No. 48

Bay of Plenty Airways Ltd., Aero Commander 680S, ZK-BWA, accident on Mount Ruapehu, New Zealand, 21 November 1961. Report No. 25/3/1192 dated 14 February 1962, released by the Accidents Investigation Branch, Air Department, New Zealand.

Circumstances

At 1117 hours Flight 92 departed Wellington Airport on a scheduled flight to Rotorua. The flight cleared Wellington Control Zone and later reported its position at Foxton and east of Ohakea. No further messages were received from the aircraft, and no distress calls were heard.

At 1155 hours the aircraft was sighted over the northeast slopes of Mount Ruapehu. A few seconds later the starboard wing, complete with engine, separated from the fuselage. As the rest of the structure plunged towards the ground an explosion occurred, and the fuselage burst into flames. The aircraft crashed on the face of the mountain, and the pilot and five passengers died instantly.

The accident occurred at an altitude of 7 300 ft amsl, 1 276 yd from Te Heu Heu Peak.

Investigation and Evidence

The Aircraft

It was registered in New Zealand in September 1958. The aircraft had been inspected by the Airworthiness Division of the Civil Aviation Administration and was issued a temporary Certificate of Airworthiness, which was fully validated on 30 January 1959. The Certificate of Airworthiness was valid at the time of the accident.

While flying the aircraft in the U.S.A. the captain had subjected it to an extremely heavy landing which necessitated structural repairs before the aircraft could again be flown.

Throughout its life in New Zealand the aircraft was maintained in accordance with the manufacturer's maintenance schedule and appropriate inspection checks were undertaken at the prescribed periods. The most recent annual inspection and a prescribed 5 000 - hour structural check was begun on 23 September 1961 and completed on 1 October.

At the time of the accident the aircraft had flown a total of 5 040 hours since new and 303 hours since its last complete overhaul. It had accumulated 4 073 hours while in service with Bay of Plenty Airways. The number of landings it made when used by its original owner could not be determined, but the great majority of them were made on paved runways. The number of landings made by ZK-BWA in New Zealand was estimated as approximately 11 440, of which 70% were on grass airfields, the remainder on paved airport runways.

The Pilot

By January 1961, when the pilot last renewed his commercial pilot's licence, his flying time had reached a total of 3 618 hours and, although it was not possible to obtain precise figures, it is probable that at the time of his death that total had increased to some 4 300, of which about 3 000 hours had been accumulated on the Aero Commander aircraft involved in the accident.

Weather

Visibility was unlimited over the entire route between Wellington and Mount Ruapehu. The sky was clear with no trace of cloud at any level in the

Ruapehu area. The wind direction was 150° true and its velocity was estimated as 36 mph over the route.

Pilots of aircraft which entered the Mount Ruapehu area within an hour of the occurrence of the accident reported that, approaching the mountain from the south, they experienced generally smooth conditions. On the lee side of it, however, extremely violent turbulence of sufficient intensity to deter them from approaching close to the mountain face was encountered.

Eyewitnesses

The most significant feature of the evidence of eyewitnesses was the unanimous claim that they had seen the starboard wing, complete with engine, break away from the rest of the structure while the aircraft was in flight. Subsequent investigation confirmed that this did, in fact, happen.

Discussion of factors which may have contributed to the failure of the starboard wing

a) turbulence;

b) a structural defect;

c) the possibility that the aircraft had struck the mountain and sustained damage which led to complete failure of the wing;

d) a combination of these or similar circumstances.

a) Turbulence

It was calculated that the Aero Commander had achieved an overall ground speed of 243 mph during its flight from Wellington to Mount Ruapehu.

Bay of Plenty Airways customarily flew the aircraft at power settings recommended by the manufacturers and if the captain had done so on his last flight - and there was no reason to suggest that he had done otherwise - a true airspeed of 207 mph at a cruising altitude of 9 000 ft had been maintained.

Under those circumstances an average tailwind of 36 mph had been experienced over the route.

