Department of Trade

ACCIDENTS INVESTIGATION BRANCH

Piper PA 31 (Navajo) G-BBPC report on the accident at Walney Island Channel, Cumbria, on 26 November 1976

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Department of Trade
Accidents Investigation Branch
Kingsgate House
66-74 Victoria Street
London SW1E 6SJ

16 December 1977

The Rt Honourable Edmund Dell MP
Secretary of State for Trade

Sir,

I have the honour to submit the report by Mr P J Bardon an Inspector of Accidents, on the circumstances of the accident to Piper PA 31 (Navajo) G-BBPC which occurred at Walney Island Channel, Cumbria on 26 November 1976.

I have the honour to be
Sir
Your obedient Servant

W H Tench
Chief Inspector of Accidents

Accidents Investigation Branch
Aircraft Accident Report No. 12/77
(EW/C 581)

Operator:	Vickers Ltd
Aircraft Type:	Piper PA 31 (Navajo)
Model:	Executive
Nationality:	United Kingdom
Registration:	G-BBPC
Place of Accident:	Walney Island Channel, Cumbria 54° 08′ N 03° 15′ W
Date and time of Accident:	26 November 1976 at approximately 2005 hrs

All times in this report are GMT

Synopsis

The accident was notified on 26 November 1976 by the Penrith police and London Air Traffic Control Centre (LATCC). The investigation was carried out by operations and engineering personnel of the Accidents Investigation Branch, and human factors personnel of the RAF Institute of Pathology and Tropical Medicine were consulted.

The accident occurred at night as the pilot was making an approach to land on Runway 30 at Walney Island aerodrome. The aircraft under-shot the runway and crashed into the west bank of Walney Island Channel, approximately 90 metres short and 6.1 metres below the level of the runway. The pilot was killed and two of the five passengers were seriously injured.

It is concluded that the undershoot occurred whilst the pilot was making a difficult approach to a poorly lit runway in adverse weather conditions. Tiredness, lack of food and poor visual accommodation were probably contributory factors.

1. Factual Information

1.1 History of the flight

The aircraft was operating a company communications flight from Edinburgh to Walney Island (Barrow in Furness) and departed from Edinburgh at 1908 hrs with five passengers on board, one of whom occupied the right hand pilot's seat. The flight proceeded normally on airways at Flight Level (FL) 80 until leaving controlled airspace south of Dean Cross at 1940 hrs, when the pilot contacted Walney Island aerodrome and requested the latest weather and landing information. The tower reported that there was heavy rain and a strong wind from 300 degrees at 25 to 30 knots, and the pilot was advised that the runway in use was 30 and the QFE 1001. It was a dark night with an estimated visibility of 8 km.

The aircraft was next in contact with Walney Island at 1952 hrs when the pilot queried the serviceability of the non-directional beacon (NDB) 'WL'. The tower replied that it was operating.

The passenger in the right hand seat states that at about this time the lights of Barrow in Furness could be seen intermittently through the cloud, but that the pilot was unable to see the runway lights. The pilot then requested the other runway lights to be put on, and the tower confirmed that all the lights were on. A short while later, the pilot called to say that he was on a left hand base leg for Runway 30 and he received clearance to land. The wind was reported to the aircraft at that stage as 300 degrees, 25-30 knots and the weather as continuous rain.

The aircraft was observed to make its approach over the slag bank to the south-east of the airfield; one witness stated that as it crossed Walney Channel the aircraft was lower than normal. (See Appendix A).

The passenger in the right hand pilot seat states that the approach appeared normal; the landing lights were on and the left hand wind screen wiper was operating and he could see the runway sodium lights ahead. He was next aware of a sudden increase in engine power and looking ahead, he saw that the runway lights had disappeared from view. He then saw some trees illuminated by the landing lights and immediately afterwards felt the aircraft's impact with the ground.

When the aircraft failed to appear on the runway, the tower operator ordered the emergency services to search the approach end of Runway 30. Some difficulty was experienced in locating the aircraft which had crashed below aerodrome level into the west bank of Walney Channel and was out of view. It was only when one of the passengers had extricated himself from the wreckage and climbed the bank, that the aircraft was found. There was no fire, but the aircraft was substantially damaged. The pilot received fatal injuries, and two of the passengers, including the one in the right hand pilot's seat were seriously injured.

