No. 11

Britten-Norman BN-2 Islander (Prototype) G-ATCT, accident at Oudega, Wymbritseradeel, Holland, on 9 November 1966. Translation of the report prepared by the Netherlands Department of Civil Aviation dated November 1968, released by the Board of Trade, United Kingdom, as C.A.P. 317.

1.- Investigation

1.1 History of the flight

The prototype aircraft, after having carried out several demonstration flights in Germany, was on its way back to England. It took off from Emden, Germany, at 1137 hrs local time on a non-scheduled international VFR flight to Southampton, England, with the pilot and one passenger. Two minutes after take-off the aircraft made radio contact with Eelde and at 1150 hrs informed Eelde that it was "abeam Eelde VOR" and flying at 1 500 ft VMC on top of cloud. At this position the aircraft could not have had any visual ground contact. At 1156 hrs the aircraft asked Amsterdam Flight Information Service for radar assistance in order to pass through Schiphol Control Zone but was informed it was not possible because positive radar contact could not be established. At 1209 hrs the aircraft was advised to divert to Eelde because weather conditions in the Schiphol Control Zone precluded VFR flight through the zone at 1 500 ft. On receipt of this information the pilot informed Amsterdam that he would proceed according to his flight plan. At 1220 hrs when flying at 1 500 ft the pilot informed Schiphol that he would clear Schiphol Control Zone to the west. This was after the controller had positively instructed him to remain clear of the Control Zone and that it was impossible to pass through the zone at 1 500 ft under VFR.

Reconstruction of the aircraft's flight path showed that at about 1225 hrs it deviated from its route and cleared the Schiphol area on a heading of about 040°. Shortly afterwards, at 1234 hrs the pilot reported he was experiencing "serious compass trouble" and asked for a "steer" but Amsterdam still had no radar contact with the aircraft. According to eye witnesses, the aircraft was, at about this time, flying at a very low height around the vicinity of the village of Rijs, returning to or passing over the same area several times. It was also established from these witnesses that the weather conditions were such i.e. fog and rain, that the pilot would not have had adequate visual reference.

At 1240 hrs the pilot reported "some compass trouble" and again requested radar guidance but radar contact had still not been established. Flight at low altitude was apparently discontinued at about 1247 hrs and at 1249 hrs the pilot reported at 3 000 ft in IMC and that he had a serious instrument failure. Schiphol Control instructed him to maintain FL 30 (3 000 ft) and a heading of 200°. Contrary to this instruction, the pilot reported at 1251 hrs as being at FL 50 and at 1254 hrs at 6 000 ft. At 1255 hrs the controller asked if the aircraft was circling, the pilot replied in the affirmative and said "I think I am going around it". The controller acknowledged this transmission and remarked that he thought the aircraft should be heading 200°; the pilot then replied "I cannot maintain a heading". At that moment the aircraft was positively identified on the radar screen. Replying to the radar controller's instruction to fly specific headings and to make a left-hand turn the pilot said he could not maintain a heading and that right-hand turns were easier to make.

At 1258 hrs the pilot requested the height of cloud tops and inquired if there were any clear layers in which he could find visual flight conditions. At his request he was cleared to climb to FL 80; however, a German military aircraft which had recently flown over Spijkerboor at FL 100 reported that it had been "fully IMC" there.

At 1301 hrs the pilot reported at 8 700 ft and "climbing as fast as I can, I want to get out on top"; this was the last recognizable transmission heard by Schiphol. The aircraft was observed on the radar screen until about 1309 hrs at which time radar contact was lost. According to the radar controller the indications observed on the screen for the last 10 to 12 minutes indicated that the aircraft made a series of random small radius right and left-hand turns.

At 1310 hrs witnesses near Ringwiel lake saw parts of an aircraft falling, most of it into the lake; these were later identified as parts of the subject aircraft.

