No: 7/92 **Ref: EW/C92/3/5** **Category: 2c**

Aircraft Type and Registration:	Rotorway Executive, G-BMYH	
No & Type of Engines:	1 Rotorway RW 152 piston engine	
Year of Manufacture:	1986	
Date & Time (UTC):	28 March 1992 at 1520 hours	
Location:	Coalport, Shropshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - Nil
Injuries:	Crew - Fatal	Passengers - N/A
Nature of Damage:	Aircraft destroyed	
Commander's Licence:	PPL (Helicopters)	
Commander's Age:	61	
Commander's Flying Experience:	3747 hrs, including 447 on helicopters (of which 14 were on type)	
Information Source:	AAIB Field Investigation	

History of the flight

The pilot involved in this accident initially gained his PPL (Aeroplanes) in 1963, subsequently adding R/T, Night and IMC Ratings to his licence. Extensive use was made of his PA30 Twin Comanche aircraft for business and recreational purposes, until it was sold in June 1991.

Training for his PPL (Helicopters) was undertaken in a Bell Jet Ranger during 1983, and he continued flying this machine for approximately 1 year, gaining some 91 hours on type. A conversion course was then undertaken for a type rating on the Enstrom F28 series, this being successfully completed during September 1984. This type was also owned and operated for business and recreational purposes until it was sold in October 1989, the pilot having flown approximately 342 hours on type.

Apart from one flight for renewal of his Certificate of Test on the Enstrom F28 in October 1990, the pilot flew only the PA30 Twin Comanche aircraft during the period from October 1989 to May 1991. He then attended the Rotorway International factory in Phoenix, Arizona, USA, for a type conversion

course on the Rotorway Executive helicopter, flying a total of 7.5 hours under instruction between the 20 and 24 May 1991.

As there were no designated CAA examiners for this type of helicopter in the UK, a temporary examiner approval was issued by the CAA to enable the Flight Operations Manager of Rotorway International to conduct the necessary examinations and flight tests for the issue of a Rotorway Executive type rating on a UK PPL. The necessary application forms were duly signed by the Rotorway Flight Operations Manager, and submitted to the CAA for issue of the type rating in July 1991.

G-BMYH was purchased on the 8 June 1991 from the aircraft's constructor, and transported by road to the pilot's home at Callow End, near Worcester. He first flew it from his home to Chirk airfield on 26 July for maintenance, and renewal of the Permit to Fly, which had expired two days earlier. The helicopter was then test flown on 22 September, and subsequently flown back to the pilot's home. Four further flights were recorded in the period to 19 October 1991. The aircraft did not then fly again until the day of the accident, being kept on the lawn of the pilot's home with the rotor blades tied to prevent movement in wind conditions. Engine runs were apparently carried out periodically.

On the 7 March 1992, the pilot telephoned the Rotorway maintenance organisation at Chirk, informing them that he would be flying the helicopter to them on that day for maintenance, and for the fitting of a new standard of instrument panel. A further telephone call later that day cancelled the arrangement, as the helicopter had a starting problem caused by an electrical fault. The symptoms of the electrical problem were diagnosed as being due to a broken, or defective, alternator drive belt. A replacement belt was posted to the pilot's home address.

Around 1400 hrs on the 28 March, the pilot telephoned the maintenance organisation once again, to inform them that it was his intention to fly the helicopter to them that afternoon. The pilot apparently made a short flight around the area of his home before landing back. He was reported to have mentioned that the helicopter still had an electrical fault, and had attempted to cure the problem. On the next attempt to start the engine, the battery was found to be 'flat'. The engine was subsequently started using 'jump' leads from a car battery and, after disconnection of the leads, the helicopter departed normally for Chirk. Witnesses in the area estimated that the time of departure from Callow End was 1430 hrs.

