AIU R9/83

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3 September 1984

Sir

ACCIDENT TO WESSEX HU Mk 5 XT459 ON 7 DECEMBER 1983

I have the honour to forward the report by Lieutenant Commander [redacted] Royal Navy and CCAEA(L) [redacted] on the investigation into the accident to Wessex aircraft XT459 which occurred at 68° 52' N 18° 23' E whilst the aircraft was operating with RN Detachment BARDUFOSS.

I have the honour to be

Sir

Your Obedient Servant

[redacted]

Lieutenant Commander
Royal Navy
Officer in Charge

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Accident Investigation Unit

AIU Report No	R 9/83
Operator	845 Squadron
Aircraft Type	Wessex
Mark	HU 5
Serial No	XT459
Place of Accident	68° 52'N 018° 23' E (In the Bardufoss area of Northern Norway)
Date and Time	7 December 1983 at about 0930A

Synopsis

The aircraft was carrying out a routine personnel and baggage transfer with the pitch channel of the Autostabilization Equipment selected OFF. When the pilot attempted to re-engage the pitch channel the aircraft pitched nose down and hit the ground before recovery action could be effective.

The report recommends changes to the Aircrew Manual.

1. FACTUAL INFORMATION

1.1 History of the flight

XT 459, with a crew of two, was being used to transport personnel and equipment from one dispersed site (Eagle Base) to another during the forenoon of 7 Dec 1983.

The aircraft had been parked out in the open overnight and was manned for the start of the day's operations shortly before 0900. During the post start checks the pitch channel of the Auto Stabilisation Equipment (ASE) was erratic in its behaviour and the pilot decided to leave it switched out. The first sortie was uneventful and the aircraft returned to the original Eagle Base to pick up the second group of six passengers. When the aircraft took off with the second load it was carrying the pilot, one passenger in the co-pilot's seat, the aircrewman, six passengers and their kit in the cabin. After completion of the take-off and having settled into the transit stage at about 90-100 knots and 300 ft AGL the pilot decided that he would make a further attempt to engage the pitch channel of the ASE. The aircraft was at the time heading approximately NE over relatively open country, having passed over the outskirts of the town of Saetermoen. The pilot reached up with his left hand to the bank of channel selector switches on the selector panel above his left shoulder and switched on the pitch channel. The aircraft immediately pitched nose downwards and the pilot attempted to cancel the pitch channel selection.

After making violent movements in both pitch and roll the aircraft struck the ground in a nose down, left wing low attitude, bounced back into the air and came to rest finally about thirty metres from the initial impact point still heading in a North Easterly direction. The aircraft was severely damaged and both aircrew incapacitated by the impact. The seven passengers were able to extricate themselves from the wreckage and assist the pilot and aircrewman until help arrived.

1.2 Injuries to persons

Injury	Crew	Passengers	Others
Fatal	-	-	-
Non fatal	2	-	-
Minor/none	-	7	-

1.3 Damage to aircraft

The aircraft was severely damaged by the impact. The tail detached from the front fuselage which suffered vertical fractures at the engine bulkhead and immediately aft of the cabin forward bulkhead at station 112.

The port undercarriage was torn off by the initial impact and the main rotor head/transmission came to rest partly underneath the upright fuselage between the port undercarriage radius strut attachment and the forward port cabin window.

1.4 Other damage

Minor damage was caused to the pasture field during the wreckage recovery operations.

1.5 Personnel Information

1.5.1	Aircraft Captain	Sub Lieutenant (P) RN
	First Pilot Experience	
	Total All Types	226 hours
	This Type	186 hours
	Last 30 days	22 hours
1.5.2	Aircrewman	Leading Aircrewman
	Total experience over	1000 hours

1.6.1 General Information

a.	Manufacturer	Westland Helicopters Ltd
b.	Date of Manufacture	30.6.65
c.	Contractors number	NK
d.	Held on charge by	845 Sqdn
e.	Last MARTSU Survey	1 April 82
f.	Servicing System	Flexible servicing in accordance with current instructions
g.	Total A/F hours	3438:10
h.	Weight at last T.O.	13125 lbs
i.	Weight at time of occurrence	13045 lbs
j.	Fuel remaining at time of occurrence	600 lbs (approx)

1.6.2 Recent Maintenance History

On 29 November the ASE pitch channel was placed unserviceable due to "ASE input pushing the cyclic forward and the force required to move the cyclic increasing the more the stick is pulled back."

The job card entries covering the investigation read as follows:

"On engagement of ASE in the pitch channel cyclic stick moved forward last quarter of travel, forces opposes stick movement. On return of stick to the centre position the stick is held in the fwd position before it is allowed to return. Motor bind check carried out on pitch servo motor. Readings taken were correct, further investigation required on servo motor, see line 18."

(Line 18) "Trim actuator checks carried out. F/A actuator found to run forward on reaching stop intermittently. With ASE out, stick trim in, F/A movement found lumpy, ASE out, stick trim out, F/A movement found to be normal, F/A stick trim actuator assessed as U/S see line 28".

Line 28 et seq cover the replacement of the trim actuator, functional testing, and independent inspections. The aircraft was assessed serviceable and flew a further 6:45 hours until the accident with no further defect reported on the system.

1.6.3 Engine History

Port ECU	Gnome Mk 11201	Ser No 250118
	Installed	18 October 1983
	Running time at occurrence	2122:55 hours
STBD ECU	Gnome Mk 11301	Ser No 260065
	Installed	25 November 1983
	Running time at occurrence	1512:20 hours

No recent history relevant to this accident.

1.7 Meteorological Information

The weather at the time of the accident was recorded as follows:

Wind	Light and variable
Visibility	10 Km +
Cloud	4/8 2000 ft
Temperature	- 10°C
Humidity	95%
Barometer	1010 Mbs

1.8 Aids to Navigation

Not relevant to this accident

1.9 Communications

No communication problems were experienced.

1.10 Aerodrome Information

Not relevant to this accident.

1.11 Flight Records

1.11.1 Flight Data Recorders

None fitted.

1.11.2 ATC Recordings

Not relevant to this accident.

1.12 Examination of the wreckage

1.12.1 The accident site

Between the accident occurring and the arrival of the AIU team some 2½ days later there had been a further fall of snow giving an overall covering to the site of about 3 feet with some drifting. This had obscured the majority of the marks made during the accident sequence however many aerial photographs had been taken of the scene by the Royal Norwegian Air Force. The field was described by people familiar with the site in summer as rough pasture and at the time of the accident the snow was between 1 and 1½ feet deep.

Removal of the snow in the area indicated by witnesses as being the original impact point revealed disturbed ground with pieces of fibreglass structure protruding from the surface. These pieces have been identified as ducting from the lower side of the nose. The next item of any size along the wreckage trail was the port main wheel and radius arm, which had been torn from the lower fuselage with some damage to the inner locating lugs. Beyond the undercarriage was the frame of the co-pilot's sliding window, in one piece but minus its perspex. The remainder of the wreckage was aligned on a heading some 70-80 degrees to the right of the line of travel indicated by the positions of the initial mark, undercarriage, and window, and about thirty metres from the initial impact point. The aft section of the tail cone and pylon had separated from the fuselage and was lying on its starboard side some 5 metres aft of where it would have been had the whole structure remained intact.