1.2 Injuries to persons

Injuries	Crew	Passengers	Other
Fatal	1	Nil	Nil
Non-fatal	-	2	-
None	-	3	

1.3 **Damage to aircraft**

Substantial

1.4 **Other damage**

None

1.5 **Personnel information – the pilot**

Age:	54 years.
Licence:	Commercial Pilot's Licence valid until 15 February 1986.
Medical certificate:	Last medical examination 4 June 1976 valid until 4 December 1976. Limitations: Holder to have available spectacles which correct for near vision whilst exercising the privileges of the licence.
Aircraft ratings:	Group A & B.
RTF licence:	Restricted to VHF only.
Certificate of experience:	Group A & B valid until 5 June 1977.
Instrument rating:	Valid until 5 August 1977.
Total flying experience:	Not established; in excess of 10,000 hours.
Total hours as pilot in command:	No recent record available: As of July 1973, 7,085.
Hours in command on type:	Not established, current log book not located.
Hours during previous 28 days:	75 hours 10 minutes.

The pilot was one of the company's most experienced pilots and had been employed by Vickers Ltd since 1973. Though he had operated into Walney Island many times, it is not known how often he had landed at night on Runway 30 or when was the last occasion. The accident flight was the sixth sector flown by the pilot that day and the fifth since 1500 hrs. Between operating the first and second sector the pilot was off duty from approximately 0915 hrs to 1500 hrs. During that period the pilot took lunch at approximately 1300 hrs.

1.6 **Aircraft information**

(a)	Type:	PA 31 Navajo.
	Date of manufacture:	1972.
	Certificate of Airworthiness: (C of A)	Private category valid until 21 December 1976.

Flying hours:	(1) Since new: 1,647 hours 50 minutes.	
	(2) Since last check (CE 7): 35 hours 05 minutes.	
	(3) Since last renewal of C of A: 752 hours.	
Engines:	Two Lycoming T10 – 540 – A2C, manufactured 1972 (new with aircraft).	
Total engine running time:	1,647 hours 50 minutes.	
Since last check (CE 8):	15 hours.	
(b) Maximum weight authorised:	6,500 lb.	
Estimated take-off weight:	6,560 lb.	
Estimated weight at time of accident.	6,404 lb.	
Centre of gravity range: (aft of datum)	Maximum Forward	Maximum Aft
	6,500 lb – 134 inches	138 inches
	6,000 lb – 128.5 "	- " -
	4,800 lb – 120 "	- " -
Estimated centre of gravity at time of accident:	131.46 inches	
(c) Type of Fuel	Avgas 100 L	

1.7 Meteorological information

1.7.1 Glasgow–Walney Island en-route weather

There is no meteorological service available at Walney Island aerodrome and weather information is obtained from Preston. Although there is no evidence that the pilot visited the Edinburgh Meteorological Office before his departure at 1908 hrs, a forecast had been requested for the Walney Island to Edinburgh flight at 1800 hrs. Having thus flown the route twice during the day and taking into account the pilot's experience he would have been familiar with *en-route* conditions. He could also have made use of the London VOLMET (north) broadcasts.

1.7.2 Walney Island weather conditions at 2005 hrs

Witnesses on the ground at the time of the accident stated that there was a strong north-west wind with rain and that the visibility was estimated as 8 km. An appreciation prepared by the Meteorological Office at Bracknell for the period 1900 to 2045 hrs is as follows:

'Synoptic situation

A cold front moving eastwards cleared Walney Island by 1730 hrs. A following trough, some 60 nm behind this front reached Walney Island at 1930 hrs, but the clearance behind the trough did not reach the area until 2030/2045 hrs.

Weather conditions

Cloudy, hill fog and rain, the rain persisting until perhaps 2045 hrs, being moderate intensity at the time of the accident.

Surface wind

270 degrees veering to 300 degrees 24-30 kts as the leading edge of the trough reached the area, with possibility of gusts up to 45 kts.

Upper wind

2,000 feet	300/55 kts
5,000 feet	300/45 kts

With winds of this magnitude, wind shear is unlikely to have been significant at the levels from surface to 2,000 feet.

Clouds

8/8 total, base 800 – 1,000 feet amsl, with tops over 15,000 feet.

Turbulence

Moderate to severe and could well have been affected by the slag bank on the approach to Runway (RW) 30. It is likely that this turbulence would extend to several times the height of the slag bank, but it is difficult to give any accurate assessment.

Mean sea level pressure

Approximately 1002 mb.