No eye witness evidence was obtained concerning the flight of the helicopter between Callow End and the vicinity of the River Severn just south of Coalport, Shropshire, a distance of 27 nm. The primary radar at Clee Hill, closest to the intended route, was not operational that day, and the route was flown

at too low an altitude for reception by any other station. Since the helicopter was not equipped with a transponder, secondary radar data was not available. No record was found of any R/T transmissions from the aircraft's portable VHF communication radio to any ground station along the route. (A Southern England aeronautical chart (edition 8) recovered from the wreckage, showed a track line drawn from Callow End direct to a point on the River Severn, just south of Telford. The track then turned north west, following the river, to a point just south of Shrewsbury, thence direct to Chirk. Previous flights between Callow End and Chirk were recorded in the pilot's log book as having taken some 1 hour and 5 minutes, for a distance of 58 nm. No flight log was recovered.)

At approximately 1510 hrs, the helicopter was observed by a witness to be following the River Severn, approximately one mile south of the accident site. The helicopter was described as having a relatively high engine rpm note, but was not travelling at great speed. Several other witnesses, in and around the river valley, observed the helicopter to be crossing a tree-lined ridge, heading in a north north westerly direction, at an altitude of approximately 400 feet agl. At around 1520 hrs, the witnesses heard a sudden metallic 'cracking' sound, followed by several other metallic impact noises. The main body of the helicopter was then seen to pitch down by some 45°, with part of the tailboom broken away and rotated through 90° to the left of the main body. Several small pieces were also observed to be falling from the helicopter.

Witnesses reported that as the helicopter fell, the engine rpm note remained constant, or possibly increased. The main rotor blades were observed to continue to turn, and the main body of the helicopter was observed to rotate as it fell. Witnesses saw the helicopter enter the tops of trees adjacent to the river bank. The emergency services were alerted, and several witnesses proceeded to the wreckage site to render assistance. There was no fire. The pilot was found a short distance from the main body of the helicopter by the first witness on the scene, who also administered first aid. A Police helicopter was rapidly deployed to transport the injured pilot to hospital. However the pilot died from his injuries some hours later.

A meteorological aftercast for the Coalport area indicated that, at the time of the accident, a warm front was lying from Manchester to Gloucester, moving slowly eastwards, with a westerly airstream over the area. The visibility was 10 to 15 km, with outbreaks of intermittent slight rain (although witnesses reported that it was not raining at the time). The only relevant cloud was scattered/broken strato-cumulus, base 2000 ft. The mean sea level pressure was 1008 mb, surface temperature +6°C, with a wind of 280°/8 kt at the surface, and 14 kt at 2000 ft.

Impact parameters

The helicopter had crashed into an area of mature woodland on the steeply sloping east bank of the River Severn near Coalport, with the fuselage having come to rest some twenty metres from the water's edge. It was evident from the damage caused to the trees that it had been descending with a high vertical speed, that its trajectory had been at approximately 45° to the horizontal and that its track had been approximately northerly. As the helicopter entered the trees, the tailboom (complete with fin and tail rotor) had lodged in a 'fork' of the trunk close to the top of a tree, some 60 ft above the local ground level. The tailboom had suffered a complete structural failure about its point of support in the tree, *ie* within the area of the horizontal stabiliser, but had not separated since the tail rotor drive belt in this part of the boom had remained intact. The bulk of the fuselage had struck the ground on its left lower quarter, failing the skid landing gear on that side. The tubular steel frame of the fuselage, however, had remained largely undistorted. Debris from the fuselage, including the contents of a large cardboard box strapped into the right seat, was scattered locally around the fuselage.