The passenger in the co-pilots seat had been ejected from the wreckage, still strapped in the seat, and had continued in the direction of travel for a further ten metres. The main rotor head and transmission was alongside the aircraft and partly underneath it, the blue blade lying underneath the fuselage and at right angles to the fore and aft axis, protruding some 15 feet to starboard. The outboard portion of the yellow blade had detached and travelled some 200 metres, coming to rest in a snow bank almost directly behind the aircraft.

Some minor damage was caused to the surface of the field during the clearing operations to recover the aircraft.

1.12.2 Examination at Lee on Solent

The mechanical parts of the flying controls were checked for completeness and pre-impact integrity. Two items with potential to influence the flying characteristics were not recovered. These were the fore-and-aft primary servo jack control arm and the starboard main gearbox aft bracing strut. However the attachments of both these items provided clear evidence of overload forces being applied to them during the crash sequence. It is unlikely that the overload evidence would have been there had either item suffered a pre-impact failure.

1.12.3 The ASE system was examined, where possible, in situ. The following points were noted:-

i. All cable looms were heavily contaminated with hydraulic fluid and dirt.

ii. The CG and A box and Vertical Gyro Type B were both sprung from their anti-vibration mountings.

iii. Several cables within the ASE loom running along the starboard side and then into the inter-seat console to the ASE controller had been severed within the console by flying control rods pushed forwards through the console during impact.

iv. The altitude servo-motor type C end connector back shell was broken and several soldered cable joints broken.

Apart from these defects, the system appeared complete and undisturbed. To facilitate a close examination of all components of the ASE, the system, together with the secondary hydraulic servo-pack, was lifted from the aircraft wreckage and laid upon a bench. The only electrical disturbances to the system were severing the power supply cables and the barostatic height controller loom.

1.13 Medical Aspects

[redacted] Medical opinion describes these injuries as [redacted] in a natural grasp of the cyclic stick." The starboard side of the cockpit area was much more severely damaged than the port, the sliding window frame, starboard windscreen and canopy arch being broken into several pieces. The whole of the canopy assembly was displaced to port. (Photo 2 and 3)

The aircrewman's injuries were consistent with being thrown around, during the crash sequence, whilst restrained only by his despatcher harness.

1.14 Fire

There was no fire.

1.15 Survival Aspects

It was noted during the wreckage examination that the pilot's seat had collapsed, the seat pan being detached from the frame, and the seat back broken at about one-third height. The seat back upper rail had been distorted by shoulder harness loads consistent with the application of at least 7g.

The co-pilot's seat had been released following failure of the cockpit rear bulkhead along the line of rivets attaching the outboard seat rail to the bulkhead.

	NSM 3186	Strengthening of Pilot's and Co Pilot's seats
and	NSM 3187	Introduction of 5 point harness

had not been embodied on either seat.

Both seats were fitted with hard PSP's. The pilot's PSP had opened and the dinghy had inflated in the co-pilots side of the cockpit.

Because of the speedy arrival of the rescue services survival in cold conditions was not a problem. No survival aids were used.

1.16 Tests and Research

1.16.1 Before any disconnection, the complete system, with particular attention to the pitch channel, was closely examined on the bench. On removal of the pitch servo-motor fibre-glass cover, two cables coded CA1KS and CA3HS were found detached from their eye ends, which were still secured to terminals 1 and 3 of the servo-motor position feedback transducer. The barrel of the transducer was severely dented. Apart from the cable disruption of the controller loom, no other significant damage was found. A full check of the system was then carried out for electrical continuity and insulation resistance. Despite the contamination all results were satisfactory.

On completion of these tests, all system interconnections were inspected and then disconnected. No faults were found apart from the broken altitude channel connecter. Each component of the ASE system was subjected to a Standard Serviceability Test in accordance with current servicing instructions. The vertical gyro in the CG and A box 'rumbled' during initial start up, but was satisfactory when running at speed. The pitch servo-motor was stripped before being tested to determine its mechanical position. The trunnion was found to be fully withdrawn on the lead screw. The yoke was found to be broken, held together only by the position feedback transducer screws and washers. The motor was rebuilt with a serviceable yoke for testing. The dent in the feedback transducer casing did not affect its performance.

Apart from mechanical defects attributable to impact damage, all system components performed satisfactorily under test. The two cables found detached from the pitch servo-motor position feedback transducer were sent, together with their respective ring tongued terminations, to the Electrical Quality Assurance Directorate (Electrical Materials Group) EQUAD for analysis.

1.16.2 Autopilot Rig Testing

The Air Engineering School has an hydraulically powered Mk 19 Autopilot training rig. This was used throughout the investigation for "Dynamic Testing". ASE components from XT459 fitted into this rig caused no degradation of its performance. This supports the bench testing in proving that no significant component fault existed.

Analysis of the pilot's report indicated that the most likely initial cause of the aircraft's initial departure from straight and level flight would have been an ASE initiated hard down in pitch caused by an open circuit position feedback in the pitch servo-motor. The detached cables beneath the servo-motor cover support this postulation.

Various trials were carried out with the ASE training rig to induce a 'hard over' reaction from the pitch channel.

Four methods were found:

i. Full rotation of the CG trim knob.

ii. Operation of the override check switch on the servo motor switch unit.

iii. Inducing a fault into the CG and A box.

iv. Removing terminals 1 or 3 from the servo-motor position feedback transducer.

Three of the above can be discounted for the following reasons:-

i. The pilot did not report operating the CG trim knob at the time of the accident and the item is not defective.

ii. The override check switch is a gated switch and is well guarded by a metal cover. Inadvertant operation in flight is not possible.

iii. The CG and A box is electrically serviceable.

Considering the fourth method, disconnection of only one of the two subject connections effectively applied "positive feedback" to the pitch servo-amplifier in the CG and A box, producing an amplified driving signal to assist, rather than oppose, the travel of the servo-motor. Disconnection of both removes position feedback completely from the motor, which will remain quiescent until a driving signal is received from the servo-amplifier. The motor will then run unchecked in the appropriate direction until the mechanical end stop is reached. The motor will remain in this position until a signal in the opposite sense is received to drive the motor in the opposite direction. Again, the motor will drive unchecked until a mechanical stop is reached. This can also be discounted as the operation of the system with both connections removed is 'normal' i.e. a nose down error will induce a nose up correction, albeit 'hardover'. Uncorrected, the aircraft will porpoise.

The pitch servo-motor trunnion was found fully withdrawn on the lead screw. In this position the secondary servo pitch pilot valve would be fully open to apply a nose-down input to the flying controls. With both connections removed the aircraft nose down attitude would have left the trunnion fully extended on the lead screw giving a nose-up input to the flying controls.

