No. 7

BOAC, Boeing 707, G-APFE, accident at the foot of Mount Fuji, Japan, on 5 March 1966. Report released by the Board of Trade, United Kingdom, C.A.P. 286.

1. - Investigation

1.1 History of the flight

The aircraft, G-APFE, on scheduled flight 911 (San Francisco/Honolulu/Tokyo/ Hong Kong) was expected to arrive at Tokyo International Airport at 1645 hours on 4 March. However, due to poor meteorological conditions at Tokyo International Airport and because the precision approach radar (PAR) of the GCA was out of service*, it diverted to Itazuke (alternate airport) and landed there at 1800 hours. After staying overnight at Itazuke, it left for Tokyo at 1125 hours on 5 March and proceeded on Jet Airway J40L via Oshima at flight level (FL) 290 in accordance with the instrument flight rules; it landed at Tokyo International Airport at 1243 hours.

Between 1300 and 1330 hours, the pilot-in-command, accompanied by the co-pilot, received briefing for the Tokyo-Hong Kong sector from the BOAC Duty Operations Assistant, in the international passengers' departure lounge. He briefed them on the 500 mb, 300 mb and 200 mb prognostic charts, prognostic tropopause chart, prognostic chart of significant weather and terminal forecasts for aerodromes at the estimated time of arrival which had been provided by Tokyo International Airport Aviation Weather Service.

At about 1330 hours, the Operations Assistant filed with the Operations Section of Tokyo Aeronautical Aids Office a flight plan, for a flight in accordance with the instrument flight rules via Oshima on JG6 to Hong Kong at FL 310 with proposed time of departure of 1345 hours and total estimated flight time of 4 hours and 17 minutes, and handed a copy to the co-pilot.

At 1342 hours, G-APFE commenced communications with air traffic control at Tokyo International Airport, requesting permission to start engines and clearance for a VMC climb via Fuji-Rebel-Kushimoto. The aircraft left the ramp at 1350 hours and, after receiving an instruction at 1357 hours to make "a right turn after take off", departed Tokyo International Airport at 1358 hours.

The estimated flight path from Tokyo International Airport to Gotemba City, based on an 8-millimetre cine photo colour film of the countryside taken by a passenger on board, is as follows:

> The aircraft, after taking off from Tokyo International Airport, flew over Samezu, made a right turn and proceeded, climbing, towards a point between Yokohama and Ofuna. It then made another right turn and flew over a point (see Fig. 7-1, between A and B) approximately 13 km to the north west of Odawara City and approximately 5 km to the north of Mt. Myojindake, at an altitude of 5 100 m on a heading of approximately 246°M at an indicated airspeed of 320 to 370 kt.

* PAR was out of service between 1525 hours and 1650 hours. The glide slope of the ILS was awaiting flight check.

The aircraft subsequently flew over Gotemba City (see Fig. 7-1, between C and D) on a heading of approximately 298°M at an altitude of approximately 4 900 m and indicated airspeed of 320 to 370 kt. (Immediately after this, the film skipped two frames, followed by vague pictures of something like the passenger seats or cabin carpet, and suddenly came to an end.)

The estimated flight path from Gotemba City to the crash site, based on the statements of many witnesses and the pictures is as follows (see Fig. 7-3):

The aircraft, trailing white vapor, was losing altitude over the Takigahara area, and parts of the aircraft began to break away over Tsuchiyadai and Ichirimatsu.

Finally over Tarobo at an altitude of approximately 2 000 m, the forward fuselage broke away. The mid-aft fuselage together with the wing, making a slow flat spin to the right, crashed into a forest* at 2109, Nakahata, Gotemba City at approximately 1415 hours.

The forward fuselage crashed into the forest (2110 Nakahata) approximately 300 m to the west of the above site and caught fire.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	11	113	
Non-fatal			
None			

Post-mortem examinations of the flight crew members revealed no evidence of any pre-existing disease or drugs that might have affected the performance of their duties.

1.3 Damage to aircraft

The aircraft broke into pieces in the air and the forward fuselage (including the cockpit) was almost destroyed by ground impact and fire.

1.4 Other damage

Some parts of the forest on which the pieces of G-APFE fell received damage.

* Latitude 35°19'45"N Longitude 138°48'17"E
Elevation 1 320 m

1.5 Crew information

The pilot-in-command, aged 45, joined BOAC on 6 March 1946, and qualified as captain on Boeing 707 on 3 December 1960.

He obtained United Kingdom airline transport pilot's licence (ALTP) No. 22160 on 4 May 1950 and was qualified as captain on Boeing 707 and co-pilot on Canadair C4 and Douglas DC-7C.

On 1 November 1965, he passed a medical examination and his medical certificate was valid till 11 May 1966.

He had accumulated a total of 14 724 flying hours including a total of 2 155 hours in Boeing 707 aircraft (2 101 hours as pilot-in-command and 54 hours as co-pilot).

He had flown 19 hours in the 30 days preceding the accident.

According to the BOAC flight control manager, the pilot-in-command had operated to Tokyo International Airport in aircraft of various types since 1950 and was experienced in operation in the Tokyo area. He was fully conversant with meteorological conditions on the route and around Tokyo and was fully aware of the problems associated with flight in turbulence and mountain wave systems. In addition, he attended a special lecture in April 1965, on flight in turbulence and recovery from any resulting abnormal flight attitudes.

The co-pilot, aged 33, joined BOAC on 29 September 1957, and qualified as co-pilot on Boeing 707 on 26 June 1962 and as second-in-command on 8 May 1963.

He obtained United Kingdom airline transport pilot's licence No. 46165 on 5 January 1966, with a rating for co-pilot on Boeing 707. He also held a flight navigator's licence. He passed a medical examination on 3 January 1966 and his medical certificate was valid till 8 July 1966.

He had accumulated a total of 3 663 flying hours including a total of 2 073 hours in Boeing 707 (710 hours as co-pilot, 1 214 hours as third pilot and 149 hours as navigator). He had flown 54 hours in the 30 days preceding the accident.

The second first officer, aged 33, joined BOAC on 23 September 1957, and qualified as co-pilot on Boeing 707 on 8 July 1962 and as second-in-command on 11 June 1963.

He obtained United Kingdom airline transport pilot's licence No. 46673, on 25 May 1965 with a rating for co-pilot on Boeing 707. He also held a flight navigator's licence.

He passed a medical examination on 15 September 1965 and his medical certificate was valid till 27 March 1966.

He had accumulated a total of 3 906 flying hours including 2 538 hours in Boeing 707 (812 hours as co-pilot, 1 406 hours as third pilot and 320 hours as navigator). He had flown 53 hours in the 30 days preceding the accident.