Wreckage examination - general

An initial on site examination of the two-bladed helicopter revealed that most of its structure could be identified, but with the significant exception of the left side (pilot's) door and the lower aluminium skin from one of the two main rotor blades (MRBs). The other three skins were essentially intact and either attached to the blade spars or found local to the wreckage. One blade spar was intact but distorted, the other having been broken into three sections by its passage through the trees, but both root sections had remained attached to the rotor mast. A search of the ground beneath the helicopter's track leading up to the impact site revealed the missing items, which had fallen in a relatively localised area some 200 metres before the entry point of the fuselage into the trees. The door was relatively undamaged, but the blade skin had been torn into 7 sections, all of which had received at least one strike from the main rotor. The tail rotor exhibited no evidence of rotation or damage, suggesting that it had ceased to rotate before entering the trees. The tailboom had separated from the fuselage just aft of its bolted attachment to the fuselage framework, the nature of the failure suggesting that this had occurred in flight, rather than on contact with the tree. Witness marks around the failure, from a rubber seal on the fuselage fairings, suggested that the tailboom had been moving relative to the fuselage prior to failure and that it had then separated by collapsing to the left. Examination of the fracture surfaces revealed no pre-existing defects.

The wreckage was taken to the AAIB facility at Farnborough for detailed examination, which was carried out in conjunction with the manufacturer. This examination revealed, with the exception of the

detached door, MRB skin and tailboom, that all damage present could be accounted for as a result of the impact with the trees and the ground. There was evidence to show that the engine had been running at high speed at the time, and that the main rotor had been turning. The engine was free to turn, with four even cylinder compressions, the transmission to the main rotor was intact and the freewheel unit was serviceable. The 'teeter' stops on each blade root had both been severely distorted by contact with the mast, but there was no evidence of a strike by either main rotor blade on the tailboom. There were adequate quantities of fuel, oil and engine coolant on board, the related systems having remained free of leakage after the accident. The flying control connections from the cyclic and collective levers were still connected through to the rotor mast and free to operate, but the teleflex cable to the tail rotor had been pulled from its attachment at the yaw pedal mechanism in the cockpit as the tail boom separated from the fuselage. This system was, however, free to operate. Only one of the drive belts to the tail rotor had broken, that which spanned the tailboom failure area, and this was found amongst the wreckage of the fuselage. Despite detailed inspection, no evidence was found of contact between the detached door and the main rotor, tail rotor or tailboom. The pilot's harness was examined and found to be serviceable. There were no signs that it had strained in the impact and it was reported that it had been found undone by the first persons to arrive at the scene of the accident, and that the pilot was found lying in front of the wreckage.

One of the wires associated with the alternator, ie that supplying the field current, was found to have detached at its entry point to a crimped connector. Although there was no impact damage on the airframe adjacent to this failure, it could not be positively established if this separation had been precipitated by the impact, or had been pre-existing. The general examination of the helicopter revealed that surface corrosion was present on most of the aluminium castings, alternator, water pump steel bolt heads, control rod ends, etc.. The level of this corrosion was consistent with reports that the helicopter had been parked in the open throughout the 1991/1992 winter period.

Main rotor blade (MRB) description

The asymmetrical section of the main rotor blades on this helicopter consists of a constant section extruded aluminium alloy spar, to which is bonded an upper and lower aluminium alloy trailing edge skin, as illustrated in Figure 1. These skins are also blind-riveted to the spar over the outer 50% of its span. The trailing edge is both bonded and riveted together. There is no honeycomb or other filler within the blade interior. The blades are vented by holes drilled through the root end and tip closure blocks. The blades are supplied to the builder, as in this case, with most of the basic bonding and rivetting operations already carried out, the builder then being required to add the root end straps, doubler plates, tip weights and closure blocks. If necessary, the builder is also allowed to apply a

filler material over the areas of skin/spar joints such that this area may be sanded down to produce a smooth aerodynamic profile. It was, and is still, strongly recommended by the kit manufacturer that the blades are painted prior to final balancing.

MRB examination

The as found distribution of the fragmented skin from one MRB in relation to the main wreckage suggested that detachment of this skin had occurred early in, or at the start of, the break-up sequence of the helicopter. Both rotor blades were therefore subjected to a detailed examination. It was established that all fractures and tears of the aluminium spars were not associated with fatigue cracking or corrosion, and that the material conformed to the manufacturers specification for 2024-T3 aluminium alloy. There were no signs that either rotor blade had suffered any birdstrike, or made contact with any other foreign object.