The effects of a strong wind blowing across a mountain barrier are well known. First, strong updraughts on the windward side are created as the wind is forced upward by the rising slope of the mountain. These updraughts are in turn converted into strong downdraughts of a very turbulent character on the lee side after the wind has swept across the summit. The effects of turbulence created by the general flow pattern of strong winds are known to extend vertically upward, in many cases, to heights as great as twice the height of the particular mountain. Even in moderate winds of, for example, 25 mph velocity, these effects are commonly present at heights of 2 000 - 3 000 ft above the crest.

The turbulence over Mount Ruapehu conforms to this general pattern but further interruptions in the air flow are provided by the presence of subsidiary peaks and the creater lake depression on what amounts to a relatively broad summit area. It is obvious, therefore, that subsidiary updraughts and downdraughts are created by winds sweeping over the summit region itself. The result is an area of extremely turbulent and unstable air immediately above the mountain.

An aircraft crossing the mountain from the windward side and in close proximity to the face would therefore encounter a strong updraught initially followed immediately by a severe downdraught as the windward crest was crossed. It would then encounter strong turbulence across the summit area in the lee of the subsidiary peaks and over the crater lake and finally experience severe downdraughts and violent turbulence on emerging over the far crest and reaching the lee side.

That such conditions essentially existed, at least over the lee slopes of Mount Ruapehu when ZK-BWA was in the area, was clearly established.

Because of this experience and familiarity with the route the pilot certainly expected turbulence in the Mount Ruapehu area on the morning of the accident. He must have realized from the groundspeed he had achieved between Wellington and the mountain that a strong wind was blowing. Although the absence of cloud over Mount Ruapehu precluded his being able to judge, visually by reference to swirling cloud masses, the amount of turbulence present or the areas in which it was most heavily concentrated, a pilot of his experience ought to know that clear air turbulence can and does exist.

The Aero Commander first appeared at a low altitude from a direction indicating that it had, a few moments before, flown across the crater lake which lies on the summit and was now flying on course in the general direction of Mount Ngauruhoe. Such a track would bring it into the immediate lee of the mountain where in view of its comparatively low altitude it must have been buffeted by a very marked degree of turbulence. Just before in-flight disintegration occurred a number of witnesses had seen the nose of the aircraft drop and then rise again - a movement that might well have resulted from turbulence.

b) Structural defect

Separation of the starboard wing had occurred at Station 24 and a preliminary examination of the structure, with particular reference to the fractures of all spar caps, was made at the wreckage site. It revealed that:

i) The front (main) spar upper cap had fractured as a result of a considerable movement upward and also a a rearward movement of the whole wing;

ii) The front (main) spar lower cap had a fatigue crack on one-half of its cross-section;

iii) The rear spar upper cap had a tensile-type fracture, and a portion of it appeared to be of some age;

iv) The rear spar lower cap had a tensile-type fracture which appeared of considerable age.

Metallurgical tests and microscopic examination of the spar cap fractures were then carried out independently by the DSIR (Department of Scientific and Industrial Research) in New Zealand and by the ALCOA Research Laboratories of the Aluminum Company of America. The results follow.

The fractured portion of the rear spar upper cap was a tensile failure, and traces of corrosion were found. It happened well before the day of the accident.

The fracture of the rear spar lower cap resulted from static tension. The surface of the fracture was covered with a dark oily film which was also present on the surface of the spar cap. The appearance of the oily film determined with certainty the sequence of spar cap failure ... i. e. the rear spar lower cap failed before the front spar lower cap. It could not be determined how long ago failure of the rear spar lower cap occurred, but it had the appearance of being a considerably old one.

A study of the history of the aircraft was then undertaken to see whether some particular event could have produced fractures which had undoubtedly resulted from a single severe shock load.

Incidents involving the aircraft while in the hands of its first owner could not be determined. There were no records to show that it had ever been involved in an accident necessitating structural repair thereafter.

The aircraft, while being flown by the subject pilot, had made an extremely heavy landing at Tuelakes Airport, Oklahoma City (U. S. A.) on 26 September 1958, and an extensive repair was carried out in the United States. Of particular interest were repairs made to the starboard wing which included the following:

i) the centre fuel cells were removed to facilitate an internal inspection of the wing structure.

ii) a repair was made to the rear spar of the starboard wing in the region of the engine nacelle.

iii) doubler plates, in the form of a reinforcement to the skin of the lower surface of the starboard wing between Stations 36 and 48 at the rear spar, were installed.

iv) the starboard inboard aft fuel cell support was repaired.