1.16.3 Aircraft Tests

A serviceable servo-motor type C was fitted with a modified loom which included a switch allowing the simulated disconnection of either CA1KS and CA3HS from the position feedback transducer, but not both. This modified motor was then fitted to a serviceable Wessex Mk 5 supplied by Yeovilton Naval Air Support Unit. The aircraft was tied down, and with rotors running, trials were carried out on the ASE system.

At indicated torques varying from 0 - 3000 lb ft., the switch was operated to simulate an open circuit pitch servo-motor position feedback. At all torques the main rotor disc reaction was identical both in the amount of disc movement and in speed of response in both directions. This disc reaction was at all times immediately recoverable by application of cyclic control column movement in the opposite sense. An identical movement of the main rotor disc can be achieved by moving the cyclic control column about three inches quickly but smoothly in the appropriate direction.

1.16.4 Flight Tests

It can be shown that if, during straight and level flight, the cyclic control column is moved forwards quickly and smoothly by three inches, then the aircraft, if left unrecovered, will lose two to three hundred feet in two to three seconds. At any time during this manoeuvre the aircraft is immediately recoverable by normal control inputs.

1.16.5 Hydraulic Tests

The secondary servo pack was rebuilt with serviceable servo motors set to mechanical and electrical neutral. It was noted that the hydraulic cut off valve was excessively stiff to move before hydraulic pressure was applied and could not be moved to the 'off' position after hydraulic pressure had been applied. The stiffness is considered to be due to impact damage. Various distortions were apparent in the servo valve input mechanism, principally at the pilot input end of the unit. The mixer unit end, better protected by the side plates of the mixer unit, was undamaged. This is the end of the unit to which the electrical servo motor inputs are applied. Of the three channels the pitch channel had suffered least impact damage and performed best on test. Whilst it could not have satisfied all aspects of the standard serviceability test there was nothing in its behaviour which would bave given undemanded inputs to the flying controls. 'On aircraft' adjustment is permitted to match the servo pack to the flying controls and could account for the anomalies noted.

1.17 Additional Information

1.17.1 System Description

The Autopilot Mk 19 fitted to the Wessex 5 aircraft provides stability in pitch, roll, yaw and altitude. The system is fully automatic once engaged, except for the altitude channel which must be disengaged when ever the aircraft changes its height datum. The authority of the autopilot is limited to 20% of full control movement in pitch, roll and collective but in yaw, by means of an open loop servo arrangement, it has full authority. The autopilot can be over-ridden at any time by operation of the manual controls. When the autopilot system is operating it does not feed any movement to the manual controls except when its authority is extended in yaw. The setting of the manual controls does, however, determine the datum of the autopilot control. The autopilot is basically a four-channel closed-loop electrical servo system which feeds a correction signal mechanically into the aircraft's flying controls system.

The three secondary servos are identical in operation. Each pilot valve can be opened by either the pilot's flying controls or the appropriate autopilot servo motor; the resulting movement of the power piston re-centres the valve. The authority of the autopilot is limited at this point to 20% of the pilot's authority, since 20% of the piston travel is sufficient to close the pilot valve when full deflection of the servo motor is applied; hence, the pilot can always over-ride the autopilot. Failure of secondary hydraulic pressure releases a single actuator piston operating on all three power piston by-pass valves at once (they are all on the same shaft). At the same time three links, known as 'slop eliminators', move across locking the connections between the pilot's input levers and the pilot valves; subsequent movements of the pilot's controls move the power pistons directly.

A flight path disturbance causes the aircraft attitude to change so that an error signal is now applied to the autopilot which operates the controls system to correct the disc attitude. As the disc attitude changes, the fuselage follows to maintain equilibrium and the error signal reduces until it is zero, when the aircraft attains its original attitude. As the error signal reduces, the autopilot system runs in the reverse direction to remove the control system movement. The autopilot will not hold the aircraft against a long term error.

1.17.2 Basic Servoloop

Consists of an error detection device which feeds a position error electrical signal into the amplifier. The amplifier produces a rate signal from the error and adds the two together. The resultant signal drives a magnetic amplifier, which in turn drives a servo motor. The servo motor feeds a mechanical movement into the aircraft flying controls system and at the same time produces a positional feedback electrical signal to the amplifier to cancel the applied error signal, thus completing the minor loop.

The servo motor also drives a tachometer to produce velocity feedback to dampen the system. Movement of the flying controls system corrects the aircraft and the major loop is thus completed by an aerodynamic feedback to the error detection device, which removes the error. The minor loop is now again out of balance due to its positional feedback signal and the servo motor runs again to remove it. In doing so, it moves the aircraft's flying controls returning them to their datum the original error having been corrected.

For all flight disturbances and changes of flight path, the rotor disc and the fuselage can be considered as moving together, although in practice there will be a slight lag between them. In anything other than a level altitude there is a signal from the error detection device to the autopilot system; but since the position of the controls determines the flight attitude of the aircraft, the stick position signal cancels the error signal and there is no output from the autopilot.

1.17.3 Switches and Indicators - Brief description

1. Null indicator; a built in test facility for examining the behaviour of the servo-motors in all four channels of stabilisation. The indicator is a small centre reading moving coil instrument situated on the autopilot control panel in the inter-seat console. Whenever the servo-motor position feedback transducer wiper is off-centre the meter indicates the direction and amount the transducer, and therefore the servo-motor, is off centre.

2. Channel selector switch; to obviate the need for separate channel motor position indicators, a gated rotary channel selector switch, normally gated to select the pitch channel, can be ungated and rotated to select any of the four channels.

3. Over-ride switch; used to test the run of the motor. It's action is to earth one side of the servo-motor selected by the channel selector switch, and cause the motor to run hard-over in one direction.

4. Motor position switch; included so that the null indicator may be used to read the output of the appropriate servo magnetic amplifier instead of the motor position feedback transducer. Used for checking motor bind during maintenance.

5. Channel disengage switches; one for each channel, these can be used to 'switch out' a single channel. Operation of the switch to the 'channel off' position removes the 115 v.a.c. reference phase from the servo-motor two phase windings, rendering the motor inoperative. This will freeze the motor in the position it happens to be in, it does not incorporate the delay embodied in the selection of STANDBY on the ASE controller which permits the servo motors to recentre.

1.17.4 Aircrew Manual

The following extracts from the Aircrew Manual and Flight Reference Cards are relevant:

> "The aircraft's attitude is established manually by using the cyclic stick, during which time any unwanted signals are automatically cancelled to prevent the ASE opposing control movement ... Attitude in pitch will be affected by movement of the C of G. A manually operated CG trim control is provided ...." (A.M. Chap 1.7 para 14)

....

"(d) The panel on the switch unit has the following controls:

Control	Function
PITCH, ALT, ROLL, YAW switches	To engage their respective channels

The following switches must not be used in flight;

OVERRIDE CHECK switch
MOTOR POSITION switch" (A.M. Chap 1.7 para 17)

....

