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FOREWORD

Accident investigation is recognized today as one of the fundamental elements of improved safety and accident prevention. Nearly every accident contains evidence which, if correctly identified and assessed, will allow the cause to be ascertained so that corrective action can be undertaken to prevent further accidents from similar causes. Thus, the ultimate object of accident investigation and reporting, which is to permit the comparison of many accident reports and to observe what cause factors tend to recur, can be accomplished. These factors can then be clearly identified and brought to the attention of the responsible authorities.

The Accident Investigation Division of the Air Navigation Committee of PICAO* at its first session in 1946 recommended that States forward copies of reports of aircraft accident investigations and inquiries, and aeronautical publications and documents relating to research and development work in the field of aircraft accident investigation, to PICAO in order that the Secretariat might appraise the information gained and disseminate the knowledge to Contracting States.

The world-wide collection by ICAO of accident reports and aeronautical publications and documents relating to research and development work in the field of aircraft accident investigation, and publication of the material in condensed form, assist States and aeronautical organizations in research work in this field. By stimulating and maintaining continuity of interest in this problem the dissemination to individuals actively engaged in aviation of information on the actual circumstances leading up to the accidents and of recommendations for accident prevention also contributes to the reduction of accidents.

The first summary of accident reports and safety material received from States was issued in October 1946 (List No. 1, Doc 2177, AIG/56) under the title of "Consolidated List of Publications and Documents relating to Aircraft Accident Investigation Reports and Procedures, Practices, Research and Development Work in the field of Aircraft Accident Investigation received by the PICAO Secretariat from Contracting States". This was followed by further summaries at regular intervals, the last report being issued on 31 July 1950 (List No. 12, Doc 7026, AIG/513). These summary reports were found to be of considerable technical interest to States, and in view of the large number of requests for copies, it was decided, early in 1951, to revise the method of publication and to produce the material in the future in the form of an information circular entitled "Aircraft Accident Digest".

The first Digest was issued in 1951 under the present title and with the new method of presentation. Since then, the usefulness of the series has continued to elicit favourable comment from the aeronautical world.

However, late in 1964, the Secretariat carried out a study of the problems associated with the publication of the Digest and considered various methods which, it was thought, would lead to a more rapid dissemination of accident reports forwarded to ICAO for release in summarized form in the Digest. This study also considered amending the presentation of the summaries with a view to producing them in a more standardized manner.

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*Provisional International Civil Aviation Organization.

Accordingly, the Secretariat prepared a uniform plan using fixed subject headings, in an agreed order and with standard paragraph numbering, to enable readers to extract pertinent information more readily, according to their particular interests. This plan was submitted to the Third Session of the Accident Investigation Division (Montreal, 19 January - 11 February 1965) for its consideration and development. The meeting accepted the concept of a uniform plan but modified the details. Summaries of accident inquiry reports are now being prepared in accordance with the final version of the uniform plan, as approved by the Council. This plan for the "Summary of Accident Report" appears in Appendix 3 of Annex 13 - Aircraft Accident Inquiry (Second Edition).

Digests are now published in separate volumes. Two of these volumes contain summaries prepared by the Secretariat from the inquiry reports received from States on accidents which occurred in a particular year and also normally contain one or more safety articles. The second volume contains, in addition, accident data such as classification tables, statistics and a list of laws and regulations of States pertaining to accident investigation. The other volume(s) contain summaries of reports prepared by States in accordance with paragraphs 6.3 and 6.4 of Annex 13. These summaries are published as received as soon as a sufficient number justify the publication of a separate volume.

It is hoped that States will continue to co-operate to the fullest extent permitted by their national laws in submitting material for the Digests in accordance with the provisions of 6.3 and 6.4 of Annex 13. It is recognized that investigations take a diversity of forms under the variety of constitutional and juridical systems that exist throughout the Contracting States of ICAO and that, for this reason, accident investigation presents one of the most difficult problems of standardization in international civil aviation. At the same time it is a most fruitful source of material for the attainment of the objectives of the Chicago Convention.

The usefulness of such a publication as this is directly proportional to the thoroughness with which accidents are investigated, the frankness and impartiality of the findings, and the readiness with which they are disclosed and authorized to be published. It is in this way only that this most fertile field for international co-operation can be effectively exploited. The measure of interest that this publication has aroused, and the vital information it imparts amply demonstrate the possibilities of ultimate achievement when every accident is investigated with the greatest thoroughness and the findings disclosed with complete frankness.

Restriction upon reproduction in the Digest seriously impairs, of course, the usefulness of any report, as it is only by comparison between the circumstances that occasioned the accident and the circumstances of other operations that potentially hazardous circumstances can be foreseen and avoided. Names of persons involved may, however, be omitted without detracting from the value of the report.

Follow-up action and other supplementary information or comments on an accident report by the State of Registry or State of Occurrence provide useful material for inclusion in the Digest.

The material for this Digest has been obtained from various sources, is printed for information only and does not necessarily reflect the views of the International Civil Aviation Organization.

SUMMARIES OF AIRCRAFT ACCIDENT REPORTS AS PREPARED BY STATES

No. 1

Linjeflyg AB, Convair 340/440, SE-CCK, accident at Ängelholm, Sweden, on 20 November 1964. The report was submitted to the Swedish Government on 26 May 1965 by a Special Commission of Inquiry

1. - Investigation

1.1 History of the flight

Flight LF 267 V, being engaged in scheduled domestic air transport operations from Stockholm-Bromma Airport to Ängelholm Airport, took off from Bromma on 20 November 1964, at 1846 hours GMT.

The aircraft was flown in accordance with an approved flight plan via Jönköping and Halmstad towards Ängelholm. While under approach in instrument meteorological conditions to runway 14 on Ängelholm Airport, the aircraft collided with the ground at 2014 hours GMT about 2 km from the runway and was destroyed.

The site of the accident has the co-ordinates N 56° 18' E 12° 51' and is situated about 20 m above sea level. The accident took place in darkness.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	2	29	-
Non-fatal	1	8	-
None	1	2	

1.3 Damage to aircraft

The aircraft was destroyed. The tip of the right wing and the right undercarriage struck the ground first and almost simultaneously. About 80 m further on, the aircraft tore off the electrical cabling of the railway line between Halmstad and Ängelholm. The right outer wing then struck and bent a pylon. At the same time the right inner wing knocked down a concrete pole. Upon colliding with the pole, that part of the right outer wing which lies outside the engine nacelle was torn off. After that the aircraft rolled over to the right and, about 250 m from the spot where it had first struck the ground, struck the ground once more with the remains of the right wing. This resulted in the right engine and the right undercarriage being torn off the fuselage. The aircraft bounced and, as it continued to turn over on its back, the forepart of the fuselage and the left wing struck the ground after a further 35 m. Thereupon the fuselage trailed along on its back for another 150 m. It came to a standstill upside-down, with its nose heading about 320 degrees. With the fracturing of the left wing the escaping petrol caught fire. The fire did not, however, spread to the fuselage.

1.4 Other damage

Part of the electrical cabling of the railway was torn off and a number of poles were knocked down or bent.

1.5 Crew information

The pilot-in-command was born on 10 June 1926; he was the holder of a valid airline transport pilot's licence. This included a rating for Convair 340/440. He underwent periodical flight training on 31 August 1964, and emergency training on 26 October 1964. His total flying time amounted to about 6 200 hours, of which 600 hours were on Convair 340/440. During the most recent 24-hour period, he had been on duty 5:40 hours; during the most recent 7 days' period, 29:10 hours, and during the most recent 30 days' period, 142:40 hours, his flight time being 3:10 hours, 10:45 hours, and 59:35 hours respectively. The pilot-in-command was killed in the accident.

The co-pilot was born on 24 August 1926; he was the holder of a valid commercial pilot's licence and of an instrument rating, which included Convair 340/440. He underwent periodical flight training on 29 August 1964, and emergency training on 12 October 1964. His total flying time amounted to 6 100 hours, of which 850 hours had been accumulated on Convair 340/440. During the most recent 24-hour period, he had been on duty 10:15 hours; during the most recent 7 days' period, 32:50 hours; and during the most recent 30 days' period 148 hours, his flight time being 5:10 hours, 18:40 hours, and 75:35 hours respectively. The co-pilot was killed in the accident.

The two air hostesses were engaged by the Company in June and October 1964 respectively. When the aircraft crashed they were seated in a double seat farthest back on the right-hand side with their seat-belts fastened.

1.6 Aircraft information

The Certificate of Airworthiness was valid until 31 March 1965. All the required modifications of the aircraft and the engines of importance to its airworthiness had been carried out. Further, the aircraft had been modified in accordance with Convair Service Bulletin No. 340-144. From the flight log of the aircraft, it could be seen that no remarks regarding the aircraft, the engines, or the rest of the equipment which might have been of interest to the investigation had been made during the period 16-20 November 1964, and that all the remarks which had been made previous to this period had been seen to.

The weight and centre of gravity were within the prescribed limits.

The type of fuel used was grade 108/135.

1.7 Meteorological information

Over southern Scandinavia and northern Germany the weather was very bad; in general, it was characterized by haze and a large amount of cloud with a very low ceiling. Occasionally there was rain or drizzle. Western Scandinavia was under a depression, with a front system developing its peak activity over Denmark and southern Sweden travelling fairly rapidly in a south-easterly direction. In the rest of Sweden, too, the weather was bad. Over Finland the weather was comparatively good, and over northern Norway very good. At Bromma Airport there was some mist when the aircraft took off. The reported runway visual range was 1 500 m, and vertical visibility 120 m.

When the aircraft was on approach to Ängelholm Airport there was 8/8 stratus with a base at about 100 m. Below this there was 6-8/8 fractostratus with a base at about 60 m. The meteorological visibility varied between 1.5 and 3 km. In the ground layer there was a wind shear. Thus, from 25 kt at about 300 m altitude, the speed of the wind abated to 6 kt on the ground. At the same time the wind was veering to the left at about 20 degrees as one approached the ground.

At the alternates - Malmö-Bulltofta and Copenhagen-Kastrup - weather conditions became more unfavourable as the evening progressed. At the time when a proposed alternative landing might have been made, there was about 5-7/8 cloud at both these airports, with the base at about 100 m, and meteorological visibility about 3 km.

The meteorological information given to the crew prior to take-off was rather brief, partly owing to pressure of work at METEO, but the crew would all the same seem to have got a fairly good idea of the situation on general lines. The flight planning seems mainly to have been based on the available aerodrome forecasts, all of which were slightly too optimistic.

The accident occurred in darkness.

1.8 Aids to navigation

Two non-directional radio beacons (NDB) on medium frequencies, both located approximately in the assumed extension of the runway, the one 10,4 km, and the other 3 080 m from the runway threshold. In all probability, both were functioning when the accident occurred. Measurements of the field strength showed that the propagation and the effect from both were normal. The range of the locators exceeded the nominal, which is 15 NM. The range of the outer locator was about 40 NM. The check made of nearby beacons within the same frequency range did not indicate possibilities for interference even during darkness.

1.9 Communications

The recorder at the tower showed that the radio communications were of good quality. The radio communications of the aircraft were mainly handled by the co-pilot.

1.10 Aerodrome and ground facilities

The aerodrome, which is situated about 5 km north of the town of Ängelholm, is a military base. The official aerodrome elevation is 56 ft. It has two main runways, 14-32 and 04-22. Their dimensions are 1 950 x 40 m and 2 000 x 40 m respectively. Runway 14-32 was provided with white high intensity runway lights at a distance of, in the main, 75 m from each other, and with green and red high intensity threshold lights at both ends of the runway. Runway 14 was further provided with a single row of high intensity approach lights at 50 m from each other along a total distance of 340 m. Apart from these lights, the lighting system installed at the aerodrome comprises red non-directional low intensity runway lights on runway 14-32, red obstruction lights, and a rotating aerodrome beacon located near the tower.

Northwest of the aerodrome, at a distance of 2 250 m from the threshold of runway 14, and about 110 m southwest of the assumed extension of the runway centre line, there was a kind of approach light beacon, a so-called lead-in light specially constructed for the aerodrome. It was installed in 1959 as an aid in the military operations.

The beam, whose intensity exceeded that of the high intensity approach lights of the aerodrome, was directed to the northwest parallel to the runway centre line. It consisted of nine landing headlights mounted in a stand in 3 groups over each other, with 3 lights in every group.

1.11 Flight recorder

A flight recorder was not carried on board.

1.12 Wreckage

The site of the accident consists of arable land with groups of trees only near the farmhouses in the vicinity of the site. The terrain is somewhat hilly. The spot where the aircraft first struck ground lies about 3 m lower than the spot where it finally came to a standstill. The distance between the spot where the aircraft first struck ground and the spot where it stopped is about 440 m. According to the marks in the ground it moved, when it first struck the ground, at a heading of about 195 degrees. The distribution pattern of the wreckage is given in 1.3.

1.13 Fire

As stated in 1.3, the fuel tank of the left wing caught fire on impact. The first fire engine arrived at about 2025 hours GMT. The rescue team that finally arrived at the site of the accident totalled 92 persons, 2 of whom were doctors. Seven fire engines and 13 ambulances were at the disposal of the rescuers. Since the accident had occurred at an aerodrome situated near several local fire brigades and several hospitals, the available facilities were sufficient to cover requirements.

1.14 Survival aspects

On the basis of the information provided by the cabin attendants, it may be assumed that the passengers were distributed fairly evenly over the cabin. According to the post-mortem examination reports the heads and thoraxes of all the passengers who lost their lives showed severe bruises. For all of them these injuries constituted the primary cause of death.

The aircraft was equipped with double seats of type QC-2, made in Sweden according to type certificate C 106/62. At the crash, the seats were subjected to the heaviest strain when the right side of the aircraft struck the ground and when it bounced until it landed upside-down. The seats withstood the strain but, since the sideways load to the right was considerably in excess of what they are supposed to withstand according to the valid standard (1.5 g), the seats on the left side of the cabin were bent to the right and permanently deformed. For this reason the mountings fixing them to the cabin wall came loose and the rivets fell out. The mountings attaching the seats to the floor rail held. On the right side, the sideways strain on the seats was absorbed by the cabin wall, so that these were not deformed and the mountings did not loosen here. All the safety belts held.

1.15 Tests and research

The technical investigation showed that both engines were functioning entirely satisfactorily. The position of the flaps was about 25-30 degrees, and the undercarriage was extended and locked. The landing headlights were extended and had in all probability been switched on. The communications and navigational equipment had not suffered any damage that could not be assigned to the accident.

Test flights were made repeatedly in the approach area in both aeroplanes and helicopters in order to form an estimate of the probable combined effect of the runway and approach lights and the so-called lead-in light.

The lead-in light had not been marked on the IAL-chart, but it was briefly mentioned by the ATC when the aircraft was on approach to Ängelholm. A special investigation showed that, of the company's 39 pilots-in-command, 32 knew that there was a lead-in light at the aerodrome, and 19 of the 32 also knew where it was located.

2. - Analysis and Conclusions

2.1 Analysis

The investigations made by the Commission show that the duty programme of both the pilot-in-command and the co-pilot had been planned in accordance with the valid limitations. Before the flight in the course of which the accident occurred, they had been given the opportunity to enjoy the prescribed rest, and there is nothing to contradict the assumption that, on the day when the accident occurred, they were both entirely fit physically. No injuries or sickness symptoms that might have caused the accident or contributed to it were found.

In the course of the technical examinations of the engines and other installations in the aircraft that were carried out, no defects or signs of malfunction that might have caused the accident or contributed to it were found to exist.

It would seem impossible to raise any objections to the pilot-in-command's decision to carry out the flight in the existing meteorological conditions. The flight was planned in accordance with the operational regulations.

While descending from cruising altitude, the crew received information that weather conditions at Ängelholm had grown somewhat worse. The meteorological data transmitted simultaneously showed however that, considering the weather minima in force for the runway in question, there was nothing to hinder the aircraft from making an approach and landing. The crew stated also that the intention was to take the shortest route to the aerodrome.

It is probable that, between the outer and the inner locator, the aircraft was flown either on or slightly left of the approach line. A VDF-bearing taken by the ATC officer shows that, in an estimated position about 1 km from the inner locator, the aircraft was flown slightly to the left of the approach line. The position was established with the assistance of the time data on the TWR-recorder and an estimate of the aircraft's speed while on approach. During the last phase of the flight, however, the aircraft made a turn to the right. The turn can hardly have been started before the aircraft was almost abeam the inner locator.

The distance between the inner locator and the spot where the aircraft first struck the ground is somewhat less than 1 km. The difference between the altitude which, according to the IAL-chart, the aircraft should have maintained over the inner locator and the spot where it first struck the ground is about 150 m. In view of the aircraft's probable speed at that time, this would imply that the rate of descent of the aircraft would have amounted to about 10 m/sec if, from the altitude over the inner locator which was given on the IAL-chart, the aircraft was to strike the ground at the site of the accident. Such a rapid descent should have been observed by somebody among the survivors, but that was not the case. The survivors who were interrogated said they had sat with their seat-belts fastened as instructed and awaited the landing. Several of them have even said that the first impact against the ground appeared to them as a normal touchdown. Some of the passengers had also seen lights, especially from the railway line, and felt everything was normal. It is therefore probable that, on passing the inner locator, the aircraft was flown at an altitude that was lower than it should have been according to the IAL-chart.

There is no reason to assume that a malfunction of the altimeter can have been the cause of the low altitude. The normal tolerances of the instrument and the difficulties a crew has in maintaining an aircraft at exactly the prescribed altitude may, however, have led to an altitude somewhat lower than had been intended, but probably not so low that the rate of descent should, between the inner locator and the site of the accident, have reached a normal value. Some other circumstance entirely independent of the altimeter would, in the manner described below, seem to have led to the low altitude.

According to the tape recorder the co-pilot - probably when the aircraft was abeam the inner locator - said he saw a light. Even at that moment, about a quarter of a minute before the final catastrophe, there is nothing whatever to show that anybody on board the aircraft was conscious of the fact that the aircraft was in a serious or abnormal situation. The voice of the co-pilot sounded normal. The Commission is of the opinion that the crew must have believed that the lead-in light marked the beginning of the row of approach lights and consequently embarked on the final descent prior to landing at the very moment when they noticed the lead-in light, i.e. at less than one kilometre's distance from the inner locator.

Two circumstances point to the conclusion that, either owing to an error in judging the position of the lead-in light or because they mistook the lead-in light for the approach light, the crew embarked too soon on the final landing procedure. In the first place, the aircraft crashed directly after passing the spot where the lead-in light is located. In the second place - according to what was ascertained from investigating the wreckage - the crew probably took two of the steps which are normally taken immediately prior to a landing, viz. they extended the wing flaps from the position they had when the outer locator was passed, i.e. 24 degrees, to the probable position 28 degrees, and switched on the landing headlights.

Immediately before reaching the lead-in light, however, the crew seem to have realized that the situation of the aircraft was dangerous. The engines were in any case opened up in an attempt to pull the aircraft up. Most of the survivors said they had noticed a marked increase in the roar of the engines and felt that the nose of the aircraft was going up. The technical investigation has also shown that, on collision with the ground, the nose had been in a high position. Further, the loud boom of the engines was heard by many people in the vicinity of the site of the accident. However, the effort to pull up the aircraft was made at too low an altitude to be successful.

As assumed by the Commission, the course of events must have implied that, prior to taking up radio communication with Ängelholm, the crew must have had no information regarding the lead-in light and its location which, according to the results of a special investigation, is quite possible. It must further have implied that the crew had omitted to realize that the aircraft could not have reached the approach lights according to either the time-check made at the outer locator or the position established with the assistance of the inner locator, and that it was thus too early to abandon the instrument approach procedure and embark on a visual approach. There is no reason to assume that there were defects in the locators or the two ADF carried on board.

To this must be added that work in the cockpit had to be condensed because a shortened approach procedure was being applied. Owing to a strong tail wind at the beginning of the final approach there was a further compression of work. In addition, wind conditions were difficult since the tail wind component changed from about 23 kt at the beginning of the approach to 3 kt at ground level. In addition, there were more protracted radio communications than usual between the ATC and the crew. Consequently it does not seem impossible that the time in which the crew could carry out the manoeuvres required according to the check-list and the time at the co-pilot's disposal for exercising supervision had grown short. The result of the examination of the aircraft's stop-clocks can perhaps serve as an indication in this respect. The examination showed that the clock in front of the co-pilot's seat had started as a consequence of the collision with the ground. It would not seem to have been started, as is usually the case, by the co-pilot upon passing the outer locator. If the approach procedure had been followed up, the intention may, however, also have been not to start the clock until passing the inner locator.

Certain information was received to the effect that the approach and runway lights on runway 14 had not been switched on in connexion with the approach. The Commission felt compelled to devote a great deal of attention to this question; it discussed, inter alia, whether the lights could have been switched off in connexion with the visibility measurements with the assistance of the lights on runway 04/22, and also noted that it was difficult to check the lights on runway 14 from the tower. The investigation which was made would, however, seem to lead to the assumption that the approach and runway lights for runway 14 were switched on in the usual manner while the aircraft was on approach. Nevertheless, it appears from the investigation that they were switched off very soon after the accident, but this circumstance is of no importance whatever for the course of events.

Even if it may thus be assumed that the approach and runway lights were switched on, the lead-in light may all the same have been mistaken for the former lights owing to the distance between the approach lights and the lead-in light, because the visibility range down to a level of about 50 m above the ground may have been shorter than the distance between the two units of lights and because - during the final phase of the flight - the approach lights, if looked at from the longitudinal axis of the aircraft, were on the left, i.e. beyond the immediate field of vision of the crew.

The installations at the aerodrome did not fully meet the requirements one would seem justified in expecting of an aerodrome used for scheduled air traffic. As far as this refers to the installations initially approved in 1960 - a short row of approach lights and an abnormally great distance between the beginning of the row of approach lights and the inner locator - the improvements subsequently decided on have not yet been implemented. It is true that the approach procedure and the weather minima established according to the valid prescriptions were applied in the way they suited the existing installations, but the situation has all the same resulted in the application of an approach procedure which deviates considerably from the normal procedure and thus makes it more difficult for the crews of aircraft to carry out correct approaches in pronounced instrument meteorological conditions. Furthermore, the supervision of the lights illuminating the aerodrome and of the radio beacons has not been organized in a satisfactory manner.

2.2 Conclusions

Cause or
Probable cause(s)

The probable cause of the accident was that the crew while on an approach in instrument meteorological conditions abandoned the established approach procedure and prematurely prepared to land. The reason for this must have been that the crew allowed themselves to be misled by a lighting installation belonging to the aerodrome, of which, apart from certain information received during the approach, they probably had no knowledge.

3. - Recommendations

In the opinion of the Commission, flight safety is endangered if, as was found to be the case here, there are differences between the civil and military systems regarding air traffic control and ground equipment. The Commission wishes to stress the importance of quick action in the elimination of these differences.

The Commission is given to understand that the plans for modifications of the approach facilities existing at Ängelholm have reached an advanced stage. It does not therefore regard it as necessary to make suggestions in this respect, but the Commission wishes to point out that the ATC personnel must be provided with better aids for supervising the functioning of the approach and runway lights and of the radio beacons.

