AIRCRAFT ACCIDENT REPORT

No. 91-012

Gardan GY20 "Minicab"

ZK-DAG

Wainui Forest
12 nm SE of Taupo Aerodrome

24 April 1991

Transport Accident Investigation Commission
Wellington - New Zealand

Price $13.50 (including G.S.T.)

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AIRCRAFT:	Gardan GY20 "Minicab"	**OPERATOR:**	Mr M W Meredith
REGISTRATION:	ZK-DAG	**PILOT:**	Mr M W Meredith
PLACE OF ACCIDENT:	Wainui Forest, 12 nm SE of Taupo Aerodrome	**OTHER CREW:**	Nil
DATE AND TIME:	24 April 1991 at 0823 hours NZST	**PASSENGERS:**	One

SYNOPSIS:
See Page 3

1.1 HISTORY OF THE FLIGHT:
See page 4.

1.2 INJURIES TO PERSONS:
Pilot: One Fatal
Pax: One Fatal

1.3 DAMAGE TO AIRCRAFT:
Destroyed

1.4 OTHER DAMAGE
Nil

1.5 PERSONNEL INFORMATION:
The pilot was aged 60. He held Private Pilot Licence (Aeroplane) No 11512. At the medical examination for the renewal of his licence on 11 April 1990 he was assessed fit.

Flight Times

	Last 90 days	Total
All Types	47	2728
On Type	45	1550 (approx)

1.6 AIRCRAFT INFORMATION:
See page 4.

1.7 METEOROLOGICAL INFORMATION:
See page 6.

1.8 AIDS TO NAVIGATION:
Not applicable.

1.9 COMMUNICATIONS:
No communications were heard from ZK-DAG.

1.10 AERODROME INFORMATION:
Not applicable.

1.11 FLIGHT RECORDERS:
Not applicable.

1.12 WRECKAGE AND IMPACT INFORMATION:
See page 8.

1.13 MEDICAL AND PATHOLOGICAL INFORMATION:
Pathological and toxicological examination disclosed no factors likely to have affected the conduct of the flight.

1.14 FIRE:
There was no fire.

1.15 SURVIVAL ASPECTS:
The impact was not survivable.

1.16 TESTS AND RESEARCH:
Nil.

1.17 ADDITIONAL INFORMATION:
See Page 11.

1.18 USEFUL OR EFFECTIVE INVESTIGATION TECHNIQUES.
Nil.

2. ANALYSIS:
See page 13.

3. FINDINGS:
See page 19.

4. SAFETY RECOMMENDATIONS:
See Page 19.

5. OBSERVATIONS
See Page 24.

6. APPENDICES
A. Glue failures in wooden aircraft construction.

* All times in this report are NZST (UTC + 12 hours)

SYNOPSIS

The pilot of ZK-DAG had been on a holiday with a companion. On the day before the accident they had attempted to return to the pilot's farm, near Waipukurau, but bad weather had forced them to stop at Broadlands, near Taupo, to wait for a clearance.

On the day of the accident the weather at Taupo was clear under a stratus layer estimated at 5000 feet, and at Waipukurau was clear under a high overcast; a westerly wind had resulted in a build-up of cloud on the ranges between. ZK-DAG took off and was seen climbing through a gap in the layer cloud, heading towards Waipukurau. It did not arrive and the next evening wreckage was located on track, 12 nautical miles (nm) south-east of Taupo.

Mr D.V. Zotov was appointed investigator in charge and commenced the on-site investigation the following morning.

The aircraft suffered an in-flight structural failure due to flutter of the tail surfaces originating at the elevator trim tab.

No conclusive reason could be established for the aircraft's speed increasing to the extent that flutter would ensue but defects in the trim control system and a rudder modification rendered ZK-DAG susceptible to flutter at a lower airspeed than other aircraft of the same type.

A deliberate high speed descent by the pilot was considered unlikely. However the prevailing weather suggested that the aircraft may have been trapped by rapidly developing cumulonimbus, or have failed to outclimb a rising layer of cloud. Alternatively an existing deficiency in the carburettor air box could have resulted in a loss of power causing a descent into cloud. Entry into cloud, for whatever reason, was likely to result in loss of control by the non-instrument rated pilot with consequent potential for airspeed excursion and control inputs sufficient to induce flutter.

Safety recommendations were made to the Amateur Aircraft Constructors' Association in respect of construction techniques; and to the Meteorological Office and the Minister of Transport, in regard to the standard of weather forecasts available to General Aviation pilots.

1. FACTUAL INFORMATION

1.1 History of the flight

1.1.1 The pilot and his passenger had been on a fishing holiday in Northland and were returning to the pilot's farm near Waipukurau. On the day before the accident, adverse weather forced them to stop at Taupo Aerodrome, where 24.5 litres of Avgas from an underground supply was added to the main tank. The aircraft was then flown to a friend's airstrip at Broadlands, 16 nm north-east of Taupo, where the pilot and passenger spent the night.

1.1.2 On the morning of the accident the weather at Broadlands had improved. A pilot witness reported that there was a layer of medium level stratus and a light northerly wind. Visibility was good in the general direction of Opotiki. The pilot rang home and was told that the sky at Waipukurau was clear with a high overcast.

1.1.3 A buildup of cloud on the ranges south-east of Taupo was to be expected and the pilot discussed with his host the possibility of flying to Whakatane and refuelling, then going round East Cape. The aircraft took off at about 0800 hours and initially turned north-east towards Whakatane. Shortly afterwards however, it turned south and subsequently was seen climbing through a large hole in the stratus layer, at a height estimated as about 5000 feet.

1.1.4 The aircraft did not arrive at Waipukurau, but a search along track was not possible that day, because of severe weather south of Taupo. Next evening a searching helicopter located the wreckage of ZK-DAG in the Wainui Forest, 12 nm south-east of Taupo, close to the direct track between Broadlands and Waipukurau.

1.1.5 There were no witnesses to the accident, but two deerstalkers sheltering in a bivouac downwind of the impact point heard a single burst of aircraft engine noise at 0823 hours, followed by a short period of silence and then a soft thump. The weather was overcast and raining; cloud was clear of the ridges in their immediate vicinity.

1.1.6 The accident occurred in daylight at about 0823 hours on 24 April 1991. The accident site was in the Wainui Forest, at an elevation of 2300 feet, 12 nm south-east of Taupo Aerodrome, grid reference 887500, NZMS 260 sheet U19 "Kaimanawa", latitude 37°55' south, longitude 176°13' east.

1.6 Aircraft information

1.6.1 Gardan GY20 "Minicab", Amateur Aircraft Constructors Association (AACA) Serial Number 14/1, was a fabric and wood aircraft constructed by the pilot in 1971 and registered as ZK-DAG. The last recorded total time, as at 25 February 1991, was 1557 hours. A 100 hour check to the AACA schedule was performed by Mr Meredith on 25 January 1991, at which date the flight time was recorded as 1515 hours. The two yearly check of instruments and avionics for its Permit to Fly was made on 7 December 1989.

1.6.2 The aircraft was inspected for the latest renewal of its Permit to Fly, by the owner, on 30 November 1989. The owner signed the survey report, which was oversigned by a licensed engineer. On the basis of this report the Permit to Fly was revalidated until 7 August 1991. The last time that the aircraft was inspected by a surveyor was on 6 August 1987.

1.6.3 The aircraft was equipped with a Rolls Royce Continental O-200A engine serial number 20R279. At the last logbook entry on 31 January 1991, the recorded total time was 5595 hours, with 220 hours since overhaul. The propeller was a two bladed, fixed pitch McCauley A100 MCM serial number 6952.

1.6.4 The aircraft was equipped with a turn and slip indicator and a radio compass, but there was no artificial horizon or directional gyro. It was not equipped with a heated pitot head.

1.6.5 The maximum permitted all-up weight of ZK-DAG was 1234 pounds and its empty weight was 835 pounds. 62 pounds of luggage was recovered from the wreckage; it had been stowed above the rear fuel tank at the back of the cockpit. (The maximum permitted weight in this area was 35 pounds). The pilot and passenger each weighed about 170 pounds. The main fuel tank, ahead of the cockpit, could hold 95 pounds of fuel and in view of the amount added at Taupo it was probably topped up to full there. (A witness believed the rear tank was left empty to compensate for the weight of the luggage in that location; this view was supported by the wreckage examination: see paragraph 1.12.24). Based on these figures, the estimated all-up weight on departure from Taupo was 1332 pounds, 98 pounds above the maximum permitted all-up weight. Take-off and en route fuel consumption would have reduced the weight, but it was likely that the aircraft was about 80 pounds above the maximum permitted all up weight at the time of the accident.

1.6.6 The permitted range for the centre of gravity was 12.75 inches to 17.6 inches aft of datum (the leading edge at the wing root); it was calculated to have been 16.6 inches aft of datum at take-off from Taupo Aerodrome, and would have moved slightly aft as fuel was consumed from the main tank.

Note: Units in paragraphs 1.6.5/6 are consistent with official manuals, documents, reports, and instructions used by or issued to the pilot. One kilogram equals 2.205 pounds, and one inch equals 25.4 mm.

1.6.7 A pilot familiar with the "Minicab" type advised that, with the load the aircraft was carrying, its operational ceiling would have been of the order of 10 000 to 11 000 feet.

1.6.8 The never exceed speed (Vne)was 139 knots and the manoeuvring speed (below which sudden and complete deflection of any control surface would not cause structural damage) was 80 knots.

1.6.9 ZK-DAG was originally covered with cotton fabric, but was re-covered in 1985 with Ceconite, a synthetic "heat-shrink" material. It was found that the superior shrinkage of this material tended to bow the light wooden trailing edge of the elevators. These were therefore reinforced with a strip of aluminium alloy sheet, bent to a "V" section, which covered the original trailing edge.

