Department of Trade

ACCIDENTS INVESTIGATION BRANCH

Piper PA 28 (Cherokee) Series 140 G—AYMJ Report on the accident at Carlisle Municipal Airport, Cumbria, on 28 November 1978

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List of Aircraft Accident Reports issued by AIB in 1979

No	*Short Title*	*Date of Publication*
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2/79	Vickers Viscount Series 802G–AOJF Leeds/Bradford Airport November 1978	January 1980
3/79	Piper PA24 Comanche 180G–ARSC Preston Hitchin Herts December 1978	February 1980
4/79	Rockwell Commander 114HB–NCM Waterloo Farm Nr. Dundry Bristol Sept. 1978.	May 1980
5/79	Cessna 337A (Skymaster) G–ATNY Moel Siabod North Wales June 1979	February 1980

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No	*Short Title*	*Date of Publication*
1/80	Strojirni Prvni Potiletky Super Aero 145 G–ASWS Lydd Airport July	May 1980
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Department of Trade
Accidents Investigation Branch
Kingsgate House
66–74 Victoria Street
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5 June 1980

The Rt Hon John Nott MP
Secretary of State for Trade

Sir,

I have the honour to submit the report by Mr J S Owen, an Inspector of Accidents, on the circumstances of the accident to Piper PA 28 (Cherokee) Series 140 G–AYMJ which occurred at Carlisle Municipal Airport, Cumbria, on 28 November 1978.

I have the honour to be
Sir
Your obedient Servant

W H Tench
Chief Inspector of Accidents

Accident Investigation Branch

Aircraft Accident Report No. 2/80
(EW/C647)

Registered Owner and Operator:		Oxford Air Training School, Carlisle
Aircraft:	*Type:*	Piper PA 28 (Cherokee)
	Model:	Series 140
	Nationality:	British
	Registration:	G–AYMJ
Place of Accident:		Carlisle Municipal Airport, Cumbria Latitude 54° 55′ 55″ North Longitude 02° 49′ 10″ West
Date and Time:		28 November 1978 at 1148 hrs All times in this report are GMT

Synopsis

The accident was notified by the Cumbria Constabulary to the Department of Trade on 28 November 1978 at 1330 hrs and the investigation commenced at Carlisle Airport the following day.

Within two minutes of a Hawker Siddeley (AW Armstrong Whitworth 650) Argosy 101 commencing a departure from runway 25 using the full length of the runway, the Piper Cherokee started to take-off from an intermediate position on the same runway approximately 880 metres from the threshold. When it was about 50 feet above the runway the Cherokee pitched sharply nose-up, rolled rapidly left into an almost vertical bank, side-slipped and crashed in a nose-down attitude, killing both occupants instantly.

It is concluded that the accident was caused by an encounter with a wake vortex, generated by the Argosy, at a height which precluded recovery from the ensuing upset before impact with the ground.

1. Factual Information

1.1 History of the Flight

When the accident occurred a flying instructor and student pilot were taking-off in a Piper Cherokee, call sign 'MJ', on an *ab-initio* training flight from Carlisle Airport. Shortly after 1134 hrs, the aircraft was cleared by Air Traffic Control (ATC) to taxi to the holding point for runway 25 which was located on runway 13/31 adjacent to and north-west of the intersection between the two runways. On arrival at the holding point it was held while an AW 650 Argosy 101 entered and back-tracked along the runway. According to the pilot of the Argosy it was lined up on runway 25 approximately 100 metres into the runway from the threshold and, after receiving take-off clearance, he called 'rolling'. This call was timed at 1145:35 hrs. According to the pilot of another aircraft following the Cherokee, the Argosy became airborne near the runway 13/31 intersection. It then climbed ahead through 500 feet, turned right onto a north-easterly heading and cleared the circuit.