Calculations and evidence suggested that the aircraft climbed to an altitude above 10 000 ft where it would have encountered severe icing and would have reached a region of moderate to severe turbulence. The time of impact was estimated to be approximately 1310 hrs.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	1	1	
Non-fatal			
None			

1.3 Damage to aircraft

The aircraft was destroyed.

1.4 Other damage

There was no other damage.

1.5 Crew information

The pilot, aged 46, held a valid commercial pilot's licence with an instrument rating and aircraft-type ratings for de Havilland DH 89A and Avro Anson 652A aircraft. He also held a valid radiotelephony licence. His medical certificate was valid until 6 December 1966. He passed the last two checks for the renewal of his instrument rating on 2 March 1965 and 22 June 1966. He had flown a total of approximately 7 700 hrs including 30:25 hrs in "Islander" aircraft, all of which were flown during the 30 days prior to the accident, and 24:50 hrs of which were flown during the week preceding the accident. His instrument flying experience on type under semi or simulated instrument flight conditions was estimated at about 8 hrs. He had no experience on type under full instrument flight conditions.

He had been test pilot for fourteen years and was employed as demonstration pilot by Britten-Norman Ltd. since 12 October 1966. The following information is relevant to the accident:

- He was a very competent pilot; however, he was not given to pre-planning and preferred to take things as they came and deal with problems on an ad hoc basis.
- He was an individualist and his reaction to regulations could have been to resist or to try to circumvent them.
- In the past it was his habit to fly below clouds in bad weather conditions.
- He was a competent user of ADF but his ability to use VOR, ILS and similar navigational aids was not known.
- He had little recent experience in instrument flight on airways.
- He was not a "smooth" pilot and was rather harsh on controls.
- His radio conversation was off-hand and wavering and, on occasion, he was inaccurate in maintaining and reporting his altitude.

He had been instructed and briefed on the 2g limitation applicable to this aircraft and on the selection of the fuel tanks.

1.6 Aircraft information

The Certificate of Airworthiness of this prototype aircraft had been issued in a "special" category on 16 June 1965 and was valid until 6 October 1967.

Although the flying hours of the aircraft were recorded only until 4 November 1966, it was estimated that at the time of the accident the aircraft had flown a total of approximately 546 hrs, including 412 hrs since installation of the present engines and propellers.

At the time of the accident the weight of the aircraft was calculated as being 4 939 lb, i.e. below the maximum take-off and landing weight of 5 300 lb and its centre of gravity as being either 20.5 in. or 22.85 in. aft of datum, depending on the location of the luggage, i.e. within the permissible limits of 16.5 to 25.6 in. aft of datum.

Prior to certification, the United Kingdom Air Registration Board had checked the airworthiness of the aircraft and had concluded that the calculated strength of the wing at the maximum weight of 5 300 lb was 4g. As this did not comply with the British Civil Airworthiness Requirements, which require an ultimate load factor of 5.6g with flaps retracted, the ARB imposed some operational restrictions on the aircraft in terms of speed, acceleration and weather conditions, in order to maintain a satisfactory margin of safety*. They were included in the flight manual of the aircraft and amongst others the following were particularly pertinent to the accident:

* The design of the wing was modified on production aircraft and the new wings meet fully the BCARs.

- the aeroplane shall not be flown intentionally into clouds in which the possibility of icing conditions exists;

- the aeroplane shall not be flown intentionally into appreciable turbulence;

- manoeuvres shall be restricted to those with load factors between 0 and 2g.