The flight engineer, aged 31, joined BOAC on 8 July 1957, and was appointed as flight engineer on Boeing 707 on 17 April 1963. He obtained United Kingdom flight engineer's licence No. 726 on 24 June 1958.

He passed a medical examination on 9 June 1965 and his medical certificate was valid until 21 June 1966.

He had accumulated a total of 4 748 flying hours including 1 773 hours in Boeing 707. He had flown 54 hours in the 30 days preceding the accident.

Investigation of the flight experience of the crew in the 30 days preceding the accident and their activities at Itazuke on 4 and 5 March revealed no evidence to indicate any factors which could be associated with the accident.

1.6 Aircraft information

(a) G-APFE, a Boeing 707-436, manufacturer's serial No. 17706, was manufactured in 1960 and issued with a United States Export Certificate of Airworthiness on 29 April 1960. The aircraft had accumulated a total of 19 523 hours 33 minutes flying with a total of 6 744 landings.

Its United Kingdom certificate of airworthiness (No. A.6676) was renewed on 29 April 1965 and was valid till 28 April 1966. The aircraft and power-plants were properly maintained in accordance with BOAC maintenance procedures.

(b) The gross weight of the aircraft at the time of the accident was computed to be approximately 112 500 kg. The weight at the time of take-off from Tokyo International Airport was 117 832 kg and the centre of gravity was within limits at INDEX +190.

The aircraft carried 40 400 kg of fuel in the wing tanks and 2 570 kg in the centre tank.

(c) The aircraft was serviced with Shell Aviation Kerosene Jet A-1.

1.7 Meteorological information

(a) Meteorological Conditions between Tokyo and Mt. Fuji

A depression intensified during the night of 4/5 March and moved rapidly NE across Japan. After this, there was an anticyclone over the Asian Continent and a depression over the sea to the east of Japan; a steep pressure gradient from west to east predominated over Japan at low levels.

On the afternoon of 5 March, westerly or north-westerly winds blew at the surface between Tokyo and Gotemba, the weather being fine with such good visibility that, quite unlike the previous day, Mt. Fuji could be seen from Tokyo. (see Fig. 7-4). At higher levels, the winds were generally west-north-westerly (see Fig. 7-5) between Tokyo and the Mt. Fuji area. Accordin to the observations taken at the Fuji-san Weather Station (elevation 3 776 m), at the summit of Mt. Fuji, the wind was 60 to 70 kt north-west and the temperature was -9°to -12°C.

(b) Turbulence Reports from Aircraft

Air reports were collected from 100 aircraft which flew within 150-km radius of Mt. Fuji on 5 March. 79 aircraft among the 100 aircraft experienced turbulence, mostly below 3 000 m, and principally at low altitude during climb or descent.

4 aircraft out of the above 79 encountered severe turbulence within a 50-km radius of Mt. Fuji in its eastern quadrant.

(c) Meteorological Service to G-APFE

The Tokyo Aviation Weather Service furnished the BOAC Operations personnel on duty with the prescribed weather charts regarding the G-APFE flight between Tokyo and Hong Kong.

Prior to the departure of G-APFE from Tokyo, neither the pilot-in-command nor the operations personnel on duty informed the Weather Service of the intention to fly via Fuji, nor requested briefing on weather conditions along the airway from the Aviation Weather Service.*

1.8 Aids to navigation

The operating conditions of the NAVAIDs related to Tokyo International Airport and to the flight plan of G-APFE on the day of the accident were as follows:

Tokyo International Airport	Date of Last Flight Check	Operating Conditions	Operating Hours
PAR (33L)	6 Jan. 1966	In operation	24 hours
PAR (33R)	5 Mar. 1966	"	"
ASR	4 Feb. 1966	"	"
ILS (Glide Slope)	5 Mar. 1966	Awaiting flight check	
ILS (Localizer)	15 Feb. 1966	In operation	24 hours
NDB			
Haneda NDB(HM)	29 Jul. 1965	In operation	24 hours
Kisarazu NDB(KZ)	6 Aug. 1965	"	"
Chigasaki NDB(LW)	29 Mar. 1965	"	"
Hamamatsu NDB(LH)	29 Jul. 1965	"	"
Kushimoto NDB(KH)	1 Feb. 1966	"	"
Range			
Oshima Range(XA)	15 June 1965	"	"
VOR			
Tokyo VOR(TYO)	29 Jan. 1966	"	"
Kushimoto VOR(KHO)	10 Dec. 1965	"	"
VORTAC			
Oshima VORTAC(XAC)	6 Jan. 1966	"	"

* BOAC have stated that their pilots do not normally attend for personal briefing unless any matter in the documentation provided appears to require further clarification.

Flight checks along the estimated flight path could not be accomplished since the aircraft conducted a VMC climb outside the airway between Tokyo International Airpor and Fuji.

1.9 Communications

The last communications between the aircraft and Tokyo Tower (frequency 118.1 Mc/s) at 1400 hours after take-off were as follows:

ACFT Tokyo Tower Speed Bird 911 we are 2 000 ft climbing, are we cleared your frequency?

TWR Roger, Speed Bird 911 ... cleared to leave our frequency contact Tokyo Approach approaching -er- joining airway over.

ACFT Will do. Frequency please.

TWR Roger, frequency will be 135.9 over.

ACFT Roger, 135.9, Good day.

1.10 Aerodrome and ground facilities

G-APFE departed Tokyo International Airport at 1358 hours, using runway 33L.

Runway 33L, 3 000 m long, 45 m wide, has elevation of 2.5 m and runway gradie less than 0.2%. When the aircraft took off, the runway surface was dry.

1.11 Flight recorders

The SFIM flight recorder and the RAE counting accelerometer installed below the cockpit floor were destroyed by fire and no data were available. These recorders we carried as part of the United Kingdom civil aircraft airworthiness data recording progra the accident occurred before the U.K. requirement for the carriage of accident flight da recorders became mandatory.

1.12 Wreckage

(a) Major parts which broke away in the air

Starboard wing tip (section outboard of STA 733)
Starboard wing between the vicinity of STA 500 and STA 733 (including No. 4 pylon attachment section)
Each pylon (including engine)
Forward fuselage (section forward of STA 600K)
Aft fuselage (section aft of STA 1592), ventral fin and tail cone
Vertical stabilizer and rudder
Port horizontal stabilizer and elevator
Starboard horizontal stabilizer, stabilizer centre section and starboard elevator

(b) Distribution of the Wreckage

The above aircraft parts and other fragments were scattered over an area approximately 16 km long from east to west and approximately 2 km wide (see Fig. 7-2).