"ASE Malfunctions

a) Malfunctions of the ASE may cause erratic behaviour of the aircraft, the aircraft's behaviour and the in flight circumstances dictate whether the ASE should be disengaged" (Note The AUTOPILOT REL Buttons are situated on the cyclic sticks)" The behaviour of the aircraft may indicate which channel is defective; that channel should be switched off using the associated channel selector switch. .....

b) If the behaviour of the aircraft is satisfactory following the disengagement of an ASE channel, or of the ASE as a whole, the flight may be continued". (A.M. Chap 1-7 para 18)

" ASE Management

a) Normally the ASE should be engaged for all flying but if specifically not required it should be set to STANDBY. The autostab release is intended for emergency use only.

b) After take off the pitch servo should be checked for null. Adjustment is made by removing half the error from the indicator using the CG trim control. The remaining error will be removed when the cyclic stick is retrimmed to maintain the hover attitude. .....

....

f) The ASE must be set to STANDBY before the engines are shut down, so that the servo motors are in the null condition for the next start." (A.M. Chap 3-2 para 14).

The Flight Reference Cards call for the ASE to be set to STANDBY (ASE controller, centre console) after checking and before starting the rotor. ASE is selected as required before take off.

Card 19 reads as follows:

CONTROL MALFUNCTIONS

Erratic aircraft behaviour.

Disengage ASE

Fault Clears	Fault Persists
Disengage affected channel	Select SEC OFF
Re-engage ASE	
Continue flight.	

2. ANALYSIS

2.1 Aircraft Behaviour

From the pilot's statement the in-flight behaviour of the aircraft had been perfectly satisfactory until he decided to investigate the performance of the pitch channel of the ASE by switching the pitch channel back on by means of the PITCH channel switch on the switch unit. Immediately after making the switch the aircraft pitched nose down and the inference must be that the pitch down was caused by the switch selection.

Post crash examination of the secondary servo unit has shown a full stroke deflection of the pitch servo motor, which is consistent with the behaviour of a servo motor with open circuit position feedback. Such a movement of the servo motor would give a disc reaction similar to that described in para 1.6.3.

The test described in 1.16.4 indicates that if this type of ASE input remained uncorrected for one or two seconds, the aircraft could well have arrived at a point where recovery in the height available was not possible. The damage to the aircraft, and consequent personnel injury is more consistent with uncompleted recovery than with an uncorrected and sustained dive into the ground.

2.2 Feedback cable disconnection

The feedback transducers are fitted to the end of the servo motor that is best protected from accident damage, being situated beneath individual fibreglass covers surrounded on three sides by the two mixer unit side plates and the servo motor mounting plate. The plug/socket assemblies through which pass, inter alia, the three cables from each transducer had been damaged, but there was no evidence that this damage had applied tensile loads to the cables. The cover for the pitch channel feedback transducer was intact so the dent in the transducer body can only have been made with the cover removed, that is, on some occasion previous to the accident. The blow that caused the dent in the transducer body may also have cracked its supporting brackets, but is unlikely to have affected the cable terminations.

2.3 The behaviour of the aircraft on the day of the accident would support there being an intermittent fault in the ASE pitch channel. Aircraft behaviour when the pitch channel was reselected by the pilot would suggest a subsequent open circuit of connection CA1KS to the feedback transducer, which would induce an uncontrolled nose-down ASE input to the flying controls. Analysis of the subject cables by EQUAD proved that the subject cable had been subjected to a tensile load, the amount and direction of which it was not possible to determine. However, the quality of the crimped connections was proved to have been above the required minimum.

As no other electrical or mechanical fault of any significance was found in the aircraft flying controls, the following conditions were thought to apply prior to during and after the accident.

1. Crimped connection coded CA1KS was intermittently open circuited, having been subjected to a tensile load.

2. Crimped connection coded CA3HS was weakened by a tensile load.

3. Between selecting the pitch channel 'out' and selecting it back 'in' again, the crimped connection coded CA1KS became open circuit.

4. On reselection of the pitch channel this open circuit caused a hard down ASE input to the flying controls. The aircraft assumed a nose-down attitude which, uncorrected by the pilot for 2-3 seconds whilst attempting to de-select the pitch channel, reduced the height of the aircraft such that recovery was not possible.

5. During impact and/or transit to AIU, the subject cables became further separated from their terminations until discovery at AIU.

2.4 Pilot's Injuries

Medical opinion is that the pilot's injuries were caused by a severe blow upwards and inwards. The substantial damage to the starboard side of the canopy and displacement of the whole canopy to port is also consistent with 'inward' (relative to the pilot) forces.

The recovered parts of the canopy, when reassembled, exhibit a damage pattern not inconsistent with a blow from a main rotor blade spar which had failed in a downward direction a short distance out from the cuff. The blue blade has such a failure at the right radius and the leading edge polyurethane strip is scuffed, torn and abraded in the same area, however none of this latter damage can be related absolutely to the canopy damage, in particular there were no particles of polyurethane adhering to the canopy structure.

2.5 Aircrew Manual

It is considered that the advice given in the aircrew manual is less than complete. The accident would not have occurred if the pilot had not attempted to re-engage a suspect channel. In this particular instance, selecting the system to 'STANDBY' would have only re-centred the error detection system. It is suggested that the Aircrew Manual should incorporate an instruction that once a suspect ASE channel has been selected 'OFF' by use of the channel disengage switch, it should remain 'OFF' until the aircraft lands.

3. CONCLUSIONS

3.1 Findings

1. There was a pre existing defect in the pitch channel of the ASE detected by the pilot during his checks and switched out before take off.

2. Attempted re-engagement of the pitch channel in flight caused a nose down pitch which the pilot could not control in the height available.

3. The pitch servo motor feedback transducer had sustained mechanical damage at some time prior to the accident.

4. There is no evidence that the above damage had affected the performance of the pitch channel.

5. One or more of the pitch channel transducer cables had been mechanically overloaded at some time prior to the accident, causing intermittent faults in the pitch channel.

6. Information on the behaviour of the ASE given in the Aircrew Manual is incomplete and possibly misleading.

3.2 Cause

The accident was caused by engagement of a defective ASE channel at an altitude insufficient to permit recovery from the resultant pitch down.

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~~IN CONFIDENCE~~

<u>Photograph 1</u> Taken from near the starboard side of the nose. The port main wheel and copilot's window can be seen on the left. BLUE blade in right foreground with tail pylon in the background.