Comments

The passage of the trough was in most places characterised by strong gusty winds, moderate or severe low level turbulence and moderate precipitation. This may have reached maximum intensity over Walney Island at around 2000 hrs, the time of the accident'.

1.8 Aids to navigation

The only navigation aid available at Walney Island is a radio beacon 'WL' (282.5 kHz) situated on the aerodrome alongside the control tower. Normal cloud break procedure for company aircraft arriving from Edinburgh would be to fly overhead the beacon at 3,000 feet QFE and turn on to a heading of 220 degrees magnetic descending over the Irish Sea to secure visual meteorological conditions (VMC) and then return to the aerodrome. The radio beacon was operating at the time of the accident.

1.9 Communications

Communications between the aircraft and ATC were routine during the flight from Edinburgh and RTF recordings were available until the time of departing from the controlled airspace in the vicinity of Dean Cross at 1940 hrs. As Walney Island aerodrome is private and there are no radio aids for precision approaches, there is no requirement for the recording of radio transmissions and no recording apparatus was available. Communications with Walney Island on 129.9 MHz were normal at the time of the accident.

The tower operator on duty in Walney Island ATC at the time of the accident was an airfield clerk and was not a licensed air traffic control officer. There was no requirement that the tower operator should be licensed to handle this aircraft movement.

1.10 Aerodrome and ground facilities

1.10.1 Aerodrome information

Barrow-Walney Island aerodrome has an elevation of 47 feet and is privately operated and administered by Vickers Ltd. It has three tarmac runways, the dimensions of which are as follows:

RW	*Dimensions*
06/24	1018 x 46m
12/30	1196 x 46m
18/36	909 x 46m

The aerodrome has a licence and can be used during daylight hours as a place for take-off and landing of aircraft engaged in flights for the purpose of public transport. The flights undertaken by the company's aircraft were not classified as public transport flights.

The aerodrome was last inspected by the CAA in September 1976 and the Inspecting Officers Observations were as follows:

> 'The aerodrome is little used by other than company aircraft and is adequate for its requirements. Runway 18/36 has been re-surfaced and installed with lights to the requirements of the company which they do not wish to be licensed for night use'.

1.10.2 Aerodrome lighting

The runway (RW) lighting available at Walney Island aerodrome is as follows:

RW 18/36	Runway inset lights (28 total) with threshold and end lighting plus Visual Approach Slope Indicators (VASI) on both runways.
RW 06/24	Runway inset lights (30 total), plus end lights. VASI only available on Runway 24.
RW 30	Runway inset lights (12 total) together with three sodium lights on each side of the runway for the first 318m. A further sodium light was positioned at the threshold but directed towards the south-west at right angles to the runway. It would not have been visible on the final approach. No VASI was installed on this runway.

RW 12 Runway inset lights (12 total) together with 7 sodium lights for the first 250 metres only. No VASI installation.

The sodium lighting on Runways 12 and 30 needs to be operating approximately 15 minutes to achieve optimum brilliance and it was established that the sodium lighting had been switched on for 15 minutes prior to the aircraft's approach to Runway 30.

1.10.3 Use of Runway 30 at night

The company's chief pilot stated that since Runway 36 had been fully equipped for night flying some two years previously the use of Runway 30 was not envisaged for night use. He would not have expected the pilot to use 30 in the conditions prevailing on the night of the accident. The chief pilot explained that though the aircraft was advised that Runway 30 was in use, this was only meant to indicate the runway nearest into wind. The choice of runway was always left to the discretion of the pilot.

1.11 Flight recorder

Not fitted and not required to be fitted.

1.12 Wreckage examination

1.12.1 Site inspection

The aircraft had first struck the ground on the western shore of Walney Channel approximately 12 metres short of a 6 metre high bank. The point of impact was in line with the right hand edge of Runway 30 and approximately 90 metres from the threshold.

There is evidence that at the time of the initial impact, the aircraft was laterally level and in a nose up attitude. The rate of descent was low. On impact, the main landing gear broke off and both propellers contacted the ground. The slash marks made by the port propeller corresponded to a ground speed of 95 mph on impact, assuming the propeller to be rotating at 2,400 rpm at that stage.

The aircraft then struck the bank and bounced back, rotating 30 degrees in an anti-clockwise sense before coming to rest. The nose of the aircraft was crushed and displaced to the left. The port wing and both engines were damaged on contact with the bank and a small tree. Aft of the cockpit, the aircraft structure was relatively undamaged.