The pilot of the Cherokee asked for take-off clearance after the Argosy's departure but, because of the calm conditions, this was not given; it was, however, cleared to line up on the runway. The Cherokee moved slowly towards runway 25 and the controller's recollection was that the Argosy had already turned right after its initial climb and was approximately 6 miles WNW of the aerodrome at about 2000 feet when he gave the Cherokee take-off clearance. It taxyed slowly into position and its take-off from the intersection with runway 13/31 was logged at 1148 hrs, however, the recording of the Radio Telephony (RTF) communications showed that take-off clearance was issued at 1146:53 hrs. It was established from the evidence of the pilot of the other aircraft at the holding point, when matched with the RTF recording, that the Cherokee began its take-off run at or shortly before 1147:24 hrs. The take-off appeared normal to witnesses on the ground. When it was about 50 feet above the runway, it pitched sharply nose-up, rolled rapidly left into an almost vertical bank, then side-slipped and adopted a nose-down attitude. It struck the grass at the left side of the runway, cartwheeled and caught fire as it came to rest on the right side of its fuselage. Airport Fire Service units alerted by the ATC and the crash alarm responded promptly and dealt with external and internal fires but both occupants had been killed instantly.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	2	–	–
Non-fatal	–	–	–
Minor/none	–	–	

1.3 Damage to Aircraft

The aircraft was destroyed by the combined effects of ground impact and fire.

1.4 Other Damage

There was minor damage to the grass surface of the airport where the aircraft crashed.

1.5 Personnel Information

1.5.1	*Commander:*	Male aged 54 years
	Licence:	Commercial Pilot's Licence valid to 24 July 1980.
	Aircraft ratings:	Part 1: Auster variants, Beagle 109 and 206, Beagle Pup 100/150, Fuji FA 200, Druine D62, Aircoupe F1A, Cessna 150/210, Piper PA 22/28/30/32/39.
	Instrument rating:	Valid until 11 November 1979.
	Flying Instructor's Rating:	Commercial, valid until 30 April 1979 for the aircraft types specified in the instructor's rating which were those contained in Aircraft Ratings, Part 1 of the licence and aircraft in Groups A and B under the PPL privileges.
	Last certificate of test:	26 October 1978 (on Piper PA 28 aircraft)
	Last medical examination:	12 July 1978 and valid until 31 January 1979. Assessed fit, but required to have available spectacles to correct for near vision.
	Flying experience:	Total pilot hours 14,280
	Experience as flying instructor:	Approximately 12,800 hours
	Total hours on type:	3575 hours
	Total flying hours in last 28 days:	23 hours 30 minutes (all in command on the accident type).
1.5.2	*Student Pilot:*	Male age 21 years
	Licence	Not applicable (Student Pilot)
	Last medical examination:	14 August 1978, valid until 31 August 1980
	Total pilot hours:	4 hours 25 minutes (all under instruction on type)
	Total flying hours in last 28 days:	4 hours 25 minutes.

1.5.3 *General Information*

The commander had been a qualified flying instructor for about 36 years and since 1975 had been Chief Flying Instructor of the Oxford Air Training School, Carlisle. He was a member of the panel of examiners which, on behalf of the Civil Aviation Authority (CAA), conducts tests for the issue and renewal of flying instructors' ratings. He was also authorised by the CAA to examine student pilots for the issue of a Private Pilot's Licence (landplanes), to conduct flight tests for the grant or renewal of the Instrument Meteorological Conditions (IMC) rating, also for the purpose of renewing or extending the privileges of the aircraft rating included in a Private Pilot's Licence and to sign Certificates of Test in respect of these ratings.

It was established that the commander did not have spectacles available on the accident flight as required by the limitations in his medical certificate; however, in the opinion of a medical expert it is probable that he would have been able to read aircraft instrument figures without these aids to vision.

The student pilot was undergoing training for a Commercial Pilot's Licence. Entries in his Student Flying Record indicate he had yet to be instructed in take-off exercises. The exercises authorised for the accident flight were: taxying, straight and level flying, climbing, descending and medium turns.

1.6 Aircraft Information

1.6.1 Details of Aircraft

Type:	Piper PA 28 Series 140
Date of manufacture:	1970
Certificate of airworthiness:	General Purpose Category, valid until 19 January 1980
Certificate of maintenance release:	Issued on 25 October 1978 and valid for 42 days or 75 flying hours whichever expired first
Total airframe hours:	6408, of which 46 were flown since the last inspection
Engine:	One Lycoming 0–320–E2A
Engine running time:	1623 hours 56 minutes
Maximum weight authorised:	2150 lb (975 kg)
Estimated weight at time of accident:	1918 lb (870 kg)
Centre of gravity range for accident weight:	85.57 to 95.9 inches aft of datum (non-aerobatic operation)
Estimated centres of gravity at time of accident	86.64 inches aft of datum
Estimated fuel at time of accident	34 Imperial gallons
Type of fuel:	Avgas 100 LL.

