its propeller at the eastern end of a scoured trench approximately 56 metres from the seawall and 215 metres, on a bearing of 285^{0} 17' 14.15, from the buoy called the South Cardinal Mark. This buoy is located at position:- WGS84(GPS) 33 58 26.2879S: 151 11 30.0601E.

***** There needs to be a drawing/sketch of this location for the report*********

A copy of Hydrographics Surveys P/L report H 401 is attached at......**Appendix 1**

Minute Note to File - Coast Guard Report..**Appendix 2**

The Sydney Water Police Divers, using the San Souci Police launch and personnel, floated the engine on airbags and towed it across Botany Bay into the San Souci boat recovery jetty where it was winched ashore.

s.47F(1) [redacted]

2 Post recovery examination

2. 1 Aircraft structure

2.1.1 Right engine nacelle.

The right engine separated from the nacelle at the firewall in a downward movement towards the aircraft centreline. The propeller disc to fuselage clearance was reduced during separation allowing two blade strikes to the fuselage side as the engine passed down and beneath the wing centre section. During separation, disruption of the flexible lines and controls, engine mount structure, nacelle engine fuel filter, shut-off valves and surrounding nacelle structure occurred.

2.1.2 Flight controls.

2.1.2.1 Right Aileron -

The control attachment to the aileron was broken and the control surface jammed in the down position. There was major crumpling of the outboard section skins which were punctured and torn at the mid point. The aileron attachment fittings had been utilised at sometime during the salvage as evidenced by the coils of rope attached to them. The aileron trim tab was set about 2^0-3^0 down. There were no marks to indicate the aileron position in relation to the wing prior to impact. The right aileron damage is consistent with a possible aircraft yaw at impact.
The aileron trim control in the cockpit was set indicating 2 out of 12 right wing down.

2.1.2.2 Left aileron -

A matching score mark on the aileron and wing lower surface near the aileron outer tip, when aligned, would indicate that the mark had been made when the aileron was close to the neutral position. It could not be ascertained whether or not this score had been made at impact or during the subsequent recovery operation.

2.1.2.3 Right and left flaps -

The flaps, being driven by common mechanism, were in the approximate 20-22^0 down position. Flap push pull rods were broken in overload. Both flaps exhibited deformation consistent with water impact. The right flap was extensively damaged when the lifting belly band, about the trailing edge, folded the flap assembly forward beneath the wing structure.

2.1.2.4 Elevator -

The elevator was resting on the lower stops. There was no damage to either elevators or trim tabs. Both trim tabs were in the neutral positions.
The elevator trim control in the cockpit was set at 1^0 nose down.

2.1.2.5 Rudder -

The rudder was resting about 4-5^0 to the right, was free to move without restriction. There was no impact related mark which would indicate it's position at the time of impact. The rudder trim tab was in the neutral position.
The rudder trim control in the cockpit was set indicating 1 out of 12 left.

Rudder, aileron and elevator controls responded normally to cockpit input.

There were no indications, or reported abnormalities prior to impact, which would indicate that these controls were not capable of full and free movement , in the correct sense, prior to water impact.

2.1.3 Emergency Locator Transmitter (ELT)
The ELT fitted to this aircraft was a NARCO ELT Model 10 serial No. A 22782. The battery fitted to this component showed a 'replace by date' of 28 Jul 1992. The battery life had expired 21 months prior to this accident. When this was pointed out to the operator he insisted that the battery had been changed at the 100 hourly period inspection which was completed in March 94. The certification records of this inspection do not reflect this.
The component is being examined by the Flight Recorder section of BASI.

**** **Awaiting ELT report** ******** Completed.

2. 1. 4 Cockpit Inspection:
A detailed inspection of the cockpit area gauges, switches, selectors and engine, hydraulic and landing gear controls was undertaken after recovery of the aircraft to hangar 13 Mascot airport. A copy of that inspection is attached at....... **Appendix 4**
The positions of aircraft flight controls and trims, engine controls (RPM , propeller and mixture) and fuel system management selectors are referred specifically in those

paragraphs of this report which discuss them. ie

- Flight controls - Para 2.1.2
- Fuel system - Para 2.3.2
- Engines - 2.4

2.2 Landing gear

Underwater divers, during recovery of the aircraft, secured the lifting cable to the right side of the aircraft through the right wheel axle. Although the right landing gear was beneath the aircraft, without the engine, this was the only available place for them to attach the lifting sling. Detachment of the engine and disruption of the hydraulic system pipelines to the retraction jack allowed the landing gear to fall free after water impact and again when the slinging/lifting position was changed. The right upper 'H' frame was physically locked to the nacelle firewall during recovery by the insertion of a locking bolt through the locking hole. The lower part of the right leg and wheel assembly was removed from the aircraft to facilitate road transportation of the aircraft from the seawall of the third runway to hangar 13 for detailed examination.

2.2.1 Right main landing gear.

Post recovery examination of the right landing gear structure and lower wing skin panels behind the wheel well revealed that:-

. The landing gear rear drag brace strut had become detached from the wing when the fuselage fitting for the strut attachment failed in overload.

. Extensive damage to the lower wing skin structure directly behind the wheelwell matched the shape of the rear drag brace strut and was consistent with this component being forced up into the skins after the drag brace attachment failure.

. The lower welds of the main landing gear upper truss were fractured, most probably from a front and right force.

. The left and right landing gear locking pins were located in the appropriate door stowage position and not fitted to the landing gears.

> BASI Comment The most likely occasion when this damage was sustained was either when the aircraft was initially lifted and dragged towards the seawall or when the aircraft was lowered back to the seabed after the aircraft rear slinging fitting pulled out of the aircraft during the initial lift from the water or when the aircraft was re-slung from the wing centre section.
>
> The damage is consistent with recovery loads imposed on the landing gear and not pre-existing to water impact.

2.2.2 Left main landing gear.

During aircraft recovery the left sling was placed around the left propeller to crankshaft flange behind the propeller blades. During the initial lift, when the tailplane lifting fitting pulled from the aircraft, all of the load was transmitted to the engine mountings on the left side which broke causing the engine to be pulled upwards of its normal thrust line position. Subsequently, when the aircraft was lowered to the seabed to reposition the slings, the engine sagged below the normal thrust line and in doing so pushed the oil cooler back into the landing gear. This prevented the gear from falling down from the wheelwell when the aircraft was lifted from the water onto the low loader for transportation to the hangar. Post recovery examination revealed that:-

. The landing gear rear drag brace strut was detached due to failure of the wing strut attachment bracket from an overload force.

. The tyre was fully stowed within the wheelwell and was displaced some 13-20 cm further upwards and about 6 cm rearwards beyond the rubber stop blocks.

The damage is consistent with recovery loads imposed on the landing gear and not pre-existing to water impact.

Witness reports indicate that at the time of impact with the water both main landing gears were in the retracted position. This is consistent with examination of the damage sustained by the left and right main landing gears.

2.3 Fuel system.

2.3.1 Description

The aircraft fuel system has a capacity of 800 usable US gallons (2730 litres) held in two separate tank systems comprising left and right main (202 US gallons each) and left and right auxiliary tanks (199 US gallons each), selectors, wobble and engine driven fuel pumps, cross feed cock and shut-off cocks. Fuel tank selectors, mounted on the left and right sides of the control pedestal, operate valves via cables and pulleys to direct fuel from selected tanks to engines. Any tank may be selected to supply either or both engines via a crossfeed selector and valve.

A schematic of the aircraft fuel system is contained at......................... **Appendix 5**

2.3.2 Cockpit fuel system selections.

Post recovery inspection of the cockpit revealed that the left and right fuel selectors were selected to the left and right main tanks respectively and the crossfeed selector to the off position. The fuel selectors were subsequently turned to off. The throttles were in the closed position and mixtures at idle cut off. It could not be established when and in what sequence these selections had been made as the aircraft was floating for some time after water impact and before sinking.

2.3.3 Fuel samples

To obtain fuel samples from the left engine disconnections were made at the carburettor fuel filter, fuel supply line from the nacelle fuel filter to the fuel pump via the firewall, inlet and outlet pipes of the engine driven fuel pump and carburettor return line to the tank. There was no fuel (or water) in the carburettor fuel filter nor were there collectable amounts of fuel (or water) in any of the lines between the nacelle fuel filter and the engine. A small quantity of fuel, insufficient for analysis, was obtained from the fuel pressure outlet line of the carburettor filter housing. A sample of fuel was obtained from the left nacelle fuel filter which, together with the left nacelle filter and carburettor filter elements, were sent for laboratory analysis.

The laboratory report indicates that the fuel sample from the left nacelle filter element showed a higher than normal (6x) quantity of existent gum. In the opinion of the chemist which analysed this sample, this would not have adversely affected the ability of the fuel to flow through the filter. Particulate matter on the filter was minimal and insufficient to have affected fuel flow across it.

Laboratory report of fuel sample and fuel filters is contained at......... **Appendix 6**

Fuel samples taken from the supply which was used to refuel this aircraft prior to flight were obtained and analysed. Copies of the BP release note for the fuel were provided with those samples. The analysis report identifies the fuel supplied as meeting the specification for Avgas 100.

Copies of these reports are attached at ....**Appendix 7**

2.3.4 System examination.

Post recovery examination of the fuel tank contents showed that:-

- The left main tank was full.
- The left auxiliary tank was almost empty (estimated less than 20 gallons)
- The right main tank contained approximately 130 gallons
- The right auxiliary tank contained approximately 120 gallons

BASI Comment:

Recovery slinging of the aircraft from the sea severely damaged the left wing centre section trailing edge when the sling cut into the wing. It is possible that undetected left auxiliary fuel tank damage was sustained at this time. This may account for the left auxiliary tank being nearly empty. Fluid sucked from all tanks consisted of a fuel/seawater mixture.

Operational checks were conducted of the left and right fuel selectors and valves, crossfeed selector and valve, wobble pumps and firewall shutoff cocks to determine the systems capability to deliver fuel to the left engine. With the selectors positioned to supply fuel to the left engine from each of the tanks, fuel flowed freely via the wobble pumps to the left nacelle fuel filter. Operation of the firewall shutoff selector, despite some control damage, enabled the valve to move to the almost full open (90%) position. The control damage, sustained during recovery operations, may have been preventing this shut off cock from moving to the fully open position. Post recovery examination of the cockpit had determined the firewall shutoff selector lever to be stowed and selected to the valve 'open' position. Neither of the flight crew indicated that this selector had been operated during the left engine shutdown sequence. It is therefore assumed that the firewall shut-off cock did not limit fuel from passing to the engine. Examination of the installed fuel lines from the nacelle fuel filter to the engine driven pump and the carburettor found all fittings to be tight with no evidence of leakage.

Subsequent laboratory examination of the fuel supply lines from the filter, through the firewall to the engine driven pump and to the carburettor identified them to be capable of full and free flow.

Engineering examination of the fuel pump and its drive failed to detect any abnormality which would have prevented its operation and ability to supply fuel to the carburettor.

Engineering evaluation of the engine fuel pump is contained at..... **Appendix 8**

Specialist examination of the left carburettor during strip examination revealed that there was extensive corrosion within the air passages but that the fuel chambers were full of fuel.
The carburettor strip report is contained at..**Appendix 9**

> <u>BASI Comment:</u>
> The lack of fuel in the left carburettor filter and its supply lines was remarkable especially as the carburettor of the right engine, when recovered from the sea with broken fuel supply lines, was full of fuel. The difference between these two engines was their status at water impact. The left engine had been shutdown in flight and the engine feathered, whereas the right engine had impacted the water and separated from the aircraft whilst turning at high RPM.

In an attempt to establish how much residual fuel would remain in the carburettor of an engine which had been shutdown and feathered in flight the question was asked of Pratt & Whitney. Their response is reproduced below:-

"When a Pratt radial engine is shut down and prop feathered in flight residual fuel is contained within the carburettor. Even if the firewall shutoff valve (if installed) did not close at the time the propeller was feathered fuel would not continue into engine once the mixture was placed in idle cutoff. The amount of fuel remaining in carb can vary from almost full to almost empty (depends on when mixture control was placed in idle cutoff)."

Copies of correspondence with P&W are contained at........................ **Appendix 10**

However, this response would not answer or account for the fact that there was virtually no fuel in the lines between the nacelle filter, the engine driven fuel pump, the pump supply to the carburettor or the carburettor fuel filter.

For reasons which have not been established these lines were empty.

2.3.5 Water drains.

Water drains cocks are located in the sump areas of each fuel tank to enable accumulated water to be drained.

On this aircraft there were two water drains to each of the main and auxiliary tank sumps. These drain cocks were a mixture of 'push to drain' and 'screw to drain' fittings. Post recovery examination of these drain cocks revealed the following abnormalities:-

1. Of the two screw type cocks in the left main tank the swagged turning handle of the inboard one was free to rotate without actuating the valve. There was no other damage in proximity to this drain cock which would indicate its unserviceability to have been sustained during impact or post impact recovery.
2. The outboard valve in the left main tank was tightened such that abnormal force was required to unscrew it into the 'drain open' position.
3. The outboard drain cock in the right auxiliary tank was located in the tank out of alignment with the wing skin cutout. This made accessibility with the hand to the valve extremely difficult, such that without tooling the valve could not be operated.

BASI Comment:

The abnormalities identified above would make it difficult to comply with the requirement to conduct normal post refuelling and pre-flight water drain checks of the left main and right auxiliary tanks, or to ensure that the fuel being supplied to the engines from these tanks was water free.

Typical drain cock of the type fitted to the left main tank ....**Appendix 11**

2.4 Left engine/Powerplant assy P&W 1830 - 92 Serial No CP329666

This engine had suffered installation damage to the mounting structure during the aircraft recovery phase and secondary damage to the firewall and accessories when the weight was taken off the engine and it dropped onto the oil cooler which was impacted back into the wheel well. The engine was subsequently removed for detailed strip and inspection.

Refer Airworthiness Inspection s.47F(1) [redacted] ....**Appendix 12**

The following checks were accomplished prior to engine removal:-

2.4.1 Engine Structure

Visual inspection of the external engine structure, propeller, reduction gear, cylinders, exhaust and inlet manifolds, rear casing and mounted accessory components failed to identify any abnormalities which are considered to have been pre-existing at the time of impact.

2.4.2 Oil System.

The oil system for each engine comprises a nacelle mounted oil tank containing 25 US gallons (95 litres) of oil, an engine driven oil pump, a cockpit operated firewall shut off valve, an oil cooler with thermostatically controlled temperature system and associated flexible pipelines.

The tank on this engine was found to be full when the oil filler cap was removed. The fluid contained within the tank included some saltwater.
Oil samples were taken from:-

- The oil pump to tank connection at the oil pump. Initially the sample flow was a mixture and saltwater and oil. the sample sent for analysis was taken after the majority of saltwater had drained off.
- The oil inlet pipe to the oil pressure filter - approx 50 ml. This sample contained a mixture of saltwater and oil. Pressure filter was examined for contamination - Nil metallic debris.
- The propeller dome during propeller removal. There was minimal sludge buildup in oil wetted areas of the propeller hub.

Laboratory examination of the samples submitted confirmed that the samples conformed to Mobil Aero Oil 100.

A copy of MTL report No 9405001 is attached (refer appendix 6)

BASI Comment:

- During the subsequent disassembly of the engine, all oil wetted surfaces showed signs of an adequate supply of lubricating oil.

- There were no abnormalities with the oil or the system which would indicate that lubrication to the engine or oil to the propeller control system had been compromised or that this system was contributory to the reported loss of power on the left engine.

2.4.3 Engine strip inspection

After engine removal a strip inspection was conducted by members of the Historical Aircraft Restoration Society (HARS) under BASI supervision. This group includes ex Qantas maintenance engineers who are currently employed, in addition to other products, in the restoration of a Super Constellation in Tucson Arizona. These persons are s.47F(1) [redacted] Most have DC3 and/or P&W 1830 engine experience and/or licences. s.47F(1) [redacted] They work from the old 'York' building at Sydney Workshop Company 62-74 Kent Road Mascot. The engine was transferred from the secure facility at Australian Jet Charter P/L to the HARS workshop under the supervision of s.47F(1) [redacted]

The following abnormalities were noted during this inspection:-

1 <u>Magneto driving gears - Spline wear:</u> Prior to removal of the left magneto S/No. 804353 it was noticed that the magneto body had been secured on its mounting pad fully rotated anticlockwise in the body slots on the mounting studs. Removal of the magneto revealed that the splines of the accessories driving gear were found to be excessively worn.

Because of the abnormal, excessive wear on the magneto driving gear, failure of positive drive to the magneto was imminent.

The logbook records show that this engine when overhauled in 1987 had magneto S/No 26254 fitted to the left position. There are no records of that magneto having been removed and replaced with S/No 804353. Since the overhaul there have been 1025 hours of recorded engine operation. However, because there are no certifications as to when this magneto was fitted it cannot be determined when the driving gear splines were last inspected.

The fact that the magneto was rotated fully anticlockwise on its mounting pad should have alerted maintenance engineers of an abnormal condition sufficient to warrant further inspection and/or adjustment to centralise the studs in their mounting slots.

With the magneto removed this can be accomplished by either rotating and re-positioning the distributor finger, and/or re-positioning the magneto drive gear on its splined shaft. Had this been done, visual inspection of the magneto driving gear prior to refitting the magneto would have detected the abnormal driving gear wear.

<u>BASI Comment:</u>
A copy of military maintenance manual TO No 01-40NC-2 (AP No 2445A) was obtained from South Pacific Airmotive as a document being used by them to do maintenance on this aircraft. Section 4 para 4 (a), (b) and (c) define the maintenance procedures to :-

- check the timing of both magnetos,
- adjust the timing of each magneto, and

- to SET the timing of each magneto.

Compliance with these instructions at the last inspection would have, whilst re-setting the left magneto, identified the abnormal wear of the magneto driving gear.

A copy of the relevant section of the above document is attached at **Appendix 13**

Magneto timing and synchronisation checks are a requirement at each 100 hourly periodic inspection for maintenance release issue.

Detailed examination of the magneto driving gear splines by BASI and the CAA Materials Evaluation Facility (Report No 43-94) revealed that:-

- The left gear internal spline wear exceeded the allowable limit by 0.040 inch.
- The right gear spline wear was approaching the maximum wear limit.
- There was no evidence of case hardening on the internal spline surfaces of either gear. Rockwell hardness measured 68 for the left and 67 for the right spline surfaces.
- Pratt & Whitney SB 1074 refers to the replacement of driving gears with non-carburised internal splines with with splined gears which exhibit Rockwell hardness 80-85.

Although SB 1074 does not reflect the -92 series engine as being applicable for compliance, difficulties of part identification and the approved rework to some gears, as advised by P & W, would not preclude the fitment of a 'soft' splined gear to these engines.

Magneto timing or synchronisation, although compromised by excessive wear on the driving gear, is not thought to have been contributory to this accident.

2 The 90º pulley block: The pulley securing bolt sleeve of the propeller governor pitch control cables (on the right side of the engine) was excessively 'step' worn. This is remarkable considering that there is a certification on the periodic inspection worksheets, at the time of issue of the current maintenance release on 25 February 1994 and some 4.50 hours prior to the accident, that the assembly had been renewed.

3. No 3 Cylinder: On removal of the No. 3 cylinder inlet valve pushrod cover, pushrod and tube, excessive wear of the pushrod and upper end of the cylinder head where the pushrod passes through the tube was revealed.

Subsequent removal of this cylinder and further inspection revealed that one of the thrust shims, which are fitted either side of the rocker arm on the rocker shaft, was missing - ie not fitted to the shaft. It dropped out from the rocker cavity. The 'loose' shim was oval in shape having suffered impact damage during engine operation. At the last time of fitting and/or adjustment of these tappets the shaft when installed failed to engage the shim which subsequently was 'left' within the rocker cavity. The housing through which the cover tube is located and through which the tappet rod operates was damaged at the point coincident with the damage on the rod itself.

A review of the CAAs major defect reporting system for P & W 1830 series engines; and the BASI accident and incident summary reports for DC3 aircraft; failed to identify any previous reports relating to the mis-assembly of cylinder valve, rocker, shafts or thrust washers.

Copies of the review documents and a 'minute note to file' are attached at.................. **Appendix 14**

Examination of this cylinder, complete with inlet and exhaust valve assemblies, inlet valve pushrod and cover and the damaged shim was conducted by BASI engineering to determine the cause and effect of this loose article within the rocker cavity. The examination revealed that:

The washer was deformed into an ellipse and bent. In addition to the general mutilation marks there were three bright new marks on this washer. Two were matched with wear marks on the push rod upper end fitting and the other with the inside edge on the rocker arm half balled end. The rocker arm side of the pushrod contained heavy rub marks which penetrated deep into the push rod. The curved edges of these wear marks matched the shape of the washer. Rub marks within the push rod cover tube could be matched with the deformed washer. There was a curved depression within the rocker cavity, adjacent to the inlet pushrod tube, which matched the shape of the deformed washer. Flow of the material into this depression indicated the compression nature of this mark. The amount of material rolled inside the depression mark suggests that the washer had been in this position for a considerable period of time or that it had in the past taken up this position. With the washer located in this depression it is possible for the other side of it to become jammed between the rocker arm and the push rod upper end thus preventing the inlet valve from closing. The amount of permanent lift was measured to be approximately 4 mm. ||

Engine operation with the inlet valve of this cylinder held in the open position will cause manifold pressure fluctuations reflecting the cylinder power cycle pressure peaks and loss of power. Intake manifold mixture will be ignited depriving the remaining cylinders of of an adequate fuel/air mixture. The overall effect being loss of engine power and irregular running. Black deposits covered by fire residues were evidence of burning within this cylinder intake cavity and the adjacent intake manifold.

4 Examination of the air intake assembly debris screen revealed deposits of

black soot within the carburettor air intake and on the screen indicative of backfiring. There is visual evidence of possible intake fire on the screen. Where the black deposits have been burnt off there is now red rust corrosion which gives the grill the appearance of a BBQ plate. This may or may not be indicative of fire in the intake manifold.

5 During removal of the number 12 cylinder two cylinder base studs were found to be sheared prior to disassembly. Light loosening pressure to the nut of another stud adjacent to the already broken ones, resulted in that stud breaking also. Cylinder removal from the cylinder base pad revealed an area of galling/fretting in the vicinity of the broken studs indicative of cylinder movement on its mounting pad.

Engineering examination of the broken nut/stud portion revealed that the stud had failed in fatigue initiating from multiple origins around the stud circumference. To compensate the two previous fractured adjacent studs, the increased load fluctuations experienced by this stud, and other studs during engine operation, would trigger a chain reaction of stud failures around the cylinder base.

> Comment: It is a maintenance requirement to inspect cylinder base attachment studs at each period inspection. This engine was last inspected 6-8 hours previously without detection despite there being a blackened area of the crankcase adjacent to these broken studs.

Disassembly/engine strip notes are attached at...................................... **Appendix 15**

2.4.4 Accessories/components (Left Engine):

The following components were removed for further detailed bench examination:-

2.4.4.1 Magnetos Type SF14LN-3 Left - S/No 804 353
Right - S/No 2620

Strip examination notes for these components are included at.......... **Appendix 16**

2.4.4.2 L/H & R/H magneto driving gears.
2.4.4.3 Carburettor Model PD12H4, P/No 391699-1 S/No 289519.
2.4.4.4 Oil Pump Assy P/No 158501 S/No C2785N.
2.4.4.5 Fuel Pump .
2.4.4.6 Propeller governor Model 4G(8)-ADH(38) S/No ADH 101.
2.4.4.7 No. 3 Cylinder Inlet valve/rocker thrust washer assy.
2.4.4.8 Others:

- . Exhaust valve pushrod #4 cylinder - loose tappet/cam end fitting.
- . Broken stud c/w nut from the #12 cylinder base.
- . Pitch control pulley assembly.

2.5 Left propeller S/No 1G1B14

Following the reported left engine power loss the pilot had shut down the left engine and selected the left propeller to feather. The blades had moved towards the feather position and the left engine stopped rotating.

Post recovery inspection of this propeller revealed no visible damage and blades in the partially feathered position. Oil flowed from the dome plug during the propeller removal process. There were no abnormal deposits of sludge within the propeller dome or blade operating mechanisms. The absence of a shim to control meshing between the cam driven pitch and individual blade gears was noted. Visual inspection after removal confirmed that the cams were not on the feather stops.

Subsequent engineering evaluation of this propeller and the feathering mechanism confirmed that the propeller was at 65 - 66° of pitch instead of the fully feathered 88° pitch. The pitch angles were read from the scales on the cam assembly and from two blade butts - there was no scale present on the third blade butt. When cleaned a "No shim" remark was found engraved into the body of the dome. There was no visual indications of abnormal wear on any parts of the pitch change mechanism. Oil wetted surfaces within the dome and operating mechanism were well lubricated with no abnormal amount of sludge present.

Propeller examination by BASI, in consultation with s.47F(1) [redacted] Australian Air Propellers P/L, was conducted to establish the reason for the propeller not being in the fully feathered position. This examination revealed that:-

- Torque to turn individual blades within the hub was measure to be about 55, 40 and 25 ft lb respectively, the required torque being 30-40 ft lb.

- To prevent water penetrating into the hub, while the blade is pointing upwards as the aircraft is parked, a plastic sleeve is placed onto each blade butt during hub assembly to prevent water ingress. The sleeve of the blade which required 55 ft lb to turn was dislodged from its position. Specialist opinion suggests that the higher torque required to turn this blade was probably due to water penetration and the presence of corrosion by-products and corrosion related pitting at the bearing area. It is highly unlikely that the sleeve become dislodged during the accident.

- Once removed from the dome, the cam assembly with piston attached remained 'frozen' in the 'as found' position and did not respond to an applied force trying to move it towards the fine or feathered pitch positions.

  Note: Correctly assembled cams with the piston attached are required to move freely throughout the range when being propelled by their own weight and without any outside forces being applied.

• Disassembly of the cam/roller mechanism revealed that both the internal and the external cams contained heavy polished roller contact marks and grooving wear over a distance equivalent to that of the propeller mechanism moving in the operating range.

Note: In the opinion of the propeller specialist, this in-service wear, if presented at overhaul, would be sufficient for rejection of the cams.

There were lightly polished areas on the cams indicating that the rollers had at some time been operating through to the fully feathered position. All four roller assemblies rotated freely and contained no flat spots.

• Despite the cam profile in-service wear, when the cam assembly pre-load nut was backed off by about 40° the mechanism achieved unrestricted movement of both cams throughout their range, driven by their own weight, and without any application of an external force.

It is considered that there was no damage or abnormal wear to any of the blades, blade bearings or propeller operating cam mechanism within the hub which would have prevented the blades from reaching the fully feathered position had the cam assembly pre-load nut been correctly tightened.

It is considered unlikely that the blade which required 55 ft lbs to turn would have restricted the propeller from moving to the fully feathered position.

Propeller feathering is initiated by a push to activate feathering switch located in the cockpit. This starts the feathering pump which delivers oil under pressure onto one side of the propeller piston thus moving the blades into the feathered position. When the blades contact the feathering stops, pressure build up activates a pressure switch in the propeller governor which electrically releases the feathering pump switch. The switch is spring loaded into the OFF position.

Subsequent testing of the feathering pump and propeller constant speed unit/pressure switch assembly revealed no operational abnormalities of these components.

There have been verbal reports that the blades on this propeller had moved from the fully feathered position during aircraft recovery operations. However, this could not be substantiated.

Propeller examination notes are contained in.................................... **Appendix 17**

2.6 Right Engine P&W 1830 - 92 Serial No BP 463388
Right propeller serial No FA 5612

This engine, having been torn from its mounting on the firewall during water impact, was subsequently recovered from the seabed at the water impact point complete with its propeller which was still intact and attached. Due to the length of time immersed, there was extensive saltwater corrosion damage to the rear accessories casing the majority of which had disintegrated.

2.6.1 Engine examination:
This engine was subjected to strip examination and removal of the accessories for shop inspection. There were no abnormalities identified which would have adversely affected the operation of this engine.

Engine strip inspection notes are attached at ....**Appendix 18**

2.6.2 Engine accessories:
The Magnetos, Propeller Governor and Carburettor from this engine were removed for bench strip and inspection by Aveco P/L and Wiltshire Enginering P/L.

2.6.2.1 Left/right magnetos: Strip examination concluded that in the opinion of s.47F(1) [redacted] AVECO, "... that both of these units were operating normally when the engine stopped, there was no evidence at all to support any other conclusion."

Bench strip inspection reports of these components are included at.... **Appendix 19**

2.6.2.2 Propeller Governor S/No WH32824: Prior to disassembly it was reported by Wiltshire engineering that the governor was mis-rigged and failed to meet the test specifications when attached to the test rig. Subsequently, when the pulley had been correctly rigged and adjusted it met the manufacturers test specifications. The locked, castellated nut securing the pulley to the hexagon shaft was found to be little more than finger tight when the correct assembly torque is 60 in lb of force.

Further examination by BASI to determine why the governor was found to out of rigging revealed that there was abnormal wear of the broached hexagon hole of the alloy pulley. This wear was sufficient to enable 40^{0} - 45^{0} free rotational movement of the pulley about the steel hexagon shaft on which it was located. It is therefore considered likely that the pulley had rotated into the out of rig position when tension was applied to the cables during engine separation from the aircraft at water impact.

2.6.2.3 Carburettor S/No 224786/29306 (type PD12H4): It was not possible to flow check this component due to salt water contamination. However, strip examination of the unit revealed it to have been assembled in accordance with manufacturers assembly drawings and no abnormalities which would have prevented normal operation.

2.6.3 Right propeller serial No FA 5612:
The right propeller was recovered from the seabed still attached to the engine. Each of the three blades were symmetrical bent rearwards at the mid position through approximately 5 - 10^0. The blades were set in the fine pitch, operating range. There were no pre existing abnormalities identified which would have prevented normal operation of this propeller.

2.7 Spark plugs

Left engine: On removal of the spark plugs from the left engine it was noted that there was a mixture of massive electrode and fine wire type plugs fitted. The electrode 'gap' settings were noted to be inconsistent between plugs and the majority showed evidence of electrode wear beyond normal life.

These plugs were subjected to post recovery examination and testing. After cleaning and re-gapping 5 plugs either did not fire or were found to be electrically breaking down on test.

Right engine: Twenty five spark plugs which were recovered from the right engine were similarly cleaned gapped and tested. Of these 11 were considered to be unserviceable, either failing to fire or from electrical breaking down when being tested.

There was a mixture of the following types of spark plug fitted between the two engines:-

	Left	Right
REB-37E - Massive electrode	13	13
RS19 -2RS - Fine wire	10	11
RS19-3RS - Fine wire	5	1

Note: 1. REB-37E is an approved plug for use on the R1830 engine in accordance with P&W SB No. 1175.
2. RS19/2RS and 3RS were approved plugs for use on the R1830 engine in accordance with ANO section 108.4.17 appendix 1. Although this document is no longer current, the technical information contained within it is still valid.

BASI Comment:
Considering that this aircraft had been certified as completing a 100 hourly periodic inspection for maintenance release issue 4-6 hours prior to this accident the visual condition of the spark plugs suggests that little attention had been given to the inspection and setting of the spark plug gaps, or the worn condition of the electrodes. Failure of some of the plugs tested may

have been as the result of their immersion in salt water, assuming that they all tested serviceable prior to fitment at the last inspection.

Condition reports in respect to spark plug examination and considerations of type fitted are contained at ....**Appendix 20**

3 Aircraft records

3.1 Maintenance release(s)

Certifications in the aircraft logbook indicate that the following Maintenance Releases (MR) have been issued to this aircraft by Groupair P/L s.47F(1) [redacted]

MR No	Date	A/C Hours TTIS	MR Expires
202752	16 Oct 92	40009.32	40109.32
202754	11 Sept 93	40108.47	40208.47
202756	6 Mar 94	40191.15	40291.15

The inspections carried out for the issue of these maintenance releases have been identified on the documents as being to the 'CAA Schedule 5.'

BASI Comment
1 This refers to Civil Aviation Regulations Schedule 5 which in accordance with subregulation 2 (1) is interpreted to mean the "CAA Maintenance Schedule".
2 Class B aircraft may use this schedule for inspections for the issue of a maintenance release. **However, VH-EDC has a certificate of Airworthiness which indicates the aircraft to be in the transport category and therefore, according to the regulations, it cannot be a Class B aircraft for maintenance. (Refer para 5.2)**

Each of the maintenance releases were signed by s.47F(1) [redacted] at Camden NSW.

All of the MRs were issued for Operational Category Private/Aerial Work/Charter.

Apart from the first eight Daily Inspection certifications on MR 202752, none of the other certification entries include pilot licence numbers despite the recording of this to be a requirement.

MR 202752 reflects 98:18 hours of recorded operation since issue with one maintenance required item to correct leaking R/H nacelle fuel filter which was signed off s.47F(1) [redacted]

BASI Comment
This unserviceability endorsement was incorrectly entered in the Part 1 maintenance required section of the MR instead of the Part 2 endorsements section, and therefore did not reflect by whom and when the deficiency was noticed s.47F(1) [redacted] Nor did that certification for remedial action in part 1 constitute a certification required by CAR 34 as it would have done had it been entered in part 2.

MR 202754 reflects 82:10 hours of recorded operation since issue with one unserviceability endorsement by Rod Lovell on 10 dec 1993 which was cleared by s.47F(1) [redacted] changing both plugs in the No 11 cylinder.

BASI Comment
1. The rough running which generated this entry resulted in an IFSD shortly after takeoff and a return to Sydney

s.47F(1) [redacted]

3. At the time of Maintenance release issue the left engine was 940:38 hours TSO and due to be removed prior to it exceeding the 1000 hour TBO due at 40164:09 aircraft hours. **There was no entry in part 1 of the maintenance release (Maintenance required) advising that the left engine should be changed prior to the aircraft reaching 40164:09 hours TTIS. (ie Before the engine TBO, iaw AD/ENG/4 Amdt 3. expired.)** 40164:09 hours were achieved on 13 December 1993 - refer investigator comment in 3.2.2.

This MR ceased to be in force with the commencement of an inspection for the issue of a new maintenance on 25 Feb 1994. CAR 47(5) refers. Certifications as a part of that inspection were made in the aircraft and engine log books and on additional worksheets on and after the 25 Feb 94 although the new MR (No 202756) was not issued until 6 March 94. **Despite a maintenance release inspection being started this aircraft flew three flights on the 2, 3 and 6 March using, and recording them on, MR No 202754 which was no longer in force.**

<u>MR 202756</u> signed by s.47F(1) [redacted] and issued on 6 March 1994 at aircraft TTIS 40191.15, following a 100 hourly periodic inspection, was current and valid when this accident occurred.

At the time of issue of maintenance release No. 202756, the right engine hours were 1081:03 and the left engine hours 1023:06. Both engines were operating on approved concessions to 1100 hours and would be due for removal within the period for which the MR was expressed to remain in force.

> <u>BASI Comment</u>
> **There were no entries in part 1 of this MR advising of the maintenance requirement to remove both these engines prior to them achieving 1100 hours of operation at 40210 :12 and 40268:09 aircraft TTIS respectively.**

The MR expires at 40291.15 hours TTIS.

The recorded hours of operation in Part 3, from flights on 12 March, 15 March and 16 March, reflect 4: 50 hours. A Daily Inspection certification for 31 March has no flight time recorded against it.

Aircraft **recorded** TTIS therefore as at 24 April 1994 is 40195:05 hours.

Copies of these documents are attached at ....**Appendix 21**

<u>3. 2 Certificates of Airworthiness and Registration.</u>

<u>3.2.1 Current Certificate of Airworthiness:</u>
A copy of the Certificate of Airworthiness No 1680 for VH-EDC was mounted in the aircraft on the cockpit door. This copy reflects that certificate at folio 103 in the CAA aircraft file Part 6 (Bar Code FNO26641). There was also a copy folded and filed in the back pocket of the current aircraft log book.

This certificate was issued 3 October 1980 to VH-EDC by s.47F(1) [redacted] delegate to the Secretary. It classifies VH-EDC as being in the TRANSPORT Category.
The aircraft file at folio 188b and in the front cover, reflects another draft Cof A with supplements listed on the reverse side which has never been signed dated or formally issued. This draft was in preparation at the time when South Pacific Airmotive were negotiating with the CAA regarding the aircraft maximum take-off weight. This draft also reflects that VH-EDC is a TRANSPORT category aircraft.

<u>3.2.2 Current Certificate of Registration:</u>
The current Certificate of Registration No 1680 reflects South Pacific Airmotive Pty

Limited as being the holder of the certificate.

This certificate was issued from the CAA Bankstown office on 30 July 1992. (Folio 168 of the CAA aircraft file refers. Copy attached)

3.2.3 History - Certificates of Airworthiness and Registration

This information was extracted from the listed CAA aircraft files and from discussions with the Custodian of the Register of Aircraft:-

- VH-EDC Part 4 (Barcoded FNO26644).
  This file has folios dated from 14 June 61 to 21/12/71.
- VH-EDC Parts 4/5 (Barcoded FNO 26641)
  This file has folios dated from 18/1/72 to 18 March 1994.

Note: Aircraft files parts 1, 2 and 3 are not available without archive searching which is not warranted.

3.2.3.1 Certificate of Airworthiness

Date issued	Certificate No	Period of validity	Comment
23 Aug 63	1646	to 7 Sept 63	
17 Sept 64	1646	to 16 Sept 65	
26 Oct 64	1646	to 25 Oct 73	Reflects aircraft manufacturers S/N 12874 instead of RAAF No 42-93010
26 Oct 64	1680	to 25 Oct 73	With the change of aircraft S/No this issue aligns the certificate No. with that of the Certificate of Registration.
15 Nov 71	1680	to 14 Nov 1980	
24 Jan 73	1680	Valid until being withdrawn.	Replaces lost Certificate
3 Oct 80	1680	CURRENT C of A	

3.2.3.2 Certificate of Registration

17 Nov 49	1680	to 14 July 50	Dept of Civil Aviation as VH-JVF
14 July 50	1680		Dept of Civil Aviation Registration changed to VH-CAR
7 June 61	1680	to 3 Oct 67	Qantas Empire Airways. Registration changed to VH-EDC
3 Oct 67	1680		Qantas Airways Ltd

6 June 70	1680	15 Nov 71	Qantas Airways Ltd
15 Nov 71	1680	26 June 72	Queensland Pacific Trading Co Pty Ltd
26 Jun 72	1680		Bush Pilot Airways Ltd
24 Jan 73	1680	8 Aug 73	Ditto - Replaces lost certificate
8 Aug 73	1680	27 Jan 77	Bush Pilot Airways (PNG) Ltd
27 Jan 77	1680	7 Apr 88	Bush Pilot Airways Ltd
7 Apr 88	1680	30 July 92	Air Rambler (Australia) P/L
30 July 92	1680		South Pacific Airmotive P/L

Copies of the above Certificates of Airworthiness and Registration are attached at ....**Appendix 22**

3. 3 Engines and Propellers TBO/TSO

The following information, pertinent to the engine and propellers which were recorded as being fitted to this aircraft, has been extracted from the aircraft logbooks.

The components, by serial number, which were fitted to the aircraft are confirmed as being those documented.

The following aircraft hours TTIS are the recorded hours at the last periodic inspection for maintenance release issue + the recorded hours flown since its issue.
ie Aircraft TTIS 40191 + 4.50 = 40196 : 50 hours.

3.3.1 Engines:
The Time Between Overhauls (TBO) are defined in the Civil Aviation Authority Civil Aviation Orders (CAO) Part 6 - Schedule of Airworthiness Directives: Engines - General.

AD/Eng/4 Amdt 3 requires that the P&W R1830 series engines be overhauled at periods not exceeding 1000 hours.

An extract of AD/Eng/4 amdt 3, and
AAC No 6-32 (compression testing) is attached at ....**Appendix 23**

TSO - Engines (Pratt & Whitney R1830-92)

	Serial No	Time since overhall(TSO)
Left	CP329666	1027:56 hours
right	BP463388	1085:53 hours

Both of these engines were operating on approved concessions to overrun the published TBO.

CAA Fax/letter dated 7 July 1994, in response to questioning, advises that this is the only operational DC3 with engine TBO concessions.

3.3.2 Engines TBO concessions

Concession to over-run right engine S/No BP463388 TBO:

An application, s.47F(1) [redacted] for South Pacific Airmotive P/L on 28 June 1993, complete with two oil sample analysis reports and a compression/ground run test sheet, was approved for 100 hours over-run on concession approval No BK 93/422 by the CAA Bankstown office on 6 July 1993.

Concession to over-run left engine S/no CP329666 TBO:

An application, s.47F(1) [redacted] on 24 December 1993, complete with two oil sample analysis reports (57507 and 57508) and a compression/ground run test sheet, was approved on 1 Feb 94 as Concession BK/401 and notified to the Operator on 4 Feb 1994.

Copies of these application and approved concession form DA560 together with a Minute note to file on these operator requests for both the right and left engine concession applications are attached at..**Appendix 24**

Further application to the CAA s.47F(1) [redacted] on 9 March 1994, to extend the TBO of these engines to 1600 hours has been unsuccessful.

BASI Comment:

There are three subjects of concern when considering the granting of the concessions for these engines to over-run the published TBO period:-

1. Both engines were operating in the over-run period on the same aircraft at the same time.
2. The left engine was granted its approval when the oil sample analysis reports, which were submitted by the operator to support the over-run request, did not support the mechanical integrity of the engine.
3. The operator continued to operate the left engine beyond its published TBO period prior to the granting of the approval for them to do so.

In respect to 1 above:-

The AWI assigned to South Pacific Airmotive states that he was verbally advised by the Operator on 26 April 1994 that the right engine had been changed on VH-EDC. He was of the opinion that both engines should not operate, on the same aircraft, in the over-run period at the same time and was of the opinion that when the left engine was granted over-run approval, the right engine had been changed. There is an entry in the aircraft log book of VH-EDC, dated 24 April 94 (the day of the accident), that the right engine S/No. BP463388 had been removed and S/No 667 had been installed. This entry had subsequently been crossed out and noted as an 'Incorrect entry.'

Neither the approved concessions, or the letters advising of the granting of those approvals, identified to the operator that he could not operate the aircraft with both engines in their over-run period at the same time. If it is the CAA's intention that two engines which are operating beyond the published TBO should not be on the same aircaft at the same time, then they will need to document this accordingly. Surely if an engine has been given the approval to operate beyond its published TBO then that approval would have been given without compromising on the continuing airworthiness of that engine. In which case there can be no objection to having both engines on the aircraft operating in the overrun period at the same time.

<u>In respect to 2 above:</u>
South Pacific Airmotive commenced operation of this aircraft with an inspection for ferry flight 12 August 1992. At that time the aircraft TTIS was 40009:12 hours, the left engine was TSO 840:43 and the right engine TSO 899 hours.

Oil samples, to support the application for concessional over-run of the left engine TBO were taken, for analysis, at 949 and 996 hours respectively. The analysis reports from both these samples indicate abnormally high wear metals of iron, lead and aluminium. Although the reports recommend that the oil be resampled after a further 100 hours, these samples are not good indicators of engine health when there is no previous trend for them to be compared against. Furthermore, they represent only 150 hours of engine operation by this operator (47 hours between samples) and are not indicative of either his operating technique or type of operation. These abnormalities should have been sufficient, coupled with marginal cylinder compressions, to indicate doubts as to the integrity of this engine and request further justification prior to approval. This did not happen.

<u>In respect to 3 above:</u>
Concession BK/401 was approved and advised to South Pacific Airmotive on 4 February 1994. From the maintenance release No 202754 and the entry in it for 3 Feb 94, the hours flown since maintenance release issue were 74.05. At the time of the issue of that MR aircraft TTIS was 40108.47 and the left engine (S/No 329666) was 940.38 hours TSO. Adding 74.05 to 940.38 brings the total engine hours to 1014.43. This was on the day before the concessional over-run was approved by the CAA and notified to the operator. **The operator pre-empted the approval of this concession and operated the engine illegally for approximately 15 hours. This would be the result of the operating crew not knowing that the engine TBO had expired because it had not been entered onto the maintenance release as maintenance required.**

<u>3.3.3 Propellers:</u>
The Time Between Overhaul (TBO) for propellers are defined in CAOs Part 107 - Propellers General.

AD/Prop/1 requires that the Hamilton Standard Model 23E50, as fitted to this aircraft, be overhauled at periods not exceeding 2000 hours with partial dismantling of the dome for sludge cleaning at each 500 hours time in service.

Note: An extract of AD/Prop/1 is attached at appendix .... ?

TSO Propellers (Hamilton Standard - Model 23E50 -473)

	Serial No	TSO
Left	1G1B14	550:25 hours
Right	FA 5612	830:48 hours

Note: 1 **There are no certifications to indicate that the left propeller was 'desludged' in accordance with the requirements of AD/Prop/1 on achieving 500 hours of operation.**

Note: 2 The right propeller was certified as being 'desludged' when the propeller was at 564 hours and again at 631:33 hours when the propeller was fitted to VH-EDC.

3.4 Aircraft Log Books

The log books which were being used for the maintenance, certification and recording of the history records of this aircraft and its major components included:-

Aircraft:	(Log Books No's 4 & 5)	CA Form 9 - Pre 1964.
Engines:	Left S/No CP-329666 Right S/No BP 463388	CA 10 (1964) DA 10 (revised 1/84)
Propellers:	Left S/No 1G1B14 Right FA-5612	CA 32 (1975) CA 32 (1967)
Radio:		CA 69 (1970)

Refer to copies of each of these log books at **Appendix 42 for the aircraft log books,** and, at **Appendix 43 for engine prop and radio log books.**

Civil Aviation Regulation 50 A,B,C &D define the requirement for log books, alternative log books, directions relating to aircraft maintenance records and their inspection. Civil Aviation Advisory Publication (CAAP) 50B-1(0) discusses the use of alternative log books for class B aircraft.

BASI Comment:

1. Although VH-EDC was not a Class B aircraft, South Pacific Airmotive were using CAA approved log books (listed above) for maintenance

purposes.

2 The advise given in CAAP 50B-1(0) which includes instructions to users electing to use an alternative log book, if followed, are more demanding than any instructions which are contained in the older log books and which are still being used.

3 CAAP 39-1(0) -(Referring to CAR 39 (1) -advises the, "Maintenance Requirements for Class A Aircraft."

Currently there is a new CAA aircraft logbook available. AAC 6-12 dated 13 June 1991 advises its availablity and use and includes 'Instructions to Users'. This new log book adopts the loose leaf concept for the recording of aircraft maintenance history using divided sections each with their own instructions to users which total 12 pages. There are sections in this log book cover for the log book statement, aircraft & engines records, major assembly/component history cards and expired maintenance releases. Pre-printed pages for inclusion into these sections include non-recurring ADs, special inspections and modification certification log, engine and lifed component installation/removal record and recurring AD and maintenance control pages.