~~IN CONFIDENCE~~

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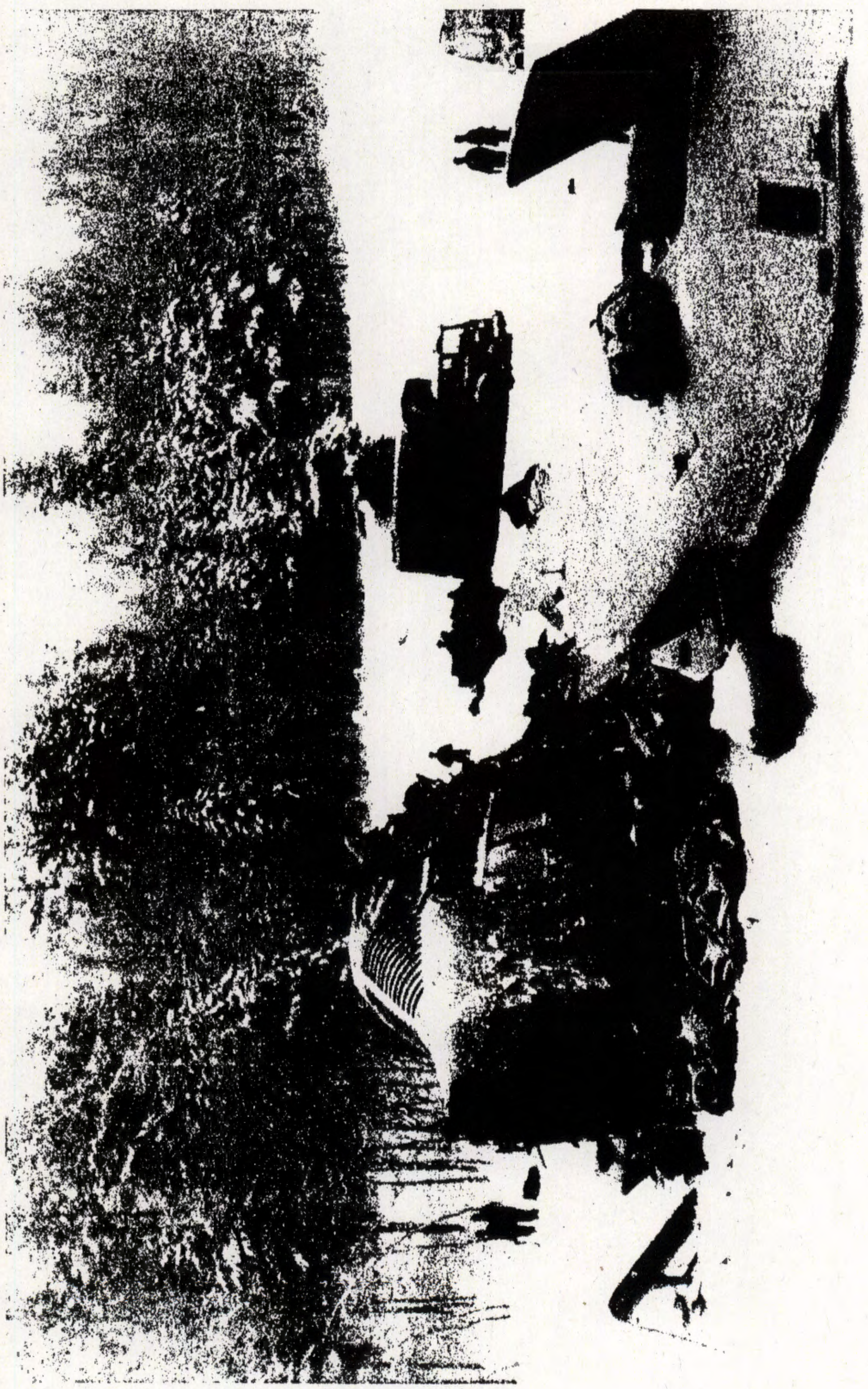

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<u>Photograph 2</u> The main wreckage as viewed from starboard forward showing damage to pilot's side of cockpit.

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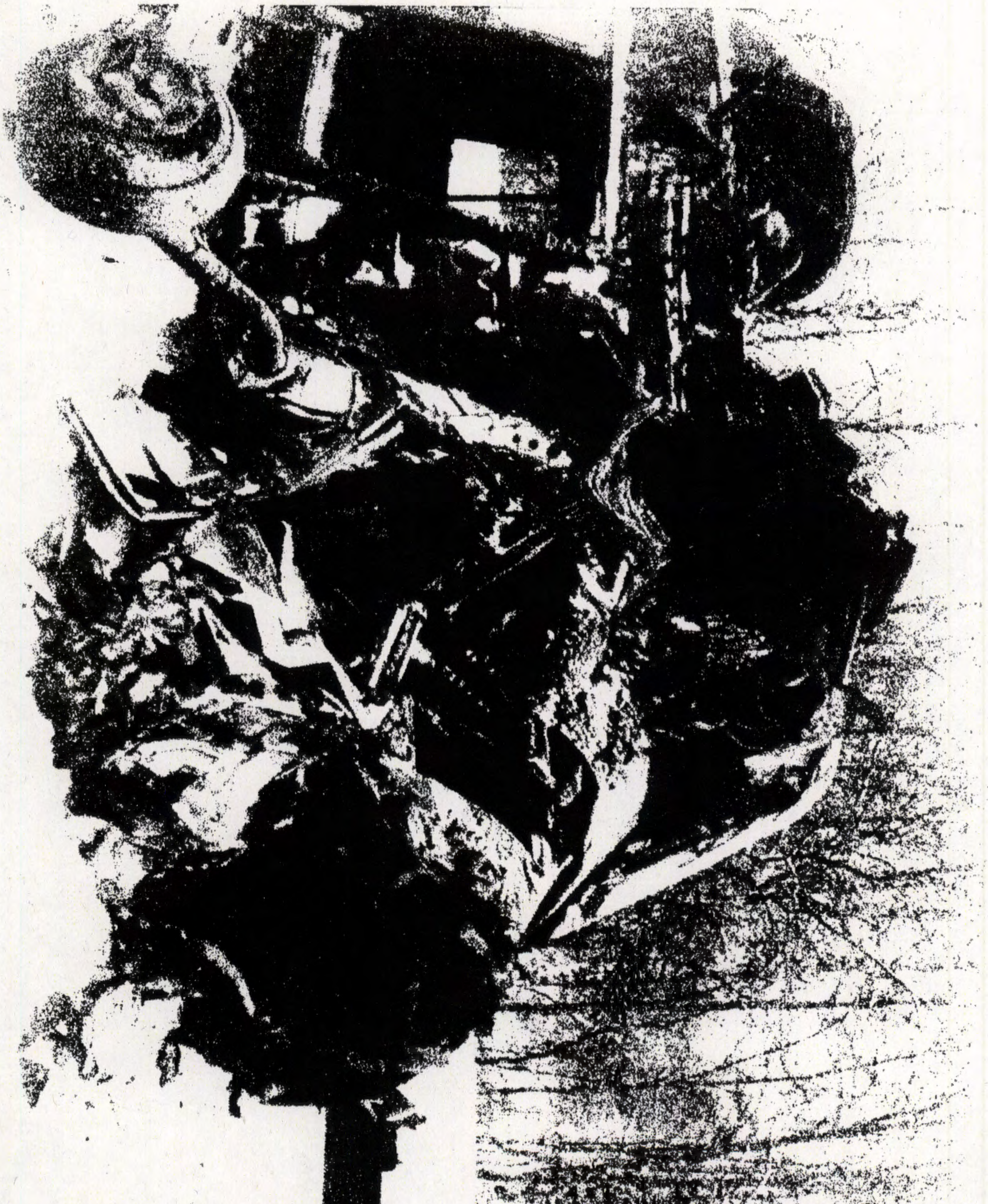