- Airspeed Limitations:

never exceed speed	:	VNF	174 kt IAS
normal operating speed	:	VNO	110 kt IAS
manoeuvring speed	:	VA	109 kt IAS
wing flaps extended speed	:	VFE	86 kt IAS
rough airspeed	:	VB	91 kt IAS

The aeroplane was instrumented for instrument flight and was equipped with the following instruments:

Instrument	Operation
gyro horizon	vacuum
directional gyro	vacuum
magnesyn compass	electric
turn and slip indicator	electric
compass E 2 B	direct
airspeed indicator (port)	pitot-static
airspeed indicator (starboard)	pitot-static
rate of climb indicator	static pressure
altimeter (port)	static pressure
altimeter (starboard)	static pressure

The gyro horizon and the directional gyro were driven by air with the help of a vacuum pump on each engine, via a vacuum shuttle valve, which automatically regulated which vacuum pump operated these instruments. There was no pilot-controlled shuttle valve which had to be switched over in the event of a failure of an engine or pump.

Technical records revealed the following information with regard to some instruments:

(i) The magnesyn compass was installed on 3 February 1966. It was compensated on 7 April 1966 and 11 October 1966. No difficulties with this compass were reported.

(ii) Some difficulties were reported with the E2B compass (a normal ball-type liquid magnetic compass). During a flight to Spain from 9 to 18 April 1966, and whilst on a test flight on 19 April 1966, during a steep climb with full power the compass was observed to revolve at a rate of 4 rpm. After the compass was removed from the central post of the cockpit front windows and re-positioned at the top of the left cockpit front window no further complaints were reported. The compass was compensated on 11 October 1966.

(iii) During the flight to Spain it was observed that the airspeed indicators indicated a speed which was 10-15 mph too low for about ten minutes after every take-off. This was attributed to the possibility of water in the pitot-static system.

(iv) The turn and slip indicator was replaced during a 100-hour inspection on 7 April 1966.

(v) The flight test reports contain severe criticism of the quality of the instruments. The Chief Test Pilot stated that the purpose of his criticism was to encourage the installation of a better class of instruments, the existing instruments being of a standard which was offered in light aircraft and which he considered to be of too low a standard. Although more instrument failures occurred than normally might be expected, they were never of a serious nature.

A considerable number of test flight reports concerning the flying characteristics and engine operation were examined. The following remarks are relevant to the accident:

(i) Stalling characteristics

During stalls carried out in a 30° banked starboard turn the aeroplane tended to roll into the turn, particularly in the flap fully-down full power configuration. It was also noted that the aeroplane showed a tendency to drop a wing when stalling in level flight; starboard wing drop was more frequent than port (2.1.66).

(ii) Control characteristics

The ailerons were not effective enough during approaches in gusty weather (30.12.65). During stalls in starboard turns as mentioned under item (i), the aileron power was insufficient to return the aeroplane to level flight (2.1.66). In particular the aeroplane tended to roll into the turn with flaps fully-down and with the engines at full power. This was established at 10 000 ft. Extension of the flaps caused a fairly strong nose-up movement of the aeroplane.

The control forces on the elevator are very light. In order to increase these forces the elevator was provided with an anti-balance tab.

(iii) Engine operation

On selection of engine hot air with the engines at 75 per cent power with outside air temperature -1°C, the carburettor air temperature increased by 25°C. British airworthiness requirements require a temperature rise of 50°C. This value is in accordance with the capacity needed in practice; so the capacity of the carburettor heating installation on this aeroplane was about half of the required capacity.

When approaching the stalled condition with full power at about 10 000 - 12 000 ft, the engines lost rpm and eventually died out completely (30.7.65 and 2.8.65). The test flight report of 2.8.65 mentioned:

> "The engines die out completely while still in level flight immediately before the stall occurs."

During these test flights the fuel booster pump was on and the mixture fully rich. Further test flights showed that this characteristic would not occur when the mixture is not fully rich and the booster pump is switched off (20.8.65).

"Whilst climbing with full power and both engines selected to run from the starboard tank, they can stop completely." This was attributed to insufficient fuel supply due to too small capacity of the fuel feed pipes of the fuel system. After the test flights, during which this characteristic was observed, engines with a higher rated power were installed. However, the pipes of the fuel system were not modified, so a similar power failure may occur.