An Aviation Regulatory Proposal (ARP) circulating for comment on its proposed introduction received adverse industry comment. Hence, there are no CAA requirements to make its use mandatory either in the short or long term. Operators are at liberty to continue using older CAA log books, which have been outdated with the passage of time ad infinitum.

BASI Comment:
The 'new' CAA looseleaf log book incorporates an acceptable location to adequately record and maintain a traceable audit history of the aircraft in an organised schedule far superior to the collection of outdated log books listed as belonging to VH-EDC above. The decision by the CAA, in response to industry comment, not to phase the new log book into service is contrary to ensuring a good airworthiness and audit history trail.

<u>3.4.1 Log book instructions to users.</u>

'Instructions to users' are pasted in the front cover of all of the older log books referred to in 3.4 above.

Instructions to users of aircraft log books have been changed periodically over the years to reflect changes to the regulations and the requirements for certification, the recording of airworthiness directives and the management of maintenance records generally. These changes instruct users how and where in the book records and certifications are to be made. Such an instruction change occurred in 1976. This change was advised to the industry via Airworthiness Advisory Circular (AAC) 97-5 issued in February 1977. This instruction also made it no longer necessary to make reference to ANR 39 when making certifications.

In respect to those log books being used by South Pacific Airmotive for VH-EDC, the following general comments are made:-

- The log book "instructions to users" issued in 1976 and referred to in AAC 97- 5, were not incorporated into those aircraft log books being used for this aircraft
- There is still a requirement, according to these books, that certifications are made pursuant to Reg 39
- Had the new instructions been pasted into this old book when issued they would not have been relevant because the page numbering of this old log book does not equate to the new instructions.

3.4.2 Log book statement:

In accordance with the requirements of CAR 50 and supporting instructions, Log book Statements are submitted to the CAA by the Certificate of Registration holder:

Part 1 nominates the aircraft's maintenance schedule.

Part 2 lists the approved variations to that schedule

Part 3 contains details of exemptions granted.

- The log book statement Part 1, pasted in the front of the current log book for VH-EDC, refers to the aircraft as being Class B and nominates the CAA schedule 5 as the inspection document. This is pasted in front of a previous statement dated 1976 which defines the system of maintenance current at that time when the aircraft was being operated by Bush Pilot Airways Ltd.

BASI Comment:

It was this current log book statement which, when submitted to the CAA Bankstown office , generated their letter to South Pacific Airmotive advising that the log book statement was unacceptable and that VH-EDC was in fact a class A aircraft which should be maintained as such with a maintenance control manual and maintenance controller being appointed.

3.4.3 Log book history

- There is a period of maintenance history between June 1977 and May 1988 (11 years and 12,565 hours of aircraft operating TTIS) when no certification were made in this log book. Nor were there any maintenance records available which would cover this period.

BASI Comment:

The aircraft was being operated in Airline service during the referenced 11 year period. Attempts to retrieve those records from the current owner have been unsuccessful. There were no loose leaf log book entries summarising the aircraft's use, maintenance certifications, airworthiness directive compliance, modification status or component removal and replacement record during this period.

- The log book contains no record of non-recurrent airworthiness directive certifications.
- The log book contains no formal listing, within the numbered pages of the book, of components removed/fitted.
- The log book contains no listing of its modification status within the numbered pages of the book.
- There is a listing of Airworthiness directives, components and maintenance requirements with their subject periodicities and due dates attached in the front of the log book.

  BASI Comment:
  These 6 pages are not identified as being a part of this record, and there is no entry within the book stating their existence or substantiating certifications relevant to the periods documented on them.

- A review of the log books, the CAA aircraft file and available maintenance history in respect to AD/DC3/26B and 29B (these require radiographic/x-ray techniques) revealed that both inspections were overdue. (refer appendix 26)

  BASI Comment:
  Confirmation of compliance, without reference to previous certifications which may have taken place during the period of missing records, could not be substantiated.

- AD/GEN/ 61 - Cabin Attendant seats - Mod: There is no record of compliance with this AD.
  Note: The seat fitted in the FA position on this aircraft was manufactured in 1985 by Ansair, Tullamarine. It is a type G4401 - DOT CTA No 31/79. The logbooks show record of its installation or the design approval to fit this seat in this position for use by the Flight Attendant.

- There are no certifications for 100 hourly recurring AD/Prop/2 (Feathering Checks) at the last two periodic inspections.

- There is a certification dated 6 November 1993 for compliance with those sections of the DC3 Supplemental Inspection Document (SID) for aging aircraft. The TTIS on this date was 40108 hours. The items selected became due at the structural thresholds between 20, 000 and 36, 000 hours. Each item is a repetitive inspection at various intervals dependent on the item.

BASI Comment:
Compliance with the Douglas DC3 SID was only made mandatory by the CAA when airworthiness directive AD/DC3/33 - Supplemental Inspection Program was issued in July 1994 ie, 2 months after this accident. (Copy attached at appendix ..... ?). Compliance with this SID was not listed on the log book statement submitted for this aircraft by s. 47F(1) [redacted]. s. 47F(1) [redacted] had been instrumental in the production of this manual with the Douglas A/C Co.

BASI Comment:
The errors and omissions identified above should have been addressed by the CAA had the appropriate, and required, CAA surveillance of this operator and his aircraft be undertaken.

The 'history of use' documentation referred to above for VH-EDC has been inadequate in this instance to document an airworthiness audit or history trail.

The errors and omissions referred to above are not considered to have been contributory to this accident.

Repeated attempts to contact and obtain further maintenance related documentation from the owner of this aircraft have been unsuccessful.

A detailed review of the the log books, certification entries, compliance with regulatory requirements, continuing airworthiness and history audit trail was conducted. The report on this review together with supporting documentation is included at ....**Appendix 26**

3.4.4 Log books - Endorsement after saltwater immersion

Subsequent to the recovery of this aircraft it became apparent that the owner at the time of the accident, were he to become the new owner after insurance considerations, intended that the aircraft and/or parts of it may be 'redeemed' and put into further operational service. He was actively pursuing a convenient time to remove and inhibit the wings, for reuse or resale, and to gain access to the cabin to clean and conduct preservation work.

There are major safety of flight and continuing airworthiness concerns should any of the components of this aircraft be re-used without proper review, inspection, serviceability assessment and certification prior to fitment.

Civil Aviation Regulation (CAR) 42W, 42Y and possibly 42ZA control the installation and use of aircraft components in maintenance. These regulations generally apply to new components or 'used' components the history of which is known or can be substantiated. These regulation imposed fines against those persons who choose to disregard them. However, component distress as the result of saltwater immersion is subtle and can remain undetected using normal inspection methods with disastrous results at some later date. This is especially true in respect to critical components which during normal operation are highly stressed ie wing spars.

These activities were advised to the CAA (by BASI) who responded by saying that they had issued an Aircraft Survey Report (Form DA 2596) on 9 May 94 advising South Pacific Airmotive that;-

> "Any part or component of the aircraft that was subjected to salt water immersion must comply with FAA AC43.13-1A and in conjunction with manufacturers approved processes prior to use on any Australian aircraft."
> (A copy of that document Serial No A01184 is attached at..... **Appendix 27**)

Although this CAA directive has been issued in respect to the possible reuse of components, neither the maintenance release, which was current at the time of the accident, nor any of the log books, which record the history of the aircraft and its major components, have been endorsed.

CAR 50 requires that defects and major damage are to be endorsed on the maintenance release by, the Holder of the Certificate of Registration, the operator or a flight crew member. Endorsements on maintenance releases can be either signed off on the maintenance release by appropriately licensed or authorised persons or entered into the log books for correction, rectification and/or repair. Maintenance releases are currently considered to be a part of the aircraft maintenance log book history.

There are no provisions in the regulations for maintenance releases or log books of aircraft which have been involved in accidents to be endorsed by other persons.

BASI Comment: Advise from s.47F(1) CAA Maintenance and Durability Manager, is that there are no regulations which would preclude me, as a Bureau of Air Safety Investigator undertaking an investigation, from entering an endorsement into the log books of this, or any other aircraft during the course of an investigation. Such an entry would identify an investigation by number, indicate the possible extent of damage (which will need to be corrected) and provide an historic and continuing airworthiness record.

Endorsements on the maintenance release or in the log books would not, by themselves, prevent the major components of this aircraft from being reused, or for those without logbooks what exactly they been subjected to. Without an endorsement in the log books there would be no history audit trail. Whereas an endorsement, in this case, would convey to the log book reader that the aircraft had been subjected to immersion in salt water.

A letter has been sent to the CAA for inclusion into the aircraft file advising that this aircraft has been ditched into the sea.

Each of the log books for this aircradft which have come into the possession of BASI has been endorsed to indicate that the aircraft has been subjected to an investigation by BASI.

> Comment: These actions however will not by themselves prevent the reuse of any component which are subsequently removed which do not in themselves carry their history on a separate component record card.

Endorsement of aircraft logbooks refer atached at.................................... **Appendix 28**

4 Company Structure

4.1 Groupair Pty Ltd

Groupair Pty Ltd are an approved organisation based at Moorabbin Victoria. They are the holders of the following Civil Aviation Authority approvals:-

- Certificate of Approval No 1137 dated 16/10/92.
- Air Operators certificate No V/T 652 dated 15 February 1994. This certificate replaces that dated 8 February 1993 and was issued to reflect the change of address from Casey Field to Moorabbin Airport.

4.1.1 Certificate of Approval:

This certificate grants approval for Groupair to undertake the following activities subject to conditions: -

- Maintenance of Class B aircraft with maximum take-off weight not exceeding 5700 kg and Douglas DC3.
- Maintenance of aircraft components limited to airframe components of those listed aircraft excluding fibre reinforced plastic structural components.

> BASI Comment: This certificate, issued by the CAA Moorabbin office, includes approval to do maintenance on the DC 3 and implies that it is a Class B aircaft. Refer Para 5.2.

s.47F(1) [redacted]

> s.47F(1) [redacted]

s.47F(1) [redacted]

The Chief Pilot s.47F(1) [redacted] receives formal reports from Rod Lovell on DC3 operational matters.

s.47F(1) [redacted]

4.1.2 <u>Air Operators Certificate:</u>
This certificate, issued by the CAA Moorabbin District Office, includes approval to operate the DC3 aircraft in charter (within Australian Territory) and aerial work, except flying training.

Copies of these certificates are attached at... **Appendix 29**
Documents pertinent to Groupair group structure are attached at.... **Appendix 30**

4. 2 South Pacific Airmotive Pty Limited

South Pacific Airmotive Pty Limited were registered with the National Companies and Securities Commission as a proprietary company on 22 Sept 1988 - registration No 430141-34 refers.

Copy of certificate 430141-34 attached at...................................... **Appendix 31**

V-EDC was acquired s.47F(1) [redacted] South Pacific Airmotive Pty Ltd) from Air Rambler (Aust) Pyt Ltd. s.47F(1) [redacted]

Copy of acquisition form attached at.. **Appendix 32**

Maintenance on VH-EDC is carried out under the Groupair Certificate of Approval No 1137 and certified for and on behalf of them by s.47F(1) [redacted] an appointed person on the Groupair certificate.

[redacted]

[redacted]

Note: Copy of referenced letter is at appendix 30

5 Civil Aviation Authority

Refer
> DC3 Type certification Data sheets A669 and A618 at attachment.. **Appendix 33**
> CAA VH-EDC aircraft file folios 164 to 208 attachment at ....**Appendix 34**
> Minutes of meeting BASI/CAA 24 May 1994 attachments at.......... **Appendix 35**

5. 1 Groupair surveillance

Groupair P/L, the registered holder of Air Operators Certificate No V/T 652 and Certificate of approval No 1137 carry out maintenance of DC3 registration VH-EDC at the Camden (NSW) based subsidiary company premises of South Pacific Airmotive. This aircraft type and that facility at Camden are listed on the Groupair Certificate of Approval. [redacted]

The Civil Aviation Authority airworthiness surveillance of Groupair is controlled by the Moorabbin office [redacted]

[redacted] Airworthiness surveillance of approved organisations is conducted in accordance with the policies, procedures planning and instruction guidelines of the National Airworthiness Surveillance System (NASS). Instructions for NASS users are contained within two books - 'Policy and Procedures' and ' Planning System User and Training ' manuals.

> Note: Although the NASS system has now been superseded by the Aviation Safety Surveillance Program (ASSP), at the time of this accident the NASS system was in use throughout the CAA.

South Pacific Airmotive acquired VH-EDC in 1992 at which time operational and maintenance activities appropriate to this type of aircraft were incorporated into the Groupair Certificates.

On 5 February 1993 [redacted] in response to [redacted] submitting a logbook statement for VH-EDC, wrote to South Pacific Airmotive advising that in respect to VH-EDC:-
- the aircraft was classified as Transport category on the Certificate of Airworthiness,
- the logbook statement submitted by them was not applicable to Class A aircraft,
- there was a requirement to submit a 'System of Maintenance' for approval, and
- that CAR 42ZV requires that an operator of a class A aircraft must have a Maintenance Control Manual (MCM) and a Maintenance Controller.

[redacted]

<u>BASI Comment</u>

1. Prior to the 5 February 93 South Pacific Airmotive [redacted] submitted a logbook statement for VH-EDC to the CAA Bankstown office and therefore considered them to be the relevant office with which they should be doing business. [redacted] in response to that document wrote to them on 5 February 93. This was before Bankstown were officially asked to undertake the Groupair (Camden) surveillance role [redacted]

2. A framed copy of the Certificate of Airworthiness for this aircraft was displayed in the cockpit of the aircraft. It clearly showed that the aircraft was in the Transport Category.

3. Up to the time of the accident [redacted] had neither submitted a MCM for approval or nominated a maintenance controller. Furthermore, he certified for two 100 hourly periodic inspections on 11 Sept 93 and 6 March 94 and issued Maintenance Releases (No's 202754 and 202756) following those inspections which had been conducted in accordance with the CAA Inspection Schedule 5. This is not an approved schedule for the

maintenance of Class A aircraft. Neither is [redacted] an approved maintenance controller for Class A aircraft, which VH-EDC is.

Because the DC3 was to be maintained in Camden (NSW), [redacted] CAA Bankstown office on 28 May 1993 requesting that they (Bankstown),
".......arrange the required local audit and surveillance activities."
This request was accepted and the following message passed to [redacted] Bankstown, in respect to Groupair - Camden on 28 May 1993.
[redacted]

The only surveillance undertaken by the Bankstown office since that date was a NASS 10 survey of the aircraft at Bankstown on 2 March 1994. This is recognised as an opportunity surveillance activity and not a planned activity. There was no formulated plan in accordance with NASS procedures for surveillance of South Pacific Airmotive by the Bankstown assigned AWI. However, the assigned AWI related that attempts to contact [redacted] to arrange a meeting when the aircraft and its maintenance documents were together had been unsuccessful. There are no formal documented attempts, by the CAA, requesting that the management of South Pacific Airmotive make themselves, the Camden facility, the aircraft and its documentation available to initiate the surveillance process.

Documentation supporting this paragraph are contained at.................... **Appendix 36**

5. 2 DC3 - Class A or Class B aircraft.

Refer documents, minutes and record of discussions pertinent to this Class A/B subject attachments at ....**Appendix 37**

The last three maintenance releases were issued to VH-EDC [redacted] for and on behalf of Groupair, following inspections carried out in accordance with Schedule 5. This schedule is not approved for Class A aircraft.

Civil Aviation Regulation (CAR) 2 defines a class A aircraft as one which satisfies either or both of the following paragraphs:-

(a) the aircraft is certificated as a transport category aircraft;
(b) the aircraft is authorised by an Air Operators Certificate to be used for the commercial purpose referred to in paragraph 206(c).

Note: (a) above is applicable to VH-EDC

CAR 2C qualifies that, for the purposes of these regulations, an aircraft is certificated as a transport category aircraft if:

(a) there is a certificate of airworthiness in force in relation to the aircraft; and
(b) the certificate includes a statement to the effect that the certificate is issued in the transport category.

Note: (a) and (b) are both applicable to VH-EDC

The Certificate of Airworthiness No 1680 issued on 3 October 1980 was current and valid and issued for this aircraft in the transport category.

All of the above identify this aircraft to be Class A aircraft which should have been maintained accordingly. This fact was advised to South Pacific Airmotive by the CAA Bankstown office on 5 February 1993 and acknowledged s.47F(1) [redacted] s.47F(1) [redacted]

s.47F(1) [redacted] (CAA Moorabbin) during our discussions on this subject 26 May 94 was surprised to hear that this aircraft was in the transport category. He commented that he thought VH-EDC was a normal cetegory aircraft and was aware of other DC3s which were in the normal category, although he could not quote any specific registrations. He subsequently agreed that VH-EDC should be a Class A aircraft after reading the relevant CARs (referred to above) and being told that the aircraft file's Certificate of Airworthiness stated it was transport category. However, he then queried the CAA aircraft register computer system to reproduce a duplicate certificate of Airworthiness for VH-EDC. The document which was produced identified VH-EDC as being a normal category aircraft. This document, in error, also stated that the aircraft had been constructed in 1949, when in fact it was built in 1944 and came onto the Australian Civil Register in 1949.

Another CAA document, an electronic memo (EM) s.47F(1) [redacted] dated 20 October 1992, identifies several DC3s as being normal category aircraft, including VH-EDC. The information in this EM had also been compiled from the aircraft register computer.

During discussions with s.47F(1) [redacted] CAA Maintenance and Durability Manager Canberra) on the topic of Class A/B aircraft and the production of a duplicate Certificate of Airworthiness which was at variance with the aircraft file data, he advised that he was unaware of the computer database which would do this suggesting that it may be a 'local' office management tool. He agreed that if the Certificate of Airworthiness was issued in the transport category then VH-EDC was a Class A aircraft which should have been maintained as such.

In response to questions regarding how many DC3s on the Australian register are transport and how many are normal category aircraft, s.47F(1) [redacted] Airworthiness Branch advised on 7 July 1994 that,
"All DC3 aircraft on the register with current Certificates of Airworthiness are in the

Transport category." and,
"With the exception of VH-EDC, all DC3 aircraft are being maintained as Class A aircraft."

> <u>BASI Comment:</u>
> There has been conflicting and confusing information within the CAA concerning Certificates of Airworthiness for the DC3 fleet. ie
> - whether or not the certificate for this aircraft type is:-
> transport (class A for maintenance) or, normal category (class B for maintenance)
> - confusing, in that a duplicate certificate can be issued with an incorrect category nominated.

BASI discussions with CAA officers during the course of the investigation, and no doubt internal CAA discussion, has culminated with [redacted] Airworthiness Branch [redacted] clarifying, and advising, the policy issue for VH-EDC and other registered DC3s in respect to their transport categorisation. However, there has been no advise as to what will become of the aircraft register computer which, during this investigation, demonstrated its capability to produce an inaccurate duplicate Certificate of Airworthiness when 'asked' to do so.

6 Identified Errors and Omissions

1) The aircraft was being maintained and certified for, by a Groupair LAME, as a Class B aircraft knowing that it was an aircraft with a Certificate of Airworthiness in the Transport category, contrary to formal advise being given to him by the CAA to that effect and despite the fact that a copy of this Certificate was displayed in the aircraft and another copy was retained in the aircraft log book.

Error - On the part of [redacted] Certificate of Registration holder VH-EDC who failed to ensure that the log book records were accurately entered.

Error - On the part of [redacted] submitted a log book statement to the CAA which identified this as a class B aircraft even though the Certificate of Airworthiness identified the aircraft as being in the Transport category.

Error - On the part of [redacted] coordinated the inspections for the issue of the previous three maintenance releases contrary to the regulations.

Omission: On the part of [redacted] failed to submit a MCM for approval or to nominate a maintenance coordinator as requested by the CAA and required by the regulations, especially when he previously advised that he would.

Error - On the part of Groupair who failed to ensure an adequate maintenance chain of command within the Groupair structure.

Error - On the part of Groupair management to adequately identify the class of aircraft the DC3 was in respect to the Certificate of Airworthiness and it being in the transport category, prior to them including it on their Certificate of Approval.

Omission - On the part of the CAA Bankstown s.47F(1) [redacted] who failed to follow up their advise to SPA on 5 February 1993 concerning the standard of maintenance applicable to this aircraft.

Omission - By the CAA Bankstown office who failed to initiate the surveillance activities of SPA, as requested by CAA Moorabbin on 28 May 1993.

2) Maintenance Release documents MR202754 (issued 11 Sept 93) and MR202756 (issued 6 March 94) issued s.47F(1) [redacted] **for and on behalf of Groupair P/L, did not show in the 'Maintenance Required' section that the approved lives, or the concessional overrun of these lives, for the left and right engines would expire during the validity period of each of these maintenance releases.**

Omission- On the part of s.47F(1) [redacted] nominated LAME for Groupair and maintenance coordinator for the issue of the maintenance releases for this aircraft who omitted to enter maintenance due as required by the regulations when issuing the maintenance release documents referred to above.

3) The left engine was operated approximately 15 hours beyond its approved 1000 hours TBO before concessional approval was granted for the engine to operate to 1100 hours.

Omission -The omission s.47F(1) [redacted] to notify 'maintenance required' on the maintenance release when he issued it failed to indicate to the operating crew when the engine life was due to expire.

4) An endorsement on MR202754, by Rod Lovell, on 10 December 1993 - "Port engine running rough" (resulting in an IFSD and return to Sydney Airport) was signed off s.47F(1) [redacted] **as being rectified by changing both spark plugs in the number 11 cylinder.**

Error - On the part of s.47F(1) [redacted] certified for rectification knowing that the aircraft was a transport category aircraft which should have been maintained as a class A aircraft, and that he was not either licensed or qualified to do so.

Omission - By Groupair who failed to ensure an adequate maintenance chain of command within the Groupair structure.

5) The left engine was granted a concession to operate for 100 hours beyond its approved TBO laid down in AD/ENG/4 when the oil sample reports which were submitted to substantiate the internal health and integrity of the engine, were in fact indicative of an engine with internal problems sufficient to warrant further questioning prior to giving that approval.

Omission - By s. 47F(1), who having commissioned an analysis of samples of oil from the left engine, failed to determine the source of reported high wear metals prior to submitting these reports to the CAA and who did nothing to prevent the continuance of operation without knowing the source of abnormal wear metals.

Error of Judgement - By the CAA assigned AWI who, instead of asking the operator to 'explain', recommended the concession application be approved when it was referred to the CAA Canberra specialist area for their approval.

Error of Judgement - By the CAA who approved the concession to overrun the approved engine TBO using oil sample reports which failed to substantiate the internal integrity of the engine and were instead indicative of internal distress.

6) Both the left and right engines, which were on approved concessional overruns of the published TBO period and were being operated on the same aircraft at the same time contrary to the advised intention of the Bankstown CAA assigned AWI. There were no published instructions issued by the CAA which would have prevented this from happening.

Omission - By the CAA, who have no published guidelines which would indicate to their AWIs, or the industry, whether or not the operation of two engines on the same aircraft with both engines in the over-run period is acceptable or not.

7) The last entry in the aircraft logbook, which detailed a right engine change was made on the 24 April 1994 and crossed out as entered- in- error. This entry was made on the date of the accident.

Error - s.47F(1) Groupair P/L who for reasons unknown decided that on the morning of the accident the right engine of VH-EDC had been changed and then that it had not?

8) The aircraft fuel system water drain cocks in the left main and right

auxiliary fuel tanks were found to be unserviceable or inappropriately located thus preventing positive operation or the assurance that fuel being supplied from these tanks was water free.

Error - [redacted] who having signed for the airframe inspection and issued three maintenance releases as coordinator for those inspections, for and behalf of Groupair, failed to document an unserviceability or access problem with the water drain cocks.

Omission - By [redacted], who on the morning of 24 April 1994 advised that he had conducted two water drain checks of the fuel tanks, before and after refuelling, without ensuring that the fuel tanks were free of water because of the defective cocks. Furthermore he did not enter the deficiencies as endorsements on the maintenance release which would have identified them for rectification either before the accident flight or at some later date.

Error - By Rod Lovell who signed for the daily inspection without actually doing it. [redacted] did the daily inspection, including fuel drains, then he should have signed the maintenance release for the Daily Inspection.

9) Incorrect assembly of the number 3 cylinder inlet valve rocker shaft and thrust washer assembly which at some time during the take off sequence of this aircraft on 24 April 94 allowed the loose thrust washer to jam the inlet valve in the partially open position thus destroying the induction charge to the other cylinders.

Error - On the part of person or persons unknown who, during assembly of the inlet rocker arm to this cylinder failed to fit the rocker arm thrust washer correctly; and, the 'supervisor' who failed to detect that one of the thrust washers had not been correctly installed.

10) The aircraft was operating with an out of date battery fitted to the ELT. The battery was identified with a 'replace by date' of 28 July 1992. This date was prior to the aircraft belonging to South Pacific Airmotive (SPA). Since that date Groupair have conducted three 100 hourly periodic inspections for maintenance release issue.

Error - On behalf of the AME who carried out the inspection of the ELT at the last periodic inspection for maintenance release issue; and, [redacted] LAME signatory for the airframe inspection and coordinator for Groupair who signed out the maintenance release.

11) The left engine left magneto drive gear exhibits abnormal wear of the internal splines. Examination has determined that the internal splines were non-carburised and did not meet the hardness specifications of the manufacturer. This abnormal wear is sufficient to question the serviceability of the gear at the time of the last engine overhaul , that the correct part had been fitted or that the hardness of the part for this model engine was sufficient. The extent of wear raises the question of the integrity of drive for continued operation beyond the approved TBO period unless intermediate inspections of the gear are carried out.

Possible Error - On the part of Field Aircraft Services Central Africa, Harare Airport, Zimbabwe who last overhauled this engine on 4 March 1987 and who may not have ensured integrity of the magneto driving gear fitted at the last overhaul.

Omission - on the part of s.47F(1) [redacted] investigate the source of abnormal wear metals in oil sample analysis reports, which could have detected this abnormal wear.

Omission - on the part of s.47F(1) [redacted] during periodic inspection checks for magneto synchronisation, failed to remove the magneto to investigate the cause of the magneto body being rotated fully against the end of the mounting slot when removal and readjustment would have detected the abnormal wear prior to magneto refitment.

12) The 90^{0} pulley block securing bolt of the left engine propeller pitch control cables were found to be severely worn despite a certification at the last periodic inspection (5 -8 hours prior to the accident) that the assembly had been renewed.

Error- On the part of s.47F(1) [redacted] certified for maintenance which had not been undertaken. This would indicate a breakdown in the 'direct supervision' aspects s.47F(1) [redacted] of the maintenance which was being carried out by the AMEs employed by, or being used, to maintain VH-EDC for South Pacific Airmotive under the Groupair Certificate of Approval.

13) There were two broken studs securing the No 12 cylinder to the engine crankcase. On removal, another adjacent stud broke with minimal loosing torque application. The crankcase was discoloured in the vicinity of the broken studs. This discolouration was visible prior to disassembly. When the cylinder was removed, there was evidence of cylinder base movement on the mounting pad.

Error- On the part of s. 47F(1), or whoever inspected this engine at the last 100 hourly inspection for which he signed, in that the broken studs were not detected even though it is an engine inspection item in the CAA Schedule 5 to inspect the cylinder base to crankcase area. If such an inspection were undertaken, there are no records which indicate that the broken studs had been detected.

14) Left propeller S/No 1G1B14 on disassembly was found to have been assembled with abnormally high nut pre-load on the cam/piston assembly which was restricting the movement of the pitch mechanism to travel into the feathered position.

Error - Of assembly by person or persons unknown who did, during assembly apply an incorrect over-tightening of the nut which retains the cam/piston assembly of the pitch change mechanism. The records show that this propeller was overhauled by Air Prop Services on 26/5/88 and that the current TSO is approximately 550 hours. There are no certification which would indicate that this assembly has been 'reworked' since the last overhaul.

15) There are no certifications in the logbooks to indicate that the left propeller was 'de-sludged' in accordance with the requirements of AD/Prop/1 on achieving 500 hours of operation. Nor are there any certifications for 100 hourly compliance of recurring AD/Prop/2 feathering checks (both engines) at the last two period inspections for maintenance release issue.

If this work was undertaken and not certified for, then there is an

Omission- s.47F(1) (Groupair P/L) in not documenting and certifying for the compliance of these airworthiness directives, or

If this work was not undertaken then there is an

Error - On the part of s.47F(1) Groupair P/L) in not complying with the requirements of mandatory Airworthiness Directives.

16) The log books being used to record the continuing airworthiness and history of this aircraft and its equipment, although meeting the current CAA requirements are inadequate to provide a continuing airworthiness or history audit trail record.

Omission- On the part all those persons who have carried out work, changed components, complied with ADs and inspections and certified within the pages of these old log books without complying with, or questioning, the current instructions to users which are not necessarily applicable to these older log books.

Omission- By the CAA in not taking into account those persons using old log books and providing instructions to users of them to ensure that an audit trail for continuing airworthiness and history is documented. Phasing in the use of the 'NEW' CAA aircraft logbook would satisfy that requirement.

Omission- By the Certificate of Registration holder who failed to ensure that the maintenance records of this aircraft were current and in accordance with the requirements for the keeping of log books.

17) There is approximately 12 years and 12000 hours of operation 'missing' from the aircraft records between 1977 and 1988. During this period the aircraft was being operated by Bush Pilots and associated companies. However if the records were passed to the next owner Air Rambler, then they were not apparently on-forwarded to South Pacific Airmotive.

Omission- By the CAA; who, if they had conducted adequate surveillance of those operators of this aircraft, would have identified a major break in the audit history of the aircraft and taken early steps to retrieve that data before it was lost. Additionally they would have taken steps to ensure that regulations regarding the continuance of log books and maintenanc e records were enforced.

Omission- By the current certificate of registration holder who, having taken possession of the aircraft, failed to ensure that the maintenance records were complete.

18) Groupair Certificate of Approval fails to adequately identify an engineering chain of command for the maintenance of DC3 Class A aircraft at Camden, NSW, when the parent Groupair company are located at Moorabbin, Victoria.

Omission- On the part of Groupair who failed to set up and advise to the CAA a company structure which identified how maintenance of the DC3 was to be conducted.

Omission- By the CAA Bankstown office and the assigned AWI to properly initiate their surveillance of Groupair Camden, T/A South Pacific Airmotive, and identify the maintenance link between

SPA and Groupair.

19) Although the CAA have subsequently advised that all DC3s have Certificates of Airworthiness in the Transport Category, there is a CAA Aircraft Register computer program which, when queried, is capable of issuing a duplicate Certificate of Airworthiness. These duplicate certificates identify some specific DC3s as being in the Normal category.

Error - Within the CAA between the Safety Regulation Group and the Aircraft Register section which enabled a duplicate Certificate of Airworthiness to be issued advising that this aircraft VH-EDC, was a normal category aircraft. This computer printout likewise advises of other DC3 aircraft being in the Normal category

7 Unsafe acts

1 Active failure:

<u>Incorrect assembly of the left engine No. 3 cylinder inlet valve rocker, shaft and thrust washer</u> either:-

- during the engine overhaul in 1987 or
- by persons unknown doing unrecorded maintenance.

Defences
* Failed supervision at the time of assembly.

The incorrect assembly, which left one of the rocker shaft thrust washers lying in the rocker box cavity as a loose article had lay dormant for a considerable period of time as evidenced by the mechanical deformation of the washer, the abnormal wear on the pushrod tube and the internal rocker cavity damage. Accepting a failure by somebody either doing the work, or the work not being adequately supervised, there are two other occasions when this incorrect assembly may have been identified and corrected.

On 10 December 1993 the left engine was shutdown in flight after rough running and the aircraft returned to base. The problem was certified as being corrected by s.47 s.47F(1) [redacted] changing both plugs in the No 11 cylinder. s.47F(s.47F(1 [redacted] had no Australian engineering qualifications to diagnose the problem or change the plugs. There is physical evidence to suggest that the rough running due to this inlet valve being held open has occurred on more than one occasion. Correct diagnosis of the rough running which caused the previously mentioned IFSD may have identified this incorrect assembly and damage being caused by the loose washer.

Likewise, when a concession application was made by s.47F(1) to the CAA, to exceed the published TBO period for the engine, he submitted two oil analysis reports from samples of oil taken from this engine. Both reports indicated abnormal concentrations of iron, aluminium and lead. Despite these reports the CAA granted approval for the engine to operate for a further 100 hours without requiring that the operator identify the source of this contamination.
Had further inspection of the engine been undertaken by the operator, when he received the adverse oil samples, or if he had been directed by the CAA to determine the source of these metals then the incorrect assembly and the mechanical damage being perpetrated by this loose article may have been found.

As the result two further windows of opportunity to find the problem were missed.

8 Correspondence Re Documents received/returned at................. **Appendix 38**

8.1 Ownership/Release from Custody refer to attachments at... **Appendix 39**

8.2 Invoices Correspondence refer to attachments at ....**Appendix 40**

8.3 Additional correspondence/Minute Notes to file
Refer to attachments at..................................... **Appendix 41**

Minute Note to File BO9401043 VH-EDC

Findings:

* Both main landing gears were retracted at the time of water impact.
* The left main fuel tank inboard cock was unserviceable and not possible to open.
* The right auxiliary fuel tank outboard drain cock did not align with the skin cutout.
* The NARCO Elt 10 battery was 21 months expired.
* Post recovery examination found no fuel in the left carburettor fuel filter or lines between the nacelle filter, the pump and the carburettor body.
* Post recovery examination found the left propeller blades were not in the feathered position. Abnormally high cam bearing nut preload prevented the left propeller from moving into the fully feathered position.
* There were no log book certifications to indicate compliance with AD/Prop/2 - Feathering Checks, or that feathering checks had been carried out, at the last two periodic inspections for maintenace release issue.
* The left engine, left magneto crankcase drive gear splines were excessively worn. (The magneto body was rotated fully anticlockwise on it mounting pad.)
* The left engine #3 cylinder inlet valve, rocker, rocker shaft and thrust washers had been incorrectly assembly. The washer which had been deformed during engine operation was found within the rocker cavity.
* There were 3 broken cylinder base mounting studs on the #12 cylinder of the left engine.
* Spark plugs on both engines were in generally poor visual condition considering a periodic inspection was certified for approx 6-8 hours prior to the accident.
* The aircraft was being maintained as a class B aircraft when the Certificate of Airworthiness was issued in the Transport category which made it a class A aircraft for maintenance.
* Both engines were being operated beyond the published TBO of 1000 hours on concessions approving them to operate to 1100 hours TSO.
* There were no entries on the last two maintenance release documents, in the maintenance required sections, to indicate when either of the

engines time-in-service was due to expire both at the 1000 hour TBO period, or the period granted for them to operate to 1100 hours TSO.

* The left engine was operated for 13 hours beyond the 1000 TBO period before approval was granted for the operator to do so.
* Flights of 4.5 hours are recorded on Maintenance Release No 202754, when that maintenance release ceased to be in force due to the commencement of an inspection for the issue of a new maintenance release and before that new maintenance release was issued.
* The maintenance records for this aircraft were incomplete and failed to provide a continuing airworthiness and/or history audit trail.
* There are no maintenance records to indicate certification or compliance with AD/Prop/1 note 1 - De-sludging of the left propeller at 500 hours TSO.
* The left engine 90 ^{0} propeller pitch control pulley block securing bolt sleeve was excessively step worn despite there being a certification on the additional worksheets of the last inspection that the assembly had been changed.

COMMONWEALTH OF AUSTRALIA
DEPARTMENT OF TRANSPORT

BUREAU OF AIR SAFETY INVESTIGATION

ENGINEERING GROUP REPORT

DOUGLAS DC 3C, VH - EDC

1) CRASHWORTHINESS AND ASSESSMENT OF THE SEAT AND HARNESS INTEGRITY
2) LEFT ENGINE COMPONENTS EXAMINATION
3) STRUCTURE AND SYSTEMS EXAMINATION
4) LEFT PROPELLER AND PROPELLERS COMPONENTS EXAMINATION

OCCURENCE No: 9401043

TASK NO: 9400018

s.47F(1) [redacted]

29 September 1994

1. Crashworthiness and Assessment of the seats and harnesses integrity

a) Pilot seats

Both seats were fitted with a four point harness consisting of lap and shoulder straps. Both seats shoulder straps were neatly stowed behind the back part of the seat, indicating that they were not used. With the exception of the inertia reels the seats and harnesses showed only normal wear.

Both seat's shoulder straps were anchored into the MA-2 Pacific Scientific inertia reel. The inertia reel controls were in the forward, fully automatic, position. When pulled on the harness, the pilot seat reel operated normally in both control lever positions, the co-pilot reel was stiff & hardly moved. The reels were not examined in detail.

b) Flight attendant seat

The base of an Ansair 6440-1 type seat was about 5 cm narrower than the pitch between the seat attachment rails, running longitudinally along the fuselage, requiring an additional length of the rail profile to be attached to the floor at the seat location. The seat was loose on the outboard side, but the feet attaching the seat to the floor were in the rail groove. The seat looseness was traced to the locating pin not being correctly engaged within the rail. The seat base stiffness then prevented the feet disengaging from the rail. No damage to any of the seat or rail parts was observed.

It was reported that the attendant was thrown forward during the accident. The four point harness was undamaged, its examination found no fault or abnormality likely to account for the uninitiated unlocking of the buckle providing it had been properly done up.

A comment was made about the strength of the shoulder harness to structure attachment point. The harness was attached to the double walled, reinforced bulkhead between the cabin and the toilet. General examination tends to indicate that the point was strong enough to withstand the required loads.

c) Passenger seats

The aircraft was fitted with two sets of "Flying Service Engineering and Equipment" model 2090-001 double seats. There were six rows on the left side and five seats on the right side - see Figure 1.

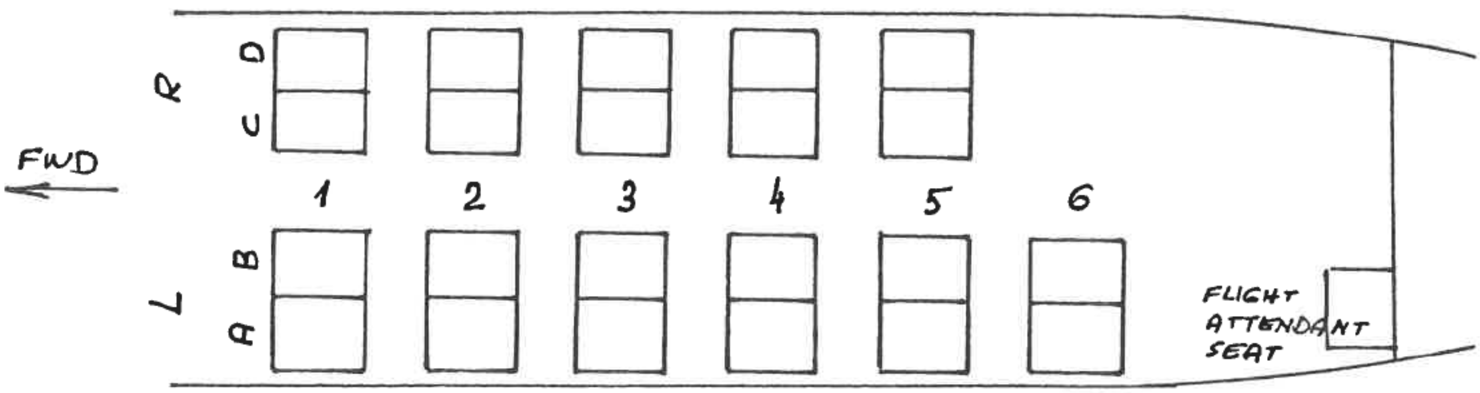


Figure 1: Seat location

Three feet on each side of the seat frame, one at the front and two at the rear, engage with the floor rails (Douglas track) running along the length of the aircraft. Insertion of the locating pin into the cut out in the rails then assures that the seat feet are correctly positioned in the rails and thus security of the seat to the floor. It was found that:

• Two rear feet on the outboard side of the 1 R seat were dislodged from the rail, just sitting on top of it, while the front foot was in the rail groove. Flexibility of the seat frame, however, permitted the foot to travel along the rail and would have allowed it to become dislodged under the load. The locating pin was found stuck in the upwards, stowed, position within its guiding tube, its operating arm missing. There was no evidence to suggest that the pin was damaged or the arm torn off during the accident, indicating that this situation probably existed for some time prior to the fight - see Figure 2. Neither the feet nor the rail were damaged.

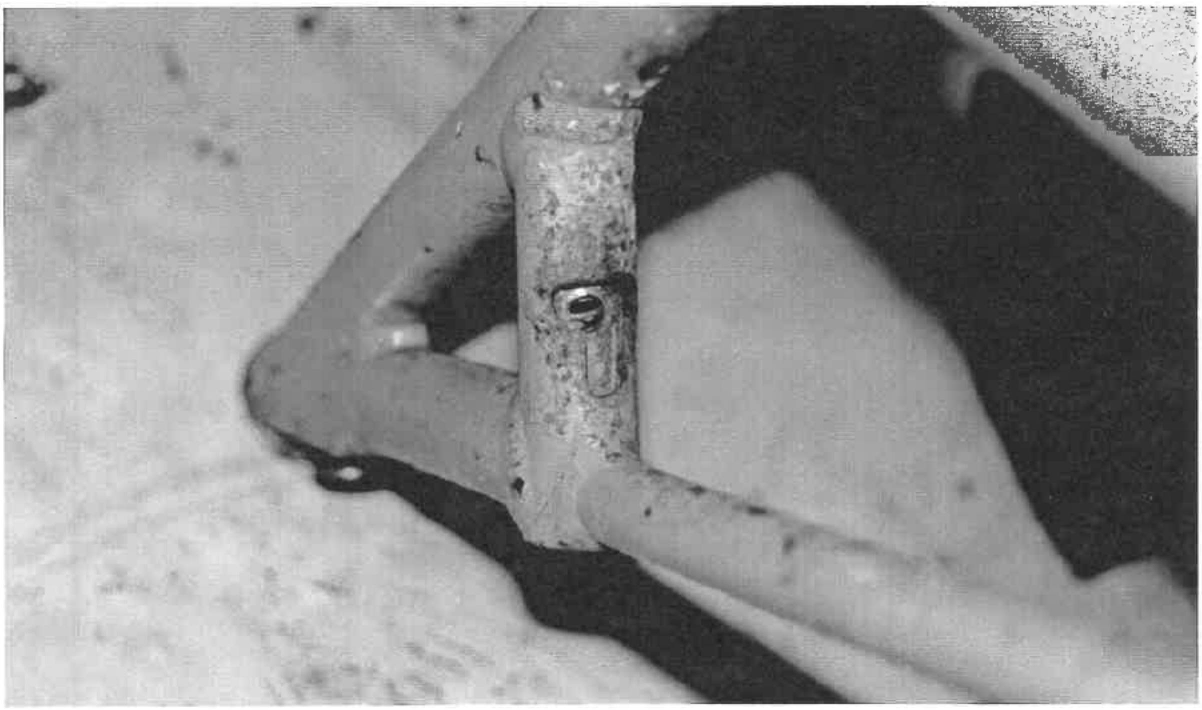


Figure 2: The locating pin stuck within the tube, the operating arm missing.

• The 5 L seat two outboard rear feet were also dislodged from the rail, while the front foot was in the groove and the locating pin was correctly engaged. None of the seat structure or the rail were damaged to offer any explanation for the feet to become dislodged. It appears that this situation must have existed from the time the seat was installed.

• The outboard end of the 6 L seat was completely dislodged and all three feet were just sitting on top of the rail and the floor panel. The locating pin was in the extended position and functioned normally. The frame was deformed so that when the front foot was placed back into the appropriate part of the rail, the rear end was about 3 cm outboard of the rail, not allowing for the two rear feet to become inserted into the rail - see Figure 3. being the only damage sustained by any seat or structure it seems likely that this damage was present prior to the accident. The feet, locating pin and rail were free of any damage.

NOTE: It was reported that the 5 L & 6 L seats were moved before the flight in order to obtain appropriate emergency exit clearance.

Figure 3: Deformation of the rear portion of the seat frame.

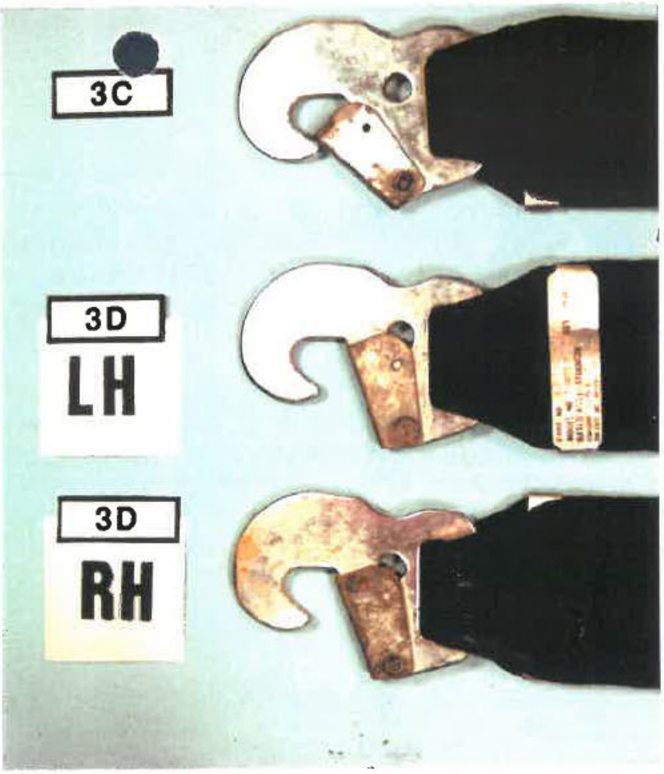
d) Passenger harness

All seats, with the exception of 4 L (A & B), were fitted with an Am-Safe, P/N 500800 H-2256, Model 449470 type lap straps manufactured at 06/90. Each half of the strap is attached to the seat by a hook shaped end fitting. To prevent the strap from becoming detached from the seat, the end fitting is fitted with a spring loaded gate - see Figure 4 A &B.

The 4 L seat straps had a triangular shaped end fittings which, once installed, became an integral part of the seat.

During the on site examination, the right half of the 3 D seat strap was found dislodged from the seat, its gate was jammed in the stowed position leaving the hook open. The gate on the opposite half of the strap end fitting was also jammed open, though, the strap remained attached to the seat. Both straps had the spring from the gate missing.

Examination of the remaining seat straps and their end fittings revealed the spring from the gate on the right half of the 2 C seat strap was also missing. The gate itself was deformed and partially open. The deformed and partially open gate was also found on the right half of the 5 C seat strap, though, the spring was present.



A   B

Figure 4: A) 3 D seat straps as found, with the gates jammed in the open positions. 3 C seat strap is shown for comparison to demonstrate position of the correctly functioning gate.
B) Detail showing arrangement of the spring within the gate mechanism.

The return spring sits in a recess on the attachment hook and butts against the gate under load - see Figure 4 B. It is not physically attached to the hook. While this is not the most secure way of designing this return mechanism, the spring is not considered likely to fall out under normal circumstances.