Twelve incidents were also brought to light, which may have contributed to some weakening of the aircraft structure.

Payload

In the course of the investigation the impression was formed that the aircraft had been overloaded beyond the maximum permissible all-up weight shown in the Certificate of Airworthiness.

Examination of the company's load sheets showed that the aircraft had, in fact, been frequently overloaded. Contrary to the requirements of the Civil Aviation Regulations, the vast majority of the load sheets were incomplete and unsigned. It would appear, however, that after National Airways Corporation acquired an interest in Bay of Plenty Airways, loading of the aircraft was kept within limits.

The all-up weight of the aircraft on the fatal flight was within limits, and the partially completed load sheet had been signed by the pilot. The load sheets for the three previous flights that day were, however, incomplete and unsigned.

Persistent overloading could have had a cumulative detrimental effect on an already weakened structure, particularly when the aircraft was being operated from rough grassed surfaces.

It was shown that structural defects had existed in the rear spar caps of the starboard wing prior to the accident. Arrangements were made to have an independent check made of another Aero Commander 680S aircraft abroad. As a result, advice was received that the particular spar areas in question were buried in the wing structure and were not capable of visual inspection. This explained why the defects were not detected.

A 5 000 hour structural check was carried out on the aircraft in September 1961 and was a particularly comprehensive one. Inspection panels were a feature of the Aero Commander's design, and although in this type of aircraft it is possible to see a portion of the rear spar lower cap, that portion of the component where fracture occurred could not be seen.

The only method by means of which the crack might have been detected would have been by X-ray examination. The successful operation of over 1 100 Aero Commander aircraft has shown no necessity for making such X-ray inspections necessary or mandatory. The New Zealand accident was the first in which structural failure in flight of an Aero Commander had ever occurred.

Of the incidents and circumstances discussed, the heavy landing made in the United States in 1958 appeared to be the most likely cause of complete failure of the rear spar lower cap and partial fracture of the upper cap. There can be no certainty about this, however. Individually, the incidents reported in New Zealand would be unlikely to result in any serious defect, but taken collectively they could well have had a cumulative adverse effect upon a

structure already weakened by failure of a major component.

In brief, in respect of structural defects, it was concluded that after the aircraft was purchased by Bay of Plenty Airways and prior to its last flight, the following occurred due to pilot mishandling:

i) A complete tensile-type fracture of the rear spar lower cap had taken place.

ii) A tensile-type failure of part of the rear spar upper cap had occurred.

iii) The starboard wing structure was thereby weakened and additional loading was transmitted to the front spar structure.

iv) Resultant therefrom, a fatigue crack was initiated in the front spar lower cap.

v) A series of incidents which occurred while the aircraft was being flown in New Zealand, aggravated the already weakened structure of the starboard wing.

c) Mountain strike

An examination of the wreckage revealed that at some time during the last flight of the aircraft the main landing gear had been extended so violently that fracture of the lower arm of the drag brace on each side had occurred. From discussions with representatives of Aero Commander Inc. it was learned that a gust loading of something like 6g could result in the gear being forcibly ejected from the retract wells. There were three arguments against the possibility that a 6g loading had occurred. It was, therefore, concluded that the most likely cause of the fracture of the drag brace arms of the main landing gear was loss of hydraulic pressure after wing separation, and this resulted in the gear being hurled out of its respective retract wells while the starboard wing and the rest of the structure were falling independently to earth.

Since it appeared unlikely that a combination of severe turbulence and of fractured rear spar caps had caused the starboard wing to part from the main structure, the possibility that a third factor might be involved arose. All witnesses who had seen the aircraft just prior to disintegration had commented on the unusual sound of the engines. Because the noise heard by one witness lacked the usual "high-pitched bark", one possibility that suggested itself was a loss of power. The report of another that the engines were making a "chugging" sound could imply a similar cause. Another person mentioned "a thrashing noise like the rotor blades of a helicopter in flight". This recalled the statement made by a witness to an accident involving a similar type of aircraft overseas in which it was known that an in-flight propeller strike had occurred. This focussed attention on the propeller blades.