1.6.10 The owner had sought approval to fly ZK-DAG at night. For this purpose he had added navigation lights. The tail light was mounted on a fairing on the trailing edge of the rudder, at the point of maximum chord.

1.6.11 Most of the aircraft had been constructed by the owner from raw materials, chiefly spruce strips and birch ply. The adhesive was mainly "Aerodux" resorcinol resin, but in some places "Aerolite" urea-formaldehyde glue had been used. However, the laminated spar caps for the wing mainspars had been made professionally; they were glued with Aerodux.

1.7 Meteorological information

1.7.1 On the morning of the accident a deep depression straddled South Island and a strong cyclonically curved north-westerly airstream covered North Island. The air over North Island was very unstable with thunderstorms and periods of heavy rain being reported from most areas and culminating in an outbreak of tornado activity over Northland and Auckland about the middle of the day.

1.7.2 There were short periods of heavy rain recorded at Taupo Automatic Weather Station (AWS) and Motu AWS, about 100 nm north-east of Taupo, at about 0400 hours. Lightning was recorded at Waiouru AWS between 0200 and 0600 hours and thunderstorms at New Plymouth at about the time of the accident.

1.7.3 With the advent of the Kaitaia meteorological station, radiosonde ascents from Auckland had been discontinued. The only ascents in North Island were from Kaitaia and Paraparaumu. No midnight ascent was made from Kaitaia on the day of the accident, so the only relevant information was that from Paraparaumu. The midnight ascent indicated that cloud tops could rise to 10 000 feet, while the midday ascent indicated that tops could rise to 30 000 feet.

1.7.4 There was no weather radar coverage of the central North Island.

1.7.5 The area of the intended flight path was masked, on the satellite photographs, by a band of high cloud. There was therefore no direct evidence of the cloud that might have been encountered by the aircraft. There were occasional cumulonimbus clouds covering much of North Island and the South Taranaki Bight; the East Coast north of Cape Turnagain was clear of cloud.

1.7.6 Gisborne reported a shear of 12 knots between 3000 and 5000 feet at 0600 hours and 15 knots at noon. Rotorua reported a shear of 11 knots between 2000 and 3000 feet at noon. These shear values, in conjunction with the unstable conditions, were likely to result in mechanical turbulence.

1.7.7 The actual weather recorded at Taupo at 0900 hours was:

Wind:	040°/10 knots
Visibility	30 km
Cloud:	1/8 stratus base 1000 feet
	4/8 cumulus base 1500 feet
	6/8 altostratus base 10 000 feet

The actual weather recorded at Napier at 0900 hours was:

Wind:	310°/15 knots gusting to 34 knots
Visibility:	50 km
Cloud:	1/8 cumulus base 3000 feet
	4/8 cirrus base 20 000 feet

1.7.8 The General Aviation Weather forecast for the North Island, issued by the New Zealand Meterological Service and valid for 0700 to 1800 hours, stated:

"... A large area of active cumulonimbus ... will move across the North Island today.

... Gisborne, Hawkes Bay, Wairarapa: Showers and isolated thunderstorms in the ranges spreading east at times. Areas of broken cumulus and stratocumulus base 1800 feet tops above 10 000. Isolated embedded cumulonimbus base 2000 feet tops above 30 000.

Remainder of North Island: Bands of occasional cumulonimbus 1500 feet tops above 10000 feet moving from the west. Heavy showers, isolated hail and isolated thunderstorms with areas of broken stratus at 1000 feet. Areas of broken altocumulus/altostratus above 7000 feet.

Visibility 30 km, but 3000 m in heavy showers and thunderstorms, 6000 m in other showers.

No significant icing, away from cumulonimbus.

Turbulence occasionally moderate below 8000 feet over all the North Island, isolated severe as in SIGMET [warnings].

Freezing level 6500 feet.

Winds at 0600 hours NZST:

	3000 feet	5000 feet	7000 feet	9000 feet
... Rotorua (estimated)	310/35	310/40	310/45	310/45
Gisborne	315/36	315/48	310/54	305/55

Forecast: Little Change

Aerodrome Forecasts:

Taupo:	Wind 350°/15 knots, visibility more than 8 km, showers, broken cloud base above 2000 feet. Temporarily, wind 330°/25 knots, visibility 1500 m to 5 km, thunderstorms, broken cloud base 1000 to 1500 feet above aerodrome level.
Napier:	Wind 350°/15 knots, visibility more than 8 km, showers, broken cloud base above 2000 feet above aerodrome level. Temporarily, wind 330°/25 knots.

SIGMET warnings for Auckland and Wellington Flight Information Regions:

Forecast isolated severe turbulence below 8000 feet over the North Island."

1.7.9 The NZMS advised that the severe turbulence SIGMET should be taken to refer to mechanical turbulence over the ranges, because:

(a) reference to cumulonimbus implied severe turbulence and it would not be the subject of a SIGMET warning;

(b) there could be no rotorflow on a day when there were cumulonimbus clouds.

The forecaster would have come to this conclusion because of the considerable shear in the lower layers. In the "General Aviation Weather", this was reflected only in the Gisborne report.

1.7.10 The NZMS would not provide weather information to pilots unless they held a Personal Identification Number, so that they could be charged for the forecast: Mr Meredith, in common with nearly all General Aviation pilots, did not hold one. Meterological information was available from attended aerodromes during their hours of service, but Taupo did not open until 0830 hours on the day of the accident. Meterological information was obtainable from the Christchurch Flight Information Service, but this had not been extensively publicised at the time of the accident.

1.12 Wreckage and impact information

1.12.1 The principal wreckage lay in a pile in a recently planted section of a pine forest. Immediately surrounding the pile were young saplings, which were unscathed. The principal wreckage comprised the engine, forward part of the fuselage, wing main spars and undercarriage. The majority of the wing structure including the tips, the empennage, and the rear fuselage, were missing.

1.12.2 The wreckage trail is illustrated at Diagram 1. The tailplane and elevators, apparently intact, lay about 1 km to the south-east of the principal wreckage, while the fin and rudder were found further down the wreckage trail. Thereafter the trail comprised smaller items, some as small as 2 cm square, and in general progressively lighter with increasing distance from the principal wreckage. For the most part of the trail lay through mature pine forest, but the far end stopped at a tract of native forest which was too dense for a search on foot. The trail lay on a heading of 150°T from the principal wreckage and was 2.5 km in length.

1.12.3 The location of each item was marked on a map and the individual items were marked with reference numbers. All items from the wreckage trail, and the principal wreckage, were recovered to a workshop for reconstruction.

1.12.4 The extent of the reconstruction of the aircraft is shown at diagram 2. This reconstruction enabled the individual parts found along the wreckage trail to be identified. It is evident that not all the wreckage was recovered. The small size of some of the pieces recovered suggests that significant items were unlikely to have been missed during the search of the pine forest (which involved some 50 searchers): it seems probable that the remaining pieces fell into the native forest beyond.

1.12.5 Examination of the reconstructed wreckage disclosed many glue failures. The nature of these failures varied, but they were due to a number of deficiencies in constructional technique. These were the subject of detailed recommendations to the Amateur Aircraft Constructors' Association. (See Annex A). The principal regions of defective gluing were:

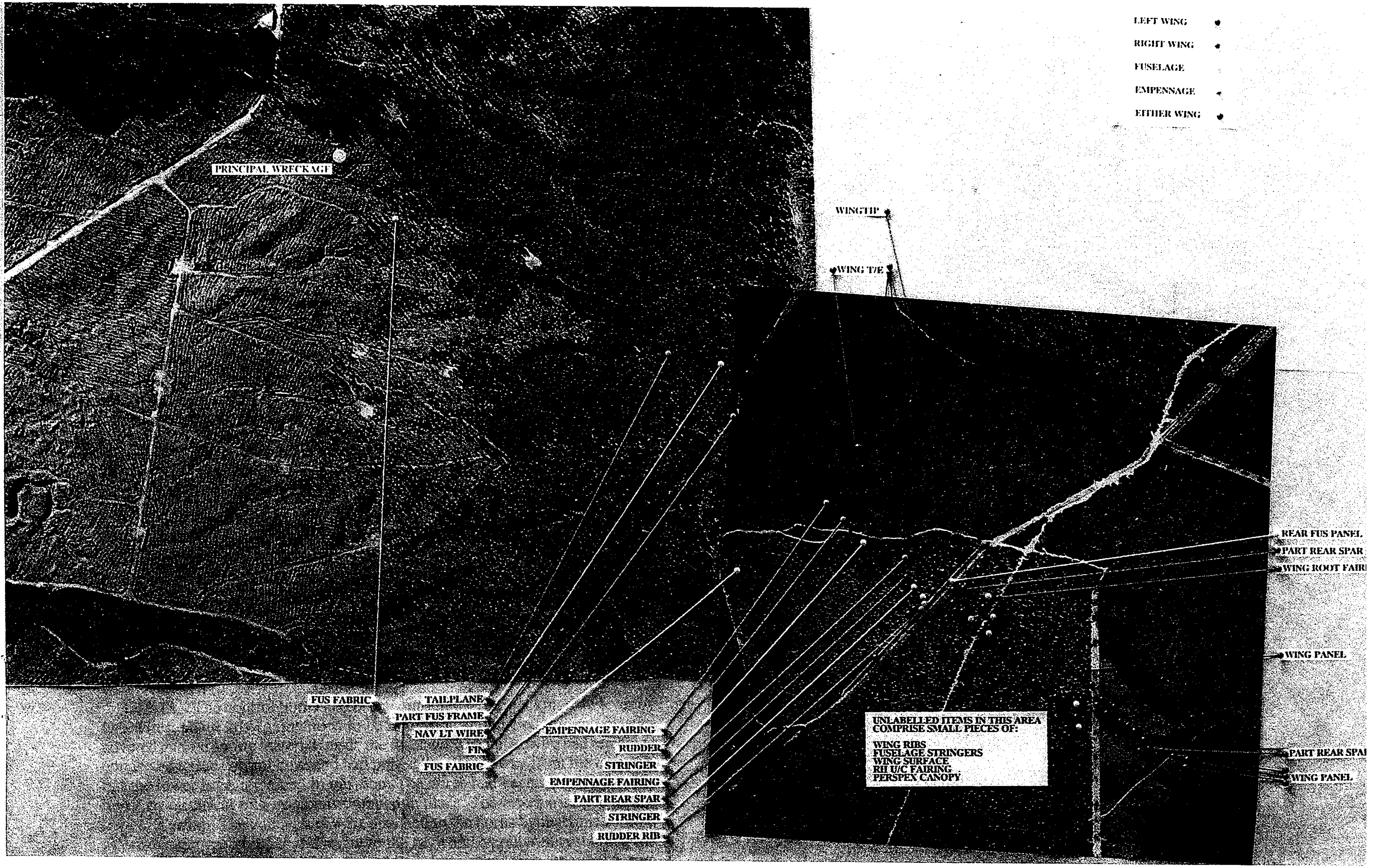
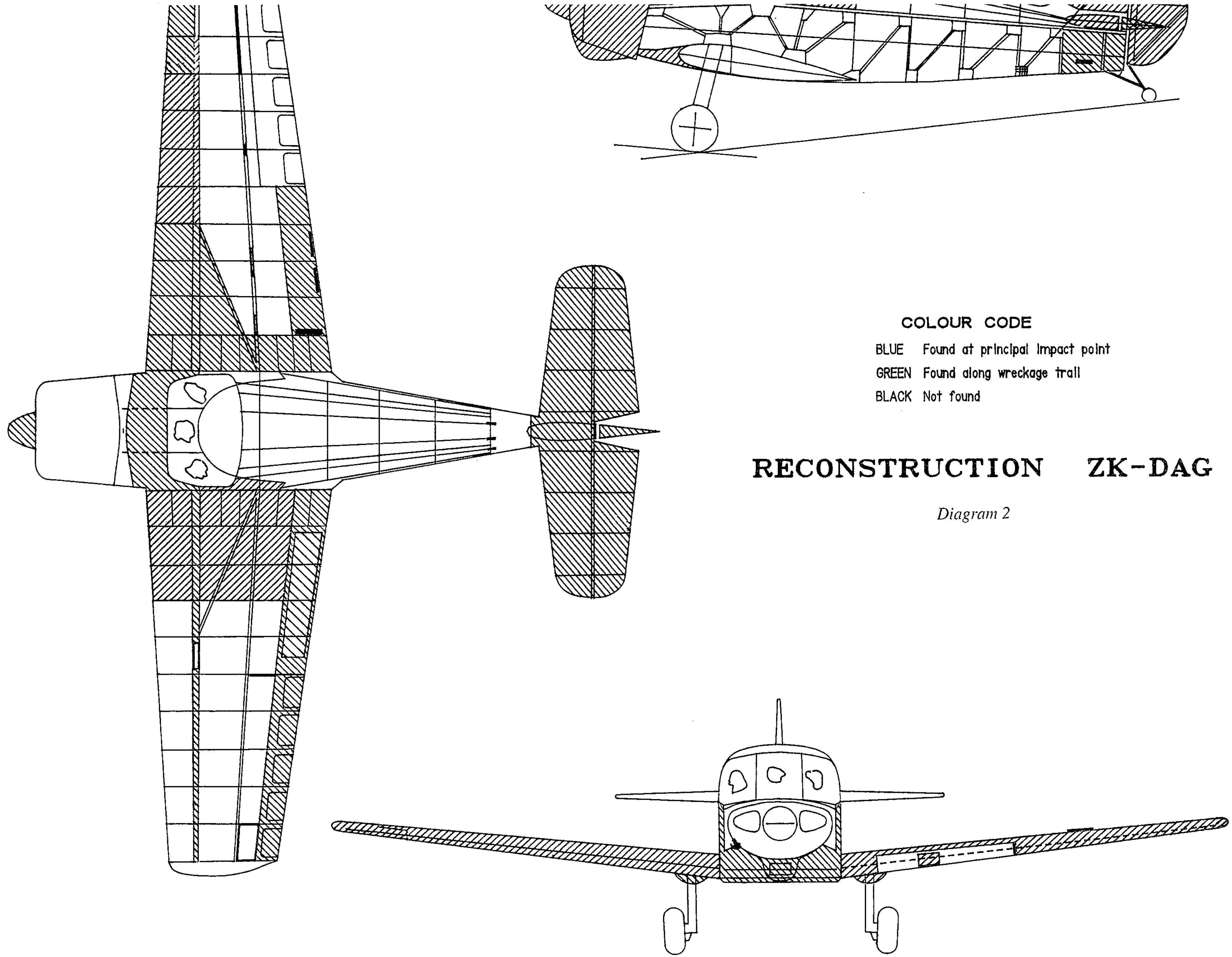

LEFT WING
RIGHT WING
FUSELAGE
EMPENNAGE
EITHER WING
PRINCIPAL WRECKAGE
WINGTIP
WING T/E
FUS FABRIC
TAILPLANE
PART FUS FRAME
NAV LT WIRE
FIN
FUS FABRIC
EMPENNAGE FAIRING
RUDDER
STRINGER
EMPENNAGE FAIRING
PART REAR SPAR
STRINGER
RUDDER RIB
REAR FUS PANEL
PART REAR SPAR
WING PANEL
WING PANEL
UNLABELLED ITEMS IN THIS AREA COMPRISE SMALL PIECES OF:
WING RIBS
FUSELAGE STRINGERS
WING SURFACE
RH U/C FAIRING
PERSPEX CANOPY

Diagram 1



RECONSTRUCTION ZK-DAG

Diagram 2

- the mainspar webs to the spar caps
- the leading edge skins to the ribs and mainspars
- the wing ribs
- the fuselage gusset joints
- the tailplane mount

1.12.6 The rudder had struck the left elevator half, when the latter was at full downward deflection and the rudder had deflected left beyond its normal limit. There was one strike on the rudder stop on each side.

1.12.7 The paint on the rudder fabric showed evidence of ballooning, and tapes doped over the fabric above the ribs had lifted. There was a tear where the trailing edge had broken, level with the top rib. The rudder fabric was cut away to permit internal examination.

1.12.8 The ribs had fractured just aft of the rudder spar, in a manner consistent with over-travel while the spar was restrained by the rudder stops. There was no stitching to hold the fabric to the ribs.

1.12.9 The rudder cables were connected to horns attached to the bottom rib of the rudder and thence, via springs, to the solid tailwheel. The cables had remained attached to the principal wreckage and the tailwheel and rudder horns and rib were still attached to them. There was little evidence of adhesion between the bottom rib and the rest of the rudder frame.

1.12.10 The fin spar had failed at the root, in bending, such that the top of the fin had been deflected to the left at the moment of failure. The fin was otherwise intact, apart from a skin fracture shown to have been made by the tailplane during the break-up sequence.

1.12.11 The tailplane was still bolted to its mount which had broken away from the rear fuselage. The sternpost, attached to the mount, was rotten at the bottom and there was defective gluing in the area of the break.

1.12.12 The elevator trim tab was formed from bent aluminium alloy sheet, about 26 gauge, rivetted together at the leading edge. There were no end ribs and it lacked torsional rigidity. Two of the leading-edge rivets had pulled through the outer skin at the overlap, where the trim tab had been over-extended against the piano hinge which located it to the tailplane. Two control horns had been rivetted to the skin, top and bottom, at the inboard end: there were indentations where both had struck the fabric covered surfaces ahead of them. There were also light marks on the rear of the sub spar which appeared to have been made by rivets touching it.

1.12.13 The control horns had been connected to the cockpit trim lever by two wires, about 20swg, intended to be in tension and ducted through plastic-covered curtain spring material inside the fuselage. The upper wire had remained connected to the control horn and had pulled the rivets away from the trim-tab, but the lower horn remained in position. The wires had been connected to the horns by electrical ring terminals crimped in place. The lower wire had pulled out of its crimp. The connectors were attached to the horns by machine screws, with an inner nut retaining the screw to the horn and an outer nut retaining the connector. On the horn which had pulled free, there was about 2.5 mm clearance between the inner and outer nuts, the connector had 1.5 mm free play fore-and-aft on the screw and the screw itself was loose on the horn.

1.12.14 The wire which had pulled out of the crimp was examined microscopically. The area which had been within the crimp was heavily corroded, but there was no indication of any contact between the crimp and the wire.

1.12.15 The spruce sub spar, to which the trim tab hinge was attached, had failed in vertical shear at the inboard end.

1.12.16 The fabric of the right elevator half showed paint distress indicative of torsional loading in both directions. Both halves showed paint distress consistent with the fabric ballooning and in some areas doped-on tapes over the ribs had lifted from the fabric. The fabric was removed to permit internal inspection. There was no rib-stitching.

1.12.17 The elevators had both fore-and-aft and diagonal bracing ribs. On the right half of the elevator, to which the trim tab was mounted, the diagonal ribs showed compressive failure; on the opposite half of the elevator the fore and aft ribs had failed near the leading edge spar. The carry-through between the elevator halves was the substantial spruce leading edge.

1.12.18 The conduits which carried the trim tab cables through the elevators were made from plastic-coated spring curtain rod. These conduits passed through holes in the woodwork at each end but were not secured in any way. There was significant curvature in the conduit runs.

1.12.19 The left wing main spar had failed at the root in downward bending. There were extensive glue failures in the spar shear webs of both wings and in the leading edge skinning, but there was no sign of glue failure within the main spar caps.