During normal service operation the spring usage is limited to the installation or removal of the strap from the seat. Otherwise, with the gate open, the spring is only lightly loaded preventing the gate from moving freely. With the load mainly on the attachment hook, it is unlikely that the loads encountered in the accident were sufficient enough to break or dislodge any of the missing return springs. Also, there is no evidence indicating that the spring material or design are at fault as the springs in the 3 C and other seat strap gates functioned flawlessly.

Entry in the aircraft log book indicates that all passenger seat belts were replaced by the new, FAA approved, belts on 3 March 1994. It is highly unlikely that the return springs could have broken or went missing within the estimated 6 to 8 hours the aircraft had accumulated since the 3.3.1994 and the time of the accident, suggesting that they were probably already missing at the time of the belt installation.

The gate is only exercised during the strap installation or removal. It seems that the only way for the gates to remain jammed in the open positions, as observed on the gates from the 3 D, 2 C and 5 C seats, is that the gates must have been previously deformed. Then, when pushed open during the strap installation, the gate is likely to jam on the fitting.

The straps webbing was in good condition, there was no evidence of an abnormal wear. The stitch pattern was of a type normally seen on the straps.

e) Crashworthiness.

With the exception of the 6 L seat frame no other seat, floor, floor rail or structure sustained any damage, indicating that the accident related deceleration loads remained low, well below the FAA structural substantiation limits. In absence of a measurable deformation, to base calculations on, no crashwothiness calculation was performed.

CONCLUSIONS

a) There was nothing amiss with the pilot and copilots seats, but their shoulder straps were not used. The pilot seat inertia real appeared to be operating normally, the co-pilot seat inertia reel was inoperative.

b) The flight attendant seat was partially loose due to the locating pin on the outboard site not being correctly engaged with the floor rail. No fault with the safety harness buckle was found to explain for it to open uninitiated.

c) Three out of eleven passenger seats were found not having the window side of their frames securely attached to the floor. 1 R seat locating pin was not operational and was seized in the stowed position, the 5 L and 6 L seat locating pins were not engaged with the floor rail. It is unlikely that the seats become disengaged during the accident, the situation appears to have existed since their installation.

d) The right half of the 3 D seat strap was found disengaged from the seat. Both halves of the 3 D and the right half of the 2 C seat straps had the springs in their end fitting mechanisms missing. The above mentioned straps and the right half of the 5 C seat strap further had the gates jammed in the open positions. It is highly unlikely that the springs went missing or the gates jammed during the accident, this situation was probably present at the time of the straps installation.

e) In absence of any structural deformation, no crashworthiness calculation was performed.

s.47F(1)
[redacted]

20 July 1994

2. Left engine components examination

a) Oil pump with the fuel pump drive

The pump was forwarded to determine the reason why the drive shaft, which drives the fuel pump could not be rotated. Numbers on the pump casting read 29804-130, 37586-D, 158501 and C 2785 $_N$. Also forwarded was the fuel pump drive housing number A 25616.

The pump consists of three individual sections, one supplying oil to the engine, the remaining two picking up oil from the rear case and the main sump. The pump was covered by mixture of iron and aluminium oxides resulting from the components being submerged in the sea. The pump front end plate side section contained the greatest amount of corrosion products literally covering both gears - see Figure 1.

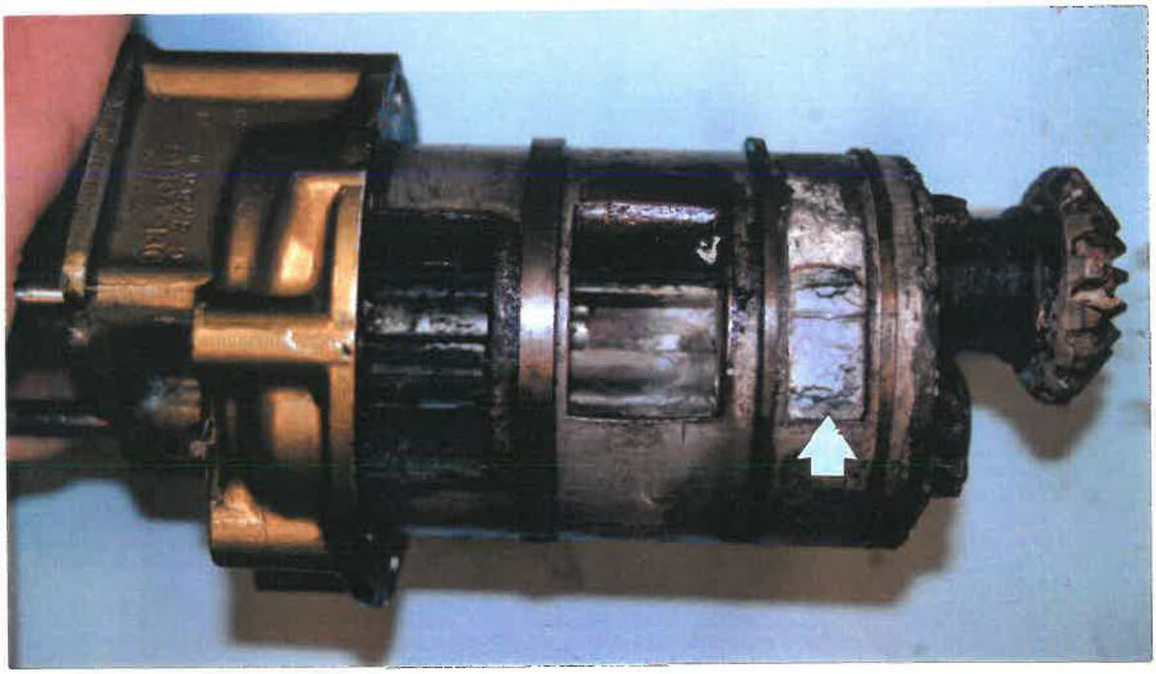


Figure 1: The oil pump showing the amount of corrosion products present on the front end plate side section.

During the pump disassembly the gear teeth imprints, surrounded by the corrosion products, were found inside the individual section cases - see Figure 2 A. It indicates that it was the corrosion growth preventing the shaft from rotating freely when operated by hand and that the corrosion took place only after the gears become stationary and pump exposed to sea water. No pitting was observed on the shaft or the sump case. This would have indicated that the corrosion had started some time prior to the accident.

The shaft passage through the pump end plate is designed as a close fit between both components. The hole in the plate contained an oil gallery for the shaft improved lubrication. Neither the shaft nor the hole in the plate were damaged, though they were covered by a light coat of fresh corrosion products associated with exposure to sea water and causing the shaft jerky movement when rotated.

The amount of corrosion products covering the pump teeth and the shaft passage through the end plate was the only reason for the shaft not rotating freely.

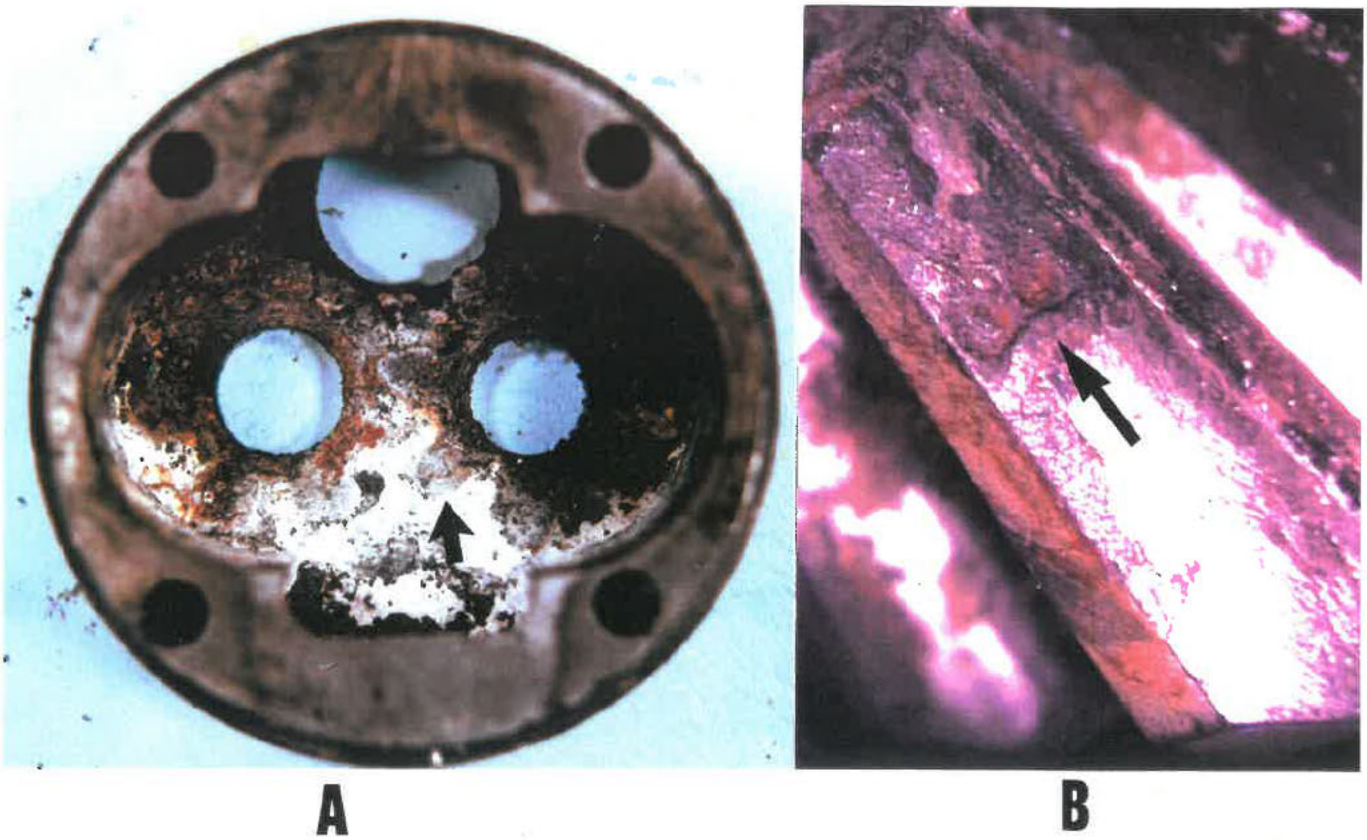


Figure 2: A) The pump gear teeth surrounded by the corrosion products.
B) The corrosion pits of crater size on one of the pump teeth, the hardened layer is broken and mostly missing.

Ten out of sixteen shaft bevel gear teeth contained corrosion pits of crater size penetrating deep into the teeth parent metal - see Figure 2 B. From the sizes of individual craters, it is apparent, that the teeth had been subjected to corrosion for a long time prior to the accident. The corrosion attack was facilitated by some teeth having substantial areas of the hardened, probably nitrated, layer missing. The damage is quite surprising considering that the gear is operating in well lubricated environment.

The fuel pump drive housing was free of any obvious damage, the fuel pump drive coupling rotated freely.

b) LH magneto driving gear

During the engine disassembly the abnormal magneto drive gear spline wear was noticed, the gear examination carried out by another BASI officer is enclosed at Appendix A.

c) Broken stud from #12 cylinder

It was advised that the stud failed during the cylinder disassembly after only a small force was applied on its nut. Two preceding studs, in the anticlockwise direction, had already been broken off and missing.

The stud examination revealed presence of a fatigue crack initiating from multiple origins around its circumference.

From the provided information it is apparent that one of the previously failed studs had not been correctly torqued during the cylinder assembly. The load fluctuation experienced by the stud during the engine operation probably resulted in the stud failing in fatigue; no part of the stud was examined. To compensate for the failed stud, the remaining studs around the cylinder flange would then experience higher loads. Combined with the cylinder base deformation, it is usually the adjacent stud which experiences greater load increase and also fails in fatigue, triggering a chain reaction of the stud failures around the cylinder base.

d) Propeller pitch control pulley assembly

It was advised that the assembly had been replaced with a serviceable unit during the last periodic inspection, but the bolt securing the pulley assembly to the bracket exhibits abnormal wear.

The 4.7 mm diameter bolt has a 7.9 mm diameter aluminium alloy sleeve inserted on it. The sleeve had worn through the wall thickness in two locations corresponding with the pulley assembly arms positions. Holes in the assembly arms exhibited corresponding wear and elongation - see Figure 3.

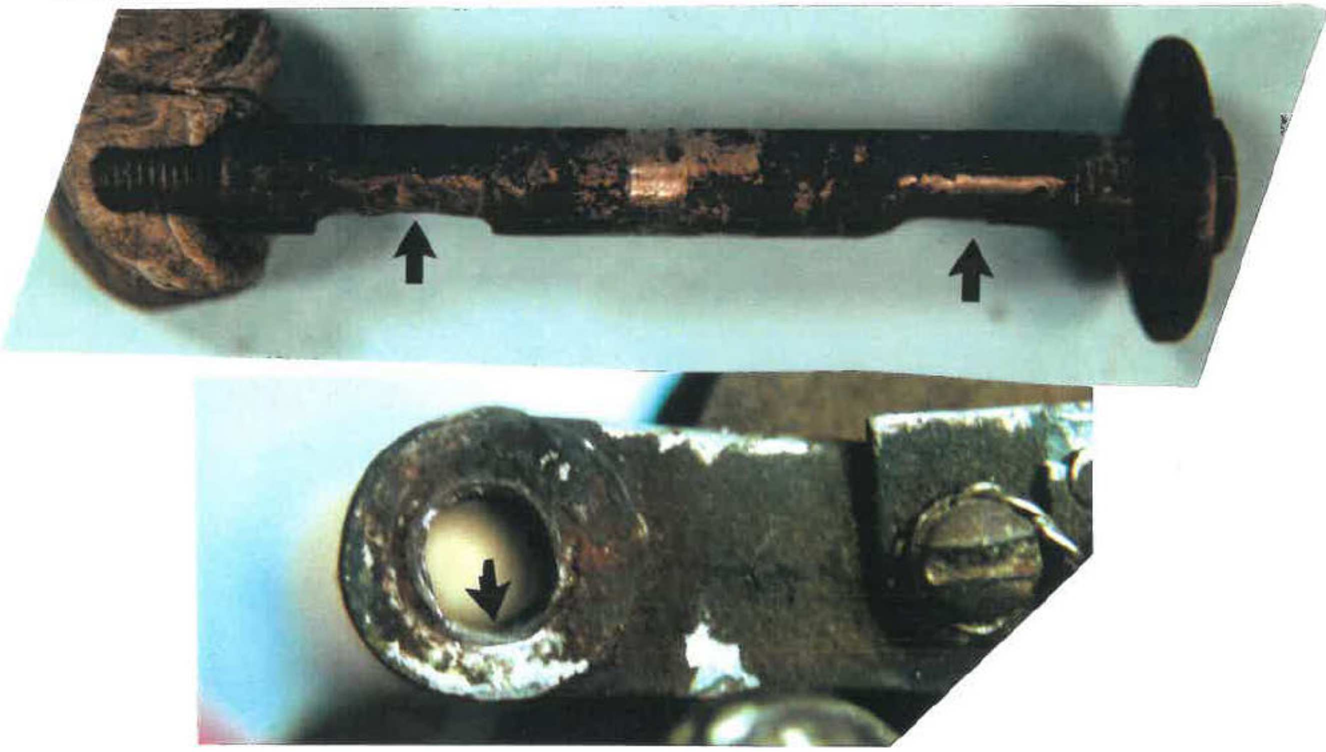


Figure 3: The worn out sleeve and elongated holes in the pulley assembly arm.

The pulley assembly is fitted with a spring to provide continuous preload to the control cables. The operation of cables is likely to result in a minute rotation of the assembly, the bolt providing the pivot point. The observed sleeve wear is not compatible with the recorded assembly time in service.

Two phenolic cable guiding pulleys were damaged due to the excessive cable load when the engine mount deformed during the accident or the aircraft recovery. The absence of marks indicating that the cable was sliding on the pulleys suggests that the pulley bearings were in adequate condition, they were not examined in details.

e) Fuel pump examination

As the pump shaft was not rotating, the pump could not be subjected to the compliance test, it was strip examined.

The pump number plate was torn off and missing, not allowing to identify its S/N and P/N. The numbers casted and stamped on the individual components read: PESCO, C 5139 A, P-7,R600-83B on the valve body and R600-84C on the valve cover.

The pump rotor with four vanes rotated within the stator which was in turn inserted into the pump body. The stator and the rotor components were made of steel, the pump body was made of a cast aluminium. The appropriate fuel passages were provided within the casting. The steel components were covered by a thin layer of fresh corrosion products, consistent with the pump having been submerged in sea water - see Figure 4 A. Some vanes were free to move in their appropriate slots, the movement of the others was restricted by the presence of corrosion.

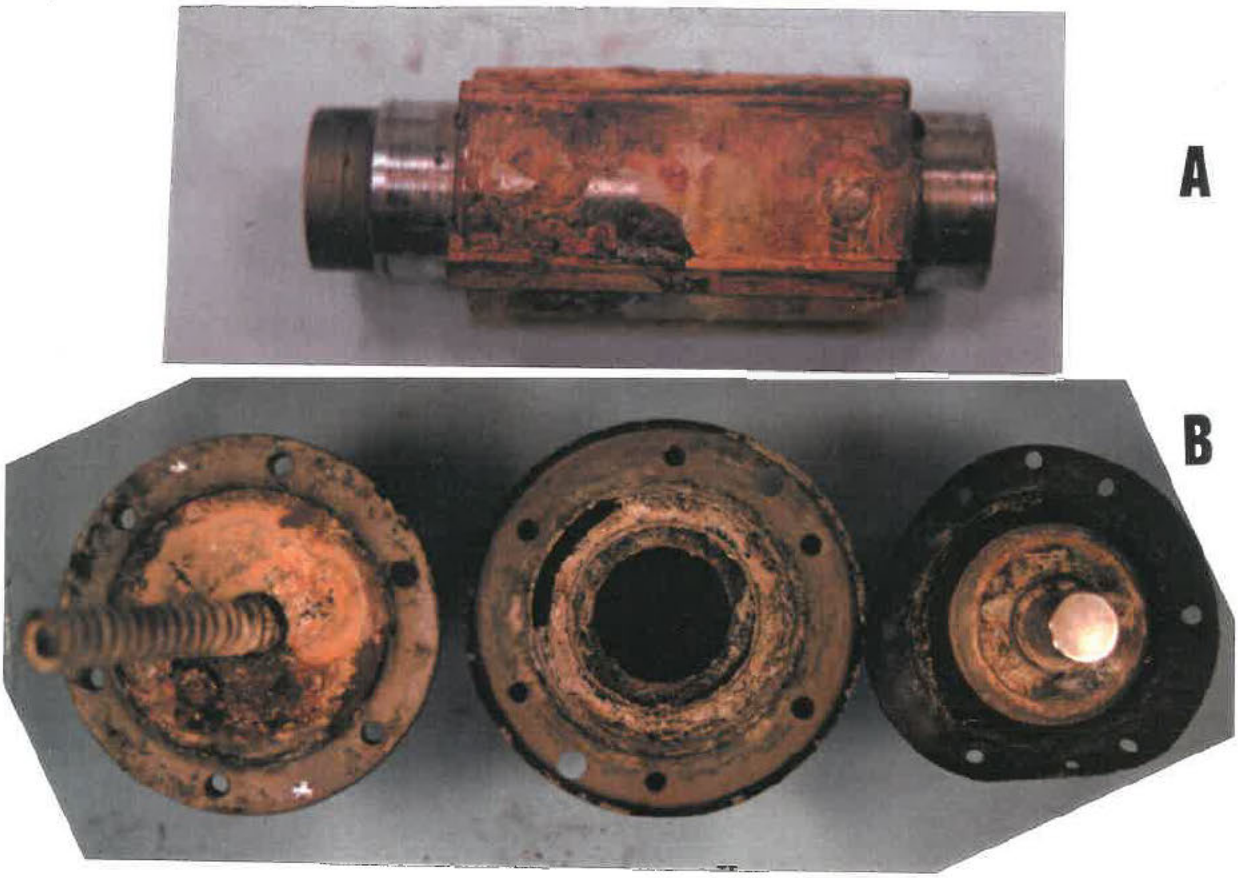
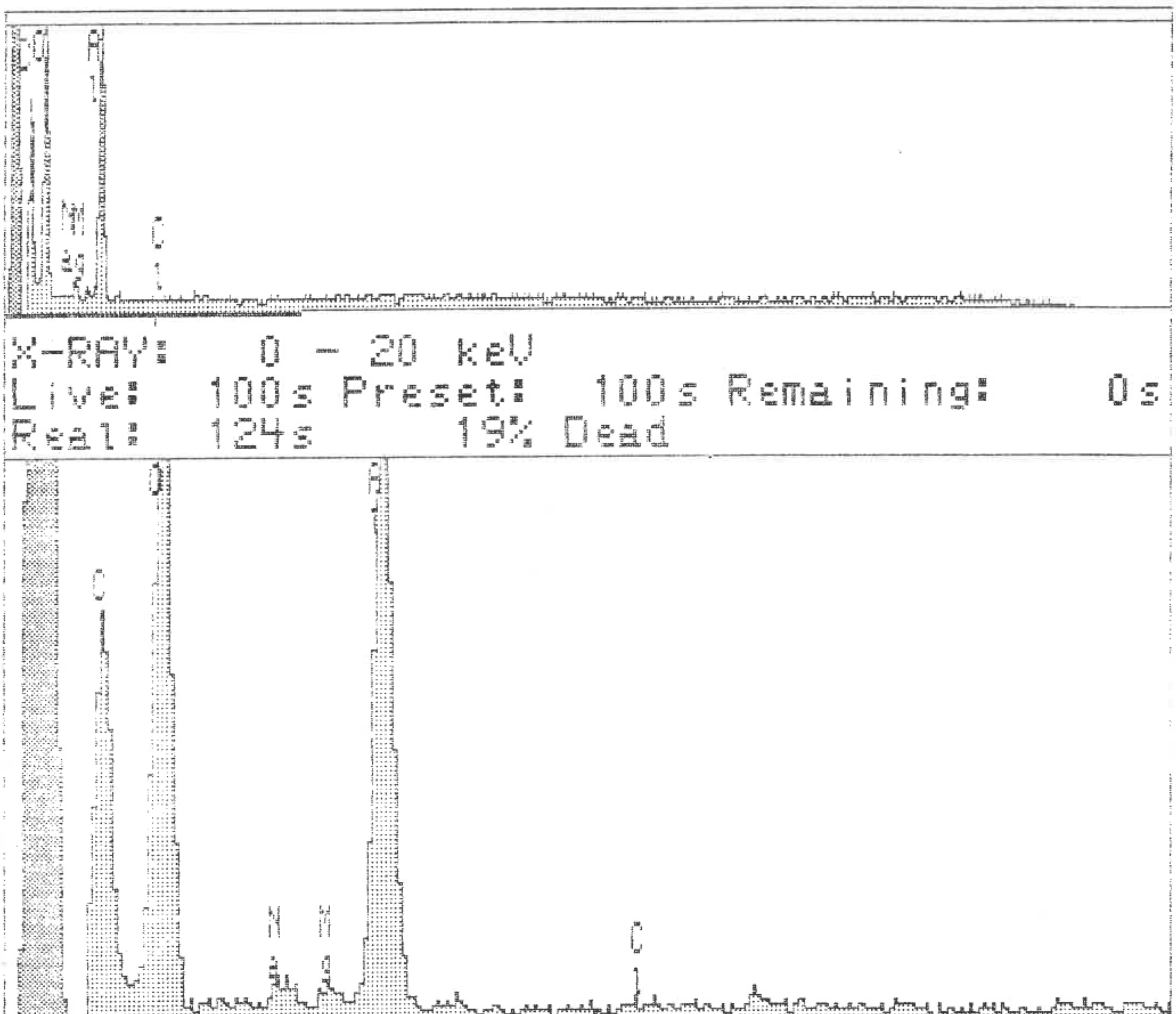


Figure 4: A) The pump rotor.
B) Corrosion products inside of the pump fuel pressure regulating valve.

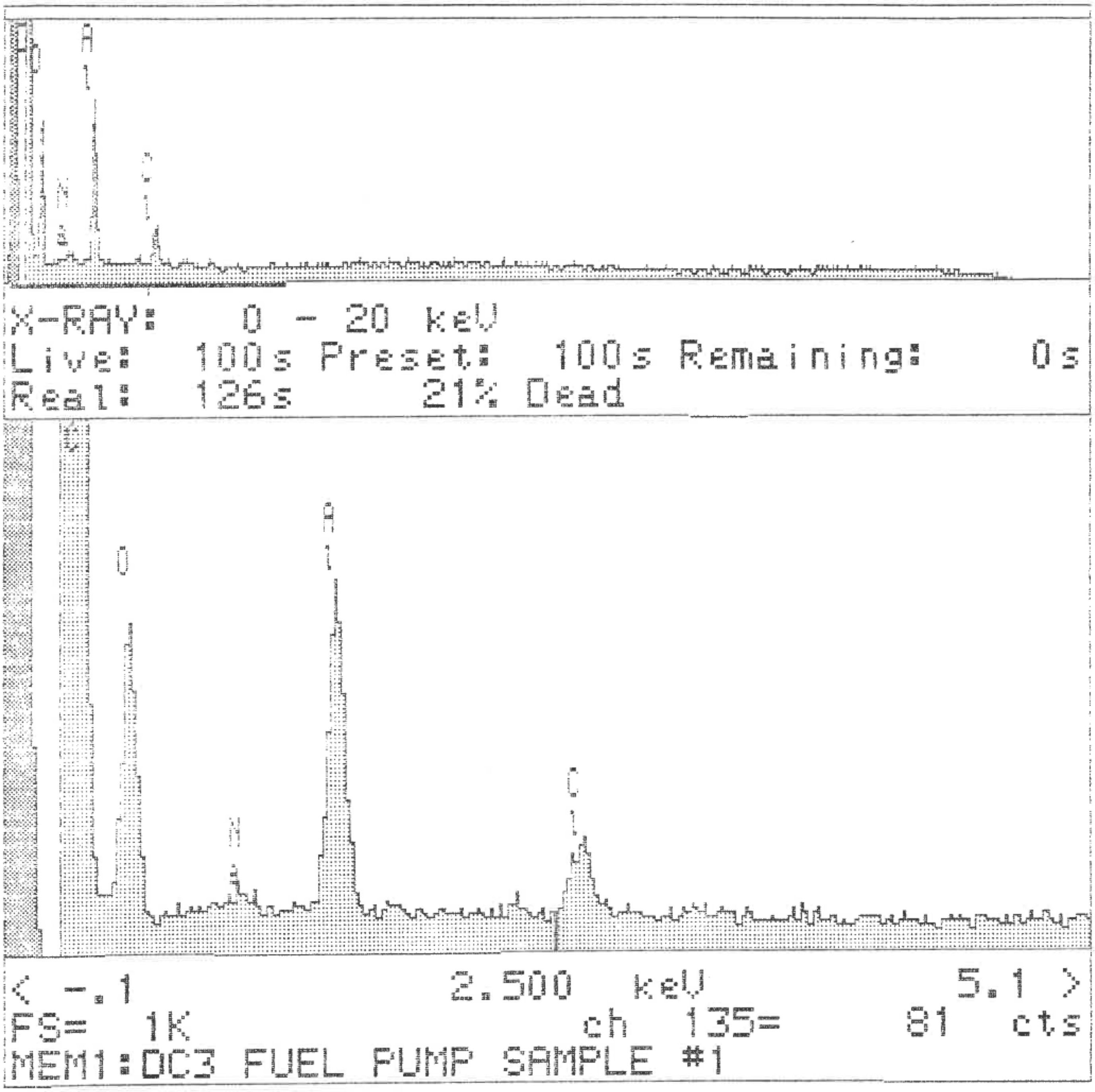
The spherically shaped cavities between the stator and the pump body, adjacent to the IN and OUT ports, contained an abnormal amount of whitish corrosion products. An amount of corrosion products was also present inside of the pump pressure regulating valve, rendering it inoperative - see Figure 4 B. Analysis of two corrosion product samples, to determine whether the corrosion resulted from exposure to fresh or sea water, showed a strong presence of chlorine and sodium, typical of sea water exposure - see graphs at Figure 5 & 6. It appears that the corrosion products growth had been accelerated by the galvanic corrosion between the steel and the aluminium alloy parts while the pump was submerged in the sea.

There was no indication of any abnormality likely to interfere with the pump`s normal operation prior to the accident.



— Impeller side of diaphram

FIGURE 6



Inside Surface Cover of the diaphram

4. Left propeller and propellers components examination

a) Left engine propeller

Type : Hamilton Standard 23E50-473
S/N : 1G1B14
Cam No : A 52932-187 98
TSO : 552.44 hours

During the aircraft on-site examination it was noticed that the blades were not in the fully feathered position. Readings of the blades pitch angle from the vernier scale on the outside cam and from the scales on two blade butts, no scale was present on the third blade butt, confirmed the blade pitch angle to be 65 - 66° - see Figure 1. The pitch angle of the fully feathered blades should be 88°. Neither the blades nor the hub exhibited any obvious damage likely to effect the blades pitch setting.

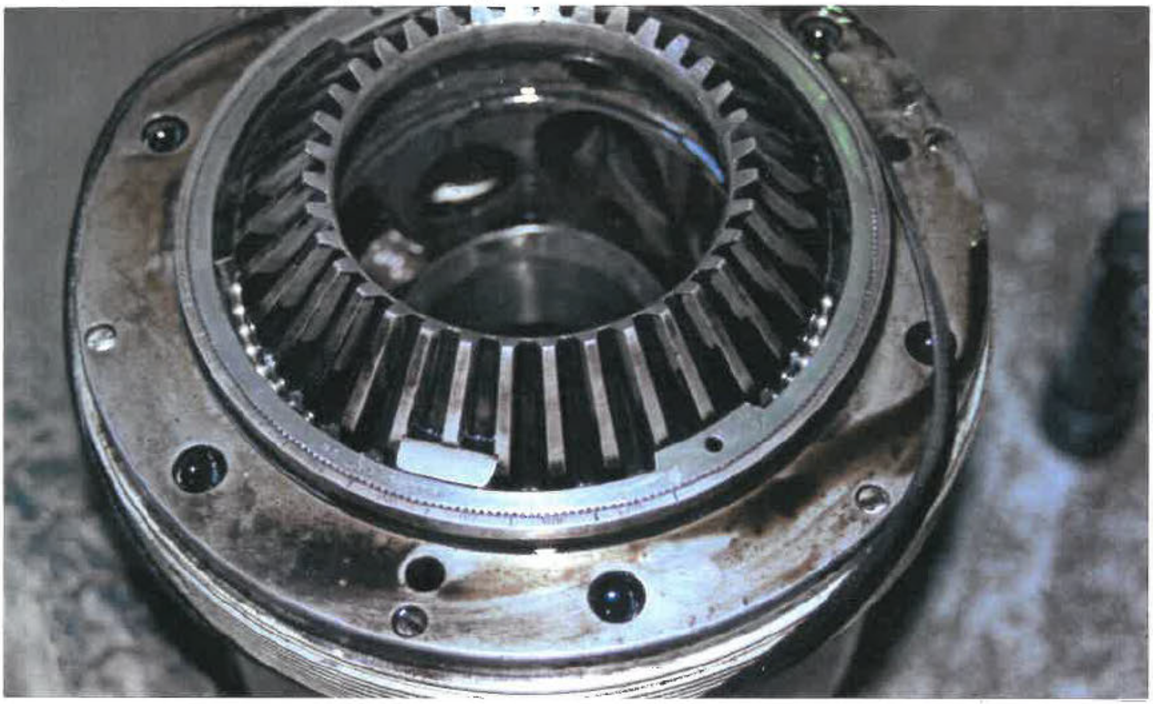


Figure 1: The vernier scale on the outside cam with feather stop giving blade pitch angle of 65 - 66°.

During removal of the dome, the specialist assisting with the aircraft examination, noted the absence of a shim between the dome and the hub. The shim is used to facilitate the correct meshing between the cam and the individual blade gears. Once further disassembled and cleaned, the "No shim" remark was found engraved on the piston. The propeller mechanism was well lubricated, neither the propeller nor the dome contained an abnormal amount of sludge. No part of the propeller mechanism was damaged or exhibited other then a service related wear.

The specialist examination to establish the reason for the propeller not travelling to the fully feathered position was carried out in my presence s.47F(1) [redacted] s.47F(1) The propeller was first examined at the Australian Jet Charter P.L. where it was stored at that time. The dome and the hub were then taken to the Australian Air Props workshop where the following was found:

- Torque to turn individual blades within the hub was measure to be approximately 55, 40 and 25 ftlb respectively, the required torque being 30-40 ftlb.

- To prevent water from penetrating into the hub while the aircraft is parked, a plastic sleave is placed onto the blade butt during the hub assembly. The blade requiring 55 ftlb to turn had he sleave dislodged from its position. The specialist commented that the higher torque reuired to move the blade was probably due to the water penetration and the likely presence of the corrosion products in the blade bearing area. The specialist did not considered likely, that the sleave became dislodged during the accident or that the eventual bearing corrosion would have played any major role in the propeller not going into the feathered position; the hub was not parted and the bearing was not examined.

- Once removed from the dome, the cam assembly and the piston remained "frozen" in the "as found position" not responding to any amount of human force trying to move the piston in either direction. The correctly assembled cams are required to move freely being propelled by their own weight only.

- To achieve this freedom of movement, the cam assembly pre-load nut had to be backed off by approximately 40°. Both, the cams and the bearings were in good condition, no abnormality to interfere with their normal function was found.

- Both the internal and the external cams to rollers contact surfaces contained heavy contact marks extending along the blades operational range. The fine pitch to cruise pitch range contained the heaviest marks - see Figure 2. All four roller assemblies rotated freely and contained no flat spots. The depth of marks would require the cams to be overhauled before they could be placed back into the service.

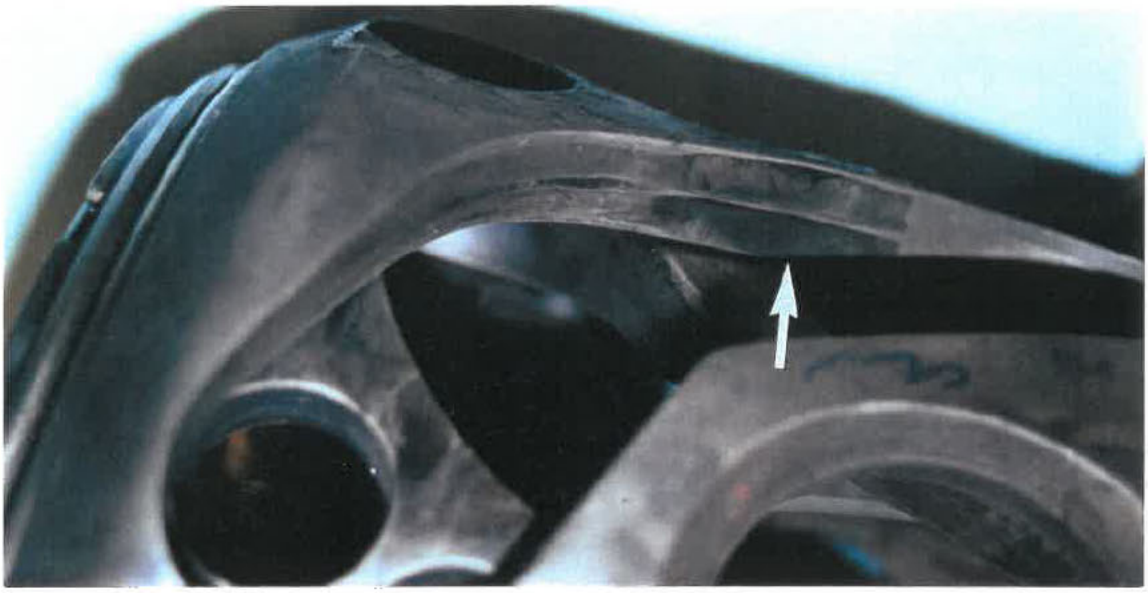


Figure 2: Contact marks on the outside cam.

The propeller feathering is initiated by pushing in a feathering switch located in the cockpit. This starts the feathering pump which delivers oil under pressure on one side of the piston, moving the blades into feather. On the cycle completion, after the blades reached the fully feathered position, the pressure build up within the dome activates the pressure switch in the propeller governor which sends an electric signal to release the switch. The feathering switch is spring loaded into the OFF position, which is the position the switch was found in during the cockpit examination.

The feathering pump and the governor were tested by Wiltshire Engineering for compliance with the appropriate specifications. No report has been received yet, though the verbal advice from the manager indicated that both units were in the excellent condition complying in every respect.

b) Left propeller distributor valve

The number on the Distributor valve body read: S/N 23522 and the number on the spring housing s.47F(1) [redacted]

The function of the Distributor valve (DV) is to provide a passage for the oil, metered by the propeller governor, to both sides of the propeller piston to maintain the propeller constant speed operation. Further, it facilitates the propeller feathering and unfeathering.

The position of the valve within the DV thus dictates the propeller function mode. During the constant speed and feathering operations, the spring housed within the valve housing at the forward part of DV, keeps the valve in the rearward position. The valve position is changed only during the propeller unfeathering operation when the oil pressure, higher then that during the constant speed and feathering operations, overcomes the spring and moves the valve forward, re-routing the oil flow.

Apart from the light DV surface corrosion there was no another damage present. The spring housing was lock wired, its position relative to the DV body is shown in the Figure 3. On removal, the spring showed nothing abnormal, its constant was not measured. The spring facing side of the washer placed between the spring and the valve contained a substantial amount of sludge. The valve fitted snugly into the DV body, once removed it showed no evidence of abnormal wear or any other damage. As far as it could be examined, without considerable DV disassembly, the valve lands were in good condition. There was no evidence of any port having been restricted or of any wear, corrosion or cavitation damage between any two ports. No apparent wear to the relief valve, likely to affect its function, was found.

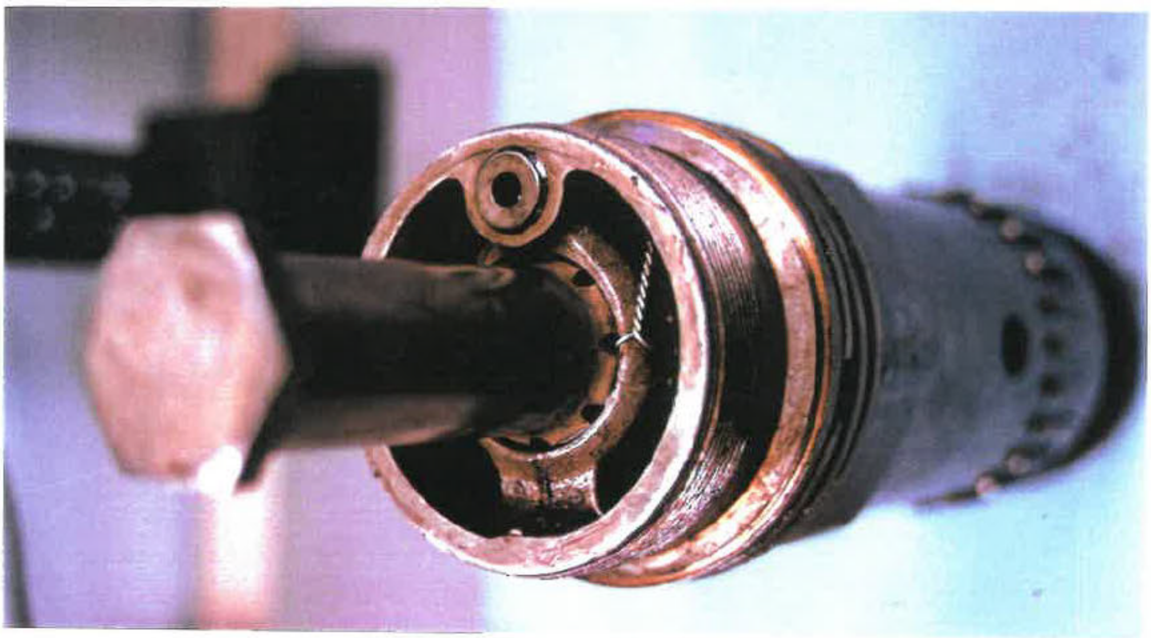


Figure 3: Position of the spring housing relative to the DV body.

Nothing was found to effect the DV function in both modes of operation. The presence of the sludge on the washer in between the spring and the valve is probably not unusual considering the expected minute flow of oil in that area.

c) Right engine propeller governor

Type : Hamilton Standard 4G8-G30M
S/N : WH 32824

The Wiltshire Engineering, who was contracted to test the governor against the specification, reported that the governor was grossly misrigged. To get it to constant speed at maximum RPM:

- the pulley had to be removed and placed from the position No 5 to the position No 6, there is a 60 ° difference between both positions,
- the pulley stop had to be moved by 20 ° and
- the high speed adjacent screw had to be re-adjusted to the equivalent of approximately 10° of the pulley rotation.

The examination of the pulley to determine whether the pulley was incorrectly placed on the governor shaft during some unrecorded maintenance or had rotated on the shaft during the engine separation from the wing during the aircraft accident was requested.

The aluminium alloy pulley, with the internal hexagonal hole, is placed on the hexagonal end of the steel governor shaft where it is secured by the nut and the cotter pin. One of the six pulley index marks thus always end up aligned with the index mark on the shaft. Given by the fixed position of the cable clamp on the pulley, it is usually the index mark No 5 matching with the mark on the shaft.

It is required that the washer is placed on the shaft in between the pulley and the governor body, leaving only approximately 5 mm length of the shaft exposed. With the pulley being 6.4 mm thick, and having approximately 0.6 mm deep round relief cut into its face, the shaft is thus approximately 0.8 mm below the pulley surface. During the disassembly at Wiltshire Eng workshop, the nut securing the pulley on the shaft was noticed to be only lightly tightened. The torque was not measured, but it must have been substantially less that the required 60 inlb.

Examination of the hexagonal hole revealed a substantial amount of wear, on the governor facing side of the pulley. The worn hole is shown in Figures 4. In contrast, the damage to the steel governor shaft was almost negligible.

The pulley was placed on the shaft with the mark No 5 aligned with the mark on the shaft, this being the normal service position. The pulley was then rotated by the hand while it was simultaneously pushed towards the governor. It could be turned by some 40 - 45 ° in the clockwise direction i.e. from the position No 5 to the position No 4 - see Figure 5. Note, that in order to adjust the governor, the pulley had been placed from the position No 5 to the position No 6 i.e in the anticlockwise direction. It is thus considered likely that the pulley could have rotated on the shaft when the tension was applied to the propeller pitch control cables during the engine separation at impact.

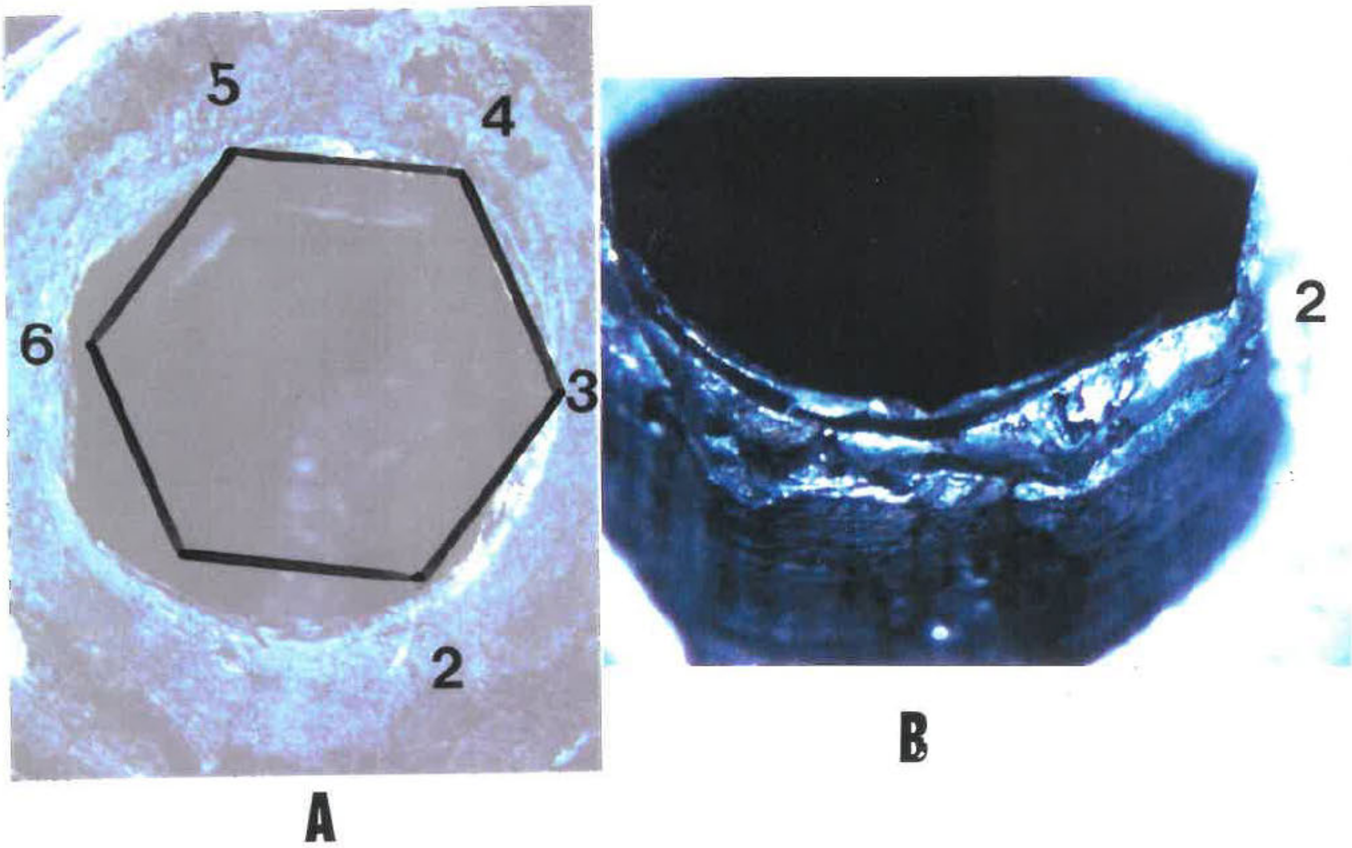


Figure 4: A) The amount of the pulley wear and distortion of its original hexagonal shape is highlighted by the comparison with the superimposed shaft hexagonal profile. Also marked are the corresponding pulley index marks.

B) Wear of the hole when viewed from the inside. The original hexagonal shape of the hole is outlined by the white markers.