The investigation has shown that the authorities must devote more attention in every individual case to the selection methods applied by operators in promoting co-pilots to the post of pilots-in-command. It should be considered whether the medical examination preceding the granting of an airline transport pilot's licence and perhaps also of a senior commercial pilot's licence should not be supplemented with a psychological test under the control of the authorities.

In the Aeronautical Information Publication (AIP) published by the Royal Board of Civil Aviation, the term "Critical Height" is defined as follows: "The height above aerodrome elevation at which descent during instrument approach should be discontinued if the approach cannot be continued visually"(see AIP RAC 1, item 2.7.1.1). The wording of the last sentence of the definition should be amended in such a way that it is made quite clear that an approach shall not be continued unless there is visual reference to the runway, the runway lights, or the approach light system.

In view of the circumstances that have come to light during the investigation, the Commission wishes to propose, on the one hand, that the importance of reporting observations and events connected with a flight and of significance for flight safety should be emphasized to the crews, and, on the other, that all reports received should be adequately dealt with.

The emergency lighting in the aircraft did not function because the so-called g-lamps came loose when the aircraft turned upside-down. The possibility of placing such lamps in some other way should be examined.

It was learnt during the investigation that, after the crash, some passengers experienced difficulties in freeing themselves from their safety belts. The Commission proposes that this matter should be attended to.

ICAO Ref.: AR/859

No. 2

Balair, Fokker Friendship, HB-AAU, incident which occurred at Schiphol Airport, Kingdom of the Netherlands, on 7 June 1965. Summary report dated 29 July 1965, prepared by the Dutch authorities, released as Swiss Accident Report No. 1965/40/234*

1. - Investigation

The flight took off from Geneva Airport at 1550 hours GMT to Basel-Mühlhausen. The flight was uneventful until over Bern at 12 000 ft. the aircraft was struck on the right-hand side of the nose by lightning. The crew noticed that the right wing tip had been damaged and notified the Zürich control tower accordingly. At 1624 hours GMT the flight was cleared to descend to Basel. The approach procedure proceeded normally until the captain noticed that when he tried to bring the undercarriage down the nose wheel green light did not come up. When making the final approach the nose wheel light was still red and the captain decided to make an overshoot. As the aeroplane passed the control tower, the tower operator observed that the nose gear was not extended. The pilot again tried to extend the nose gear; he applied all conceivable means but did not manage to extend the gear. After a consultation by radio with the managing director of Balair, it was decided to proceed to Schiphol Airport (Fokker Aircraft Factory) and to make a landing there. At 1717 hours GMT the aircraft left Basel and entered the terminal area of Schiphol Airport at 1951 hours GMT. In the meantime, the airport authority at Schiphol had started to lay a foam path (10 ft wide) on runway 06; the foam path was ready at 2020 hours GMT. The chief test pilot of the Fokker Aircraft Factory, who was at the control tower, advised the pilot about the approach procedure to be followed and about the emergency procedure to extend the nose gear. However, it was not possible to extend this gear and the captain therefore decided to land with the nose gear up. After a normal approach he landed the aircraft at 2036 hours GMT and touched the ground with the main gear about 100 m before the foam path with minimum speed (90-95 kt).

The nose of the aircraft touched the ground in the foam path about 300 m from the beginning of this path. The aircraft came to a standstill about 6 m past the end of the foam path. All occupants left the aircraft without injuries.

* Although the following does not come within the ICAO definition of an aircraft accident and therefore does not appear in the classification tables, the summary is included for general interest.

1.2 Injuries to persons

None of the 4 crew members and 46 passengers was injured.

1.3 Damage to aircraft

The underside of the nose was damaged by ground contact.

During the removal of the aircraft, it had been necessary to open the jammed nose wheel doors by means of a crowbar in order to extend the nose gear; the nose wheel doors had been damaged by this operation. Close inspection of the nose section revealed that the skin at the right-hand side and the bottom had been deformed by a local increase of air pressure due to the lightning stroke.

The wheel well doors were damaged at the left side due to ground contact; the damage to the left door disclosed that this door had been opened more than the right door before ground contact was made. The right wing tip, the right-hand side and the bottom of the nose section showed burn marks due to the lightning discharge.

1.4 Other damage

None.

1.5 Crew information

From the pilot-in-command, the following information was collected:

Name	:	Roland Haefeli
Born	:	August 1927 at Solothurn
Nationality	:	Swiss
Address	:	Hirslandweg 36, Arlesheim/BL
Licence	:	Führerausweis für Linienpiloten No. 370, issued 17 February 1961, valid until 8 June 1965.
Ratings for	:	Vickers Viking since 17 February 1961 Douglas DC-4 since 17 February 1961 Douglas DC-6B since 19 January 1962 Fokker Friendship since 29 April 1964
Experience	:	As pilot-in-command about 7 000 hours; on Fokker Friendship about 800 hours in command.

1.6 Aircraft information

Registration marks	:	HB-AAU
Type	:	Fokker F-27 Friendship
Serial number	:	10200
Manufacturer	:	Fokker Aircraft Factory, Schiphol Airport

Certificate of registration	:	2287/a/1, issued on 30 March 1965 to Balair AG., Basel
Certificate of airworthiness	:	2287/b/1, issued on 30 March 1965, valid until 31 March 1966.

The aircraft maintenance log did not contain any entry in relation to the operation of the nose gear. The chief engineer of Balair stated that before the incident no defect had occurred to the nose gear.

Both at take-off and landing the aircraft all-up weight and centre of gravity were within the prescribed limits.

1.7 Meteorological information

According to the report of the Institut Suisse de Météorologie a heavy thunderstorm was located over Bern at about 1600 hours GMT. It was accompanied by lightning and rain, and local heavy turbulence.

2. - Analysis and Conclusions

2.1 Analysis

1. When flying over Bern the aircraft was struck by lightning on the right-hand side and bottom of the fuselage nose.

2. When approaching Basel-Mühlhausen Airport it proved to be impossible to extend the nose gear.
   The flight was diverted to Schiphol Airport to make an emergency landing there.

3. After renewed efforts to extend the nose gear the aircraft landed at Schiphol Airport, with the main gear extended, on runway 06, on which a foam path had been laid.

2.2 Conclusions

Findings

1. The aircraft was properly certificated and maintained. It was operated within the operating limits. Before the incident no defects had occurred to the nose gear.

2. The pilot-in-command was properly licensed. His experience as pilot-in-command on the type of aircraft involved was about 800 hours.

3. The technical investigation revealed that the nose wheel doors were jammed due to deformation of the fuselage nose as a result of the lightning stroke, which made extension of the nose gear impossible.

Cause or
Probable cause(s)

The incident was caused by lightning striking the nose section of the aircraft, which resulted in jamming of the nose wheel doors and made it subsequently impossible to extend the nose gear.

ICAO Ref.: AR/058/65

No. 3

Cambrian Airways Ltd., Viscount 701, G-AMOL, accident near Liverpool Airport, England, on 20 July 1965. Civil Accident Report No. EW/C/0108 released by the Accidents Investigation Branch, Board of Trade, United Kingdom, C.A.P. 288.

1. - Investigation

1.1 History of the flight

The pilot-in-command and co-pilot reported for duty at Liverpool Airport at 0700 hours on the day of the accident and took off at 0800 hours in G-AMOL to operate passenger flights CS 354 to Guernsey and Jersey and CS 355 to Liverpool. They arrived back at Liverpool at 1208 hours and the aircraft was loaded with freight for Ronaldsway. At Ronaldsway the aircraft was refuelled and took off at 1649 hours on the return flight to Liverpool. The flight was made at flight level 70 and at 1708 hours the aircraft was identified by Liverpool radar over Wallasey and positioned for a PPI continuous descent radar approach to runway 26. The radar approach began 5 miles from touchdown and in accordance with normal practice the pilot was told not to acknowledge further instructions.

Headings were given for the aircraft to maintain the approach path and the pilot was advised of the height the aircraft should be according to the distance from touchdown. The approach proceeded normally and only small alterations to the aircraft's heading were necessary. Half a mile from touchdown the radar approach was completed and the aircraft was then seen (on radar) to be just discernably to the right of the centre line. No radio messages were received from the aircraft after the start of the talk-down procedure.

Witnesses on the ground saw the aircraft about a mile from the threshold of runway 26. It appeared to be in the normal approach attitude, slightly to the right of the extended centre line and a little lower than normal for an aircraft approaching this runway. At 600 yd from the threshold, it was estimated to be at a height between 200 and 100 ft and about 40 yd to the right of the centre line. At this point witnesses saw the aircraft bank and turn to the right. According to the pilots of aircraft at the runway holding point, the angle of bank increased smoothly "as if from a fairly rapid application of aileron". The fuselage was level and the aircraft was banked almost vertically for part of the turn. When heading in approximately the opposite direction to the runway, it rolled on to its back and crashed into the roof of a factory about 400 yd to the right of the extended centre line of the runway and about 600 yd from the threshold. Most witnesses heard little change in engine power, but two said they heard an increase of power before the turn began. Nothing abnormal was noticed about the flaps. All propellers were seen to be revolving at about the same rate.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	2		2
Non-fatal			
None			

1.3 Damage to aircraft

The aircraft was destroyed.

1.4 Other damage

The factory workshop struck by the aircraft was almost completely destroyed by impact and fire. Machinery and goods in the factory were also destroyed.

1.5 Crew information

The pilot-in-command, aged 39, qualified as a pilot in the Royal Air Force and held a short service commission. On completion of his service in 1957 he joined Aden Airways as a co-pilot and in 1960 was promoted to command Dakota aircraft. He joined Cambrian Airways as a First Officer on 1 February 1964, flying Dakota and Viscount aircraft, and on 1 May 1965, was promoted to Captain. At his last competency check on Viscounts he was assessed as a sound pilot who exhibited qualities of good airmanship and captaincy. He held a valid airline transport pilot's licence endorsed in Group 1 for Viscounts and his total flying amounted to 8 350 hours, of which 185 were in command of Viscounts.

A post-mortem examination revealed no abnormalities which could have contributed to the accident and the cause of death was multiple injuries.

The co-pilot, aged 27, learned to fly at the London School of Flying, Elstree, in 1961. He joined Cambrian Airways on 14 December 1964, as a co-pilot when his total flying amounted to 550 hours. Since that date his logbook shows he had completed a further 285 hours, bringing his total to 835 hours, of which 273 were in Viscounts. His last Viscount competency check was carried out on 16 March 1965. He held a valid commercial pilot's licence endorsed in Group 2 for Viscounts, a current instrument rating and a restricted radiotelephony operator's licence.

Post-mortem examination revealed the cause of death was multiple injuries. There was no "naked eye" evidence of any pre-existing disease, but an examination of certain tissues under a microscope at the RAF Institute of Pathology revealed focal myocarditis (inflammation of the heart muscle).

1.6 Aircraft information

G-AMOL was built by Vickers-Armstrongs Limited, Weybridge, in 1953 and after service with British European Airways it was purchased by Cambrian Airways Limited in April 1963. The records show that all mandatory inspections and modifications had been carried out to the airframe and engines, and at the time of the accident the aircraft had been flown for 20 694 hours.

The aircraft had a valid certificate of airworthiness in the transport category (passenger) and it had been maintained to an approved schedule. The certificate of maintenance was valid and had been issued after the last Check 1 inspection on 23 June 1965. The weight of the aircraft at the time of the accident was about 39 600 lb; the centre of gravity position (372.79 in aft of the datum) was within the prescribed limits.

1.7 Meteorological information

An aftercast by the meteorological office of the weather for the route Ronaldsway to Liverpool gave scattered thunderstorms. The freezing level was 8 500 ft.

At 1702 hours the following weather report for Liverpool was passed to the aircraft:

Surface wind - 150 degress less than 3 kt

Visibility - 2.2 km in rain

Cloud - 3/8 1 500 ft, 5/8 2 000 ft, 8/8 4 000 ft

QNH - 1 011 mb

A weather observation made at 1720 hours (2 min after the accident) was:

Surface wind - calm

Visibility - 2.2 km

Weather - rain

Cloud - 4/8 1 500 ft, 6/8 2 000 ft, 8/8 4 000 ft

QNH - 1 011 mb

QFE - 1 008 mb

The flight from Ronaldsway was made at flight level 70. Therefore, with a freezing level of 8 500 ft, airframe icing is not considered to have occurred.

The pilots of a Viscount which landed at 1654 hours and a Britannia which departed at 1723 hours reported that the lowest cloud was between 400 and 500 ft and that they had no difficulty in seeing the approach and aerodrome lights.

1.8 Aids to navigation

The following facilities were available:

(1) Ronaldsway NDB

(2) Wallasey NDB and VOR

(3) Liverpool NDB.

1.9 Communications

The aircraft established normal VHF radio contact with Ronaldsway Tower, Preston Airways, Liverpool Approach and Liverpool Radar.

1.10 Aerodrome and ground facilities

Runway 26 at Liverpool airport has a tarmac surface 1 715 m long and 46 m wide. At the time of the accident, the runway lighting, the threshold lighting and the approach lighting (a high intensity centre line and two sodium bars) were at 100% intensity. There were no reports of any lighting unserviceability. The Decca 424 radar used by G-AMOL was checked after the accident and found to be satisfactory.

Speke Hall Road crosses the approach path to runway 26 approximately 235 yd from the threshold. Traffic lights on the road, controlled by a switch in the Air Traffic Control Tower, halt traffic when an aircraft is approaching to land. A road tanker was alleged to have ignored the lights and continued north along the road when G-AMOL was on its final approach. Neither the aerodrome controller nor the crews of the aircraft at the holding point of the runway saw any vehicle moving along the road which would balk the approaching aircraft. No other aircraft was known to be flying in the vicinity at the time.

1.11 Flight recorders

Not fitted.

1.12 Wreckage

Inspection at the scene of the accident showed that the aircraft had plunged through the roof of a factory workshop approximately 25 ft high. It had struck the roof inverted and with its nose and port wing down. Its heading had been approximately 050°M. After penetrating the roof, the aircraft had struck a heavy steel girder which had caused it to tip "tail-over-nose". It had then come to rest the right way up on the floor of the workshop with the tail resting on the steel roof trusses. An intense fire broke out which consumed almost the whole structure of the fuselage. The metal components of the centre section, with the exception of the heavy spar sections, had melted. Fire had consumed almost all of the port wing except about 12 ft of the tip. The starboard wing had been burned away progressively from the wing root but the section outboard of No. 4 engine remained and was found lying the right way up on the roof trusses of the adjoining workshop. Both port engines had broken away on impact and had been thrown forward on to the workshop floor. The starboard engines were found on the workshop floor in front of the remains of the starboard wing. All propellers had been broken off. An examination of the wreckage on the site showed that at the time of impact the undercarriage was locked down. The wreckage was removed to a hangar and subjected to a detailed examination.

1.12.1 Flying controls

(a) Ailerons

Examination of the remains of the aileron control system revealed no evidence of pre-crash mechanical failure or malfunction. The aileron control locks had not been engaged at the moment of impact. The trim tab indicator showed that the tab had been in the neutral position and this was confirmed by the position of the tab operating rod.

The port wing tip had been crushed inwards. It had contacted the left-hand trailing edge of the aileron and a mark made showed that at the moment of impact the aileron was fully up.

The mode of failure of the co-pilot's control wheel and the setting of the chain on the aileron jockey sprocket confirmed that full left aileron was applied at the moment of impact. There was no evidence that this chain had been jammed by extraneous articles.

(b) The rudder

This had been almost completely destroyed by fire but an examination of the torque tube, to which the trim tab is attached, showed that the actuator had been driven beyond its normal travel. It is considered that this occurred during the break-up of the aircraft. The trim tab control on the pilot's console had been set two thirds of a division nose left.

(c) Elevators

The tail plane and elevator were severely burned but no evidence was found to indicate pre-crash mechanical failure or malfunction. The elevator trim tab was found to be fully UP. This was most probably due to one side of the operating circuit breaking and the jack running the tab to the fully UP position. The elevator trim wheel on the pilot's console had been set to one third of a division nose UP.

The rudder and elevator trimmers have their own closed circuits within the control pedestal. Selections on either trimmer control are transmitted by sprockets on splined shafts to the bottom of the control pedestal and thence to the fuselage circuits. These shafts had been driven out of engagement at the moment of impact which indicates that the trim settings on the pedestal are reliable evidence of the settings prior to impact. They are normal settings for the aircraft.

(d) Flaps

The flap system had been severely disrupted by the impact and most of the aluminium alloy torque shaft had been melted in the ground fire.

The top section of the flap selector lever had been broken off but marks on the selector gate showed that at the time of the accident the lever was in the fully UP position. This was confirmed by the position of the electrical selector switch in the console. The condition of the filaments of the flap overrun warning lights indicated that they were not illuminated at the time of fracture.

Examination of the burnt remains of the gear box, which operates the flaps through torque tubes and chains, showed that its shaft could be aligned to correspond to 1-degree, 11-degree or 20-degree flap positions. The port torque shaft extension from the side of the gear box had melted away, leaving only the square steel drive in the gear box and the steel flange to which the next outboard section of the torque shaft had been bolted. The coupling nuts and bolts which are of high tensile steel, were not found. Examination of the holes in the steel flange revealed signs of distortion indicating shear loads in three of the holes and bending in the fourth. It is concluded, therefore, that the four bolts failed due to abnormal torsional and bending loads acting upon the flange coupling during the crash impact. The bolts were renewed during a

Check 4 completed on 4 December 1964. A similar coupling on the starboard side survived intact with the light alloy flanges securely bolted together. Some outboard sections of the torque shaft were recovered but no evidence of pre-crash mechanical failure or malfunctioning was found.

The flap beams, which house the chain drives of the flap operating gear, are numbered 1 to 4 outwards from the wing root. Examination showed that No. 2 on the port wing and Nos. 2 and 4 on the starboard wing were complete; the others had melted. All the flap beam anchorages to the wing rear spars were found to be secure. The modification to the flap beams for attachment to the spars, introduced after the accident to Viscount G-ALWE at Manchester on 14 March 1957, had been embodied.

The flap surfaces were largely destroyed by fire but the steel chains, sprockets and telescopic rods of the operating gear were recovered.

The single chain of No. 1 port flap beam had parted in tension and torsion on the top of the front driving sprocket. It is considered that this occurred during the crash. The other chains were unbroken. Examination of the chains and their associated sprockets revealed no evidence of jamming and the chain sliders and flap attachment trunnions showed no evidence of any pre-crash failure. Inspection of the remains of the flap guide-rails showed no sign that the rollers had jammed or jumped out of engagement.

Only two telescopic radius rods of the starboard flaps and one telescopic radius rod of the port flaps were straight when recovered from the wreckage; the others were either bent or fractured. None had been fractured or had become disconnected prior to impact, but because of fire damage it was impossible to say whether any had seized.

Measurements of the chains and telescopic radius rods were taken to try to determine the post-crash position of the flaps. The average flap angle derived from these measurements indicated that after the accident the flaps were approximately symmetrical at an angle between 5 and 6 degrees. Although it was not possible to determine whether the flaps were symmetrical prior to the impact, it is apparent that they had been forced upwards towards the fully UP position from either 11 or 20 degrees, two of the three possible settings indicated by the gear box.

1.12.2 Engines and propellers

Examination of the engines revealed no evidence of pre-crash mechanical failure or malfunctioning but they had been badly damaged by impact and fire. No. 4 engine had suffered considerably less damage than the others. The nitrided surface of the spring drive shaft of this engine was only cracked, whereas the shafts on the other engines were completely fractured under torsional loads. The evidence indicates that all engines were rotating at impact, and that No. 4 engine was either brought to rest less rapidly than the others or was developing less rpm and power at the time. Strip examination of this engine and its accessories revealed no mechanical fault or failure which was not attributed to the crash and subsequent fire. Although it was rotating at the time of impact, it was not possible to determine the rpm and power.

The condition of the broken filaments of the warning light bulbs for the flight fine and ground fine pitch stops of the propellers indicate they were not illuminated at the time of fracture.

Examination of the propellers revealed no defects other than from impact and their condition was consistent with low power absorption. The blade angles of Nos. 1, 2 and 3 propellers were at 29½, 28½ and 29 degrees respectively. No. 4 propeller had three possible angles, viz: 39, 27 or 21 degrees but the most probable was 27 degrees. Blade angles between 27 and 30 degrees would be produced during steady state power ON conditions, with a throttle opening consistent with the final stage of the landing approach. In the case of No. 4 propeller, the other two angles 21 or 39 degrees could be produced by both a steady state or a transient state, viz:

(a) Blade angle of 21 degrees

(i) Steady state - power ON - throttle closed.

(ii) Steady state - propeller windmilling and dead engine.

(iii) Transient state - following a rapid opening of the throttle.

(b) Blade angle of 39 degrees

Transient state during a feathering cycle.

The condition of the blades of No. 4 propeller is consistent with low power absorption and associated with rpm. This is not compatible with the power selection suggested by a transient 21-degree blade angle produced by a rapid opening of the throttle. To achieve the required transient peak, the required power selection would have to be made within one second of impact. It is considered that neither the steady state nor the transient state conditions associated with the possible blade angles of 21 or 39 degrees would have affected the handling of the aircraft sufficiently to produce the change of flight path that preceded the crash.

All H.P. and L.P. fuel cocks were ON, which indicates that feathering had not been initiated. A blade angle of 39 degrees was therefore unlikely.

1.13 Fire

An intense fire had broken out on impact, probably as the result of fuel from the burst wing tanks being ignited by the hot engines. The fire had been intensified by the wreckage being contained within the area of the new roofless workshop, which measured approximately 100 ft by 60 ft, and by being fed by large quantities of combustible materia containing naphthalene. A 2-in diameter gas pipe which had been fractured had ignited unde the fuselage of the aircraft.

There was prompt attendance at the scene of the accident by both the City of Liverpool Fire Brigade and the airport fire appliances. The first appliance was on the scene within two minutes of the accident, but the intense heat and smoke prevented immediate rescue attempts; it was necessary for some firemen to wear breathing apparatus. A hazard was created by the explosions of small methyl-bromide fire extinguishers fitted in the aircraft and by the violent reaction which occurred when water was brought into contact with the hot magnesium alloy parts of the aircraft. Terniary eutectic chloride dry powder extinguishers were used to control isolated fires involving magnesium alloy. The fire was brought under control at 1813 hours, i.e. almost one hour after the crash.

1.14 Survival aspects

The accident was not survivable.

1.15 Tests and research

The aircraft's departure from the approach path occurred about half a mile from the runway threshold, approximately where the talk-down was completed. At this position, the flaps would normally be lowered from 32 degrees to 40 degrees. An analysis of the flight path shows that it could have been achieved by the application of half aileron; alternatively, with the flaps at 32 degrees, it could have been the result of two engines failing on the starboard side while the two port engines had been at full power. In this case full opposite aileron would not hold the aircraft level. The third possibility is that flap asymmetry of 20 to 25 degrees occurred and calculations show that this would produce the observed rolling acceleration against the application of full opposite aileron.

With regard to the aircraft's controllability with asymmetric flap, reference has been made to a flight test report by Vickers Armstrongs Limited, in April 1954. This shows that at 150 kt, with the starboard flap units locked in the fully retracted position and 15 degrees of port flap, the residual stick force was at least 10 lb with full aileron trim. At 190 kt it was only just possible to maintain lateral trim with two hands. With 20 degrees of port flap at 150 kt, it was considered that the residual stick force could not be held by one pilot for more than a few seconds. Even with the assistance of a second pilot, a very dangerous situation could arise if this happened unexpectedly. With 20-degree asymmetric flap, irrespective of stick force, there is insufficient aileron control to correct for the initial wing drop.