The commander had already flown this aircraft on a training detail prior to the accident flight; no defects were reported or recorded.

1.6.2 Stalling

The Piper PA 28 Series 140 is a single engine, four seat, low wing monoplane fitted with a fixed tricycle undercarriage, manually operated flaps and dual flying controls. The aircraft Flight Manual states there is no aerodynamic stall warning. A visual warning is provided by the stall warning light on the instrument panel at speeds of 5 to 10 miles per hour above the stall speed in all configurations. The stall characteristics are described in the owners handbook as being conventional. According to pilots familiar with the type of aircraft, it does not exhibit any unusual flight characteristics and is docile to handle.

1.6.3 Performance

The take-off distance from rest to the 50 feet height point as calculated from the performance section of the aircraft Flight Manual was 445 metres, taking into account the aircraft's weight, the ambient temperature conditions and runway gradient, with a take-off ground run of 245 metres.

1.7 Meteorological Information

The weather at the time of the accident was good. When G–AYMJ was cleared for take-off at 1146:53 hours, the surface wind was given as 'calm'.

Carlisle Airport at 1140 hours:

Weather	Nil
Cloud	3 Oktas at 5,000 feet
Surface wind	Calm
Visibility	12 kilometres
Temperature	+1 °C
QNH and QFE	1022.8 mb and 1015.8 mb

The winds in the lower levels at Carlisle Airport for the period 1100 hours to 1200 hours, as estimated by the Meteorological Office, were as follows:

50 feet above ground level (agl)	290° (T) at 02 knots
100 feet (agl)	300° (T) at 04 knots

The accident occurred in daylight.

1.8 Aids to Navigation

Not relevant.

1.9 Communications

Communications with the aircraft were normal. Speech recording equipment was installed in ATC and a transcript of RTF messages was compiled from the recorded information. The last transmission from G–AYMJ was at 1146:55 when the commander acknowledged take-off clearance. The next aircraft 'KV', requested take-off clearance as 'MJ' began its take-off run; the start of this transmission was recorded at 11.47 + 24 seconds.

1.10 Aerodrome and Ground Facilities

Carlisle Airport, Cumbria, is at an elevation of 190 feet amsl and has three tarmac surfaced runways; 01/19, 13/31, and 07/25. Runway 25, from which both the Argosy and the Cherokee took off, was 1827 metres long and 46 metres wide; a holding point, used by aircraft prior to entering runway 25, was located on runway 13/31 adjacent to and north-west of the intersection of the two runways. This intersection was approximately 880 metres from the threshold of runway 25 and aircraft wishing to use the full length of the runway would need to backtrack along the runway from the intersection to the take-off position. The declared take-off run available was 1557 metres. There was no declared distance for the take-off run available from the 13/31 intersection of runway 25 but the distance from this position to the upwind end of the paved surface was approximately 945 metres.

1.11 Flight Recorders

1.11.1 Cherokee

None required and none fitted.

1.11.2 Argosy

The Argosy was fitted with a Sundstrand engraved foil flight data recorder, type FB 542 which was serviceable and the data pertaining to the subject take-off was retrieved. A profile of the take-off and initial climb performance, which was constructed from the recorded data, showed that it became airborne just before the runway 13/31 intersection after a ground run of 700 metres. It passed the intersection 30 seconds after commencing its take-off run and traversed above the estimated position where the Cherokee later started to go out of control 99 seconds before the Cherokee itself reached that point. Its height was then about 120 feet higher than that of the Cherokee. At take-off the Argosy's laden weight was 36,526 kg which was approximately 3,500 kg below its maximum allowable weight. According to its commander, the initial climb to 300 feet was made at an IAS of 107 knots (V2) before accelerating to its en-route climbing speed.

The Argosy commenced a right turn on to a heading of about 025° (M) when it was 550 feet above the ground and approximately 2 nm from the beginning of the runway; this was 75 seconds after it started its take-off run and the integration of this time into the RTF recording showed that 3 seconds later the Cherokee was issued with its take-off clearance. When the Cherokee started its take-off run from the intersection the Argosy was about 2.8 to 2.9 nm approximately west of the threshold of 25 runway. These calculated times and the sequence of events leading to the accident are illustrated on a sketch plan of the aerodrome in Figure 3 of the Appendix.