Reported defects

In a report on the demonstrations in Germany, signed by the pilot, the following defects were reported: rotating beacon housing missing, starboard brake weak, crack in the trailing edge of the starboard flap.

1.7 Meteorological information

At 1300 hrs local time a cold front was located from about 50 km west of Sylt, over the Lauwers Zee, to the west of Flushing. The weather encountered by the pilot during the last 30 minutes of the flight can be summarized as follows:

There was fog and rain at low level and visual reference to the ground would have been prevented.

Whilst climbing to 10 000 ft the aircraft would have encountered fog and stratus cloud, changing to altostratus, and altocumulus amongst which would have been altocumulus castellatus. Whilst climbing through 6 000 ft icing would have been light but through 8 000 ft it would have been heavy. Generally, the flight would have proceeded in cloud and between cloud layers. To the west and within the frontal zone it is probable there was moderate turbulence between 1 500 ft and 4 000 ft. To the east of the front the turbulence would have been light but between 9 000 to 14 000 ft there was probably moderate to heavy turbulence.

It is almost certain that the pilot did not achieve visual flight on top of cloud whilst flying over the Netherlands.

In order to have found better weather conditions it would have been necessary to him to have flown on a north-westerly heading.

1.8 Aids to navigation

The aircraft was equipped with a Bendix radio compass (ADF) which was found set to the 190-440 kc/s band. Two Bendix transceivers for VHF communication and VOR navigation were also installed.

All radio beacons and other radio navigational facilities listed in the aeronautical information publication for the provinces of Groningen, Friesland and North Holland were serviceable and in operation. For the subject flight the following facilities were relevant:

Position	NDB frequency	VOR frequency	Marker beacon frequency
Eelde	374 kc/s	112.4 mc/s	nil
Lemmer	347.5 kc/s	nil	75 mc/s
Enkhuizen	316.5 kc/s	nil	75 mc/s
Spijkerboor	381 kc/s	113.3 mc/s	nil
Amsterdam	nil	108.4 mc/s	nil
Ijmuiden	279 kc/s	nil	75 mc/s

1.9 Communications

The aircraft communicated on several frequencies with the air traffic control services at Eelde and Schiphol. Speech recording equipment was in use and transcripts were made of radio traffic which passed between the aircraft and these ground stations. No communication difficulties were encountered.

1.10 Aerodrome and ground facilities

Not pertinent to this accident.

1.11 Flight recorders

Not mentioned in the report.

1.12 Wreckage

The main wreckage, comprising the fuselage, the port wing with its engine and propeller and the tail assembly, fell into Ringwiel Lake. Other parts of the aircraft fell in nearby meadows, almost in a straight line on a magnetic bearing of 125°-305°, the main wreckage being about 450 m to the north of that line (see Fig. 11-1). It was determined that the starboard wing failed at station 52.5 between the fuselage and the engine as a result of overloading, and that the separation of the starboard engine and undercarriage immediately followed as a result of precession and inertia forces.

Examination of both engines revealed that they were developing little or no power at impact, but no evidence of malfunction or failure of the engines were found. Both propellers were in the fine pitch range. The starboard carburettor heat control valve was in the "cold" position, and the spark plugs of both engines were in a sooted condition.

Examination of the cabin heater revealed that it was operating at impact which indicated that electric power was available and no evidence of leakage or loose connexions were found.

No evidence of flutter or fatigue or pre-impact failure were found either in the control mechanism or in any other part of the aircraft.

The cockpit and passenger cabin were completely demolished but the settings of all cockpit controls were established; no settings were found which gave any indication of the cause of the accident. The instrument panel and instruments were salvaged almost complete and subsequent examination revealed no indication of defect in the instruments. However, because of the damage it was not possible to determine whether or not there had been an inflight malfunction of the electrically-driven instrument.

Examination of the fuel selector valves indicated that both engines were being fed from the starboard fuel tank; the positions of the valves, however, are not fully reliable because of impact damage to the control cables.