2. - Analysis and Conclusions

2.1 Analysis

From the examination of the wreckage no evidence came to light to establish the cause of the accident. Therefore, of the possibilities to be examined, consideration was first given to the question whether the turn was a deliberate manoeuvre or was brought about by factors beyond the control of the pilots.

If the manoeuvre had been deliberately made, it must follow that the approach had been abandoned. However, the evidence suggests that overshoot power was not applied; the flaps were selected fully UP instead of to the take-off position. The undercarriage remained selected down and ATC were not informed of an overshoot. If the pilot had decided to abandon the approach by turning to the right, it is to be expected that he would have made a climbing turn and it is unlikely that he would have lost control during this manoeuvre. There could have been no difficulty in seeing the approach and runway lights and the street lights were not on. It seems unlikely, therefore, that the accident stemmed from an attempt to overshoot.

There is no evidence of other air traffic which could have caused the pilots to take avoiding action. However, there is evidence that a road tanker had ignored the traffic lights on the road crossing the approach to the runway while the aircraft was on final approach. The height of the tanker was about 2 ft above the street lighting standards. This would not call for avoiding action by an aircraft almost a quarter of a mile away at a height between 200 and 100 ft. It is considered, therefore, that this incident has no bearing on the accident.

The possibility of an accidental stall was also considered. The power-off stalling speed for the weight and configuration of the aircraft at the time of the accident was 74 kt. Calculations based on the timing of the radar approach show that the average speed from 5 miles out to the completion at half a mile was 128 kt. This margin of speed makes it unlikely that an accidental stall was the cause of the final turn. Had the speed been much lower than 128 kt the stall would have occurred earlier in the turn.

It was therefore concluded that the manoeuvre was unintentional and could not be prevented by the pilots and consideration was therefore given to the possibility of pilot incapacity or a defect in the aircraft.

Pilot incapacity

It is the practice in Cambrian Airways Limited to carry out instrument approaches with the co-pilot at the controls, the pilot-in-command taking over when completion of the approach and landing by visual reference becomes possible. It appears most likely that this procedure was being used on this occasion as the CL2 compass switch had been selected to the starboard compass indicator. The medical evidence that the post-mortem examination of the co-pilot had revealed a heart condition (focal myocarditis) introduced the possibility that he may have collapsed over the controls and caused the aircraft to bank steeply to the right.

Both pilots were strapped in by safety belts. From tests in a Viscount 70 it was found that a pilot collapsing forwards in his seat struck the coaming and not the controls; even if he did interfere with the movement of the controls, the other pilot would be able to pull him clear. The evidence that the turn was smooth and in no way erratic argues against this sort of obstruction and, in addition, it has been established that the controls were operated to an extent that at impact full opposite aileron had been applied.

Therefore, although sudden total collapse could result from focal myocarditis, such an occurrence does not fit the circumstances of this accident.

Aircraft defects

It is considered that the examination of the wreckage provided evidence that reasonably eliminated malfunction of the flying controls, engines and propellers as causes of this accident. Because of the extreme damage caused by the crash and subsequent fire, the evidence with regard to the flaps was not so conclusive and it was not possible to determine their relative pre-crash settings. It appears likely that on impact the flaps were driven upwards almost to the fully UP position from either 11 or 20 degrees (two of the possible settings indicated by the gearbox) and that the impact forces, acting on the port flaps against the resistance of the gear box, caused the failure of the bolts on the port torque shaft coupling. It is not possible to say why the bolts in the starboard coupling remained intact but it is unlikely that the impact forces were identical.

When considering the possibility of malfunction of the flaps, it should be noted that, although the reason why they had been selected fully UP is unexplained, it is not normal to do so for an overshoot. The position on the approach where the turn began is the normal position where a change of flap setting from 32 to 40 degrees is made. If for any reason the starboard side went to the trail position when this selection was made, approximately 25 degrees of flap asymmetry would have resulted and calculations have shown that this would have produced the observed flight path against the application of full opposite aileron. The normal time taken for retraction of the flaps would mean that control could not be regained in time. Therefore, although the examination of the wreckage provided no evidence of malfunction, it is considered that in the absence of other evidence to account for the turn, the possibility that it was brought about by flap asymmetry cannot be entirely eliminated.

2.2 Conclusions

Findings

1. The aircraft was airworthy, properly maintained and correctly loaded.
2. The pilots were properly licensed.
3. The manoeuvre to the right from the approach path was unintentional and one which could not be controlled by the pilots.
4. No evidence of pre-crash failure was discovered.

Cause or Probable cause(s)

The aircraft went out of control during the final stage of an approach to land but the reason for this has not been determined.

ICAO Ref: AR/069/65

No. 4

Trans World Airlines Inc. Boeing 707-331, N 766 TW, accident at Frankfurt/Main Airport, Federal Republic of Germany, on 30 January 1966. Summary of report released by the Federal Office of Civil Aeronautics.

1. - Investigation

1.1 History of the flight

The aircraft was operating a scheduled TWA service on the route Frankfurt/Mai New York (John F. Kennedy Airport) under flight No. 741. The estimated flight time to New York was 8 hours and 16 minutes; the fuel supplies on board were calculated on the basis of a maximum flight time of 11 hours and 30 minutes.

After the pilot had received taxiing clearance by the aerodrome control he taxied to the taxi holding position of runway 25 R where the check list was read out. I wing flaps were extended to 30° and the stabilizer trim was set to 4.5 units "nose-up". Following the take-off clearance the four engines were brought to take-off power. In th beginning the take-off was normal. The front wheel controls were applied up to a speed 80 kt. The precalculated V 1 speed of 146 kt as well as the precalculated VR speed were reached and the unstick phase was initiated. At about the same time when the nose wheel landing gear lifted off the runway, the horn of the take-off warning system sounded. Th pilot decided to interrupt the take-off and initiated the necessary measures such as lowering the nose, applying the thrust reverser and activating the brakes. The runway distance available was not sufficient, however, to bring the aircraft to a stop so that the aircraft overran the runway threshold and came to a stop in an unpaved area. The pa sengers were evacuated immediately. It is the pilot's responsibility to interrupt or tc continue the take-off in case the take-off warning system starts sounding.

1.2 Injuries to persons

None of the passengers was injured.

1.3 Damage to aircraft

The aircraft was slightly damaged.

1.4 Other damage

Minor damage to ground in the extension of runway 25 R.

1.5 Crew information

The crew consisted of the pilot-in-command, the co-pilot, the flight enginee one steward and five stewardesses.

The pilot-in-command, aged 56 years, held an airline transport pilot's license endorsed for Boeing 707-100/200/300 series. He had passed his last medical examination on 9 October 1965. He had flown a total of 25 537 hours, 4 635 of which had been on aircraft Boeing 707. During the preceding 24 hours he had not been on duty.

The pilot stated i.a. that prior to take-off the stabilizer trim was set to 4.5 units "nose-up", while after the interruption of the take-off the indicator showed 5.5 units "nose-up", although - according to his statement - he had not changed the trimming.

The co-pilot, aged 38 years, held an airline transport pilot's license for Boeing 707/720. He had passed his last medical examination on 22 December 1965. His flying experience amounted to 12 044 hours, of which 3 972 hours had been flown on Boeing 707. Prior to the time of the accident he had not been on duty.

The statements made by the co-pilot with regard to the setting of the stabilizer prior to take-off and the indicated setting after the interruption of the take-off correspond with the statements made by the pilot-in-command.

The flight engineer, aged 47 years, held a flight engineer's license. He had passed his last medical examination on 17 January 1966. He had flown a total of 14 181 hours, 1 817 of which had been on aircraft type Boeing 707. During the preceding 24 hours he had not been on duty.

1.6 Aircraft information

The aircraft had flown a total of 20 789 hours, 4 721 hours of which since its last overhaul. After 21 January 1966 no difficulties were listed in the maintenance log book concerning the functioning of the take-off warning system including the indicator switch for the wing flaps, the air brakes or the stabilizer. According to the load sheets the take-off weight was 299 143 lbs. The maximum permissible weight was 300 500 lbs. The trimming of the stabilizer resulting from the calculation of the centre of gravity was 4.5 units "nose-up".

1.7 Meteorological information

The meteorological conditions were not a factor contributing to the accident.

1.8 Aids to navigation

These are not relevant to the accident.

1.9 Communications

The aircraft had radiotelephony contact with the aerodrome control tower. The crew did not report any disturbance or difficulties.

1.10 Aerodrome and ground facilities

The runway 25 R of the airport Frankfurt/Main extends in a magnetic direction of 254°. The take-off distance available amounts to 3 960 m and the accelerate-stop distance available to 3 900 m.

1.11 Flight recorders

The flight recorder indicated that the maximum speed was 165 kt (KIAS). The was no evidence that the aircraft had lifted from the ground. However, at the time of t accelerate stop the nose wheel landing gear may have been off the ground.

1.12 Findings at the site of the incident and at the aeroplane

The first brake marks caused by the left main undercarriage were visible abou 800 m before the end of runway 25 R, while the marks of the nose wheel landing gear bega about 320 m before the end of the runway. The scrapes of the right main undercarriage were recognizable at the end of the runway over a distance of about 70 m. The aircraft then overran the stopway which had a length of 100 m, and came to a stop on a soft lawn after additional 225.6 m at a point 33.1 m to the left of the extended runway centre lin The distance covered by the aircraft from the starting point on the runway was 4 226 m. The thermal plugs of the tires of the following main undercarriages had melted:

right main undercarriage, front, inside;

right main undercarriage, rear, inside;

left main undercarriage, rear, inside.

Both main undercarriages had sunk into the soft ground up to the wheel axles.

Findings on the take-off warning system

The wing flaps were extended to 30° which corresponded to the indication in t cockpit; the air brakes had not been activated, and the stabilizer was trimmed to 5.5 un "nose-up". This trim setting could also be seen on the trimming indicator. Furthermore the warning system was switched on.

Investigation of the take-off warning system

The parts and switches of the aircraft connected with the take-off warning sy tem were thoroughly investigated and measured. At the measuring point, it was ascertaine that with a stabilizer trimming of 5.5 units "nose-up" the distance was 23.78 inches. Since the relevant table gives only up to 5 units "nose-up" the trim setting was reduced by one half unit to 5 units and examined; it was within the tolerances. The switch whic released the warning reacted within the prescribed tolerances. The warning was released when the trim setting was 5.2 units "nose-up". According to the operational documents, t warning will be released as soon as the trim setting is one half unit before or behind t green range (5.5 units "nose-up"). When the trim setting is changed by one unit the tri wheel at the console turns about 12 times. A switch for the trim setting of the stabili is at the control stick horn of the left control column.

Also the setting of the warning switch for the air brakes and the wing flaps were in line with the regulations and the tolerances.

1.13 Fire

No fire occurred when the aircraft overran the runway.

2. - Analysis and Conclusions

2.1 Analysis

The aircraft was duly licensed for operation. The investigation of the parts which could have caused the disturbance, did not reveal any deficiencies. The crew held the licenses required for the orderly operation of the flight; these licenses were valid on the day of the accident. Both pilots had sufficient flight experience. The weather did not have any influence on the accident, nor did the navigation systems. The radio-telephony communication worked alright and did not give any indications as to the source of the disturbance. The runway used did not have any deficiencies. Take-off weight and centre of gravity were within the permissible limits.

The aircraft took off for a direct flight to New York. 14 passengers, 9 crew members, 673 lb of freight and baggage and 157 500 lb of fuel were on board. According to this load, the setting of the stabilizer was calculated with 4.5 units "nose-up" and adjusted prior to take-off. After the interruption of the take-off the trim setting was 5.5 units "nose-up". As the co-pilot did not control the aircraft but was occupied with other tasks, it must be assumed that the pilot-in-command during the take-off phase - possibly without noticing it - trimmed the aircraft further "nose-up". As soon as the position was reached which releases the take-off warning, the warning horn sounded. Since the pilot did not recognize the reasons for this warning, he assumed a genuine disturbance and decided to discontinue the starting phase. Such a decision is the pilot's own responsibility. When judging this case, however, the unusual loading and the resulting setting of the stabilizer should be taken into consideration.

2.2 Conclusions

Findings

The aircraft overran the runway end after the accelerated stop.

Cause or Probable cause(s)

In all probability the pilot-in-command during the take-off phase changed - possibly without noticing it - the trim of the stabilizer from 4.5 units "nose-up" to 5.5 units "nose-up"; this resulted in the release of the take-off warning system which caused the pilot to interrupt the take-off. The runway distance still available was not sufficient for bringing the aircraft to a stop before the end of the runway.

No. 5

Compañia Aviación y Comercio S.A., Convair 440 Metropolitan, EC-APU, accident at Las Palmas Airport, Gran Canaria, on 2 February 1966. Report dated 31 January 1967, released by the Department of Civil Aviation, Spain.

1. - Investigation

1.1 History of the flight

The aircraft was performing a scheduled passenger flight between Tenerife and Las Palmas (Flight 1B-112). It proceeded normally from take-off at Tenerife until arrival at Las Palmas, where the touchdown was made with landing gear retracted. The aircraft slid along the runway about 300 metres and came to a stop without fire occurring.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	-	-	-
Non-fatal	-	-	-
None	4	39	

1.3 Damage to aircraft

The aircraft sustained various damage to the propellers, engines, gondolas, flaps and the lower part of the fuselage.

1.4 Other damage

None.

1.5 Crew information

The pilot-in-command of the aircraft had logged a total of 6 000 flying hours, of which 2 000 on this type of aircraft. He had a valid airline pilot licence, No. 445. He had been a war pilot and observer, and was a teacher at the basic pilot training school; he had taken courses on DC-3, Convair 440, and had a radiotelephony rating. (He was in the co-pilot's seat).

The co-pilot had logged altogether 4 000 hours, of which about 40 on this type of aircraft. He held airline pilot licence No. 522. He had been a war pilot and observer and taken courses on DC-3 and Convair 440. He had a radiotelephony rating. (He was in the pilot-in-command's seat).

The flight engineer had logged 3 000 hours, of which about 2 000 of this type of aircraft.

1.6 Aircraft information

The Certificate of Airworthiness was valid up to 29 July 1966. The aircraft had flown 15 873:50 hours: 10 442:55 hours since last overhaul and 61:10 hours since its last inspection.

The port engine had been operated 12 659:16 hours: since last overhaul 1 260:05 hours and since last periodic inspection 61:10 hours.

The starboard engine had been operated 10 353:10 hours: since last overhaul 175:40 hours and since last periodic inspection 61:10 hours.

When the accident occurred, the weight of the aircraft and its centre of gravity were within the permissible limits.

1.7 Meteorological information

The meteorological conditions at the airport at the time of the accident were:

QAM: Gando QAN: 010° -8 kt QBA: 30 km QNY: NIL
QBB: 1/8 Sc 750 + 7/8 Cs 9 000 QNH: 1 023 mb QMU: 21/14

1.8 Aids to navigation

Nil.

1.9 Communications

Normal.

1.10 Aerodrome and ground facilities

Not mentioned.

1.11 Flight recorders

Not concerned in this accident.

1.12 Wreckage

The components damaged were: both propellers, engines and engine nacelles, flap and lower part of fuselage.

1.13 Fire

Fire did not occur.

2. - Analysis and Conclusions

2.1 Analysis

The possibility was initially considered that the crew might not have been able to see that the landing gear was retracted, if the horn did not function and if they did not notice the visual safety system because the sun was shining on the instrument panel, but these considerations were later discarded, since the flight engineer stated that he had not checked the landing gear position indicators because this check is the reply to the order to lower the landing gear, which, he states, was not given. Also the pilot at the controls, Mr. Montoya, says he does not remember whether he gave this order, nor does the pilot-in-command, Mr. Sancho, remember giving the order to lower the landing gear, stating only that, when he was on final approach and after concluding the checks, he asked the Tower for the wind data and initiated the landing manoeuvre quite normally. Furthermore, in the subsequent technical report it is stated that the landing gear lever was in the "landing gear retracted" position; the emergency systems for lowering it had no been applied. The landing gear position indicators, activated by ground batteries, were functioning correctly after the accident. Finally, the horn system to indicate "landing gear down" functioned on the ground when the throttle lever was pulled back.

2.2 Conclusions

Cause or
Probable cause(s)

The crew did not lower the landing gear and did not carry out the corresponding checks with the necessary care.

3. - Recommendations

None was made.

ICAO Ref: AR/035/66

No. 6

Iberia, Spanish Airlines, DC-8, EC-AUM, accident at Las Palmas Airport, Gran Canaria, on 2 March 1966. Report dated 22 November 1966, released by the Department of Civil Aviation, Spain.

1. - Investigation

1.1 History of the flight

The aircraft was engaged on a scheduled passenger flight between Madrid and Las Palmas de Gran Canaria (Flight IB-681). The flight proceeded normally from Madrid Airport to the airport of Las Palmas, where an accident occurred on landing at 2324 hours, when the wheels struck the edge dividing the allotted runway from its approach end, which is situated some 30 cm below the surface of the runway itself. This caused the blow-out and separation of the wheels from the undercarriage. Six of them were strewn about the runway and adjacent areas, while the other two remained attached to the right landing-gear leg until the end of the aircraft's run.

The left leg became detached 380 m along the runway and the aircraft, supported by the right landing gear and engine No. 1, continued to a point 1 050 m from the approach end of runway 03.

Friction with the runway caused a fire in the two wheels still attached to the right leg, but this was put out by the fire-fighting service of the airport.

A fire also broke out in engine No. 1 and was extinguished by the aircraft's own equipment.

The two nose-wheels were the only wheels not to blow out.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	-	-	-
Non-fatal	-	3	-
None	10	66	

1.3 Damage to aircraft

Serious damage occurred mainly to the flaps, undercarriage and the mounts which join engine No. 3 to the aircraft.

1.4 Other damage

None.

1.5 Crew information

The pilot-in-command of the aircraft had a total of 20 000 flying hours, including approximately 3 000 on this type of aircraft. He had a valid commercial pilot's licence (No. 64). He was a military pilot with ratings for DC-3s, DC-4s, Super-Constellations and DC-8s.

The co-pilot had a total of 17 500 flying hours, including 60 on this type of aircraft. He held a valid certificate (No. 172), was a military pilot and observer, with ratings for DC-3s, DC-4s, Convair 440s, Super-Constellations, Caravelles and DC-8s.

The flight mechanic had a total of 10 500 flying hours, including approximately 1 100 on this type of aircraft. He held crew member and instructor ratings for DC-3s, DC-4s and Super-Constellations and a DC-8 rating.

The flight radio operator had a total of 16 000 flying hours, including approximately 2 000 on this type of aircraft. He had completed courses on the equipment of DC-3s, DC-4s, Convairs, Super-Constellations, Caravelles and DC-8s.

1.6 Aircraft information

The airworthiness certificate was valid until 23 August 1966. The aircraft had logged a total of 7 098:35 hours, including 343:48 hours since the last regular overhaul.

The engines had logged the following hours since reconditioning: No. 1 engine: 1 955:25, No. 2 engine: 1 483:20, No. 3 engine: 7 632:07, No. 4 engine: 7 905:25; and since regular overhaul: No. 1: 343:48, No. 2: 343:48, No. 3: 343:48 and No. 4: 11:25.

When the accident occurred, the weight of the aircraft and the location of its centre of gravity were within the prescribed limits.

1.7 Meteorological information

The weather conditions at the airport at the time of accident were the following: Wind 360° 08/12 kt QNH 1 021.6 mb, temperature 17°C, dewpoint 14°C.

The meteorological office at Las Palmas pointed out the possible effect of meteorological conditions in that the aircraft might have lost height suddenly due to flying at low levels in a layer of humid air or to a change of 180 degrees in the direction of the wind during the approach to the runway.

This possibility was discarded in the final report.

1.8 Aids to navigation

Not applicable.

1.9 Communications

Air-ground communications were normal.

1.10 Aerodrome and ground facilities

The threshold of runway 03-21, on which the accident occurred, was displaced 60 m at its 03 end.

Due to work being carried out at the above location, the entire thickness of the concrete pavement protrudes above the natural terrain, forming a step some 30 cm high.

1.11 Flight recorders

Of no relevance to this accident.

1.12 Wreckage

The aircraft and its power plant suffered damage, especially No. 1 engine, flaps and main undercarriage, collapse and detachment of the left undercarriage leg, separation of six tires from the main undercarriage leaving only two wheels attached to the right gear. All the above damge was due to impact with the runway.

1.13 Fire

There was no fire before the impact.

The fire occurred after the impact of the undercarriage and the contact of the motor with the ground. The first was put out by the airport's fire-fighting service and the second by the aircraft's own appliances.

2. - Analysis and Conclusions

2.1 Analysis

The cause of the accident was undershoot, which resulted in contact with the runway occurring 30 cm below the level of the runway surface.

From the statements of the pilot-in-command, it appears that he was confused by the colour of the ground ahead of the runway approach end and by the fact that this terrain is 2 m lower.

The co-pilot likewise made an error of judgement for the reasons mentioned in his statements in that he considered the height sufficient to reach the lights of the threshold and for this reason made no observations to the aircraft's pilot-in-command.

These statements show that both misjudged the terrain. It is quite possible that, as both declared, this error was due to confusion of the colour of the terrain before the runway with that of the runway safety zone.

Misjudgement of the height is more difficult to understand, as the impact occurred 60 m ahead of the threshold lights.

Bearing in mind that the pilot-in-command and the co-pilot have considerable experience, it did not seem normal, on the face of it, that both should commit the same error of judgement. The possibility noted in paragraph 1.7 "Meteorological Information" was therefore considered, but finally excluded.

2.2 Conclusions

Cause or
Probable cause(s)

Human error on the part of the pilot-in-command who executed an undershoot.

3. - Recommendations

The report contains none.

ICAO Ref: AR/033/66

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-millisecond 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 airframe structure was investigated in accordance with airworthiness requirements (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^{o} 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^{o}.

(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^{o}.

(b) The horizontal stabilizer was designed for an ultimate distributed 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 following 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^{o} 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.