There was one very significant fact. All three propeller blade tips bore a typical and exactly similar curvature, and all carried multiple strike damage and mutilation indicative of a presence of considerable engine power when that damage was inflicted. It is necessary to consider whether all that damage could have occurred when the detached starboard wing, complete with engine and propeller, struck the ground.

It is highly improbable that the engine would have continued to run under power with its fuel lines torn away even during the relatively short time that elapsed between wing separation and ground strike. If, however, it had continued to run the thrust of the propeller would have caused the detached wing to describe an erratic trajectory whereas in fact it struck the mountainside at a point along the track taken by the rest of the structure. No witness mentioned having seen the detached wing describe a gyratory or erratic fall. Furthermore, a principal witness stated that the noise of the engines ceased altogether after disintegration occurred. If power had still been on when the wing reached the ground the effect of propeller blade rotation would have tended to twist the wing round in the snow, leaving evidence of this accordingly. The wing, however,

made a single clean impression and, in addition, the only blade impressions in the snow were separate marks of a static character made by the two "lower" blades. There was no interconnecting slash mark between those impressions and, furthermore, the "upper" blade carried no impact bend. There was no obstruction on the open snow on which the detached wing fell which could account for the tearing, scoring, and, in the case of two blades, one of which was the "upper" one, shearing of the tips, the lost portions of which could not be found in the wreckage area.

There could, therefore, be only one possible conclusion: that, unobserved by anyone, and a few brief moments before the aircraft came into view over the crest, the starboard propeller (and possibly an adjacent portion of the bottom of the fuselage as well) had struck an isolated projection somewhere on the top of the mountain.

It is firmly believed that this mountain strike did occur.

Events leading up to separation of the wing (based on all available evidence)

As a result of a single incident which occurred an appreciable time ago but which could not be identified with complete certainty, the rear spar lower cap of the starboard wing was completely fractured and the rear spar upper cap was partially fractured.

The strength of the entire rear spar structure of the starboard wing was thereby weakened and some proportion of the load it previously carried was transmitted to the surrounding structure and to the front spar.

The existing spar defects, together with the cumulative effects of a number of incidents in which the aircraft was involved while being flown in New Zealand, combined to cause the initiation of a fatigue crack in the lower cap of the front spar.

The aircraft was flown in that condition for an appreciable but undeterminable time.

On the morning of the accident the aircraft approached Mount Ruapehu from the windward side in relatively smooth air conditions which gave no prior warning of turbulence.

The pilot decided to show his passengers the crater lake and other features of the mountain by flying low across the summit area.

In the summit area severe turbulence was encountered.

At some undetermined point over the summit area some circumstance forced the aircraft into such close proximity with the surface that the tips of the starboard propeller struck a rock outcrop and were badly damaged.

Severe engine vibration resulted from the now unbalanced propeller blades, and the pilot probably endeavoured to reduce its intensity by closing the starboard throttle.

The aircraft attained the lee side of the summit area and came within view of persons working on the lee slopes.

Immediately it came within the lee of the mountain the aircraft encountered very violent turbulence.

Because the starboard wing structure was already weakened by three defective spar caps; because a severe vibration through propeller damage was imposing additional and rapidly changing loads on the wing structure; and because the aircraft had entered a region of violent turbulence, the starboard wing was subjected to stresses and loadings beyond its capacity to withstand.

The front spar lower cap, in which a fatigue crack already existed, progressed extremely rapidly through fatigue propagation to complete failure.

The starboard wing began to separate from the fuselage at Station 24 by folding upwards.

That upward movement caused the fuel interconnect tubes between centre

(fuselage) and inboard (wing) fuel cells to become disconnected, thereby allowing fuel in considerable volume to pour out of the fuel cells.

Fuel was discharged into the atmosphere where it created a visible white vapour trail.

The damaged starboard propeller created a continuous thrashing noise similar to that made by the rotor blades of a helicopter in flight.