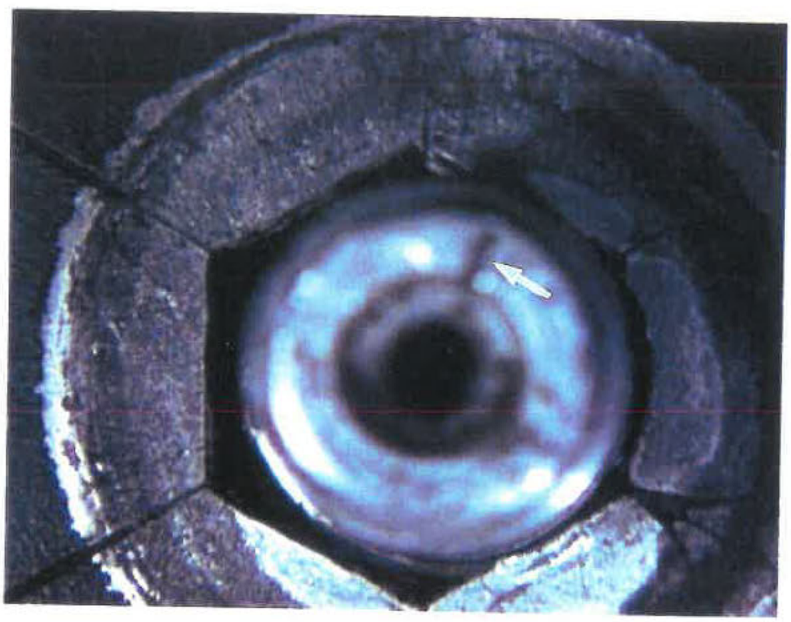


Figure 5: The amount of the pulley free rotation on the governor shaft due to the pulley hole excessive wear.

Conclusion

1) The blades failed to reach the fully feathered position of 88° of pitch. They were found having stopped at 65-66° of pitch.

2) This was due to the excessive preload applied to the cam assembly preload nut preventing the cam from moving freely. The correctly assembled cams are required to travel freely, being propelled by their own weight only. To achieve this, the preload nut had to be backed off by approximately 40°. The excessive loads, required to move the cams, resulted in heavy contact marks being made on the cam to rollers contact surfaces.

3) Remainder of the propeller and the propeller feathering system components were in a condition indicative to their time in service.

4) No abnormality likely to affect the left propeller distributor valve function and thus operation of the propeller, was found.

5) The pulley hexagonal hole was worn sufficiently to allow the pulley to rotate on the shaft by some 40 - 45 ° when rotated by hand. It is thus considered likely that the pulley could have rotated on the shaft when the tension was applied to the propeller pitch control cables during the engine separation at impact.

s.47F(1) [redacted]

22 September 1994

APPENDIX A

Excessive wear of splines on Left Hand Magneto Drive Gear (Bendix SF14LN-3) from Left Hand Engine (Pratt & Whitney 1830 S/N CP329666) of Douglas DC-3 (VH-EDC)

Both the Left Hand and Right Hand drive gears from the above engine were taken to the Materials Evaluation Facility (MEF) of the CAA for measurement of the wear on the internal splines and to determine the hardness of the internal spline surfaces of both gears. The MEF specialist assessment *(MEF Specialist Report 43-94 refers)* can be summarised as follows:

- Measurement of drive spline wear: Maximum spline spacing from the LH Magneto drive gear was measured at 4.1 mm (0.161 inch) - this is 0.040 inch more than the specified wear limit (refer to page 116B, as revised December 1971, of Pratt & Whitney (R1830) Overhaul Manual). Maximum spline spacing from the RH Magneto drive gear was measured at 3.0 mm (0.118 inch), the maximum wear limit.

- Spline hardness: There was no case hardening evident on the internal spline surfaces of either gear (the external surfaces were case hardened). The core and spline of both gears consisted of tempered martensite. The Vickers hardness measurements of the core and near the spline ranged from 354 to 357 VH 10 Kgf (68 on the Rockwell A scale) for the LH gear and 336 to 339 VH 10 Kgf (67 on the Rockwell A scale) for the RH gear.

Pratt & Whitney Service Bulletin 1074 refers to the replacement of magneto drive gears with non-carburised internal splines. The replacement drive gears are to have carburised internal splines with a Rockwell A hardness of 80 - 85. Note that this Service Bulletin was originally issued 17 March 1950 and the latest amendment (Revision A) is dated 24 April 1963. This model of engine (-92), however, is not covered by the above service bulletin. The engine manufacturer was asked to explain why this engine model was excluded from SB 1074 and to clarify where the part number for this drive gear may be found. Their response follows:

"Part number could be 38460 modified at production to 57612. This was done in the years 1944 to 1949 but part should be marked 57612 with 38460 crossed off.

Case hardening (carburised) of part except for splines was always done. Splines were carburised starting in 1949 and info in S/B 1074 applies. The parts were marked to PWA Spec 310 class 26 which is an inactive class at this time. Class 26 allowed many methods of marking but suspect either electro etch or vibro peen was used with shallow depth.

Another possibility could be same as reported by RAAF and Hawker de Havilland in Sydney about 1963/64 time. 57612 gear are being made from 18394 gear [note that there was no description provided for this gear] by cutting and adding collar and other types of machining to get a part which will dimensionally be like 57612. This unapproved part may not have a part number identification (except the bag or box it was packed in). RAID [there was no explanation for this acronym] 1718 was issued by Pratt in 1964 asking O/H shop representatives to be aware of this (note also that carburising of splines would not have been done)."

As the part numbers cannot be identified on either of the drive gears, it is difficult to say with any certainty whether these are the original parts, replacement non-carburised parts or bogus parts.

All engine and aircraft log books obtained from the operator were reviewed and there is no indication that either of the magneto drive gears had ever been replaced. CAA Airworthiness Directives for electrical equipment (107), Pratt & Whitney engines (106) and DC-3 aircraft (105) have been checked and no obvious relevant ADs have been issued for this component.

The LH magneto was cleaned and inspected for any discrepancies that may have led to the extreme wear on the drive gear splines. There was no indication that this magneto contributed to the extreme wear of the splines on the magneto drive gear. The magneto strip report from AVECO indicated that there was no problem with any of the magneto components in this particular magneto. There have been many magnetos on this engine. The records for both the aircraft and engines are not detailed enough to show what magnetos had been installed and when they were changed but it is not improbable that sometime in the past a faulty magneto may have contributed to the poor condition of the drive shaft splines.

CONCLUSION

Part identification: There is no easy way of identifying the part numbers for these gears. The lack of adequate detail in the log books of both engines has meant that there is no indication as to when these gears would have been inspected and/or changed. The advice received from the manufacturer that there were different part numbers with different internal splines and the possibility of bogus parts does nothing to clarify this situation.

Effect on Engine Operation: There wear on these gears must have had some effect on the operation of the engine as the left hand magneto (to which the gear with the most wear was attached) was adjusted to the maximum of its limit. It is possible that the magneto was progressively 'corrected' to account for the wear on the internal splines of the drive gear.

Lack of Maintenance Records: The main area of concern throughout this investigation has been the lack of adequate records. This is especially true of maintenance documentation. The log books seem to be adequately maintained up to the transfer of ownership of this aircraft from Air Queensland in the late 1980s. Field Air Services of Zimbabwe carried out the last overhaul for this engine in 1987. Since then the magnetos were changed but there is no record as to when and by whom they were changed. Without this information we cannot establish whether the wear on the internal splines of the drive gear is normal and was not picked up at inspection or magneto change, or whether the wear is abnormal in that it occurred over an unacceptably short period.

s.47F(1) [redacted]

29 September 1994

Attachment: CAA MEF Specialist report 43-94

3. Structure and systems examination

a) Structure

The following damage was sustained during the aircraft ditching:

• The right engine and propeller had torn off.

The engine, the propeller and the cowling had torn off the fire wall due to the application of excessive impact related loads. The severed engine mounts showed no evidence of any pre-existing condition. Two propeller cut marks on the fuselage right side were consistent with the separated engine moving to the left and underneath of the wing. The engine and propeller controls, the fuel and the hydraulic flexible lines had severed during the engine's separation.

• The right landing gear structure and the underwing fairing panel.

It was advised that, to facilitate the aircraft transport, the lower part of the leg assembly, with tyre and drag brace, was disconnected shortly after the wreckage was recovered. When examined, the upper "H" frame was in the locked down position with the locking pin inserted. Two "H" frame diagonal struts were fractured just underneath the plate in the middle of the cross, consistent with the force having been applied on the lower part of the assembly, probably the wheel tyre, from the front and right. All of the leg attachment points were free of any damage.

The drag brace to wing attachment severed in overload. The underwing fairing damage was consistent with it having been hit by the liberated brace. The hydraulic actuators remained attached, though all lines were severed allowing for unrestricted ram movement. It was not possible to determine the likely leg position at the time of contact with water.

• The left undercarriage leg

No damage to any of the leg attachment points or the leg elements was observed, the exception being the broken off drag brace which failed in overload at the wing attachment point. The tyre was fully stowed within the gear bay, the wheel axis was pushed some 13 - 20 cm further upwards and about 6 cm rearwards beyond the stops made of rubber blocks. It was advised that this was consistent with loads applied on the leg during the aircraft recovery.

• Deformed right aileron.

The aileron was severely deformed, consistent with the application of an hydraulic pressure, and pushed down, well beyond the natural limit of travel. The observed deformation is shown on photographs taken just before the aircraft sunk indicating that it occurred during the ditching stage, consistent with the aircraft yawing suddenly to the right while the aileron was partially submerged.

• Broken landing flap push pull rods, flaps deformed.

Some control rods had broken in overload, probably due to the hydraulic pressure having been applied on the flaps during the ditching stage. The observed flap deformation was a combination of that occurring during landing and recovery stages. No indication of any pre-existing abnormality was evident.

• Broken off antennas.

Some antennas on the aircraft nose were missing having probably been torn off during the aircraft ditching.

b) Control surfaces position

The control surfaces were found in the following positions:

• Left aileron; there was a mark on the wing lower surface, about a metre from the tip,extending onto the aileron surface. The marks could only be matched if the aileron was placed in or close to the neutral position. However, there was no evidence allowing to ascertain whether the mark was made during the ditching or the recovery stage - see Figure 1.

Figure 1: Mark on the aileron and wing lower surfaces.

• Right aileron was damaged as mentioned previously, no indication of its position prior to having been damaged was found.

• Right aileron trim was about 2-3° down (right wing down), when examined. No other marks were present.

• Flaps were about 20-22° down. The flaps are driven from the common unit in the centre of the fuselage. As some of the control rods remained undamaged, it can be assumed that this position represents the flaps setting at the time of ditching.

• Elevator, was resting on the lower stops, no indication of any pre-impact position was present.

• Both elevator trims, on the left and the right sides, were in neutral positions.

- Rudder rested about 4-5° to the right, but it moved freely through its control range without any restriction. No evidence of any impact related mark indicating its position at the time of ditching was present.

- Rudder trim was in neutral position.

All control surfaces responded correctly to inputs from the cockpit, no abnormality or anything missing was observed.

c) Fuel system

The following observations of the fuel system and its individual components were made:

- The left auxiliary fuel tank was found almost empty. An attempt to locate a possible crack allowing the fuel to escape was, without an appropriate tool like a boroscope, unsuccessful.

- Fuel tanks drain points. Each wing contains main and auxiliary fuel tanks, each tank being fitted with two drain points. There was a mixture of a "push in" and a "screw in" drain valves used on the aircraft. It was noticed that:

  a) Both left main tank valves were of the screw in type. The inboard valve`s "butterfly" handle swaging had deteriorated to a degree that allowed the handle to rotate freely without actuating the valve. There was no damage in the area which indicated that the observed looseness was caused during the aircraft ditching or recovery. The outboard valve was also of a screw in type, but it was tightened to the extent that an excessive force was required to undo it. The question comes to mind whether the tank was actually drained before the last flight.

  b) The right wing auxiliary tank outboard valve was out of alignment with the cut out in the wing skin, i.e. inside in the wing. A special tool would be required to properly operate this valve.

- Function and condition of the fuel system components was tested by operating hand pumps and utilising remains of the fuel in tanks. Combining different fuel selector valve selections the system function, up to the points were the fuel lines were severed, was established. No fault was found, the fuel flowed freely, without any noticeable restriction.

d) Cockpit instruments

The instruments were examined in situ, giving no impression of anything abnormal. Due to the low level of deceleration experienced during the accident sequence it was highly unlikely that the examination of the faces to ascertain readings at impact would yield any meaningful results. No instrument was removed for inspection.

s.47F(1) [redacted]

18 August 1994

f) Fuel hoses

Examination of the fuel pump to the carburettor, the fire wall to the fuel pump and the fuel pump to the cross feed line fuel hoses was requested.
All three hoses were straightened and, using a light source, examined for possible restriction or deterioration of the wall. Nil were found.

g) Number 3 cylinder

During the cylinder disassembly one of the thrust washers, fitted on each side of the inlet rocker arm, was found loose within the rocker arm cavity. The washer was deformed, with internal edges of the push rod entry hole into the rocker arm cavity and the push rod upper end section containing a number of deep rub marks. The components examination was requested to determine whether the washer may have held the inlet valve open during the engine operation.

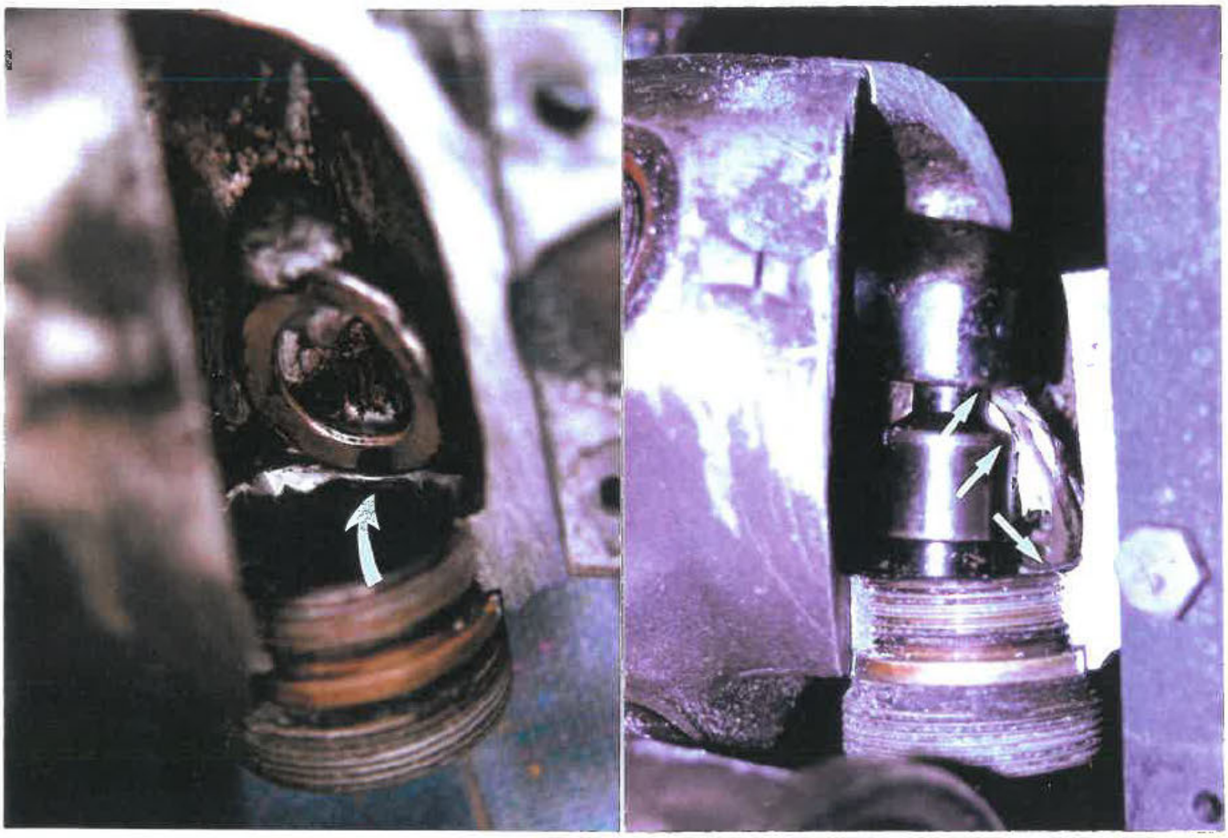
The washer was deformed into an ellipse and was bent in its plane. It contained three fresh marks, two could be matched with the push rod upper end fitting, the third one matched with the inside edge on the rocker arm half balled end. The rocker arm side of the push rod contained heavy rub marks, two of them penetrated deep into the rod surface. Their curved edges matched with the shape of the washer - see Figure 7.

Figure 7: Deformed washer and deep rub marks on the push rod.

The rub marks inside of the push rod entry hole could be matched with deformed washer. Further, the entry hole upper edge, facing into the rocker arm cavity, contained a shallow curved mark. Flow of the material into the hole indicated the compression nature of the mark, clearly different to the rest of the rub marks. The shape of the mark again matched with that of the washer - see Figure 8 A. The amount of the material rolled inside of the hole suggests that the washer must have been in this position for a considerable period of time or that this situation may have arisen previously.

It appears that the previously deformed washer had at some stage been caught between the side of the push rod entry hole and the push rod, rubbing into both. The push rod movement, especially after two deep marks had rubbed into it, could have lifted the washer above the push rod entry hole edge. As seen from Figure 8 B, it is then possible for the washer to become jammed between the rocker arm and the push rod upper end while its opposite side thrusts against the edge of the hole preventing the intake valve from closing. The amount of the permanent valve lift was measured to be approximately 4 mm.

This is likely to cause the manifold pressure to fluctuate considerably, reflecting the cylinder power cycle pressure peaks. Further, it is possible for the mixture in the intake manifold to become ignited, depriving the remaining cylinders of fresh air/fuel mixture. The overall effect being the loss of engine power and irregular running.



A B

Figure 8: A) The mark on the edge of the push rod entry hole. Its shape matched the shape of the washer.
B) The washer with one end thrusting against the push rod entry hole edge, while the opposite end is jammed between the rocker arm and the push rod upper end. To facilitate demonstration, blutack was used to hold the washer in place.

The evidence of fire burning inside of the intake manifold was present on the intake manifold attached to the cylinder. It was black inside, covered by fire residues, though it was not possible to determine whether they were fresh or resulted from any previous backfiring. Also, the wire mesh on the top of the carburettor contained deposits of black soot. Anecdotal evidence indicates that it is not unusual for the engine to backfire on the start.

CONCLUSION

a) The oil pump drive shaft could not be rotated by hand due to the corrosion growth around the pump gears. The growth took place during the time the pump was submerged in the sea. Ten of the sixteen shaft bevelled gear teeth had corrosion pits of crater size penetrating into the teeth parent metal. The corrosion appears to have been present before the accident.

The fuel pump drive housing was free of damage, its coupling rotated freely.

b) Wear of the left magneto drive was well beyond the wear limits, the right magneto drive wear was just on the limit. While the external surface of both gears was case hardened, the internal spline surfaces were not case hardened showing Rockwell hardness of 67 and 68 respectively. (Replacement gears under the P & W SB 1074 issued in March 1950 are to have Rockwell hardness of 80-85, though this bulletin does not apply to the - 92 engines.)

As there were no part numbers found on the gears, their status could not be identified.

Examination of the magneto found nothing likely to contribute to the extreme wear of the splines. The magneto installed on the engine at the time of accident is not the one installed during the engine overhaul, status of the previously used magnetos is not known. Without knowing their status it can not be establish whether the wear of the internal splines of the drive gears is normal and was not picked up at overhaul or magneto change, or whether the wear is abnormal in that it occurred over an unacceptably short period.

c) The stud from the #12 cylinder base failed in fatigue initiating from multiple origins around the stud circumference.

d) The propeller pitch change mechanism bolt aluminium alloy sleeve had worn through the wall thickness on two locations corresponding with the assembly arm positions. Holes in the assembly arm exhibited similar wear and elongation. The component wear is not compatible with the claimed assembly time in service.

e) No defect or any abnormality likely to effect the fuel pump operation prior to the accident was found. The amount of the corrosion products found inside of the pump and preventing its shaft from rotating, was consistent with the pump having been submerged in the sea.

f) The fuel hoses from the engine compartment were free of any restrictions likely to interfere with free fuel flow.

g) Matching the marks found on the washer, push rod and push rod entry into the intake valve cavity hole, it was demonstrated that one end of the loose washer had been jammed between the rocker arm and the push rod upper end while its opposite side thrusted against the edge of the hole preventing the intake valve from closing, at some stage. The amount of the permanent valve lift was measured to be about 4 mm.

This would have caused fluctuation of the manifold pressure, reflecting the cylinder power cycle pressure peaks. There is also a possibility of the flames penetrating into the intake manifold. The overall effect being the loss of engine power and irregular running.

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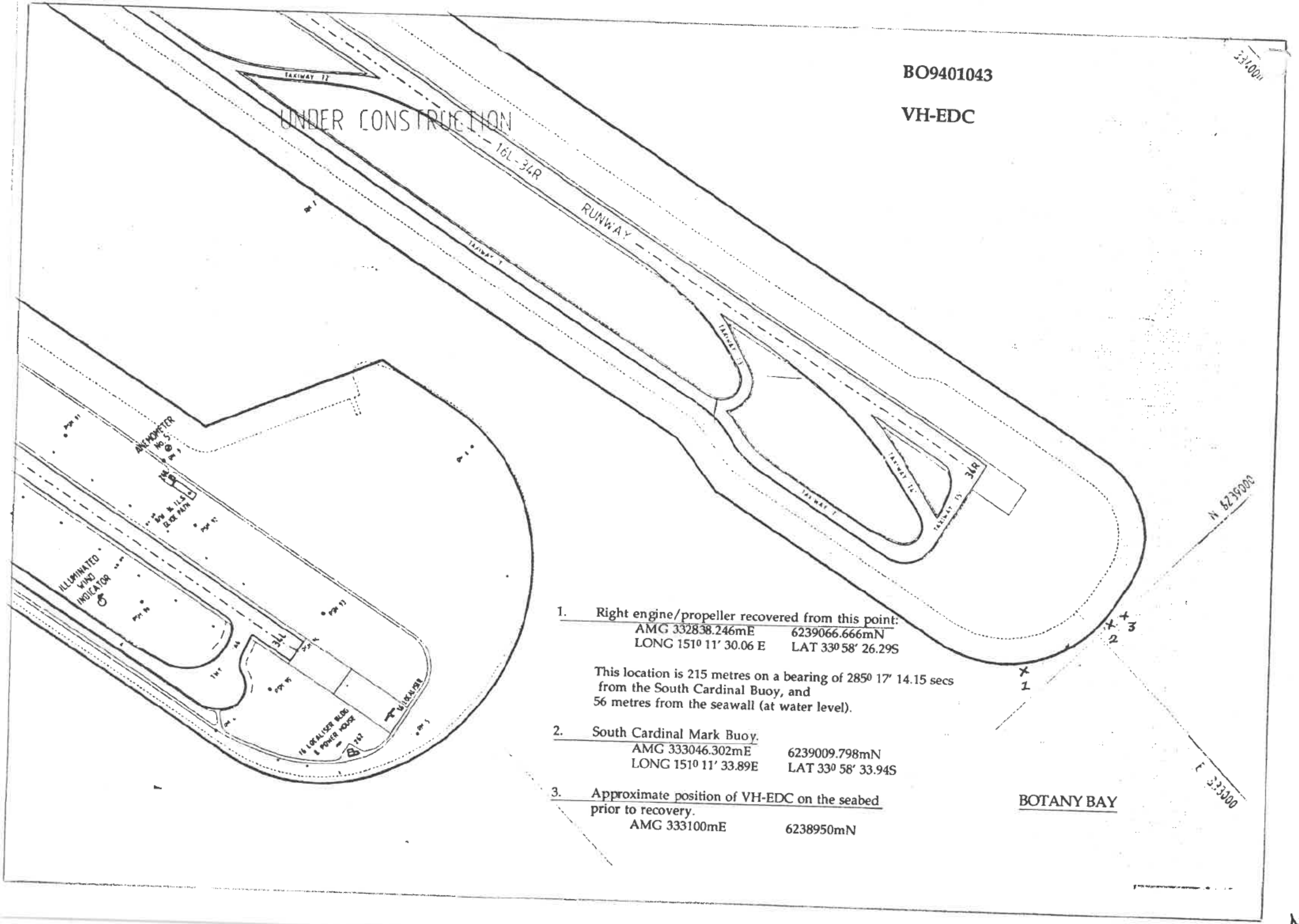
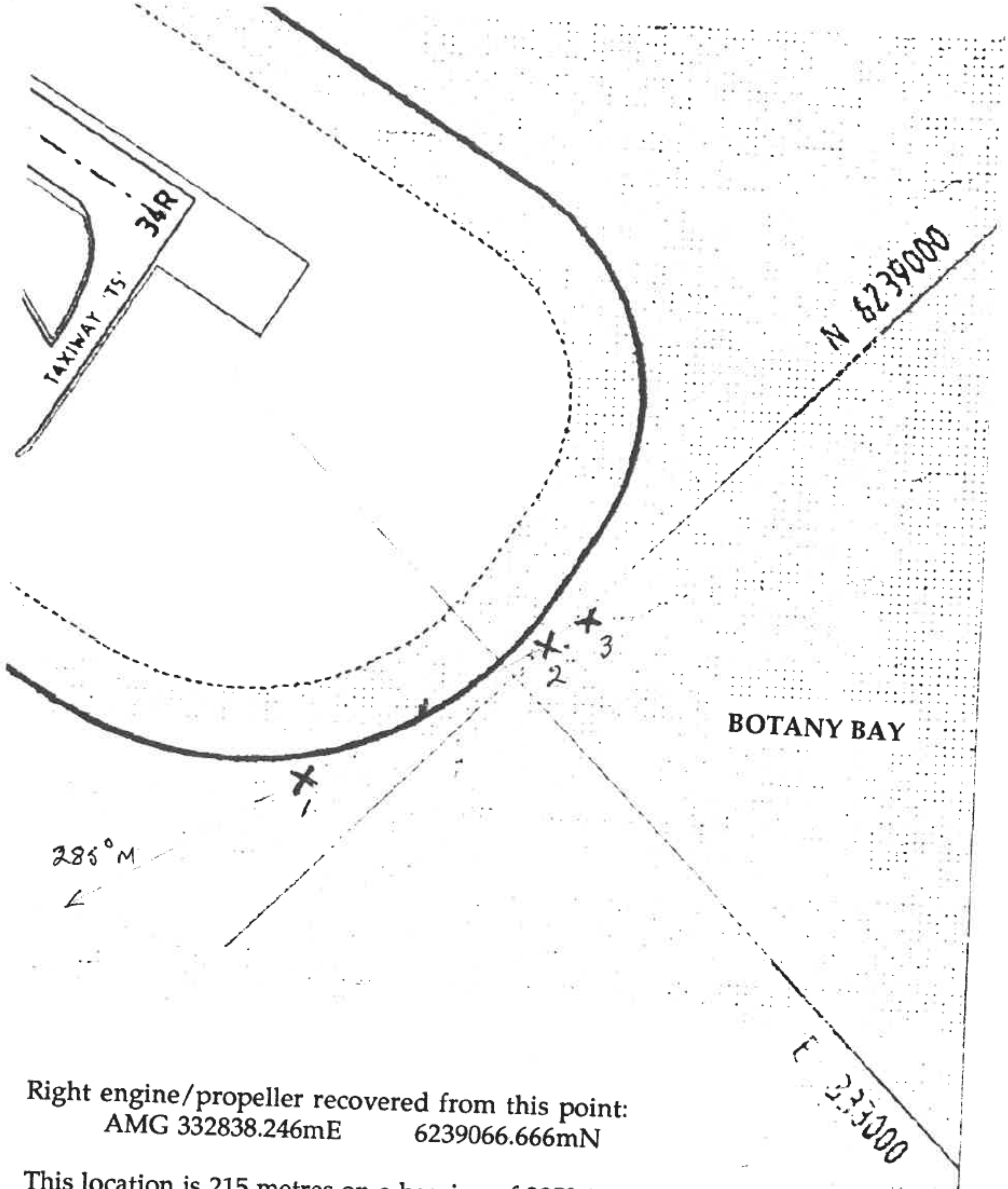
18 August 1994

Appendix A: The left magneto driving gear examination


BO9401043
VH-EDC
UNDER CONSTRUCTION
16L-34R
RUNWAY
TAXIWAY 12
TAXIWAY 1
TAXIWAY 13
TAXIWAY 14
TAXIWAY 15
34R
34L
ANEMOMETER No 5
ILLUMINATED WIND INDICATOR
16 LOCALISER BLDG & POWER HOUSE
N 6239000
E 333000
1. Right engine/propeller recovered from this point:
AMG 332838.246mE 6239066.666mN
LONG 151° 11′ 30.06 E LAT 33° 58′ 26.29S
This location is 215 metres on a bearing of 285° 17′ 14.15 secs from the South Cardinal Buoy, and 56 metres from the seawall (at water level).
2. South Cardinal Mark Buoy.
AMG 333046.302mE 6239009.798mN
LONG 151° 11′ 33.89E LAT 33° 58′ 33.94S
3. Approximate position of VH-EDC on the seabed prior to recovery.
AMG 333100mE 6238950mN
BOTANY BAY



1. Right engine/propeller recovered from this point:
   AMG 332838.246mE 6239066.666mN

   This location is 215 metres on a bearing of 285º 17′ 14.15 secs from the South Cardinal Buoy, and
   56 metres from the seawall (at water level).

2. South Cardinal Mark Buoy.
   AMG 333046.302mE 6239009.798mN

3. Approximate position of VH-EDC on the seabed prior to recovery.
   AMG 333100mE 6238950mN

BO9401043

VH-EDC

UNITED TECHNOLOGIES
PRATT & WHITNEY

FAX

TO: Name s.47F(1) [redacted] Company B.A.S.I.

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Phone: s.47F(1) [redacted]
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SYDNEY AUSTRALIA
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Pratt comments on residue fuel in R1830 carburettor after IFSD and Feather.

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Contact Export Management Group with questions: s.47F(1) [redacted]

Signature s.47F(1) [redacted] Date 4 July, 1994

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2H

s.47F(1) [redacted] BASI

PRATT & WHITNEY

C611 A 940701 SYD CACTUS 07/01/94 PAGE 1

Attn: s.47F(1) [redacted]
Author:

Airline: QFA PW-RC-00
Status: F

Number: C611 A 940701 SYD

Ref: R032 Q 940624 SYD
Reply-Due:

Actionee: PWC NINNESS
Eng/Acft: NONE
ATA: PW-RC-00

Priority:
Eng-S/N: 329666

Subject: CRASH - DC3 - NO FATALITIES

s.47F(1) [redacted]

REFER YOUR R032 REGARDING 1830 QUESTION.
THE FAX YOU SENT JUST ARRIVED I AM NOT SURE WHY OR WHERE IT WAS.

WHEN A PRATT RADIAL ENGINE IS SHUT DOWN AND PROP FEATHERED IN FLIGHT RESIDULE FUEL IS CONTAINED IN CARBURETTOR. EVEN IF THE FIREWALL SHUTOFF VALVE (if installed) DID NOT CLOSE AT TIME PROP WAS FEATHERED FUEL WOULD NOT CONTINUE INTO ENGINE ONCE THE MIXTURE WAS PLACED IN IDLE CUTOFF. THE AMOUNT OF FUEL REMAINING IN CARB CAN VARY FROM ALMOST FULL TO ALMOST EMPTY (depends on when mixture control was placed in idle cutoff)
FOR YOUR INFO I HAVE WORKED RECIP ACCIDENTS FOR PRATT SINCE 1986. THIS INCLUDES ON SITE INVESTIGATION AS WELL AS COURT ROOM ACTION.

I AM NOT SURE IF THIS ANSWER IS GOING TO BE FULLY UNDERSTOOD AND IF ADDITIONAL DETAIL IS NEEDED I CAN HELP.

s.47F(1) [redacted] TECHNICAL SUPPORT
END OF MESSAGE.

THROTTLE
FEATHER
MIXTURE.

Expect response by 4 July 94

DOCUMENT 6

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COMMONWEALTH OF AUSTRALIA
DEPARTMENT OF TRANSPORT AND COMMUNICATIONS

BUREAU OF AIR SAFETY INVESTIGATION

COPY

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Fax number : 02 693 1627

Organisation : P&W Australia

Name : s.47F(1) [redacted]

FACSIMILE FROM

Bureau of Air Safety Investigation

Name : s.47F(1) [redacted] Tel: s. 47F(1) [redacted]

s.47F(1) [redacted]

Date: 24 June 1994

s.47F(1) [redacted] Further to our telecon please be advised:-

<u>Subject:</u> <u>P&W 1830 - Residual Fuel in Carburettor after shutdown and feather?</u>

<u>Refer:</u> <u>VH-EDC Botany Bay 24 April 1994</u>

<u>Background:</u> VH-EDC ditched into Botany Bay following reported fluctuating MAP, backfiring and powerloss which resulted in the pilot shutting down the engine and feathering the propeller. The right engine power was reduced prior to water impact. However, there was sufficient RPM with the propeller in fine pitch to tear the right engine from the nacelle as the aircraft impacted the water. The aircraft was recovered after 2 days in the sea from a depth of approx 16 metres. Examination of the left engine carburettor after recovery revealed nil fuel in either the fuel supply pipe or the carburettor filter housing. However, there was some (unmeasurable) residual fuel in the carburettor body.
The carburettor and fuel filter housing of right engine, when recovered from the sea after 7 weeks, was found to be full of fuel.

<u>Question:</u> What is the effect on the residual fuel contained within the carburettor, fuel filter housing and inlet pipe when an engine is shutdown in flight and the propeller feathered? Assuming fuel supply had not been

interrupted, would the action of shutting the engine down and feathering the propeller empty the carburettor of fuel?

I will be on leave from this evening until Monday 4 July.

Your (P&W) comment on these questions would be appreciated.

yours sincerely

s.47F(1) [redacted]

Total number of pages including this cover: 2

REPORT OF FINDINGS OF AIRWORTHINESS ASPECTS, DOUGLAS DC3 AIRCRAFT VH-EDC.

Having been retained by the Bureau of Air Safety Investigation as an invited participant to assist in airwothiness aspects of the investigation of the accident in which Douglas DC3 aircraft VH-EDC ditched shortly after take off into Botany Bay as a result of reported failure of the left hand engine, this report is submitted.

Having been retreived from its sinking in the bay the aircraft was positioned in Hangar 13 at Kingsford Smith Airport, where I commenced my inspection on Thursday 28 April 1994.

The aircraft was supported on three wheeled trolley's, the left hand main landing gear being in the fully retracted position, though displaced rearwards approximately 12 cm to the extent the "y" brace attachment on the backstay was fractured. This displacement was the result of the oil cooler being forced rearwards on impact with the water thus distorting the firewall which in turn contacted the tyre.

The right hand main landing gear upper truss was in the down and spring latched position. A bolt and nut had been fitted in the safety pin position as a safety precaution by the operator of the aircraft on its removal from the water.

The lower truss complete with mainwheel assembly and backstay, which exhibited a fractured "y" brace had been removed on retrieval from the water.

The upper truss showed evidence of a severe rearward applied load in that the diagonal struts were partially fractured at the two lower lugs of the centre gusset.

s.47F(1) [redacted]

This damage could only have occurred with the landing gear extended.

It is considered that the mainwheel impacted the water in the ditching, at which time the "Y" brace failed. With the backstay now detached the wheel continued on its rearwards path pivoting on the oleo truss attach bolts into the lower nacelle area, the damage observed there being consistent with the scenario described. a)

The right hand engine, which had been at full power on impact with the water had torn itself free from its firewall complete with the majority of the engine mount, and most of the firewall.

The fuselage exhibited a diagonal cut in the skin on the right hand side consistent with having been struck by the propeller as the engine left the aircraft.

The left hand engine was still in position in the airframe although the engine mount frame was mostly broken and detached.

The left hand propeller was undamaged and was only partially feathered. It is estimated that the blades had another 18-20 degrees of travel to reach the fully feathered position. At least two witnesses, one of whom was the first officer, were adamant that the propeller was fully feathered and that it must have been "disturbed" during the retrieval from the sea bed. This is considered unlikely, especially as, later; when the propeller dome plug was removed as part of the propeller removal procedure, the dome was found to be full of oil, as it should be, and in which condition the dome piston would have been hydraulically locked thus preventing the blades from moving from the feathered position.

Following removal of the propeller from the engine a visual inspection confirmed that the cams were not on the feather stops. The same inspection did not reveal any obvious mechanical reason why the propeller should not have gone into the full feather position.

External inspection of the engine revealed no evidence of mechanical failure. All the cylinders appeared normal and the engine was totally intact.

The engine was free to rotate within the very limited range of movement permitted by the proximity of the propeller to the hangar floor.

The air inlet area of the carburettor and its wire gauze were blackened and sooty in appearence, suggesting the possibility of backfiring in the induction system, something that the R1830 engine is prone to do with weak mixtures.

Throttle,mixture and carburettor heat controls, although damaged in the course of retrieval, would have been capable of normal operation.

FUEL SYSTEM
Inspection of the carburettor fuel inlet filter showed the filter to be free of any contamination. The filter housing and fuel inlet chamber however, were completely dry and contained neither sea water or residual fuel.

Some time later, following removal of the engine, the carburettor was removed and tagged for dismantling and internal inspection, to be arranged by BASI.

Disconnection of the fuel pump to carburettor inlet pipe displayed an extremely small amount of fuel. The inlet to the fuel pump had been disconnected at the firewall and it was found to contain a very small quantity of fuel.

The fuel pump was removed and tagged for bench testing to be arranged by BASI.

The fuel filter in the nacelle contained raw fuel and because of the difficulty of access to this filter, whilst a substantial sample was obtained it was not possible to gauge the quantity of fuel, though at an educated guess, it was probably full.

The fuel filter itself was clean with no evidence of contamination.

The fuel tank selectors in the cockpit were both found to be selected OFF but their movement was checked and found to be normal.

Subsequent checks revealed that the left hand fuel selector, when selected to left hand main tank (the tank selected for the take off) and the wobble pump operated, on residual fuel, the fuel tanks having been drained, fuel was delivered to the fuel pump inlet at the firewall.

There is no reason to believe that fuel was not able to be supplied to the fuel pump from the airframe fuel system.

Both of the fuel sample drain cocks on the left hand main fuel tank, the tank supplying fuel to the left engine, were unserviceable in that the "wings" simply rotated and did not open the drain.

With the drain cocks in this condition it would not have been possible to drain a sample of fuel from this tank prior to flight.

OIL SYSTEM

The engine oil tank quantity was checked and despite the tank containing a quantity of sea water on which the oil was floating, there was an adequate supply to enable the engine to operate satisfactorily.

Whilst removing the feathering pump assembly, it was noted that there was an adequate supply of oil to enable its operation to be completed.

The oil pressure filter was removed and inspected but apart from some corrosion products as a rsult of the immersion, the filter was uncontaminated. It was tagged and handed to BASI.

During the course of general dismantling of the engine some time later, the oil pump was removed from the rear case. The fuel pump is attached to the oil pump,it having been removed earlier, and is driven by the oil pump drive shaft. This shaft, the oil pump itself, and its associated drive gears were found to be satisfactory.

IGNITION SYSTEM

The covers at the rear of the magnetos were removed to reveal the contact breaker points.

Both magnetos were synchronised, with No 1 cylinder having stopped at TDC.

C.B.points gap and the condition of the points themselves appeared to be satisfactory, although the left hand magneto was badly contaminated with engine oil as a result of a defective magneto drive seal.

Both magnetos were removed, BASI having arranged for internal inspection and testing.

The magneto drives in the rear case were worn, the left hand one especially so, to the extent that in the writers opinion, loss of drive to that magneto was imminent.

The magneto drive gears and shafts were satisfactory.

Spark plugs were a mixture of Lodge wire electrode plugs and Champion massive electrode. In itself, whilst not a recommended practice, this would not be considered a problem. The general condition of the spark plugs was poor, being indicative of having operated a very high number of hours in service.

The ignition harness appeared to be in a satisfactory condition.

ENGINE

The engine itself was extensively dismantled, all the cylinders and the rear case being removed.

No 12 cylinder had two broken cylinder base studs and a third stud failed in the course of loosening its nut. The cylinder base flange showed signs of fretting.

No 3 cylinder inlet push rod indicated evidence of extensive chafing as did the rocker box in the area contacted by the push rod.
This was found to be due to one of the rocker arm spacer washers being loose in the rocker box, having fallen out of position when the rocker shaft was last fitted. The spacer had been caught up at some time, being bent and distorted.
The chafing of the push rod resulted from the rocker arm operating "off centre" due to the absence of the spacer on the rocker shaft.

It is conceivable that the spacer could find a position where the inlet valve could be held off its seat causing loss of compression in No 3 cylinder, and backfiring in the induction system.

Apart from the foregoing, the engine was mechanically serviceable in that there were no failures of any parts that would contribute to a loss of power.

The rotating assembly, ie crankshaft,master rods and connecting rods was normal and intact.

The cylinder assemblies, including induction and exhaust pipes were intact and serviceable. Pistons did not exhibit any sign of damage or distress, their rings all being free and unbroken. Valves were all normal and none indicated burning or other damage.

Both front and rear cam drives were operating normally, and whilst the front cylinder cam drive and tappet rollers were not visible it was possible to determine by rotation of the propeller shaft that these were in fact operating satisfactorily.

The rear cylinder cam ,cam drive and tappet rollers were visible and were satisfactory.

All other ancillary drives were normal including the supercharger drive.

CONTROLS.

Inspection of the cockpit revealed the following:

Both fuel selectors selected OFF.
Auto pilot-Off
Crossfeed-Off
Carburettor heat- Off and locked.
Throttle levers- approximately 1 1/2" open.
Pitch controls- full coarse.
Mixture- right hand full rich, left hand slightly behind the right, out of detent.

Landing gear selector lever-neutral.
Landing gear latch lever- spring latch.
Hydraulic pump selector lever- to both engines hydraulic pump.
Flap selector lever-neutral.(Flap indicator-Up)

Ignition switches-both off and centre swich pulled to off.
Battery master switch-centre off.
All other electrical services had been switched off.

Elevator and rudder controls operated normally. The ailerons themselves were impact damaged, and the control wheel was at full deflection for correction of right wing low. The wheel could not be moved due to aileron damage but there was no reason to suspect that the system was not operating normally prior to impact.

No conclusion has been drawn thus none is given. The left hand engine does not exhibit any mechanical fault that would have prevented its continued operation, albeit at reduced power if the inlet valve in No 3 cylinder was held open by the loose rocker arm spacer.

In the remote chance that this may have occurred, it was only a momentary problem as the spacer was quite free when the valve gear was inspected.

The broken cylinder base studs on No 12 cylinder did not and would not have contributed to the reported failure.

End of report.

s.47F(1) [redacted]

9 May 1994

Examination notes during strip of DC 3 VH-EDC left engine 4 May 1994

The strip is being conducted by members of the Historical Aircraft Restoration Society (HARS). This group includes ex Qantas maintenance engineers who are currently employed in the restoration of a Super Constellation in Tucson Arizona. These persons are a s. 47F(1) [redacted] Most have DC3 and/or1830 experience and/or licences. s.47F(1) [redacted] They work from the old 'York' building at Sydney Workshop Company 62-74 Kent Road Mascot. There services were obtained through the negotiations s.47F(1) [redacted] who is personally know to many of the group. Under s.47F(1) [redacted] supervision the engine was transported to this facility from Australian Jet Charter P/L pm 3 May 1994.

It was agreed s.47F(1) [redacted] on my behalf that they would undertake a bulk strip for $3000 and that the work was to be completed, barring unforeseen hold-ups by COB Friday 6 May 1994.

Prior to commencement of work they were advised of the sensitivity of their work they would be doing for BASI as 'invited participants' and each read the BASI information for participants document. This will be repeated for others of the group who are used Thursday and Friday.

Present to assist in the bulk strip of this engine Wed 4/5 were:-

s.47F(1) [redacted]

After a brief talk about the requirements work commenced at approx 0915. During this day there were minor delays due to the immediate non availability of cylinder base nut tooling and a crankshaft lifting eye.

During the day discussion were held with:-

s.47F(1) [redacted]

s.47F(1) [redacted] Thursday and Friday and s.47F(1) [redacted] view the disassembled engine 1000 hours Friday 6 May.

s.47F(1) [redacted] on availability Thursday/Friday

s.47F(1) [redacted] AVECO Bankstown 7921526 or 018 964921. to arrange the examination, testing (if possible) strip and report of both magnetos. These components were taken s.47F(1) [redacted] on completion of the days work for delivery to Bankstown first thing tomorrow morning 5 may. He will be going to Wiltshire at this time anyway.

[redacted] Wiltshire Engineering Co P/L Bldg 438 Bankstown Airport. to discuss his capability of strip examination of the Carburettor. During these discussions the question of bench flow testing was addressed prior to any disassembly. Wiltshire are not able to flow check this model carburettor. The question of whether or not a flow test will tell us anything considering the saltwater immersion and accumulated corrosion is considered by me and will be discussed with [redacted] prior to any work being undertaken on this component. [redacted]

[redacted] to appraise him of the commencement of work and discuss recovery of the right engine from the bay. I will not be taking any action with its recovery until advised after he has discussed the matter with BASI executive.

[redacted] requested that [redacted] be given the aircraft logbooks to enable them to prepare a chronology of the log book history. They are concerned that despite previous negotiations with [redacted] on the right engine being changed the change was not made. this they say was a condition of the other engine being approved to overrun the 1000 hour TBO. I advised him hat they would be advised of the condition of the logbooks and the aircraft file after I have had a chance to preview each of them and that would not be until at least the week beginning 16 May.

The following are notes relevant to those sections of this engine which were disassembled today 4 may 94:-

- Spark plugs are a mixture of types - Massive electrode and fine wire (Platinum)

- Left magneto P/No 10-15364-21 (SF14LN-3) S/No 804353 removed.
  *** Drive splines in engine casing severely worn. Doubt their ability to provide positive drive to the magneto.**
  *** The magneto body was secured on the mounting pad rotated fully anticlockwise(viewed from the rear) on the mounting studs.**
  . Overhaul tag on mag body reflects AEC aircraft electrical/ Instruments Parafield [redacted] Date not readable.
  . free to rotate.
  . Distributor examined in-situ. Nil signs of damage or tracking.
    Note: This distributor was subsequently broken when the engine slipped from the stand whilst being repositioned.

- Right magneto (Bendix Scintilla) P/no 10-15364021 (SF14LN-3) S/No 2620 Date of manufacture 26/3/41 removed.
  . drive splines in casing OK
  . Mag body centrally disposed within the slots on the mounting studs

. free to rotate.
. Distributor examined in-situ - Nil damage or signs of tracking.
Note: The engine was not free to rotate so neither magneto was check timed to the engine.

- <u>Starter</u> (Bendix Eclipse) type 402 F84769 (24 volt) Model 12 S/No 4652 removed.