1.12 Wreckage and Impact Information

1.12.1 Impact Information

The aircraft struck the ground in a position 15 metres from the southern edge of runway 25 and 240 metres before the upwind end of the paved surface. Inspection at the site revealed that at impact it was on a heading of approximately 200° (M) in a nose-down attitude and banked almost vertically to the left. It had then cartwheeled about the left wing tip and nose and both wings with their respective main landing gear legs became detached. The Cherokee came to rest on the right side of its fuselage on a heading of 010° (M) about 17 metres from the first point of impact. The left wing tank had ruptured on impact. A considerable quantity of fuel was found in the right tank but fuel in the left tank had ignited causing extensive fire damage to the left wing and its undercarriage. The propeller which remained attached to the engine showed evidence of rotation under power at impact.

1.12.2 Wreckage

A detailed examination of the wreckage revealed no evidence of pre-crash defect or malfunction of the airframe, the engine or flying control system. No evidence was found of a bird strike or of an in-flight fire. It was established that on impact:

The throttle lever was fully forward
The mixture control was at full rich
The engine fuel cock was selected to the left tank
The electric fuel booster pump on 'on'
The engine ignition switch was set to 'both' magnetos
The carburettor heat control was selected to 'cold'
The pilot heater was switched 'on'

The horizontal stabilator and rubber trims were set to a near neutral position
The flaps were fully retracted
The forward seats were securely attached to their mounting rails and the safety harness anchorages were secure.

The visual stall warning actuating vane had become detached on impact and was not recovered. The wiring connecting the vane to the stall warning light had been damaged by fire and could not be tested. Examination of the stall warning light bulb filament revealed no evidence of stretching.

1.13 Medical and Pathological Information

Post-mortem examination showed that both occupants had died from severe multiple injuries; there was no evidence of pre-crash incapacitation and toxicological findings for both persons were negative. In the case of the commander there were injuries to his right hand and right ankle compatible with him holding the control column firmly and applying full right rudder on impact.

1.14 Fire

Fire occurred when the left fuel tank ruptured on impact. Burning fuel from the tank enveloped the left wing and its main landing gear leg after it had detached from the fuselage. When the aircraft came to rest, burning fuel formed a fire area extending from a point 20 feet forward of the nose, around the underside to the right tip of the horizontal stabilator. Small fires occurred in the engine compartment and on top of the instrument panel when fuel lines and fuel system components forward of the engine fire wall were disrupted on impact.

The Airport Fire Services arrived at the scene with two appliances shortly after the occurrence and extinguished the fire with foam. The quantities of medium used were: 250 gallons of water, 15 gallons of FP foam liquid and 3 lbs of BCF. The outside emergency services, acting in a back-up capacity, arrived 15 minutes after being alerted by telephone.

1.15 Survival Aspects

The occupants were wearing seat belts with single diagonal strap upper torso restraints which remained intact; however, the nature of the impact was such that the accident is considered non-survivable.

1.16 Tests and Research

In the absence of experimental data, the effect that an Argosy wake vortex might have on a following Cherokee was estimated using a theoretical model of vortex behaviour. These calculations indicate that at a wake age of 50 seconds the maximum circumferential velocity of the vortex would be about 18 feet per second and the core radius would be about 13 feet. At a wake age of 100 seconds these figures become 12.7 feet per second and 18.5 feet respectively. Estimates indicate that the rolling moment experienced by a Cherokee wing in the centre of an Argosy vortex at wake age of 50 seconds would lead to a bank angle of around 70° after one second and a bank angle of about 40° after one second if the age of the vortex was 100 seconds.

Experimental data on the rolling power available in the Cherokee indicate that it is less than the estimated rolling moment produced by the vortex at an age of 50 seconds. An encounter with an Argosy vortex at this age could mean that the Cherokee would be banked through about 45° after one second even if full aileron control had already been applied to counter the vortex-induced roll. It was estimated that the Cherokee's aileron power was of the same order as the rolling moment caused by the vortex at a wake age of 100 seconds.