Both propellers were damaged to a similar extent and in a manner consistent with a high power setting on each engine at the time of the initial impact. The port propeller was found to be on a fine pitch setting, but the starboard propeller was in a feathered position on impact with the bank. However the damage to the blades indicated that they were in fine pitch and rotating on initial impact. A strip examination of the propeller pitch change mechanism later established that it had been broken by initial impact forces, allowing the blades to move into the feathered position. Witness marks within the pitch change mechanism confirmed that the propeller had been within 8-10 degrees of the fine pitch setting on initial impact.

Both engines had the appearance of having been regularly maintained and there is no evidence of pre-crash malfunction or failure of either unit.

The configuration of the aircraft at the time of impact was as follows:

(a) Landing gear – down

(b) Flaps – fully extended

(c) Rudder and aileron trims – neutral

(d) Elevator trim – aircraft nose up.

With the exception of the following settings, the position of the cockpit controls and instrument settings gave no reliable indication of pre-impact conditions. However the following significant settings were noted:

(a) Left hand altimeter subscale – 1001 mb. (The QFE setting passed by the tower).

(b) Windscreen wiper – on and set to low speed.

(c) Throttle levers – 1/8 inch from fully open.

(d) Mixture controls – fully rich.

(e) Propeller control levers – ½ inch from maximum rpm position.

(f) Landing gear selector – down.

(g) Radio altimeter –on; bug set to 1,000 feet.

The following electrical services were also found selected to 'ON':

Position light

Anti-collision light

Pitot heaters

Propeller de-ice.

The taxi and landing light switches were respectively at the on and off positions, but these were not considered to be reliable indications of the pre-impact selections.

Fuel was present in all tanks to a total quantity of 58 gallons, with equal distribution on both sides of the aircraft. All tanks remained intact on impact.

1.12.2 *Seats*

The left hand pilot's seat was securely anchored to the aircraft and the lap belt attachments were intact. The seat was in the fully forward position and raised to the 5th position. The right hand arm rest was broken off. The right hand cockpit seat and lap belt attachments were also intact.

The left rearward facing passenger seat at the forward end of the cabin had partly broken away from its floor attachment, allowing the seat to tip back sufficiently for the back to contact the air conditioning unit. The attachment rail of the other rearward facing seat on the starboard side had slightly lifted.

The left forward facing seat was intact and attached to its rails, the left one of which had lifted slightly at the rear of the seat.

The right forward facing seat had become completely detached from its rails and was loose in the cabin. The rear half of the inboard seat rail had pulled out of the floor and broken away. The seat was badly distorted by the asymmetric loads imposed as it was wrenched from its rails.

1.12.3 *Emergency exit*

Though the emergency exit located on the starboard side of the cabin was subsequently opened by the emergency services, it is understood that attempts by the occupants to release it after the aircraft had come to rest were unsuccessful. It was found that there was slight distortion of the emergency exit frame due to impact forces, but this in no way impaired the operation of the hatch locking mechanism or the removal of the hatch. It was noticed however that given a very slight degree of jamming along the lower edge of the hatch, a push to its top edge tended to lock the hatch geometrically so that it could not be removed. This geometric lock did not occur if only moderate pressure was applied at its lower edge. The emergency hatch opening instructions were written in small non-luminous lettering on a plate between two windows with no distinctive colour identification to indicate which window was the emergency exit.

1.12.4 *Heating and ventilation system*

The aircraft was fitted with a combustion heater located in the nose of the aircraft underneath the electronics bay. Fuel from the aircraft supply is sprayed into an annular combustion chamber and ignited by a special sparking plug. Fresh air is drawn from an intake in the nose of the aircraft and is ducted around the outside of the combustion chamber and heat is exchanged. The warmed air is then introduced into the cabin in accordance with the selection of the heating and ventilation controls made by the pilot. On the ground, the air is drawn into the aircraft by a fan which is automatically cut out when the aircraft is airborne, and the air is then delivered by ram pressure.

An examination of the combustion chamber was made and cracks were found in two of the three radial ducts which form part of the unit. The cracks extended around approximately one quarter of the joint between the duct and the outer annulus and also the end face of the outer annulus itself. There were signs of corrosion and sooty deposits on each of the crack faces, suggesting that the cracks had been present for some time and that combustion gases had been passing through them into the cabin air supply.