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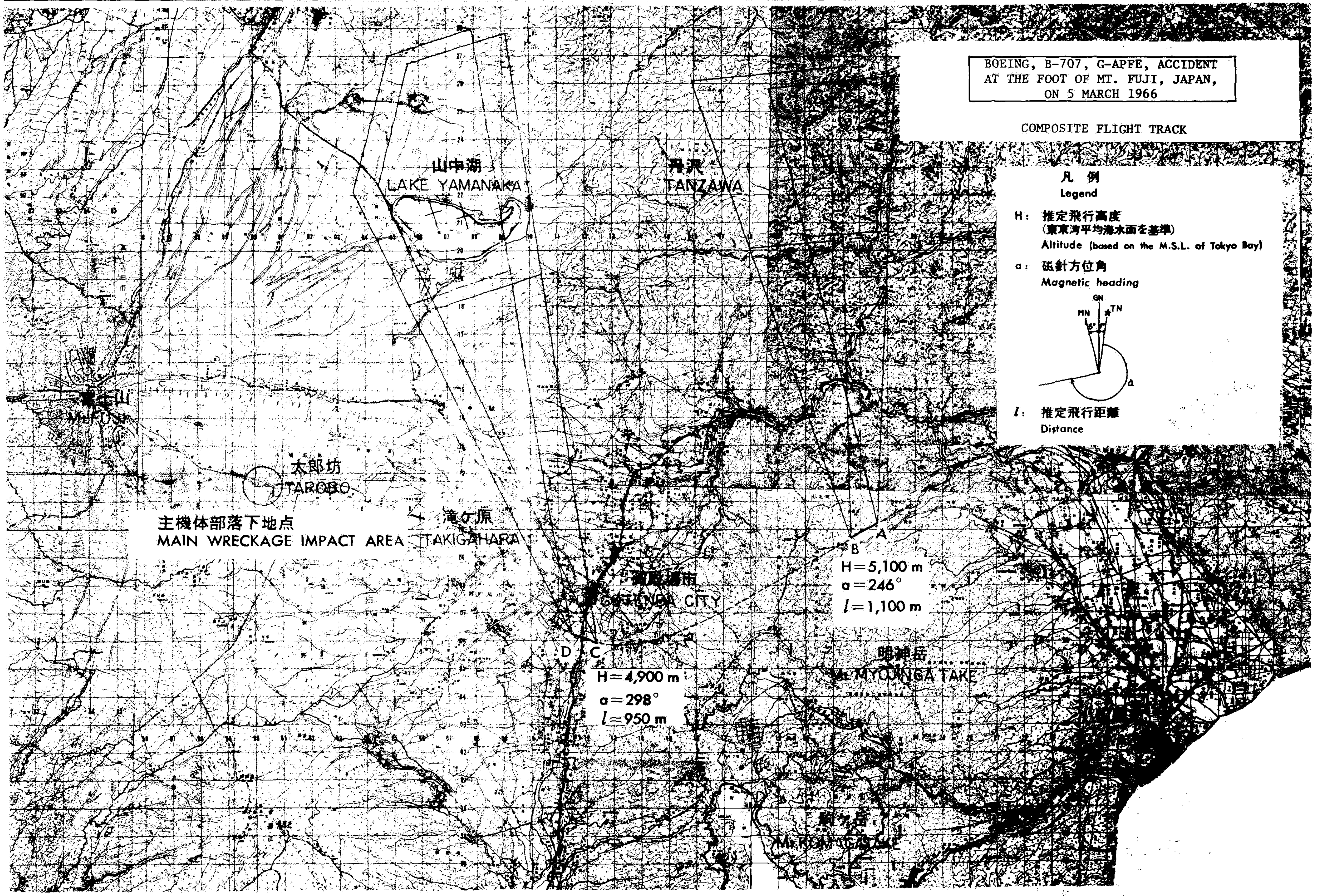
BOEING, B-707, G-APFE, ACCIDENT
AT THE FOOT OF MT. FUJI, JAPAN,
ON 5 MARCH 1966
COMPOSITE FLIGHT TRACK
凡 例
Legend
H： 推定飛行高度
(東京湾平均海水面を基準)
Altitude (based on the M.S.L. of Tokyo Bay)
a： 磁針方位角
Magnetic heading
GN
MN
TN
a
l： 推定飛行距離
Distance
山中湖
LAKE YAMANAKA
TANZAWA
太郎坊
TAROBO
主機体部落下地点
MAIN WRECKAGE IMPACT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

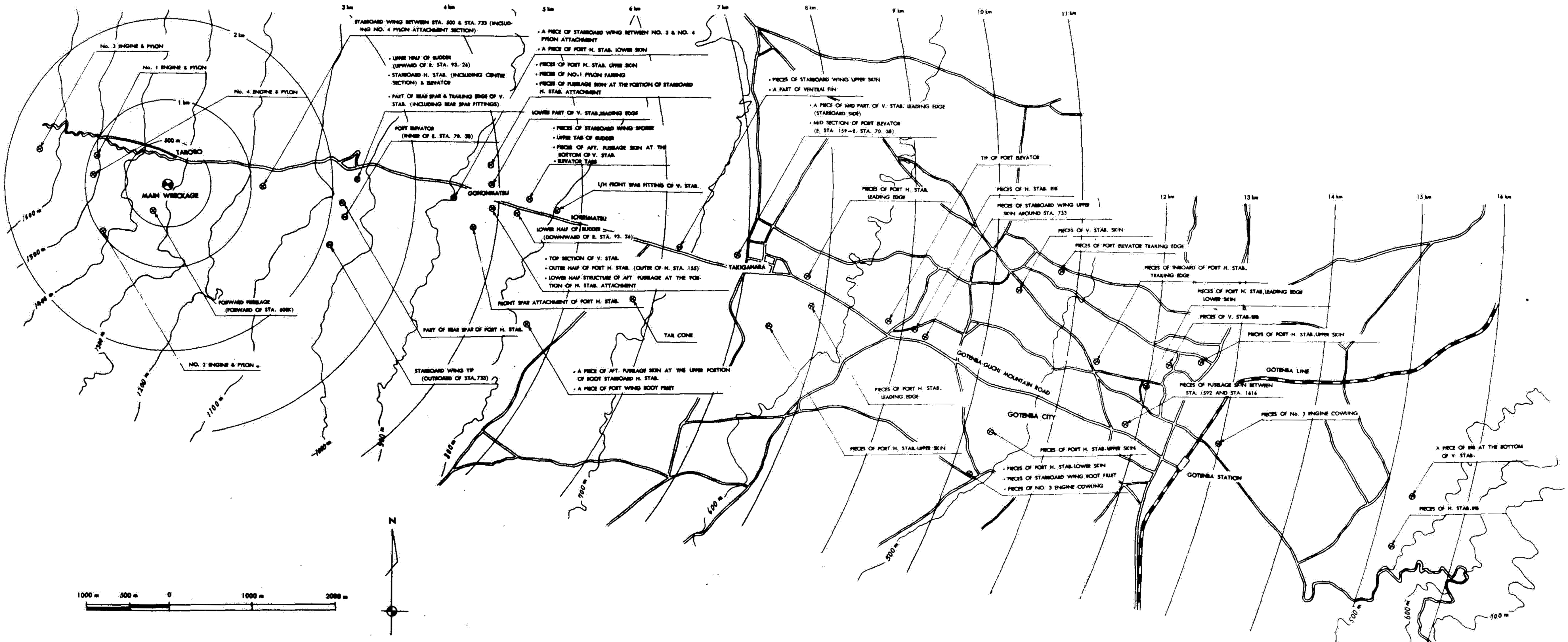

FIGURE 7-2

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

ESTIMATED ALTITUDE PROFILE

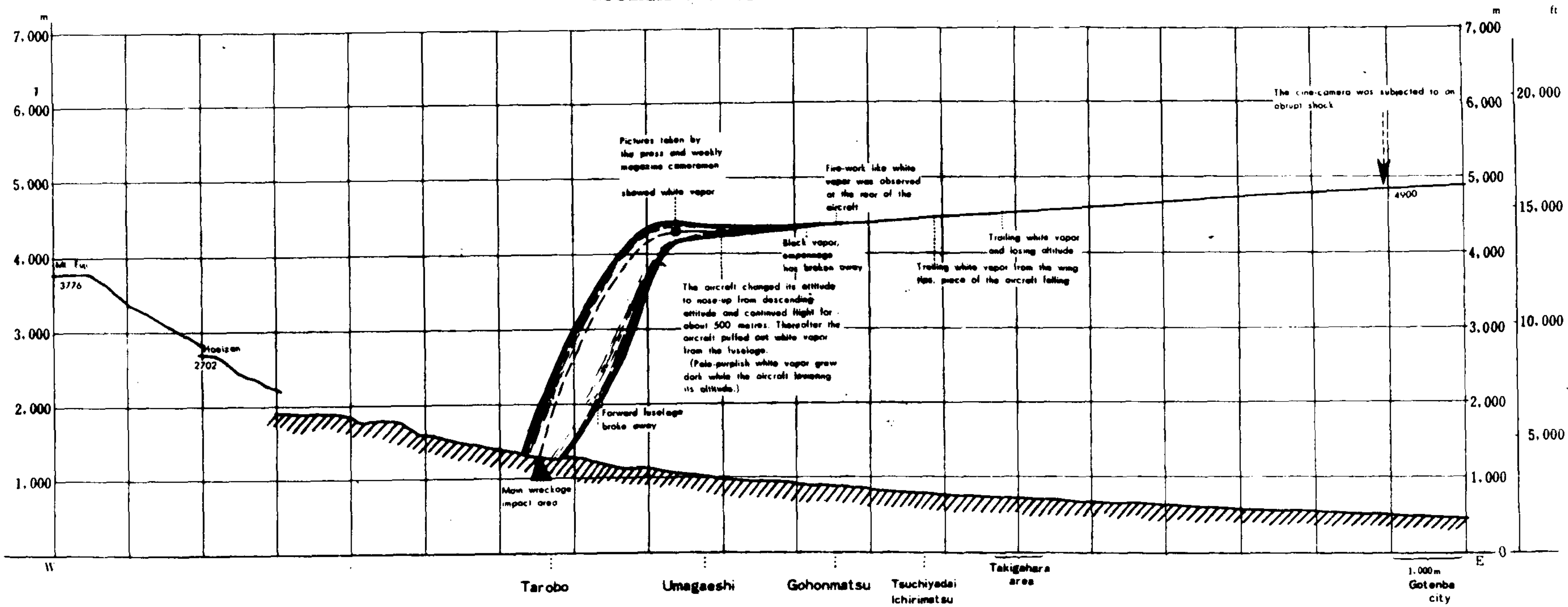

FIGURE 7-3

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

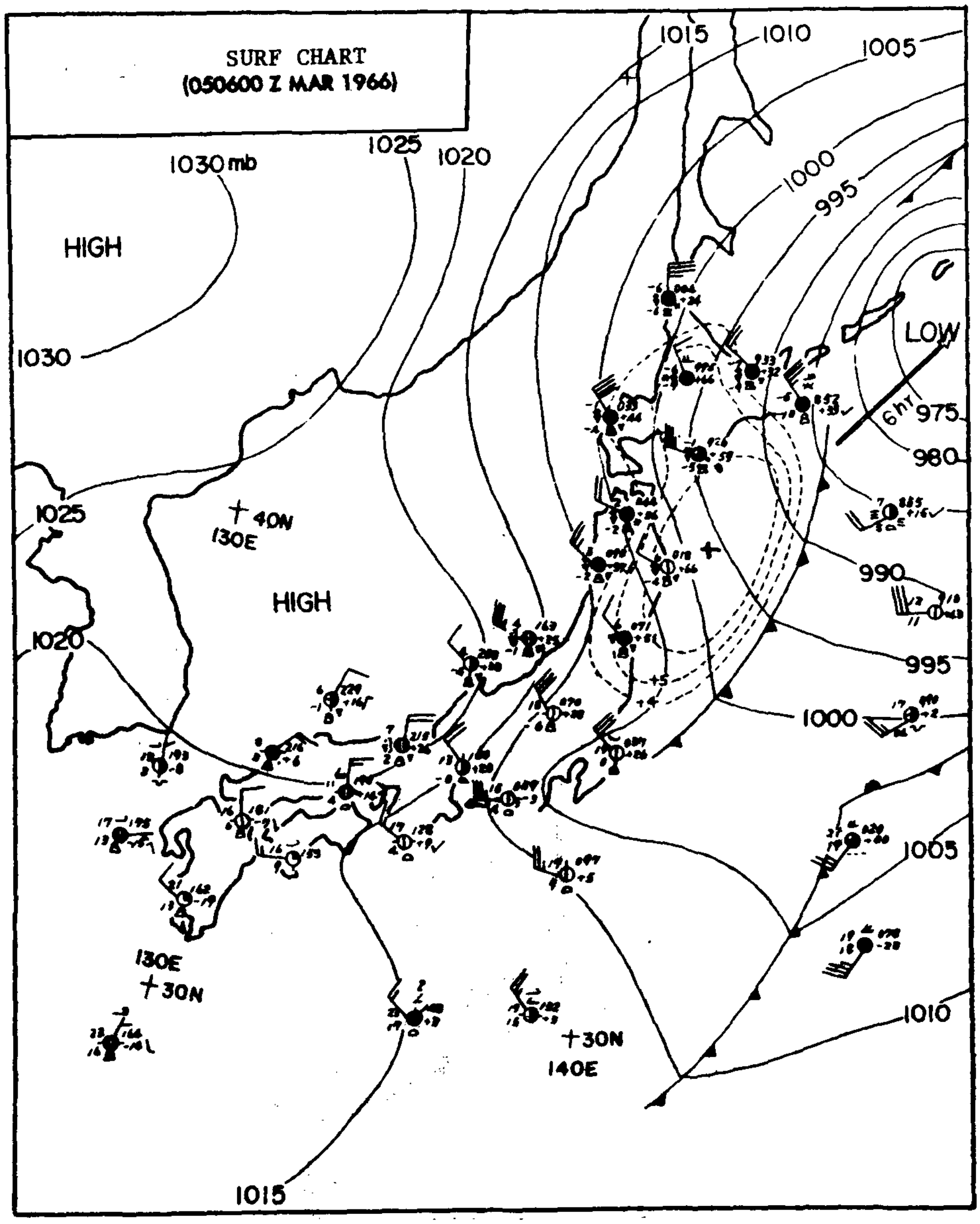

FIGURE 7-4

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

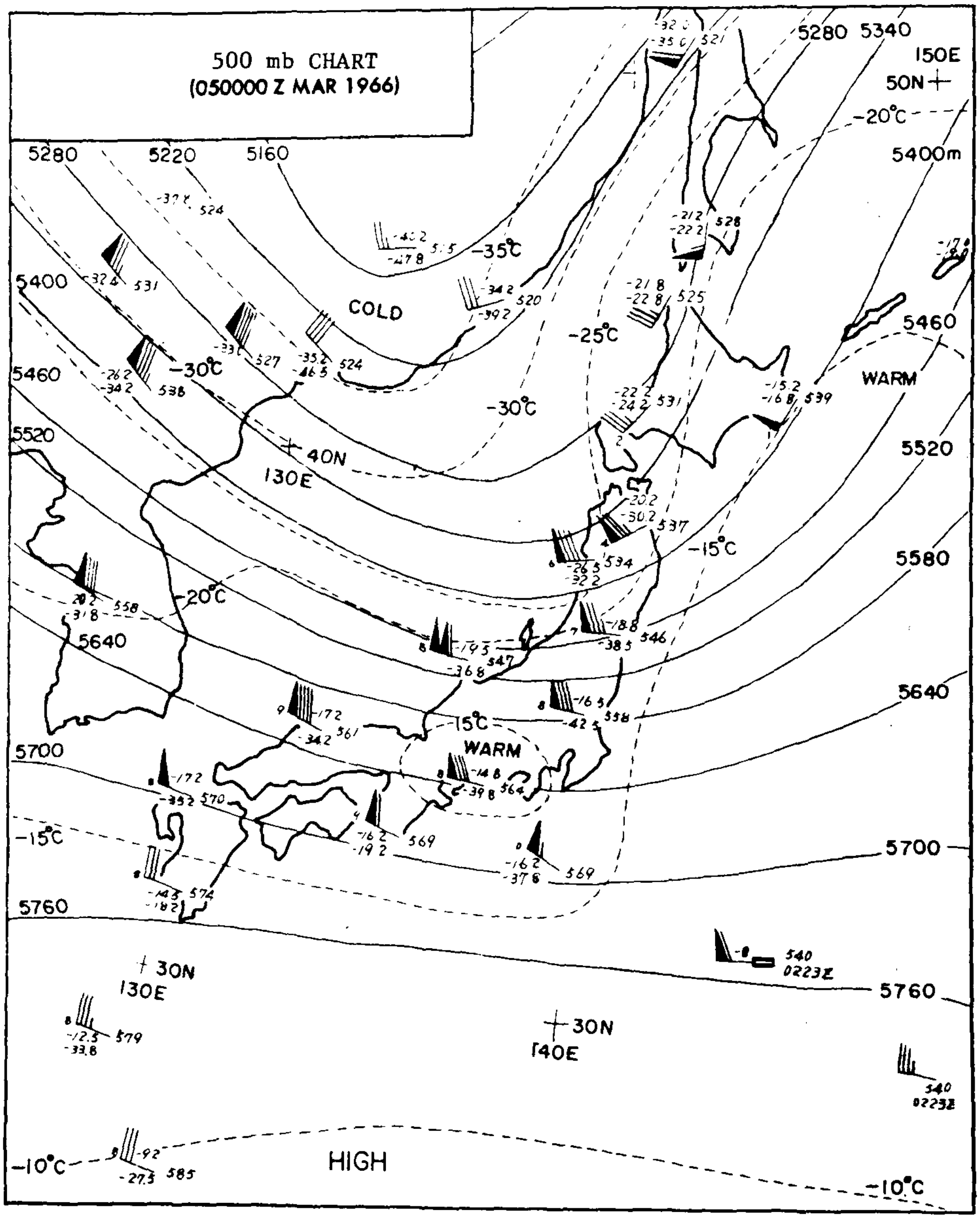

FIGURE 7-5

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.

1.6 Aircraft information

The airworthiness certificate was valid until 2 May 1966. The aircraft had a total flight time of 24 179:35 hours, including 2 935 hours since last overhaul.

The right engine had a total of 12 895:45 hours, including 841:45 since last overhaul.

The left engine had a total of 12 545:35 hours, including 475:15 since last overhaul.

1.7 Meteorological information

Weather conditions at the airport were:

Wind speed and direction: 140^{o}/10 kt

Horizontal visibility: 20 km

Cloud cover: 3/8 Cirrus at 6 000 m

Atmospheric pressure: 1 015.6 mb, equivalent to 29.99 in

Temperature: 19^{o}

Dew point: 12^{o}

1.8 Aids to navigation

Not applicable.

1.9 Communications

Not applicable.

1.10 Aerodromes and ground facilities

Not concerned in the accident.

1.11 Flight recorders

Not concerned in the accident.

1.12 Wreckage

When it came to rest, the aircraft was approximately 15 m from the runway centre line, about 150 m from the head of runway 32 and aligned on magnetic bearing 160^{o}.

1.13 Fire

There was no fire.

2. - Analysis and Conclusions

2.1 Analysis

It is known that the right wheel of the main landing gear was punctured at the end of the take-off roll. As the air escaped from the tube, the wheel rotated irregularly round its axis producing violent shocks which rendered the aircraft almost uncontrollable. Vibration was also set up in the cockpit controls and panel, making it impossible to read the instruments.

As the wheel entered the undercarriage well, these shocks and vibrations were intensified and the pilot accordingly decided to land as quickly as possible, since the length of runway still available to him was restricted to 1 875 m owing to construction work. Action was taken to re-extend the landing gear, which was in process of retraction, but owing to the suddenness of the manoeuvre it did not have time to lock. As a result it was pushed back into the well during the landing roll owing to the hydraulic pressure present in the system and the gradual loss of aerodynamic lift, until it was totally retracted.

The intensive braking action during the landing roll, coupled with the fact that the brakes were of the shoe type, caused overheating of the wheel rim, provoking the explosion of the inner tube and tire of the right wheel.

2.2 Conclusions

Cause or
Probable cause(s)

Damage to the tire of the right wheel of the main landing gear.

3.- Recommendations

None.

ICAO Ref: AR/036/66

No. 9

Cessna 337A, G-ATJO and RAF Varsity T.1 WF 334, collision at Stallingborough, near Grimsby, England, on 14 June 1966. Accident Report No. EW/E/02, released by the Board of Trade, United Kingdom, C.A.P. 278.

1. - Investigation

1.1 History of the flight

The Cessna was returning to Leavesden aerodrome from Tees-side Airport, Middlesborough, after having flown from Leavesden earlier in the morning. The pilot did not file a flight plan; his expressed intention was to fly east of the Vale of York military aviation activity area to the Ottringham VOR, approximately 8 miles north of Grimsby, and then to Leavesden direct. The aircraft took off at 0935 hours, and shortly afterwards reported to Preston ATCC giving an ETA at Ottringham of 1004 hours. The ATCC acknowledged the call and said there was no known traffic. At 0943 hours the pilot reported he was climbing to flight level 75 and would descend to flight level 60 at Ottringham.

The Varsity was returning to its base at Lindholme, via Grimsby, from a coastal bombing range south of Grimsby. It left the bombing range at 5 000 ft, climbed to flight level 65 and in accordance with normal procedure asked Midland Radar, a military radar station at North Luffenham, for recovery to Lindholme. The Varsity was identified by Midland Radar 2 miles south-east of Grimsby and was informed it was "contact under surveillance"; shortly after 1003 hours the aircraft turned over Grimsby onto a heading of 270°T and Midland Radar, after ascertaining that the aircraft was flying in visual meteorological conditions (VMC)*, passed the following message:

> "Roger there is traffic in your two o'clock position right to left range ten miles indicating about a thousand or so above you".

The captain of the Varsity instructed the co-pilot to look for the reported traffic and also looked himself in the direction given. Neither of them saw an aircraft and Midland Radar were informed: "Roger looking no contact this time" followed by "We have about six-eighths at fifteen hundred above". The controller at Midland Radar was unable to pass any further information as the radar response, which is now known to have been the Cessna, faded from the screen after having "painted" for approximately two miles.

About two minutes later when the crew of the Varsity had commenced their approach checks for Lindholme, the captain saw a red and white aircraft through the flight deck windscreen at about the one o'clock position at an estimated range of 50 yd. He immediately pushed the control column hard forward but the two aircraft collided; the upper part of the fin and rudder of the Varsity was severed and the rudder jammed to the left. The Varsity then yawed violently and entered a left-hand spiral dive. The captain

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* VMC means weather permitting flight in accordance with the visual flight rules, i.e. aircraft flying outside controlled airspace shall remain at least one nautical mile horizontally and 1 000 ft vertically away from cloud and in a flight visibility of at least five nautical miles.

ordered the crew to abandon the aircraft and, whilst they were preparing to do so, he left his seat to assist the staff navigator who appeared to be having difficulty in opening the forward escape hatch. The staff navigator abandoned the aircraft but when his parachute deployed he fell from his harness and was killed. In the meantime the co-pilot, who had previously left his seat to collect parachute packs for the captain and himself in accordance with the established drill, moved into the left-hand seat and endeavoured to regain control. During a sudden application of 'g' loading the captain was ejected involuntarily through the escape hatch; he made a comparatively safe landing. One of the student navigators then abandoned the aircraft successfully but the three remaining occupants were unable to do so due to insufficient height.

The co-pilot checked the steep spiral dive by the use of asymmetric power and attempted to land on a disused airfield. However, he was unable to maintain directional control but succeeded in touching down in an adjacent field with the undercarriage extended; the port main undercarriage broke off when the aircraft ran across a ditch. The aircraft then swung into a tree and was severely damaged; one of the occupants sustained serious injury. Fire did not break out.

The Cessna broke up in the air as a result of the collision and the pilot was killed.