A description of the phenomenon of wake vortices and diagrams relating to their expected distribution and flow patterns behind a departing aircraft during its initial climb-out, in still air and crosswind conditions, may be seen at Appendix A to this report. In the case under consideration, the variation of crosswind with height, combined with the predicted movement of the vortex system relative to the air, was such as to make it very likely that the vortex from the right wing would have been nearly stationary and directly over the runway at a stabilised height of 40 to 50 feet, at the time when the Cherokee went out of control.

1.17 Additional Information

1.17.1 Manual of Air Traffic Services

The following extracts are taken from the version of the Manual current at the time of the accident:

" APPENDIX 'B'

"The UK differs from the ICAO wake vortex categories used for flight planning purposes. In the UK, aircraft are divided into four categories according to their maximum total weight at take-off; Heavy, Medium, Small, Light.

Heavy:	136000 kg or greater
Medium:	40000 kg to 136000 kg
Small:	17000 kg to 40000 kg
Light:	less than 17000 kg"

The Hawker Siddeley (Armstrong Whitworth) Argosy with a maximum take-off weight of 42,100 kg was placed in the Medium Category.

1.17.2 Section 1, Chapter 3, paragraph 9, Vortex Wake Separations

"Aerodrome Operations

The minimum spacing listed below is to be applied between successive flights, both IFR and VFR.

(a) Aircraft departing from the same runway or from parallel runways less than 760 metres apart (including grass strips).

Leading Aircraft	**Following Aircraft**	**Minimum spacing at time aircraft are airborne**
HEAVY	MEDIUM) Departing from the SMALL) same take-off LIGHT) position	2 minutes
HEAVY Full length take-off	MEDIUM) Departing from an SMALL) an intermediate LIGHT) take-off point"	3 minutes

Section 2, Chapter 1, paragraph 10, Take-Off Clearance

"Turbulent Wake

The pilot of a departing aircraft may request a delay in take-off because of the danger of turbulent wake from the preceding aircraft. There is a particular danger for aircraft commencing the take-off run part of the way along the runway."

"Supplementary Instruction No 2/1977 – Aircraft spacing – Vortex Wake" . . . "as technical methods are not yet operationally available to predict or measure vortex wake, they (the controllers) cannot assume responsibility for issuing advice at all times, or for its accuracy."

1.17.3 Aeronautical Information Circular (AIC) 52/1978 – Extracts

This AIC was available to pilots at the Oxford Air Training School and the following extracts are relevant:

Paragraph 2. Wake Vortex Weight and Separation Criteria

"2.1 Weight parameters (maximum take-off weight in kg)

	ICAO (from 10. 8. 78)	UK (from 10. 8. 78)
Heavy (H)	136,000 or greater	136,000 or greater
Medium (M)	Less than 136,000 and more than 7,000	Less than 136,000 and more than 17,000
Light (L)	7,000 or less	17,000 or less"

"2.3 Wake Vortex Spacing Minima – Departures

Leading Aircraft	Following Aircraft	Minimum Spacing at the Time Aircraft are Airborne
Heavy	MEDIUM) Departing from or) the same LIGHT) position	2 minutes
Heavy (Full length take-off)	MEDIUM) Taking off from an or) intermediate part LIGHT) of the same runway	3 minutes

2.8 Application of Wake Vortex Minima

2.8.2 Wake vortex minima may be applied for any situation not covered by specific minima whenever a controller believes there is a potential hazard due to wake vortex.

2.8.3 The separation standards listed are minima and when applied by ATC may be increased at the discretion of the controller, or at the request of the pilot."

Paragraph 4 Wake Vortex Avoidance

This paragraph demonstrates with a number of illustrations the types of manoeuvre that may be performed to avoid wake vortex in various situations. Fig 12 demonstrates departures behind large aircraft on the same runway and says: 'Note the large aircraft's rotation point and rotate before it. Climb above and stay upwind of the large aircraft's climb path until turning clear of its wake.' Fig 14 describes take-off from an intersection along the same runway and is noted: 'Be alert to adjacent large aircraft operations, particularly upwind of the runway.'