- *** Pitch control cable pulley block securing bolt (stbd side front of engine) excessively 'step' worn (Photo).**

- <u>Hydraulic pump</u> 'ART No 1 P 582K removed. S/No AQ002 etched. S/No 5865 RC on data plate.
  . Splines OK on pump and in wheelcase.

- <u>Generator</u> Technico type 314 model 5a S/No 392 date of manufacture 4/9/43 removed.
  . Free to rotate.
  *** Approx 20 degrees free play (Check internally)**
  *** Left upper mount nut not fitted.**

- *** <u>No 3 inlet valve push rod</u> upper end at cylinder excessive wear (photo) This amount of wear should have been detected during oil sampling.**

- **<u>Carburettor air intake assy</u> c/w grill screen. * There are deposits of black soot within the carburettor and on the screen indicative of backfiring. There is visual evidence of possible intake fire on the screen. Where the black deposits have been burnt off there s now red rust corrosion. Looks like a BBQ plate.**

- <u>Carburettor</u> Bendix P/No 391699.1 Model PD12H4 Parts list 30132E S/No 289519 - removed.
  Note: After removal fuel drained from the small open line fitting behind and below the fuel filter housing. (Need to qualify what this line is from carburettor diagram).
  *** Excessive white build up of deposits in the throat of the carburettor behind the throttle butterflies on the jet finger assy . (Check terminology). It looks like magnesium corrosion but suspicious in quantity and location. Sample taken for MTL analysis.**
  . Control rods levers and linkages to carburettor intact and functional.
  . Throttle butterflies free.
  . impact tubes intact and undamaged. There is evidence of saltwater contamination of these and other exposed surfaces of the carburettor internal surfaces which may make flow checking of the carburettor prior to disassembly unnecessary. (Check/discuss s.47F(1) [redacted] Following a

discussion with [redacted] it was decided that a strip inspection without attempts to flow check prior to disassembly is the way to go.

- After engine was re-slung from the crankshaft lifting eye fitting, disassembly and removal of the cylinders commenced.

  note: During the transfer of the engine from resting on the transportation stand and slinging from the crankshaft lifting eye the engine fell from the stand to the ground. This resulted in damage to the left ignition harness distibutor which was broken and may well result in secondary damage to the lower cylinder assys.

- No 6 cylinder removed.
  . Valves intact
  . No broken rings
  . Piston, piston pin and plugs all OK.

  Finish 1600 hours.*******

Cylinder removal will continue tomorrow 5 May 1994.

<u>Engine strip continued 5 May 1994</u>

Present:

[redacted] negotiator on behalf of HARS with [redacted] I suspect that he will be the one to submit the invoice for this work. The money obtained from BASI for this work will be donated by each of the HARS group who have been working on this strip to their 'Super Connie' project in which they are all heavily involved.

[redacted] BASI invited participant was present and assisting from 0845 to 1700.

[redacted] called to enquire about only receiving 3 out of the 5 life vests which she had intended taking back to Canberra. I went to the hangar where the DC3 was worked but there was no sign of any life vests which we may not have been packed last Saturday. It is possible that the 'new' owner has picked them up whilst working on the wreck last weekend. Suggested to [redacted] talk with the [redacted] (handling pilot) [redacted] to see if he had taken them.

1020 [redacted] of AVECO advised that he was in receipt of magnetos and that they were at that time ceased. He is currently soaking them in inhibitor to free them up before working on them and seeing if they can be run. He will advise tomorrow.

1100 - After discussion with [redacted] regarding the propeller which is still at Australian Jet Charter it was decided that for expediency [redacted] would work in with [redacted] to report on the propeller, the position of the blades at recovery and the system to determine why the blades did not reach full feather. Advised [redacted] that the prop governor (CSU) complete with feathering switch would be sent to Wiltshire engineering Bankstown. It would be appropriate for him to take the feathering pump to Wiltshire with him when he comes to Sydney next week. [redacted] (Australian Jet Charter) was advised of this itinery. [redacted] had already spoken with him.

NOTE: [redacted]

Wiltshire Engineering Bankstown - [redacted] After discussion [redacted] he has agreed to Examine, strip and report on the condition of the carburettor, prop governor and feathering pump when delivered [redacted] After discussion with him, [redacted] it was decided that there would be little to gain in having the carburettor flow checked prior to disassembly due to the saltwater immersion and extensive corrosion which was accumulating within the throttle butterfly choke and impact tube areas. Wiltshire do not have that capability anyway. (Superior in Moorabbin do have the capability.) During the examination he will document the disassembly on video. No firm quote for the job because of the unknowns however he did indicate that the job should be finished early next week if he can make a start on it today. The Carburettor and Prop governor were taken [redacted] this evening for delivery to Wiltshire am 6 May 94. A work order, written by me, accompanied these components.

During the course of the day the following items are noted:-

- No 5 cylinder removed: Valves intact - Piston rings & tappet rods OK
- Ignition booster coil S/No EWA 722 (Bosch USA) removed,
  Note: This component has been taken to Aveco [redacted] for testing.
- DeHavilland Propeller governor (CSU) model 4G(8)-ADH(38) S/no ADH 101 c/w Pulley.
  . Drive coupling splines, and component mating splines OK.
  note: Coupling sent with the governor to [redacted]
- Remove no 7 cylinder assy -Valves intact, pushrods and rings OK
- remove no 8 cylinder - valves intact, pushrods and rings OK
- Remove No 4 cylinder - Valves intact and rings OK. Pushrod end on the inlet was loose and became detached from the rod at the cylinder end.

- remove No 9 cylinder - Valves intact, pushrods and rings OK.
- remove **no 3 cylinder. - This is the cylinder from which the damaged inlet valve pushrod was found on the 4 may. * one of the thrust shims which are fitted either side of the rocker arm on the rocker shaft was missing - ie not fitted to the shaft. It dropped out from the rocker cavity. It was oval in shape having suffered some impact damage during engine operation. At the last time of fitting and/or adjustment of these tappets the shaft was installed but failed to engage the shim which subsequently was 'left' within the rocker cavity. The housing through which the cover tube is located and through which the tappet operates was damaged at the point coincident with the damage on the rod itself. The significance of this mis-assembly has yet to be determined. (Photo).**

  Note: On the 9 May 94 s.47F(1) [redacted] **requested that this no 3 cylinder complete with the assembled valves, and the no 3 pushrod cover tube be retained for further examination by BASI.**

  . Valves intact piston and rings OK.
- No 2 cylinder removed - piston and rings OK valves intact.
- No 1 cylinder removed - piston and rings OK valves intact.
- No 10 cylinder removed - piston and rings OK valves intact.

During the relocation of the engine from being supported by the transport stand and slinging it from the crankshaft slinging fitting the engine slipped rearwards and broke the left magneto distributor into about three pieces. This occurred after the distributors had been visually examined by me.

The day ended at 1730 leaving 4 cylinders still to be removed.

s.47F(1) [redacted] was in attendance during the morning to see what had been found.

Engine Strip Continued 6 May 1994.

Start 0845

Present

s.47F(1) [redacted]

For ease of further disassembly the fire shield was removed from the accessories casing and the power section separated from the accessories casing at the flange joint just forward of the supercharger impeller. As there were still 4 cylinders left to remove his enabled disassembly of the accessories wheelcase coincident with the continued removal of the remaining cylinders.

- Accessories case impeller gears OK Nil teeth damage or excessive wear, nil obvious gear shaft bearing damage or excessive wear. (Photo)

- Rear cylinder bank camdrive gear assembly and roller mechanisms nil obvious damage.

- Fuel Pump Drive Accessory Pad removed. Note; This is an extension of the oil pump P/No 158501 (?37586D?) S/No C2785N. (This component is being returned to Canberra for further detailed examination.

- **L/H Magneto Accessory Drive. *Excessively worn splines. The drive to this magneto appears on initial examination to be almost non existent. detailed measurement of this and the mating magneto spline will be undertaken at Canberra.**

- **R/H Magneto Accessory Drive * also shows some abnormal wear but not as severe as that of the spline drive to the L/H magneto.**

- Tacho generator Removed. General electric AN5531-2 P/N 7AAN S/No 5946.

- **No 12 Cylinder (Master Rod). refer Photo. Two studs found to be sheared prior to disassembly. Light disassembly pressure to another stud adjacent to the already broken ones resulted it breaking. The nut/stud portion of this stud has been returned to Canberra for examination. When this cylinder was removed there was evidence of cylinder movement on the casing identified by areas of galling/fretting in the vicinity of the broken studs.**

- Vacuum Pump removed. P/No AE207JA MFr No 24612A

S/No AC33957

- **No12 Cylinder.** Cylinder, piston ,rings valves and pushrods OK

- **Front Camdrive** ring assy checked by rotation of the crankshaft within the cylinder block casing - all tappets working.

- Wheelcase halves separated. Supercharger to accessory driving gears within the casing halves inspected nil obvious mechanical and/or wear. (Refer Photos)

- 1500 Hours. Advised [redacted] we had now finished with the engine strip and requested permission to release the 'bits' to the owner. verbal release was approved. I could not make contact [redacted] so spoke briefly with [redacted] Airclaims. [redacted] indicated that they, the insurers were currently still the owner of this wreckage as negotiations for its sale had not yet been completed. [redacted] advised accordingly.

The following components were hand carried back to Canberra:-
- defective pushrod #3 inlet valve
- #3 inlet rocker shaft c/w good and damaged thrust washer.
  Note: The #3 cylinder c/w valves assembled available for collection at HARS.
- oil pump c/w fuel pump drive.
- prop governor pulley assy c/w worn bolt.
- spark plugs
- broken distributor block.
- air intake grill.
- Spline drive to L/H magneto
- Spline drive to R/H magneto.

Work completed 1430.

[redacted]

6 May 1994

Strip Report notes - P & W R1830 S/No CP 329666

The following notes were taken during the strip examination of this engine which was removed from the left side of DC3 VH-EDC. The strip was conducted by members of the Historical Aircraft Restoration Society (HARS) under my supervision on 4, 5 and 6 May 1994.

Bolded text identifies abnormalities identified during this examination.

- Spark plugs are a mixture of types - Massive electrode and fine wire.

- Left magneto P/No 10-15364-21 (SF14LN-3) S/No 804353 removed.
    - *** Drive splines in engine casing severely worn. I doubt their ability to provide a positive drive to the magneto.**
    - *** The magneto body was secured on the mounting pad rotated fully anticlockwise(viewed from the rear) on the mounting studs.**
    - . Overhaul tag on magneto body reflects AEC aircraft electrical/ Instruments Parafield s.47F(1) [redacted] Date not readable.
    - . Is free to rotate.
    - . Distributor examined in-situ. Nil signs of damage or tracking.
      Note: This distributor was subsequently broken when the engine slipped from the stand whilst being repositioned.

- Right magneto (Bendix Scintilla) P/no 10-15364021 (SF14LN-3) S/No 2620, Date of manufacture 26/3/41 removed.
    - . Drive splines in casing OK
    - . Magneto body was centrally disposed within the slots on the mounting studs
    - . Is free to rotate.
    - . Distributor examined in-situ - Nil damage or signs of tracking.

  Note: The engine was not free to rotate so neither magneto was check timed to the engine. However, these magnetos were synchronised.

- Starter (Bendix Eclipse) type 402 F84769 (24 volt) Model 12 S/No 4652 removed.

- *** Pitch control cable 90° pulley block securing bolt (stbd side front of engine) excessively 'step' worn (Photo).**
  Note: there is a certification in the aircaft logbook that this pulley was renewed at the last periodic inspection 4:50 operating hours prior to the accident.

- Hydraulic pump 'ART No 1 P 582K removed. S/No AQ002 etched.
  S/No 5865 RC on data plate.
    - . Splines OK on pump and in wheelcase.

- Generator Technico type 314 model 5a S/No 392 date of manufacture 4/9/43 removed.

. Free to rotate.
. Approx 20 degrees free play (Check internally)
. Left upper mount nut not fitted.

- *** <u>No 3 inlet valve push rod</u> upper end at cylinder excessive wear (photo). This amount of wear should have been detected during oil sampling.**

- **<u>Carburettor air intake assy</u> c/w grill screen. * There are deposits of black soot within the carburettor and on the screen indicative of backfiring. There is visual evidence of possible intake fire on the screen. Where the black deposits have been burnt off there is now red rust corrosion. Looks like a BBQ plate.** This may or may not be indicative of fire in the intake manifold.

- <u>Carburettor</u> Bendix P/No 391699.1 Model PD12H4 Parts list 30132E
  S/No 289519 - removed.
  Note: After removal a small amount of fuel drained from the small open line fitting behind and below the fuel filter housing. (Need to qualify what this line is from carburettor diagram).
  . Excessive white build up of corrosion deposits in the throat of the carburettor behind the throttle butterflies on the jet finger assy. It looks like magnesium corrosion but suspicious in quantity and location. Sample taken for MTL analysis.
  . Control rods levers and linkages to carburettor intact and functional.
  . Throttle butterflies free.
  . Impact tubes intact and undamaged. There is evidence of saltwater contamination of these and other exposed surfaces of the carburettor internal surfaces which may make flow checking of the carburettor prior to disassembly unnecessary. (Check/discuss [redacted] Following a discussion [redacted] it was decided that a strip inspection without attempts to flow check prior to disassembly is the way to go.

After engine was re-slung from the crankshaft lifting eye fitting, disassembly and removal of the cylinders commenced.
  Note: During the relocation of the engine from being supported by the transport stand and slinging it from the crankshaft slinging fitting the engine slipped rearwards and broke the left magneto distributor into about three pieces. This occurred after the distributors had been visually examined by me.

- No 6 cylinder removed.
  . Valves intact no broken springs.
  . No broken rings
  . Piston, piston pin and plugs all OK.

- <u>No 5 cylinder</u> removed: Valves intact - Piston rings & tappet rods OK
-
- <u>Ignition booster coil</u> S/No EWA 722 (Bosch USA) removed,

Note: This component has been taken to Aveco [redacted] for testing.

- DeHavilland Propeller governor c/w pulley removed -(CSU) model 4G(8)-ADH(38) S/no ADH 101
  . Drive coupling splines, and component mating splines OK.
  Note: Coupling sent with the governor to [redacted]
- No 7 cylinder removed -Valves intact, springs, pushrods and rings OK
- No 8 cylinderremoved - Valves intact, springs, pushrods and rings OK
- No 4 cylinder removed- Valves intact, springs and rings OK. Pushrod end on the inlet was loose and became detached from the rod at the cylinder end.
- No 9 cylinder removed- Valves intact, springs, pushrods and rings OK.
- **No 3 cylinder removed - This is the cylinder from which the damaged inlet valve pushrod was found on the 4 may. * One of the thrust shims which are fitted either side of the rocker arm on the rocker shaft was missing - ie not fitted to the shaft. It dropped out from the rocker cavity. It was oval in shape having suffered impact damage during engine operation. At the last time of fitting and/or adjustment of these tappets the shaft was installed but failed to engage the shim which subsequently was 'left' within the rocker cavity. The housing through which the cover tube is located and through which the tappet rod operates was damaged at the point coincident with the damage on the rod itself. The significance of this mis-assembly has yet to be determined. (Photo).**
  Note: On the 9 May 94 [redacted] requested that this no 3 cylinder complete with the assembled valves, and the no 3 pushrod cover tube be retained for further examination by BASI.
  . Valves and springs intact, piston and rings OK.

- No 2 cylinder removed - piston and rings OK valves and springs intact.

- No 1 cylinder removed - piston and rings OK valves and springs intact.

- No 10 cylinder removed - piston and rings OK valves and springs intact.

For ease of further disassembly the fire shield was removed from the accessories casing and the power section separated from the accessories casing at the flange joint just forward of the supercharger impeller. As there were still 4 cylinders left to remove this enabled disassembly of the accessories wheelcase coincident with the continued removal of the remaining cylinders.

- Accessories case impeller gears OK Nil teeth damage or excessive wear, nil obvious gear shaft bearing damage or excessive wear. (Photo)

- Rear cylinder bank camdrive gear assembly and roller mechanisms nil obvious damage.

- Fuel Pump Drive Accessory Pad removed. Note; This is an extension of the oil pump P/No 158501 (?37586D?) S/No C2785N. (This component is being returned to Canberra for further detailed examination.

- **L/H Magneto Accessory Drive. *Excessively worn splines. The drive to this magneto appears on initial examination to be almost non existent. Detailed measurement of this and the mating magneto spline will be undertaken at Canberra.**

- **R/H Magneto Accessory Drive * also shows some abnormal wear but not as severe as that of the spline drive to the L/H magneto.**

- Tacho generator Removed. General electric AN5531-2 P/N 7AAN S/No 5946.

- Vacuum Pump removed. P/No AE207JA MFr No 24612A
  S/No AC33957

- Nos 11, 13 & 14 Cylinders removed. Valves, springs, piston, rings & pushrods OK

- No12 Cylinder removed. Cylinder, piston, rings valves, springs and pushrods OK
  *** During removal two cylinder base studs were found to be sheared prior to disassembly. Light disassembly pressure to another stud adjacent to the already broken ones resulted it breaking. The nut/stud portion of this stud has been returned to Canberra for examination. When this cylinder was removed there was evidence of cylinder movement on the casing identified by areas of galling/fretting in the vicinity of the broken studs.**

- Front Camdrive ring assy checked by rotation of the crankshaft within the cylinder block casing - all tappets working.

- Wheelcase halves separated. Supercharger to accessory driving gears within the casing halves inspected nil obvious mechanical damage and/or wear. (Refer Photos)

On completion of the engine strip examination the following components were sent to approved organisations or BASI Engineering Lab as indicated for further detailed examination:-

- Carburettor -	Wiltshire Engineering Bankstown
- CSU -	ditto
- Feathering Pump -	ditto
- Fuel pump -	ditto
- Magnetos -	Aveco Bankstown
- Booster coil -	ditto

- Oil pump -	BASI Canberra
- No 3 Cylinder assy	ditto
- Spark plugs -	ditto then Vee H Aviation Canberra
- Prop governor 90^0 pulley -	BASI Canberra
- Engine fuel hoses -	BASI Canberra

The following Historical Aircraft Restoration Society (HARS) members assisted with this strip examination and/or organisation of the task.

[redacted]

[redacted] CAA Bankstown office who is the South Pacific Airmotive Airworthiness Inspector was invited and attended to view the findings of the examination on 6 May 1994.

The findings of this examination have been briefed to the CAA Central office [redacted] and his team of engine specialists.

[redacted]

Examination notes during strip of DC 3 VH-EDC left engine 4 May 1994

The strip is being conducted by members of the Historical Aircraft Restoration Society (HARS). This group includes ex Qantas maintenance engineers who are currently employed in the restoration of a Super Constellation in Tucson Arizona. These persons are a [redacted]. Most have DC3 and/or1830 experience and/or licences. [redacted] They work from the old 'York' building at Sydney Workshop Company 62-74 Kent Road Mascot. There services were obtained through the negotiations [redacted] personally know to many of the group. Under [redacted] supervision the engine was transported to this facility from Australian Jet Charter P/L pm 3 May 1994.

It was agreed [redacted] that they would undertake a bulk strip for $3000 and that the work was to be completed, barring unforeseen hold-ups by COB Friday 6 May 1994.

Prior to commencement of work they were advised of the sensitivity of their work they would be doing for BASI as 'invited participants' and each read the BASI information for participants document. This will be repeated for others of the group who are used Thursday and Friday.

Present to assist in the bulk strip of this engine Wed 4/5 were:-

[redacted]

After a brief talk about the requirements work commenced at approx 0915. During this day there were minor delays due to the immediate non availability of cylinder base nut tooling and a crankshaft lifting eye.

During the day discussion were held with:-

[redacted]

[redacted] for Thursday and Friday and to invite [redacted] to view the disassembled engine 1000 hours Friday 6 May.

[redacted] on availability Thursday/Friday

[redacted] AVECO Bankstown 7921526 or 018 964921. to arrange the examination, testing (if possible) strip and report of both magnetos. These components were taken by [redacted] on completion of the days work for delivery to Bankstown first thing tomorrow morning 5 may. He will be going to Wiltshire at this time anyway.

[redacted] Wiltshire Engineering Co P/L Bldg 438 Bankstown Airport. to discuss his capability of strip examination of the Carburettor. During these discussions the question of bench flow testing was addressed prior to any disassembly. Wiltshire are not able to flow check this model carburettor. The question of whether or not a flow test will tell us anything considering the saltwater immersion and accumulated corrosion is considered by me and will be discussed with [redacted] prior to any work being undertaken on this component.
[redacted]

[redacted] to appraise him of the commencement of work and discuss recovery of the right engine from the bay. I will not be taking any action with its recovery until advised after he has discussed the matter with BASI executive.

[redacted] requested that [redacted] be given the aircraft logbooks to enable them to prepare a chronology of the log book history. They are concerned that despite previous negotiations with [redacted] on the right engine being changed the change was not made. this they say was a condition of the other engine being approved to overrun the 1000 hour TBO. I advised him hat they would be advised of the condition of the logbooks and the aircraft file after I have had a chance to preview each of them and that would not be until at least the week beginning 16 May.

The following are notes relevant to those sections of this engine which were disassembled today 4 may 94:-

- Spark plugs are a mixture of types - Massive electrode and fine wire (Platinum)

- Left magneto P/No 10-15364-21 (SF14LN-3) S/No 804353 removed.
  *** Drive splines in engine casing severely worn. Doubt their ability to provide positive drive to the magneto.**
  *** The magneto body was secured on the mounting pad rotated fully anticlockwise(viewed from the rear) on the mounting studs.**
  . Overhaul tag on mag body reflects AEC aircraft electrical/ Instruments Parafield [redacted] Date not readable.
  . free to rotate.
  . Distributor examined in-situ. Nil signs of damage or tracking.
    Note: This distributor was subsequently broken when the engine slipped from the stand whilst being repositioned.

- Right magneto (Bendix Scintilla) P/no 10-15364021 (SF14LN-3) S/No 2620 Date of manufacture 26/3/41 removed.
  . drive splines in casing OK
  . Mag body centrally disposed within the slots on the mounting studs

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. free to rotate.
. Distributor examined in-situ - Nil damage or signs of tracking.
Note: The engine was not free to rotate so neither magneto was check timed to the engine.

- Starter (Bendix Eclipse) type 402 F84769 (24 volt) Model 12 S/No 4652 removed.

- *** Pitch control cable pulley block securing bolt (stbd side front of engine) excessively 'step' worn (Photo).**

- Hydraulic pump 'ART No 1 P 582K removed. S/No AQ002 etched. S/No 5865 RC on data plate.
  . Splines OK on pump and in wheelcase.

- Generator Technico type 314 model 5a S/No 392 date of manufacture 4/9/43 removed.
  . Free to rotate.
  *** Approx 20 degrees free play (Check internally)**
  *** Left upper mount nut not fitted.**

- *** No 3 inlet valve push rod upper end at cylinder excessive wear (photo) This amount of wear should have been detected during oil sampling.**

- Carburettor air intake assy **c/w grill screen. * There are deposits of black soot within the carburettor and on the screen indicative of backfiring. There is visual evidence of possible intake fire on the screen. Where the black deposits have been burnt off there s now red rust corrosion. Looks like a BBQ plate.**

- Carburettor Bendix P/No 391699.1 Model PD12H4 Parts list 30132E S/No 289519 - removed.
  Note: After removal fuel drained from the small open line fitting behind and below the fuel filter housing. (Need to qualify what this line is from carburettor diagram).
  *** Excessive white build up of deposits in the throat of the carburettor behind the throttle butterflies on the jet finger assy . (Check terminology). It looks like magnesium corrosion but suspicious in quantity and location. Sample taken for MTL analysis.**
  . Control rods levers and linkages to carburettor intact and functional.
  . Throttle butterflies free.
  . impact tubes intact and undamaged. There is evidence of saltwater contamination of these and other exposed surfaces of the carburettor internal surfaces which may make flow checking of the carburettor prior to disassembly unnecessary. (Check/discuss s.47F(1) [redacted] Following a

discussion with s.47F(1) it was decided that a strip inspection without attempts to flow check prior to disassembly is the way to go.

- After engine was re-slung from the crankshaft lifting eye fitting, disassembly and removal of the cylinders commenced.

  note: During the transfer of the engine from resting on the transportation stand and slinging from the crankshaft lifting eye the engine fell from the stand to the ground. This resulted in damage to the left ignition harness distibutor which was broken and may well result in secondary damage to the lower cylinder assys.

- No 6 cylinder removed.
  . Valves intact
  . No broken rings
  . Piston, piston pin and plugs all OK.

  Finish 1600 hours.*******

Cylinder removal will continue tomorrow 5 May 1994.

Engine strip continued 5 May 1994

Present:

[redacted] I suspect that he will be the one to submit the invoice for this work. The money obtained from BASI for this work will be donated by each of the HARS group who have been working on this strip to their 'Super Connie' project in which they are all heavily involved.

[redacted] BASI invited participant was present and assisting from 0845 to 1700.

[redacted] called to enquire about only receiving 3 out of the 5 life vests which she had intended taking back to Canberra. I went to the hangar where the DC3 was worked but there was no sign of any life vests which we may not have been packed last Saturday. It is possible that the 'new' owner has picked them up whilst working on the wreck last weekend. Suggested to [redacted] talk with the [redacted] (handling pilot) [redacted] to see if he had taken them.

1020 [redacted] of AVECO advised that he was in receipt of magnetos and that they were at that time ceased. He is currently soaking them in inhibitor to free them up before working on them and seeing if they can be run. He will advise tomorrow.

1100 - After discussion with [redacted] regarding the propeller which is still at Australian Jet Charter it was decided that for expediency [redacted] would work in with [redacted] to report on the propeller, the position of the blades at recovery and the system to determine why the blades did not reach full feather. Advised [redacted] that the prop governor (CSU) complete with feathering switch would be sent to Wiltshire engineering Bankstown. It would be appropriate for him to take the feathering pump to Wiltshire with him when he comes to Sydney next week. [redacted] (Australian Jet Charter) was advised of this itinery. [redacted] had already spoken with him.

[redacted]

Wiltshire Engineering Bankstown - [redacted] After discussion with [redacted] has agreed to Examine, strip and report on the condition of the carburettor, prop governor and feathering pump when delivered [redacted] After discussion with him, s.47F(1) was decided that there would be little to gain in having the carburettor flow checked prior to disassembly due to the saltwater immersion and extensive corrosion which was accumulating within the throttle butterfly choke and impact tube areas. Wiltshire do not have that capability anyway. (Superior in Moorabbin do have the capability.) During the examination he will document the disassembly on video. No firm quote for the job because of the unknowns however he did indicate that the job should be finished early next week if he can make a start on it today. The Carburettor and Prop governor were taken s.47F(1) this evening for delivery to Wiltshire am 6 May 94. A work order, written by me, accompanied these components.

During the course of the day the following items are noted:-

- No 5 cylinder removed: Valves intact - Piston rings & tappet rods OK
- Ignition booster coil S/No EWA 722 (Bosch USA) removed,
  Note: This component has been taken to Aveco s.47F(1) for testing.
- DeHavilland Propeller governor (CSU) model 4G(8)-ADH(38) S/no ADH 101 c/w Pulley.
  . Drive coupling splines, and component mating splines OK.
  note: Coupling sent with the governor to s.47F(1) s.47F(1)
- Remove no 7 cylinder assy -Valves intact, pushrods and rings OK
- remove no 8 cylinder - valves intact, pushrods and rings OK
- Remove No 4 cylinder - Valves intact and rings OK. Pushrod end on the inlet was loose and became detached from the rod at the cylinder end.
- remove No 9 cylinder - Valves intact, pushrods and rings OK.
- remove no 3 cylinder. - **This is the cylinder from which the damaged inlet valve pushrod was found on the 4 may. * one of the thrust shims which are fitted either side of the rocker arm on the rocker shaft was missing - ie not fitted to the shaft. It dropped out from the rocker cavity. It was oval in shape having suffered some impact damage during engine operation. At the last time of fitting and/or adjustment of these tappets the shaft was installed but failed to engage the shim which subsequently was 'left' within the rocker cavity. The housing through which the cover tube is located and through which the tappet operates was damaged at the point coincident with the damage on the rod itself. The significance of this mis-assembly has yet to be determined. (Photo).**

  Note: On the 9 May 94 s.47F(1) requested that this no 3 cylinder complete with the assembled valves, and the no 3 pushrod cover tube be retained for further examination by BASI.
  . Valves intact piston and rings OK.
- No 2 cylinder removed - piston and rings OK valves intact.
- No 1 cylinder removed - piston and rings OK valves intact.
- No 10 cylinder removed - piston and rings OK valves intact.

During the relocation of the engine from being supported by the transport stand and slinging it from the crankshaft slinging fitting the engine slipped rearwards and broke the left magneto distributor into about three pieces. This occurred after the distributors had been visually examined by me.

The day ended at 1730 leaving 4 cylinders still to be removed.

s.47F(1) [redacted] was in attendance during the morning to see what had been found.

Engine Strip Continued 6 May 1994.

Start 0845

Present

s.47F(1) [redacted]

For ease of further disassembly the fire shield was removed from the accessories casing and the power section separated from the accessories casing at the flange joint just forward of the supercharger impeller. As there were still 4 cylinders left to remove his enabled disassembly of the accessories wheelcase coincident with the continued removal of the remaining cylinders.

- Accessories case impeller gears OK Nil teeth damage or excessive wear, nil obvious gear shaft bearing damage or excessive wear. (Photo)

- Rear cylinder bank camdrive gear assembly and roller mechanisms nil obvious damage.

- Fuel Pump Drive Accessory Pad removed. Note; This is an extension of the oil pump P/No 158501 (?37586D?) S/No C2785N. (This component is being returned to Canberra for further detailed examination.

- **L/H Magneto Accessory Drive. *Excessively worn splines. The drive to this magneto appears on initial examination to be almost non existent. detailed measurement of this and the mating magneto spline will be undertaken at Canberra.**

- **R/H Magneto Accessory Drive * also shows some abnormal wear but not as severe as that of the spline drive to**

the L/H magneto.

- <u>Tacho generator</u> Removed. General electric AN5531-2 P/N 7AAN S/No 5946.

- **<u>No 12 Cylinder</u> (Master Rod). refer Photo. Two studs found to be sheared prior to disassembly. Light disassembly pressure to another stud adjacent to the already broken ones resulted it breaking. The nut/stud portion of this stud has been returned to Canberra for examination. When this cylinder was removed there was evidence of cylinder movement on the casing identified by areas of galling/fretting in the vicinity of the broken studs.**

- <u>Vacuum Pump</u> removed. P/No AE207JA MFr No 24612A S/No AC33957

- <u>No12 Cylinder.</u> Cylinder, piston ,rings valves and pushrods OK

- <u>Front Camdrive</u> ring assy checked by rotation of the crankshaft within the cylinder block casing - all tappets working.

- Wheelcase halves separated. Supercharger to accessory driving gears within the casing halves inspected nil obvious mechanical and/or wear. (Refer Photos)

- 1500 Hours. Advised [redacted] we had now finished with the engine strip and requested permission to release the 'bits' to the owner. verbal release was approved. I could not make contact with [redacted] so spoke briefly with [redacted] Airclaims. [redacted] indicated that they, the insurers were currently still the owner of this wreckage as negotiations for its sale had not yet been completed. [redacted] advised accordingly.

The following components were hand carried back to Canberra:-
- defective pushrod #3 inlet valve
- #3 inlet rocker shaft c/w good and damaged thrust washer.

  Note: The #3 cylinder c/w valves assembled available for collection at HARS.

- oil pump c/w fuel pump drive.
- prop governor pulley assy c/w worn bolt.
- spark plugs
- broken distributor block.
- air intake grill.
- Spline drive to L/H magneto
- Spline drive to R/H magneto.

Work completed 1430.

s.47F(1) [redacted]

6 May 1994

Aveco

A.C.N. 060 288 002

ELECTRICAL COMPONENT OVERHAUL

DOCUMENT 13

Hanger 50
Tower Road
Bankstown 2200
s.47F(1) [redacted]

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BASI
PO BOX 967
CIVIC SQUARE
CANBERRA ACT 2608

ATTENTION s. 47F(1) [redacted]

Dear s.47F(1) [redacted]

MAGNETOS EX VH-EDC L/H ENGINE
S/N 804353/2620

The above mentioned magneto's were recived in a seized and water contaminated condition. The external covers were removed and access gained to the bearings, these were then soaked with light machine oil and the rotors "worked" until the units rotated freely.

At this time and without disturbing any setting a visual inspection revealed no abnormalities i.e. no broken teeth on gears/distributor etc. It was obvious that no damage of a mechanical nature was evident that could be attributed to a siezure or sudden stoppage.

The points of both magneto's were cleaned in situ and the units mounted on the test bed for functional testing results are as follows:-

804353	L/H :-	Nil operation
2620	R/H :-	Unit operates (but not in a satisfactory manner).

The coils were removed and tested servicable and within tolerance all timing was within tolerance and correct.

The primary condensors were removed and tested u/s, both units had small cracking evident on the cases which would have allowed water ingress. These units (condensor) were cleaned and baked for several hours and then refitted to there respective magnetos:- L/H still no operation, R/H now operating reasonably well. The condensor from the R/H unit was fitted to the L/H mag and it too performed satisfactory.

.../2

Conclusion:- In my opinion these units would have been operating normally prior to impact and immersion. The defective condensor on the L/H magneto would have been caused by salt water contamination, because if it had been unserviceable prior to the accident this magneto would have effectively been "dead", and I assume would have made starting the engine difficult, and been obvious during engine checks i.e. mag drop check.

s.47F(1) [redacted]

2.6.94

Telephone: 790 4107
Facsimile: XXXXXXXXXXxx 791-0329

DOCUMENT 14

Wiltshire Engineering Co. Pty. Ltd.

438 Avro Street, Airport Bankstown, N.S.W. 2200
AUSTRALIA

C.A.A APPROVED FOR THE DISTRIBUTION OF AIRCRAFT GOODS

MANUFACTURE OF FLEXIBLE HOSE ASSEMBLIES

OVERHAUL OF:
ENGINE DRIVEN PUMPS
PROPELLER GOVERNORS
FEATHERING PUMPS
SOLENOID VALVES
ELECTRIC BOOSTER PUMPS
SUBMERGED FUEL PUMPS
WHEEL BRAKES
HYDRAULIC,
PNEUMATIC,
FUEL,
FUEL INJECTION,
DE-ICING,
AUTO PILOT HYDRAULIC SYSTEM COMPONENTS

19th September 1994

B.A.S.I.
P O Box 967
Civic Centre
CANBERRA ACT 2608

Attention s.47F(1) [redacted]

Report on Pressure Injection Carburettor
ex GH-EDC Left Hand

Bendix Part No. 391669-1
Type PD12H4
Serial No 289519

It was not possible to flow check unit because of salt water contamination, so it has been stripped as to check component condition and assemblies which appear to be in correct order in accordance with manufacturers manual.

We have supplied video tape of the stripping.

s.47F(1) [redacted]

Telephone: 790 4107
Facsimile: XXXXXXXX
791-0329

Wiltshire Engineering Co. Pty. Ltd.

438 Avro Street, Airport Bankstown, N.S.W. 2200
AUSTRALIA

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C.A.A APPROVED FOR THE DISTRIBUTION OF AIRCRAFT GOODS

MANUFACTURE OF FLEXIBLE HOSE ASSEMBLIES

OVERHAUL OF:
- ENGINE DRIVEN PUMPS
- PROPELLER GOVERNORS
- FEATHERING PUMPS
- SOLENOID VALVES
- ELECTRIC BOOSTER PUMPS
- SUBMERGED FUEL PUMPS
- WHEEL BRAKES
- HYDRAULIC, PNEUMATIC, FUEL, FUEL INJECTION, DE-ICING, AUTO PILOT HYDRAULIC SYSTEM COMPONENTS

19th September 1994

B.A.S.I
Post Office 967
Civic Square
CANBERRA ACT 2608

REPORT ON VH-EDC Left Hand Engine
~~Un~~feathering Pump Assembly

Type 1473-MK Serial No. 48581 Motor

Pump Type 280-B Serial No. 68685BB

The motor assembly is too corroded to test so we removed pump assembly and tested it to Pesco Manual. The capacity is 148 GPH @ 1000 PSI and 2500 RPM'S WITH relief valve Pressure of 1400 PSI @ 2500 RPM'S with no Flow.

See attached copy of manual charts.

s.47F(1) [redacted]

Minute Note to File B/940/1043 VH-EDC

<u>Subject: Record of telecon s.47F(1) [redacted] 0900 14 November 1994.</u>

I called s.47F(1) [redacted] Wiltshire engineering s.47F(1) [redacted] this morning to solicite a response to my letter of 30 Sept 94 re

. Left Carby fuel content and throttle opening, and
. report for left propeleller governor.

s.47F(1) [redacted] advises that he has found the report for both the left carburettor and the left governor which he would forward to me in the next couple of days.

In respect to the amount of fuel in the left carby chambers he advised that it was considerable but could not confirm whether or not it was normal. He receives carburettors which have been drained of fuel and others where every attempt has been made to retain fuel. It all depends on the person taking it off. He will comment in a report to me.

In respect to the amount of opening of the throttle he advised that it was only a few degrees and quite normal. In the open position the diameter of the throttle shaft itself becomes a partial restriction to flow and the throttle plate itself was within that diameter and only a few degrees from fully open. This would be insufficient to limit max power especially on a supercharged engine. he will comment on this in a report.

s.47F(1) [redacted] s.47F(1) [redacted]

14 November 1994.

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Printed By: s.47F(1)	14/11/94 1407	Page: 1

From: s.47F(1) (14/11/94)
To: s.47F(1)

Reply to: RE>DC 3 ENG RPT

Barry - No change from that which was put there on 7 Oct 94.
This morning I have spoken with Wiltshire regarding the report for left Carby and how much fuel it contained and the position of the throttle plate in the full throttle position. He says he will formally respond in the next couple of days.
In essence he advises that there was fuel in the chambers of the left Carby but he couldn't say if it was a 'normal' amount because he gets them in various states dependent on how they were removed from the engine. The few degrees that the throttle plate was from the fully open position is minimal and not as great an obstruction than the diameter of the the throttle shaft itself.

I have also spoken again with Air Prop Services (Vic) seeking answers to question s.47 and I posed of them regarding the left prop not being in the fully feathered position. They are stalling and reluctant to respond formally probably because of the implications for them who overhauled the propeller last. Never-the-less s.47F(1) has sauid he will respond in the next few days.

You can have all of the files if you like????

s.47F(1)

Date: 14/11/94 815
To: s.47F(1)
From: s.47F(1)
CAN YOU PUT THE LATEST VERSION IN THE DC3 FILE ON THE INVES SERV PLS
s.47F(1)

==

DOCUMENT 16

COMMONWEALTH OF AUSTRALIA
DEPARTMENT OF TRANSPORT AND COMMUNICATIONS

BUREAU OF AIR SAFETY INVESTIGATION

CENTRAL OFFICE

24 Mort Street
Braddon ACT 2601
AUSTRALIA

Telephone :+61 06 2746424
Telex : AA62591
Fax :+61 06 2473117

Postal Address : P O Box 967
: Civic Square
: ACT 2608
: AUSTRALIA

FACSIMILE TO

Fax number : s. 47F(1) [redacted]

Organisation : Air Prop Services (Vic) P/l

Name : s.47F(1) [redacted]

FACSIMILE FROM

Bureau of Air Safety Investigation

Name : s.47F(1) [redacted]

s.47F(1) [redacted]

Date: ~~29~~ 31 August 1994 RE SEND 14 NOVEMBER 94.

Dear Lyall

Subject: Propeller S/No 1G1B14

This propeller was fitted to the left engine of VH-EDC when it ditched into Botany Bay on 24 April 1994. It has 552 recorded hours of operation since being overhauled on 26 March 1988 - Air Prop Services J/No 10721 refers.

Shortly after take-off the left engine was shut down and the left propeller selected to feather. Prior to water impact the left engine was observed to have stopped rotating - estimated aircraft speed at water impact 60-65 kts. On examination, the piston/cam/roller assembly was found in the 65 degree position. The cam roller assy would not budge from this position until the nut securing the cam/cam bearings had been loosened approximately 40 degrees.

Further to our discussion last week, and my further talk with Kevin Fox (Monday 29/8), please find attached two photographs; one showing the cam vernier scale and position of the feathering stop indicating a blade angle of approx 65 degrees (as disassembled), the other showing roller wear on the cams in the operating range. This wear is measured in the order of 4 to 5 thou of inch.

The roller to cam clearance, on the unworn section of the cam profile, has been measured at approx 10 thou of inch. All rollers were free to rotate.

Would you please advise of, or make comment on:-

- The torque/assembly criteria applied to the cam bearing retaining nut and cam during assembly.
- Whether or not abnormal torque would prevent the assembly from travelling into the fully feathered position.
- Whether or not the cam(s), rollers or bearings were replaced during the overhaul on 26/5/88.
- Is the distributor valve overhauled as part of the propeller?
- Did you receive the distributor valve assy for overhaul with this propeller?
- What is the overhaul criteria/period for the distributor valve?
- Whether or not wear as indicated on the cam profile is normal for a propeller with 552 hours TSO and whether or not this wear may have affected travel into the fully feathered position.
- What is the wear criteria for these items and how much wear is allowed before cam profile rework or replacement?
- How many cams would be rejected at overhaul for this type of wear?
- Indicate the blade turning torque required to move the piston assy from the fully feathered position to the 65 degree blade position when the assy is full of oil and return flow from the feathering side of the piston is governed by the distibutor valve.
- What volume of oil would need to be displaced to allow movement of the piston from the

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feathering stop to the 65 degree position?

- What is the operational in-flight time to feather of this 23E50-473 model prop?

We have the cam, piston and distributor valve assembles in our engineering workshop here in Canberra. Please feel free to visit, examine and discuss this matter with us if you wish. Contact to arrange this can be made with either:-

s.47F(1) [redacted]

Your sincerely s.47F(1) [redacted]

s.47F(1) [redacted]

Total number of pages including this cover: 5

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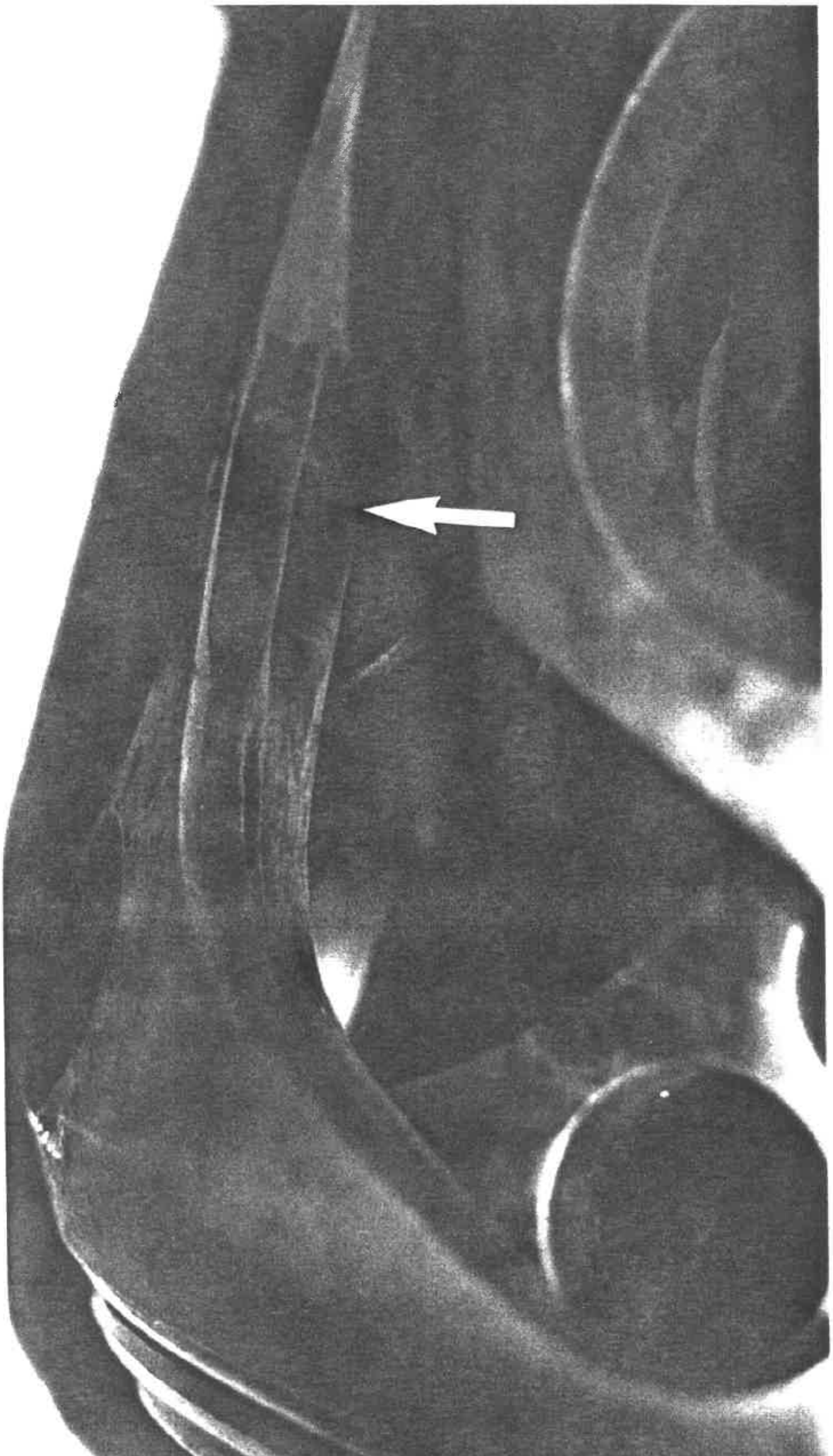
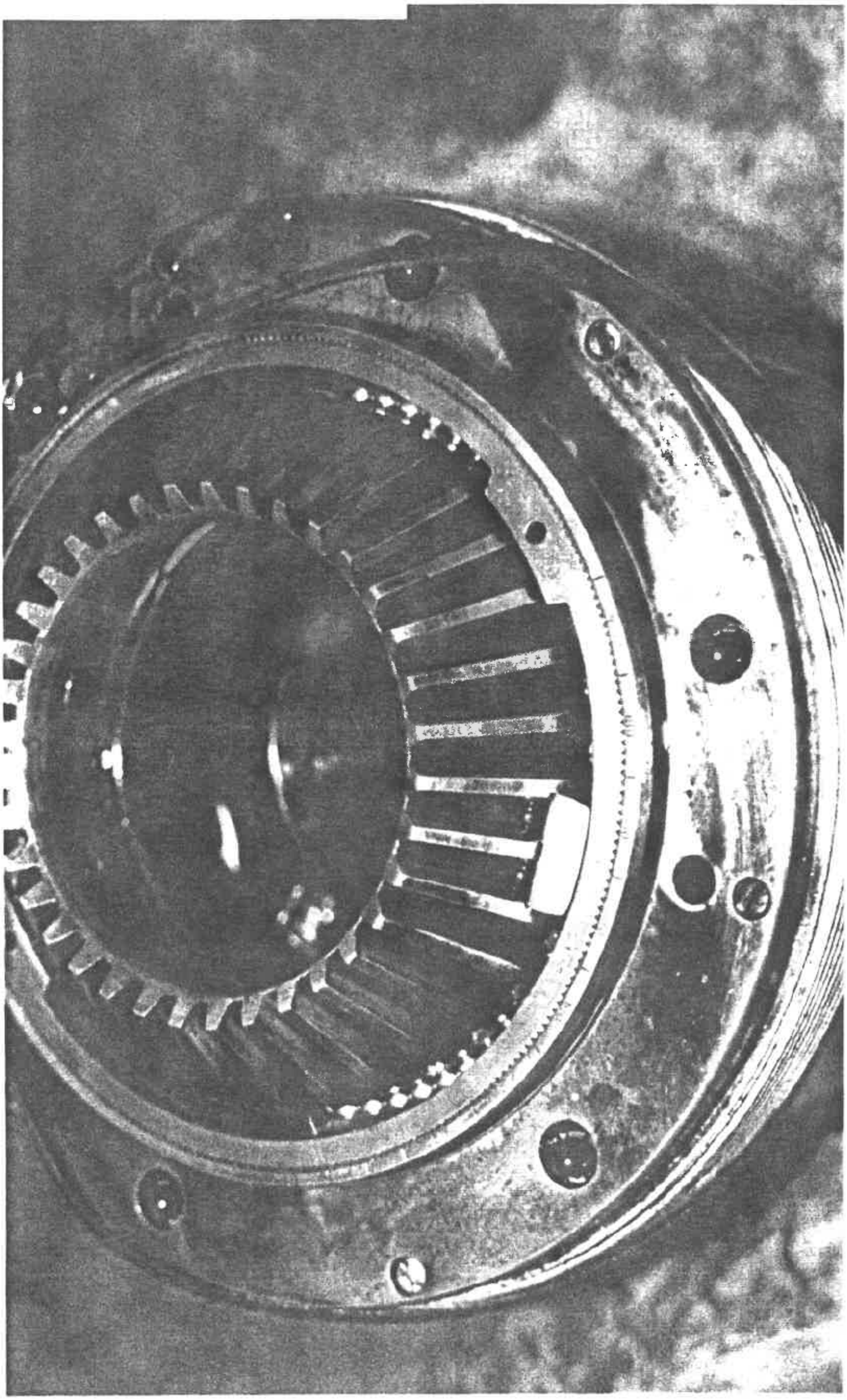
128





Minute Note to File BO9401043 VH-EDC

Subject: Left propeller S/No 1G1B14 - Record of conversation [redacted] Air Prop Services (Vic) P/L 25/8/94 [redacted]

This propeller was at 552 hours TSO when VH-EDC ditched into Botany Bay 24 April 1994.