Evidence of the tracks of both aircraft has been made available by a R.A.F. master radar station, whose radar is not remoted to Midland Radar. It is fortuitous that photographs of their radar display, taken at 15-second intervals, have provided a record of the aircraft tracks during the five minutes preceding the accident. A reconstruction of their flight paths, based on the photographic evidence, is appended. The relative altitudes of the aircraft were not determinable. The photographs show that at 1001 hours the Cessna and Varsity were approaching one another on near reciprocal tracks of 140°T. Two and a half minutes later the Varsity turned to port and thereafter made good a track of 270°T. Less than a minute after the turn of the Varsity the Cessna turned to starboard and made good a track of 201°T; the aircraft then converged on a line of constant bearing of 310°/130°T up to the moment of impact.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	1 (Cessna 337A) 1 (Varsity)		
Non-fatal	4		
None	1		

1.3 Damage to aircraft

Both destroyed.

1.4 Other damage

Both aircraft crashed on farm land; there was some damage to crops.

1.5 Crew information

Cessna 337A

The pilot, aged 42, was employed by H. Fairweather & Co. Ltd., and had been a pilot in the Royal Air Force from which he retired in 1962. He held a valid airline transport pilot's licence endorsed in Group 1 for Cessna 337 aircraft; his last competency check on this aircraft type was completed successfully on 22 March 1966. His total flying experience amounted to 2 874 hours, of which 88 hours had been flown in Cessna 337 aircraft. He had a rest period of 12:45 hours before commencing duty on the day of the accident.

Varsity

The pilot-in-command, aged 40, was a Royal Air Force pilot and had flown 2 735 hours, of which 812 hours were on Varsity aircraft. He was a qualified Varsity captain and his green instrument rating had been issued on 7 March 1966; he had carried out crash and parachute drills on 25 May 1966.

The co-pilot, aged 45, was a Royal Air Force pilot and had flown 3 698 hours, of which 480 hours were on Varsity aircraft. He was a qualified Varsity captain and his green instrument rating had been renewed on 18 April 1966. He carried out crash and parachute drills on 25 May 1966.

A staff navigator, aged 38, was aboard and was instructing the three student navigators in bombing technique. He carried out crash and parachute drills on 25 May 1966.

Three pilot officers aboard were student navigators undergoing a course of instruction at the Bomber Command Bombing School, Lindholme. They carried out crash and parachute drills on 8 June 1966.

1.6 Aircraft information

Cessna 337A

The Cessna 337A aircraft is a six-seater all metal, high wing, twin boom monoplane with two engines in tandem, one being in front of the cabin and the other aft. It was constructed in 1965 in the U.S.A. and issued with a United Kingdom Certificate of Airworthiness on 7 January 1966. It had been maintained in accordance with an approved maintenance schedule and at the time of the accident had a current certificate of maintenance. It had flown a total of 126 hours since manufacture, 4:30 hours being subsequent to a Period 2 inspection carried out on 6 June 1966; no defects had been reported during this time.

The design of the cockpit windscreen is such that the forward vision to the left is obstructed within the 0930/1030-o'clock sector by a metal supporting structure, of normal proportions, between the left and front panels; a map reading lamp is attached to this structure. The sector obscured is, of course, dependent upon the seating position of the pilot but, nevertheless, it is at all times necessary to occasionally move the head in order to maintain an adequate look-out. The aircraft was fitted with an anti-collision beacon on the top of the right fin.

The weight at take-off was below the maximum total weight authorized and the centre of gravity was within the permitted limits.

The type of fuel used was 100/130 octane aviation gasoline.

Varsity T.1

The Varsity was constructed in 1951 and was maintained in accordance with R.A.F. standards; its last servicing certificate was completed at 0805 hours on the day of the accident.

The cockpit "glasshouse" design provides an unobstructed forward view for both pilots. Flexible plastic day-glow panels were fitted to the fin, around the aft fuselage below the fin, on the nose, and on both mainplanes.

The weight at take-off was below the maximum total weight authorized and the centre of gravity was within the permitted limits.

The type of fuel used was 100/130 octane aviation gasoline.

1.7 Meteorological information

The Cessna pilot requested the Leavesden actual weather from air traffic control Tees-side, but this was not available and he accepted an actual weather report of Luton. He did not request or obtain any other meteorological information and no flight forecast was issued for the flight.

An appreciation of the weather in the area of the collision at the time of the accident made by the meteorological office showed the following conditions:

Wind - 5 000 ft:	230°/15 kt, temperature + 6°C
Wind - 7 000 ft:	230°/15 kt, temperature + 3°C
Cloud:	In several layers with occasional embedded cumulus developing. Lowest stratocumulus layer 3/8 to 6/8 base, 2 500 to 3 000 ft. Another stratocumulus layer above with top about 8 000 ft. Any gap between these two layers would be around the 4 500 ft level but there would be solid patches where cumulus was developing.
Surface visibility:	10 to 16 km
Weather:	Nil

According to a statement by the captain of the Varsity, the cloud cover on the return flight to Lindholme, made at a height of 6 500 ft, was 6/8 cumulus, tops 5 000 ft, and 7/8 stratocumulus, base 8 000 ft; visibility was approximately 5 miles between the two cloud layers.

At the time of the accident the sun was approximately 52° above the south-easterly horizon.

1.8 Aids to navigation

Ottringham VOR station was used by the Cessna as a turning point.Enquiries concerning its operation have revealed that on the day of the accident the beacon was transmitting on the standby transmitter from 0935 hours and that at 1000 hours the main transmitter was selected. It has been found that during the change-over a period of 65 to 85 seconds would have elapsed during which no transmission would have been made.

1.9 Communications

The VHF radio contacts between the Cessna and Preston ATCC and between the Varsity and Midland Radar were normal.

1.10 Aerodrome and ground facilities

Not applicable.

1.11 Flight recorders

Neither of the aircraft was fitted with a flight recorder.

1.12 Wreckage

Cessna 337A

The wreckage of the Cessna was scattered along a trail of about one mile on a heading of 200°T, the main wreckage - front engine and lower rear fuselage - having fallen in a field a quarter of a mile south-east of Stallingborough village, Lincolnshire. Fragments of the upper six feet of the fin and rudder of the Varsity, together with its rudder trim tab, were found in the wreckage.

The wreckage of the Cessna was collected and reassembled at R.A.F. Leconfield. Examination of the wreckage and of the detached parts of the Varsity fin and rudder indicate that the Cessna'a left wing struck the right-hand side of the Varsity's fin and rudder; the fin had then progressed along and into the Cessna's wing, cutting the fuselage in two. This led to the separation of the left and right wings, both tail booms and the tail plane, the detachment of the rear engine and propeller and the break-up of the cabin structure.

The two altimeters were found correctly set at 1013 mb. The No. 1 VOR receiver was selected to the frequency 113.9 Mc/s (the frequency of Ottringham VOR); the No. 2 VOR receiver was destroyed. The No. 1 omnibearing selector was positioned to 197° and the No. 2 omnibearing selector to 191°. (The track from Ottringham to Leavesden is 192°M.) The No. 1 VHF communications equipment was selected to 124.4 Mc/s (the frequency of London ATCC) and the No. 2 VHF communications equipment to 125.5 Mc/s (the frequency of Preston ATCC).

It has not been possible to determine whether the anti-collision beacon was operating at the time of the collision.

Varsity

The aircraft crashed at Ulceby approximately six miles north-west of the main part of the Cessna wreckage. Inspection showed that during an attempt to land in a large field with the undercarriage down the aircraft had passed over a ditch, which broke off the left main undercarriage, and then collided with a tree. The collision with the tree severed the front fuselage and left wing.

1.13 Fire

No fire occurred.

1.14 Survival aspects

The pilot of the Cessna was found close to the main wreckage of his aircraft; he had fallen during the break-up of the aircraft following the collision. He was not provided with a parachute.

Three members of the Varsity crew abandoned the aircraft using parachutes; two of them made successful landings although one was slightly injured; the third member fell from his harness and was killed. One member of the crew was seriously injured when the aircraft landed. The evacuation and survival aspects have been the subject of separate investigation by the R.A.F.

Units of the local ambulance service were at the scene of both accidents withi approximately 30 minutes of the collision and conveyed the injured to hospital.

1.15 Test and research

The acceptance trials report of the Midland Radar Unit equipment showed that a Canberra aircraft gave only a 50 per cent probability of "paint" when at a height of 6 500 ft and distance of 60 NM. It was therefore decided to conduct a test flight to evaluate the radar response of a Cessna 337A in the lower levels of the radar lobe; a number of flights were made over the Ottringham VOR simulating, as closely as possible, the flight of G-ATJO on the day of the accident.

The test showed that on that day the radar had adequate cover; there were a number of missed paints spread throughout the sorties flown but, bearing in mind the aeri sweep rate, these were of little consequence in the overall performance. It was also fo that stopping the front propeller did not materially affect the radar reflecting qualitie of the aircraft.

1.16 Other pertinent information

The Air Traffic Control Radar Unit, North Luffenham, is part of Military Air Traffic Operations (MATO) in the United Kingdom and provides recovery, climb-out, airways crossing and transit surveillance radar services for military aircraft. The radar recove and climb-out service is provided for a number of designated aerodromes of which Lindholm is one.

Radar surveillance is defined in MATO Air Staff Instructions as a service in which the pilot is informed of the bearing, distance and (if available) height of conflicting traffic, and is advised of a heading which would provide the prescribed separati Should the pilot have visual contact and/or elect not to take the advice given, he is responsible for initiating any avoiding action that may subsequently prove necessary; thi applies in VMC only and when not crossing airways.

Under Section IV of the Rules of the Air and Air Traffic Control Regulations, 1960, which contains the general flight rules for civil aircraft, it is the responsibilit of the pilot-in-command of an aircraft, even if the flight is being made with air traffic control clearance, to take all possible measures to ensure that his aircraft does not collide with any other aircraft. The Rules also provide that "when two aircraft are converging in the air at approximately the same altitude, the aircraft which has the other o its right shall give way". Similar rules are laid down in Ministry of Defence Flying Ord for the Royal Air Force.

2. - Analysis and Conclusions

2.1 Analysis

The collision occurred in the Preston FIR in uncontrolled airspace. Shortly before the accident, the aircraft had been flying at the quadrantal cruising levels appropriate to their respective tracks; the Varsity at flight level 65 and the Cessna at flight level 75. Because of the change in direction of its intended track on passing the Ottringham VOR,it was necessary for the Cessna to change its flight level in order to comply with the quadrantal rule; in this case the pilot chose to descend to flight level 60. The collision occurred during the descent. While it is not known whether the Cessna was flying in VMC at flight level 75, it is known that shortly before the collision the captain of the Varsity informed Midland Radar that his flight was being carried out in VMC with 6/8 cloud at 1 500 ft above. It seems clear, therefore, that the latter part of the descent of the Cessna was made in VMC.

It was the duty of the commanders of both aircraft to maintain an adequate look-out for aircraft. It is thought likely that the failure of the Varsity's pilots to see the Cessna in time to initiate successful avoiding action may be partly attributable to preoccupation with the approach checks which they were carrying out. It is considered that the pilot of the Cessna may also have been engaged on internal cockpit activities during the descent from flight level 75 after passing the Ottringham VOR. These activities could have included an adjustment of the engine power setting, the setting up of new radials on the omnibearing selectors, filling in the flight log and preparing to inform Preston ATCC of his passage of the Ottringham VOR. He may also have been preoccupied checking his VOR receivers, since it is known that this facility was not transmitting for a period of 65 to 80 seconds after 1 000 hours. The break in transmission would have caused the OFF flags to show on the omnibearing indicators, thus attracting the pilot's attention and consequently adding to his workload. Although the Cessna was not probably flying in conditions of good visibility shortly before the collision, an additional factor which may possibly account for its pilot not seeing the Varsity was the obstruction caused by the windscreen panel structure. The approach of the Varsity was on a line of constant bearing of approximately 130°T, i.e. within the 0930/1030-o'clock sector in which vision was obstructed by the windscreen frame and reading lamp.

This accident emphasizes the importance of maintaining an adequate look-out at all times and of ensuring that vigilance is not relaxed when cockpit drills are carried out or distractions from routine flight occur.

Although the flight evaluation of the Midland Radar showed that the radar response of a Cessna 337A provided adequate cover on the day the test was conducted, it is, nevertheless, accepted that on the day of the accident the response faded from the screen after "painting" for about 2 miles. This difference in performance may have been due to one or more of the following factors:

(i) Anomalous propagation of radar waves due to atmospheric conditions.

(ii) Small changes in the sensitivity and power output of the radar.

(iii) Slight variations in the relative positions of the aircraft and the radar antennae caused by differences, due to wind effect, between trial tracks and actual track flown.

2.2 Conclusions

Findings

(i) The documentation of both aircraft was in order.

(ii) There was no pre-crash failure or malfunction of either aircraft.

(iii) The pilots of both aircraft were properly qualified and sufficiently experienced to carry out their respective flights.

(iv) The flight visibility was sufficient to ensure that each aircraft could have been observed from the other in time to avoid a collision.

Cause or
Probable cause(s)

The collision resulted from a failure to maintain an adequate look-out from either aircraft.

General aviation and military
En route
Collision - aircraft - both airborne
Pilot - failed to observe aircraft
Failure to maintain an adequate look-out from either aircraft

ICAO Ref: AR/039/66

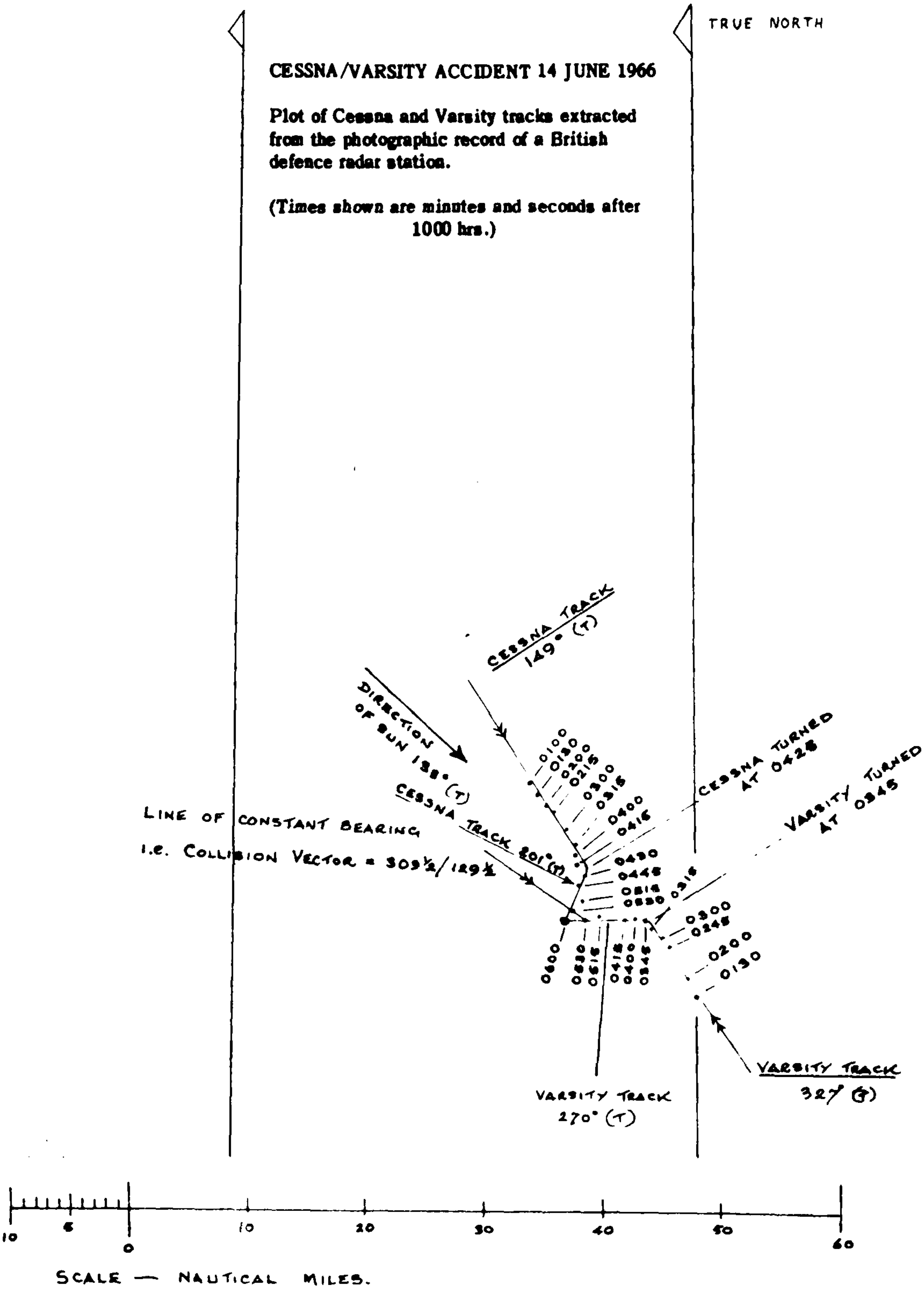
TRUE NORTH
CESSNA/VARSITY ACCIDENT 14 JUNE 1966
Plot of Cessna and Varsity tracks extracted from the photographic record of a British defence radar station.
(Times shown are minutes and seconds after 1000 hrs.)
CESSNA TRACK 149° (T)
DIRECTION OF SUN 128° (T)
CESSNA TRACK 201° (T)
LINE OF CONSTANT BEARING
i.e. COLLISION VECTOR = 309½/129½
CESSNA TURNED AT 0425
VARSITY TURNED AT 0345
VARSITY TRACK 270° (T)
VARSITY TRACK 327° (T)
10 5 0 10 20 30 40 50 60
SCALE — NAUTICAL MILES.

FIGURE 9-1

No. 10

Air New Zealand Limited, Douglas DC-8-52, ZK-NZB, accident at Auckland International Airport, on 4 July 1966. Summary of accident report dated 15 September 1966, produced by Accidents Investigation Branch, Department of Civil Aviation, New Zealand.

1. - Investigation

1.1 History of the flight

The aircraft was making the first take-off of a routine crew training flight at Auckland International Airport, New Zealand. Time of departure was 1559 hours New Zealand Standard Time. All five occupants were seated on the flight deck. Shortly after rotation, the starboard wing dropped, the aircraft failed to accelerate and gain height normally and side-slipped inward until the wing tip struck the ground. The aircraft then cartwheeled clockwise about the nose radome and progressively disintegrated. Initial impact took place 3 865 feet beyond the threshold and 97.5 ft to starboard of RW 23, the active runway. Geographic location: Lat. 37° 00' 36" S., Long. 174° 47' 29" E. Elevation 22 ft AMSL.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	2		
Non-fatal	1	2*	
None			

1.3 Damage to aircraft

The aircraft was destroyed.

1.4 Other damage

None.

1.5 Crew information

The crew were properly certificated. The pilot-in-command, aged 46, held an ALTP Licence and had 17 966 hours total experience, with 497 hours on DC-8 aircraft. He occupied the right front seat and was giving the co-pilot continuation training.

The co-pilot, who was flying the aircraft from the left front seat, had some 4 200 hours total experience and 21 hours on DC-8 aircraft. The flight engineer had 4 250 hours air experience and held a DC-8 type rating.

* Supernumerary crew

The pilot-in-command and the flight engineer lost their lives; the co-pilot was seriously injured.

1.6 Aircraft information

The Certificate of Airworthiness and attendant documentation were valid at the time of the accident. Weight and c.g. were within prescribed limits. The aircraft had been properly maintained.

1.7 Meteorological information

Weather was not a factor in this accident.

1.8 Aids to navigation

Not applicable.

1.9 Communications

No distress message was received from the aircraft.

1.10 Aerodrome and ground facilities

Not applicable.

1.11 Flight recorders

A UDC Type FA542B flight data recorder installed in the radio rack on the flight deck was recovered intact and a readout obtained. It indicated a heading divergence of half a degree to port for four seconds following rotation, after which progressive divergence to starboard occurred until wing tip impact with the ground. V_r was 118 kt, maximum airspeed reached was 124.5 kt and airspeed at wing tip impact was 118 kt. No accurate determination of height was possible owing to the very narrow range of altitude involved.

1.12 Wreckage

Ground scars indicated an angle of bank of at least 40° to starboard at wing tip impact. The flight deck separated from the rest of the fuselage and came to rest inverted. Nos. 1, 3 and 4 engines separated from their pylons during disintegration. Distance from initial impact point to the point where the wreckage trail ended was 1 070 ft.

1.13 Fire

Fire broke out in the vicinity of the starboard wing root during disintegration. Fire in the hot section of No. 2 engine resulted in the rear half of the fuselage being gutted. Water and foam were successfully used to extinguish all fire. Fire did not reach the flight deck.

1.14 Survival aspects

Death and serious injury resulted from impact forces and general destruction in the flight deck area. The pilot-in-command and co-pilot were wearing shoulder and lap strap harness. The flight engineer is believed to have been wearing lap strap harness only.

1.15 Tests and research

Post-accident tests carried out by the investigative body and by the manufacturer, and involving at least three other DC-8 aircraft, showed that in some but not all cases in which an engine power lever was moved very rapidly rearward to the backstop to simulate engine failure, inertia force generated by the movement could cause the associated thrust brake lever to rise toward or enter the reverse idle detent, thereby arming the engine for reverse thrust. The pilot of the aircraft had been seen to snap the lever rearward by holding the spoiler disarm spigot on No. 4 power lever, not the knob.

1.16 Other pertinent information

Engine failure was simulated at or just after V_1. Witnesses saw the fan cascade doors in an open configuration between V_1 and V_r. The same doors were seen open at an undetermined time after lift-off.

2. - Analysis and Conclusions

2.1 Analysis

A copy of the full report analyses the evidence in detail. From the conclusions below, circumstances which precipitated the accident will be apparent.

2.2 Conclusions

Findings

1. No failure or defect was present in or occurred in the airframe, flight controls and allied systems, or instrumentation before the aircraft struck the ground.

2. Until they became dislodged at impact, all four engines were responding faithfully to commands transmitted to them through their respective controls.

3. Simulated failure of No. 4 engine was initiated by the pilot-in-command at or immediately after V_1; he moved the power lever very rapidly rearward by using the spoiler disarm extension.

4. Inertia force generated by very rapid rearward movement of the power lever caused the associated thrust brake lever to enter the reverse idle detent, thereby arming the engine for reverse thrust.

5. Arming of the engine for reverse thrust allowed the engine to exert powerful reverse thrust during initial stage of spooldown, particularly at and immediately after rotation.

6. The fan cascade doors and other reversal components became activated for reverse thrust between V_1 and V_r.

7. The co-pilot flying the aircraft was able to maintain directional control when the aircraft was on the runway largely because the nose wheel was still in contact with the ground.

8. A state of reverse thrust was not detected by any occupant of the aircraft before it became airborne.

9. The aircraft was rotated at a predetermined V_r which, however, was much below that necessary to allow the pilot to control the aircraft under the circumstances prevailing.

10. When the aircraft rotated and for some time afterward, No. 4 engine remained armed for reverse thrust.

11. Application of full left rudder after lift-off was effective in preventing a large amount of yaw, but not all yaw.

12. Thrust imbalance, coupled with loss of lift occasioned by disturbance of the air flow through No. 4 engine being in reverse thrust, induced a strong rolling moment to starboard which, with side-slip, continued until the wing tip struck the ground.

13. At no time after lift-off did the aircraft reach a V_{mca} appropriate to the thrust imbalance and angle of bank incurred; the pilot was never able to gain control.