1.17.4 Aeronautical Information Circular 87/1979 – Extracts

This AIC was issued on 4 December 1979 subsequent to the accident and the following extracts are relevant:

"2 Attention is drawn also to the turbulence and wake vortex dangers associated with a Light departure following that of a heavier category, particularly where the Light aircraft is taking-off from an intersection. Information Circular No 52/1978, in accordance with ICAO guidance material, specifies time intervals (minimum spacing at the time aircraft are airborne) of 2 minutes for a Medium or Light category aircraft following a Heavy or Light category aircraft taking-off from the same position, and 3 minutes for a Medium or Light category aircraft taking-off from an intermediate part of the runway and following a Heavy making a full length take-off on the same runway. However, there is good reason to believe that in conditions where wake vortex is likely to persist, eg in light winds, the intervals specified for Light/Medium following Heavy should be applied between any two departing aircraft when the follower is significantly lighter than the leader.

2 Additionally, whenever the pilot of a light aircraft, particularly in light wind conditions, remains in doubt as to the adequacy of his longitudinal separation from a heavier aircraft on approach or departure, good airmanship requires that, so far as possible, he avoids flying through, below or downwind of the receding aircraft's flight path."

1.18 New Investigative Techniques

None

2. Analysis

The Cherokee suffered a major upset shortly after take-off when it reached a height of about 50 feet. There was no evidence of mechanical failure or malfunction and the commander, who had already flown that aircraft once that morning, had not reported any defect. Post-mortem examination of both occupants revealed no medical evidence that could have had a bearing on the accident. The student pilot's training had not progressed to a stage which included take-offs and it is unlikely that he would have been allowed to control the aircraft during this stage of the flight, certainly not in all axes. Even if the student had been handling the controls the instructor was experienced enough not to allow him to continue to mishandle the aircraft without taking over control before its safety was endangered. Moreoever, the Cherokee is a docile primary training aircraft and does not exhibit any vicious stalling or unusual flying characteristics. It is, however, beyond dispute that the aircraft reacted violently and appears to have been totally out of control in spite of being commanded by a very experienced flying instructor, who, according to the medical evidence, was applying full corrective control as the aircraft struck the ground.

The Cherokee was preceded by an Argosy which commenced its take-of run on runway 25 from a position close to the beginning of the runway and became airborne when it was near the intersection with runway 13/31. The surface wind at that time was calm and there would have been a slight crosswind from the right at 50 to 100 feet. The vortices left by the Argosy during its straight initial climb after unstick would therefore have initially drifted downwind towards the aerodrome but to the left of the runway centre-line. At the same time they would have descended and on approaching the ground the right hand vortex would have moved slowly towards or across the runway on its outwards travel, or become stabilised with its core about 40 to 50 feet above the ground and its outflow retarded by the slight crosswind from the right. In either event, the conditions were favourable for the presence of atmospheric turbulence due to wake vortices over the upwind end of the runway.

Since the weather conditions on the morning of the accident were conducive to the persistence of vortices, great care needed to be exercised in proceeding with the take-off from the runway intersection behind the departing Argosy. The air traffic controller was aware of the problem and as a result cleared the Cherokee, initially, only to line up on the runway, thus delaying its take-off clearance. His recollection was that he gave the Cherokee permission to take-off approximately two minutes after the Argosy had begun its take-off run. The Cherokee, at this time, was still moving slowly into position and he considered the Argosy was sufficiently far away when he cleared the Cherokee to take-off. The evidence indicates that the Cherokee was in fact given take-off clearance approximately 78 seconds after the Argosy commenced its take-off run, however, the interval between the Argosy passing the runway intersection and the transmission of the Cherokee's take-off clearance was only approximately 48 seconds. The Cherokee did not immediately start its take-off on receipt of the clearance but the evidence of a pilot in another aircraft following the Cherokee indicates that it actually started moving approximately 79 seconds, certainly less than 90 seconds, after the Argosy has passed the intersection.

In the existing conditions the Cherokee would have been airborne after a ground run of approximately 245 metres and it achieved a height of about 50 feet above that section of the runway which was liable to be affected by wake turbulence generated by the departing Argosy. The time interval between the passage of the Argosy, then the Cherokee over this part of the runway was approximately 99 seconds; however, any vortices which existed over that part of the runway would have had a wake age of some value less than 99 seconds, which is well within the life span of a vortex in calm weather conditions. It has been calculated that an encounter by the Cherokee with an Argosy's wake vortex at wake age of 50 seconds would be an extreme hazard. At 100 seconds age, the effects would be less severe but would remain significant in terms of controllability.