1.13 Fire

There was no fire.

1.14 Survival aspects

Post mortem examinations revealed that both occupants were killed instantly by the impact. Both exhibited a similar pattern of injuries such as would result from a very heavy forwards-backwards force. Haemorrhages around the multiple fractures showed that both occupants were alive at impact. No evidence of poisoning by carbon monoxide was found.

It was ascertained that the pilot was secured to his seat by a seat-belt when the aircraft crashed. There was also evidence that the passenger was similarly strapped in.

1.15 Tests and research

Following the accident, the Royal Aircraft Establishment (RAE) analysed the strength of the wing structure and confirmed that there was no reason why a premature failure should have occurred. Tests on the material used in the construction of the wing showed that it satisfied the appropriate specification.

The Royal Aircraft Establishment also calculated the altitude and horizontal speed at which the aircraft disintegrated. Only a horizontal speed component was assumed and this was calculated as 140 knots. The altitude at which the break-up occurred was calculated as 7 000 ft (2 140 m); this altitude would have been greater had there been a vertical speed component; 7 000 ft was therefore considered to be the minimum altitude at which the wing failed.

1.16 Flight preparation

The following discrepancies were found in the preparation of the flight:

- the maps, carried in the aircraft for navigation and covering the areas between Berlin and south-east England, were two maps at a scale of 1:500,000 dated 1942 and 1944 and one map at a scale of 1:1,000,000 dating from some years before 1950. None showed the airways system, the control zones around aerodromes or the prohibited and restricted areas;

- the pilot made preparations for his flight at Emden Airfield the previous day using the above maps without taking any meteorological aspects into account. As there was no meteorological service at Emden the pilot contacted the meteorological service at Bremen on the day of the accident on two occasions, at about 0945 hrs and 1100 hrs, to obtain information concerning the weather. According to the Chief of the Bremen meteorological service an attempt to dissuade the pilot from carrying out his planned flight, because of poor visibility (100 to 900 m) and low cloud (base 30 to 60 m) which were forecast for the route, was made. However, the pilot filed a VFR flight plan with Bremen Air Traffic Control along the route: Emden - Amsterdam - Calais - Lydd - Seaford - Southampton. Rotterdam and Bournemouth were nominated as alternate aerodromes.

2.- Analysis and Conclusions

2.1 Analysis

The prototype aircraft was airworthy but the subject of a number of operating limitations clearly indicated in its Flight Manual. The evidence indicated that an inflight failure of the starboard wing by overloading occurred: no evidence of malfunction or failure of the controls, the engines or the instruments which might have led to such failure was found.

The evidence indicated that the aircraft broke up at an altitude of 7 000 ft at a horizontal speed component of 140 kt shortly after it had climbed, presumably, to over 10 000 ft. The brief time interval and the fact that the aircraft had attained a speed substantially greater than its maximum operating speed (V_{NO}) of 110 kt led to a conclusion that it had been descending rapidly either as a deliberate manoeuvre or as the result of loss of control by the pilot. Although it was only possible to speculate on the reasons for this situation the overall circumstances of the flight immediately preceding the break-up were strongly suggestive of a progressive and rapidly deteriorating situation.

Fracture analysis of the starboard wing indicated that it was the primary failure in the break-up sequence, the wing having broken in an upwards and backwards direction as a result of a positive (i.e. upwards) overload application. Design inspection showed that the wing structure was stressed for an ultimate load of 4g. Stress calculations were proved correct and the materials used in the wing structure were shown to be to specification standards; therefore it is assumed that the wing failed at a load of at least 4g. Such a load could have resulted from violent manoeuvres, high speed, severe turbulence, or a combination of all of those factors. It is nonetheless certain that the limitation load factor of 2g was exceeded.