The areas of bonding were also examined and, in the main, exhibited no signs of any significant pre-existing defect. However, examination of the bonded regions between the spars and skins at the tip of the 'slave' blade revealed that disbonding had occurred due to the ingress of water (aqueous disbonding) over a length of approximately 4 inches inboard from the tip on the upper surface, and over a length of 12 inches on the lower surface. An area of disbond was also present up to 4 inches in from the tip on the upper surface of the 'master' blade. The limit of the disbond was equi-spaced between rivets 2 and 3 on the upper surface and centered on rivet 3 on the lower surface (Figures 2 and 3). Another area of aqueous disbonding was present at the trailing edge join between the upper and lower skins between the outermost two rivet locations. This was of particular interest since it was coincident with a region of pre-existing upwards deformation/separation of the skins which was evident at the trailing edge on one of the blades on a photograph (Figure 4) taken of the helicopter shortly before it departed on the accident flight. Figure 5 shows a computer-enhanced enlargement of this area. Examination of the skins of both blades at this point showed nothing of interest on the 'master' blade, but on the 'slave' blade both skins exhibited a nearly identical upward distortion in this area. Additionally, there were a series of spanwise witness marks on the outer surface of the lower skin in the affected area, the appearance of which suggested that they existed prior to the accident. Similar marks, however, were present at other locations along the trailing edge, although not to quite the same extent, and may have been associated with the manufacture of the blade skins.

The failure directions of the rivets attaching the lower skin to the spar in this region were also examined. This indicated that that the skin had separated by lifting initially between rivets 2 and 4, as indicated in Figure 2, pulling the skin rearwards over the rivet heads in the case of rivets 4 and 5 and failing the head in tension in the case of rivet 3. The skin had then pulled over rivet heads 1 and 2 in a

direction which was approximately 45° inboard/rearwards and that retained by rivet 6 had pulled from this rivet in a direction that was approximately 70° outboard/rearwards. The screws which had attached the end of the lower skin to the wooden tip block had also pulled through the skin due to displacement of the skin in a direction which was approximately 45° forwards/inboard, indicating that the end of the lower skin had pivoted inboard about its outermost trailing-edge point. Examination of the remaining portions of the rivets that had attached the lower skin to the spar indicated that this area of skin had peeled off in an inboard direction. It was apparent from this, and a tightly curled section of the lower skin which had remained attached at the blade root, that most of the lower skin had peeled off the spar inboard and rearwards, in a rapid manner.

It therefore appeared likely that the primary reason for the detachment of the bottom skin from the 'slave' blade was because an area of adhesive disbond had developed between the skin and the spar, extending approximately 12 inches inboard from the blade tip. If, as was reported, this helicopter had been exposed to the elements for the whole of the preceding winter period, the effect of ingress of water between the spar and layer of adhesive would have been accelerated by freezing of the contained water film. It was not established whether or not this failure had been influenced by the pre-existing distortion and disbond of the skins which was apparent at the trailing-edge in this region.

Helicopter history

The Rotorway Executive helicopter is a two seat piston engine powered light helicopter, with a teetering rotor, which was assembled from a kit of parts. The kits were manufactured in the USA by Rotorway Aircraft, of Phoenix, Arizona, a company which has since ceased trading but which was taken over in 1990 to become Rotorway International. A development of the Executive helicopter, the Executive 90, is currently being produced in kit form and many parts, including the main rotor blades, are common to both types. As is fairly common with kit-based homebuilt aircraft, the more difficult (and often the more critical) parts to be fabricated are produced in the factory under controlled conditions, leaving the home builder the relatively straightforward task of assembly, detailed finishing and testing. In the USA, the Executive and Executive 90 are in the Experimental Category of aircraft, which in the UK may only be issued with a Permit to Fly, since the CAA does not grant a full Certificate of Airworthiness to such aircraft. The type was accepted onto the British Register by the CAA on the basis of its satisfactory in-service record in the USA.