After recovery the propeller disassembly inspection revealed the blades to be at 65-66 degrees and not on the fully feathered 89 degree position.

Air Prop Services (Vic) P/L last overhauled the propeller on 26/5/88.

Considering the above, I spoke with [redacted] on 25/8/94 and [redacted] on 29/8 to advise them of our findings and request comment on the last overhaul.

[redacted] advised that:-

[redacted]

. There are two types of cam assemblies: the -473 which is kneed cam with slower feathering than the -505 faster cam.
  Note: EDC had a -473 cam.
. The blades could turn fairly easily without oil pressure.
. Operationally would take 10-15 seconds to feather after selection.
. The wear on the cam profiles sounds extreme - he cant recall changing a cam for wear as described.

After review of the Job Card for the overhaul No 10721 he further advised that:-

. The work had been done [redacted] a very capable and experienced Hamilton Standard propeller man. [redacted] no longer worked for them but would be used as a consultant if needed.
. The propeller had been signed out by [redacted] the previous manager and also an experienced propeller engineer.
. The cams had not been changed during that overhaul, only minor items and seals bearings and chaffing strips.
. Prior to release the propeller was functioned fully between the fine pitch and feather stops.

Our discussion concluded with me advising that I would send photographs of the propeller and document our concerns, requesting comment. s.47F(1) [redacted] agreed with that and said he would get his QA man to call me. s.47F(1) [redacted] called me on 29 August.

I subsequently sent them a fax and photos on 31 August 94 to which I am awaiting a reply.

They have been invited to visit BASI and view the component parts of this propeller.

s.47F(1) [redacted]

1 August 94.

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..EPORT ON THE FINDINGS OF AIRWORTHINESS ASPECTS OF PRATT AND WHITNEY R1830/92 ENGINE SERIAL NUMBER BP463388.

This engine was originally installed in the right hand position of Douglas DC 3 aircraft VH-EDC, but separated from the aircraft as a result of ditching into Botany Bay, New South Wales as a result of failure or partial failure of the left hand engine during take off on April 24 1994.

The findings on the airframe and left hand engine are detailed in a report dated 9 May 1994.

Following retrieval of the engine from the bay on or about 15 June 1994, itwas positioned into the QANTAS Sydney Workshops Kent Street,Mascot, where I commenced my inspection on 21 June. The propeller was attached,in full fine pitch, with each blade bent rearwards approximately 10°, indicative of being under very low power at the time of contact with the water. The engine could not be rotated but in view of the extremely advanced state of corrosion that was evident this would have been expected. After positioning the engine into as accessible a position as possible consistent with safety, numbers 5 and 12 cylinders were removed,these being the master cylinders.

Removal of the cylinders then permitted a visual inspection of the rotating assembly which revealed it to be intact.

Removal of the rocker covers revealed no obvious problems with either inlet or exhaust valves.

The intermediate rear case and the rear case itself were almost completely destroyed by corrosion,these being magnesium, and whilst the oil pressure filter sufferred some damage during its removal, it proved to be free from any mettalic contamination although heavily contaminated with corrosion products.

It proved to be impossible to remove the oil pump but it was determined that its drive and the drive to the fuel pump were in-tact as was the fuel pump drive coupling.

Following removal of the fuel pump it was determined that the interiors of the three connections to the pump were still wet with fuel despite the prolonged immesion in the sea water.

Following removal of the carburettor, the carburettor fuel inlet filter was removed. The filter was free of any contamination and was found to be still wet with fuel, as was the filter housing.

Prior to their removal both magnetos were checked for synchronisation and found to be normal. The contact breaker points were corroded thus their conditin could not be determined.

Both magneto distributor blocks were removed and inspected and were found to be free of cracking and tracking.

The hydraulic pump contained hydraulic fluid, and its drive was intact, both the pump itself and the engine drive.

The propeller governor contained engine oil. Both governor and engine drive were normal.

Both magnetos and distributer blocks, the propeller governor and the carbrettor were dispatched to specialist contracters for assesment of their serviceability.

As far as it was possible, given the advanced state of corrosion and the subsequent inability to rotate either the engine or most components, the engine was probably serviceable in respect of its ability to produce power. The components necessary for the production of power appeared to have been serviceable at the time of immersion, having been supplied where applicable with their respective fuel and oils.

Whilst the propeller indicated having been under very low power at the time of contact with the water,this would be consistent with the throttle having been pulled back to idle.

The following is a list of serial numbers of the various components found to have been fited to the engine;-

Engine BP463388.
Governor WH32824
Carburettor 224786 (391699/1?)
RH Magneto AC32078
LH Magneto 1B1C614
Fuel pump not discernable.
Propeller FA5612.

On retrieval from the water the engine was encrusted in barnacles which proved to be extremely hazardous to the hands whilst attempting to perform work on the engine, and I would like to express my thanks and appreciation to the following members of the Historic Aircraft Restoration Society for their help with the work required in order to carry out the assesment of the engines condition.

s.47F(1) [redacted]

s.47F(1) [redacted]

28 June 1994.

14387

Aveco

A.C.N. 060 288 002

ELECTRICAL COMPONENT OVERHAUL

DOCUMENT 19

Hanger 501
Tower Road
Bankstown 2200

Phone: (02) 792 1526
Fax: (02) 792 2790

27.7.1994

Basi
PO BOX 967
CIVIC SQUARE
CANBERRA ACT 2608

Attention: s.47F(1) [redacted]

Dear Sir,

RE:- MAGNETO INVESTIGATION FOR
R/H ENGINE EX VH-EDC

Both magnetos S/N TAA 1B1C614 and 011994 were received in a very advanced state of corrosion due to an extensive time in salt water, this is rather obvious due to the barnacle type growth on the bodies of both these units.

The points covers were removed and all parts i.e. points, cam, gears etc from this section were in place and not broken or dislodged from the normal setting. It should be noted that even though the state of corrosion was advanced the points gap was correct.

The coils and condenser from the units were then removed for testing on the bench.

1. Both HT coils were bench tested satisfactory

2. Both primary condensers failed due to salt water immersion. These units were then baked in an oven and re-tested still failed.

The distributor assembly of the units were then examined and found satisfactory. The remainder of the assembly's were then freed up via heat/oil and were made to revolve.

Conclusion

It is my opinion that both of these units were operating normally when the engine stopped, there was no evidence at all to support any other conclusion.

s.47F(1) [redacted]

COMMONWEALTH OF AUSTRALIA
DEPARTMENT OF TRANSPORT AND COMMUNICATIONS

BUREAU OF AIR SAFETY INVESTIGATION

CENTRAL OFFICE

MINUTE

In reply quote: BO9041043

To: s.47F(1) [redacted]

<u>Subject:</u> <u>VH-EDC Propeller Governor Right Engine</u>

The Hamilton Standard model 4G8-630M Propeller Governor Serial No WH 32824 which was removed from the right engine of this aircraft after its recovery from Botany Bay, was presented to Wiltshire Engineering Bankstown for examination.

This governor pulley's attachment to the hexagon of the rack operating shaft was found to be rigged incorrectly. The pulley max rpm stop peg when rotated to contact the max RPM stop screw would not enable governor to govern the max RPM on the test rig.

Following the correct rigging of the governor pulley, stop and screw, the governor tested serviceable and to specifications.

Review and consideration of the following, in the as found condition, raises doubts as to how the governor could have been rigged to the aircraft:-

- . the location of the pulley on the hexagon,
- . the max RPM stop screw setting, and
- . the location of the stop peg on the pulley in relation to the cable securing clamp on the pulley circumference,

Would you please, measure and advise the unloaded angular movement, due to pulley wear, of the pulley in relation to the shaft.

From your examination of the broached hexagon of the pulley and the hexagon of the rack operating shaft, determine and advise whether or not the pulley had been 'jerked' around one complete hexagon flat by the action of the engine being torn from the firewall at water impact, and in which direction that rotation occurred relative to the shaft.

s.47F(1) [redacted]

6 Sept 1994

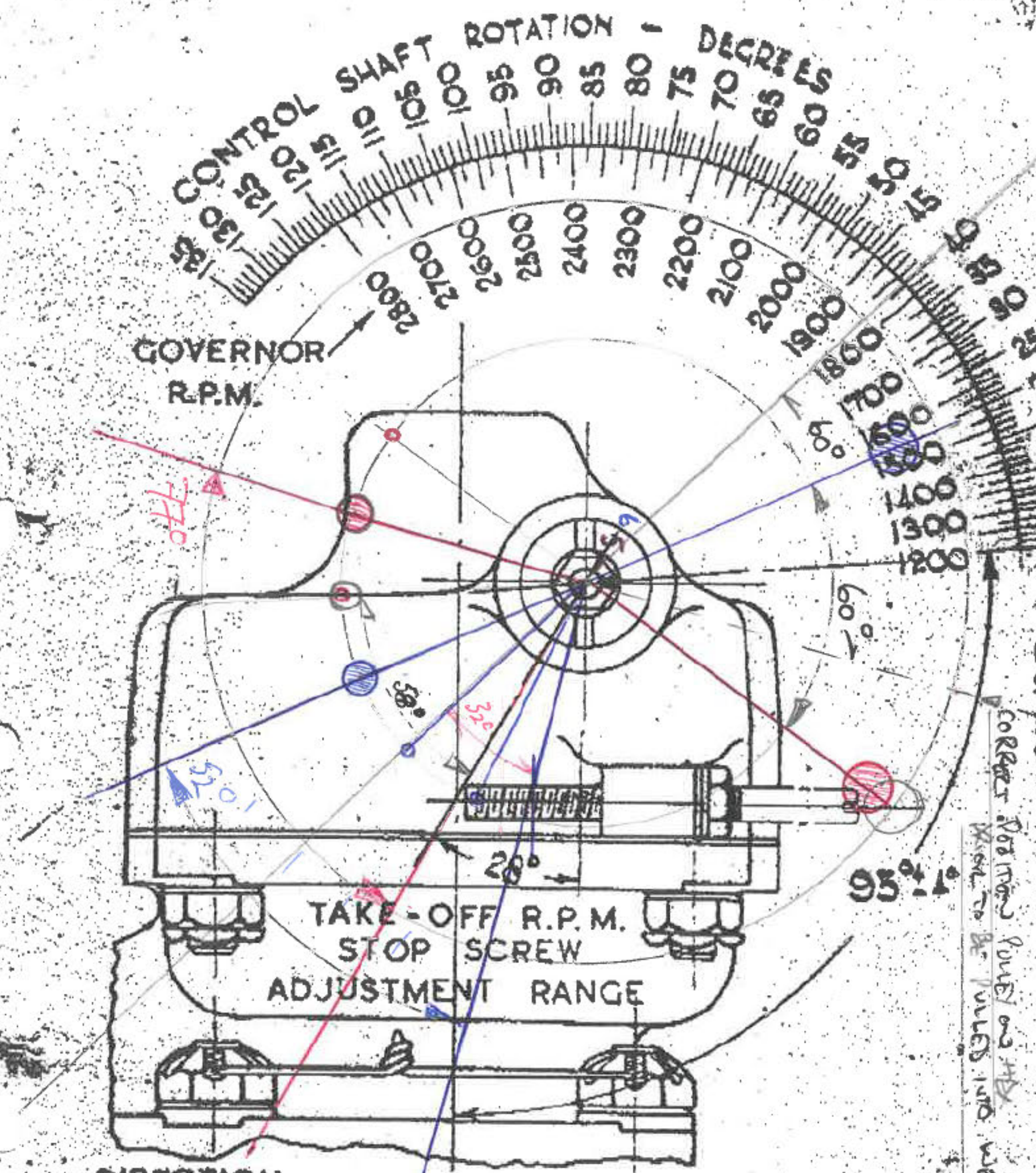
COPY

DE HAVILLAND AIRCRAFT PTY. LTD.

PROPELLER DIVISION ALEXANDRIA N.S.W.

ENGINEERING INSTRUCTION BULLETIN

No E.D.30
ISSUE 3
PAGE No 5



INTEGRAL LOW R.P.M. STOP CONSISTS OF RACK CONTACTING GOVERNOR HEAD AT THIS POSITION STAMPED LINE AT END OF CONTROL SHAFT WILL BE IN LINE WITH ZERO POSITION OF THIS CHART STAMPED LINE IS IN LINE WITH HEXAGONAL CORNER

DIRECTION

READ OPPOSITE DESIRED MAXIMUM GOVERNOR R.P.M. THE CONTROL ROTATION IN DEGREES REQUIRED

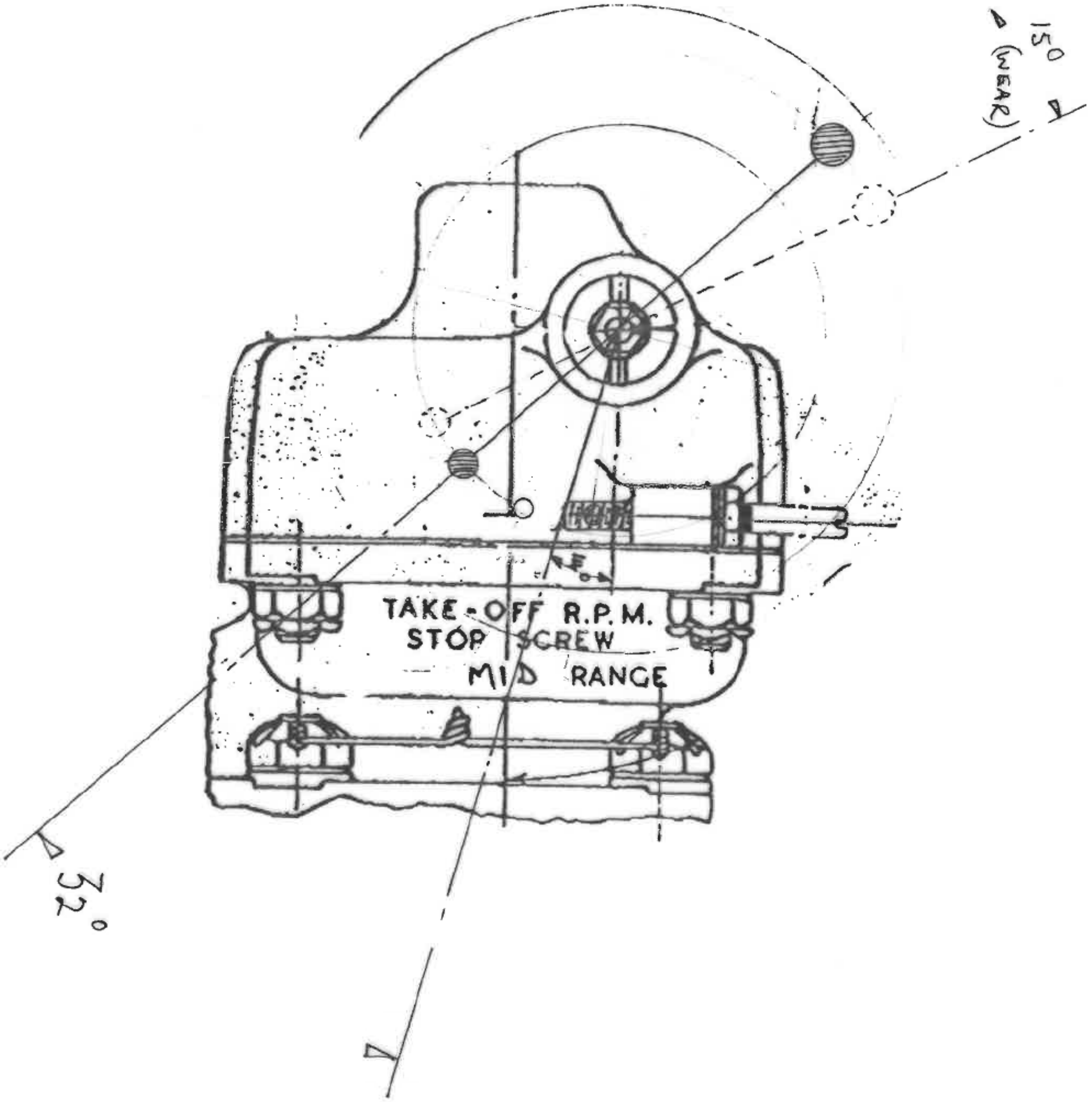
EXAMPLE

1. FIND ROTATION AT GOVERNOR NECESSARY TO GO FROM 1200 TO 2600 GOVERNOR R.P.M.
2. READ OPPOSITE 2600 R.P.M. 103.5±5 DEGREES REQUIRED.

NOTES

THIS CHART SATISFACTORY FOR 1200 R.P.M. MINIMUM ONLY.

THIS CHART APPLIES TO HYDROMATIC GOVERNORS WITH No 4 MODEL SERIES HEADS AND 50665 SPEEDER SPRING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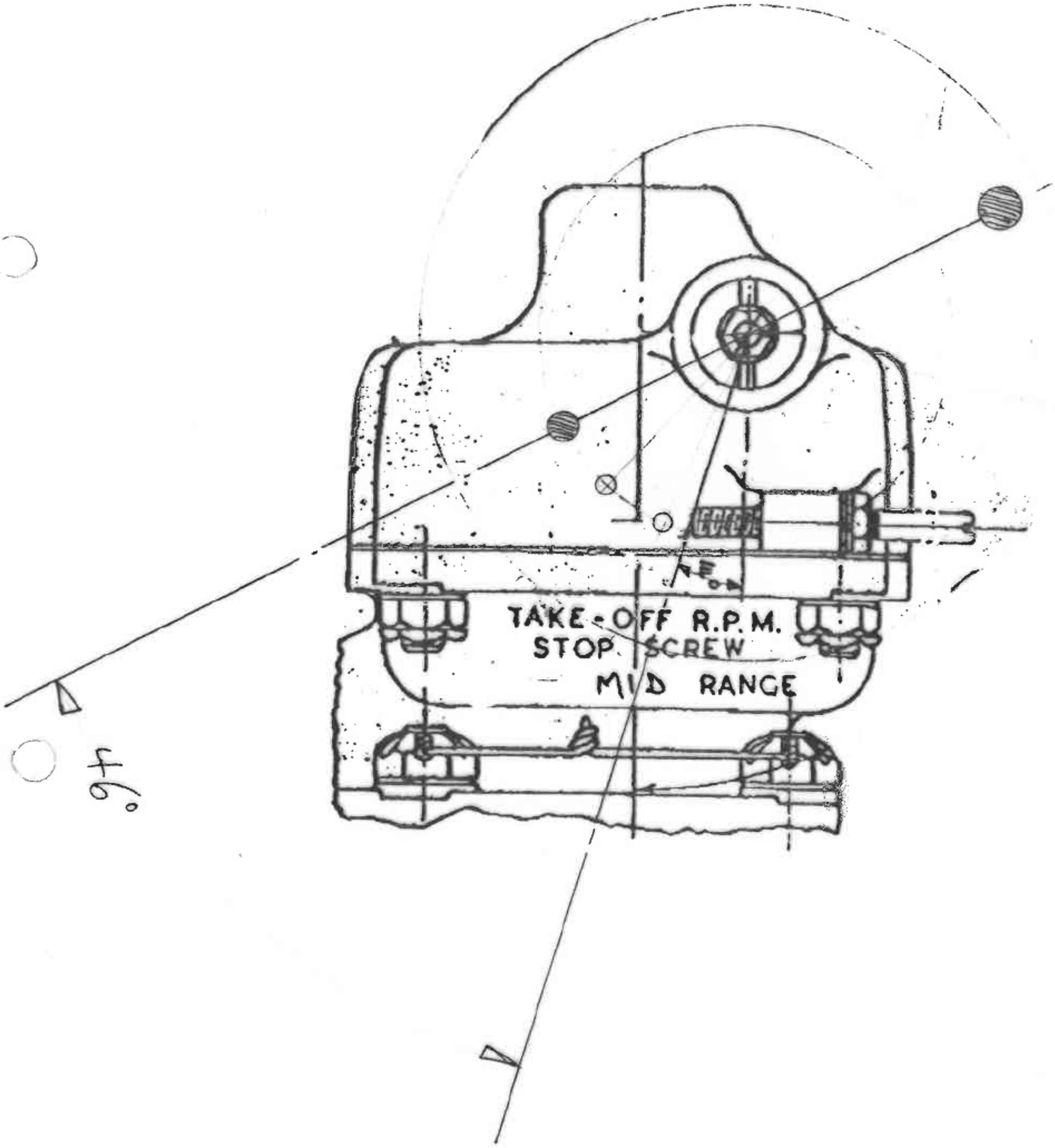
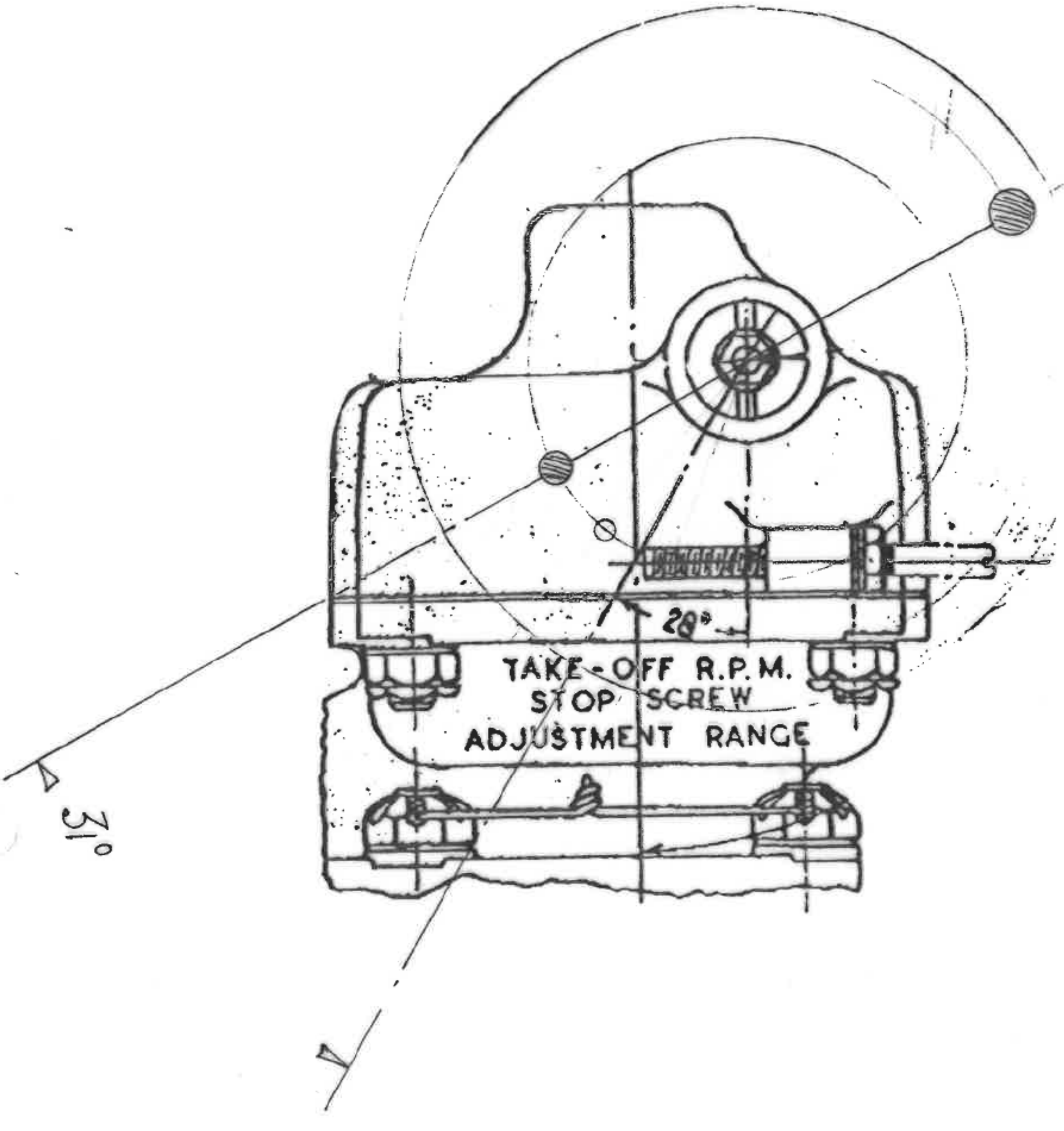
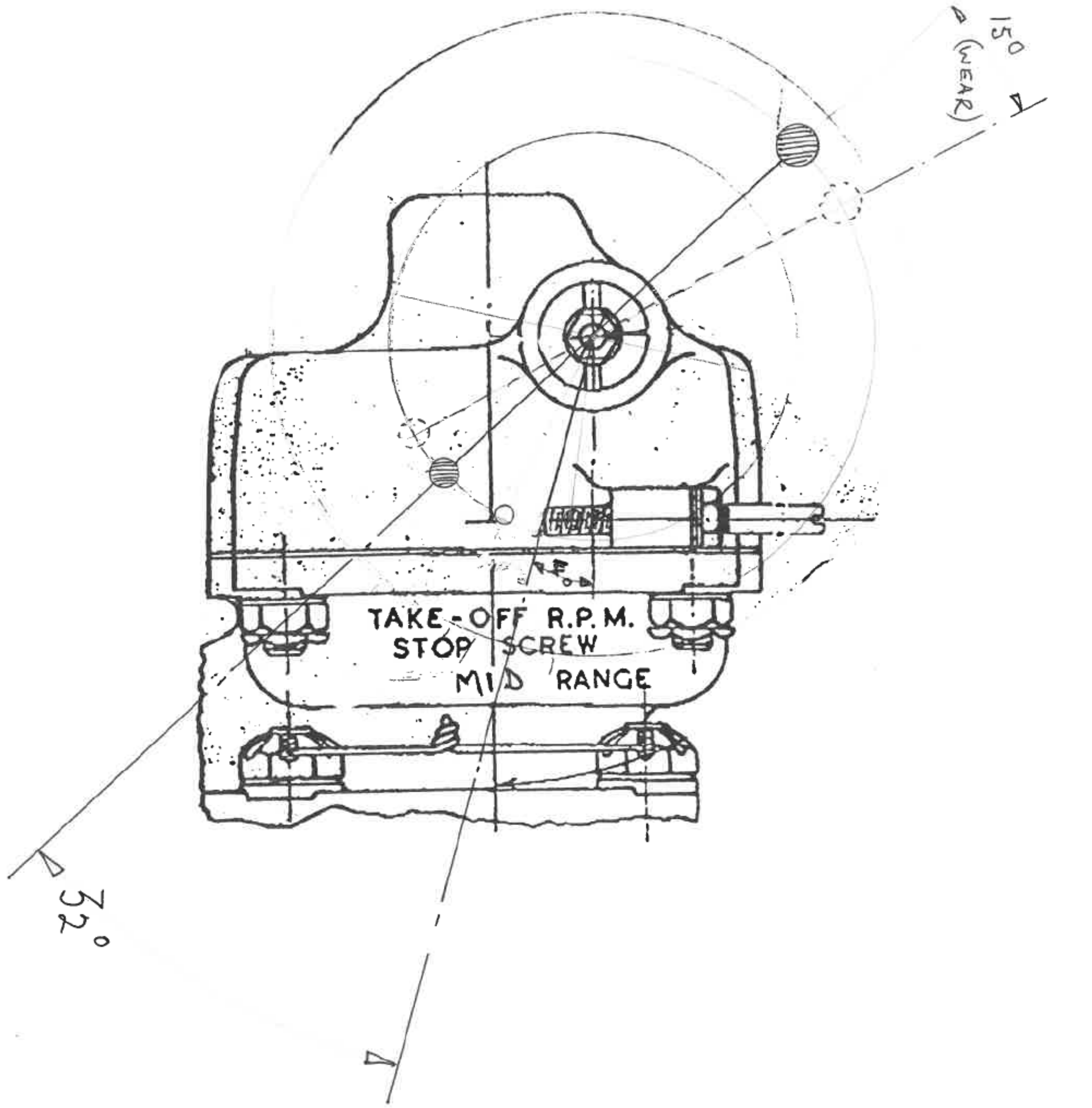
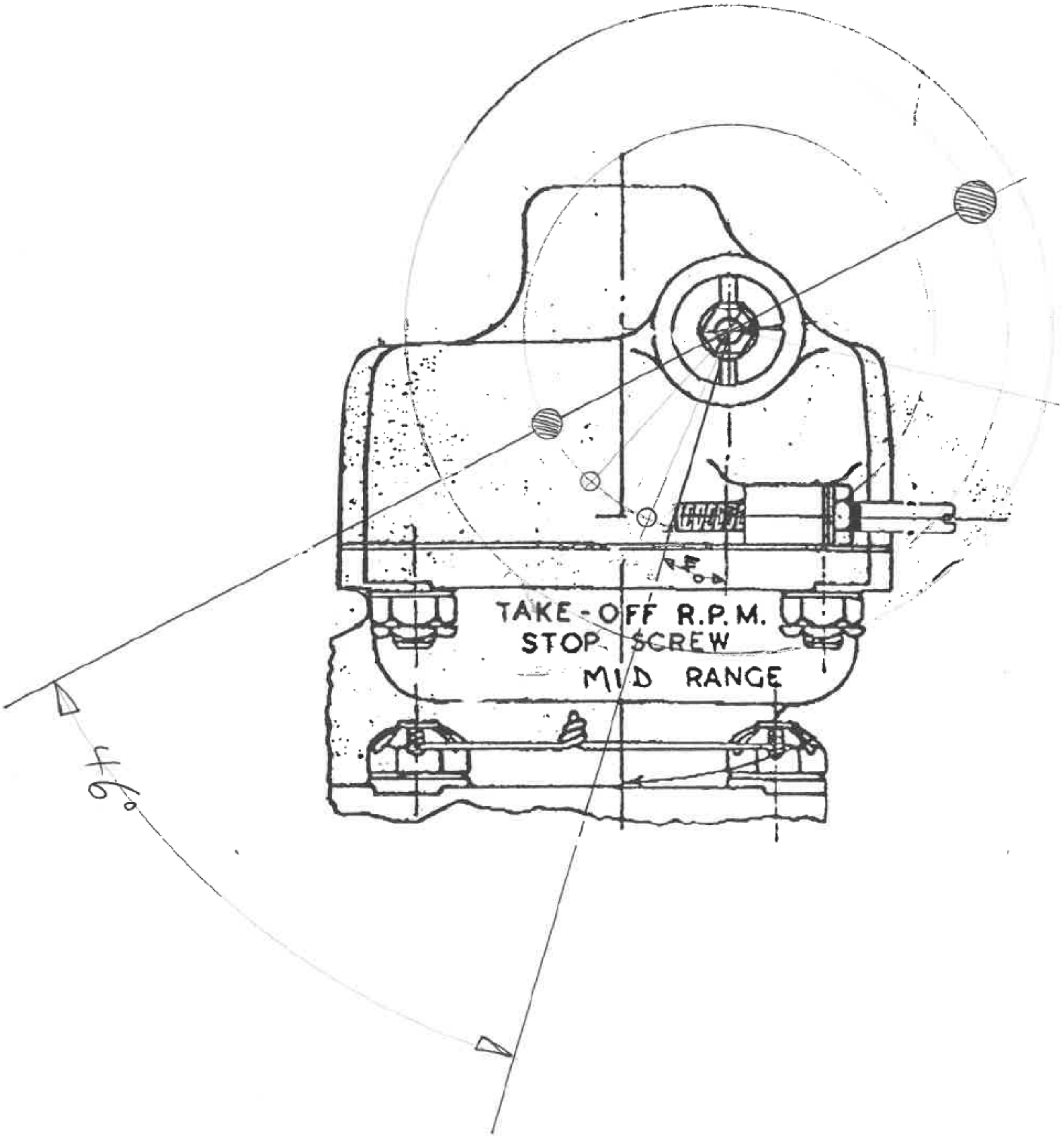
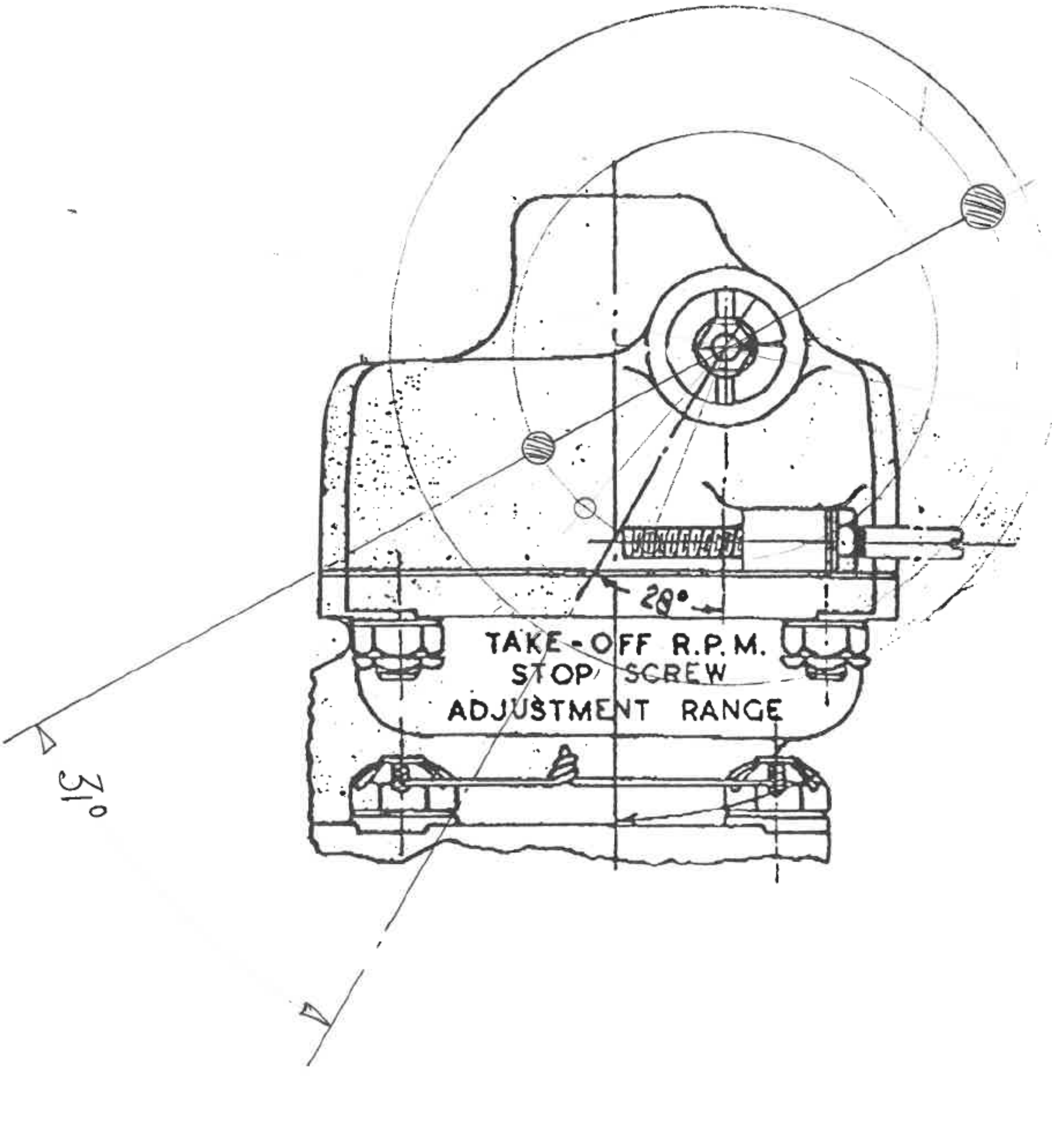
(WEAR)
TAKE-OFF R.P.M.
STOP SCREW
MID RANGE
32°

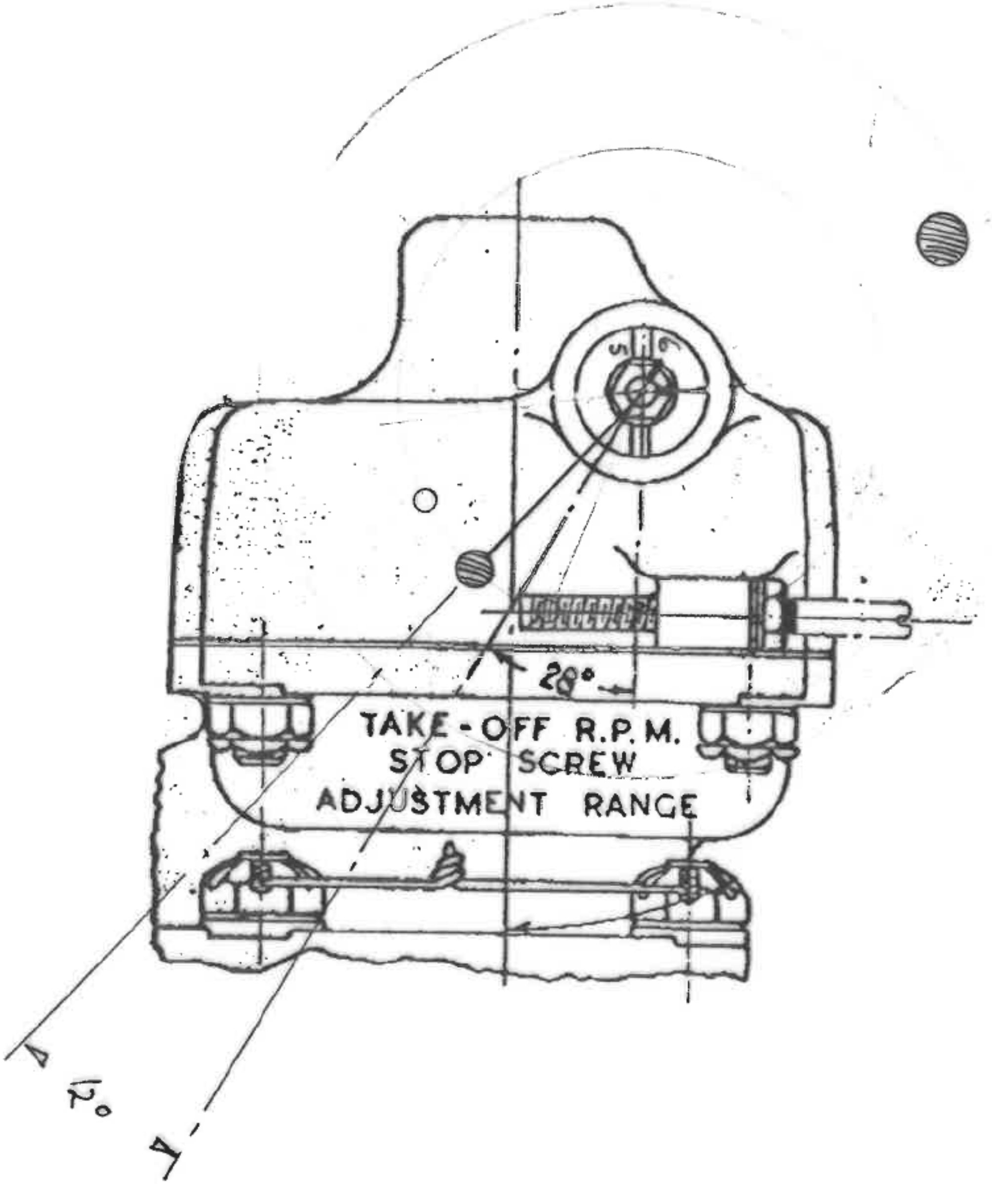

TAKE-OFF R.P.M.
STOP SCREW
MID RANGE
46°


28°
TAKE-OFF R.P.M.
STOP SCREW
ADJUSTMENT RANGE
31°


15°
(WEAR)
TAKE-OFF R.P.M.
STOP SCREW
MID RANGE
32°


TAKE-OFF R.P.M.
STOP SCREW
MID RANGE
46°


28°
TAKE-OFF R.P.M.
STOP SCREW
ADJUSTMENT RANGE
31°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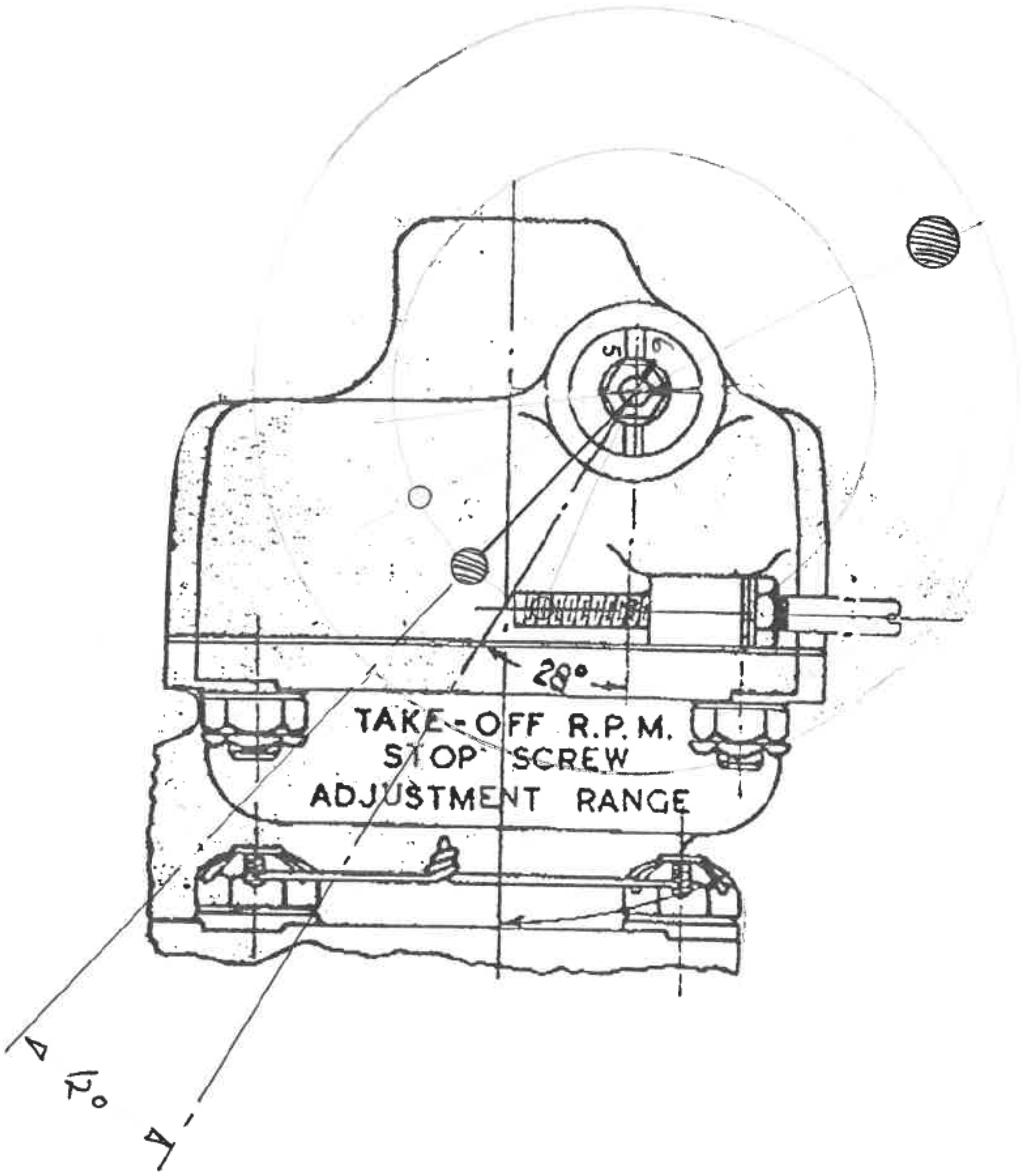
TAKE-OFF R.P.M.
STOP SCREW
ADJUSTMENT RANGE
12°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TAKE-OFF R.P.M.
STOP SCREW
ADJUSTMENT RANGE
12°