The aircraft had a valid Certificate of Airworthiness which defined its operating limitations. With the exception of the manner in which the flight was conducted, during which a passenger was being transported, there were no other deviations from the conditions of its Certificate of Airworthiness. The aircraft was neither certificated nor equipped for operation in cloud under icing conditions and it was not permitted to fly through any appreciable turbulence. During the subject flight and in the weather conditions prevailing at the time, the operational limitations were exceeded.

Examination of the engines revealed they were developing little or no power at the moment of impact. This evidence does not indicate that the engines may have stopped during the climb; it is possible that the engines may have been throttled back some time before the wing failed.

The carburettor heat installation of both engines did not meet the revelant British Civil Airworthiness Requirements. The maximum increase in carburettor intake air temperature was only 25°C, which was half the required capacity and was insufficient for operation under conditions in which carburettor icing may occur. The possibility that the climb had to be discontinued due to carburettor icing cannot be excluded; atmospheric conditions in cloud were favourable for carburettor icing.

Based on the elapsed time the climb to 8 700 feet, and to the probably attained altitude of 10 000 to 11 000 ft, it was probably made at full throttle. Carburettor icing during this part of the flight could not be proved from examination of the engines, neither could it be excluded. The technical possibility that the engines iced up and failed was potentially extant; the sooted sparking plugs which were evident during the power plant examination might be construed as an indication of this possibility.

From flight test reports it was learned that both engines could stop during a full power climb when both engines were feeding from the starboard fuel tank; this was attributed to insufficient capacity of the fuel lines. Following the test flights, when this characteristic was observed, more powerful engines were installed but the fuel lines were not changed, thus leaving the flow capacity of the system unchanged. During the post-crash inspection both engines were found selected to the starboard tank; however, because of impact damage to the cables the selector settings were subject to some doubt. On the other hand, the setting of the fuel selectors as found in the wreckage were in the configuration which had caused both engines to stop during previous test flights; this aspect cannot be entirely ignored. The selector settings, as found during the inspection of the wreckage, were not in accordance with the instructions which had been given to the pilot by the owner.

The pilot reported he was unable to maintain a heading as instructed by ATC and, later on, that a right-hand turn was easier to make than a left-hand turn. The reason for these apparent inabilities to comply could not be established but there was little doubt that the pilot was able to control the aircraft whilst on instruments during his climb from low level flight in the area of Balk up to 8 700 ft. The apparent small radius left and right turns as observed by the radar controller, and the continued climb were not indicative of deteriorating controllability. No reason was found to support an assumption that the aircraft was less controllable before it entered the fast descent during which the wing failed. It was thought likely that the pilot said he could not maintain a heading or could turn more easily to the right because of some operational reason, such as an attempt to fly around or avoid clouds. It was considered it was not positive evidence of any technical failure of the aircraft's instruments or controls. When considering the possible effects that the failure reported by the pilot would have had, the following aspects were considered.

The aircraft was equipped with two compasses, a simultaneous failure of both instruments is considered highly unlikely. Seven instruments, operating in different ways and with different systems, supplied information from which a heading could be selected and maintained; five of these instruments also provided information from which aircraft attitude could be derived. If there was a total failure of both vacuum and electrical systems, the operation of the pitot/static primary instruments, which give airspeed, altitude and vertical speed, would have been maintained; a magnetic standby compass would also have been available. A total failure of all these instruments and systems at the same moment when reported by the pilot (a serious instrument failure) can be discounted. At that time the aircraft was climbing which implies that both its engines or at least one of them was at full power, therefore one and probably two vacuum pumps would have been available to supply the artificial horizon and direction indicator. Failure of one engine would have resulted in an automatic changeover of a system shuttle valve and this would have maintained the requisite pressure to these suction driven instruments. Only a total failure of both engines, resulting in stationary propellers, would have caused both gyro suction instruments to fail.

Investigation showed there was electric power available at impact and this means that a supply was available for the electrically-driven turn and slip indicator and the magnesyn remote indicating compass; these two instruments supplement the other primary pitot/static instruments but on their own would be inadequate for continuous instrument flight.