An analysis of samples taken from the inside surfaces of the air duct found traces of lead and bromides, and as these substances are found in the products of combustion of aviation grade gasoline, this finding confirmed that combustion gases from the annulus had been introduced into the cabin air supply through the cracks in the transfer ducts. There was no other possible source of the lead and bromides than from the combustion chamber itself.

Heavy deposits of combustion products within the combustion chamber itself indicated that the unit had been running over-rich for some time. The fuel nozzle and the pressure regulator/shut-off valve were rig checked and it was found that the pressure regulator was producing a fuel nozzle pressure of 13 psi instead of the correct value of 7-8 psi. The fuel nozzle itself was found to be satisfactory and it was concluded therefore the over-rich running had been due to a defect in the pressure regulator.

The fan motor brushes were found to be badly worn and this would have resulted in a reduced performance. This would also have tended to richen the mixture even further during ground operation of the heater, when the fan is operative.

1.13 Medical and pathological information

The evidence of the post-mortem is that the pilot had not recently taken a meal and it would appear also that he was tired. In addition, he had a carboxyhaemoglobin concentration of 8 per cent in his blood. The total effect of these three factors may well have had a deleterious effect upon his powers of concentration during the final phase of the flight.

The carboxyhaemoglobin concentration in the pilot's blood could be wholly attributable to smoking, or partly to the defect in the cabin heater and partly to smoking. It is not possible to distinguish between carbon monoxide from smoking or from other sources.

Experimental work has suggested that with an 8 per cent carboxyhaemoglobin concentration there is a decrease in night vision of about 20 per cent and an increase in the contrast threshold of 5-10 per cent, equivalent to flying without oxygen at 10,000 feet. On the other hand, the pilot was a fairly heavy smoker and would thus be expected to have a high tolerance level to carbon monoxide. Thus any detriment in his performance due to carbon monoxide was probably minimal.

1.14 Fire

There was no fire.

1.15 Survival aspects

From the evidence of the slash marks made by the propellers, it has been calculated that the ground speed of the aircraft at the time of impact was approximately 95 mph. The principal decelerative force was in the horizontal plane. The damage to the nose of the aircraft resulted in some distortion of the flight deck, notably on the port side. The resulting space between the pilot's seat back rest and the control column was only 28 cm. Both pilots' seats remained firmly attached to the structure and the lap belts were intact. Shoulder harnesses were not available. At impact, the pilot's body rotated forward about the pelvic fulcrum and he received fatal injuries to the abdominal aorta and left renal artery on contact with the control column, the left hand spectacle of which broke off. Also the pilot's head went forward and struck the instrument panel, resulting in further serious injury to his jaw.

The passenger in the right hand pilot's seat sustained a fracture of his right tibia and fibula and also a wound to his forehead where it struck the instrument panel.

The passenger in the rearward facing seat of the port side immediately aft of the pilot's compartment sustained serious injuries, partly due to his lap belt and partly because of the detachment of the seat from its anchorage. The remaining passengers suffered minor injuries which were all consistent with the wearing of lap belts.

It is concluded that this was a survivable accident and that the fatal injuries sustained by the pilot would have been avoided had he been provided with and had worn full shoulder harness restraint.

When the aircraft came to rest, the cabin was in darkness until one of the passengers located the cabin light. Before the main door could be opened, it was necessary for the passenger concerned to read the instructions due to unfamiliarity with its operation. Despite several attempts, the overwing exit could not be opened and this was because it was not apparent that pressure had to be applied to it at the bottom edge. After moving the injured occupant of the right hand pilot's seat to the main cabin, one of the passengers went for assistance. The medical services arrived at 2026 hrs and attended the injured passengers.

The rescue services were considerably hampered by the difficult accessibility of the aircraft.

1.16 Tests and research

1.16.1 Runway lighting simulator tests

Utilising the computer controlled runway lighting simulator facility at the Royal Aircraft Establishment, Bedford, the lighting pattern of Runway 30 at Walney Island was simulated. The computer was programmed to display two approaches to observers seated in a cockpit mock-up. The first was a straight 6 degree approach from 400 feet amsl above the slag bank to the runway. The other commenced from the same point, but continued at 9 degrees passing through the point where the aircraft was last observed to be on its final approach (See Appendix A). This last point of sighting at 80 feet above the level of the runway and 425m from the threshold had been accurately surveyed and is believed to be valid. The observers had no control over the simulator, but were asked to state at which point on the approach the runway lighting pattern would have demanded a response from them had they been flying an aircraft in the same circumstances. A number of observers, including those not concerned with the investigation, participated in the test, and a fair consistency of results were obtained. It was found that on the steeper approach most observers first realised something was seriously wrong and expressed unease about the aircraft's situation at an altitude of 130 feet above runway level at a point 600m from the threshold. Prior to that point, most observers were unconcerned. At 65 feet above runway level, all observers agreed that it was quite apparent that the aircraft was very low and that they would have taken vigorous corrective action.