G-BMYH was assembled in the UK in 1987 and first flew on 17 February 1988. Following a period of test flying and evaluation by the CAA, it was issued with a Permit to Fly which, after one renewal, expired on 24 July 1991. After that date a new Permit to Fly was issued, but for the purposes of testing only, covering the periods 20 September 1991 to 19 October 1991, and 29 November 1991 to

28 December 1991. Prior to this the helicopter had been inspected and a Flight Release Certificate was issued by the CAA approved licensed engineer for this helicopter type, which expired on 12 October 1991. Subject to the rectification of a problem associated with vibration at high speed, and the fitment of a low voltage warning light, the CAA were prepared at that time to grant the renewal of the Permit to Fly. However, no application was made and, therefore, at the time of the accident there was no Permit valid for the helicopter.

At the time of the accident the engine hours meter had recorded a total of some 75 hours. The last flight of this helicopter prior to the accident, as recorded in the airframe log book, was on 19 October 1991 at a total time of 60 hours and 28 minutes, a date which coincided with the last entry in the pilot's log book.

Weight & balance

The loading information which was recovered indicated that G-BMYH was last weighed during May 1988. A weight and centre of gravity schedule was prepared from that data.

If the Rotorway Executive helicopter is to be flown solo, the battery must be fitted in the forward compartment and, depending upon the weight of the pilot, ballast carried in the passenger (right) seat. Ballast weights may also be required to be fitted to the right skid and/or forward battery compartment, in order to maintain the correct cyclic stick trim pressures in hover, or cruise.

For flying with two persons on board, the battery must be repositioned to the rear compartment, the skid ballast weight removed, and an amount of ballast added to the battery box depending on the exact weights of the occupants.

The weight chart recovered from G-BMYH indicated that it had been prepared for a pilot weight of 176 lb. The pilot involved in this accident weighed some 211 lb. The chart gave combinations of ballast loadings for pilots up to 200 lb. It indicated that for a 200 lb solo pilot, 50 lb of ballast would be required in the right seat, 5 lb of ballast on the right skid, and zero in the forward battery compartment.

Examination of the wreckage revealed that 25lb of spare parts had been located on the right seat, with 18 lb of ballast attached to the right skid (the quoted maximum allowable was 10 lb), and 5 lb of ballast located in the forward battery compartment. Given these figures, the helicopter weight at the time of the accident was calculated to have been 1198 lb. This was within the maximum allowable weight of 1320 lb for this type of helicopter.

Operation of the helicopter outside the balance limitations laid down by the manufacturer can lead to the onset of vibration at higher speeds. Flight test reports prepared for the renewal of the Permit to Fly for G-BMYH indicated that excessive vibration had occurred above 80 kts on test flights in May 1990, and in September 1991.

MRB pre-flight checks

In the manuals for the helicopter two references were made to checking, prior to flight, for delamination of the main rotor blade skins from the spar. In these documents it was advised that delamination would cause a crack to appear in the filler material covering the join between spar and skin. Additionally, the manufacturer advised that the coat of paint that was recommended to be applied to all blades would also give an early indication of disbonding by 'cracking' in the affected region. A 'tap' test method, using a small coin which identifies a disbonded region by changes in the sound made by the 'tap', is also known to be effective. The manufacturer also stresses the importance of painting the blades with respect towards improving their resistance to the effects of weather. The blades from G-BMYH exhibited little signs of filler, and were unpainted.

To date, the manufacturer has several sets of blades approaching 1000 hours total time, none of which are reported to have suffered any disbonding of their skins. Additionally, the documented accident history of the Executive and Executive 90 contained no records of skin disbonding having caused accidents, but such skin detachment has reportedly occurred following, for example, blade strikes on the tailboom. Since January 1992, MRB's for the Executive 90 have been manufactured with double the number of rivets along the spar-to-skin joints over the outer 50% of the blade span.