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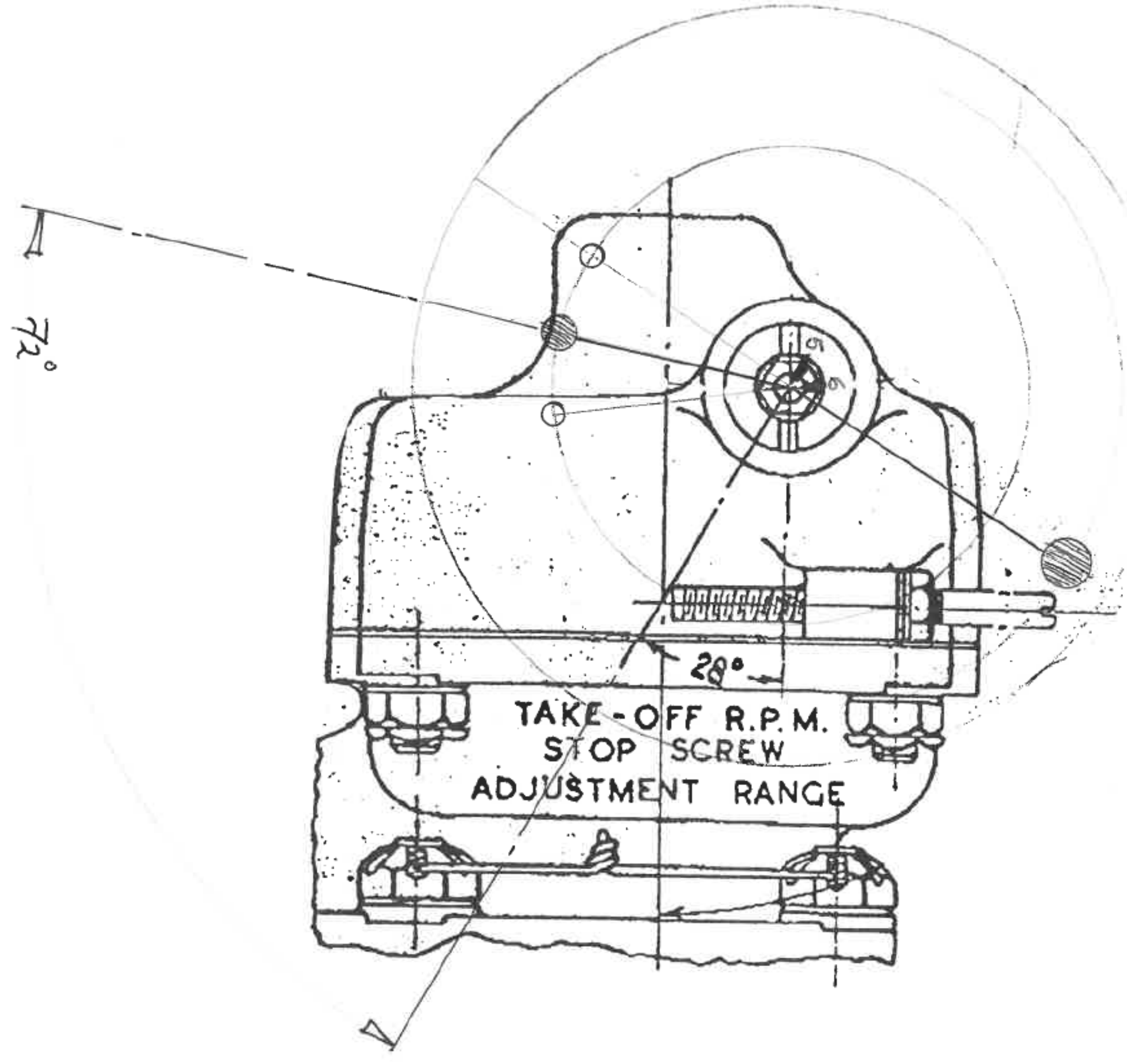
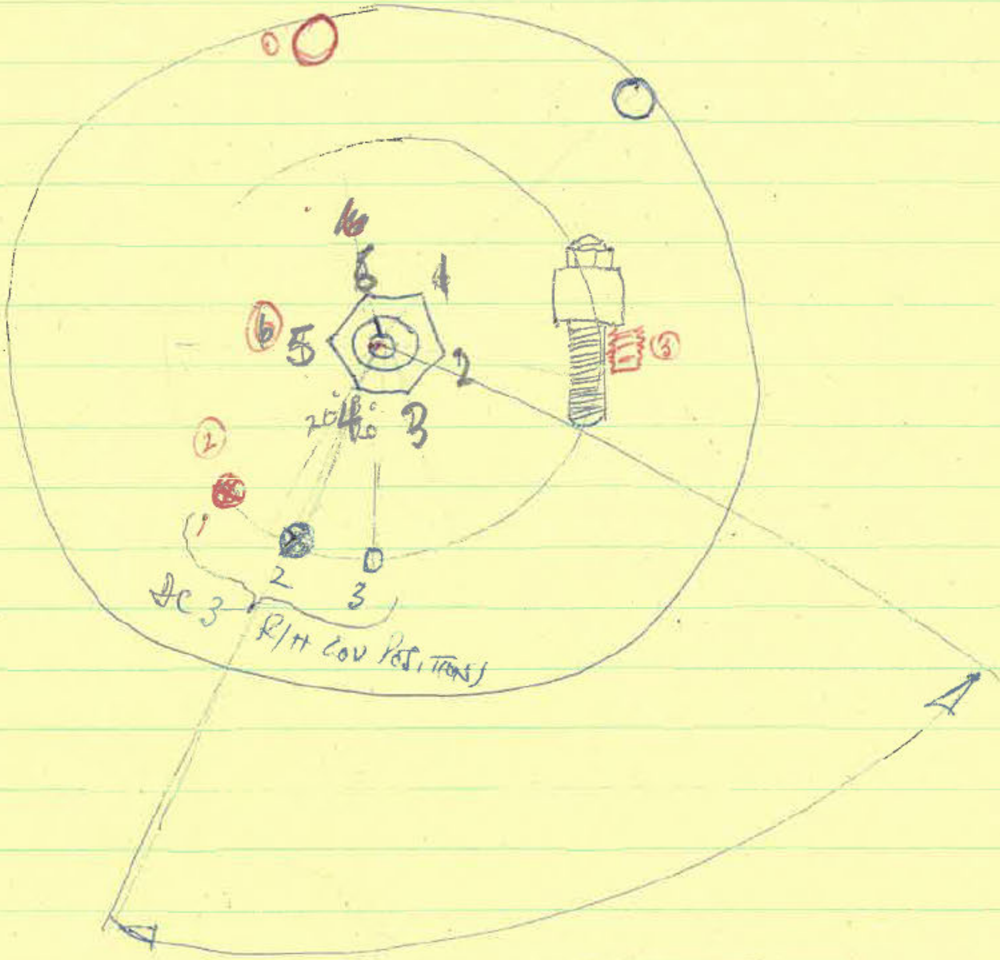
406

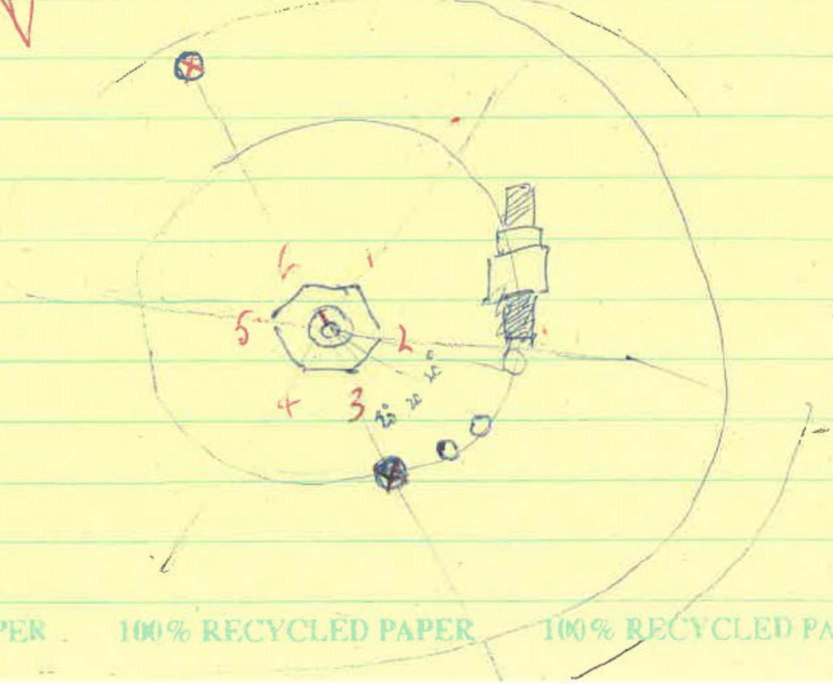


AS FOUND – (PULLEY SITTING IN NULL POSITION BETWEEN RACK SPRINGS)



TO CORRECT RIGGING

1. ROTATE PULLEY 60° ON HEX SHAFT (1 FLAT) ALIGN SCRIB MARK WITH No 6.
2. MOVE STOP PEG 1 HOLE CW TO POSITION 1.
3. SCREW STOP SCREW ANTI-CW 8 TURNS TO MID POSITIONS.



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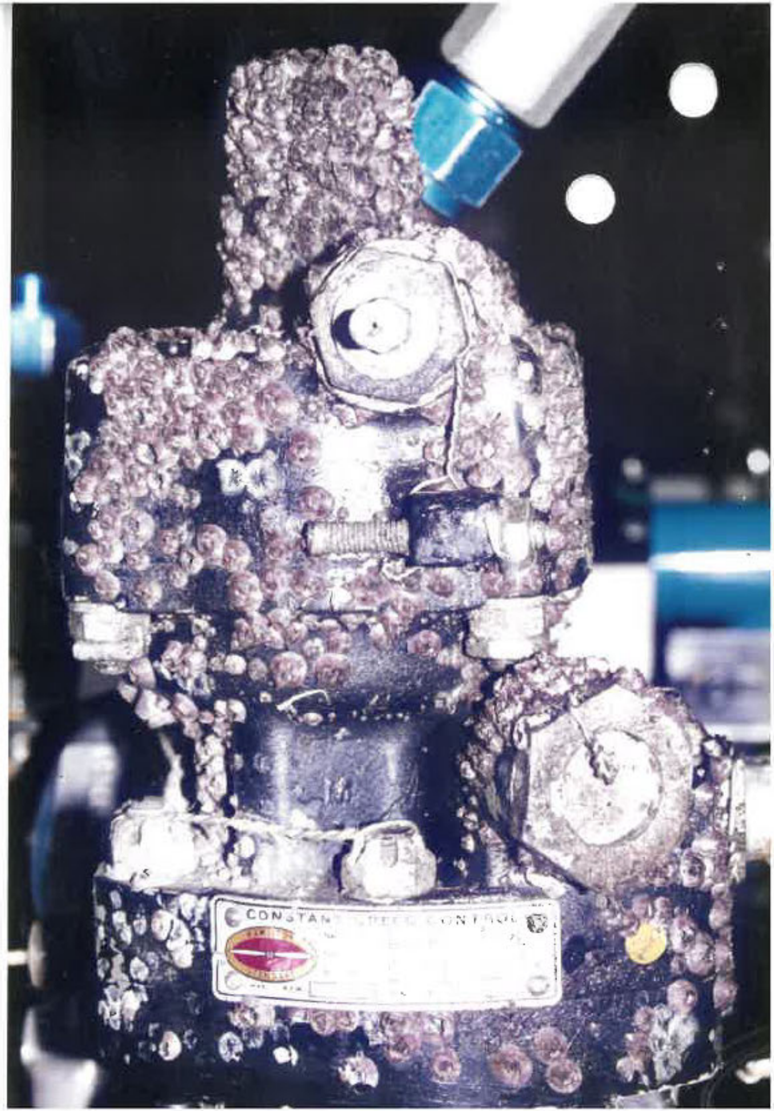

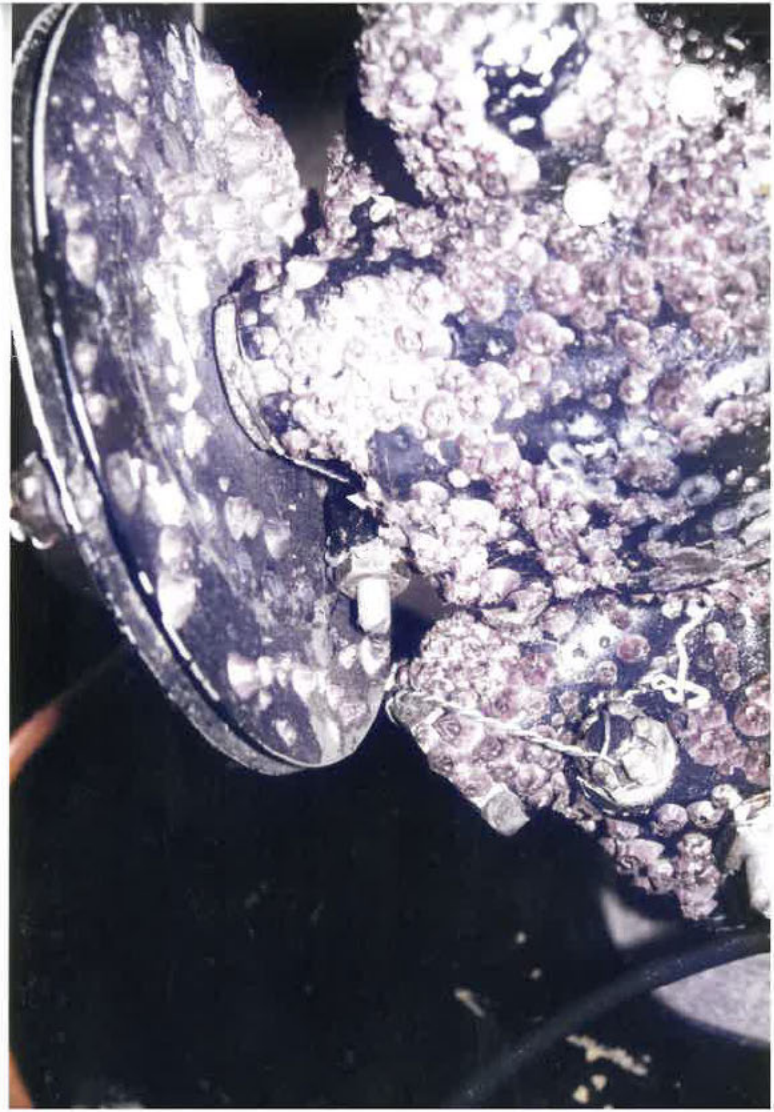

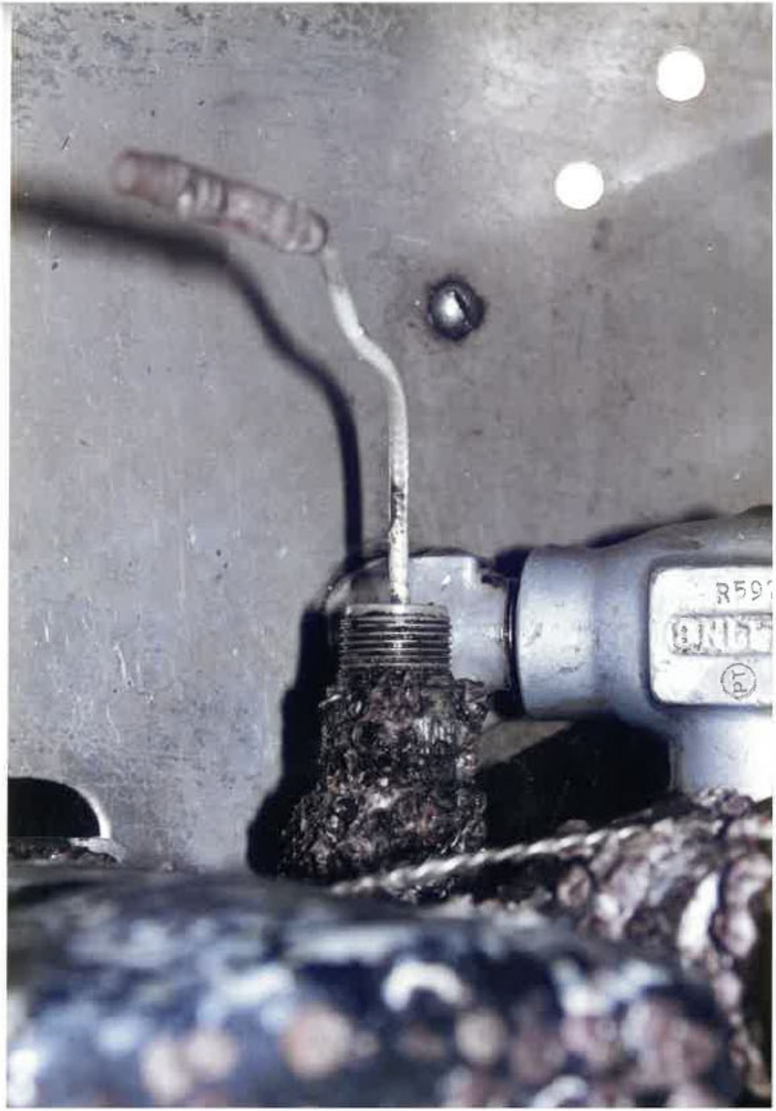

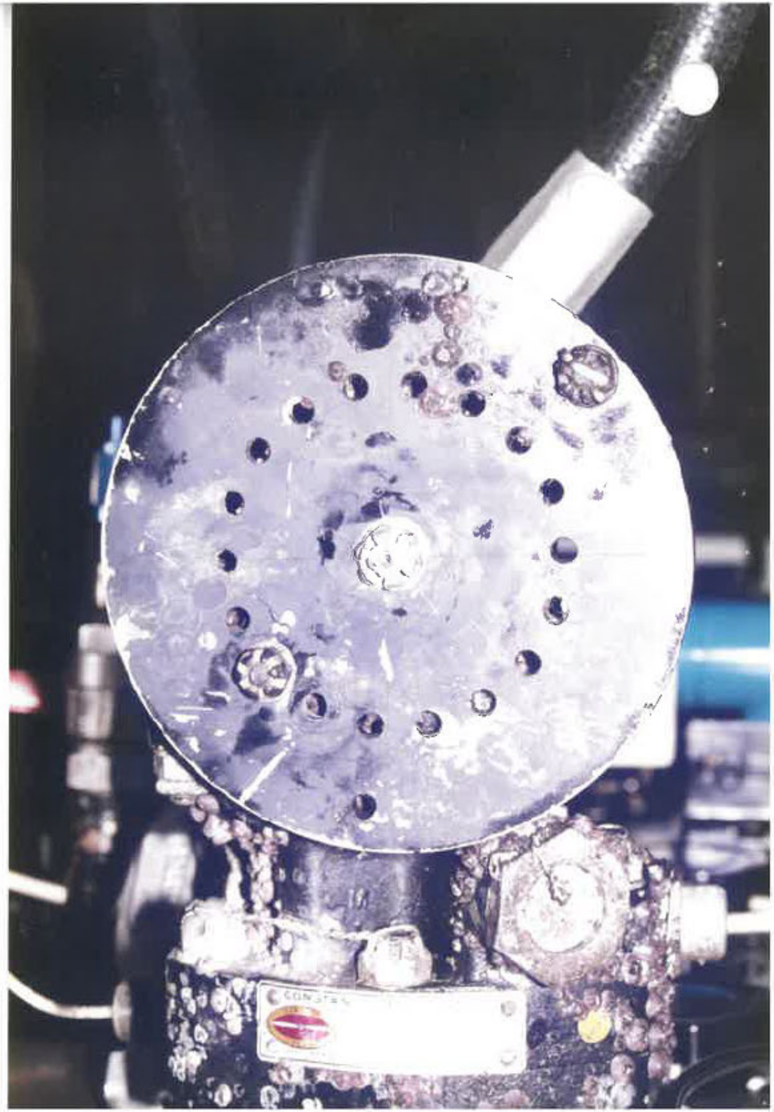

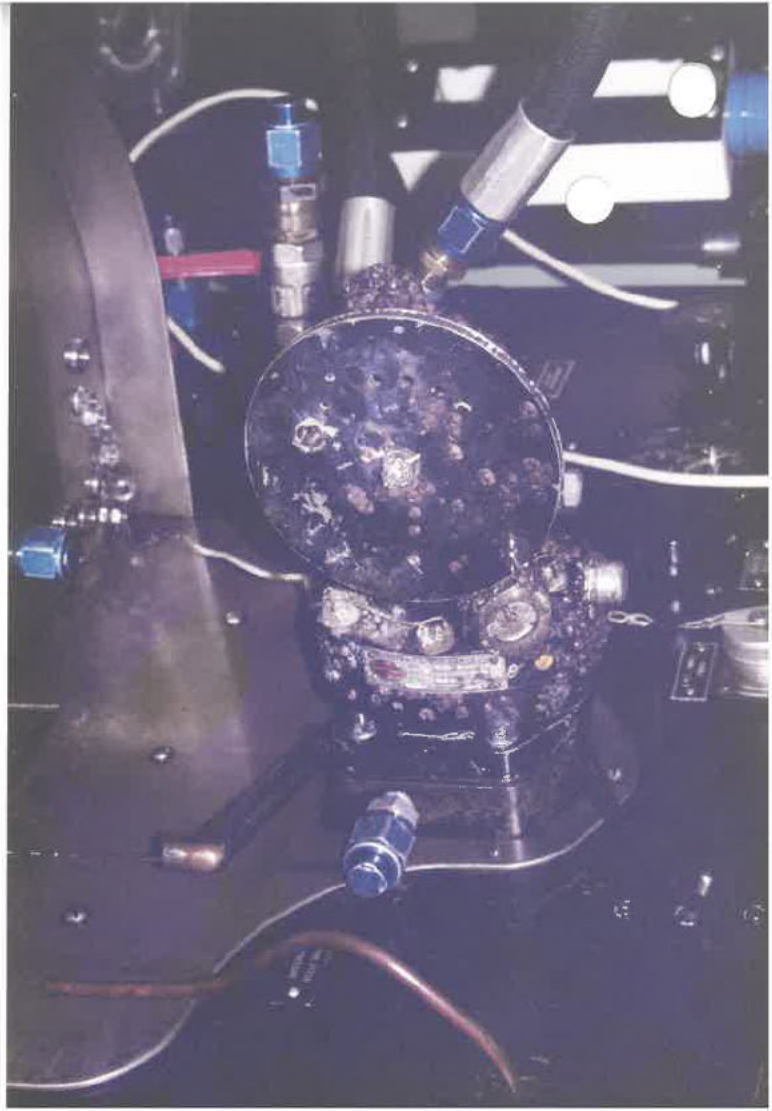

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to 2

DOCUMENT 23

COPY : THE ATTACHMENTS TO THIS MINUTE ARE TO BE AN APPENDIX TO ENGINEERING REPORT WHICH WILL BE FINALISED AFTER RECEIPT OF WILTSHIRE REPORT. (BF) 1/9/94.

Minute Note to File BO9401043 VH-EDC

Subject: Propeller Governor Right Engine - Visit to Wiltshire Engineering, Bankstown 30 August 1994.

Present: for BASI s.47F(1) [redacted]
for Wiltshire s.47F(1) [redacted]

The propeller governor Model No 4G8-G30M serial No WH 32824 when removed from the engine after recovery from Botany Bay was given to s.47F(1) [redacted] Wiltshire Engineering - Bankstown for examination.

s.47F(1) [redacted] phoned me 27 August 94 advising his concern about the rigging of this propeller governor.

s.47F(1) [redacted] and I visited Wiltshire Engineering 30 August to establish the rigging problems which had been advised.

The governor, without being dismantled, was secured to the governor test bench. Examination of the position of the pulley on the hexagon of the rack shaft, the stop peg in relation to the pulley cable clamp location and its position when the pulley was rotated towards the max RPM adjustable stop revealed that:-

- The pulley was set on the hexagon rack spindle with the indicator line towards the No 5 position.
- The stop peg was fitted to the pulley in the middle hole of three appropriate for a DC3 right engine governor.
- The max stop adjuster screw was screwed right down to a position which would decrease max RPM. (Normally this adjusting screw is set to the mid range position which will give approximately eight turns either way to provide max RPM adjustment on the ground. One turn = approx 25 RPM)

With the governor set as found on the test rig and with the pulley rotated until the stop peg was on the adjusting screw the equivalent max RPM was greater than the test rig could monitor.

When the pulley was then removed from the hexagon ended shaft the following was noted:-

. Although the retaining nut was split pinned, there was little more than finger pressure required to loosen the nut.

. With the retaining nut and washer removed the pulley was loose on the hexagon of the shaft. Excessive wear within the hexagon of the pulley allowed approximately 10-15 degrees of rotational movement.

. The scribed index line on the hexagon shaft end aligned with the No 5 position stamped on the pulley face.

. Although worn, it is considered that the wear was insufficient to enable the pulley to be rotated around the hexagon of the shaft. i.e. during disruption of the cables when the engine was torn from the aircraft.

For correct rigging it was necessary to:-

. Re-position the pulley on the hexagon shaft by rotating the pulley anti clockwise 1 hexagon flat to align the scribed line with the No 6 position. ie 60 degrees rotational repositioning.

. Relocating the stop peg on the pulley one hole clockwise (viewed from the retaining nut side of the pulley) on the pulley. ie 20 degrees, and

. Re-adjusting the max RPM stop screw anti-clockwise approximately eight turns to the mid travel, position. This allowed approximately another 10 degrees rotation of the pulley in the anti-clockwise direction to set the stop peg of the pulley against the stop screw.

With the pulley, stop peg and stop screw adjusted accordingly the governor performed the appropriate tests on the test rig to the specifications required of this model governor.

Additionally - The electrical connection to the pressure cut-out switch, which is normally a single wire Cannon plug, was, on this unit, a crimped electrical wire to the central pin of the cannon plug receptacle with a sleeved knife connector for attachment to the engine electrical loom. This is not 'kosher'.

A report on the findings of the examination of this governor will be forthcoming from s.47F(1) [redacted] Wiltshire engineering.

The significance of this 'mis-rigging' of the governor pulley in respect to operational performance of the propeller and its effect on VH-EDC during the take-off and subsequent ditching will be considered and addressed.

There are no records in the log books for the removal and replacement of either the R/H propeller governor, the pulley governor pulley or control cable assembly which would have required re rigging of the propeller controls.

There is a requirement in the CAA Schedule 5 periodic inspection (to which this aircraft was being maintained) Sect 2 para (11) to:-

> "Inspect to following controls for full and free movement in the correct sense
>
> (a) throttle, mixture and propeller.

This inspection will determine control lever spring back in the quadrant and the ability of the control cables to move the component levers to the relevant stops. In the case of the propeller, for the cables to operate the pulley so that the stop peg comes into contact with the max RPM stop screw when the control lever is moved into the increase RPM position.

With the governor pulley in the as found position this control check should have identified a gap between the stop peg and the screw stop with the lever in the Propeller lever fully forward in the increase RPM position.

s.47F(1) [redacted]

31 August 1994

Attachments:

- Governor installation/setting instructions Hamilton Service Manual No.123. Pages 35-41
- Governor Installation/adjustment instructions Manual TO No 01-40NC-2.
- Propeller CSU cable linkage diagram - Manual TO 1C-47-2
- extract from DeHavilland A/C P/I ED No 30 - Relationship between Control shaft rotation and Governor RPM

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SECTION IV
OPERATION

1. PRINCIPLES OF OPERATION.

a. GENERAL.—A typical governor (or constant speed control) consists essentially of a gear pump which takes oil from the engine lubricating system and boosts its pressure to that required to operate the propeller pitch changing mechanism; a pilot valve actuated by spring balanced fly-weights which controls the oil to and from the propeller; a pressure operated transfer valve that allows high pressure oil from an auxiliary pump to shunt out the governor when the propeller is being feathered and unfeathered; and, a built-in relief valve system that limits the load on the gear pump yet provides sufficient pressure to control the propeller under all operating conditions. Some models also incorporate a differential pressure cut-out switch connected into the oil line to the propeller on the high pressure side, and the engine supply passage in the governor on the low pressure side. This switch serves to turn off the feathering pump electric motor when the propeller reaches the full-feathered position. The accessories used with a Hydromatic type governor are a feathering pump, a cockpit push-button control switch, and a solenoid relay. The feathering pump supplies the high pressure auxiliary oil which is used to feather and unfeather the Hydromatic type propeller. The push-button control switch is operated by the pilot to energize the solenoid relay which establishes the comparatively high current circuit between the aircraft battery and the feathering pump. Figure 41 shows a typical Hydromatic type governor installation with the proper feathering accessories.

b. GOVERNOR CONTROL.

(1) GENERAL.—The governor can be set to maintain any speed within its range by adjusting the position of the rack through the cockpit control. Raising the rack decreases the compression of the speeder spring and thus reduces the speed at which the fly-weights must rotate for the on-speed condition. Lowering the rack increases the spring force and consequently the required rotational speed of the fly-weights. Because of the time required for pilot valve movement and propeller controlling oil flow, it cannot be expected that propeller response to overspeed or underspeed corrections will be instantaneous. If the throttle is advanced suddenly, the engine may momentarily overspeed before sufficient oil can flow from the governor to increase the blade angle to absorb this increase in engine power output.

(2) MECHANICAL HEAD TYPE.—In governors which incorporate the mechanical type head, the position of the rack is controlled through a pulley mounted on a shaft which is supported on bearing surfaces set within the governor cover. A portion of this shaft between the bearings is formed into a spur gear which meshes with teeth cut into the side of the rack. Moving the pulley by means of the control cable turns the control shaft which adjusts the position of the rack in the control head and thereby varies the compression in the speeder spring.

(*a*) The limit of pulley travel in the direction of low speed is reached when the top of the rack contacts the cover. The upper end of the speeder spring seats against the minimum rpm adjusting screw which is threaded into the rack. The minimum governing speed can be set at any desired value (within the limits of the unit) by adjusting the position of this screw in the rack.

CAUTION

The minimum rpm adjusting screw should not be screwed into the rack so far that it will entirely unload the speeder spring as feathering of the propeller will result. It is recommended that no attempt be made to set the minimum governor rpm below 900. For all present military and most commercial airplane installations, the minimum governor rpm has been standardized at 1200 rpm. The minimum engine rpm will then depend upon the gear ratio of the governor drive mechanism.

(*b*) The limit of pulley travel in the direction of high speed is reached when the stop pin, which can be located in any one of 18 holes in the pulley, strikes the end of the high rpm adjustment screw which is threaded through a boss on the outside of the cover. Coarse rpm adjustment is made by moving the stop pin. Shifting the pin from one locating hole to the next will vary pulley angular rotation 20 degrees with a consequent change in high rpm setting of approximately 250 rpm. Fine adjustment is made with the adjusting screw, one turn of which will vary the rpm setting approximately 25 rpm.

(*c*) A balancing spring is provided to return the rack to approximately the cruising rpm position in case the control cable between governor and cockpit breaks.

(3) ELECTRIC HEAD TYPE.—The constant speed control may also be fitted with an electric head.

leakage or get into the governor and foul the operating mechanism. Place the governor in position on the engine-governor mounting studs, and check the fit of the governor circular pilot boss. In some cases, the boss might be slightly larger than the corresponding opening on the engine pad into which it fits. If this condition exists, further investigation should be made to determine which part is to be reworked.

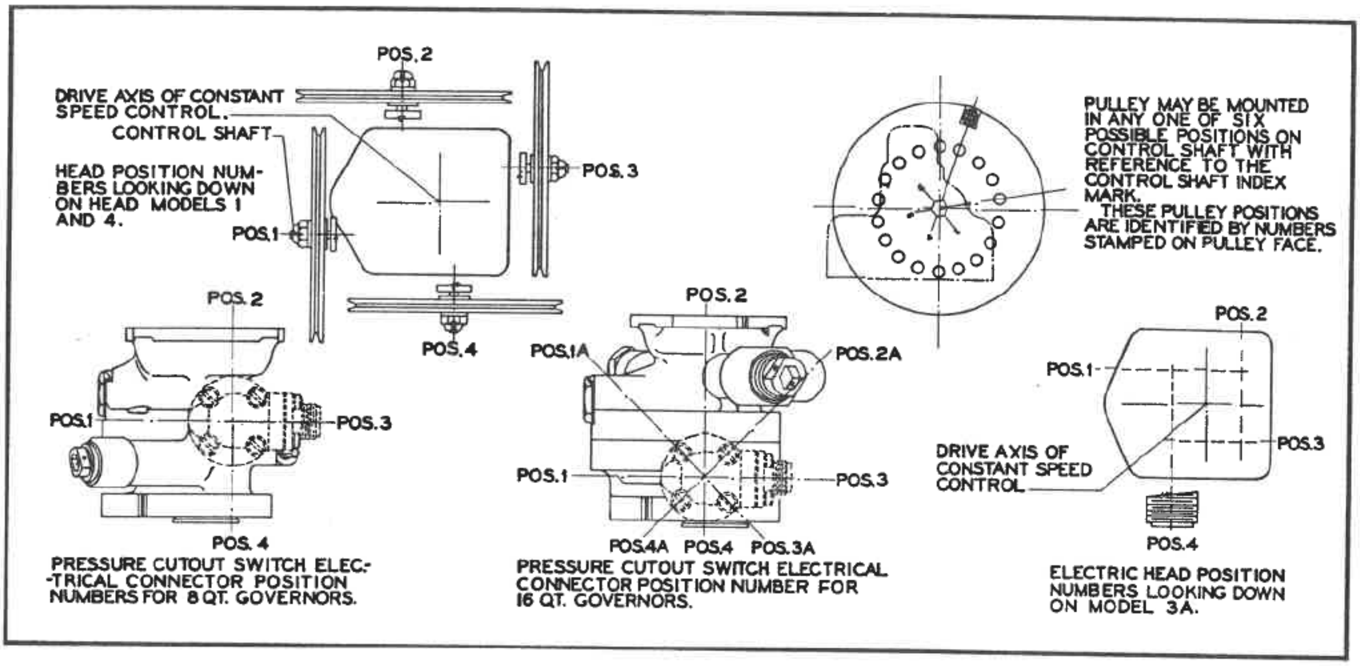
(2) Place the governor mounting gasket on the engine mounting pad with the raised screen section facing up. Install the governor in place over the attaching studs and onto the mounting gasket. Add one washer and one self-locking nut on each stud, and draw down each securing nut until it is finger tight.

Note

The upper flange of the governor base casting will interfere with the mounting nuts on the studs if the governor is resting on the engine nose pad. To finally secure the governor in place, raise the unit sufficiently to allow starting the securing nuts on the mounting studs.

When the wrench is used, it is essential that these nuts be tightened down evenly but they should not be drawn down excessively as this may cause displacement of the gasket material in the vicinity of the mounting studs resulting in warping of the governor base and subsequent leakage.

(3) If the pulley is not already on the governor, it should be installed in its correct angular position



GOVERNOR MODEL			Model 4-G Mechanical Control Head				Model 3-A Electric Control Head			
			1	2	3	4	1	2	3	4
SINGLE CAPACITY			Yes	Yes	Yes	Yes	Yes	No	No	Yes
	Available Positions for Pressure Cut-Out Switch.	1	No	No	No	No	No			No
		2	Yes	Yes	Yes	No	Yes			Yes
		3	Yes	Yes	Yes	Yes	Yes			Yes
		4	Yes	Yes	Yes	Yes	Yes			Yes
DOUBLE CAPACITY			Yes	Yes	Yes	No	Yes	No	Yes	Yes
	Available Positions for Pressure Cut-Out Switch.	1	Yes	Yes	Yes	Yes	Yes		Yes	Yes
		1A	Yes	Yes	Yes	Yes	Yes		Yes	Yes
		2	Yes	Yes	Yes	Yes	Yes		Yes	Yes
		2A	No	No	No	No	No		No	No
		3	Yes	Yes	Yes	Yes	Yes		Yes	Yes
		3A	Yes	Yes	Yes	Yes	Yes		Yes	Yes
		4	Yes	Yes	Yes	Yes	Yes		Yes	Yes
		4A	Yes	Yes	Yes	Yes	Yes		Yes	Yes
ACCUMULATOR GOVERNORS			Yes	Yes	Yes	Yes	Yes	Yes	No	No

Figure 45—Chart of Available Head and Cut-Out Switch Positions

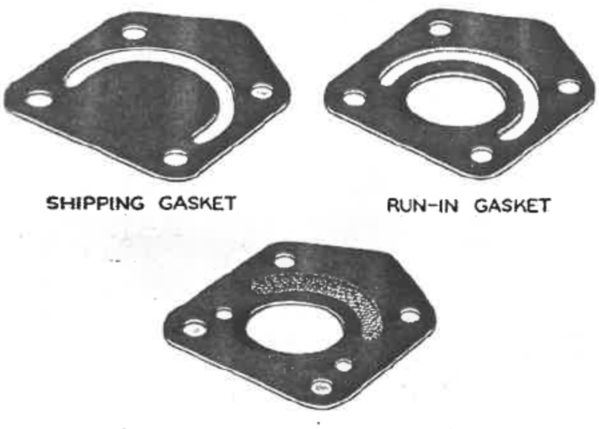


Figure 46—Comparison of Shipping, Run-In, and Mounting Gaskets

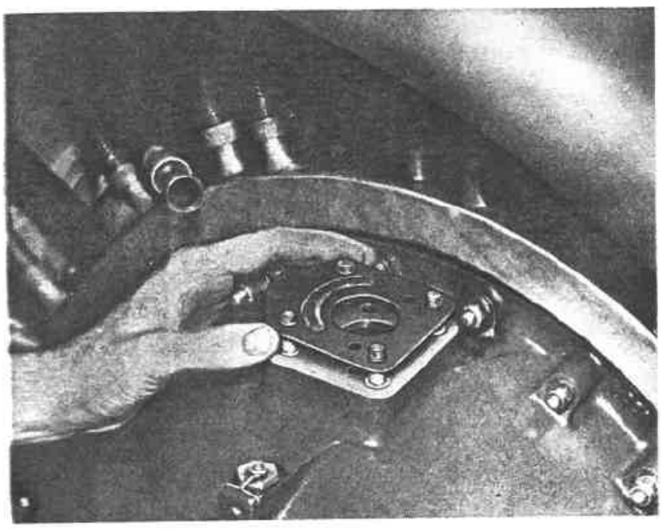


Figure 47—Placing Governor Mounting Gasket on Mounting Pad

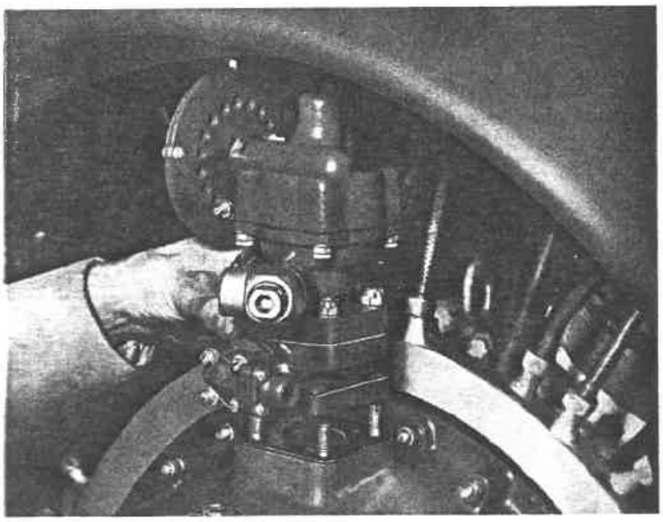


Figure 48—Installing Governor on Mounting Studs

on the hex section of the governor control shaft with a hex washer inboard of the pulley, and a circular washer on the outboard side. See figure 45 which shows and explains pulley position numbering. Tighten the castellated retaining nut with a torque of 60 pound-inches, and then lock it to the control shaft with a cotter pin.

CAUTION

To prevent the hard steel control shaft from broaching the comparatively soft aluminum pulley, make certain that the hex washer is included on the inboard side of the pulley.

If the governor speed range has previously been set on a test rig, the pulley should be in its correct numbered position with respect to the index line on the end of the control shaft. The correct relationship allows the governor to operate through a satisfactory speed

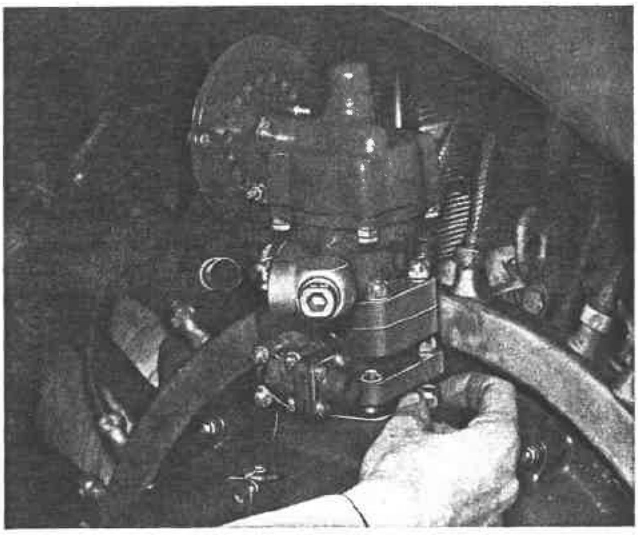


Figure 49—Installing Washers and Nuts on Mounting Studs

range; namely, from the low rpm setting established by the low rpm adjusting screw in the rack assembly, to the high rpm setting established by contact of the pulley stop pin with the high rpm adjusting screw on the governor head. If the pulley stop pin is moved to an adjacent hole in the pulley, the high rpm setting of the control will be changed approximately 250 rpm. Turning the external high rpm adjusting screw one complete turn changes the high rpm setting of the control approximately 25 rpm. The relationship between governor pulley travel in degrees and governor speed setting is shown in figure 52. To use these diagrams, first multiply the maximum engine rpm by the governor drive ratio. Read opposite the desired maximum governor rpm the control shaft rotation in degrees required. As an example: If maximum engine rpm is 2700, and the governor-engine drive ratio is .958:1, maximum governor rpm would be

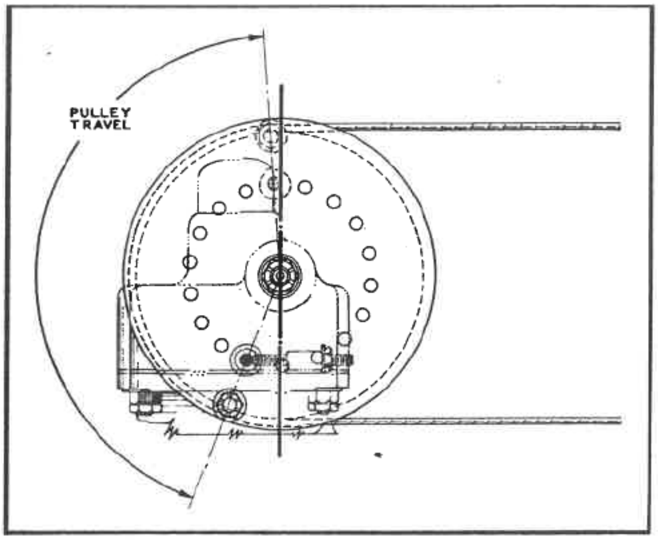


Figure 50—Correct Method of Attaching Cable to Pulley

approximately 2590, and if the governor incorporates a G-4 head, read opposite 2590 rpm to obtain the maximum pulley travel of 103 ±5 degrees. Allow a tolerance of ±5 degrees on all control shaft rotation calculations obtained from these charts. Also remember that these charts are primarily for 1200 rpm minimum settings only. When the rack contacts the governor head casting establishing the low setting, the scribe line on the control shaft will be in line with the zero position on the chart. Therefore, to obtain the required pulley travel on installations where the minimum setting is above 1200 rpm, note the pulley degrees marked on the charts opposite the desired low rpm setting and subtract this value from the pulley degrees marked opposite the high rpm setting. The scribe line is also used to indicate one of the six numbered pulley positions stamped opposite the pulley hex center hole. If the governor is being reinstalled on the same aircraft, the correct angular position of the

Figure 51—Tightening Cable Clamp

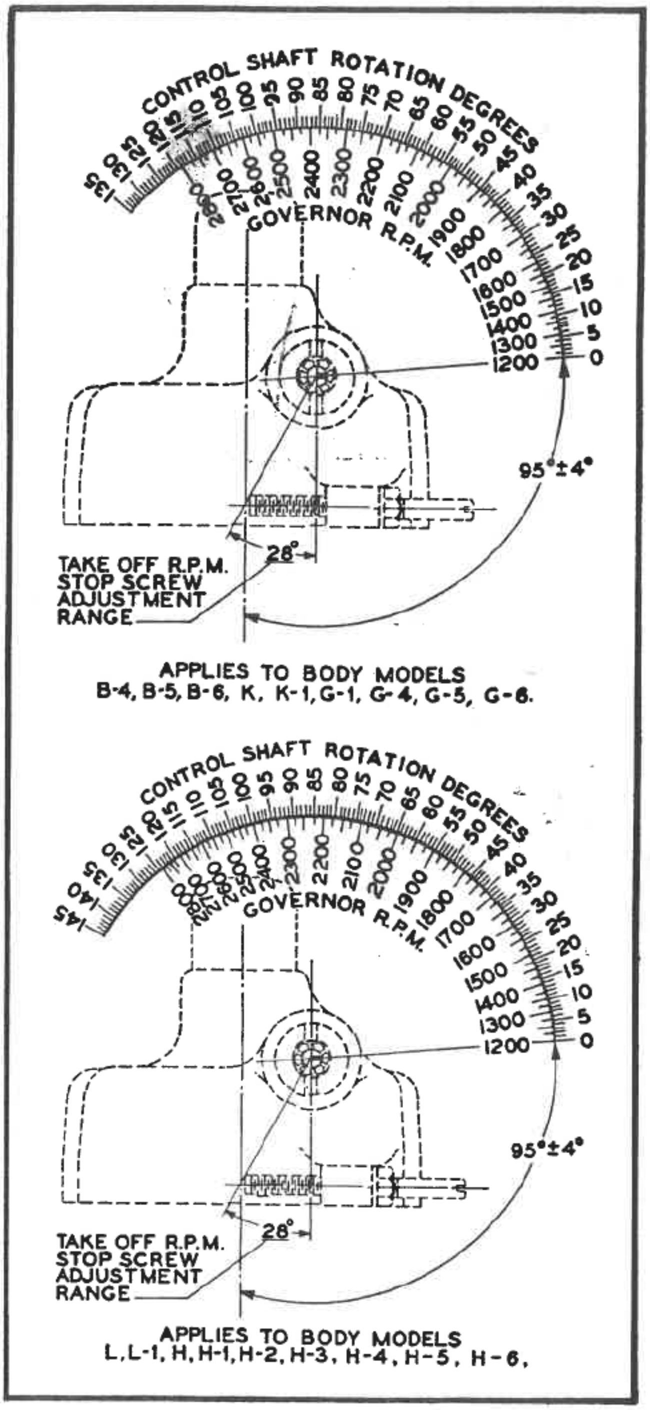


Figure 52—Pulley Travel Chart

pulley should have been noted when the unit was removed.