It was also observed that the lighting pattern during the 'accident' approach expanded only towards the upper edge of the wind shield, whereas on the normal approach the pattern expanded uniformly towards the upper and lower edges.

Some results from the simulator are shown in the diagram at Appendix B which places side by side the successive shapes of the external lighting pattern as seen from the cockpit as the aircraft approached the threshold. In particular it should be noted that during the initial part of the approach that the aircraft is assumed to have made, the lighting pattern shape changes slowly and appears to be normal. At 600m from the threshold there is a rapid and detectable expansion upwards and outwards. On the normal approach the growth of the pattern is more uniform and equal in all directions.

These results were in conformity with research data that observers normally respond to changes in the external lighting pattern when the rate of angular change of the width of the pattern reaches ½ degree/second.

1.16.2 Research by the Boeing Aerospace Company

Since the Boeing Aerospace Company were known to have researched the problem of undershoot accidents following night visual approaches, the company was asked to relate their findings to the particular circumstances of this accident. A precis of the Boeing comments is as follows:

(a) Approaches over unlit terrain.

A pilot making an approach over unlit terrain without glide path guidance may position his aircraft so that the pattern of lights on the ground subtends an angle at his eye which is constant. This would result in a curved flight path (in the vertical plane) being flown below the straight line approach path.

(b) Effect of age on visual accommodation.

The older pilot needs more light than a younger man to see fine details; is more affected by glare; and has much less focussing power. Moreover research has shown that refocussing time from near visual tasks to far visual tasks increases with age. If the older pilot adjusts his instrument lighting to a high level to improve legibility, the glare from this source will be increased and reduce the visibility of dim or small details outside the aircraft. Furthermore, after a period of instrument flight with high lighting settings, the pilot's light adaptation level may be too high initially on becoming visual to see relevant details.

(c) Limited runway lighting.

The plane of the runway is not well suggested by three sodium lights only on each side of the approach end. Moreover, research in the United Kingdom has found that 60 per cent of the subjects tested found difficulty in focussing to monochromatic sodium lights.

(d) Effect of rain on the windscreen.

In addition to blocking the view, rain on the windscreen has two adverse effects; it affects the individual's ability to focus on details at optical infinity; and it may cause the runway lights to bloom, making them appear closer than in fact they are. In such conditions it would take little scattering due to water on the windscreen to double the apparent size of the lights; hence a 10 cms light would appear to be 500 metres away instead of its true distance of 1,000 metres.

1.17 Additional information

1.17.1 Turbulence and wind effect at Walney Island

The elevation of Walney Island aerodrome is 47 feet and although the elevation of Runway 30 at its highest point is only 35 feet, it would appear that with a strong north west wind along the runway a 'curl over' or curl down effect may occur as it flows off the aerodrome and down into Walney Island channel. This is confirmed by a glider pilot operating out of the aerodrome who states that for an approach onto RW30:

> 'The curl down over the clay bank aerodrome boundary is very low down, say 20 feet, and too low to effect normal landings but adds to the pilot's problem if he is badly undershooting'.

This same pilot goes on to say that ridge soaring can be maintained quite easily in a 2 place glider in a narrow belt of rising air just upwind of the slag heap 500 to 600 feet above the airfield when the wind is from 270 to 300 degrees and speed to 20 to 25 kts.

2. Analysis

The accident circumstances appear to have conformed almost exactly to the well established tendency even of highly experienced pilots to undershoot when making night visual approaches over unlit terrain. This tendency is exacerbated by the presence of other adverse conditions, such as weather, pilot fatigue and lack of glide slope guidance, all of which were factors in this accident.

Apart from the crack in the cabin heater, which is discussed later, there is no evidence that the accident was due to any mechanical or technical failure in the aircraft, and the evidence of the passenger in the right hand pilot's seat confirms that the approach was apparently normal.