Safety Recommendations

On the basis of the known history of this model of helicopter, the design and manufacture of this type of rotor blade would appear adequate. However, the evidence of aqueous disbonding in the tip regions of the blades from G-BMYH demonstrates that the integrity of the blade can be compromised if attention is not paid to sealing the exposed areas of adhesive against the ingress of moisture. The following Safety Recommendations have therefore been made:

92-43 The CAA consider the requirement for an appropriate calendar time inspection of the main rotor blades on Rotorway Executive and Executive 90 helicopters, by a suitably qualified person, and require that all such blades should be painted.

92-44 The manufacturer of Rotorway Executive and Executive 90 helicopters should publish suitable advice on the storage of this type of helicopter, and this should be included in the construction and operating manuals.

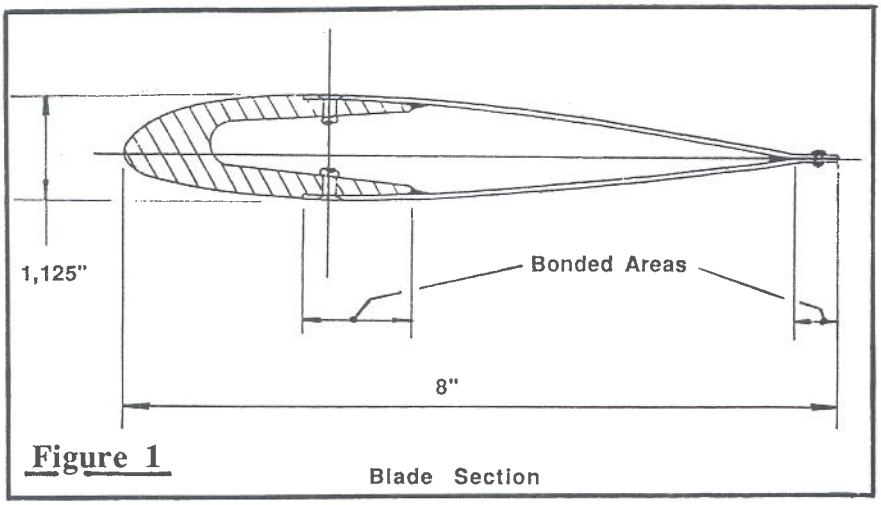


Figure 1

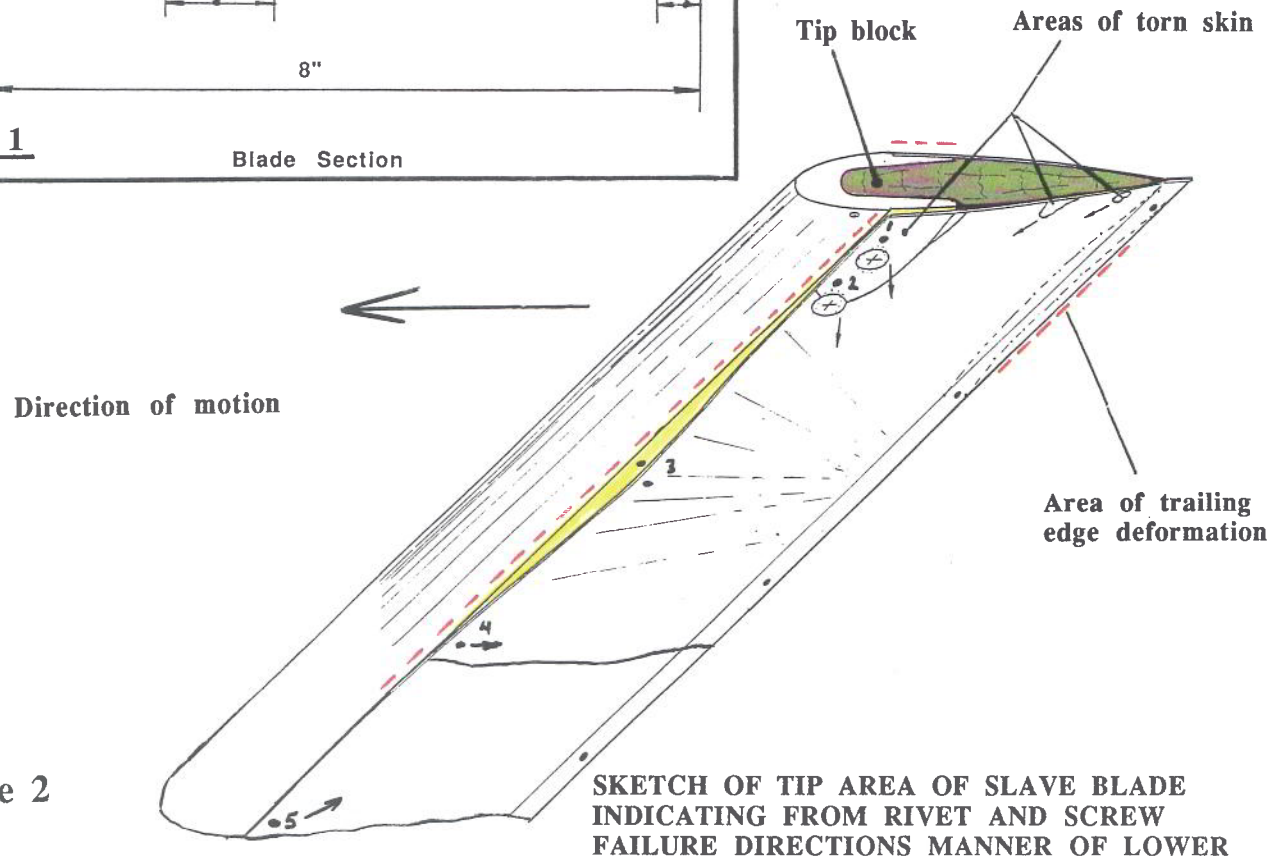
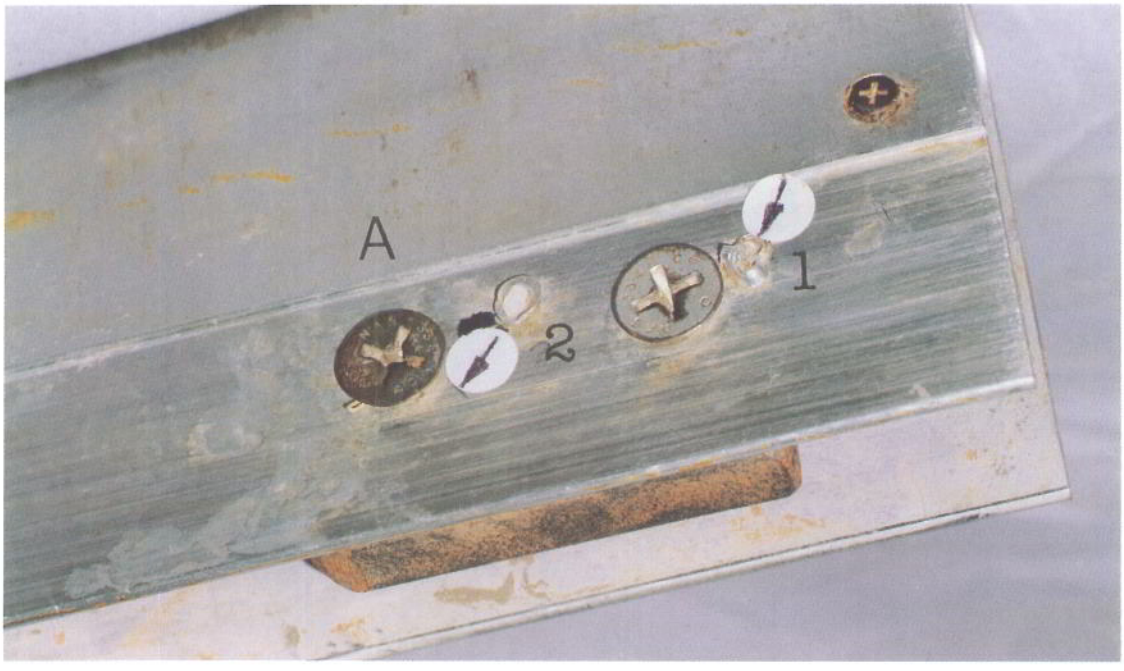