Post mortem examination showed that the pilot was alive at impact and there was no evidence of pre-crash incapacitation. Inspection of the wreckage showed that the cabin heater was in operation when the aircraft crashed but the post mortem examination revealed no evidence of carbon monoxide poisoning in the pilot. Although he held a valid licence and a current instrument rating and was an experienced test pilot his experience in instrument flying was limited and was not recent. He had no instrument flying experience on the Britten-Norman Islander under actual instrument meteorological conditions.

Based on the evidence of the pilot's history and personal traits, it is thought possible that the instrument failure which he reported during flight was nothing more than an excuse to induce Schiphol ATC to provide the necessary radar guidance when visual flight through their control zone at 1 500 ft was not possible. This supposition has to be seriously considered because it would appear to be the only logical basis for the succession of events which preceded and followed the reported instrument failure.

The pilot took off on a VFR flight plan in weather conditions, both forecast and actual, which precluded a VFR flight and, in spite of this, attempted to proceed to his destination. In so doing, he acted in violation of Air Navigation Regulations and accepted grave risks to himself and other air traffic. The air traffic services had no formal control over his flight which was notified as being conducted under visual flight rules and this being so the air traffic services were not required to know the position of the aircraft. The reason why the pilot persisted in his attempt to fly to Southampton, despite the weather and against the advice of Bremen weather service to defer the flight, may have been due to being influenced by the aircraft's intended sales demonstration to an important potential buyer. G-ATCT was the only serviceable aircraft available for demonstration but the investigation revealed no evidence that the management of the factory had exerted undue pressure on the pilot to return the aircraft to the factory.

Shortly after taking off from Emden weather conditions were encountered which may have enabled the aircraft to be flown in VMC between cloud layers but without continuous sight of the ground; on approaching the front, however, weather conditions deteriorated. When passing Eelde the aircraft was probably already flying through cloud. In order to traverse the Schiphol Control Zone the pilot requested radar guidance but this could not be provided. Nonetheless, the flight continued to within 25 nautical miles of Schiphol where the pilot was positively advised not to enter the Control Zone and that he could not be given radar guidance. It was at this stage the pilot reported, for the first time, that he had compass trouble. He then turned on to a heading which brought the aircraft over Balk where he attempted to achieve visual contact with the ground by flying low; his attempt to establish contact flight was unsuccessful and it would seem that he then attempted to climb to an altitude where the cloud was layered and would enable him to continue under visual flight rules. Whilst flying at low altitude and shortly after commencing to climb the pilot again reported compass failure, possibly, it is thought, hoping to obtain radar guidance; however, the aircraft was not visible on the radar because of weather conditions and also because of its low altitude.

The climb was continued to altitudes where heaving icing and turbulence existed and in view of the meteorological conditions prevailing it would have been impossible for the pilot to have avoided flying in cloud where these hazards existed. The aircraft was not fitted with airframe or propeller de-icing, or anti-icing equipment, nor adequate engine anti-icing heat; its only anti-icing device was its electric pitot-heating system. On entering cloud with temperatures near or below freezing the aircraft would have encountered heavy ice accretions within a short space of time; this heavy and rapid accumulation of ice may have caused a series of failures which could have occurred singly, together or in rapid succession. These failures, which would not have been immediately remediable, would have included engine failure through carburettor icing, impaired effectiveness of nearly all basic flight instruments, accretion of ice on the wings, tail surfaces, propellers and control surfaces. This would have resulted in impaired controllability of the aircraft and, possibly, the gradual freezing of control surfaces and trim tabs. Generally, these kinds of failures due to airframe and engine icing leave no evidence except for soot deposits in the engine and its exhaust area. During examination of the engines deposits of soot were found on the sparking plugs and this may be considered as an indication of carburettor icing.