From the evidence of one eye witness, whose observations were subsequently accurately surveyed, the aircraft was lower than normal during the latter stages of the approach. It follows therefore that in order to clear the slag bank, the aircraft must have started its approach at about the correct height but thereafter made a relatively steep descent. It must be assumed that during this part of the approach, the pilot believed that he had established the aircraft on the correct glide slope and that all the external visual cues he was using apparently confirmed this. He was clearly quite unaware that the aircraft was descending towards a point well short of the runway threshold as postulated in the diagram at Appendix A. The wide disparity between what the pilot believed to be happening and what in fact was happening was solely because of his misinterpretation of the external visual situation.

There were possibly two underlying factors that affected the pilot's judgement despite his considerable flying experience. The first concerns his own physical state. There was the fact of his age, which meant that his visual acuity and focusing power made it less likely that he would perceive dim or small lights outside the aircraft. Thus it is probable that he was unable to see the small inset lights on the runway against the brighter sodium lights, particularly as he would have required time to accommodate to the external situation after a period of instrument flight under cockpit lighting. Also, due to his age, he was probably more affected by the glare of the sodium lights than a younger person would have been, and he would have found it more difficult to focus on them.

There is also the evidence that the pilot had not eaten recently which must have contributed to a feeling of tiredness that he probably felt having flown five sectors since 1500 hrs. His tiredness would not only have affected further his visual acuity but also his ability to respond to subtle changes in the external lighting pattern, which is discussed more fully later in this section.

The degree to which the pilot was affected by the carbon monoxide in his blood is unknown. An 8mg per cent carboxyhaemoglobin level is sufficiently high to affect both the visual and discriminatory powers of the average person, but against that is the fact that the pilot was a heavy smoker, and could therefore be expected to have a high tolerance to carbon monoxide. There is evidence that the pilot had been smoking during the flight as ten cigarettes of the type that he smoked were found in the cockpit ash tray, and these presumably were not the only cigarettes he had smoked that day. Thus the level of carboxyhaemoglobin in the pilot's blood could be accounted for solely by his smoking. On the other hand, there is the evidence of a crack in the cabin heater and it was positively established by chemical analysis that combustion products were being introduced into the cabin air supply, though in what quantity it is impossible to determine. There is no evidence that the presence of carboxyhaemoglobin in the pilot's blood, whatever the source, was a major factor in the accident, though the possibility that it contributed to the pilot's misjudgement of the approach, however minutely, cannot be discarded.

The other underlying factor affecting the pilot's judgement was the nature of the external visual situation itself and the way this was affected by the weather conditions. Firstly, the runway lighting pattern was not one from which accurate glide slope guidance could be obtained. As the simulator tests at Bedford showed, small excursions from the required glide slope were difficult to detect, even when there were no other distractions. It was only when the angular rate of change of the width of the pattern as subtended at the eye began to reach ½ degree/second that one became aware that the aircraft was going below the required glide slope. Inherent in the situation was the lack of any lights in the area over which the aircraft was flying.

The pilot appears not to have noticed that the growth of the external lighting pattern as he approached the runway was not normal, that is, it did not expand uniformly towards the upper and lower edges of his windscreen, but simply expanded upwards. The differences in pattern growth between a normal approach and the one that appears to have been flown, illustrated at Appendix B, are such that when the angular rate of change of the pattern width becomes noticeable the aircraft is already very low. The low ground speed of the aircraft resulting from the strong surface wind would have reduced the rate of change of pattern width to less than that usually experienced.

Another factor that may have affected the pilot's interpretation of the external lights was the effect of the rain on the windscreen. As the Boeing research showed, little scattering of the light is required to double the apparent size of the sodium lights and thus persuade the pilot that he is closer in than he actually is. This in turn would result in an over-estimation of the height and a corresponding adjustment to the apparent glide slope.

In summary, it is concluded that the most probable sequence of events leading to the accident was that the pilot began his approach when he had perhaps not accommodated fully to the external lighting situation, partly because of tiredness, partly because of the overall effects of his age, and possibly the effects of carbon monoxide in his blood. When the aircraft crossed the slag bank, it probably experienced an up-slope air current which the pilot corrected for either by throttling back slightly or depressing the nose. The aircraft then continued down a steeper approach than that required to reach the runway threshold, but because of the poor visual cues provided by the limited lighting pattern, together with the effects of the rain on the windscreen, the pilot could not properly determine the actual glide slope flown. When the aircraft was closer to the runway and very low, the external lighting pattern began to change rapidly enough to alert the pilot to his situation, but his attempts to recover were too late. It is likely that at that stage, a sudden loss of airspeed was experienced when the aircraft flew into the lee of the channel bank and this affected the aircraft's response to the pilot's application of power.