In view of the circumstances, the most probable explanation for the Cherokee's sudden pitch-up and rapid roll is that it encountered wake turbulence generated during the Argosy's departure and initial climb; it consequently struck the ground because there was insufficient height available for its pilot to regain control and recover from the ensuing upset.

In providing safe separation between aircraft a controller has to regulate the time interval between aircraft taking-off, having due regard to the hazard of wake turbulence. It should also be appreciated that as technical methods are not operationally available to assist the controller to predict or measure vortex wake, he cannot assume responsibility for issuing advice at all times or for its accuracy. This, therefore, is a matter of sound airmanship and an awareness by both a pilot and a controller of the potential risk, with both or either of them being able to exercise their discretion with regard to the separation standards and wake vortex minima currently prescribed. In the case under consideration the controller was indeed conscious of the potential hazard; he made an effort to delay the Cherokee's departure but the actual time which elapsed between the commencement of both take-offs suggests that both his and the commanders' assessment of the risk were probably based more on a subjective appraisal rather than from a measured interval of elapsed time, however, no minimum separation time was recommended by ICAO or stipulated by the CAA to cater for this particular case.

The information and guidance available to pilots and ATC staff clearly illustrates that the dangers of wake turbulence have long been recognised, moreover, the risks to lighter aircraft following those in the wide-bodied 'Heavy' classification have been publicised and suitable time intervals and spacing are prescribed. At the time of the accident the Aeronautical Information Circular (AIC) (52/1978) and the Manual of Air Traffic Services drew attention to wake vortex dangers associated with a Light departure following that of a heavier aircraft, but only in respect of aircraft classified in wide-bodied 'Heavy' category were any time intervals specified when a following lighter aircraft takes-off on the runway or from the runway intersection. No time intervals were specified for an aircraft which is significantly lighter than the preceding type which is not necessarily in the 'Heavy' category.

Subsequent to the accident AIC No 87/1979 corrected this deficiency and states that the intervals specified from 'Light/Medium' aircraft following ' Heavy' aircraft should be applied between any two departing aircraft when the follower is significantly lighter than the leader. However, the lack of such detailed guidance at the time of the accident may have been a contributory factor.

3. Conclusions

(a) *Findings*

(i) The aircraft's documents were in order and it had been maintained in accordance with an approved maintenance schedule.

(ii) No defect or malfunction was found in the aircraft which had a bearing on the accident.

(iii) The commander was properly licensed and qualified to act as an instructor for the training flight.

(iv) The student pilot's instruction had not included taking-off and this manoeuvre was not among the exercises for the flight.

(v) It is most probable that the commander was handling the aircraft controls.

(vi) There was no evidence of a medical condition in either pilot which could have had a bearing on the accident.

(vii) The calm weather conditions were not conducive to the formation of atmospheric turbulence due to thermal or terrain effects.

(viii) The aircraft's departure was preceded on the same runway by an Argosy aircraft which carred out a full length take-off and became airborne near to the intersection with runway 13/31.

(ix) The calm surface wind and light crosswind above the surface layer were conducive to the persistence of wake vortices, generated by the Argosy over the upwind section of runway 25 when the Cherokee took off.

(x) The Cherokee was cleared for take-off by ATC approximately 78 seconds after the Argosy had commenced its take-off run.

(xi) The Cherokee started its take-off run from the intersection with runway 13/31 approximately 79 seconds after the Argosy had passed the same position.

(xii) When the Cherokee was about 50 feet above the runway it went out of control and struck the ground whilst recovery action was being attempted by the commander.

(b) *Cause*

The accident was caused by an encounter with a wake vortex generated by the Argosy aircraft at a height which precluded recovery from the ensuing upset before impact with the ground.

4. Safety Recommendations

It is recommended that:

1 The Manual of Air Traffic Control Services should be amended to reflect the more recent information and advice contained in the CAA AIC No 87/1979.

2 The attention of ICAO be drawn to the foregoing recommendation.

3 Positive steps be taken to ensure that instructional staff and *ab initio* student pilots, who operate from aerodromes that are occasionally used by significantly larger aircraft, fully appreciate the risk of an encounter with turbulent wake.

J S OWEN
Inspector of Accidents

Accidents Investigation Branch
Department of Trade

JUNE 1980