The main wreckage consisting of starboard and port wings and mid-aft fuselage was found on the ground heading in a westerly direction; its condition was such as to support a presumption that immediately before impact it fell almost vertically in a nearly level attitude.

No. 1 to No. 4 engines and their pylons fell in an area 0.5 to 2 km to the west of the main wreckage. The forward fuselage (including cockpit) was found 0.3 km to the west of the main wreckage.

The starboard wing section (including part of No. 4 pylon) between the vicinity of STA 500 and STA 733 was found in an area 1 to 2 km to the east of the main wreckage. In an area 2 to 3 km to the east of the main wreckag were found the starboard wing tip (outboard section of STA 733), starboard horizontal stabilizer (including centre section), starboard elevator, rear spar of the port horizontal stabilizer, a part of the port elevator, the rear spar and trailing edge section of the vertical stabilizer and the upper half of the rudder. In an area 3 to 4 km to the east of the main wreckage were found fragments of the vertical stabilizer, port horizontal stabilizer, rudder, elevators, tabs, starboard wing skin, tail cone and ventral fin. In an area 4 to 6 km to the east of the main wreckage were found fragments of the horizontal stabilizer, vertical stabilizer, rudder and cabin bulkheads.

(c) Examination of the Wreckage

The starboard wing fractured at STA 733 and in the vicinity of STA 550; both fractures were in the direction of wing tip up bending.

All the pylons fractured at their wing attachments in the same manner, due to predominantly leftward load.

The forward fuselage failed to the left (and slightly downward) in the vicinity of STA 600K.

The aft fuselage fractured in the area between STA 1440 and STA 1592. The ventral fin fractured at its fuselage attachment section due to approximately leftward load and broke away from the fuselage.

The vertical stabilizer fractured at its attachments to the fuselage due to leftward load. The starboard rear attachment fitting (on fuselage side) of the vertical stabilizer fractured at the upper bolt hole due to tension load. Fatigue cracks were found on the fracture face of one of the bolt holes.

Damage to the port horizontal stabilizer was extensive and dents, scratches and paint adhesion were found which are presumed to have been caused by it being struck by the vertical stabilizer. Subsequently, the port horizontal stabilizer separated from the fuselage at its root.

The starboard horizontal stabilizer, which was almost intact, broke away from the fuselage together with the centre section.

The jack screw rod of the horizontal stabilizer trim actuator fractured near the top end at the lower surface of the nut. The length of the screw from the stopper surface of the upper part of the screw and the upper surface of the nut was 105 mm corresponding to 1.4 units aircraft nose down on the pitch trim wheel scale in the cockpit.

Almost all instruments were destroyed by the fire in the forward fuselage and no useful data were available.

It is presumed that the aircraft was in cruising configuration because the flaps and the landing gear had been in the retracted position.

No structural defects were found in the airframe structure except the fatigue cracks in the vertical stabilizer rear spar attachment fitting (on the fuselage side).

No sign of malfunctioning was evident in the flying control systems, control surfaces and other systems.

There was no evidence of any pre-crash engine defects. No sign of explosion in the cabin was found.

1.13 Fire

Fire broke out in the forward fuselage at ground impact. It is presumed that a considerable amount of fuel entered the space below the forward fuselage floor as a result of the break-up of the centre wing front spar, which took place when the forward fuselage broke in the air at STA 600K, and the damage to the centre fuselage fuel tank which appears to have occurred at the same time. None of the wreckage other than the forward fuselage caught fire.

The Defense Agency personnel who were first to arrive at the fire site, extinguished the fire by covering it with earth.

1.14 Survival aspects

The circumstances of the accident were such that it was not survivable.

1.15 Tests and research

(a) 8-mm Camera and its Colour Film

An 8-mm cine camera (Keystone zoom) belonging to a passenger was recovered at the crash site. It contained a Kodak colour film of Tokyo International Airport, the Tanzawa Mountains and Lake Yamanaka and, after skipping two frames, something like passenger seats, carpet etc. Then the film suddenly came to an end.

Based on the analysis of this film and the photogrammetry of each frame, the flight altitude and path of the aircraft were assessed as indicated in Fig. 7-1. The airspeed was also assessed based on these data.

With regard to damage to the view-finder of the camera and the skipping of two frames, the camera was subjected to a shock test. During a 7-milli-second test in which a peak shock of 7.5g was reached, malfunctioning of film feeding occurred similar to that evident in the film recovered from the passenger's cine camera.

(b) Load and Strength of Airframe Structure

Based on the data submitted by the Boeing Co., the strength of the air-frame structure was investigated in accordance with airworthiness require-ments (CAR 4b) of the Civil Aviation Regulations, United States. For this analysis, it was assumed that the aircraft weight was 112 500 kg (252 00 lb) and the airspeed 335 kt, EAS. The principal results were as follows:

(i) The strength of the wing around STA 733 corresponds to a symmetrical load of 6.4g and, in the case of about 10° side-slip, the wing load amounts to approximately 4.6g.

(ii) The strength of the fuselage around STA 600K is 5.6g downward and 4.1g sideward and that of the pylon attachment portion is 2.75g (inboard) -- 2.55g (outboard) sideward. Any of the above areas can stand a steady side-slip in excess of 40°.

(iii) (a) The strength of the vertical fin for lateral load corresponds to the load which will be produced by lateral gust velocity (U_{de}) of 130 fps (75 kt) EAS or by side-slip of 10°.

(b) The horizontal stabilizer was designed for an ultimate dis-tributed air load of 140 000 lb (margin of safety factor is approximately 0.15). This load corresponds to the load which will be produced by a downward gust velocity (U_{de}) of 225 fps (133 kt) EAS approximately.

(c) Trajectory of Aircraft Parts

Based on the wreckage distribution chart and the estimated wind velocity at the time of the accident, and also the results of air drag experiments using models, the trajectory of representative aircraft parts was analysed and an estimation made of where they broke away in the air with the fol-lowing results:

No time difference was apparent between the break-up of the right wing at STA 733 and that around STA 550; they broke away above the main wreckage impact area.

The engine pylons and the forward fuselage broke up almost at the same time and they broke away above the main wreckage impact area.

The vertical stabilizer and the port horizontal stabilizer broke away almost at the same time above a location a little to the east of the main wreckage impact area.

It was not possible to determine the sequence of break-up of the starboard outer wing, the engine pylons and the forward fuselage.