1.12.20 Most of the wing ribs and the fabric covering was not recovered, although a large piece of fabric was seen in a tree. The left aileron had been retained by the aileron control wires, which were intact. The flap control mechanism had retained portions of the flaps, and these were able to be reconstructed almost completely.

1.12.21 The aileron and flap control systems had been intact until the aircraft began to break up. The fittings which attached the elevator cable to the pushrod had failed in tensile overload. There was nothing to suggest any pre-breakup obstruction of the flying control system.

1.12.22 Only small portions of the perspex canopy were recovered.

1.12.23 The reconstruction of the fuselage showed that the fabric of the turtledeck behind the cockpit had fluttered freely during the descent, but much of the rear fuselage framework had remained in place until the impact with the ground. The cockpit area had been essentially intact and the nose area was unaffected until the aircraft struck the ground.

1.12.24 The main fuel tank had burst on impact, in a manner consistent with it containing a considerable quantity of fuel. The rear fuel tank, by contrast, was almost intact. It was empty when found. A small hole in the tank was in the uppermost position as the tank lay in the wreckage.

1.12.25 The engine was stripped and examined. There was nothing to suggest any pre-impact malfunction of the engine itself.

1.17.1.3 The ribs of the empennage of ZK-DAG had not been stitched. However, they were covered by tapes. Sometimes tapes are used to protect areas which stand proud of the general covering, and they are also used to reduce flexing over unstitched ribs when the paint surface is polished, but neither of these cases applied to the empennage of ZK-DAG.

1.17.1.4 The purpose of rib-stitching is to ensure that the fabric follows the curvature of the ribs while under the influence of air loads. In the absence of stitching, the fabric could balloon away from the ribs, changing the effective camber of the surface and, in the case of a control surface, materially affect the control and feedback forces associated with a given surface deflection.

1.17.2 Carburettor Heat

1.17.2.1 Carburettors on aircraft engines are prone to ice formation in the throat area when flying in moist conditions. This can lead to complete loss of power. The air intake system is therefore fitted with a changeover valve which permits the pilot to direct hot air, intermittently or continuously, to the carburettor. Hot air may be selected routinely for a short period, to protect against ice build-up in the carburettor, or continuously if the aircraft is flying in conditions conducive to the formation of ice; or in order to melt ice which has already formed.

1.17.2.2 Induction of hot air, which is less dense than cold air, results in a significant power loss. If the aircraft is near its operational ceiling a loss of speed or height could result from continuous use of hot air.

1.17.2.3 In cold conditions, it is possible for the application of partial carburettor heat to raise the temperature of the air in the carburettor from below the icing range to within the range. A carburettor air temperature gauge would warn the pilot of this effect, and allow him to use the optimum amount of carburettor heat. However, ZK-DAG, like many light aircraft, was not so equipped. In such aircraft the recommended practice is to select maximum carburettor heat if it is required at all.

1.17.3 Flutter

1.17.3.1 Flutter is undamped oscillation of structure or of movable control surfaces, energised by the airflow. In either case some degree of flexibility (in the structure itself or in the linkages to a control surface) will increase the propensity to flutter.

1.17.3.2 In general, control surfaces can be made less prone to flutter by measures which raise their natural frequency of oscillation above the range of frequency associated with flutter. Lightening the control surface, and moving its centre of gravity towards the hingeline, are measures frequently used. Conversely, anything that increases the weight of the surface (e.g. excessive paint) or moves its centre of gravity aft (e.g. increased weight at the trailing edge) will increase the likelihood of flutter.

2. ANALYSIS

2.1 The Wreckage Trail

2.1.1 The long, narrow wreckage trail raised the possibility that the aircraft might have been flying in a north-westerly direction, shedding pieces as it went, until the flying surfaces were no longer able to sustain flight or control was lost. However, the absence of most of the wing structure, either at the wreckage site or along the wreckage trail, would require the wreckage at the main impact point to have covered more than one nautical mile in a ballistic trajectory, against the wind. This is improbable.

2.1.2 The essentially vertical descent of the principal wreckage, as evidenced by the undamaged adjacent saplings, combined with the dispersion downwind of a plume of progressively lighter parts, is characteristic of catastrophic in-flight breakup at a considerable altitude.

2.2 Principal features of the Breakup

2.2.1 The reconstruction showed the following significant features:

(a) The left wing had failed at the root, in downward bending: the wing construction was sound in this area, insofar as downward bending loads were concerned.

(b) A major part of the wing structure was not recovered.

(c) The empennage, largely intact, had separated from the fuselage and the control surfaces showed evidence of having fluttered.

(d) Most of the canopy was missing.

2.2.2 The vertical downward failure of the spar caps at the left wing root defined the cause of the inflight breakup. To provide the necessary negative "g" to break the wing at the root, the aircraft must have bunted violently. The wing structure must still have been essentially intact at this point, in order to derive the necessary aerodynamic force. This therefore eliminates loss of the outboard wing structure as a primary event: the absence of some of the outboard components from the wreckage trail is a reflection of their lightness, enabling them to be blown into the native forest during their descent.

2.2.3 Downward failure of the wing at the root is characteristic of loss of the tailplane at high speed: the aircraft bunts violently when the download from the tailplane is removed. Although glued joints in the vicinity of the tailplane seat had failed, these failures were secondary to the main event. Torsional forces sufficient to break the fin spar could not have been reacted by the tailplane if the glued joints had already failed. These forces were typical of those generated by flutter.

2.3 Flutter of the Tail Control Surfaces

2.3.1 There were a number of factors in the control system of ZK-DAG which would have made the tail surfaces prone to flutter, at speeds significantly lower than normal for an aircraft of this type:

(a) If a trim tab is not irreversibly controlled it can give rise to flutter. The failure of one of the trim tab crimped connections resulted in the tab being operated by a single spring-steel wire in push-pull. The linkage was thus inherently springy. This wire was led through a curved conduit which was not anchored in any way; this would increase the springiness Adding to the propensity to flutter was the backlash in the remaining coupling, which would have allowed independent movement of about 9mm at the trailing edge of the tab. The tab had been in this condition for some time, and was evidently adequate at normal speeds. Nevertheless, it was a prime candidate for flutter, possibly at speeds below V_{ne}.

(b) The addition of the sheet aluminium bracing to the trailing edge of the elevators would have tended to move their centre of gravity aft somewhat, and was undesirable in principle.

(c) The addition of the tail-light to the trailing edge of the rudder at the point of maximum chord placed a significant extra mass at the rear of the surface and would have increased the propensity to flutter.

(d) The defective glue joints in the rear fuselage, especially those involving the diagonal braces, were likely to fail under torsional load as might be experienced at the onset of flutter of the tail surfaces. The ability of the fuselage to resist torsional loading would then decrease significantly. The resulting torsional springiness would increase the likelihood of sympathetic oscillation in other surfaces, if one surface started to flutter.

(e) Despite the tape which had been applied over the ribs of the rudder and elevator, there was no rib stitching. The absence of rib stitching would permit camber changes when the surfaces were deflected in the airstream, due to the fabric billowing. These changes would tend to drive the surfaces beyond neutral as they returned from deflection and hence encourage flutter.

The evidence of full-scale deflection of the elevators, and overtravel of the rudder, of torsional loads on the elevators, and of twisting loads from the fin and tailplane, all indicate that flutter of the tail control surfaces occurred.

2.4.6 The distortion of the trim tab hinge, indications of overtravel of the tab in both directions, and fracture of the sub spar on which it was mounted, are consistent with trim tab flutter. The asymmetrical nature of the damage to the elevators is also consistent with the trim tab being the originating point for the flutter of the tail control surfaces. The tab, being mounted at the inboard corner of the right elevator half, would produce torsional loads on that half, as evidenced by the diagonal crazing of the paint in both directions, and the failure of the diagonal ribs. The loads would then be transmitted through the solid spruce joining spar, which would attempt to rotate the other elevator half against the airflow. This process would produce the fractures of the fore and aft ribs, near the leading edge, which were found. Once the ribs failed, the ensuing loss of stiffness would exacerbate flutter. Paint cracking, and delamination of the rib tapes, indicated that the fabric had billowed.

2.4.7 Asymmetric flutter of the elevator would tend to cause torsional oscillation of the rear fuselage, which would become greater as the glue joints failed and stiffness was lost. The resulting rotation would tend to deflect the rudder and had the potential to produce sympathetic oscillation. The evidence of the rudder strike on the elevator, when that surface was at full deflection, together with the failures of the rudder ribs, confirm that this occurred. The aerodynamic forces arising from the rudder deflection were such as to cause both the fin spar to fail at the root, and the tailplane mounting to twist free from the fuselage. The aircraft would then have bunted causing the failure of the left wing mainspar.

2.5 Loss of Control

2.5.1 Flutter cannot occur unless a critical speed is exceeded, and generally needs to be triggered by some disturbance. Notwithstanding the factors which made ZK-DAG more prone to flutter than other aircraft of its type, a speed sufficient to cause flutter was unlikely to have been reached in level flight near its ceiling. Excessive speed leading to flutter could have arisen from an excursion in pitch or complete loss of control resulting from pilot incapacitation, an upset due to turbulence, or flight in cloud.

2.5.2 While the pilot's age might have predisposed him to medical incapacitation, no evidence to suggest this was found. The shattered canopy raised the possibility of a bird-strike, which also might have affected the pilot's ability to control the aircraft. However, the aircraft was seen climbing above a layer of cloud, to a region where birds are seldom encountered in New Zealand. No bird remains were found. This possibility seems remote; it is probable that the canopy was shattered by loose items in the cockpit, or by the occupants' heads, when the aircraft bunted.

2.5.3 Mechanical turbulence had been forecast up to 8000 feet, due to the combination of windshear and thermal instability. Severe turbulence could have resulted in the aircraft being thrown into an unusual attitude, and if the subsequent recovery was mishandled an overspeed was possible. However, a number of factors ran counter to this possibility.