14. Failure to accelerate and gain height were due to an increase in induced drag and loss of lift resulting from the effects of uncontrollable roll.

15. At an undetermined time after lift-off, reverse thrust was recognized and eliminated.

16. No. 4 engine was delivering no thrust at the time when it separated from its pylon.

17. After elimination of reverse thrust, insufficient time and height were available to permit recovery before the wing tip struck the ground.

18. The pilot did not misuse the flying controls or take any action which might adversely have affected the performance of the aircraft under the circumstances which prevailed.

19. If a power lever of a DC-8-52 aircraft is moved rearward very rapidly, it is possible for inertia force generated by that movement to cause the associated thrust brake lever to rise and enter the reverse idle detent and thereby arm the engine for reverse thrust.

20. Prior to the occurrence of this accident, neither Air New Zealand Limited nor the Department of Civil Aviation in New Zealand was aware from its own experience or had learned from any source elsewhere that a state of reverse thrust might result from very rapid rearward movement of a DC-8 power lever or of a power lever of similar design and mode of operation installed in other types of aircraft.

Cause or
Probable cause(s)

The primary cause of this accident was the incurrence of reverse thrust during simulated failure of No. 4 engine on take-off.

That condition arose when very rapid rearward movement of the power lever (customary only on crew training flights involving simulated engine failure) generated an inertia force which caused the associated thrust brake lever to rise and enter the reverse idle detent.

After lift-off, the minimum control speed essentially required to overcome the prevailing state of thrust imbalance was never attained and an uncontrollable roll, accompanied by some degree of yaw and side-slip in the same direction, ensued.

When the condition of reverse thrust was recognized and eliminated, insufficient time and height were available to allow the aircraft to recover from its precarious attitude before it struck the ground.

3. - Recommendations

To prevent a recurrence of an accident of this nature, it is recommended:

(1) That engine handling techniques be revised to ensure that the rate at which any power lever is moved backward is insufficient to create inertia which may cause its associated thrust brake lever to rise toward or enter the reverse idle detent; additionally, that the power lever always be held in such a manner that rearward movement of the fingers or hand does not impart a rotary motion to the knob of the thrust brake lever;

(2) That some form of mechanical protection be incorporated into the power lever/thrust brake lever system so that, should the measures recommended in (1) above not be adhered to, incurrence of unwanted reverse thrust will be rendered impossible.

Training
Take-off
Loss of control
Power plant - engine control system

ICAO Ref: AR/018/66

No. 11

ANSETT-A.N.A., Viscount 832 aircraft, VH-RMI, accident near Winton, Queensland, Australia, on 22 September, 1966. Report released on 4 October 1967, by the Minister for Civil Aviation, Australia.

1. - Investigation

1.1 History of the flight

On 22 September 1966, the Viscount 832 aircraft registered VH-RMI, was engaged on a regular public transport service, designated Flight 149, from Mt. Isa to Longreach in Queensland, Australia, with a crew of four and twenty passengers on board. The flight departed from Mt. Isa at 1208 hours Australian Eastern Standard Time climbing to Flight Level 175 with an expected time interval of 73 minutes to Longreach.

The flight progressed, apparently uneventfully, until 1252 hours when the Longreach Flight Service Unit heard the crew of VH-RMI say that it was on an emergency descent and to stand by. Two minutes later the aircraft advised that there were fire warnings in respect of Nos. 1 and 2 engines, that one of these warning conditions had ceased and that the propeller of the other engine could not be feathered. At 1259 hours information from the crew of VH-RMI, relayed to Longreach through the crew of another aircraft in the vicinity, indicated that there was a visible fire in No. 2 engine and that the aircraft was diverting below 5 000 ft to Winton. The town of Winton is located some 20 miles to port of the planned track and is 90 miles short of Longreach.

No further communications were received from the aircraft but at 1303 hours a number of people located in the Winton area saw black smoke in the air west of the town, and it was subsequently established that this was associated with VH-RMI which had crashed in light timber on level ground some 13½ miles short of the Winton aerodrome.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	4	20	-
Non-fatal	-	-	-
None	-	-	

1.3 Damage to aircraft

The aircraft was destroyed by impact forces and fire.

1.4 Other damage

Apart from fire damage to some trees there was no damage to other property.

1.5 Crew information

The pilot-in-command of the aircraft, aged 41 years, held a valid First Class Airline Transport Pilot Licence endorsed for various types of aircraft including Viscount 832 aircraft. His total flying experience amounted to 14 288 hours, of which 10 003 hours had been flown in command including 1 025 hours in command of Viscount 832 aircraft. His last proficiency checks were carried out on 9 March and 2 April 1966, and the results of these checks were consistent with the very high standard of proficiency which he had exhibited throughout his flying career. He was last medically examined during April 1966, at which time he met the standards for the class of licence he held. There was nothing to suggest that the pilot-in-command was other than in good health and spirits on the day of the accident.

The co-pilot, aged 29 years, held a valid Second Class Airline Transport Pilot Licence endorsed for various types of aircraft including Viscount 832 aircraft. His total flying experience was 2 803 hours, most of which had been gained as co-pilot on airline aircraft including 249 hours as first officer on Viscount aircraft. The last proficiency check undertaken by the first officer was on 15 July 1966, when he was cleared to fly in this capacity on Viscount 832 aircraft. In a medical examination undertaken only two days prior to the accident, it was found that the co-pilot continued to meet the medical standards for the class of licence he held.

The cabin attendants (two hostesses) were properly trained for their duties.

1.6 Aircraft information

The aircraft, a Vickers Viscount 832, Serial Number 416, was manufactured for Ansett-A.N.A. in 1958-59. At the time of the accident it had flown a total of 18 634 hours since new, of which 6 586 hours had been flown since the last complete overhaul.

The aircraft was operating under a current Australian Certificate of Airworthiness which was last renewed on 10 April 1964. It was found in the investigation that this certificate, by virtue of the Australian Air Navigation Regulations, was deemed to be suspended at the time of the flight which culminated in this accident because of some irregularities which had occurred in the maintenance of the aircraft. None of these irregularities in any way contributed to this accident.

The aircraft was powered by four Rolls Royce Dart 525 gas turbine engines and the air for cabin pressurization, ventilation and temperature control was supplied by three Godfrey Type 15 blowers mounted on the engine-driven accessory gear boxes for Nos. 2, 3 and 4 engines and located aft of the airframe firewall. The No. 2 blower installed in VH-RMI at the time of the accident was fitted to the aircraft on 30 April 1966, and had completed 915 hours since the last overhaul. The unit was manufactured by Godfrey Precision Products Ltd., of England in 1959 and had completed 14 427 operating hours since new. The oil metering unit filter associated with this blower was removed and cleaned during the course of a 6 000-hour aircraft inspection carried out in late June of 1966, and the last general inspection of the No. 2 engine gear box area was carried out in Sydney two days prior to the accident.

Although the operator introduced a number of unauthorized modifications to these blowers during his overhaul of the units, it was found that none of these modifications contributed in any way to the accident. It was also found that the No. 2 blower had been assembled with the rear vent plug incorrectly positioned in the uppermost position and it was deduced that this could lead to an accumulation of some 20-25 c.c. of oil in the rear vent chamber of the blower. There was no conclusive evidence that this accumulation of oil in any way adversely affected the operation of the blower or contributed to this accident.

The aircraft was flown from Brisbane to Mt. Isa on the day prior to the accident by the same crew as was involved in the accident. No report or record of any mechanical defect was made following this flight and there is no evidence of any contamination of the aviation kerosene added to the aircraft to fill its tanks prior to the departure from Mt. Isa.

The gross weight of the aircraft at the time of take-off at Mt. Isa was 64 068 lb, which was 8 432 lb less than the maximum permissible gross weight for take-off. The weight of fuel consumed up until the time of the accident is estimated as being 2 850 lb, and thus the gross weight of the aircraft at the time of the accident was 2 782 lb less than the maximum permissible gross weight for landing. The position of the aircraft's centre of gravity at the time of the accident is estimated to have been 24.2% of standard mean chord which is within the permissible limits of travel.

1.7 Meteorological information

En route between Mt. Isa and Winton the aircraft was probably above most of the 4/8ths alto-cumulus cloud cover. The wind at Flight Level 175 was westerly at approximately 15 kt and the temperature at this height would have been minus 8°C. The weather conditions in the area of the accident were fine with broken alto-cumulus cloud having a base of 12 000 ft. The visibility was unlimited and the surface wind light and variable, swinging from the south-west through south to the south-east.

1.8 Aids to navigation

At the time of the accident there were no radio navigation aids installed at Winton and, in the critical period of this flight, the crew were able to navigate by visual reference to the terrain.

1.9 Communications

Communications between Longreach and VH-RMI were conducted direct on a VHF frequency until the aircraft's descent carried it to below 10 000 ft where terrain shielding prevented further direct VHF communication. Subsequent communications from the aircraft were relayed through other aircraft in the area and, although no record was available of the details of transmissions, a reliable reconstruction of the import of the communications from the aircraft was obtained from the recollections of the several people who overheard these communications.

1.10 Aerodrome and ground facilities

There were no aerodrome or other ground facilities relevant to this accident.

1.11 Flight recorders

The aircraft was equipped with a UDC type F-542B flight data recorder manufactured by United Control Corporation, USA. This recorder was installed in the forward belly locker of the aircraft and it recorded vertical acceleration, altitude, heading and airspeed, in addition to time. The recorder was recovered in the main wreckage area on the sixth day of the investigation. It had been buried beneath other wreckage including components of No. 3 engine and had been subjected to very severe impact damage and an intense ground fire. The recorder, along with other components, was embedded in a mass of metal which had melted and solidified around it.

When the recording medium was exposed, it was found that it had been torn from edge to edge in the vicinity of the scribe bar, the take-up spool cover had been dished inducing some mechanical damage to the medium, there had been considerable penetration of the take-up spool chamber by heat, molten metal and ash and most of the stylus actuating units and stylii had been dislodged. It was also found that the recording medium had been heavily discoloured by oxides and other contaminants and no useful amount of engraving was visible under the microscope. A cleaning process using hot, diluted nitric acid followed by light polishing in some areas was adopted and, after several months of painstaking effort, the heading, altitude and airspeed records for the whole of the flight until within two minutes of the ground impact were determined. The vertical acceleration and time traces remained substantially unreadable but the former was of little significance in the investigation and the latter was determined by calculation from the known foil transport speed.

The flight data record indicated that the aircraft reached Flight Level 175 at 1240 hours, and cruised at this level for the subsequent seven minutes with the automatic pilot engaged and the height lock facility in use. At 1247 hours, or 18 minutes prior to the point at which descent would normally have been commenced into Longreach, the automatic pilot was disengaged and the aircraft commenced a descent which was described by the flight crew five minutes later as an emergency descent. This descent was continued at an average rate of approximately 1 000 ft per minute and at an average airspeed of 180 knots until shortly before the accident occurred. A great deal of useful information was derived from a close examination of the descent profile of the aircraft. In conjunction with other evidence such as the communications from the aircraft and the results of wreckage examination, it was possible to define the sequence and times of the principal events which the aircraft experienced during this descent. By 1301 hours, or two minutes prior to impact with the ground, the aircraft had reached an altitude of 5 000 ft and was flying towards Winton at an indicated airspeed of 170 knots. The mechanical damage to the recording medium precluded the determination of any certain information relating to the last two minutes of flight, but it was possible to determine the height and heading of the aircraft at the time of structural failure by analysis of the wreckage trail.

A cockpit voice recorder was not installed in the aircraft.

1.12 Wreckage

The principal impact of the aircraft occurred on flat terrain 640 ft above mean sea level and components of the aircraft were found scattered through light timber over a distance of 6 170 ft leading to the main impact area. A wind drift analysis was carried out in relation to selected items of wreckage, and this led to a determination in conjunction with other evidence that there was a structural failure of the aircraft whilst it was on a heading of 070 degrees in a steady descending flight path at an indicated airspeed close to 170 knots and when the aircraft was between 3 500 and 4 000 ft above ground level. At this point in the flight path, the port wing failed upwards between Nos. 1 and 2 engine nacelles, struck the top of the fuselage, which at the same time was cut open by the blades of No. 1 propeller, and fell away from the remainder of the aircraft. The cabin shell above floor level was quickly broken away by air loads until eventually the rear fuselage and empennage also separated from the aircraft. The remaining forward fuselage, with the lower mid fuselage, starboard wing and engines and port wing stub with No. 2 engine still attached, struck the ground at the edge of a clay pan and was immediately engulfed in flame. The port wing section with No. 1 engine attached also burned after striking the ground.

The wreckage examination indicated that the port wing spar upper boom had been heated to a temperature of approximately 320°C at wing station 188, and that it had failed in compression when its residual strength was approximately 12 per cent of the required material specification. The point of failure in this boom was immediately adjacent to the overwing louvred air exit whence is discharged the air normally circulating inside the wing during flight. There were clear signs that an intense fire had been burning above the fuel level in cell 2 of fuel tank No. 2 which is located between Nos. 1 and 2 engines forward of the wing main spar. There were also unmistakable signs that an in-flight fire had existed in the adjacent port main landing gear bay and there were signs in some components of the rear nacelle immediately forward of this bay that they had been affected also by heat in flight. The No. 2 cabin blower which is installed in this area was recovered and it was found that it had experienced a major mechanical failure.

The rate of flow of oil to the four main bearings of the cabin blower is controlled by an oil metering unit attached to the rear end cover of the blower. The oil metering unit was missing from the No. 2 cabin blower when it was recovered and it was found separately in the wreckage. From an examination of the five studs and nuts which normally secure the oil metering unit to the cabin blower, it was established that the nuts and studs had loosened during operation allowing the oil metering unit to move rearward from the blower end cover, thus releasing the outer race of the driven rotor rear roller bearing. With the loss of radial restraint, there was an immediate failure of this bearing and gross contact between the rotating and stationary elements of the blower occurred. Since the oil metering unit continued to supply oil to the roller bearing area after the bearing failure but before it separated from the blower, an oil fire was ignited by the high friction temperatures generated. This fire escaped from the blower and ignited the resin in a fibre glass air duct which normally carries air from the blower outlet to the wing ducting system commencing in the port main landing gear bay.

It was also established in the wreckage examination that, at the time of their respective contacts with the ground, the No. 1 propeller was windmilling with the blades resting on the high pitch lock, No. 2 propeller was feathered, whilst Nos. 3 and 4 propellers were at blade angles consistent with substantial power being delivered. Furthermore, it was discovered that the low pressure fuel valves serving Nos. 1 and 2 engines were shut at the time of impact and those serving Nos. 3 and 4 engines were open. Both the undercarriage and the wing flaps were in their retracted positions at impact and a thorough examination of the remainder of the aircraft did not reveal any other evidence of defect which might have contributed to the accident.

1.13 Fire

The evidence indicates that, in flight, but at different times, fire warnings were received by the crew in respect of Nos. 1 and 2 engines. It was determined that both fire extinguishing shots available on the port side of the aircraft had been discharged into No. 1 engine. The wreckage examination did not reveal any evidence of fire occurring in flight in either of these engines, and it was concluded that the fire warnings were induced by the effects of heat on the conductor insulation for the fire warning systems contained in the electrical looms installed adjacent to the No. 2 nacelle and the port main landing gear bay. The evidence did indicate, however, that a severe fire occurred in flight aft of the No. 2 airframe firewall, in the port main landing gear bay and in the cell 2 of fuel tank No. 2. There are no fire detection or protection systems provided in these areas.

Severe ground fires broke out immediately upon impact in the main wreckage area and in the port wing to which was attached No. 1 engine. There were no fire-fighting facilities immediately available and the first fire-fighting units arrived at the scene of the accident approximately one hour after it had occurred. Their activities were confined to damping down the fire in the main wreckage area.

1.14 Survival aspects

The accident occurred close to a station homestead and it was reported by telephone to the Winton Police Station within a few minutes of its occurrence. During the in-flight structural break-up, sixteen of the occupants of the aircraft were discharged from it, eleven of them still strapped in their seats and the remaining eight occupants were carried into the main wreckage area. There were no survivors of the accident since it was non-survivable.

1.15 Tests and research

A great number of laboratory tests and experiments were carried out during the six months of intensive investigation which followed this accident. A number of these tests contributed materially to results of the investigation whilst some produced no useful information. The results of the useful tests and experiments are reflected in the wreckage examination results and in the conclusions derived.

1.16 Other pertinent information

During the course of the investigation of this accident, information relating to aircraft fires, provided by the Manufacturer from his records, referred to two earlier occurrences which proved to be of some significance. On 12 May 1964, at Toronto, Canada, a Viscount 724 aircraft operated by Air Canada experienced a severe fire in the No. 2 nacelle and port wheel bay area when a fire commenced in a cabin blower during a ground run. Detailed reports of the investigation of this occurrence carried out by the Operator were obtained through the Canadian Department of Transport.

Although it was apparent that the oil metering unit had been forced from the blower as a secondary effect in this occurrence and there were other circumstances which were dissimilar to the features established in the VH-RMI investigation, there were, on the other hand, a number of similar or significant circumstances revealed. There had been a fire inside the blower and it ignited the fibre glass duct attached to the blower outlet. The fire burned rearwards in a very short time and entered the wheel bay where its intensity was sufficient to cause the engine fire extinguishing bottle to explode violently. The fire in No. 2 nacelle severed the aluminium alloy high pressure fuel cock control rod and burned a large hole in the thermal anti-icing crossover duct. In its initial stages, the fire was ignited and sustained by the normal oil supply to the bearings and the total oil loss arising from the fire was only some 2½ pints.

On 20 September 1964, a Viscount 772 aircraft en route between Piarco, Trinidad and Seawell, Barbados and operated by British West Indies Airways experienced a fire in the No. 4 nacelle area aft of the airframe firewall. Not a great deal is known of this occurrence, but the Manufacturer's records and further inquiries show that the fire occurred in the cabin blower as a result of a loosening of the nuts and studs attaching the oil metering unit to the blower. Although the aircraft landed within approximately 15 minutes, there was considerable fire damage in the area. Since, on this occasion, the fire occurred in an outboard engine nacelle, there were some dissimilarities of environment but, nevertheless, this was another case of an oil metering unit separating in flight from the cabin blower and inducing an internal fire which erupted and was sustained outside the cabin air supply system for a sufficiently long time to endanger the aircraft.

2. - Analysis and Conclusions

2.1 Analysis

The wreckage distribution pattern with support from other evidence clearly indicates that this accident involved a structural break-up of the aircraft, commencing at a height between 3 500 and 4 000 ft above ground level. The examination of the structure revealed that the initial failure occurred in the port wing main spar between Nos. 1 and 2 engines and metallurgical tests showed that, at the time of failure, the upper boom of this spar had been reduced in strength by heat to a level of some 12 per cent of material specification. Obviously, this condition assumed great significance in the light of the advice from the flight crew that there was a visible fire in the area of No. 2 engine during the emergency descent which they were conducting.

The examination of the No. 2 cabin blower showed that the mechanical failure had been followed by a fire within the blower. It was apparent that the fibre glass duct downstream from the blower outlet had also burned in flight, and thus it was difficult to avoid the conclusion that the fire within the blower propagated either internally or externally to ignite the fibre glass duct. Since this duct enters the wheel bay, there was a ready explanation for in-flight fire which the wreckage examination indicated had occurred in this area.

The main landing gear bay is normally separated from the adjacent outboard fuel cell bay by a closing rib but there is not a complete seal between these areas since, inter alia, along the rear face of the wing leading edge member, cut-outs are provided in the rib web to allow the passage of engine control rods and electrical cables to the No. 1 engine nacelle. In this area immediately aft of the engine accessories, it is not uncommon for the electrical looms to become oil soaked in service and thus a means of carrying the fire from the wheel bay to the fuel tank bay immediately outboard was readily available. This situation provides a feasible explanation as to the source of the fire which quite obviously raged in fuel cell 2 of tank No. 2 during the flight of the aircraft.

The normal internal air circulation pattern in flight was at all points conducive to the movement of the fire from the blower to the wing spar along this path. It was also apparent, however, that the crew had the wing thermal anti-icing system in operation during the flight and this would provide an augmentation of the air flow within the fuel tank bay. Once the fire was introduced to this bay, it would have been fanned by a forced draught of air exiting through the overwing louvre which is placed forward of but immediately adjacent to the upper boom of the main spar. In these circumstances, the principal effects of the fire in the fuel tank would have been directed against the upper boom of the spar in the area where it finally failed. In this way, a very feasible explanation became available as to how the mechanical failure in the No. 2 cabin blower produced a visible fire which the flight crew associated with No. 2 engine and induced the fuel cell fire which ultimately led to the structural failure of the port wing in flight.

This explanation of the sequence of events also provided tenable explanations for several otherwise puzzling items of evidence. For instance, the activitation of the fire warning systems for Nos. 1 and 2 engines apparently arose from a cable insulation break-down occurring when fire burned in the oil soaked looms which pass through the No. 2 nacelle and landing gear bay areas. Similarly, the inability of the flight crew to feather the No. 1 propeller can be attributed to the effects of fire on the electrical feathering control cables and to the fact that the aluminium alloy control rods crossing the No. 2 nacelle area towards No. 1 engine had been burned through, as occurred in the earlier Air Canada ground fire. An examination of the remainder of the wreckage failed to reveal any other significant defect in the aircraft or to produce any other tenable explanation of the accident.

It seems most likely that, although the flight crew were no doubt puzzled by the occurrence of fire warnings for Nos. 1 and 2 engines in quick succession and by their inability to feather No. 1 propeller by the two means available, it seems improbable that they could have had any real appreciation of the seriousness of the internal fire in the wing of the aircraft. The management problems with two engines and the subsequent visible signs of fire obviously prompted their decision to divert to Winton which was the nearest suitable aerodrome. At the time of the structural failure the flight crew would have had Winton aerodrome well in sight and would have been expecting to land within the next five minutes. The preparation of the passengers for an emergency evacuation after landing indicates that the existence of an emergency situation was well appreciated, but it seems that the structural failure in flight was not an event which they expected to occur. Having regard to the information available to the flight crew, it does not seem reasonable that they should have expected such a catastrophic event at this time and it seems that the command decisions were properly taken on the information available to the captain.

2.2 Conclusions

Findings

The crew, comprising two pilots and two hostesses, were adequately and properly trained to operate the aircraft. The pilots were properly certificated and apparently medically fit to undertake the duties of the flight.

Weather was not a factor in this accident.

There was a current certificate of airworthiness for the aircraft and, at the commencement of the flight, there was no evidence of any defect in the aircraft.

The aircraft was loaded within safe limits.

The crash of the aircraft followed the failure in an upward direction of the port wing between No. 1 and No. 2 engines at approximately 1302:30 hours Eastern Standard Time when the aircraft was at a height of 3 500 ft to 4 000 ft above ground level.

The port wing failed as a result of a weakening of the main spar due to a fire in No. 2 cell of No. 2 fuel tank.

The fire originated in the No. 2 cabin blower and travelled through the rear of No. 2 engine nacelle and port wheel bay to the fuel tank.

The fire in No. 2 cabin blower was initiated as a result of a rotor break-up, the blower subsequently being driven in an out-of-balance condition by the quill shaft long enough for the metering unit to become separated from the rear end cover by the resulting vibration.