The vertical stabilizer and the port horizontal stabilizer broke away somewhat earlier than the starboard outer wing, engine pylons and the forward fuselage.

(d) Metallurgical Tests of Vertical Stabilizer Rear Spar Right Hand Attachment Fitting (on Fuselage Side)

The tests conducted by the Boeing Co. revealed that the fracture started from the upper outboard body frame attachment hole and progressed in a ductile tensile manner.

The fatigue cracks found in the bolt hole were 1.9 and 1.4 millimetres deep. The final fracture was caused by a sudden load substantially greater than the load which caused the fatigue cracks in the fitting. The mechanical qualities of the material used were up to specification.

(e) Strength Test of Vertical Stabilizer Rear Spar Right Hand Attachment Fitting (on Fuselage Side)

A test was made by Boeing on a similar attachment fitting in which the fatigue cracks found in the bolt hole of G-APFE were simulated. When the load was increased at 1 000 kips/s the fitting failed at a load of 163 kips. This load corresponds to approximately 110% limit design fin gust load.

(f) Model Experiment of Destruction Sequence of Tail

Using 1/15 scale models of the empennage and the rear end of the fuselage of a Boeing 707, made of foamed plastic material, an investigation was made to determine whether the vertical stabilizer hits the port horizontal stabilizer when it breaks up at its fuselage attachment portion due to lateral load from the right side.

The results supported the assumption that the dents, scratches and transferred paint on the port horizontal stabilizer were mostly caused by it being struck by the vertical stabilizer.

(g) Falling Conditions of the Main Wreckage

A film record was available of the last 8 seconds of the descent of the main wreckage. This was analysed and indicated that the falling speed was approximately 70 m/s, rotating cycle approximately 15 seconds, and wind-direction approximately 290°.

(h) Wind Tunnel Test of Terrain Model of Mt. Fuji

As a preliminary to the investigation of air currents around Mt. Fuji, the Meteorological Research Institude, Meteorological Agency conducted a wind tunnel test using a terrain model of Mt. Fuji.

The test was made in a Goettingen type wind tunnel of 1.5 m diameter with wind velocity of 2 m/s. The speed of the air stream was measured by a hot wire anemometer with platinum wire of 5 microns diameter and 3 millimetres long, and a hot wire anemoscope with approximately equal dimensions. The scale of the terrain model of Mt. Fuji (covering an area 50 km to the east, west, south and north of the centre of Mt. Fuji) was 1 to 50 000, with the ratio of horizontal distance and height of 1:1.2.

The results of the experiment are interesting and are outlined below. However, they cannot be applied directly to the actual air flow around Mt. Fuji, particularly in view of lapse rate and wind shear considerations.

(i) In a region from the summit to 20 km leeward there exists a reverse current in the lower layers which, according to circumstances, may not be distinct but becomes a diversified current.

In this region, the existence of the reverse current sometimes results in descent of the upper layer air current over a range from the summit to a fairly far point and the descent of the air current may take place intermittently at the end of the descent range.

(ii) In an area beyond 20 km from the summit, no air eddies of distinct form can be detected because turbulence due to terrain has largely decayed at these distances.

(iii) Turbulence due to terrain is considered to extend within a wake wedge angle of approximately 60° in the leeward, horizontal direction. It also extends vertically to the upper layer by approximately 30% of the height of the mountain.

(iv) In the air current blowing leeward around the mountain is found a sudden variation of wind velocity which is considered to be due to trail eddies. It should be noted that the average wind velocity in this area in the leeward side is higher than that of the surrounding current.

(j) Formation of Mountain Waves

(i) Mountain Waves due to a Mountain Range

An investigation was conducted on the formation of mountain waves due to the Kiso Mountain Range and the Akaishi Mountain Range in the windward of Mt. Fuji.

Analysis of the upper air observations at Wajima, Hamamatsu and Tateno on 5 March, revealed the existence of a stable layer below 3 000 - 4 000 m with winds of 60 - 70 kt blowing approximately at right angles to the two mountain ranges. The wind velocities at Yonago and Wajima increased more or less uniformly with altitude. The above meteorological conditions favoured the formation of mountain waves in the lee of the Kiso Mountain Range and the Akaishi Mountain Range on the afternoon of 5 March.

In the weather satellite pictures taken at 1330 hours on 5 March, clouds were present in the lee of the Suzuka Mountain Range; these are considered to have been formed in mountain waves but such clouds were not found in the lee of the Kiso and Akaishi Mountain Ranges. This was due to the fact that the air was too dry but it does not preclude the existence of mountain waves.

(ii) Mountain Waves associated with Isolated Peak

Wurtel* suggests that an isolated peak can form a kind of mountain wave system with form different from that of mountain waves due to mountain ranges. In the case of Mt. Fuji, the possibility of the existence of such waves can be deduced from clouds of a horseshoe shape formed in its lee. (As mentioned earlier, the air was too dry to support such cloud formation.)

(iii) Turbulence accompanying Mountain Waves

Turbulence accompanying mountain waves initiated by mountain ranges may be qualified as follows:**

In powerful mountain waves, rotors often form and severe turbulence is usually associated with rotors.

Apart from this, severe turbulence may occur at the fringe of a mountain wave system by interference with surrounding current.

Based on the assumption that the breakdown of mountain waves results in severe turbulence, severe turbulence occurs when and where the wave motion is interrupted. Such severe turbulence is likely to be of small extent and short life.

Since the energy supply for turbulence accompanying mountain waves is stored in gravity waves, it is possible that turbulence may become extremely severe if powerful (high energy) mountain waves develope.

2. - Analysis and Conclusions

2.1 Analysis

The investigation revealed that the qualifications, flight experience, work load, physical condition etc. of the flight crew had no bearing on the accident.

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* WMO Technical Note No. 34 (1960)
** WMO Technical Note No. 38 (1961)

The indicated airspeed at the time of the accident is estimated to have been between 300 and 380 kt, judging from the estimated trim position of the horizontal stabilizer, and it is highly probable that the airspeed was approximately 335 kt. The airspeed at the time of the accident deduced from the analysis of the 8-mm colour film taken by a passenger in the cabin was 320 to 370 kt. Although no other data related to airspeed were available due to destruction of the flight recorder by fire, 335 kt EAS was taken as a standard reference for the analysis of airframe strength etc. since the estimates of air speed ranges arrived at on these two bases are substantially similar.