With increasing upward movement of the wing, the starboard inboard flap broke away from its hinge bracket on the rear spar and fell away from the aircraft. This was the small panel seen by witnesses.

The front spar upper cap of the starboard wing yielded, and the wing separated from the rest of the structure.

As the wing separated, hydraulic lines supplying pressure to retain the main landing gear within its retract wells fractured, and this left the wheels free to fall by gravity into the extended position.

While the starboard wing and the rest of the structure were falling separately to the ground, the main landing gear was forcibly extended with sufficient violence to fracture the lower arm of each drag brace.

An explosion occurred, and fire broke out in the central portion of the fuselage as it fell towards the ground.

Wind vortices in the lee of the mountain carried disrupted cabin insulating material over a wide area and up the slopes almost to the summit.

The starboard wing, with engine attached, struck the mountainside, and the two "lower" blades of the stationary propeller suffered characteristic static impact bends.

The remainder of the structure hit the mountainside at a lower level and was burnt out.

Observations

The fact that the captain flew the aircraft at a low altitude across the summit of Mount Ruapehu just before the accident was proved. Film belonging to one of the passengers was recovered and processed. Pictures had been taken from the right-hand seat of the aircraft and through the front windshield in a direction coincidental with the line of flight. The first four showed Mount Ruapehu directly ahead of the aircraft and becoming progressively closer. In the fourth picture the aircraft is apparently flying at a height not greater, and possibly even lower, than the crest of the mountain. The fifth picture was taken above the crest, just before the aircraft reached the rim of the crater lake. It indicated that the Aero Commander was about to cross the crater lake at a height considerably lower than several summit peaks which could be identified. The heading of the aircraft could be established. It appeared from the photographic record that the propeller strike had not occurred before the aircraft reached the rim of the crater lake.

When weather conditions were favourable, it was customary for the Bay of Plenty Airways pilots on the Wellington - Rotorua flights to give passengers an opportunity of seeing the prominent features of Mount Ruapehu and Mount Ngauruhoe by flying over their summits. The practice did much to improve public relations and promote interest. The procedures are laudable provided the aircraft is flown at a safe height above the mountain tops. Unfortunately, this was not always the case. The Civil Aviation Regulations stipulate the minimum safe height which must be maintained above the ground. This particular regulation is considered adequate provided that pilots adopt a commonsense attitude towards it and are fully aware of the necessity for increasing the clearance

between the aircraft and the ground when flying over mountain peaks and ranges generally.

If, in this accident, there had been any seriously injured survivors, they would probably have perished before being retrieved from the mountain. The only suitable means for bringing survivors out quickly would have been by helicopter. Certain military types of helicopter are in existence which are equipped with winching gear and are of sufficiently high performance as to meet normal rescue needs. The progress of this particular investigation was hampered by the impossibility of bringing the entire starboard wing and engine off the mountain. It was, in fact, necessary to remove particularly important components from the structure by crude methods under difficult conditions, and a much more rapid and complete appraisal could have been made if the complete wing had been available.

It is felt that most serious consideration should be given to the establishment of a Service helicopter unit which could be called upon for assistance as circumstances warrant.

Bay of Plenty Airways Ltd. was a small company imbued with the enthusiasm of its founder, the pilot of the subject flight, and a genuine desire to provide good air services for the inhabitants of the Bay of Plenty. It was almost inevitable that attempts to maintain its air services, with only one suitable aircraft, introduced an element of urgency into its operations, and there is no doubt that this was an influential factor in the background of some of the operational practices resorted to.

Probable Cause

The cause of the accident was the detachment of the starboard mainplane in flight. A contributory cause was the decision of the pilot to fly close to the summit of the mountain in an aircraft in which, unknown to him, the starboard wing structure had been appreciably weakened by a combination of spar cap fractures and fatigue cracking derived from a past incident. Severe turbulence or some pilot manoeuvre caused the starboard propeller to strike a part of the mountain and the resultant vibrational loads, together with the effects of violent turbulence encountered thereafter, imposed stresses which the weakened wing structure was incapable of withstanding.

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