The metering unit continued to be driven after separation and lubricating oil continued to be supplied. The driven rotor lost its rear stub shaft radial location and caused metal-to-metal contact which generated a temperature sufficiently high to ignite the oil in that area.

It is not possible on the evidence to determine what was the cause of the rotor break-up.

Cause or
Probable cause(s)

The probable cause of the accident was that the means of securing the oil metering unit to the No. 2 cabin blower became ineffective and this led to the initiation of a fire within the blower, which propagated to the wing fuel tank and substantially reduced the strength of the main spar upper boom. It is probable that the separation of the oil metering unit arose from an out-of-balance condition induced by rotor break-up but the source of the rotor break-up could not be determined.

3. - Recommendations

Arising from matters revealed in the course of the investigation of this accident, the Department of Civil Aviation in Australia has taken the following precautionary action in respect of all types of Viscount aircraft:

(a) Required the engine-driven cabin air blowers to be inspected for looseness and possible leaks in the oil pipe banjo assemblies and required the area surrounding the blowers, the auxiliary gear box compartment and the wheel wells to be inspected for oil leaks and accumulations of inflammable fluids.

(b) Required the cabin air blower quill shaft to be modified or replaced, in accordance with Dowty Rotol Service Bulletin Number 83-210 which provides for a lower torque value at the sheer neck.

(c) Required that the nuts and studs securing the oil metering unit and the bearing cover plate to the rear end of the cabin blowers be positively locked in a manner such as lock wiring through drilled studs and castellated nuts.

(d) Required the replacement of the banjo type connection between the oil metering unit filter assembly and the oil supply line serving the cabin air blower by a more positive type connection.

(e) Required replacement of the aluminium alloy high pressure cock/feather control rods and throttle/RPM control rods in critical unprotected areas to be replaced by rods made of fire-proof materials.

(f) Required that adequate drainage be provided from accessory gear box drip trays and that blower case vents be connected to the existing nacelle drain systems.

(g) Required that the fibre glass outlet ducts from the cabin air blowers be replaced by ducts having a fire resistance at least equal to that provided by aluminium alloy.

(h) Required that engine fire extinguisher bottles incorporate a pressure relief device.

(i) Required that, if a fire warning persists after the extinguishing and feathering drill has been completed and a visual inspection reveals evidence of fire or smoke, where the fire warning is associated with the corresponding cabin pressure overheat or airflow failure warning or airframe de-icer overheat warning, both airframe de-icing systems must be switched 'OFF'. Some discretionary judgement is allowed when the aircraft is flying in icing conditions.

(j) Required that the propeller of the applicable engine be feathered if an airframe de-icing system overheat warning light illuminates when both de-icing systems are selected 'OFF'. If this warning light illuminates when both systems are selected 'ON', the same action is required if the system is selected 'OFF' and the warning light remains 'ON' after one minute has elapsed.

(k) Required that, if a cabin blower air flow failure warning light illuminates or, in the case of Viscount 700 aircraft, the light illuminates with the spill valve closed, the flight crew is to select one of the other spill valves to the 'OPEN' position. If the air flow failure light remains 'ON', the spill valve for the affected blower must be opened and regular visual inspections made for evidence of fire. If there is evidence of fire, both airframe de-icing systems are to be switched 'OFF' and the applicable propeller feathered.

In addition to the foregoing requirements, the Australian Department of Civil Aviation, in conjunction with Viscount Operators, is also conducting a programme of evaluation for the incorporation of a temperature sensor in the cabin blower case linked to an indicating or warning device in the cockpit. A number of aircraft have been experimentally fitted and appropriate cockpit drills have been devised to be carried out when a cabin blower overheat warning condition exists.

In addition to the action undertaken by the Department of Civil Aviation, the Chairman of the Board of Inquiry made a number of observations and recommendations in his report to the Minister for Civil Aviation. The following matters were referred to:

(a) The Chairman said that the evidence indicated the need for the continuous maintenance of the utmost accuracy in manuals issued by manufacturers of aircraft components and in sketches and drawings included therein. The Chairman also said that when changes are made, whether in the text or the sketches and drawings of these manuals, attention should be drawn explicitly to their purpose and they should be circulated amongst interested parties with appropriate despatch having regard to their nature.

(b) The Chairman pointed out that it was essential that the organisation using manufacturers' manuals should ensure that the manuals and revisions are made available to and closely studied by those who are required to work in accordance with them. He went on to commend the ATA-100 specification for manufacturers' manuals as being a standard worthy of adoption in Australia.

(c) The Chairman said that, where doubt is entertained by responsible representatives of an operator as to the accuracy of any drawing, whether it be an assembly or installation drawing or as to any method or procedure of overhaul or repair, it should be referred to the manufacturer for determination.

(d) The Chairman referred to the need for operating companies to maintain a very high standard of accuracy in their aircraft maintenance records systems.

(e) The Chairman emphasized the desirability of the utmost consultation between the subsidiaries or agents of manufacturers and their principals in relation to any unique or unusual incident which may be revealed.

(f) The Chairman said that particulars of modifications which vary a manufacturer's design of an aircraft component, although made in accordance with airworthiness requirements, should be notified to the manufacturers of that component.

(g) The Chairman pointed out that the unusual, unexpected or unique accident or incident will at all times repay careful scrutiny and particularly where fire is involved. He said that any such accident or incident should be reported to the manufacturer of the aircraft, who in turn should seek such further information as may be necessary to determine its cause. The Chairman also said that, in the case of a vendor component, the manufacturer of such component should be notified.

(h) The Chairman said that it is desirable that the rotors of the Godfrey blower should be balanced at each blower overhaul.

(i) The Chairman said that, although no direct evidence pointed to any specific fault which could be accepted as the primary cause of rotor break-up, he was satisfied that the modifications already undertaken would ensure that the risk of fire in future, arising from a blower failure, would be negligible. He suggested that the examination of failed rotors should continue with a view to determining the presence or otherwise of fatigue cracking.

(j) The Chairman said that it is a matter of the greatest concern that neither the Canadian nor the British West Indian occurrence of fire in a cabin blower was known in Australia until after the investigation of the loss of VH-RMI had commenced. Both fires caused considerable damage in the area aft of the airframe firewall and knowledge of the circumstances may have led to the introduction of modifications which would have precluded the VH-RMI accident. The Chairman went on to say that fire in an aircraft, whether in the air or on the ground, is an occurrence of the greatest potential danger, and he suggested that occurrences involving fire should at all times be the subject of investigation by appropriate airworthiness authorities and that their conclusions in relation thereto should be widely circulated. He also said that the matter appeared to be of such significance as to call for action on the international level.

ICAO Ref: AR/019/66

No. 12

KLM, DC8, PH-DCD, incident at Tokyo Airport, Japan, on 5 August 1966. Summary report dated 6 October 1966, released by the Japanese authorities.*

1. - Investigation

1.1 History of the flight

The aircraft PH-DCD (Douglas DC-8), operating as Flight 863 of KLM, with the pilot-in-command and ten other crew members, carrying 53 passengers on board, departed Manila Airport at 1707 hours GMT on 5 August for Tokyo International Airport in accordance with IFR.

This aircraft getting contact with Tokyo approach control office at 2044 hours GMT, then passing over Spencer Victor and Rice Victor, received the instruction from Tokyo approach control office at 2052 hours GMT that it should land at the 33R runway of Tokyo International Airport by instrument approach procedures.

After passing the Kisarazu Outer Marker at 2056 hours GMT, the aircraft entered the final approach course, and immediately having the runway in sight, at the height of 150 ft at the distance of one mile from the touchdown of the runway, at 2100 hours GMT, the pilot-in-command, who had occupied the left side seat, suddenly collapsed.

The co-pilot took immediately the command of control in place of the pilot-in-command and carried out missed approach procedure and informed the control tower.

The flight mechanic, the second co-pilot and a cabin crew carried the pilot-in-command into the lounge, laid him on the floor, and gave a treatment of artificial respiration and oxygen inhalation, but in vain.

The aircraft, commanded by the co-pilot in the left seat and the second officer in the right seat went around again over Kisarazu Outer Marker, and tried the second instrument approach and landed at 2117 hours GMT.

After landing, the death of the pilot-in-command was confirmed by the Airport Authorities.

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* Although the following does not come within the ICAO definition of an aircraft accident and therefore does not appear in the classification tables, the summary is included for general interest.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	1		
Non-fatal			
None	10	53	

1.3 Damage to aircraft

None.

1.4 Other damage

None.

1.5 Crew information

The pilot-in-command

Age: 48 years (Born on 10 May, 1918)

Licences: (1) Pilot's licence B1 issued in August of 1949

(1) Pilot's licence B1 issued in August of 1949
valid until 14 January 1967

(2) Navigator's Licence issued in April of 1959
valid until 14 January 1967

(3) R/T Licence issued in August of 1952
valid until 14 January 1967

(4) The last proficiency check was carried out in July 1966, and the last medical check on 27 June 1966

Flying career:

(1) Entered KLM Royal Dutch Airlines on 1 June 1949

(2) Total flying hours were 15 399 hours, including 3 945 hours in the Dutch Navy before his entering in KLM.

(3) His total flying hours on Douglas DC-8 were 1 425 hours, of which 1 215 hours were as a pilot-in-command and 210 hours as a co-pilot.

Latest flying experience:

(1) His flying hours during the month of July 1966 were 62:15 hours.

(2) His flying hours on Flight 863, from his departure from Amsterdam on 31 July to the time of the accident, i.e. 2100 hours GMT on the 6 August, amounted to 21:04 hours.

Activity during 24 hours before the accident:

The pilot-in-command and his crew members arrived at Manila airport at 1555 hours GMT on 4 August.

On 5 August, he refreshed himself by swimming and reading. After he had lunch at 1430 hours (Manila Time), he slept until his flying at 1700 hours GMT.

As above, no causal factor that could be recognized to be directly associated with the death of the pilot-in-command has been found in this investigation.

1.6 Aircraft information

After landing at Tokyo International Airport at 2117 hours GMT on 5 August, the aircraft PH-DCD was inspected and maintained as usual, and left as scheduled for Manila, which was the next destination, at 0305 hours GMT, 6 August.

Nothing abnormal could be observed as to the airframe and the powerplant.

1.7 Meteorological information

The meteorological conditions in Tokyo International Airport before and after the time of the accident were as follows:

2049 GMT	-X	18	OVC	1 1/8 FK	270/2	2966	RVR45
2058 GMT	-X	18	OVC	1 1/8 FK	290/4	2966	RVR50
2108 GMT	-X	E20	OVC	1 1/4 FK	290/3	2965	RVR55
2130 GMT	-X	E20	OVC	1 1/8 FK	290/3	2965	

According to the report of the crew, the meteorological conditions en route between Manila and Tokyo were also good.

Therefore, it is recognized that the meteorological conditions had no relation to the causal factor for the accident.

The conditions of natural light at the time of the accident: sunlight.

1.8 Aids to navigation

ILS and GCA were perfectly in order at the time of the accident.

1.9 Communications

The operation of the communication stations both on the ground and the aircraft were in order.

1.10 Aerodrome and ground facilities

Nothing particular to be described.

1.11 Flight recorders

Nothing particular to be described.

1.12 Wreckage

None.

1.13 Fire

None.

1.14 Survival aspects

None.

1.15 Tests and research

None.

2. - Analysis and Conclusions

2.1 Analysis

The autopsy on the remains of the pilot-in-command was performed by the authorized medical inspector of Tokyo Metropolitan Police. It was diagnosed that the direct cause leading to death was coronary arteriosclerosis. Chemical tests of the gastro-intestinal contents, blood, and urine, were all negative. Furthermore, no visible injuries were observed which could be recognized as the cause of death.

2.2 Conclusions

Cause or
Probable cause(s)

The unexpected death of the pilot-in-command was caused by coronary arteriosclerosis which attacked him in the course of final approach.

Scheduled international
Landing
Other - incident -
pilot collapsed
Pilot - other - coronary
arteriosclerosis

ICAO Ref: AR/032/66

No. 13

Bulgarian Airline, TABSO, Ilyushin IL-18, LZ-BEN, accident near Bratislava, Czechoslovakia, on 24 November 1966. Summary of report released by the State Aviation Inspection of the Czechoslovak Socialist Republic on 23 October 1967.

1. - Investigation

1.1 History of the flight

Flight 12° LZ 101 scheduled international air service Sofia - Budapest - Prague - Berlin. Last point of departure: Budapest at 1046 hours, 24 November 1966. Point of intended landing: Prague. Times quoted are GMT throughout.

Description of the flight:

Meteorological conditions at Prague Airport deteriorated. Due to this fact, the flight landed at Bratislava International Airport at 1158 hours. About 1450 hours the pilot-in-command of the aircraft decided to resume his flight to Prague. He took off from Bratislava Airport at 1528:30; after take-off he made a turn to starboard according to the flight clearance with the instruction to perform a right turn on to the OKR Beacon, to climb only to 300 m and then to climb on to the NI beacon up to the flight level of 5 100 m. At 1530:20 hours the flight was requested to change to the ATC approach service frequency, 120.9 Mc/s. The crew confirmed reception of this message, but they did not carry-out the retuning. Shortly afterwards the aircraft crashed into wooded ground in the mountains. The accident occurred 8 km away from the 31 runway threshold of Bratislava Airport (17° 09' 47" E. Long. and 48° 14' 34" N. Lat.), at the altitude of 420 m above MSL, i.e. 288 m above the airport level.

The accident happened at dusk.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	8	74	
Non-fatal			
None			

1.3 Damage to aircraft

The aircraft was completely destroyed.

1.4 Other damage

The aircraft cut a swath 340 m long and 10 - 30 m wide in a mountainous wood.

1.5 Crew information

The crew comprised pilot-in-command, co-pilot, navigator, radio operator, flight engineer and three stewardesses. The pilot-in-command, aged 41, held the following valid licences; airline transport pilot valid till 1 May 1967 with meteorological minima rating: QBA 1 000 m and QBB 100 m day and night. He had his flying technique checked on 22 November 1966 with excellent results. He logged a total of 11 959 flying hours, of which 2 002 hours were on IL-18, including 339 hours of night flying. During the last three months prior to the accident he had flown 197 hours.

The co-pilot, aged 36, held a second-class commercial transport pilot's licence and was qualified for day and night flights on the IL-18. He had his flying technique checked on 23 November 1966 with very good results. He had flown a total of 5 979 hours, of which 768 hours were on IL-18. During the last three months he had flown a total of 179 hours.

The navigator, radio operator and flight engineer had also considerable flying experience and valid licences. The three stewardesses were also in possession of valid licences.

1.6 Aircraft information

The IL-18 aircraft was operated since January 1966, with 78 per cent of its T.B.O. expired, the engines T.B.O. being 98 per cent expired and the propellers being from 4 to 48 per cent time expired. The aircraft had a valid Certificate of Airworthiness. Having examined the documentation, it may be concluded that the aircraft maintenance was performed in compliance with approved maintenance schedules and procedures, with the following exception: there was no evidence of the laboratory checks of the gyro horizons having been performed after 1 000 hours as required.

The take-off weight of the aircraft was approximately 49 960 kp this being much less than the specified maximum take-off weight. The centre of gravity of the aircraft was not shown in the loadsheet and could not be reliably ascertained.

The aircraft cargo comprised a consignment of radio-active iodine. The containers were destroyed and the radio-active substance contaminated the area of accident.

The fuel used was the PL-4 aviation kerosene.

1.7 Meteorological information

At the time of take-off, Bratislava Airport was behind an undulated cold front which was moving eastward. Due to a depression over Hungary, a north-west and west wind was strengthening and also the flow of cold air was increasing.

At 1500 hours at the Bratislava Airport the wind was 310°, 7 m/s, maximum gusts 13 m/s, visibility 7 km, overcast, continuous drizzling rain, 5/8 St at 360 m, 8/8 Ns at 900 m. At 1530 hours: wind 320°, 6 m/s, visibility 7 km, overcast, moderate continuous rain, 6/8 St in 360 m, 8/8 Ns in 900 m.

From 1530 hours until 1540 hours the Bratislava Airport registered two gusts of 15 m/s. At a distance of 5 km in the take-off direction of the aircraft, moderate turbulence of chaotic character up to the altitude of 500 m was observed.

The meteorologist on duty drew the crew's attention to the possibility of encountering moderate or severe turbulence in the Little Carpathian's area. The crew received a written flight forecast in Slovak language, although nobody did express this demand.

Sunset at Bratislava on 24 November 1966 was at 1459 hours. At the time of the accident there was twilight.

1.8 Aids to navigation

The aircraft was equipped for take-off and departure with two ARK-11 airborne automatic direction-finders, an airborne weather and obstructions avoidance radar and a marker receiver. Nothing has been ascertained to indicate any failure of these instruments. It has been established that at the time of impact the airborne weather and obstructions avoidance radar was not switched on.

Ground based radio navigation facilities available to the crew were a 75 Mc/s departure marker beacon of the runway 31, 725 m distant from its stop end, and the OKR non-directional radio beacon. By subsequent investigation it has been established that these aids were functioning properly.

The airport surveillance radar, with respect to its technical parameters, cannot be used for aircraft guidance and tracking in RW 31 sector.

1.9 Communications

There were three VHF radiocommunication sets on board. There were no failures ascertained in the functioning of the airborne VHF communication set used for maintaining communication with the ATC services.

1.10 Aerodrome and ground facilities

The runway 31 on which the aircraft took off has a geographical course of 314°, a length of 2 150 m, width of 60 m, and a zero slope. The airport reference point altitude AMSL is 132 m. At the time of take-off the runway was wet. At a distance of 5 km from the threshold of the runway 31, the flat country rises to reach at 8 km from the runway threshold a mean altitude of 430 - 440 m AMSL. (i.e. an elevation of about 300 m above the airport level). For the 31 RW a type A ICAO chart (operational limits) has been issued in the Czechoslovak AIP.

1.11 Fire

After the impact of the aircraft, the wreckage burnt out and the fire was probably initiated by an electric arc or by engine hot sections.

2. - Analysis and Conclusions

2.1 Evaluation of Technical Investigations

From the evaluation of the wreckage and from the technical investigations it follows that:

- no aircraft part separated before the aircraft contacted the obstructions;
- the aircraft was in flight configuration, the flaps and the undercarriage were retracted, the locking mechanisms of aircraft controls were in unlocked position;
- all engines were running in the last phase of flight at nearly nominal power rating;
- the communication and navigation equipment was in order;
- the fuel was faultless.

The radio-active substances carried on board had no influence on the functioning of instruments and the health condition of crew members.

A failure of one of the rate gyro switches and failures of electrolytic vertical reference gyro switches have been ascertained.

For the purpose of establishing the accident causes, the following has been evaluated:

- health condition of crew members;
- the flight path;
- influence of failure of the rate gyro switch on proper functioning of the gyro horizon;
- possibility of errors in the gyro horizon indications;
- possibility of turbulence and its effect on the aircraft;
- evaluation of weather conditions by officials of the meteorological service;
- decisions of the air traffic controllers;
- evaluation of geographical and meteorological conditions in the Bratislava Airport control area by the aircraft crew;
- activities of the crew in flight.

2.1.1 Health Condition of Crew Members

By forensic medical investigation no signs of any of the five flight crew members having taken alcohol or medicaments have been ascertained. Nor has it been established that any of the crew members inhaled combustion products prior to death.

By biochemical investigation an extraordinary mental load of the crew prior to death has been established, which was particularly heavy in the case of the flight radio operator and slightest in the case of the second pilot. The established mental load (with the exception of the flight radio operator) corresponds to data established in cases of other aircraft accidents of similar character. Causes of extraordinary mental load of the flight radio operator could, however, not be explained.

On the co-pilot no injuries typical for the hand position on the controls have been established. This fact, together with the increased muscular effort ascertained on the pilot-in-command and with the knowledge of the practice introduced by the airline, leads to the conclusion that immediately before the crash the aircraft was controlled by the pilot-in-command. Neither on the territory of Bulgaria, nor at Budapest or Bratislava Airports have data been established on violations of the rest, alimentation and work load regulations, from which it could be inferred that the efficiency of any member of the crew was reduced or defective.

2.1.2 Flight Path

In respect of the flight path the Commission endeavoured, first of all, to ascertain the true flight path. In this respect, the Commission's work was made rather difficult by the fact that the aircraft was not equipped with a flight data recorder which could furnish objective information on the flight course, from initiation of the take-off procedure to the collision with obstructions. The true flight path could not therefore be definitely established. The probable flight path was plotted on the basis of established facts, eyewitnesses' evidence and assumptions based on aircraft operation documents. In this respect the eyewitnesses' testimonies contain no discrepancies. The probable flight path plotting can be seen in the diagram.* As regards the flight altitude, it can be concluded that the 300 m height was maintained. The first impact with wooded ground occurred at a height of 281 m above the airport level. The 19-metre deviation below the 300 level is well within technical tolerances of the altimeters used and of admissible errors due to flying technique.

The possibility has also been examined whether under prevailing conditions the IL-18 aircraft could have taken off from the runway 31 and flown onto the OKR beacon by performing a turn to starboard at an altitude of 300 m in such a manner that obstructions would not be contacted by the aircraft, while maintaining exactly the Directives on Aircraft Operation(("Rukovodstvo") and with exclusion of any delay in initiating the turn. At the same time, the performance of a turn with 15° bank was taken into consideration, which would correspond to piloting conditions in turbulence.

*Note of the Secretariat: The diagram was not appended to the summary of the report.

The flight path has been established taking into account the following basic conditions:

- take-off from runway 31 initiated at a distance of 50 m from its threshold after the engines have reached full performance and with flaps set at 15°;

- unstick performed at a speed of 215 km/h, retracting the undercarriage at a speed of 250 km/h at an altitude of 5 m, retracting the flaps at a speed of 300 km/h at an altitude of 50 m, the engine power being set at "nominal" at the altitude of 100 m;

- performing of a straight-line climb up to the altitude of 200 m, at a velocity of 380 - 390 km/h;

- initiating of a turn at an altitude of 200 m and a continuous transition to 15° bank in a turn and maintaining this bank value;

- climbing up to 300 m, passing to level flight at 100 m and continuing in level turn with 15° bank and velocity of 400 km/h;

- mean values of wind vector: direction - 310°, velocity 8 m/s.

The computation and the graphic evaluation of the ground configuration show that with this flight path a vertical clearance of 97 m above the highest obstructions could be maintained and collision with obstructions could have been avoided. However, a comparison of the horizontal projection of the probable flight path with the projection of the plotted flight path (hereafter called proper flight path) shows that the aircraft deviated to the left by 1 450 m (measured along the normal to the proper flight path from the point of impact of the aircraft) in the direction of the obstructions,which in this direction and distance were higher than the altitude at which the aircraft was flying and consequently the impact of the aircraft with obstructions occurred.

2.1.3 Effect of Rate Gyro Switch Failure on Functioning of Gyro Horizon

In examining the rate gyro switches, it has been established in the case of one instrument that the time delay system was attached to the instrument casing by a single screw, while the other three screws and their washers were freely moving in the case of the instrument. These freely moving parts could therefore be locking the transmission mechanism of the instrument and thus interfering with its correct functioning, switching off the correction of gyroscopic instruments or breaking circuits of other instruments when turns or manoeuvres were being performed.