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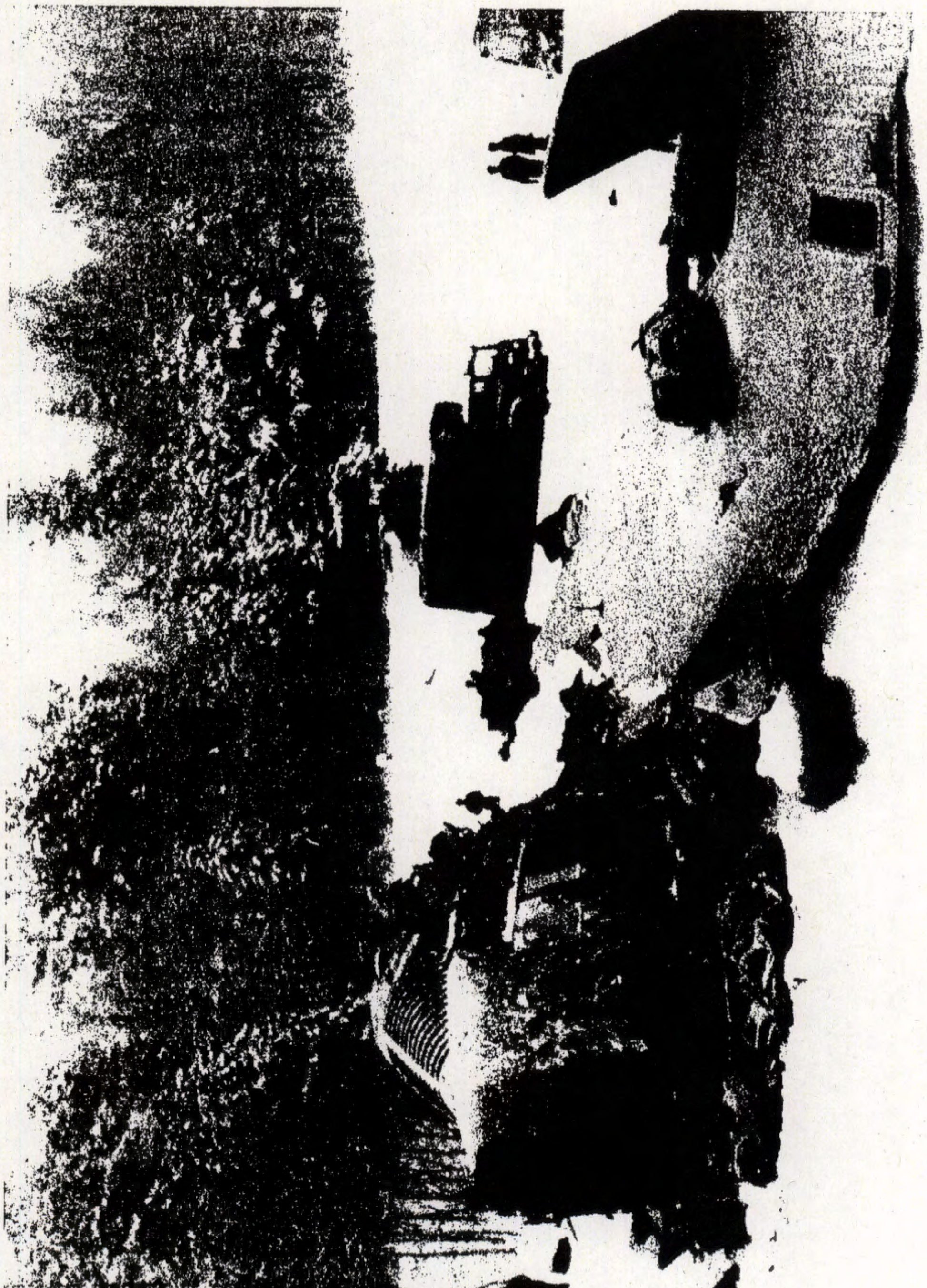
Photograph 3 — The wreckage from port side forward showing displacement of canopy. The blade in the foreground is RED, still attached to the main rotor head.

~~IN CONFIDENCE~~ unclass/NPM



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<u>Photograph 4</u> Wreckage from starboard side aft. The yellow object is the tail cone buoyancy bag.