First, the aircraft had already climbed to 5000 feet or so when last seen : had Mr Meredith begun to experience severe turbulence it would have been possible to descend to smoother air below, and return to Broadlands or proceed via Whakatane. Second, the aircraft was seen climbing above cloud, and the air there is generally smooth. Third, Mr Meredith was experienced in flying in severe weather conditions, and was unlikely to lose control even in severe turbulence. Such an occurrence was therefore improbable.

2.5.4 The possibility that Mr Meredith deliberately initiated a high speed descent for some undetermined reason could not be eliminated. However the prevailing weather suggested the most likely cause of excessive speed was an excursion in pitch, or complete loss of control, while flying in cloud. The turbulence to be expected in stratocumulus or cumulus clouds would be sufficient to initiate flutter.

2.5.5 Mr Meredith was experienced as a pilot flying under visual flight rules, but he had no instrument rating and the aircraft was inadequately equipped for flight in cloud. It can be assumed that he would not have entered cloud intentionally: if he encountered a build-up of cloud on track which extended above the aircraft's operational ceiling, he had the options of returning towards Broadlands or proceeding via Whakatane as originally planned. That he did neither suggests he experienced an emergency of some sort.

2.6 Meteorological Aspects

2.6.1 The meteorological information available to the pilot was that obtainable by direct observation and by a telephone call to his home. He knew, therefore, that the route to Whakatane was clear and that the sky was clear at his destination. He could see, to the south, a large clearance in the medium level overcast. The surface wind was light; if the upper wind was indeed a brisk north-westerly, he may have been able to see this from cloud movement above. He may have been able to see the build-up of cloud on the ranges on either side of his projected track, but in any event he would have expected it because such a build-up is commonplace in generally westerly conditions; it is not unusual to find cloud tops at about 10 000 feet over the ranges.

2.6.2 It appears that the pilot did not obtain an official meteorological forecast before departure. Taupo Flight Service Station had not opened by the time he took off and he appears not to have contacted Christchurch Information: he may not have been aware that he could obtain a forecast from that source. The Meteorological Service was unlikely to have provided him with information since, in common with most general aviation pilots, he had no PIN number. The Meteorological Service did not provide terminal forecasts for unattended aerodromes to private pilots, though these were available to commercial operators.

2.6.3 The information which was available in the General Aviation Weather was sufficiently at variance with observations that any pilot receiving it could have decided to take off and have a look at the conditions en route. Further, there was nothing contained in the forecast to preclude a flight above the tops of the low and medium level clouds over the ranges, provided that the ceiling of the upper cloud would permit it. Isolated cumulonimbus would have been avoidable and if the route from Broadlands to Waipukurau was clear the proposed flight would have been unaffected by bands of cumulonimbus drifting in from behind the aircraft.

2.6.4 There was a regulatory requirement to obtain a weather forecast, but in practice it would have been difficult for the pilot to do so, and in the case of the forecast weather at destination, it would have been impossible. Since the official forecast was at variance with actual conditions and contained nothing to suggest that the proposed flight was inadvisable, failure to obtain the forecast had no bearing on the outcome of the flight.

2.6.5 It is possible, on the information available, that the aircraft could have been flying above cloud at 10 000 feet or so, only to find cumulonimbus bursting through all round, trapping the aircraft in turbulent clouds. However, with the limited data available, the Meteorological Service was unable to determine whether the cloud tops in the area at the time were at 10 000 feet or 30 000 feet.

2.6.6 While the possibility that the aircraft was trapped by cumulonimbus development cannot be discounted, neither can it be confirmed. The probability of such an occurrence at the precise moment necessary to trap ZK-DAG must, however, be fairly small.

2.6.7 The ground rises steadily between Taupo and the ranges to the south-east. It is commonplace to find that the top of the usual area of stratocumulus in this area shelves up gently in like fashion. The top layer may have been rising, in the direction of the aircraft's flight path, at a rate such that the aircraft could not outclimb it. This might have resulted in the aircraft entering cloud inadvertently at low speed, before the pilot became aware of his predicament.

2.6.8 The stratus layer is known to have been present, and its characteristics can present a trap for non-instrument rated pilots. The probability of such an event is considered greater than that of entrapment by rapidly developing cumulonimbus. An alternative is that a loss of power may have caused the aircraft to descend into cloud.

2.7 Loss of Power

2.7.1 While the engine itself showed no signs of mechanical failure, the carburettor heating system had the potential to cause a partial or complete loss of power.

2.7.2 The carburettor air box had to be fabricated as a non-standard item, so that the air filter came to the proper place on the cowling. Wrinkling of the air box during welding prevented the valve from moving completely to the hot air position, and gave rise to a potential for the valve to jam when moved as far towards the hot air position as it would go.

2.7.3 The repairs to the changeover valve actuating lever and to the outer sleeve of the actuating cable indicate that the valve had previously stuck in the hot air position and the linkage had failed during an attempt to move it. Although the failed components had been repaired in an improvised manner, there was no sign of any attempt to dress out the wrinkling of the sidewalls of the air box, which was the root cause of the problem.

2.7.4 The changeover valve on ZK-DAG had apparently never been capable of complete operation. This would have been evident if the valve had been checked for full travel in the 'hot air' and 'cold air' positions with the air filter removed. This defect should have been found and remedied on the inspection for initial issue of the Permit to Fly, or during a subsequent inspection for renewal. At the very latest, the defect should have been remedied when the valve stuck for the first time, but the nature of the repairs indicates that these were not made by a qualified engineer.

2.7.5 The poor condition of the hot air ducting, together with the unorthodox repair to it, suggest that the pilot may not have been fully aware of the importance of effective carburettor air heating.

2.7.6 The carburettor air box defect had the potential to trap the air valve near the hot air position; the valve had been trapped before, and the witness marks and damage to the control linkage were consistent with it having been trapped on this occasion. While the damage to the actuating lever and cable could have occurred either in flight (as a result of the pilot's efforts to free it) or on impact, the valve had to be stuck for this damage to occur in either case.

2.7.7 The changeover valve was likely to have been operated at regular intervals by the pilot as a precaution against carburettor icing, and probably stuck during such operation. With the valve stuck at partial hot air, there was the possibility that ice would build up due to the air temperature being raised into the icing range, resulting in power loss and inability to maintain height.

Alternatively, the loss of power resulting from the induction of hot air might of itself have resulted in a descent, and consequent entry into cloud.

2.7.8 It is also conceivable that the pilot applied carburettor heat as a response to inadvertent entry into cloud. In that event subsequent sticking of the changeover valve would have been academic. However, while an instrument-rated pilot might have selected carburettor heat on entering cloud, it seems likely that Mr Meredith, had he entered cloud in such circumstances, would have been totally occupied in trying to keep control of the aircraft. This possibility therefore seems remote.

2.7.9 The fact of the stuck changeover valve tends to argue against the possibility that ZK-DAG was trapped by developing cumulonimbus, or inadvertently entered a rising layer of cloud. It is more likely that the sticking carburettor air box valve caused a loss of power which in turn caused the aircraft to descend into cloud over which it was flying, and this led to loss of control, overspeed, flutter and breakup of the aircraft.

2.8 Pilot Decision-Making

2.8.1 The pilot had a number of options open to him when he considered making the flight:

(a) To fly direct on track at low level
(b) To fly direct on track above cloud
(c) To fly to Whakatane and thence around the coast via Gisborne
(d) To defer the flight to a later date

2.8.2 The pilot would have known that cloud would build up on the ranges. Direct flight at low level was likely to be hazardous at best, and the pilot was unlikely to have considered it.

2.8.3 Flying direct on track above cloud, with the knowledge that the weather at destination was clear and could be expected to remain so, could have been an attractive proposition. It was the quickest way to complete the interrupted journey, the flight conditions above cloud were likely to be smooth, and such a course had sometimes been commended as preferable to trying to remain in visual meteorological conditions below cloud especially in mountainous terrain. However, with a single-engined aircraft it was open to the objection that an unforeseen event might force the aircraft to descend through cloud and strike concealed mountains, or to make a forced landing in inhospitable country. Where the aircraft was inadequately equipped for instrument flight and the pilot not instrument rated, the possibility of loss of control and in-flight break-up was very real after entry into cloud.

2.8.4 Conditions on a flight via the coast, in the lee of high ground, may have been rough but had excessive turbulence been encountered the pilot was experienced in making precautionary landings in ZK-DAG. However, this route was much longer than the direct track and if it appeared to the pilot that the short, smooth direct flight above cloud was feasible, a decision to take the direct route is understandable. A successful outcome was, however, dependent on the reliability of the engine and its ancillary equipment.

2.8.5 In the light of the actual weather conditions, with or without the forecast, the pilot's decision to attempt the flight on the day was reasonable.

3. FINDINGS

3.1 The pilot held a valid Private Pilot Licence (Aeroplane).

3.2 The aircraft's Permit to Fly had been regularly renewed and was valid at the time of the accident.

3.3 A defective carburettor air box was not detected and rectified when the aircraft was inspected for issue of the Permit to Fly or during inspection for renewal.

3.4 The carburettor air box changeover valve was stuck in a partial hot air position in flight.

3.5 Defective repairs to the carburettor heat actuating system may have failed in flight.

3.6 Loss of power associated with the sticking changeover valve may have caused the aircraft to descend into cloud.

3.7 The pilot was not instrument rated and the aircraft was inadequately equipped for flight in cloud.

3.8 In circumstances unable to be determined, but very likely while in cloud, ZK-DAG reached a speed sufficient for the onset of flutter.

3.9 The aircraft's flutter margin was compromised by a defective elevator trim tab control system and the installation of a tail light on the rudder trailing edge.