Judging from the evidence of eyewitnesses and the scattered distribution of the wreckage, it is clear that the aircraft broke up in the air. However, even if it is assumed that the break-up started from one or more of the major portions which broke off in the air, it was not possible to establish the break-up sequence* of the major portions of the entire aircraft. It was also impossible to determine clearly how much the fatigue cracks in the vertical stabilizer rear spar starboard fitting contributed to the break-up

The starboard outer wing was fractured in the upward bending direction but no evidence of excessive load applied to the port wing was found. From this, it can be deduced that the upward bending load applied to the wing was an asymmetric load with leftward component. As the other major parts (excluding the horizontal stabilizer, rear portion of the fuselage and the tail cone) were fractured by mostly leftward load, it is apparent that the aircraft broke up due to mostly leftward load.

From the above, it is presumed that the aircraft broke up in a very short period of time due to an abnormally high gust load and resulting high inertia force in excess of the design limit.

The BOAC Flight Operations Instructions provide that aircraft shall always fly on an IFR clearance; VMC flight is permitted exceptionally, subject to restriction, to expedite the progress of aircraft in the stages of climb, descent and approach-to-land. In the case of take-off, a pilot-in-command may request VMC climb clearance from ATC, or accept VMC climb clearance from ATC, to expedite progress of the aircraft, if,having sufficient separation from other aircraft, he considers a delayed departure clearance may be avoided.

Regarding IFR traffic in Kanto Air Space before and after take-off of G-APFE, it is recognized that JA 8617 (Fokker F-27), departing Tokyo International Airport at 1352 hours, was flying to Oshima via Tateyama on the same route as that in the flight plan of G-APFE but G-APFE could have taken off without being affected by JA 8617 because the radar control could have provided safe separation between the two. However, there remains a probability that the captain of G-APFE, knowing the presence of JA 8617 which was slower than G-APFE, requested VMC climb for the purpose of expediting the progress of his aircraft.

Further, it is a possibility that it was due to VFR traffic and IFR arrival traffic that the captain requested a VMC climb.

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* It is evident that the vertical stabilizer broke away at its attachment to the fuselage due to a leftward load, and fell to the left, hitting the port horizontal stabilizer which in turn was destroyed by the impact. Later, the starboard horizontal stabilizer and the aft fuselage (including the tail cone) broke away.

Based on the above, the VMC climb via Fuji was a matter left to the captain's discretion if it was made to expedite the progress of the aircraft. The VMC climb may also have been associated with the captain's desire to allow his passengers to obtain a better view of Mt. Fuji but this cannot be established with certainty.

Results of analysis of the colour film based on photogrammetry revealed that the 90 frames of the Tanzawa Mountains were taken between A and B in Fig. 7-1 and the 81 frames of Lake Yamanaka were taken between C and D in Fig. 7-1.

There was no blurring of the pictures. From the fact that the pictures of Lake Yamanaka were taken following the Tanzawa Mountains, it is presumed that the flight over this portion was smooth and the conditions were such that the passengers could take pictures at any time. In other words, it is presumed that there was no bumpiness which might have affected photography during this period. It is also presumed that the altitude change of 200 m between A - B and C - D took place so slowly that photography was not affected.

The bodies had sustained common fatal injuries resulting from an abnormally severe deceleration of the aircraft in flight. From this, it is presumed that there was a large external load applied to the aircraft with abnormal suddenness. This also accounts for the fact that a considerable amount of fuel in the centre tank moved to the forward fuselage in a very short time. Based on the camera tests, it is evident that the camera, while in operation, received an abrupt shock on its view finder at D point.

If a strong mountain wave system existed in the lee of Mt. Fuji on the day of the accident, severe turbulence would have existed in any rotor portion and at the fringes of the system as in the case of mountain waves formed by mountain ranges.

When strong winds blow against Mt. Fuji as they did on the day of the accident, it can be considered, irrespective of the existence of the mountain waves, that, as mentioned by Förchtgott*, the down draught current formed in the lee by the over mountain current and the up draught current formed in the lee by the current detouring around the mountain complicate the current in the lee.

Furthermore, as the temperature of the air which reached the summit of Mt. Fuji on the day of the accident was approximately 8°C lower than that of the free air, it is considered that this cold air, becoming a strong down draught current in the lee, may have played an important role in forming turbulence in the lee.

In consideration of the above meteorological conditions which could have existed in the lee side of Mt. Fuji on the day of the accident and the turbulence reports from aircraft on the day, it can be presumed that moderate or severe turbulence existed in the lee of Mt. Fuji at the time of the accident, but it is impossible to determine whether there was in existence turbulence corresponding in severity to "EXTREME"** under the United State classification.

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* WMO Technical Note No. 18 (1958)

** Defined as follows:

"A rarely encountered turbulent condition in which the aircraft is violently tossed about, and is practically impossible to control. May cause structural damage."

However, it is not unreasonable to assume that on the day of the aircraft accident powerful mountain waves existed in the lee of Mt. Fuji, as in the case of mountain waves formed by extended ridges, and that the breakdown of the waves resulted in small-scale turbulence, the intensity of which might have become severe or extreme in a short period of time.

2.2 Conclusions

Findings

G-APFE was making a normal flight towards Mt. Fuji till immediately before the accident in such clear weather that Mt. Fuji could be seen from Tokyo.

The evidence provided by the aircraft wreckage, the injuries to the victims and the evidence from the colour film suggest that the aircraft suddenly encountered abnormally severe gust loads exceeding the design limit load over Gotemba City and disintegrated in the air in a very short period of time.

Although it was impossible to forecast the existence over Gotemba City of turbulence sufficiently severe to destroy the aircraft and the investigation could not discover evidence which could verify meteorologically the existence of such turbulence, it cannot be denied that turbulence might have become extremely severe, if it is assumed that a strong mountain wave system was present in the lee of Mt. Fuji.

Cause or Probable cause(s)

The probable cause of the accident is that the aircraft suddenly encountered abnormally severe turbulence over Gotemba City which imposed a gust load considerably in excess of the design limit.