(4) Secure the pulley control cable to the pulley by tightening the cable clamp, and then safety the castellated nut with a cotter pin. Make certain that the pulley is installed in such a way that full angular travel is possible without pinching the control cable. As shown in figure 50, the cable clamp should never be positioned in such a way that it pulls the cable out of tangency with the pulley.

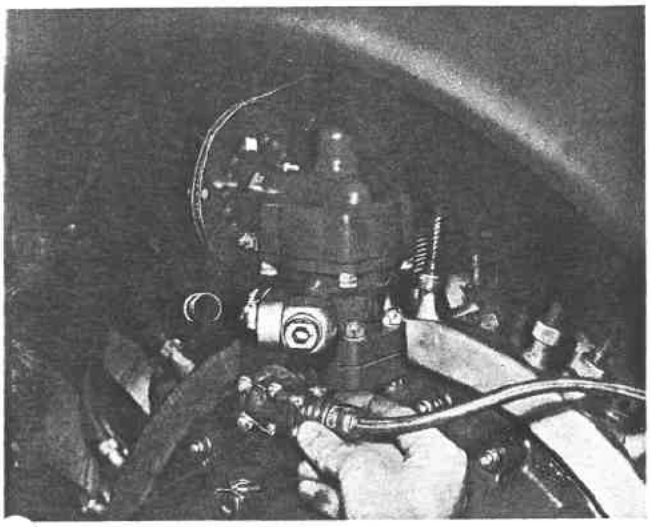


Figure 53—Connecting Electrical Line to Cut-Out Switch

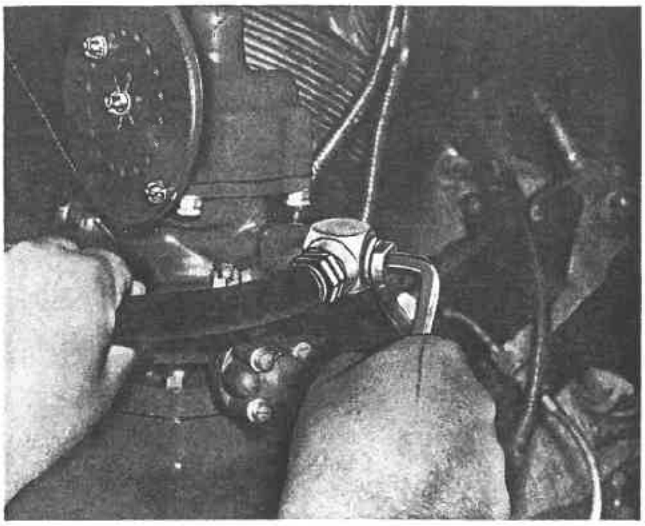


Figure 54—Tightening Feathering Line Swivel Clamp Bolt

(5) When a governor is removed from an engine, it is often more convenient to remove the pulley from the governor rather than removing the control cable from the pulley. In this event, the numbered position of the pulley with respect to the index line on the control shaft should be noted and possibly marked on the pulley at the time of removal. At reinstallation, the pulley with the control cable attached is then reinstalled in this same position. This procedure minimizes the amount of adjustment required to obtain the correct relationship between pulley range, control cable location, etc. The control cable should never be excessively tightened since this results in undue wear on the control shaft and shaft bushing. Satisfactory operation is obtained if the cable is under a tensile load of approximately 20 pounds.

Note

In adjusting control cable tension, it is necessary that allowance be made for movement of the engine on its flexible mounts. Many operators have found it convenient to compensate for this engine movement by installing a constant loading device at some convenient point in the control cable line.

(6) Connect the electric line to the cut-out switch. The tabulation shown below lists the various connectors which may be used on both single wire and double wire pressure cut-out switches. These switches may be used on either 12 or 24-volt systems. As shown in figure 45, it is usually possible to mount the cut-out switch on the governor in any one of eight angular positions. The correct position is determined by the requirements of the particular aircraft installation.

(7) Connect the auxiliary high pressure oil line (from the feathering pump) to the swivel fitting on the governor. The swivel fitting may be turned to any position required by the installation. After the correct angular position of the swivel fitting has been determined and the high pressure line connected, tighten the swivel clamp bolt and then safety it to one of the body-base castellated nuts on the governor. To insure satisfactory feathering operation, the line from the feathering pump to the governor should be primed before it is attached to the governor. A three-way valve is usually installed at the lowest point in the line between the oil tank and the feathering pump to facilitate periodic drainage of condensation. This "Y" drain should be left open until oil begins to flow from the valve. When the drain is closed, an air lock is formed between the drain valve and the pump. Expel this air by running the feathering pump until air bubbles are no longer present in the oil flowing from the feathering line at the governor. The feathering pump motor may then be stopped, and the feather-

H.S.P. Switch Part No.	Insulated Terminals	AN Receptacle (built-in switch)	AN Mating Plug	H.S.P. Part No.	Adapter Cannon Type K Plug (built-in adapter)	Cannon Type K Mating Receptacle
55526 59484	1 1	AN-3102-12S-4P	AN-3106-12S-4S *AN-3108-12S-4S	56387	WK-1-32S	WK-1-21 *WK-1-23
57633 59680	2 2	AN-3102-12S-3P	AN-3106-12S-3S *AN-3108-12S-3S	57634	WK-C3-32S	WK-C3-21 *WK-C3-23

*Plug has 90-degree angle.

ing line connected and tightened in the governor swivel fitting. This complete procedure should be followed whenever the "Y" drain is opened.

b. CONTROL ADJUSTMENTS.

(1) GENERAL.

(*a*) When installing mechanically controlled constant speed units, it is important that the system used be so constructed as to permit the pilot to adjust the desired rpm accurately and conveniently, and when once adjusted, to have the governor remain set on the desired rpm. For these reasons, the installation should be carefully designed and constructed.

(*b*) Figure 41 shows a typical cable control installation on a multi-engine aircraft. This system is recommended since experience indicates it is the most satisfactory arrangement from the standpoint of installation, adjustment, freedom from lost motion, and general maintenance.

(*c*) If a cable arrangement is used, it is important that the correct size be installed in order that the cable loading and resulting stretch will be as small as possible. If the cable size is too small, it may stretch with the result that lost motion and poor adjustment of the rpm setting will be introduced into the control system. Figure 55 is a chart indicating recommended cable sizes for different cable lengths and pulley diameters.

(*d*) The total angular pulley travel required for any installation is that which will give minimum rpm at one extreme, and take-off rpm at the other. With the control system correctly designed, the total travel of the cockpit control should be so regulated as to give the total angular range required at the constant speed control unit, plus about 1/8-inch *pinch* at each end of the cockpit quadrant. It is only necessary to adjust the installation so that when the cockpit control lever is in its extreme forward position, the constant speed control unit is set for take-off rpm.

1. Figure 52 shows the relation between control shaft rotation in degrees and the corresponding rpm range for Hydromatic governors.

Note

It should be remembered with regard to figure 52 that when a governor body model is specified as K-1, for example, these numbers represent the second and fifth units of the complete constant speed control model designation. A model 4K11-G1J incorporates a K-1 body.

2. In order to determine the angular range required for any given rpm range, use these charts and follow the directions given.

(e) ELECTRIC HEAD INSTALLATION.—Installation of the electric head is completely described in paragraph 5. of this section.

(2) ADJUSTMENT TESTS. — The following suggestions for checking and adjusting the constant speed control unit assume that a cable control system is used. In each case, the purpose is to have the cockpit lever 1/8 inch from its extreme full forward position when the constant speed control unit is set to govern at take-off rpm. Under these conditions, the pulley stop pin will be against the high rpm adjustment screw.

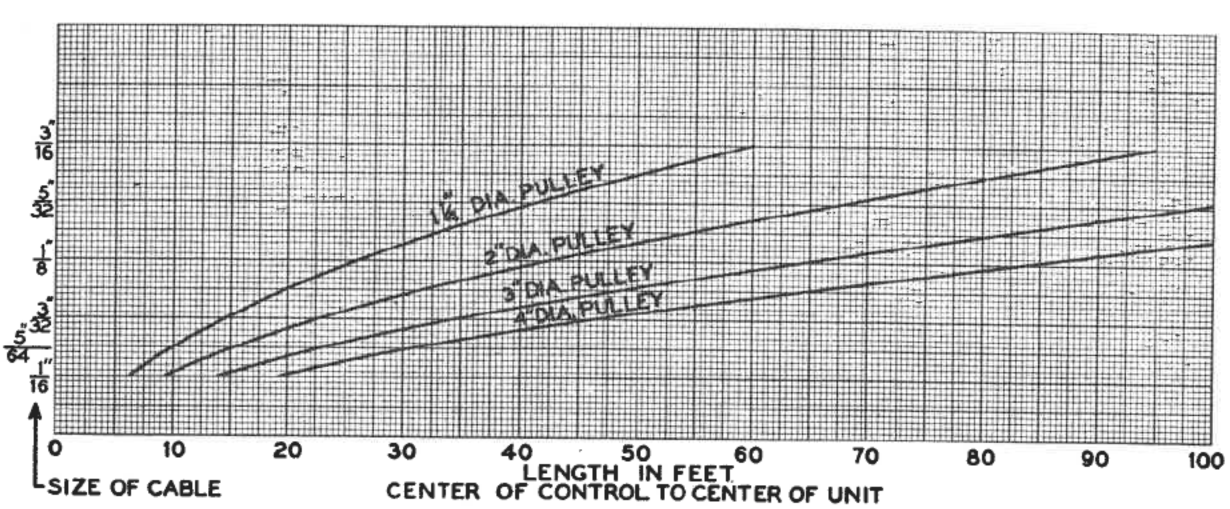


Figure 55—Chart of Recommended Cable Sizes

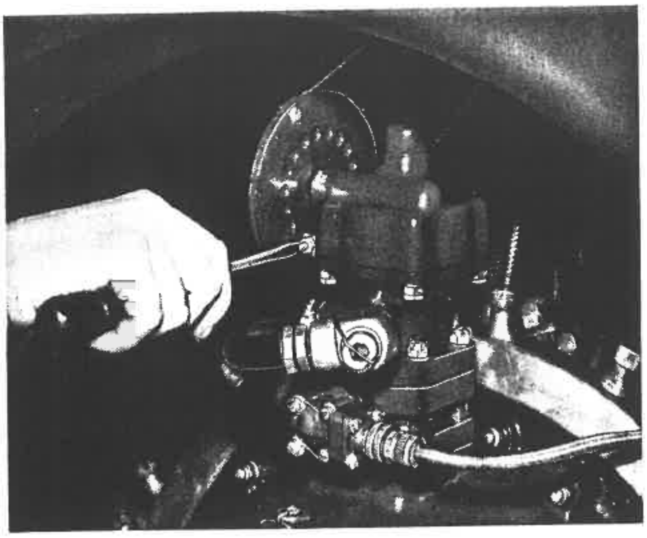


Figure 56—Setting High RPM Adjustment Screw

(*a*) GROUND TEST.—If the propeller has just been installed, the governor control should be moved back and forth (through its entire range) several times with the engine running at about half throttle to work the air out of the propeller before governor adjustments are attempted. It is assumed that the low pitch stops in the propeller are set low enough to permit the engine to turn take-off rpm on the blocks at take-off manifold pressure.

Note

With some installations, and depending upon the altitude of the field, the engine will just turn take-off rpm on the ground. This condition makes ground adjustment of the governor high rpm setting impossible since the engine would continue to indicate a correct governor take-off setting regardless of how much the actual setting exceeded the proper high rpm limit. Also, if the installation will not turn rated take-off rpm on the blocks, ground adjustment of the governor high rpm setting is impracticable. In both of the preceding cases, the governor setting should be adjusted by the flight test procedure described in this section, paragraph 2.b.(2) (b).

The propeller low pitch limit should never be adjusted so low that it will be impossible to maintain flight in case the propeller goes to full low pitch. As a rule, the low pitch angle which will give take-off rpm at take-off manifold pressure while the plane is at rest will permit level flight at reduced power.

1. If, with the low pitch stops in the propeller correctly set and the cockpit control in the full forward position, the engine speed increases as the throttle is opened until it exceeds the rated take-off rpm, the propeller blades are in full low pitch, and the constant speed control is incorrectly adjusted to govern at a higher rpm than required. To correctly adjust the linkage and constant speed control unit, pull the cockpit lever back slowly until the engine tachometer indicates a drop in rpm. This shows that the constant speed control unit is operating correctly and can be set to govern at the indicated rpm. Move the cockpit lever forward slightly until the tachometer reads the rated take-off rpm, and then without further adjustment of the propeller controls, shut down the engine. Turn the high rpm adjustment screw until it just touches the pulley stop pin, and then lock this assembly. One turn of the high rpm adjustment screw will change the speed setting approximately 25 rpm. If the correct setting cannot be obtained within the limit of this screw adjustment, reposition the stop pin in the pulley. Moving the pulley stop pin into an adjacent hole changes the angular relationship 20 degrees and the take-off setting about 250 rpm. It may also be necessary to reindex the pulley on the control shaft, as shown in figure 58, in order to avoid stretching the cable. Readjust the control linkage so that the cockpit lever is within 1/8 inch of its full forward position when the constant speed control pulley stop pin is against the high rpm adjustment screw. This setting should be the take-off rpm setting for the installation; however, minor adjustments may be required after flight test.

Note

If engine speed exceeds the proper high rpm setting when the governor cockpit control is moved into the full forward position, it is possible that the governor setting is too high, and the blade angle setting too low. To check, reduce the throttle, move the governor control into the full forward position, and then shut down the engine. Check the

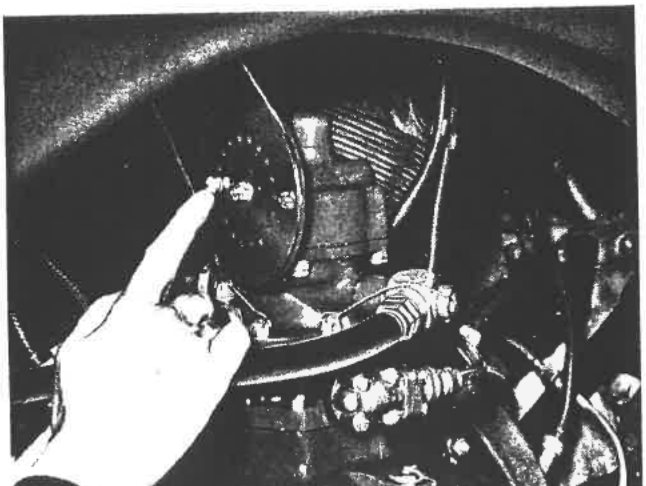


Figure 57—Repositioning Pulley Stop Pin

Note—Continued

low blade angle either by the scribe mark on the blade shank and the angle graduations stamped on the external surface of the barrel blade bore, or by using a protractor at the blade reference station. The blade reference station is the 42-inch station in propellers of 14 feet 0 inch diameter or less, and the 72-inch station in propellers of a greater diameter. If the low pitch stop ring is incorrectly set, remove the dome assembly, reset the low pitch ring, and then reinstall the dome. To adjust the take-off setting, follow the instructions described in the preceding paragraph *1*.

2. If, with the cockpit control full forward, the engine does not turn rated take-off rpm on the blocks but does respond to a slight reduction in control setting, it is an indication that the constant speed control unit is governing but the setting of the governor high rpm adjustment screw is either too low, or the cockpit lever is reaching its full travel toward the high rpm position without the pulley stop pin contacting the high rpm screw. In the first case, readjust the high rpm screw to the proper setting. In the second case, hold the cockpit control in the full forward position (allowing for 1/8-inch pinch), loosen the pulley cable clamp, rotate the pulley in a counterclockwise direction until the stop pin contacts the adjustment screw, and finally retighten the cable clamp. This procedure should be continued until the full take-off rpm is obtained. In extreme cases, it may be necessary to relocate the pulley stop pin one hole clockwise from its original position. This will increase the rpm setting approximately 250 rpm; one turn of the adjustment screw will change the rpm setting approximately 25 rpm. It should be noted that loss in engine power brought about by poor carburetion, fouled plugs, etc. may also be evidenced by the inability to obtain take-off rpm, and these factors should be taken into consideration.

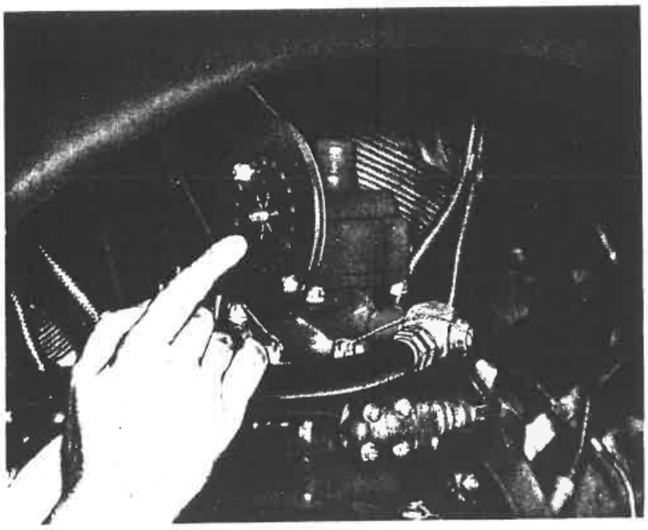


Figure 58—Reindexing Pulley on Control Shaft

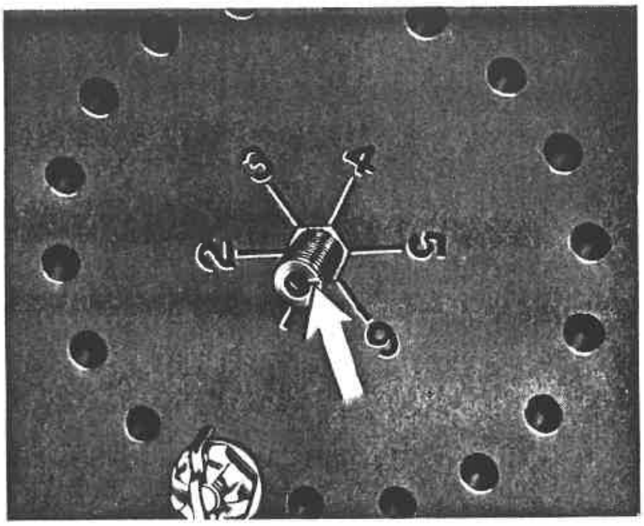


Figure 59—Control Shaft Scribe Mark and Pulley Index Numbers

(*b*) FLIGHT TEST.

1. Some installations do not turn take-off rpm on the blocks. In these cases, the low pitch blade angle setting in the propeller is such as to prevent obtaining take-off rpm at take-off manifold pressure during ground run-up, and it is necessary to make the control system adjustments after a test flight. This is accomplished by initially setting the governor high rpm adjustment well above take-off rpm position and jogging the cockpit lever in flight until the engine turns full take-off rpm as indicated by the tachometer. When this speed has been obtained, land the airplane without disturbing the control from this position. Then reset the high rpm adjustment screw until it just touches the pulley stop pin, and readjust the linkage system until this pulley setting is attained with the cockpit control lever 1/8 inch from its full forward position.

2. If take-off rpm cannot be obtained in the test flight even with the cockpit control in the full forward position, it is an indication that the constant speed control unit is governing at some lower-than-rated rpm. Under these conditions, it will be necessary to land and readjust the linkage to the pulley by rotating the pulley in a counterclockwise direction and slipping the cable to a position which will insure rated power. The installation should then be flight tested again and the procedure outlined in the preceding paragraph followed to obtain the correct high rpm setting.

[CA]UTION: When installing the dome assembly, it is ABSOLUTELY ESSENTIAL that the cam gear in the dome be meshed with the blade gear segments in the proper angular relationship and the following steps should be carried out to insure correct meshing:

8. By turning the rotating cam gear, move the piston in the dome assembly into the extreme forward position. This position will be reached when the cam gear stop lugs are against the high angle stop lugs.

9. Turn each blade to the high angle position against the stop pins.

10. Slide the dome assembly over the end of the valve assembly, making sure that the oil seal rings on the valve assembly enter properly into the sleeve inside the piston. Turn the dome in a counterclockwise direction until the dowels in the barrel dome shelf engage the aligning holes in the stop locating plate. (The dome unit may be installed in any of three possible positions, one of which is suitably marked.) The cam gear and blade gears are now in proper alignment. Slide the dome assembly, without turning it, into the barrel until the dome retaining nut can be started.

NOTE: Turning the dome assembly in a clockwise direction in order to align the dowels and holes should be avoided, as this will tend to move the stop lugs on the rotating cam away from the high angle position, thus allowing the gears to mesh incorrectly.

11. Tighten the dome retaining nut, using a composite wrench, in the manner indicated for tightening a propeller retaining nut by applying a force of approximately 180 pounds at approximately four foot radius. With the dome assembly properly seated in the barrel, the front face of the dome retaining nut will be approximately flush with the front edge of the barrel.

12. It is essential that the dome unit be firmly seated on the retaining shoulder in the barrel. Tightening of the dome retaining nut, in addition to fastening the dome unit to the hub, serves to apply the preloading force to the gears and to compress the dome and barrel seal. Its tightening, therefore, requires a relatively high wrench torque as indicated above. *Failure* to tighten the dome unit securely in the hub will result in elongation or failure of the assembly screws which fasten the dome cylinder and the stop locating plate to the stationary cam.

13. Install the dome retaining nut lock screw and safety the screw with a 1/16-inch x 1/2-inch steel cotter pin.

14. Make sure that the dome breather hole nut in the front of the dome is tight and that the lock wire is in place.

15. Check all external screws, nuts, etc., for proper safetying.

CAUTION: Using suitable levers to turn the blades, shift the propeller into full low angle and check all three blade angles by the index lines on the blades and the graduations on the barrel or with a protractor. These angles should be equal and should agree with the low angle stop setting. This check indicates that the correct relationship between the blade gears and the cam gear has been obtained.

(b) To Install Propeller Governor.

1. Check the governor for proper functioning and freedom of movement before installing on the engine.

2. Set the governor in place on the mounting pad with the proper type of gasket installed. If the circular lining boss is slightly larger than the opening on the engine into which it fits, check to see which part is to be reworked.

3. Screw the governor securing nuts onto the mounting studs and run them down finger-tight.

4. Remove the governor head and check the backlash and freedom of movement while tightening the securing nuts. These nuts must be tightened evenly but should not be drawn down excessively tight. Be sure the governor turns freely when installed to its drive on the engine. If the governor binds after tightening, back off one or more of the nuts slightly. Turn the propeller shaft to at least three positions while tightening down the nuts, testing for blacklash and freedom of movement at each point.

5. The angular range required at the governor to give take-off rpm at one end and minimum governing rpm at the other is only a part of the unit's total angular range. Before flying, it is important that the control system between the governor and the cockpit be adjusted for take-off rpm when the cockpit control lever is 1/8-inch from its full forward position, and for minimum rpm when the cockpit lever is in its rearward position.

(c) Trial Setting.

1. Place the cockpit lever 1/8-inch from the forward end of its full travel.

2. Turn the pulley attached to the governor control shaft in a clockwise direction until the rack bottoms in the cover.

3. Turn the control shaft counterclockwise far enough to give desired take-off rpm.

With the control shaft held in this position, connect the linkage between the cockpit control lever and the governor. This setting will give approximately the take-off rpm and permit sufficient movement of the cockpit control lever to obtain minimum rpm.

(*d*) *Checking Adjustments.*—With the low angle stops in the propeller set to permit the engine to turn its take-ofl rpm, or slightly more, at rated manifold pressure, the following procedure applies:

1. If, with the cockpit control full forward, more than take-off rpm is obtained at run-up, the governor is set to govern at higher than take-off rpm. To adjust correctly, pull the cockpit lever slowly back until the tachometer indicates a drop in rpm. At this point set the governor to govern at the indicated rpm. Move the cockpit lever forward slightly so the tachometer reads take-off rpm, and stop the engine. Without disturbing the cockpit lever, regulate the adjustable stop at the governor to limit the rotation of the control shaft to this exact position. Readjust the linkage system so that the cockpit lever is within 1/8-inch of its full forward position when the governor pulley is held against the adjustable stop. Minor adjustments may be necessary after flight tests.

2. If, with the cockpit control full forward, the take-off rpm is not obtained at run-up, it is because the governor is governing at an rpm lower than take-off. (Loss of engine power may give a similar indication and should be considered.) To obtain a higher rpm, stop the engine and readjust the linkage system with the governor pulley or lever rotated further in a counterclockwise direction. When take-off rpm is obtained at rated manifold pressure, proceed as outlined above.

3. When the low blade angle settings in the propeller will not permit take-off rpm at rated manifold pressure while the airplane is against the blocks, it is necessary to make the control system adjustment after a flight. Regulate the cockpit lever, in flight, until the tachometer reading corresponds with the engine's take-off rpm. Mark the position of the cockpit lever. Upon landing, return the lever to the marked position and adjust the stop at the governor unit to restrict the control shaft from rotating beyond this point. Readjust linkage system with the cockpit lever approximately 1/8-inch from its full forward position and the governor pulley against the adjustable stop.

4. If on the test-flight, take-off rpm cannot be obtained with the cockpit control full forward, it will be necessary to land and readjust the linkage system with the pulley at the governor rotated sufficiently farther in a counterclockwise position to permit take-off rpm.

NOTE: The propeller low-angle limit must not be adjusted so low as to make it impossible to maintain level flight when the propeller is forced to full low-angle. Flight tests should be made to insure that the low-angle required to give take-off rpm while standing still will permit the airplane to maintain level flight without exceeding the maximum rpm rating of the engine. If level flight cannot be sustained, the low-angle adjustment must be increased.

(4) *Maintenance Repair—Propellers.*

(*a*) *Coating With Oil.*—On completion of each day's flying, clean all external surfaces of each propeller and coat with clean engine oil.

(*b*) *Local Etching.*—To determine whether visible lines on the propeller blade surface are actually cracks instead of scratches. If blade is painted, remove the paint, clean surface with a fine grade of steel wool or fine sandpaper. Using a four-power magnifying glass inspect affected area. If visual inspection will not show whether a mark is a scratch or a crack, proceed as follows:

1. Prepare etching solution by adding to the required amount of water as much commercial caustic soda as the water will dissolve.

2. Clean and smooth the area containing the apparent defect with No. 00 sandpaper.

3. Apply a small quantity of caustic solution to the suspected area. After the area is well darkened wipe it thoroughly with a cloth dampened with clean water.

4. If a crack or other defect extending into the metal exists it will appear as a dark line or other mark in which small bubbles may be seen forming with the use of a magnifying glass.

5. Immediately after completing the final inspection all traces of the caustic soda will be removed with nitric acid solution, which in turn will be thoroughly rinsed with clean water. The blade will then be dried and coated with clean engine oil.

NOTE: General etching will be accomplished only at repair depots.

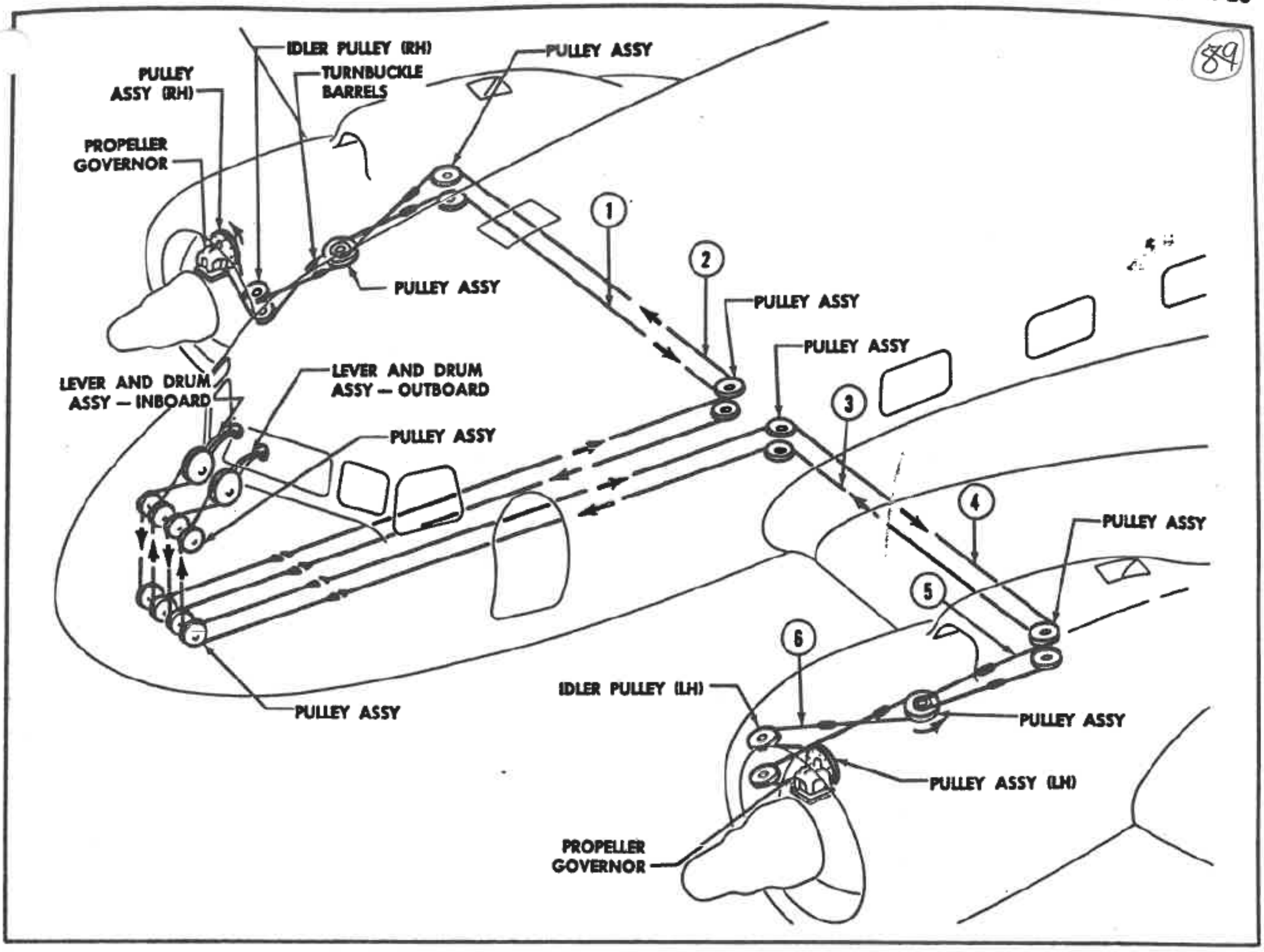


Figure 4-6 (Sheet 1 of 2). Linkage to Constant-Speed Control (Propeller Governor)—Key Drawing

GENCY RICH position is for obtaining a richer mixture, bypassing the automatic mixture control in the carburetor.

4-16. REMOVAL, MAINTENANCE AND INSTALLATION OF ENGINE MIXTURE CONTROLS. Removal, maintenance, and installation of the engine mixture controls are similar to those described in paragraphs 4-11 through 4-13.

4-17. ADJUSTMENT OF ENGINE MIXTURE CONTROLS. Adjust the link rods on the firewall until the lock catch on the two mixture control levers engages the notch in the AUTO LEAN position at exactly the same time.

4-18. CARBURETOR AIR INDUCTION CONTROLS. The carburetor air induction system furnishes hot, cold, or filtered air to the carburetor. The control-lever lock on the control pedestal consists of a wedge-shaped disc attached to the brake lever. On some airplanes, the position of the induction valve door and the aft door is controlled electrically by switches located in the flight compartment. On other airplanes, the induction valve door is controlled manually by levers, located in the flight compartment, and the floating aft door is positioned automatically by the pressure differential within the airscoop. The main cables route through the fuselage to the center wing and then to the nacelles.

4-19. REMOVAL, MAINTENANCE AND INSTALLATION OF CARBURETOR AIR INDUCTION CONTROLS. Removal, maintenance, and installation of the carburetor air induction controls are similar to those described in paragraphs 4-11 through 4-13. For additional information, refer to Section III.

4-20. COWL FLAP CONTROLS. The cowl flaps are hydraulically operated and attached to the aft edge of each engine cowling. A hydraulic actuating cylinder, installed on the lower part of the engine cowling, is connected to each movable cowl flap by a series of tie rods and operating levers. The movement of the cowl flaps is controlled by the cowl flap hydraulic controls located in the flight compartment. For additional information, refer to Section III.

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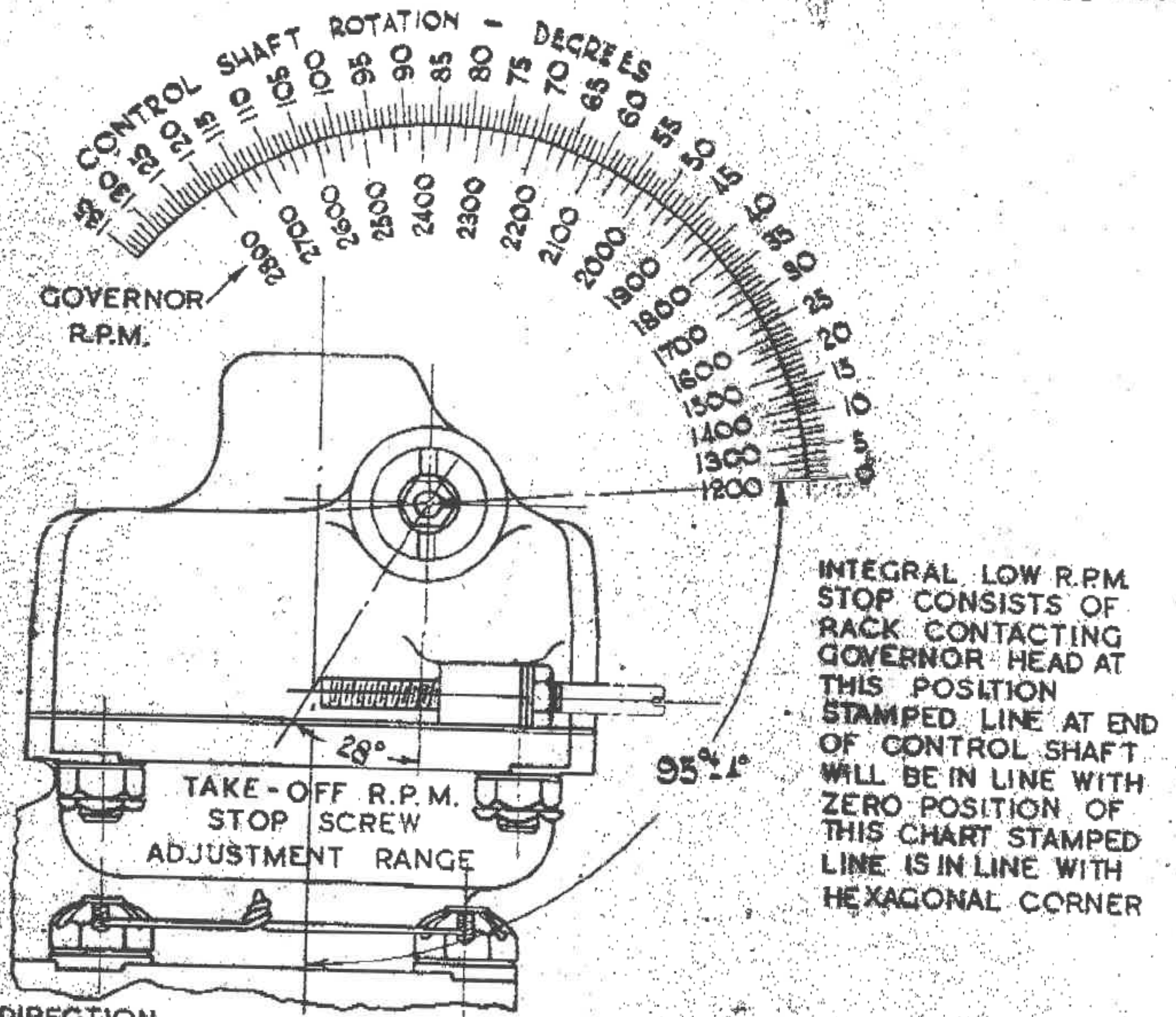
DE HAVILLAND AIRCRAFT PTY. LTD.

PROPELLER DIVISION ALEXANDRIA N.S.W.

ENGINEERING INSTRUCTION BULLETIN

No E.D.30
ISSUE 3
PAGE No 5



DIRECTION

READ OPPOSITE DESIRED MAXIMUM GOVERNOR R.P.M. THE CONTROL ROTATION IN DEGREES REQUIRED

EXAMPLE

1. FIND ROTATION AT GOVERNOR NECESSARY TO GO FROM 1200 TO 2600 GOVERNOR R.P.M.
2. READ OPPOSITE 2600 R.P.M. 103.5±5 DEGREES REQUIRED.

NOTES

THIS CHART SATISFACTORY FOR 1200 R.P.M. MINIMUM ONLY.

THIS CHART APPLIES TO HYDROMATIC GOVERNORS WITH No 4 MODEL SERIES HEADS AND 50665 SPEEDER SPRING

Minute Note to File BO9401043 VH-EDC

Subject: Propeller Governor Right Engine - Visit to Wiltshire Engineering, Bankstown 30 August 1994.

Present: for BASI [redacted]
for Wiltshire [redacted]

The propeller governor Model No 4G8-G30M serial No WH 32824 when removed from the engine after recovery from Botany Bay was given to [redacted] Wiltshire Engineering - Bankstown for examination.

[redacted] phoned me 27 August 94 advising his concern about the rigging of this propeller governor.

[redacted] and I visited Wiltshire Engineering 30 August to establish the rigging problems which had been advised.

The governor, without being dismantled, was secured to the governor test bench. Examination of the position of the pulley on the hexagon of the rack shaft, the stop peg in relation to the pulley cable clamp location and its position when the pulley was rotated towards the max RPM adjustable stop revealed that:-

- The pulley was set on the hexagon rack spindle with the indicator line towards the No 5 position.
- The stop peg was fitted to the pulley in the middle hole of three appropriate for a DC3 right engine governor.
- The max stop adjuster screw was screwed right down to a position which would decrease max RPM. (Normally this adjusting screw is set to the mid range position which will give approximately eight turns either way to provide max RPM adjustment on the ground. One turn = approx 25 RPM)

With the governor set as found on the test rig and with the pulley rotated until the stop peg was on the adjusting screw the equivalent max RPM was greater than the test rig could monitor.

When the pulley was then removed from the hexagon ended shaft the following was noted:-

. Although the retaining nut was split pinned, there was little more than finger pressure required to loosen the nut.

. With the retaining nut and washer removed the pulley was loose on the hexagon of the shaft. Excessive wear within the hexagon of the pulley allowed approximately 10-15 degrees of rotational movement.

. The scribed index line on the hexagon shaft end aligned with the No 5 position stamped on the pulley face.

. Although worn, it is considered that the wear was insufficient to enable the pulley to be rotated around the hexagon of the shaft. i.e. during disruption of the cables when the engine was torn from the aircraft.

For correct rigging it was necessary to:-

. Re-position the pulley on the hexagon shaft by rotating the pulley anti clockwise 1 hexagon flat to align the scribed line with the No 6 position. ie 60 degrees rotational repositioning.

. Relocating the stop peg on the pulley one hole clockwise (viewed from the retaining nut side of the pulley) on the pulley. ie 20 degrees, and

. Re-adjusting the max RPM stop screw anti-clockwise approximately eight turns to the mid travel, position. This allowed approximately another 10 degrees rotation of the pulley in the anti-clockwise direction to set the stop peg of the pulley against the stop screw.

With the pulley, stop peg and stop screw adjusted accordingly the governor performed the appropriate tests on the test rig to the specifications required of this model governor.

Additionally - The electrical connection to the pressure cut-out switch, which is normally a single wire Cannon plug, was, on this unit, a crimped electrical wire to the central pin of the cannon plug receptacle with a sleeved knife connector for attachment to the engine electrical loom. This is not 'kosher'.

A report on the findings of the examination of this governor will be forthcoming from s. 47F(1) [redacted] of Wiltshire engineering.

The significance of this 'mis-rigging' of the governor pulley in respect to operational performance of the propeller and its effect on VH-EDC during the take-off and subsequent ditching will be considered and addressed.

There are no records in the log books for the removal and replacement of either the R/H propeller governor, the pulley governor pulley or control cable assembly which would have required re rigging of the propeller controls.

There is a requirement in the CAA Schedule 5 periodic inspection (to which this aircraft was being maintained) Sect 2 para (11) to:-

> "Inspect to following controls for full and free movement in the correct sense
> (a) throttle, mixture and propeller.

This inspection will determine control lever spring back in the quadrant and the ability of the control cables to move the component levers to the relevant stops. In the case of the propeller, for the cables to operate the pulley so that the stop peg comes into contact with the max RPM stop screw when the control lever is moved into the increase RPM position.

With the governor pulley in the as found position this control check should have identified a gap between the stop peg and the screw stop with the lever in the Propeller lever fully forward in the increase RPM position.

s.47F(1) [redacted]

31 August 1994

Attachments:
- Governor installation/setting instructions Hamilton Service Manual No.123. Pages 35-41
- Governor Installation/adjustment instructions Manual TO No 01-40NC-2.
- Propeller CSU cable linkage diagram - Manual TO 1C-47-2
- extract from DeHavilland A/C P/I ED No 30 - Relationship between Control shaft rotation and Governor RPM

DOCUMENT 25

Telephone: 790 4107
Facsimile: XXXXXXXXX
791-0329

Wiltshire Engineering Co. Pty. Ltd.

438 Avro Street, Airport Bankstown, N.S.W. 2200
AUSTRALIA

C.A.A APPROVED FOR THE DISTRIBUTION OF AIRCRAFT GOODS

MANUFACTURE OF FLEXIBLE HOSE ASSEMBLIES

OVERHAUL OF:
- ENGINE DRIVEN PUMPS
- PROPELLER GOVERNORS
- FEATHERING PUMPS
- SOLENOID VALVES
- ELECTRIC BOOSTER PUMPS
- SUBMERGED FUEL PUMPS
- WHEEL BRAKES
- HYDRAULIC,
- PNEUMATIC,
- [illegible]L,
- [illegible]L INJECTION,
- DE-ICING,
- AUTO PILOT HYDRAULIC SYSTEM COMPONENTS

19th September 1994

B.A.S.I
P O Box 967
Civic Square
CANBERRA ACT 2608

Attention s.47F(1) [redacted]

TEST OF PROP.GOVERNOR HAMILTON STANDARD R/H
P/No. 4G8-G30M
S/No. WH32824

Head Position 2 Pully Position 5 as received.

Relief valve pressure	400 PSI
Capacity	17.5 QTS Per Min.
Min. RPM'S	1150 RPMS (1200± 15)
Counter Balance RPM'S	2150
Internal Leakage	11 QPM (Max 16)

When testing max RPM'S it was found that even at 4500 RPM'S it would not constant speed (Max normal RPM'S 2590). On removal of pully from postion No.5 to No.6 and re-adjusting speed stop and changing stop in pully one hole it was then possible to obtain 2590 RPM'S.

On inspection of pully the hexagon hole to fit control shaft was hadly worn.

The wiring to pressure switch was not standard.

s.47F(1) [redacted]

PROPELLER GOVERNOR

INSPECTION AND TEST RECORD

MAKE....Hamilton Std.........DATE IN.....6.5.94.......JOB NO.....36696

TYPE.....4G.8-ADH (38).......HOURS RUN......................RELEASE NOTE.............

SERIAL NO...A.D.H.101............REMOVED FROM..V.H. EDC LH..............................

CUSTOMER..B.A.S.I......Canberra.......ORDER NO..............LAST O/HAUL.............

PLUGGED.................................ROTATION.................SENSE.................

PRESS.SW POSITION.......................PULLY POSITION..........HEAD POSITION.........

REASON FOR OVERHAUL/REPAIR..

WORK REQUIRED.......Strip & Inspect Report.

INSPECTION RECORD

PARTS INSPECTED............CHECKED............TESTED BY..............CHECKED..............

ASSEMBLED.................CHECKED............FINAL INSP............CHECKED................

ANO'S/MODS.THIS O/HAUL........................TECH.PUBL..HAMILTON STANDARD No 123 manual

CLEARANCES

DRIVE GEAR JOURNALS......................GEARS,RADIAL CLEAR..............................

BODY AND BASE BORES......................GEARS,BACKLASH..................................

(DRIVE)..................................RACK DIAM.......................................

IDLER GEAR JOURNALS......................HEAD BORE.......................................

BODY & BASE BORES........................PILOT VALVE LANDS...............................

(IDLER)..................................DRIVE GEAR BORE.................................

GEAR THICKNESS...........................P.VALVE SPACER,LENGTH...........................

GEAR PCKET DEPTH.........................RELIEF VALVE SHIMS..............................

INSPECTOR.........................

TEST RECORD

1 Relief Valve Set@..390 (400)...P.S.I.   2. External Leakage...Nil....@...600....P.S.I.

3. Internal Leakage.....3.0........IMP.Qts./Hr.   4. Capacity....18.1 (min 16)...IMP.QTS/MIN.

5. On Speed Leakage...6.5......IMP.Qts/Hr.

6. High R.P.M.Setting...2520 (2540)..RPM .@.......°, Check...............................

7. Low RPM.Setting......1200 (1200)..RPM @.......°, Check...............................

8. ~~Unfeathering~~ centrifugal RPM..2050 (Av 2100).......,CHECK.

9. Transfer Valve Opening Pressure...120....P.S.I. Bleed Flow......—......Qts/Hr.

10.Cut-out Switch Opening Pressure......620....P.S.I.

11.Acuuracy Check......R.P.M. @.....°   12. Day Temp.....14 °C.............

.......RPM @.....°   13. Test Fluid..SAE 20 OIL..........

.......R.P.M. @.....°   14. Oil Temp...23°C..........

INSPECTOR..............................

Pursuant to A.N.R.39, I certify that the work detailed hereon has been satisfactoriiy completed in accordance with the Technical Publications and/or A.NO's noted above.

For and on behalf of WILTSHIRE ENGINEERING CO.PTY.LTD

Telephone: 790 4107
Facsimile: XXXXXXX
791-0329

Wiltshire Engineering Co. Pty. Ltd.

438 Avro Street, Airport Bankstown, N.S.W. 2200
AUSTRALIA

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WHEEL BRAKES
HYDRAULIC,
…UMATIC,
…L,
FUEL INJECTION,
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AUTO PILOT HYDRAULIC SYSTEM COMPONENTS

19th September 1994

B.A.S.I.
P O Box 967
Civic Square
CANBERRA ACT 2608

RH

Strip Report of Pressure Injection Carburettor
ex HV-EDC (Left) Hand Engine

Serial No. 224786/29306 Type PD12H4

It was not possible to flow check unit because of salt water contamination.

The assemblies all comply with Manufacturers assembly drawings and appear to be correct.

The only fault we could see that the throttle plate is not fully open, see photos and assembly.

s.47F(1)
[redacted]