Figure 2

SKETCH OF TIP AREA OF SLAVE BLADE INDICATING FROM RIVET AND SCREW FAILURE DIRECTIONS MANNER OF LOWER SKIN DETACHMENT

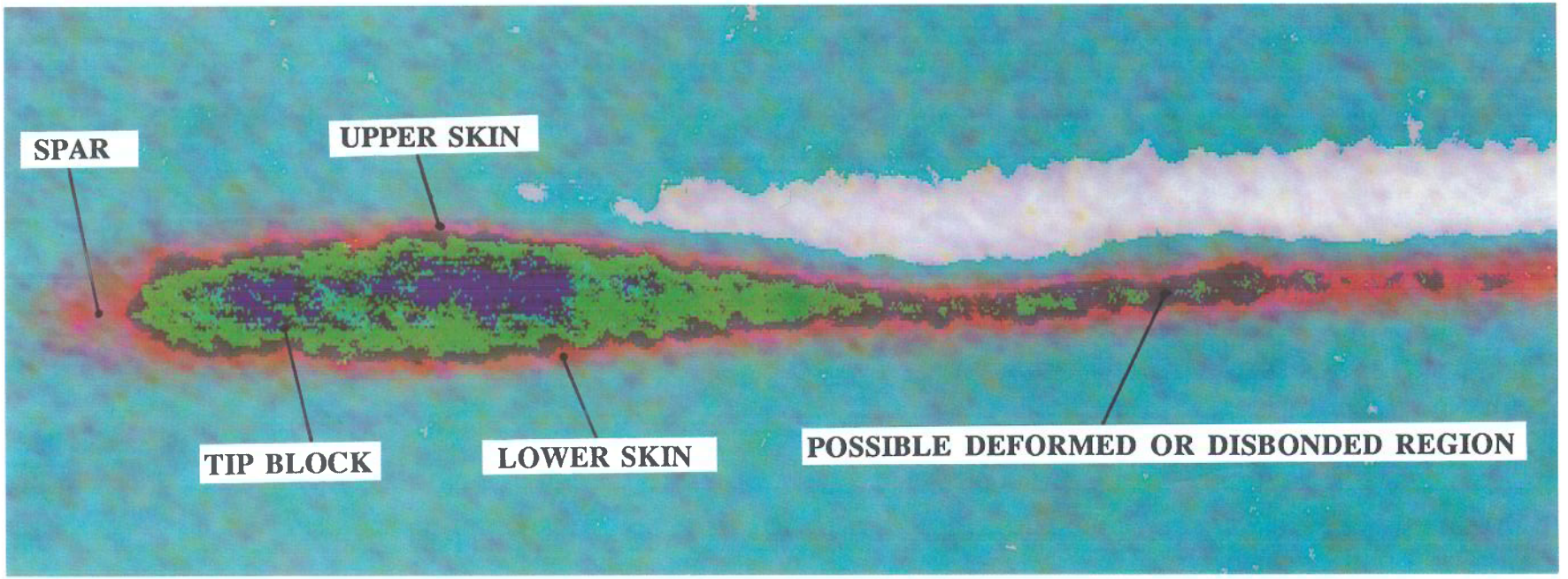


Tip section of blade lower surface showing evidence of aqueous disbonding

Figure 3

Photograph of G-BMYH taken shortly before the accident flight

Figure 4



Computer Contrast Enhancement of tip area

Figure 5