ICAO Ref: AR/008/66

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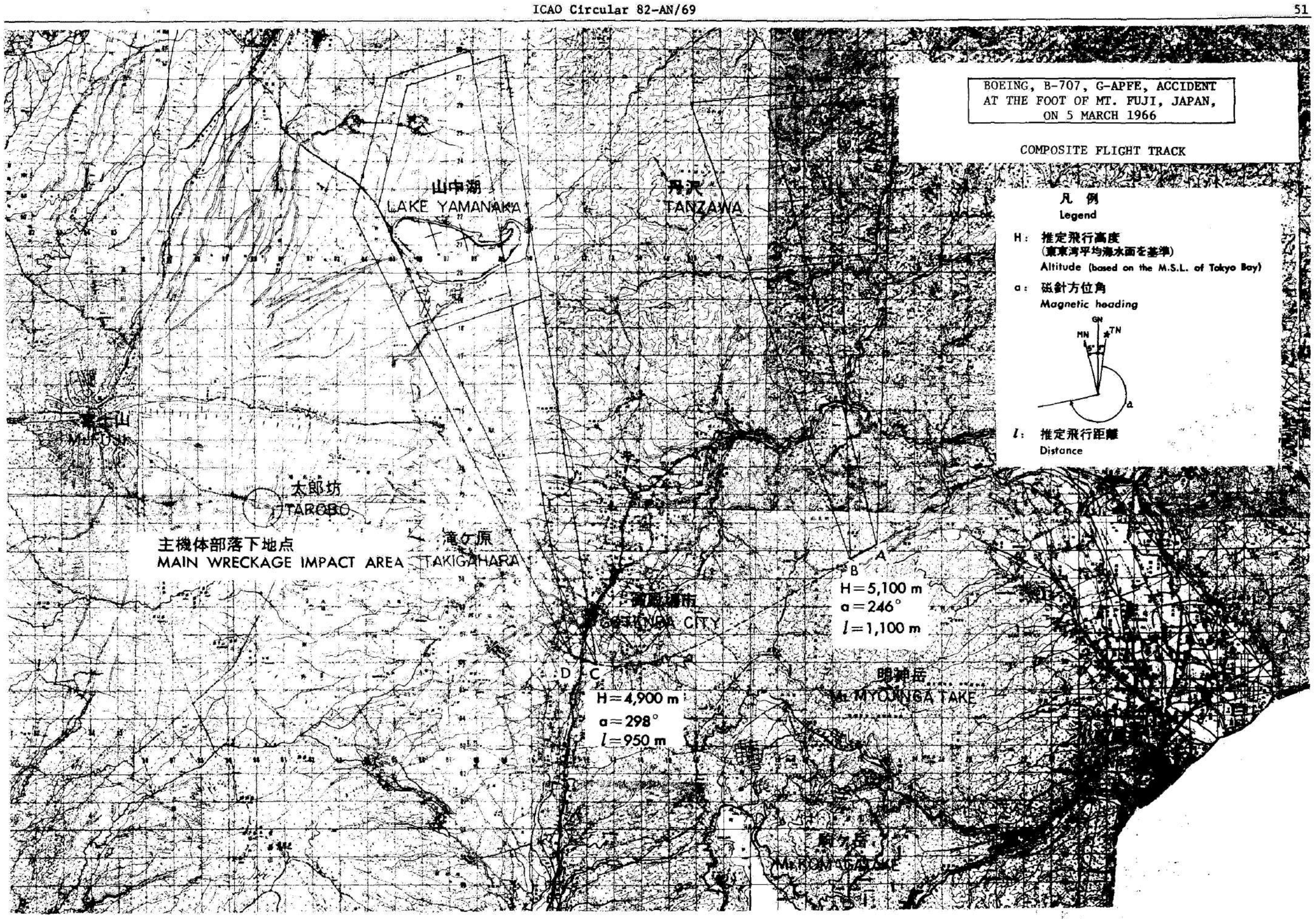
BOEING, B-707, G-APFE, ACCIDENT
AT THE FOOT OF MT. FUJI, JAPAN,
ON 5 MARCH 1966
COMPOSITE FLIGHT TRACK
凡 例
Legend
H: 推定飛行高度
(東京湾平均海水面を基準)
Altitude (based on the M.S.L. of Tokyo Bay)
α: 磁針方位角
Magnetic heading
l: 推定飛行距離
Distance
山中湖
LAKE YAMANAKA
丹沢
TANZAWA
太郎坊
TAROBO
主機体部落下地点
MAIN WRECKAGE IMPACT AREA
滝ヶ原
TAKIGAHARA
GOTENBA CITY
A
B
H=5,100 m
α=246°
l=1,100 m
C
D
H=4,900 m
α=298°
l=950 m
明神岳
Mt. MYOJINGA TAKE