Though the pilot was highly experienced and had operated from Walney Island aerodrome for some years and had presumably landed on Runway 30 many times, it does not necessarily follow that he had previously experienced the precise conditions prevailing on the night of the accident. It may well be that this was the first occasion ever, or at least for some considerable time, that he had attempted to land on Runway 30 at night in heavy rain and against a strong wind. It is possible that he did not fully appreciate the inherent difficulties of what he was attempting to do. It is unclear why the pilot elected to use Runway 30 in preference to 36, which was fully equipped for night operations, though the use of this runway would have involved landing in a cross wind that was slightly over the aircraft's limits. Though Runway 30 was stated to be the one in use, he was under no obligation to use it. The most probable reason for the pilot electing to use Runway 30 is that on breaking cloud, he found himself to be more favourably placed for an approach to 30 than to 36. Since the accident, the company has prohibited the use of Runway 30 at night, other than in exceptional cases. This is in contrast to the situation pertaining at the time of the accident, when it was only recommended that the runway should not be used at night.

The evidence is that this was a survivable accident and that the pilot would not have suffered fatal injuries had he been provided with and had worn full harness restraint. G-BBPC was the only aircraft in the company not fitted with a shoulder harness. In an Aeronautical Information Circular (No 79/1976 dated 9 August) the subject of which was 'Safety Harness in Light Aircraft', it was estimated that 30-50 per cent of General Aviation fatal accidents may be survivable. It was concluded that the cause of death in most survivable accidents was the flexing of the body over the lap strap in the absence of adequate upper-torso restraint. The Circular went on to recommend that owners took immediate steps to equip their aircraft with either a full safety harness or at least a lap strap with a diagonal shoulder strap in advance of proposed legislation. The introductions of legislation requiring the fitment of full safety harnesses or diagonal shoulder straps after 1 January 1978 is therefore timely in the light of this accident.

The failure of the anchorage of one of the passengers' seats resulted in a serious injury and this is of some concern. Clearly a compromise has to be reached as regards the strength of seat attachments in relation to their weight, but it is considered that the matter ought to be reviewed to ensure that seat anchorages in this class of aircraft remain intact in accident circumstances that are otherwise survivable.

3. Conclusions

(a) *Findings*

(i) The aircraft had been properly maintained and its documentation was in order.

(ii) The aircraft weight at take-off was slightly over the permissible limit on take-off but within limits on arrival at Walney Island. The centre of gravity was slightly forward of the permissible limit at the time of the accident but this was not considered to be a contributory factor.

(iii) The pilot was highly experienced and he was properly licensed.

(iv) Despite the defect in the cabin heater, the accident is not considered to have been due to any mechanical or technical defect or failure in the aircraft.

(v) The approach to Runway 30 at night in adverse weather conditions demanded an abnormally high degree of concentration and awareness due to the insufficiency of runway lights and a lack of glide slope guidance.

(vi) The pilot's judgement may have been impaired because he had not accommodated visually to the external lighting situation and because he may also have been affected by tiredness and a lack of food. The influence of the carboxyhaemoglobin in his blood on his judgement could not be determined, and though it is considered to have been minimal, the possibility remains that it may have been of greater significance.

(vii) The accident was survivable and the pilot would not have suffered fatal injuries had he been provided with and had worn shoulder harness restraint.

(viii) The injuries of one of the passengers were exacerbated by the failure of his seat anchorage.

(b) *Cause*

The accident was caused by the pilot allowing his aircraft to undershoot whilst making a difficult approach to a poorly lit runway in adverse weather conditions. Tiredness, lack of food, and poor visual accommodation were probably contributory factors. The effect of carbon monoxide in the pilot's blood may also have been a contributory factor.

4. Safety Recommendations

It is recommended that:

4.1 The design requirement for passenger seat floor attachments in this class of aircraft be reviewed with regard to their ability to withstand impact forces in survivable accidents.

4.2 Operators of aircraft fitted with combustion heaters be reminded that certain defects in these types of heater can result in the insidious introduction of carbon monoxide into the cabin air supply with potentially serious consequences. Crew members should be advised to be alert to any of the physical symptoms of carbon monoxide contamination whilst the heater is in operation and to have any suspected defect investigated as soon as possible.

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Accidents Investigation Branch
Department of Trade

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