Although it was only possible to speculate on the precise train of events it was assumed as a certainty, that due to a rapid onset and progressive impairment of control of the aircraft, which would include loss of engine power, the pilot was forced to descend quickly or he lost control of the aircraft. The accretion of ice on the aircraft combined with poor inherent stability characteristics, the limited instrument flying experience of the pilot on type, the absence of external visual reference and the inadequate anti-icing capability of the engines, all created optimal conditions for losing control of the aircraft.

It is thought to be an acceptable conclusion that the pilot lost control of the aircraft. If loss of control occurred it can be assumed with certainty that a relatively high speed was achieved during the descent. The calculated horizontal component of 140 kt at which the wing failed indicates that the aircraft was in a dive at an abnormally high speed for its type. The application of control which would have been necessary to restore the aircraft to normal flight at this high speed, together with the relatively light elevator stick force, could easily have led to an overload condition and failure of the wing structure. In these conditions, any degree of turbulence would have contributed to an earlier overload condition; moderate turbulence existed at 1 500 ft and above, and moderate to heavy turbulence would have been present at 10 000 ft and above. The probability that turbulence would be encountered during the aircraft's descent was therefore considerable.

2.2 Conclusions

(a) Findings

The pilot held a valid licence and was an experienced test pilot. He had a limited instrument flying experience on this type of aircraft and his overall experience in instrument flight was limited and not recent. Post mortem examination revealed no indications of sudden incapacitation or intoxication by carbon monoxide.

The aircraft had a valid Certificate of Airworthiness, the conditions of which did not permit operation in cloud where icing conditions existed, or in appreciable turbulence. During the accident flight the aircraft was not operated in accordance with the limitations imposed by its Certificate of Airworthiness.

No defects were found during the inspection of the wreckage which could have contributed to the accident.

The aircraft was equipped with an electric pitot heating installation. The engines were equipped with a carburettor heat installation of insufficient capacity. The aircraft was not equipped with any installation for de-icing or anti-icing the wings, tail surfaces, propellers or cockpit windows.

The wing failed as a result of positive overloading. There were no indications that the wing did not have enough structural strength to be used within the operating limitation which permitted maximum load factors up to plus 2g.

The pilot attempted to remain in visual meteorological conditions and to fly under visual flight rules; he persisted in his attempt to continue the flight to his planned destination and in doing so he attempted to obtain visual reference to the ground by flying at low altitude over Balk. He then attempted to climb in order to achieve visual flight on top of cloud; it was presumed that an altitude of 10 000 ft was attained during this attempt.

Both forecast and actual weather conditions precluded a flight under VFR and VMC as well as preventing visual reference over Balk. Above 8 000 ft conditions of heavy icing prevailed; above 1 500 ft there was moderate turbulence and above 10 000 ft moderate to heavy turbulence.

The aircraft was in a climb at an altitude of more than 8 000 ft in an area where, as a result of ice accretion and turbulence, a sudden accumulation of failures may have occurred. Following this, and after a short lapse of time, there was a rapid onset and progressive deterioration of the controllability of the aircraft. The inexperience of the pilot in instrument flying on this aircraft, the equipment and flying characteristics of the aircraft and the weather conditions, formed optimal conditions for a loss of control of the aircraft by the pilot.

The starboard wing broke off during a possibly uncontrolled descent at a relatively high speed. Overstressing as the result of control application at this speed, in combination with relatively light control forces, is considered to have caused the failure of the starboard wing. Turbulence may also have been a factor.

(b) Cause or
Probable cause(s)

The accident was caused by the failure of the starboard wing, as the result of overstressing during a fast descent. The descent was presumably caused by loss of control under conditions of heavy icing and turbulence, when the aircraft was flown beyond the operating limitations stipulated in its Certificate of Airworthiness.

Non-scheduled international
En route
Airframe - Air
Airframe - wing

ICAO Ref: AIG/102/66