~~IN CONFIDENCE~~ unclass/NPM

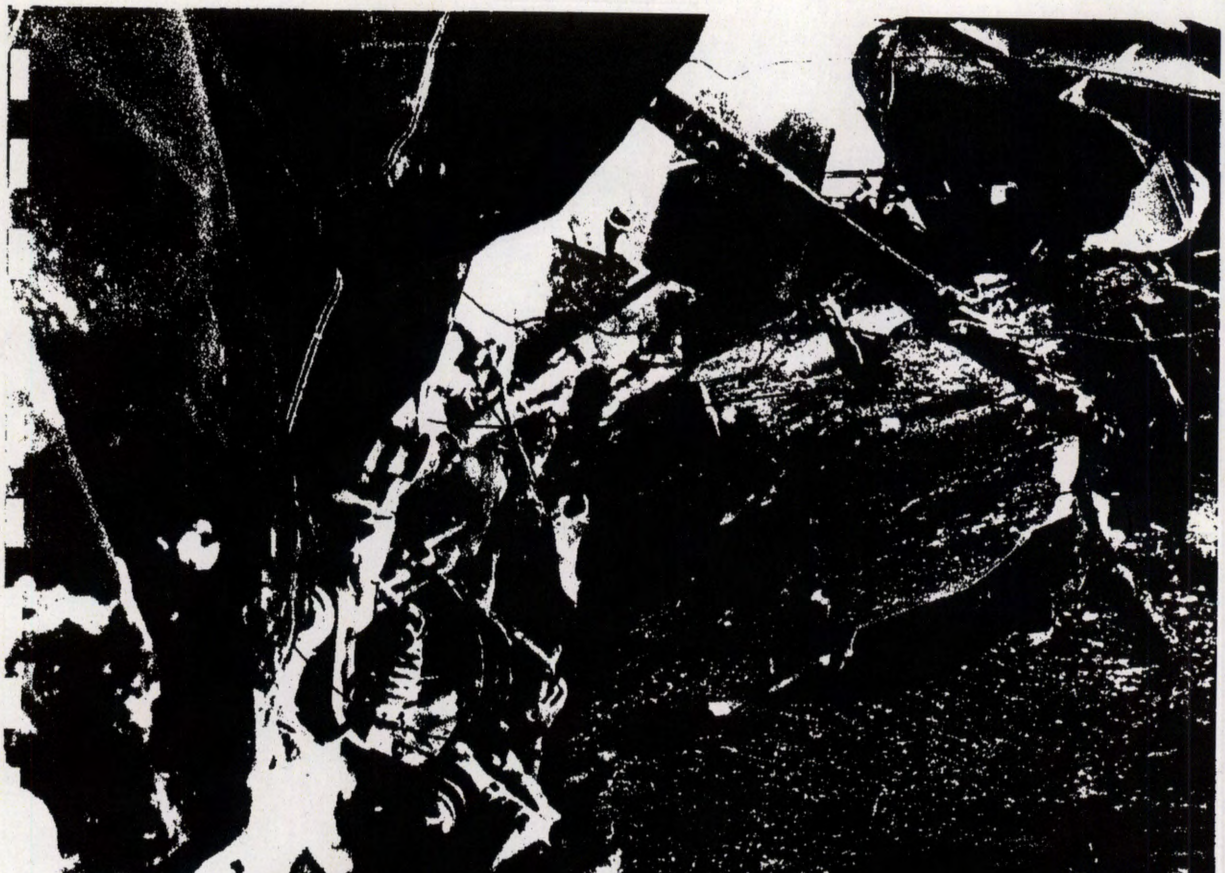
unclass/NPM

~~IN CONFIDENCE~~

__Photograph 5__ The wreckage from port side aft.
The bowed blade which has lost all its pockets is GREEN.
The item in the foreground is the root end of the GREEN blade and the RED blade is obvious left centreground.

~~IN CONFIDENCE~~

unclass/NPM



unclass/NPM

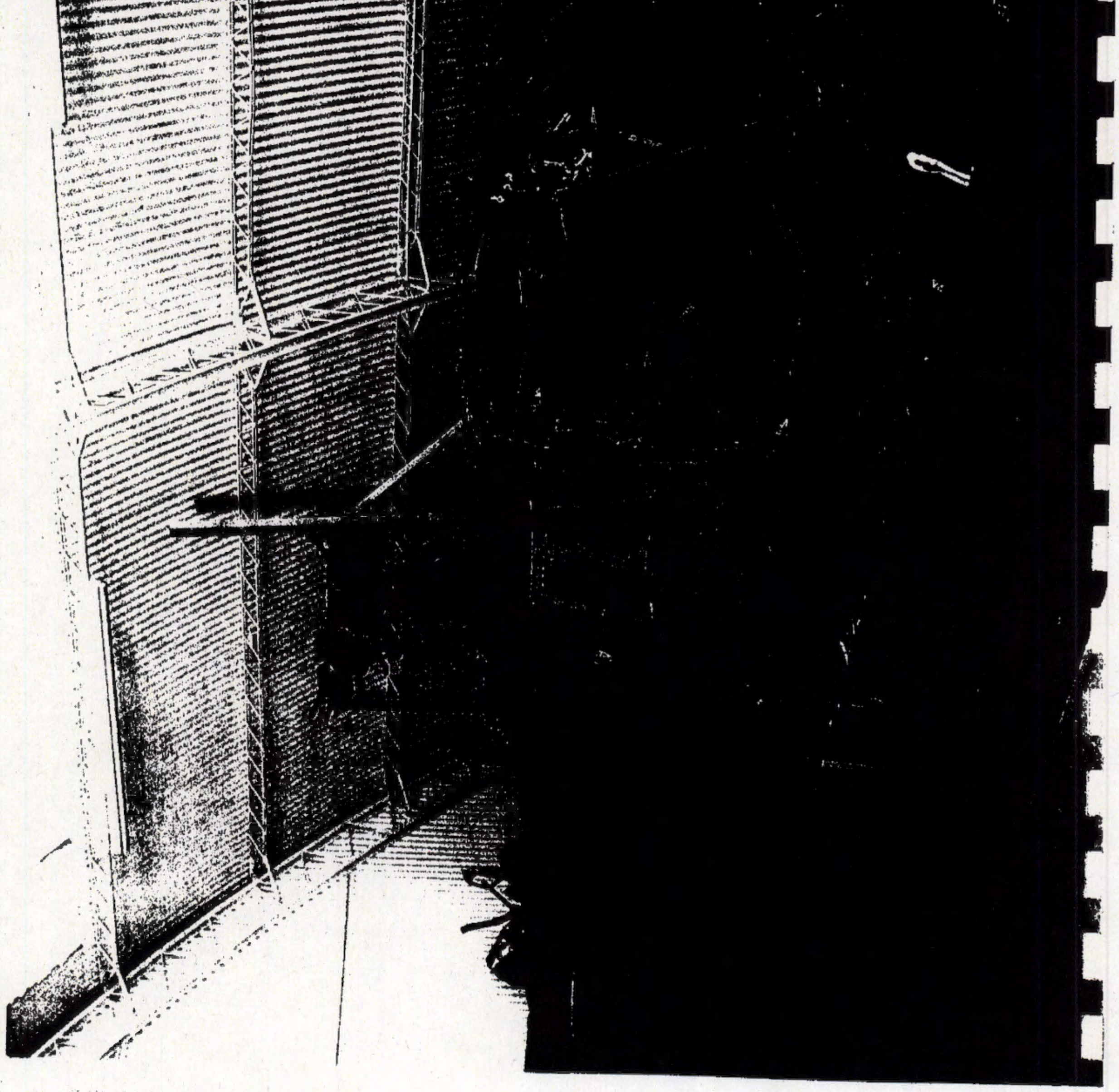
~~IN CONFIDENCE~~

Photograph 6

Close-up of port side of fuselage.
The stump of the BLUE blade can be
seen penetrating the fuselage side.
RED blade cuff also visible.