3.10 Forces arising from flutter resulted in loss of the empennage whereupon the aircraft bunted and the left wing broke off at the root.

3.11 The subsequent impact with the ground was not survivable.

3.12 The causal factors in this accident included defective construction and maintenance of the carburettor hot air system, and defective construction and maintenance of the elevator trim system.

4. SAFETY RECOMMENDATIONS

4.1 It was recommended to the President of the Amateur Aircraft Constructors Association that he adopt the following measures:

Prepare a programme to educate builders and prospective builders on:

> The need for craftsmanship, access to precision machinery and recognition of jobs which are beyond the builder's skills, and
>
> The need to evaluate any proposed changes to drawings to ensure there are no adverse consequences from incorporation of such modifications, and
>
> The need for sufficient manpower at critical stages of construction.

Provide a library of collated technical information for builders and prospective builders.

Ensure competent inspection of aircraft under construction is available by:

Selecting inspectors/designated persons who are not only sufficiently knowledgeable, but who have sufficient strength of personality to ensure proper standards of construction are met, and

Stipulating that test pieces continue to be preserved for inspection when the Regulations are changed, and

Ensuring an inspector/designated person is present when structures are enclosed.

Adopt a programme to improve the prospects of continuing airworthiness:

By requiring a mandatory strip inspection at an appropriate time interval in the life of wooden aircraft, and

Requiring inspection ports, both in fabric coverings and in closed structures.

Promulgate a requirement for independent, qualified inspection:

For renewal of a Permit to Fly, and

On the sale of an aircraft.

4.2 It was recommended to the Minister of Transport that he:

Direct that a study be made of the cost of obtaining sufficient information to enable the Meteorological Service to forecast medium-scale phenomena and that these costs be related to potential costs of aircraft accidents, and

Direct the Meteorological Service to provide Aerodrome Forecasts, using the best available information, and

Direct the Meteorological Service to sponsor a study of the best way to present weather information to general aviation pilots and to implement the system which shows the best results.

4.3 The Minister responded:

"The Meteorological Office has advised me that the present general aviation weather format was designed in consultation with the industry.

It must be pointed out, however, that while the New Zealand Meteorological Service was the only organisation supplying a formal meteorological information service to aviation in New Zealand for many years, in 1989 the previous Government decided that the Meteorological Service should be conducted on a commercial "user pays" basis. Any amendment to this decision would require not a "directive" from me but a decision by the present Government to fund services not being paid for by consumers. As I am sure you are aware, in the present economic climate it is this Government's policy that in general users of services must pay the costs of their provision.

However, the 1989 decision referred to above also opened up the prospect of contestable meteorological services and the purpose of Regulation 84A of the Civil Aviation Regulations 1953, which was introduced in September 1990, was to recognise this contestibility while ensuring that aviation safety was not compromised.

Regulation 84A requires that any meteorological report or forecast used by a pilot in command of an aircraft in accordance with the requirements of Regulations 62 and 84 must be supplied by a person or persons approved for the purpose. However, the Meteorological Service is not the only provider of meteorological information approved under the new Regulation 84A. All major organisations providing meteorological information to aviation have now been approved including the Airways Corporation, Air New Zealand and a number of other air transport operators in addition to the NZ Meteorological Service.

Regulation 84A has recently been reviewed by the Regulations Review Committee. A number of submissions received by the Committee from industry suggested that the regulation was unduly restrictive and would prevent, for example, a pilot advising another pilot of weather conditions encountered at a particular airport.

It was not the intent that the new regulation prevent such interchanges of information. The Ministry of Transport therefore suggested to the Regulations Review Committee that Regulation 84A be amended to make it plain that pilots in command must use meteorological reports or forecasts from an approved source, but that there is no restriction on them also using other reports or forecasts obtained informally. Any such amendment should also allow the use of reports or forecasts from non-approved sources where such information is not available from an approved source.

This proposal was supported by the Committee in its final recommendations on Amendment 31 to the Civil Aviation Regulations 1953, and the Ministry has included the Committee's recommendation and a proposed amendment to Regulation 84A in a list of proposed amendments to the Regulations which is currently being finalised for consultation and discussion with the aviation industry.

In conclusion, therefore, the directives which you propose in your letter are at variance with the philosophies of contestibility in relation to the overall provision of meteorological services to aviation and "user pays" relative to those services provided by the NZ Meteorological Service which have been introduced over recent years. Any change to these philosophies would require a government decision rather than a "directive" from me.

The provisions of Regulation 84A of the Civil Aviation Regulations 1953 together with the amendments now proposed to this regulation are intended to ensure that pilots can obtain weather information from the widest possible range of sources whilst ensuring that aviation safety is not compromised."

GLUED JOINT FAILURES

1. Both Aerolite and Aerodux glue had been used in unsatisfactory joints during the construction of ZK-DAG.
2. The failures appeared to lie in a number of categories:
   (a) Excessive gap — leading to glue-line failures (both glue types)
   (b) Excessive cramping pressure (Aerodux)
   (c) "Skinning over" (Aerodux)
   (d) Failure to scarify surfaces before gluing — leading to insufficient glue penetration
3. In the case of the open-frame rear fuselage, some of the excessive gaps could be attributed to lack of sizing of the members. While there is some debate as to whether wood is best used as sawn or whether it should be thicknessed it is essential, where gussets are applied to each side of a joint, that all members are of the same thickness. Otherwise, an excessive gap is inevitable (see photographs 1 and 2). This in turn implies either craftsmanship of high order, or machinery sufficiently precise to turn out finished sizes with the necessary accuracy. Aerodux may be gap-filling, but there is a difference between filling gaps of perhaps 1/64 inch (0.33 mm) and trying to make good gaps of 1/16 inch (1.32 mm) or more. (See photograph 3).
4. Aerodux (or resorcinol glue in general) requires a glue-line of finite thickness. Excessive cramping will result in squeeze-out to the extent that there is insufficient glue between the pieces to make an effective bond. Mechanical cramping should be used only with caution. (See photograph 4).
5. "Skinning-over" of resorcinol glue arises because the open-joint time of the glue, once applied to one face of a joint, may be insufficient for adequate penetration of the other face to occur. At elevated temperatures, the open-joint time may be appreciably less than the pot-life of the glue. Application of glue to both faces is highly desirable to counter this problem. "Skinning over" is more likely to be a problem where the glue is brushed on rather than applied by a spreader, since there can be little control over the thickness of the glue layer. (See photographs 5 and 6). "Skinning over" is most likely to be a problem with extensive areas of gluing which must be completed in one operation, such as application of a D-box skin. It is essential that a sufficient number of skilled helpers is on hand for such operations. If insufficient assistance is available the operation must be deferred until such time as it can be arranged.
6. Analogous to "skinning-over" is the problem with Aerolite, which starts to harden as soon as the joint is closed. If cramping is not done immediately thereafter (and especially if the joint faces move) a poor joint will result. Sufficient helpers must be available.
7. An alternative, permitting operations with fewer helpers, would be to use a slower-setting adhesive, such as some epoxies, with a long open-joint time.
8. Certain woods are known to present gluing difficulties, due to lack of penetration of the wood fibres by the glue. Plywood can present a particular problem because the production process may leave a waxy layer on the surface. It is important that the surface be scarified by sanding before

application of glue. Failure to do so will result in an apparently sound joint, but when the joint is broken it will be found that only a few fibres of the wood adhere to the glue line. (See photograph 7).

9. When test pieces are broken, the failure should be in the wood, not the glue-line. In the case of plywood, the first veneer should break away. There should be 75% wood break away on a test piece. (See photograph 8). Given the state of the glue joints on ZK-DAG, it is difficult to imagine that test pieces broke with satisfactory results. There should be a stipulation as to when test pieces are required and the existing requirement that they should have to be retained for inspection should be continued when authority for inspection is transferred to the AACA.

10. The question of inspection deserves consideration. There were a number of features which could have been seen on inspection — e.g. irregular timber sizes — which should at least have given grounds for more detailed examination.

11. Concealed areas pose a particular problem for inspectors. For example, once a leading edge D-box is closed it is impossible (short of cutting inspection ports) to determine whether it was constructed satisfactorily. In the past it has been the policy to rely on builders, who are supposed to have demonstrated a satisfactory level of competence, to build such areas properly. The number of aircraft known to have been unsatisfactorily constructed, though small in comparison to the total number of home-built aircraft, suggests that this policy is not infallible. It may be that the inspector should be present when such areas are closed off: this would give the added benefit that the inspector would be available to give advice and assistance in case of difficulty. Under the proposed new system, in which the AACA would designate an approved individual to oversee and assist a homebuilder's efforts, this requirement should be easy to meet.

12. Continuing airworthiness of wooden aircraft poses two problems: how to determine whether existing aircraft have been constructed to a satisfactory standard, and how to discover deterioration in wood or glued joints. Both problems are compounded by the use of long-life fabrics such as Ceconite, the longevity of which may be greater than the safe life of the structure. The absence of a periodical requirement for recovering deprives inspectors of the opportunity for detailed inspection of older aircraft, except during rebuilding. There may be a case for requiring a mandatory inspection after a set period (perhaps ten years) at which the covering would have to be stripped off. This would give an opportunity to detect embrittlement, oil soakage, dry rot (found in the accident under investigation), glue failure in service, corrosion, and breakage of concealed members. (Such an inspection regime was adopted by the British Gliding Association, in respect of wooden gliders).

13. It is already the procedure, in inspection of wooden gliders, to trepan inspection ports in the underside of D-box structures. These are made good with reinforcing rings and plug patches (3 per wing). For Ceconite (which cannot be zipped) plastic rings are available which can be applied during covering. Circular cloth inspection panels, which can be readily removed, are then applied: these can permit sufficient access to inspect timber and glue joints.