FIGURE 7-1

BOEING, B-707, G-APFE, ACCIDENT
AT THE FOOT OF MT. FUJI, JAPAN,
ON 5 MARCH 1966

WRECKAGE DISTRIBUTION CHART

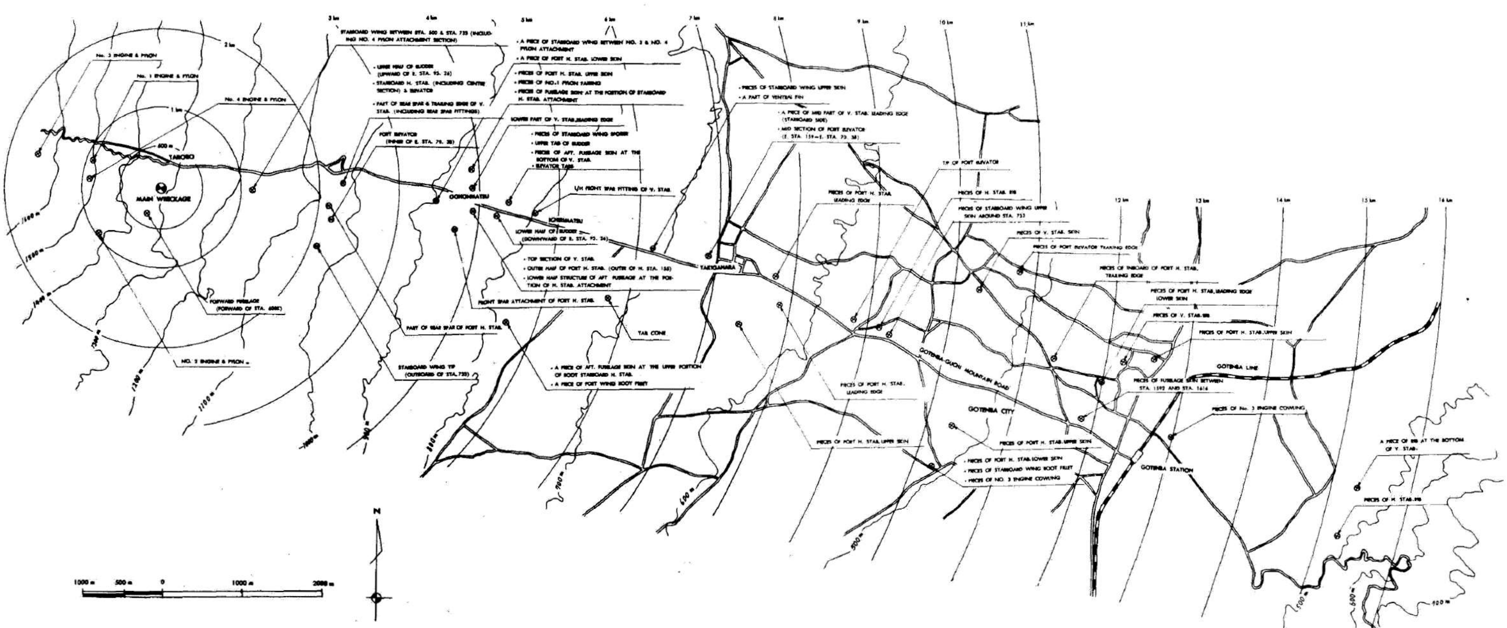

FIGURE 7-2

BOAC, B-707, G-APFE, ACCIDENT AT THE FOOT OF MT. FUJI, JAPAN, ON 5 MARCH 1966

ESTIMATED ALTITUDE PROFILE

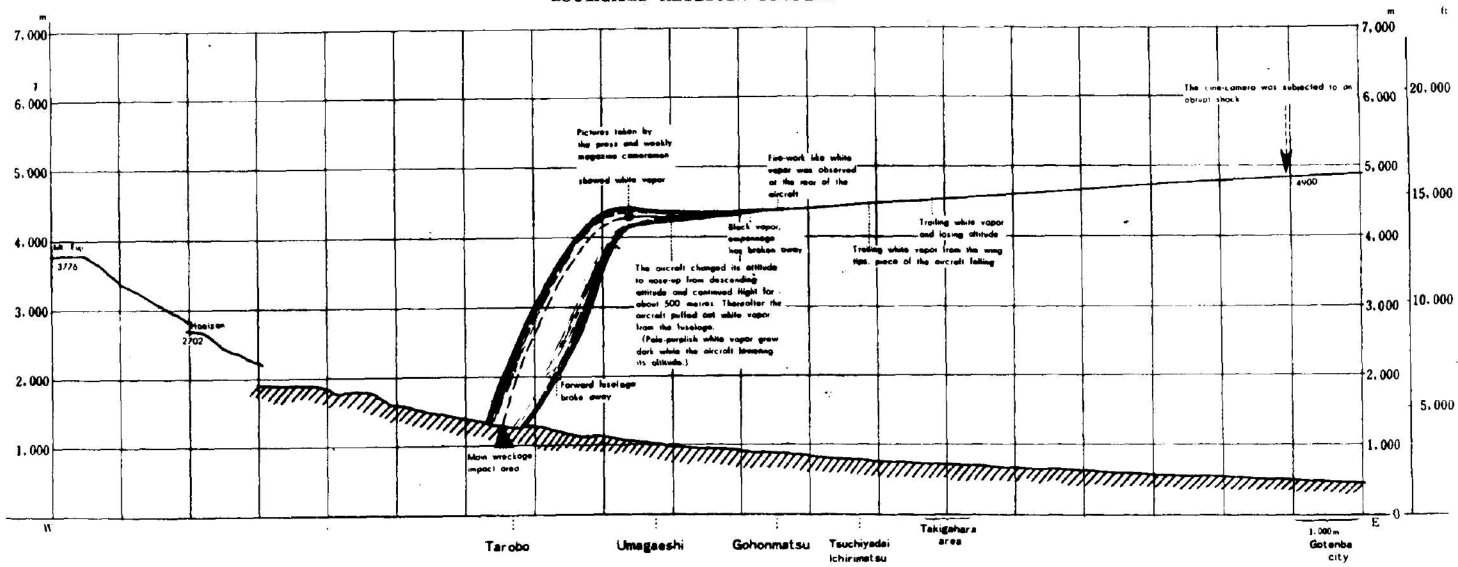

FIGURE 7-3

BOAC, B-707, G-APFE, ACCIDENT AT THE FOOT OF MT. FUJI, JAPAN, ON 5 MARCH 1966

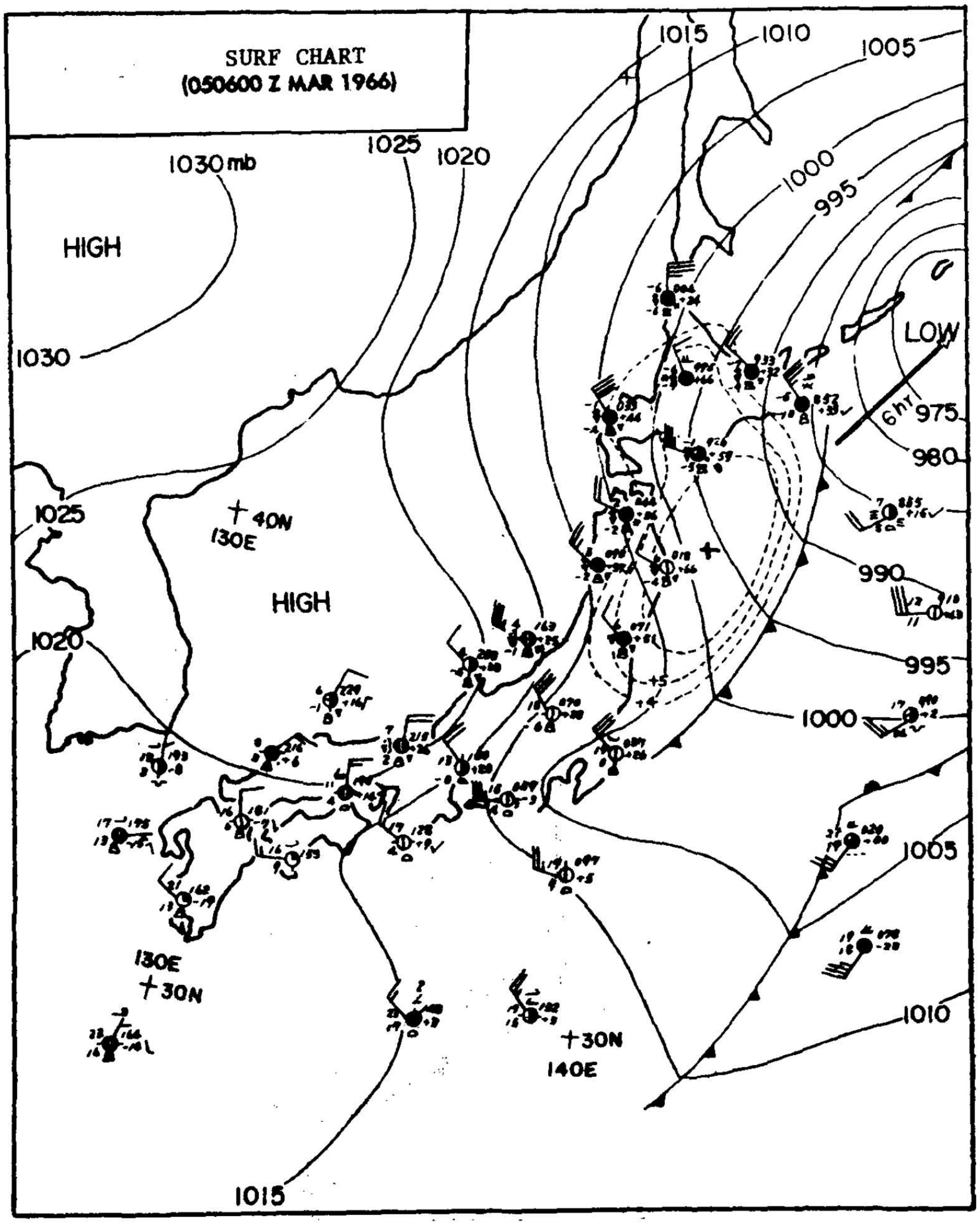

FIGURE 7-4

BOAC, B-707, G-APFE, ACCIDENT AT THE FOOT OF MT. FUJI, JAPAN, ON 5 MARCH 1966

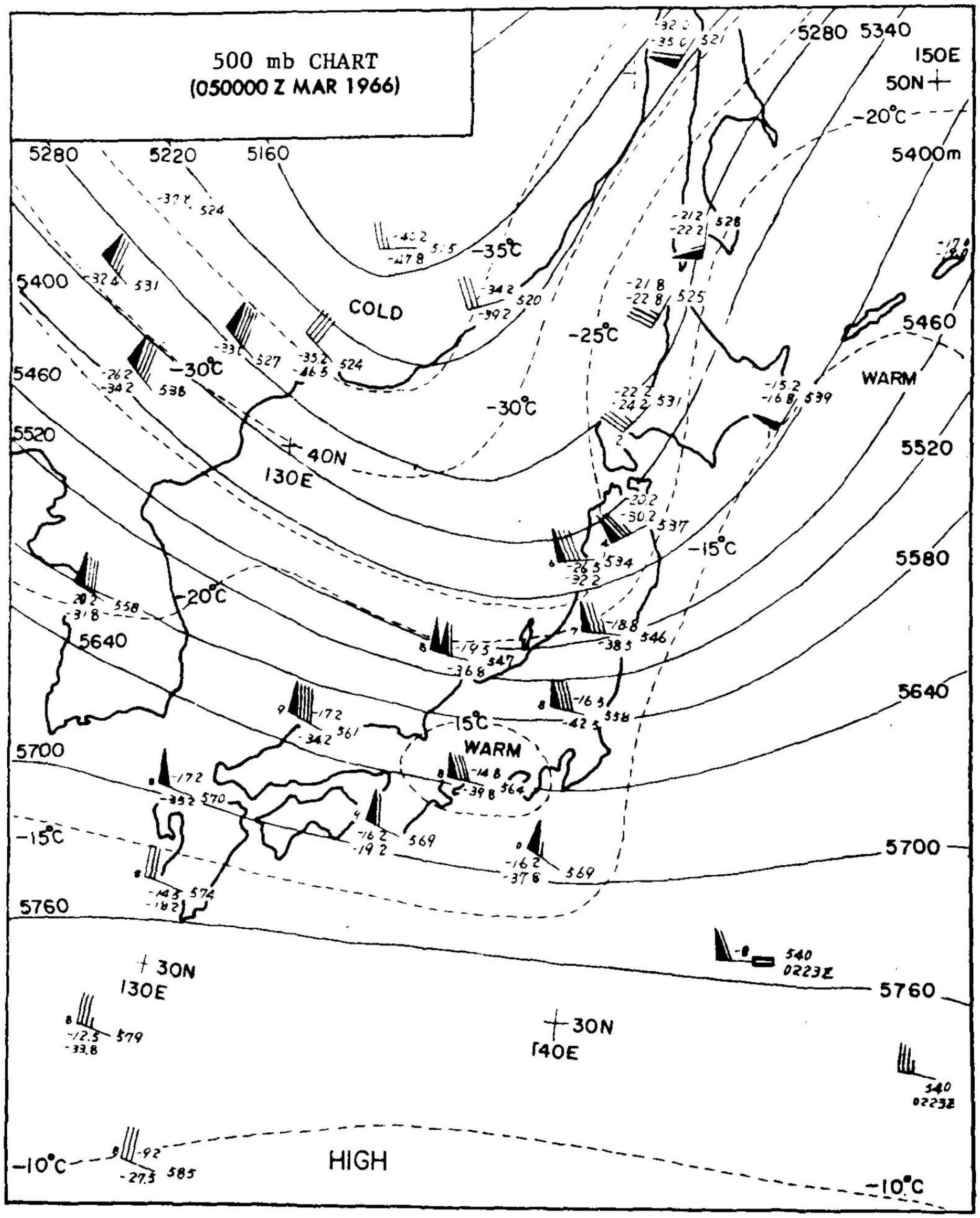

FIGURE 7-5

No. 8

Iberia, Spanish Airlines, DC-3, EC-AET, accident at Málaga Airport, Spain, on 12 March 1966. Report dated 9 February 1967, released by the Department of Civil Aviation, Spain.

1. - Investigation

1.1 History of the flight

The aircraft was engaged in a scheduled passenger flight between Málaga and Melilla. During the take-off, when the aircraft was approximately 30 m above the ground, heavy vibration was noticed on the right side and rendered it almost uncontrollable. The pilot therefore decided to abandon take-off and ordered the undercarriage to be re-extended immediately. Owing to the suddenness of the manoeuvre the landing gear did not have time to lock in position, and during landing it was gradually forced back into the well. The aircraft, with the landing gear retracted, slid to a point about 150 m from the end of the runway.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal			
Non-fatal		2 (slight)	
None	3	13	

1.3 Damage to aircraft

Serious damage was sustained by the propellers, landing wheels, engine nacelles and other components.

1.4 Other damage

None.

1.5 Crew information

The pilot-in-command had logged a total of 4 000 flying hours, including 700 on DC-3s. He was in possession of a valid airline transport pilot's licence, No. 537.

The co-pilot had logged a total of 7 000 flying hours, including 3 800 on the subject type. He was in possession of a valid airline transport pilot's licence, No. 474.