~~IN CONFIDENCE~~

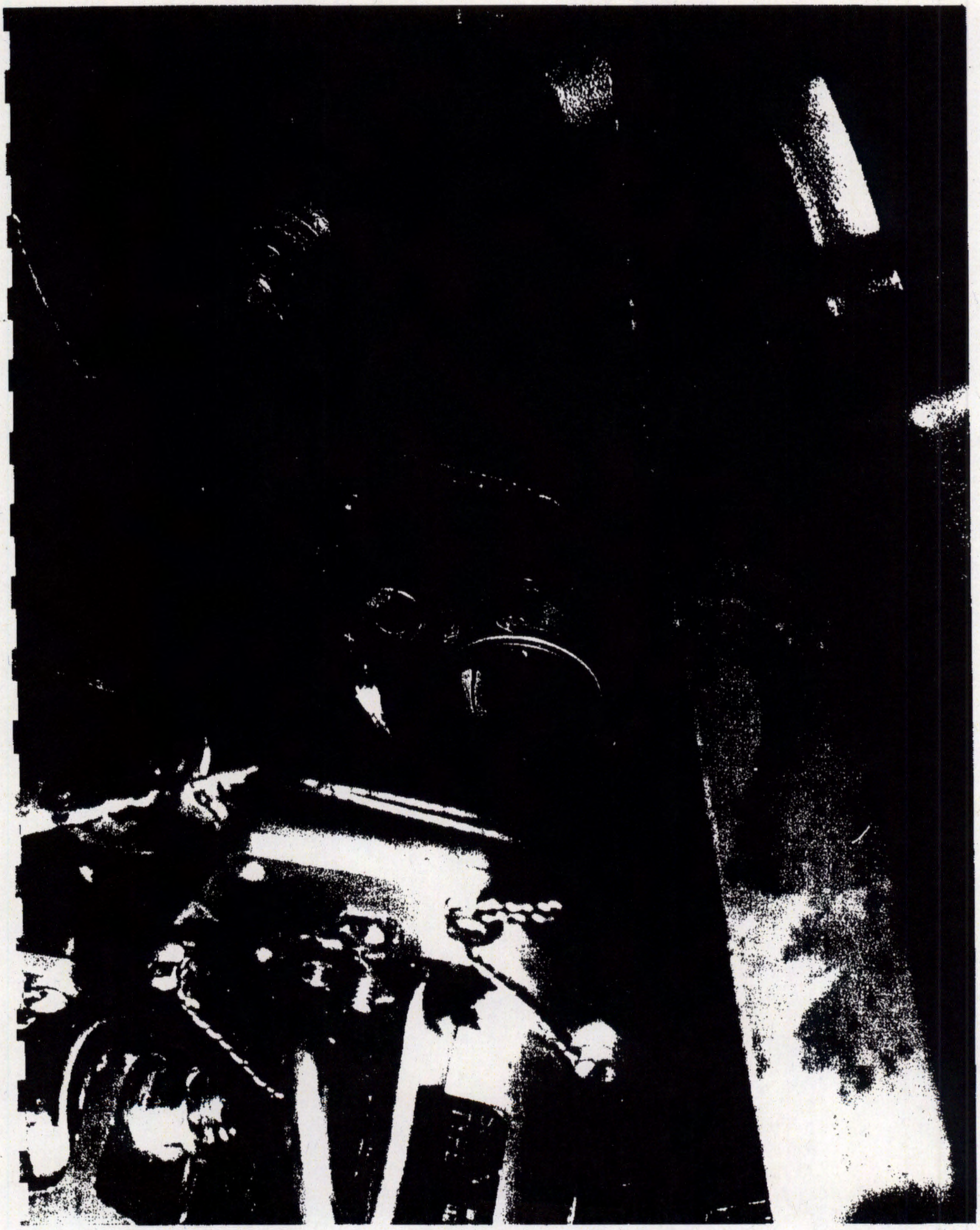
unclass/NPM



Photograph 7 The reassembled canopy and main gearbox fairing.
The wooden pole represents the main rotor shaft.

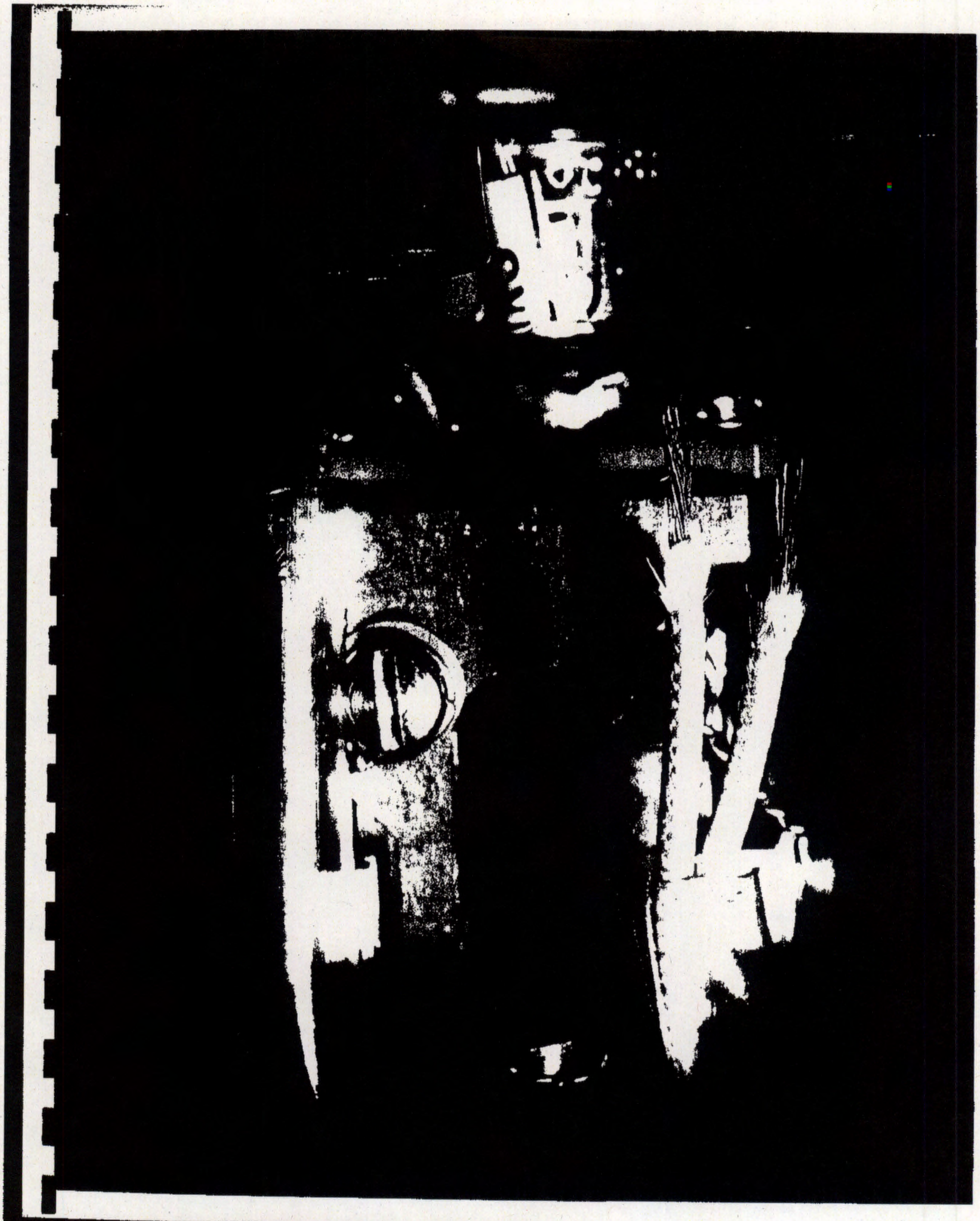
~~IN CONFIDENCE~~ unclass/NPM

Photograph 8 The pilot's seat



Photograph 9 View of pitch servo-motor type C showing empty cable crimp terminations coded CA1KS and CA3HS.

~~IN CONFIDENCE~~ unclass/NPM



<u>Photograph 10</u> Close-up view of cables coded CA1KS and CA3HS.