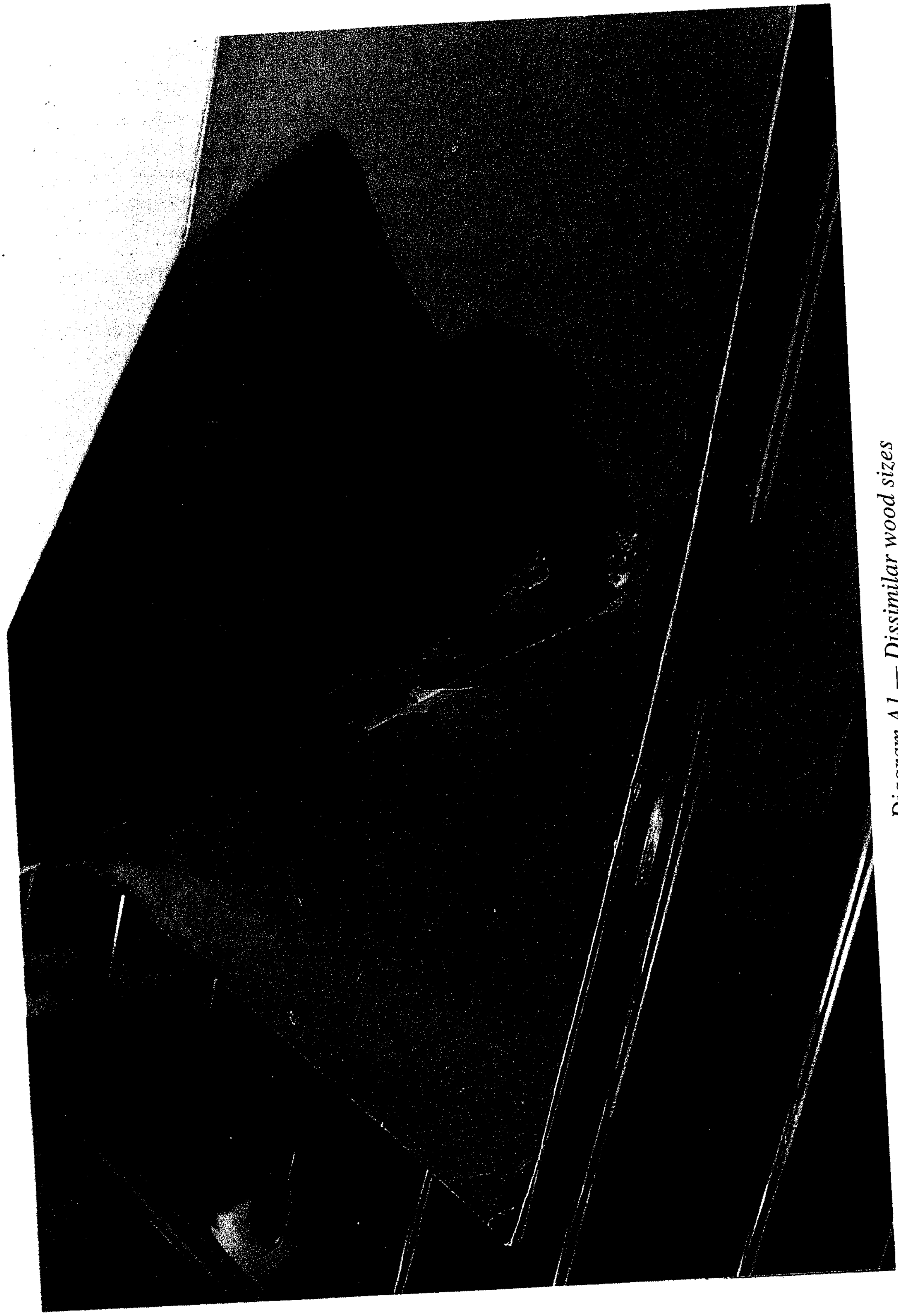


Diagram A1 — Dissimilar wood sizes

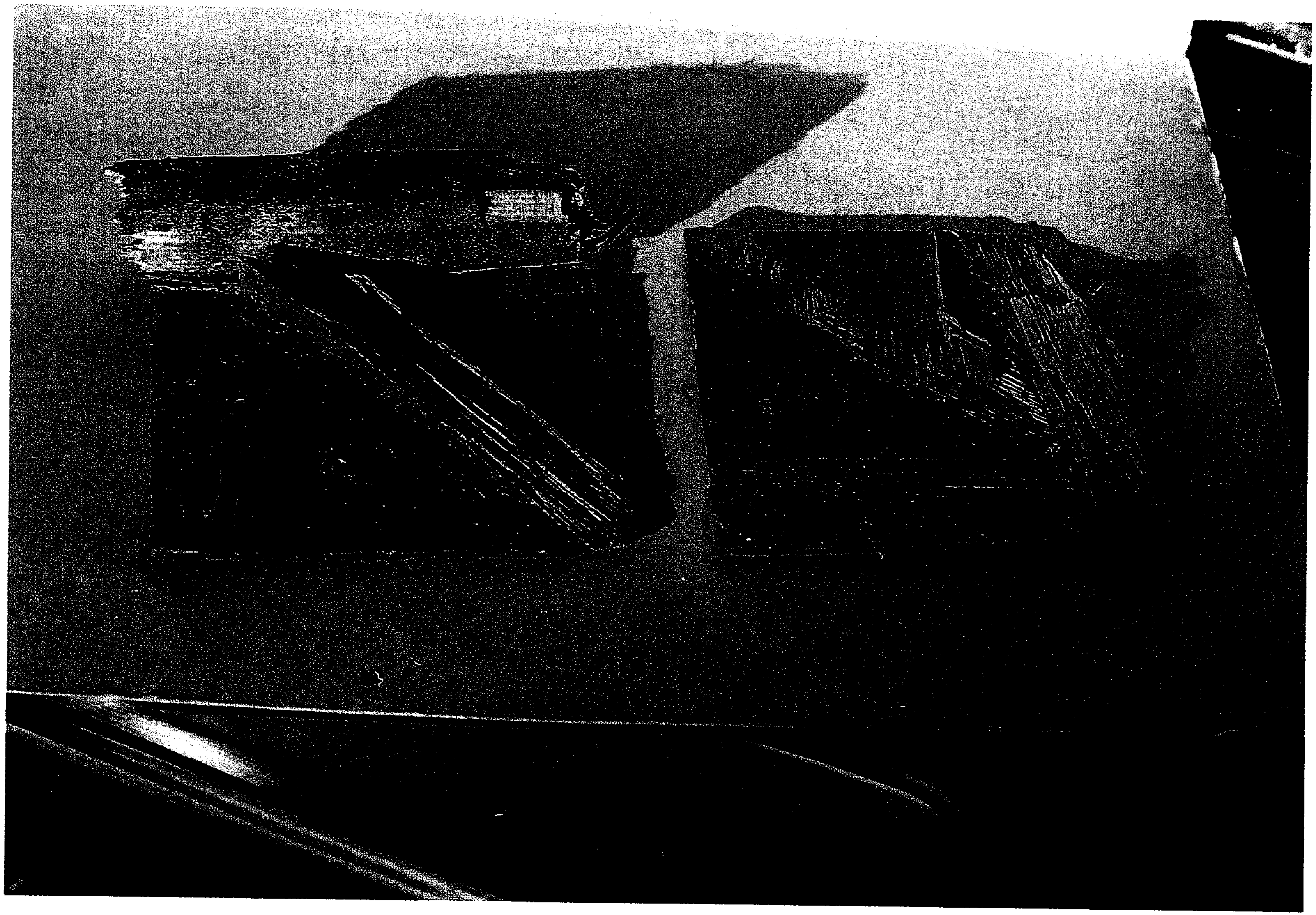


Diagram 2A — Excessive gap resulting from dissimilar used sizes

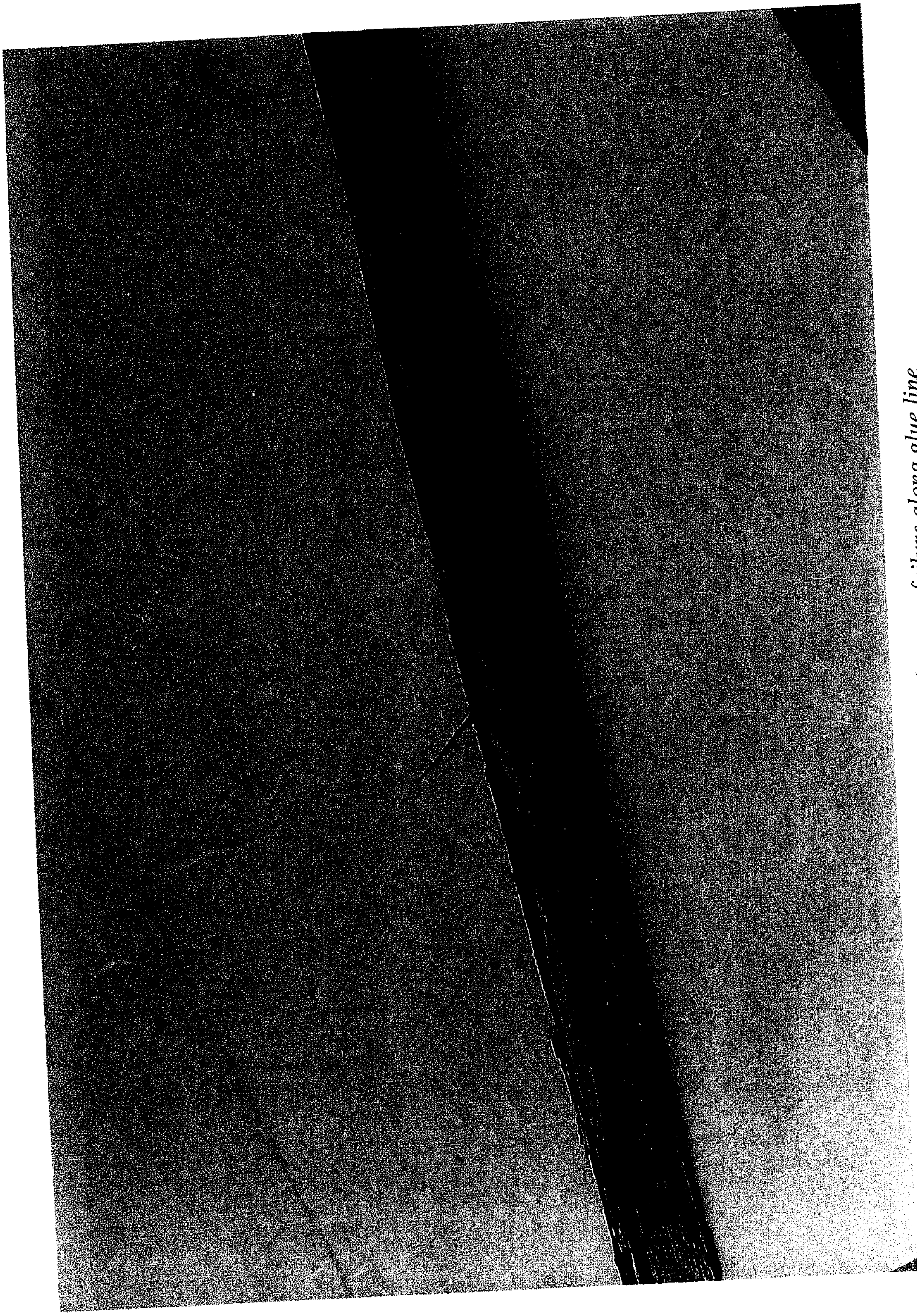


Diagram 3A — Excessive gap: failure along glue line

Diagram A4 — Overcramping of Aerodux

Diagram A5 — Skinning over: Spar web

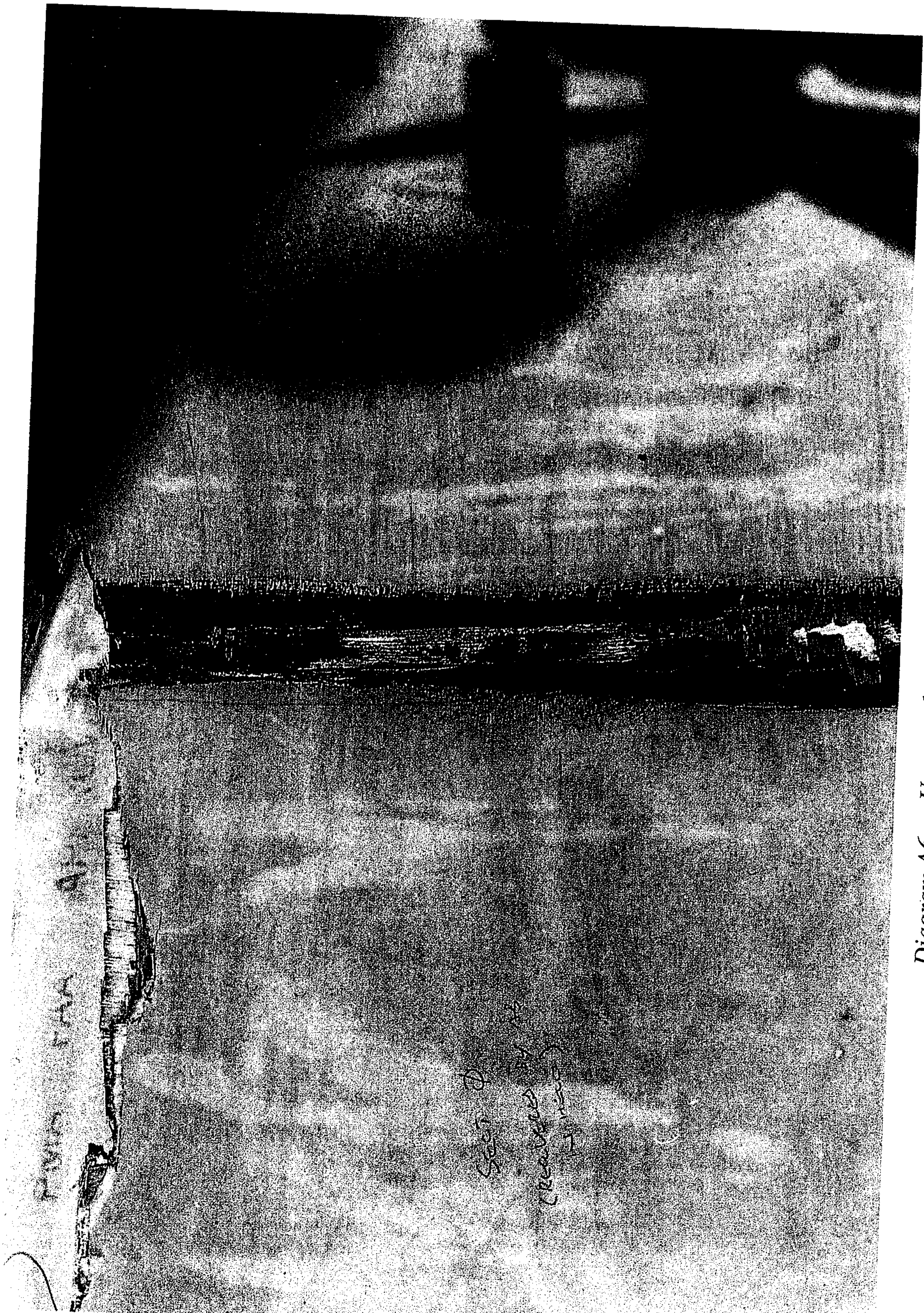


Diagram A6 — Uneven glue application by brushing

Diagram A7 — Result of inadequate preparation of plywood

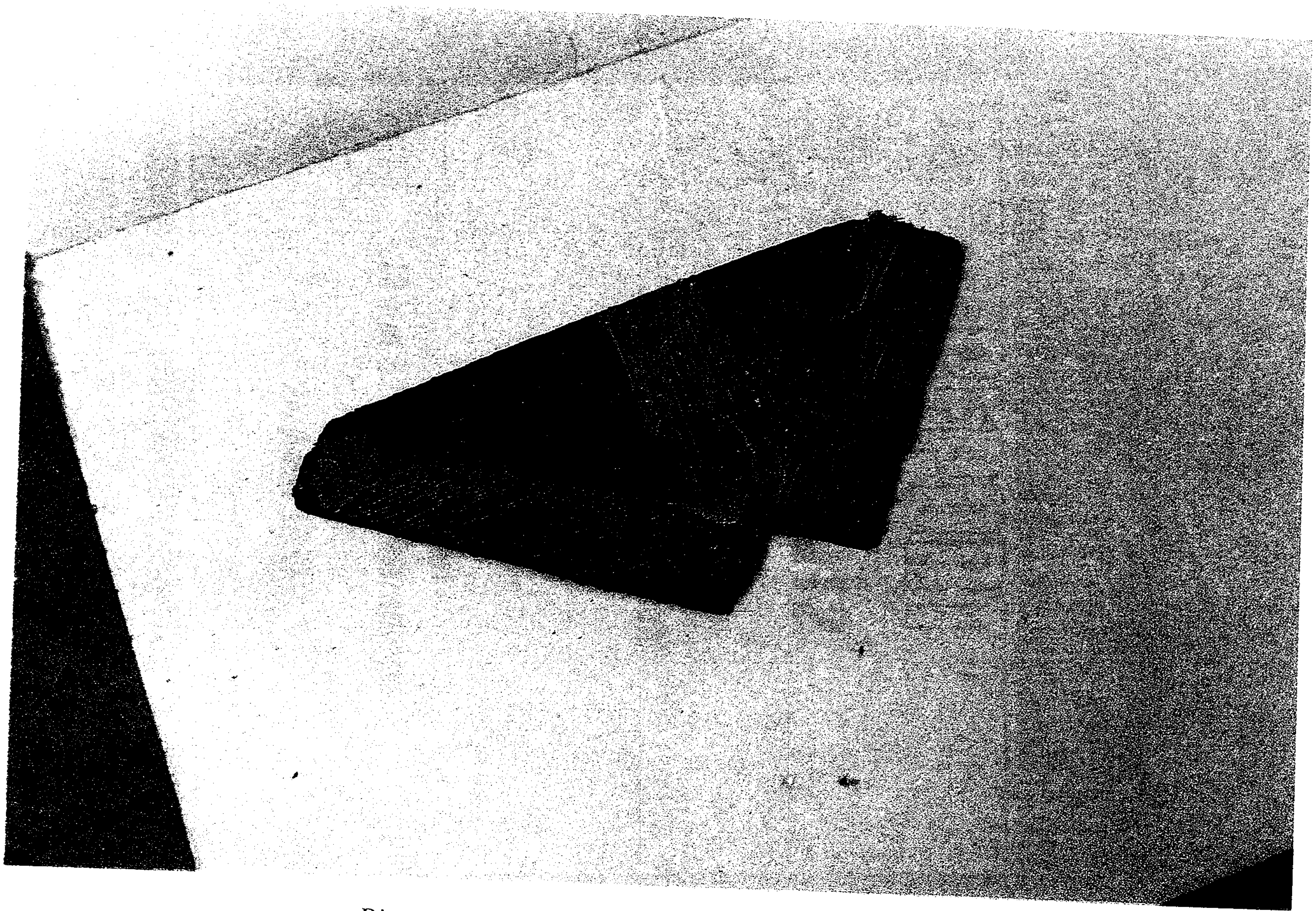


Diagram A8 — Satisfactory gluing: 75% wood breakage