Because the VK-53 RB rate gyro switch controls also the switching off of the AGB-2 horizon transverse correction, the effect of non-switching the correction on indications of these horizons was examined, especially on bank indications. By plotting by graphical means, using realistic simplification, maximum errors for the given case have been established for bank and pitch, and it has been ascertained that they do not exceed 2.5°, the sense of error being such that the gyro horizon shows a smaller bank or pitch than the true one. If, therefore, the aircraft was performing a flight according to gyro horizon indication having this defect, the pilot would perform a turn with a greater bank than the indicated one.

The Commission is therefore satisfied that, although it was not possible to ascertain whether the faulty rate gyro switch was functioning correctly, its failure could not have led to performing the turn with a smaller bank than intended by the pilot.

2.1.4 Possibility of Errors in Gyro Horizon Indications

In examining documents applicable to life-timed components it has been ascertained that the 1 000-hour periodic check on AGB-2 gyro horizons was not certified, although similar checks of other instruments were duly certified. From this fact, it can be inferred that the periodic check applicable to gyro horizons was not performed.

This possibility, together with the established fact that the aircraft, although performing a turn to starboard, struck the ground with a slight bank to the left, without evidence of any other circumstances accounting for it, has led to the assumption that the indication of gyro horizons was not correct.

Investigations have shown that the gyros of gyroscopic instruments were running and, in view of other evidence on normal functioning of the aircraft electrical system (radiocommunications; ampere meter pointer imprint against value corresponding to normal conditions in flight), an eventual drop of the gyro speed cannot be assumed.

In investigating defects which are encountered in AGB-2 gyro horizon service it has been ascertained that, due to irreversible electrolysis in the electrical level which this gyro horizon type provides for maintaining vertical spin axis of the gyro, separated copper forms deposits on an annulus insulating functional contacts of the level. Following gradual deterioration of the insulation resistance may result in bridging the functional contacts.

By the effect of this process the gyrospin axis will not be maintained in its proper position and an indication of error follows.

From the AGB-2 horizons of the IL-18 (LZ-BEN) aircraft only one considerably damaged case and one gyroscope with its inner gimbal without level have been recovered. In spite of intensive searching, the horizon levels have not been recovered and their service condition cannot, therefore, be ascertained. In order that at least their possible state could be taken into consideration, vertical reference gyro levels have been examined, which are of identical principle and analogous construction. By this expert examination, on one vertical reference gyro a level has been ascertained on which cross contacts one contact was fully short-circuited; on another vertical reference gyro a level with reduced values of insulation resistance at contacts has been established. These findings support the assumption that the horizon could have incorrect indications.

In view of this evidence, the Commission is of the opinion that a wrong indication of the AGB-2 horizons cannot be dismissed as a contributory cause of the accident.

2.1.5 Possible occurrence of turbulence and its effect on the aircraft

In establishing the causes of the flight path deviation towards the obstructions and in evaluating the last phase of flight, especially the fact that while performing the turn to starboard the aircraft collided with obstructions in a bank to the left, the Commission concentrated its attention mainly on clarifying the questions of a possible occurrence of turbulence and its effect on the aircraft. In this respect the work of the Commission was made particularly difficult because of the fact that the experts' advice which was requested for this purpose from competent organizations and meteorological services has given no definite explanation of this meteorological phenomenon in relation to the accident.

Relatively concurring opinions have been expressed in evaluating the conditions of turbulence origin and its effect on aircraft. The experts' advice is definite in pointing out that conditions originating turbulence were present and that turbulence could cause considerable bumping of the aircraft. This is corroborated also by practical knowledge of experienced pilots who say that in north-west winds aircraft control in close vicinity of the Carpathian Mountains is made difficult and effects on aircraft are strong.

In respect of a precise classification of turbulence corresponding to the prevailing circumstances in the area of Little Carpathians, the experts' conclusions are not definite. This is no doubt partly due to the fact that the problem of objective measurement of turbulence and its forecast has not yet been solved by world meteorology.

The Commission could not, therefore, decide whether the information on turbulence, as furnished by experts of the Hydrometeorological Service, corresponded with the actual turbulence at the time and place of accident. Besides, it was not possible to evaluate objectively the effects of the prevailing turbulence on the specific type of aircraft.

The Commission considers, however, that in the vicinity of the Little Carpathians the aircraft moved in an environment where the aircraft control, especially equal maintaining of bank in performing a turn, was made difficult and where the environmental effects could contribute to make the aircraft deviate towards more elevated ground and to cause its collision with obstructions in a left-bank position.

2.1.6 Evaluation of Weather Conditions by Officials of Meteorological Service

The Commission has also examined the question of whether the meteorological situation, especially from the standpoint of turbulence, was correctly evaluated.

The flight forecast prepared on 24 November 1966 at 1410 hours, which was received by the crew, envisaged a slight to moderate turbulence without any more specification in respect of space.

The meteorologist on duty, who was briefing the crew, admitted the possibility of moderate to severe turbulence in the area of Little Carpathians, drawing the crew's attention to this circumstance.

The concept of "slight, moderate and severe turbulence" has not yet been exactly defined and there are no exact criteria for its consistent determination and forecast.

As regards severe turbulence, only in 1967 the World Meteorological Organization in a letter dated 17 March 1967 (Circular letter CAeM No. IV-20, "First report of the CAeM Working Group on Definition and Classification of Aeronautical Meteorological Terms") proposed a definition of severe turbulence, but this has not yet been generally adopted.

For the Bratislava Airport control zone, where the meteorological situation as it occurred on the day of accident is the most frequent (47 per cent of all measurements in Bratislava indicate the wind direction in the west to north quadrant), no detailed methods have been so far developed which would allow the officials of the Meteorological Service to give more reliable forecasts of severe turbulence and to determine it objectively.

The evaluation of possibilities of occurrence of severe turbulence, which is a dangerous phenomenon, depends therefore on personal consideration and experience of individual officials of the Meteorological Service.

In briefing the crew, the meteorologist proceeded in accordance with regulations of the Hydrometeorological Institute which supposes that the purpose of briefing is to explain the meteorological situation, the expected developments on which the flight forecast is based, or any other phenomena with a small probability of occurrence.

The Commission considers that the information received by the crew cannot be classified as anticipation of severe turbulence which would account for issuing a warning of dangerous meteorological phenomenon.

2.1.7 Decisions of Air Traffic Controllers

The ATC flight clearance contained also the instruction to perform a turn to the right and to climb only up to 300 m.

The ATC rules of Bratislava Airport control zone permit in taking off from runway 31, to make a turn to starboard or to port. Both these turns ensure a continuous departure on to the NI (Nitra) radio beacon.

In the prevailing situation a turn to port after taking-off of the IL-18 aircraft would not require an altitude limitation.

It was not wrong to decide on a turn to starboard but, in view of the fact that 5 min prior to the take-off of the IL-18 (LZ-BEN) aircraft a slower IL-14 aircraft took off, which, after passing the OKR beacon at 1526:30 hours was performing a turn to port in order to proceed toward Břeclav, it was necessary to ensure an altitude separation between the two aircraft. At the time when the senior controller of the approach control service was issuing the flight clearance, a temporary altitude limitation for the LZ-BEN aircraft taking off was mandatory.

In order to give a correct evaluation of the second part of the flight clearance, i.e. the altitude limitation to 300 m, it is necessary to explain how far the air traffic controller must or can, in taking his decision, expressed in ATC flight clearance, evaluate the effect of the configuration of ground on the safety of flight.

The Air Traffic Control Rules provide that the Air Traffic Control Services must, among other things, "control the air traffic in such a manner that collisions between aircraft in flight with obstructions on the ground are prevented on all IFR flights". Further, Article 2.8.2.5 provides that "on IFR flights the Air Traffic Control Services are responsible for the ensuring of adequate altitude separation between aircraft and the allocation of safe flight level".

It has been established that the senior controller of the ATC approach service, in issuing the flight clearance for take-off with temporary altitude limitation to 300 m for the IL-18 (LZ-BEN) aircraft, based his considerations on the prevailing traffic conditions and the necessity of ensuring a safe altitude separation between the LZ-BEN aircraft and the slower IL-14 aircraft, as well as on the assumptions that according to the actual traffic situation he would permit the aircraft to proceed in climbing and that the aircraft would initiate the turn immediately after passing above the marker. The air traffic controllers cannot with full responsibility judge the flight characteristics of all aircraft types and know all operation limits prescribed by flight manuals. Therefore, in exceptions to Air Traffic Control Rules, Doc 4444-RAC/501-8, Part II, Section 1, Note 2 provides: "The Air Traffic Control Service has also the task of preventing aircraft collisions with the ground on IFR flights". This provision does not, however, relieve pilots of their duty to make sure that the flight clearance issued by Air Traffic Control Service is safe in this respect (see AIP CSSR, Part RAC-1). Besides, the provisions of Articles 3.3.4.1, 3.3.4.2 and 3.3.5 of the Rules of the Air make the operator responsible for determining the safe minimum height and for determining the take-off procedures and meteorological minima. The Commission considers that, at the time when the airport controller was issuing to the LZ-BEN aircraft the flight operation clearance for the flight in the airport control zone and the take-off clearance, it was already possible to fix a higher limit of temporary altitude restriction before the aircraft passing over the OKR beacon.

2.1.8 Evaluation of Geographical and Meteorological Conditions by the Aircraft Crew

In accordance with Czechoslovak regulations the flight preparation must comprise study and analysis of planned flight conditions, including evaluation of traffic situation. There is no doubt that flight conditions include also the actual geographical situation.

The aircraft crew had at Bratislava Airport all necessary documents at their disposal in order to evaluate the geographical situation.

On the "Bratislava-Ivánka Airport Control Zone Chart RAC 4-3", as well as on all RW 31 (LKIB 6/65, 7/65, 7/65, 8/65 and 9/65) approach charts, the terrain relief and artificial obstructions in take-off direction are quite clearly marked. On the LKIB 6/65, 8/65 and 9/65 charts, a cross-section of the terrain relief in the RW 31 direction is also graphically indicated. Besides, for RW 31 of Bratislava Airport the "Aerodrome Environment Chart - ICAO" (LKIB 2/63) has been published. All these charts form part of the Aeronautical Information Publication of ČSSR, which the crew had at their disposal for flight preparation. The crew had thus the possibility of thoroughly evaluating the ground relief and had also time enough for it. Since the crew had not used their right of asking for flight clearance modification, it is justified to assume that they considered the received flight clearance as appropriate. From this it can be inferred that the crew either did not sufficiently evaluate the ground relief or was unable to apply the acquired knowledge to the required manoeuvre after taking off. Causality between these circumstances and the dangerous approach to the ground can be assumed.

Flight preparation must also include the acquisition of data on meteorological situation and of forecasts for the airport of departure.

There can be no doubt that the crew received all available basic information on the weather situation and its development at Prague, Berlin, Budapest and Bratislava Airports. However, it can be assumed that the crew's attention was concentrated more on weather conditions at Prague, Berlin and Budapest Airports than at the airport of departure.

The Commission assumes that information on possible occurrence of moderate to severe turbulence above the Little Carpathians was not taken by the crew sufficiently into account, because otherwise the crew would have chosen RW 04 or performed the required manoeuvre after take-off in such a manner that they would not have flown over the Little Carpathians, if no other circumstances occurred to prevent the crew from realizing this second possibility.

It has not been ascertained that the operator had issued special instructions for taking off from various runways.

The Commission considers that by issuing such instructions for taking off the free decision of crews would be restricted in the interest of increased safety.

The Commission believes that an insufficient evaluation of the terrain relief and of the weather conditions or an inadequate application of necessary conclusions drawn from this evaluation in performing the flight had a causal connexion with the accident.

2.1.9 Crew's Activities in Flight

In the course of investigation, the Commission has not established any circumstances which from the viewpoint of aircraft control and navigation would definitely and evidently explain the causes of aircraft deviation from the proper flight path and, by inference, the collision of the aircraft with ground obstructions.

From the magnetic tape record of air-ground correspondence of the aircraft, it cannot be inferred that a technical failure or another circumstance occurred on board, by which the aircraft control would become difficult for the crew.

The aircraft deviation could have been caused by non-observation of proper speed and proper bank and by delayed initiation of the turn.

As regards velocities, these have not been definitely ascertained. It can, however, be assumed that in climbing the speed of 380-390 km/h and in level flight the speed of approximately 400 km/h were maintained, though a higher velocity than 400 km/h in level flight cannot be excluded. In this respect the "Rukovodstvo", valid from 14 March 1964, in Chapter IV, Article 4.1.3, para. 2 admits the speed of 360 km/h as minimum velocity under turbulence conditions.

The Commission has not succeeded in determining at what altitude the turn was initiated. From witnesses' testimonies it can, however, be inferred that the pilot did not initiate the turn before reaching the height of 200 m and that also, in initiating it, no substantial delay occurred. On the basis of facts ascertained at the crash site and from witnesses' testimonies it can, however, be concluded that the turn was being performed with a mean bank of less than 15°.

It has not been ascertained that in making their preparation on the ground at Bratislava Airport the crew would have paid special attention to the study of obstructions in the airport area. This circumstance could have, according to the Commission's opinion, played a negative role in controlling and navigating the aircraft in the course of take-off.

The flight radio operator who conducted the air-ground correspondence was not fully proficient in English phraseology, as has appeared from the analysis of magnetic tape records. The Commission considers that this circumstance complicated the process of making decisions by the pilot-in-command. Besides, some of the immediate replies to messages from the ground raise certain doubts whether sufficient and concentrated attention was given on board by the whole crew to their evaluation in taking decisions.

These findings are not irrelevant in view of the conditions which arose by accepting the flight clearance and under which a safe performance of flight along the proper flight path at an altitude of 300 m required precise actions of the whole crew and put higher demands on the aircraft control and navigation.

The Commission considers therefore that the aircraft's deviation from the proper flight path could be partly due to the aircraft control and navigation in performing the turn, especially in maintaining a bank smaller than 15° and a speed higher than that which is allowed by the "Rukovodstvo".

The Commission considers also that the crew's activities were not adapted to flight conditions, to begin, with reception of information and instructions, their evaluation, taking decisions by the pilot-in-command and, at last, with aircraft control and navigation. In view of the established facts, their causal connexion with the aircraft accident must be assumed.

2.2 Conclusions

Findings

No deficiencies in the crew's qualification and medical fitness, which would raise doubts about the crew's capability of performing the flight safely, have been ascertained.

The execution of take-off of the IL-18 (LZ-BEN) aircraft from RW 31 of Bratislava Airport on 24 November 1966 in accordance with ATC flight clearance (turn to starboard on to the OKR beacon and climbing only to 300 m) was possible without impact with obstructions occurring. This manoeuvre was possible without doing anything by the crew in contradiction with "Rukovodstvo".

Whereas the required height of 300 m was maintained, the aircraft deviated from the proper flight path in such a direction and to such an extent that an impact with obstructions occurred. The deviation could have been caused by a smaller than 15° mean bank or by a higher speed, but most probably by a combined effect of both.

In view of the fact that mandatory laboratory checks of gyro horizons had evidently not been carried out and that failures of electrolytic levels of vertical reference gyros have been ascertained, serious doubts about correct indications of bank as furnished by the gyro horizon have arisen. Their causal connexion with the aircraft deviation from the proper flight path cannot be excluded.

In view of the actual flight conditions, the negative influence of turbulence created in the Little Carpathian Mountains area, causing difficulties in maintaining constant aircraft bank, could probably multiply the effects of a possible incorrect indication of bank by the gyro horizon, and cannot be excluded.

Officials of the Meteorological Service gave the crew sufficient information necessary for evaluating the weather situation and for the pilot-in-command to take correct decisions.

The flight clearance given to the crew by Bratislava Airport air traffic controllers may not have been the only possible solution of the actual traffic situation, but it ensured safety of flight of the IL-18 aircraft against other aircraft in the airport control zone and did not by itself create for the IL-18 aircraft an emergency situation. The situation became dangerous only when the crew did not comply with the accepted flight clearance in performing the take-off manoeuvre, or when in the course of the manoeuvre unexpected circumstances occurred which the crew did not know of or could not cope with.

There are serious reasons to doubt whether the crew thoroughly evaluated the geographical and meteorological situation and drew from this evaluation the necessary conclusions in choosing the take-off runway, in accepting the flight clearance and in performing the take-off and the departure by making a turn to the starboard on to the OKR beacon.

The possibility must be admitted that the non-maintenance of the 15° bank and the 400 km/h speed (or the lowest possible limit of 360 km/h), which non-maintenance had a causal connexion with the accident, could be partly due also to errors in controlling and navigating the aircraft.

Cause or
Probable cause(s)

The Commission could not definitely establish the cause of accident of the IL-18 (LZ-BEN) aircraft.

The Commission assumed that the most probable cause of the accident was insufficient evaluation of terrain relief and weather conditions in the Bratislava Airport control zone by the aircraft crew and lack of adaptation of the flight to these conditions.

ICAO Ref: AR/025/66

No. 14

Iberia, Spanish Airlines, DC-3, EC-ACX, accident near Puertito de Sausal, Tenerife, Islas Canarias, on 16 September 1966. Report dated 9 March 1967, released by the Department of Civil Aviation, Spain.

1. - Investigation

1.1 History of the flight

The aircraft took off from Tenerife airport at 0821. After two minutes of flight the propeller of the left engine began overspeeding. The pilot-in-command applied the normal overspeed procedures, but obtained no response to the manoeuvre. He then actuated the feathering mechanism but this also was ineffective and as the aircraft was losing height he was obliged to ditch it approximately one mile from the coast, since the orography of the locality made a landing impossible. The ditching took place normally. The aircraft remained afloat approximately five minutes and then sank carrying with it one of the passengers who refused to abandon it and who had impeded the evacuation of the other passengers and resisted the efforts of the pilot-in-command and hostess to get him to safety.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal		1	
Non-fatal		2	
None	3	21	

1.3 Damage to aircraft

The aircraft is not aeronautically recoverable and is therefore considered to be a total loss.

1.4 Other damage

Inapplicable.

1.5 Crew information

The pilot-in-command had logged a total of 5 000 flying hours, including approximately 3 500 on the subject type. He held a valid airline transport pilot's licence.

The co-pilot had logged a total of 1 400 flying hours, including approximately 350 on the subject type. He held a senior commercial pilot's licence.

1.6 Aircraft information

The certificate of airworthiness was valid up to 16 February 1967.

The aircraft had a total of 25 134:38 flying hours, including 75:34 since its last check.

Engine history was as follows:

Engine No. 1 .- total hours: 6 812:06; since last overhaut 392:21; since last periodic check 75:34.

Engine No. 2. - total hours: 17 484:50; since last overhaul 769:20; since last periodic check 75:34.

At the time of the accident, the weight of the aircraft and the centre of gravity were within prescribed limits.

1.7 Meteorological information

Atmospheric conditions at the airport at 0825 hours were as follows:

Visibility: 10 km

Cloud cover: 3/8 Sc. at 150 m and 4/8 Sc at 180 m

QNH: 1021:7 mb equivalent to 30 - 17 inches

QFE: 947.4 mb

Temperature: 16° Dew point: 15°.

1.8 Aids to navigation

Inapplicable.

1.9 Communications

Normal.

1.10 Aerodrome and ground facilities

Inapplicable.

1.11 Flight recorders

None.

1.12 Wreckage

The aircraft sank in the sea and is not considered aeronautically recoverable.

1.13 Fire

Nil.

2. - Analysis and Conclusions

2.1 Analysis

Since the aircraft was not recovered, the only source of information is the statements of the crew and passengers.

According to the pilot's testimony, the accident was caused by overspeeding of the left engine and inability to feather the corresponding propeller.

Once the propeller is overspeeding, the only procedure to counteract this is to actuate the feathering system, which was done by the pilot without result.

It is felt that the failure to feather the propeller might have been due to the fact that, if the overspeed is large, the load to be overcome is too great for the feathering mechanism. This seems to have been the case in this instance, since the pilot declared that the system functioned correctly when he tested it on the ground and that whenever he pressed the feathering button in the air it had remained depressed (correct) and the generators had indicated consumption (also correct).

When the propeller is windmilling, even if the weights are below the normal gross landing weights, the aircraft will not maintain altitude, according to Technical Instruction O.T.-1C-47-1, section III, page 9, and for this reason the pilot-in-command has to adopt one of the following alternatives:

(a) land at the nearest aerodrome;

(b) evacuate the aircraft;

(c) carry out a forced landing or ditching;

(d) attempt a combination of the foregoing.

In view of the fact that the emergency occurred only 2 minutes after take-off, in the climb-out phase, with an indicated (QNH) altitude of 2 800 ft, that loss of altitude occurred as soon as the propeller began windmilling and that the aircraft was in cloud and below the elevation of Tenerife airport (2 073 ft), the pilot-in-command was forced to adopt alternative (c) above.

2.2 Conclusions

Cause or Probable cause(s)

The accident resulted as a consequence of propeller overspeed on the left side, the cause of which could not be determined owing to the fact that the aircraft was not recovered.

3.- Recommendations

Inapplicable.

- END -

ICAO Ref: AR/038/66

ICAO TECHNICAL PUBLICATIONS

The following summary gives the status, and also describes in general terms the contents of the various series of technical publications issued by the International Civil Aviation Organization. It does not include specialized publications that do not fall specifically within one of the series, such as the ICAO Aeronautical Chart Catalogue *or the* Meteorological Tables for International Air Navigation.

INTERNATIONAL STANDARDS AND RECOMMENDED PRACTICES are adopted by the Council in accordance with Articles 54, 37 and 90 of the Convention on International Civil Aviation and are designated, for convenience, as Annexes to the Convention. The uniform application by Contracting States of the specifications comprised in the International Standards is recognized as necessary for the safety or regularity of international air navigation while the uniform application of the specifications in the Recommended Practices is regarded as desirable in the interest of safety, regularity or efficiency of international air navigation. Knowledge of any differences between the national regulations or practices of a State and those established by an International Standard is essential to the safety or regularity of international air navigation. In the event of non-compliance with an International Standard, a State has, in fact, an obligation, under Article 38 of the Convention, to notify the Council of any differences. Knowledge of differences from Recommended Practices may also be important for the safety of air navigation and, although the Convention does not impose any obligation with regard thereto, the Council has invited Contracting States to notify such differences in addition to those relating to International Standards.

PROCEDURES FOR AIR NAVIGATION SERVICES (PANS) are approved by the Council for world-wide application. They comprise, for the most part, operating procedures regarded as not yet having attained a sufficient degree of maturity for adoption as International Standards and Recommended Practices, as well as material of a more permanent character which is considered too detailed for incorporation in an Annex, or is susceptible to frequent amendment, for which the processes of the Convention would be too cumbersome. As in the case of Recommended Practices, the Council has invited Contracting States to notify any differences between their national practices and the PANS when the knowledge of such differences is important for the safety of air navigation.

REGIONAL SUPPLEMENTARY PROCEDURES (SUPPS) have a status similar to that of PANS in that they are approved by the Council, but only for application in the respective regions. They are prepared in consolidated form, since certain of the procedures apply to overlapping regions or are common to two or more regions.

The following publications are prepared by authority of the Secretary General in accordance with the principles and policies approved by the Council.

ICAO FIELD MANUALS derive their status from the International Standards, Recommended Practices and PANS from which they are compiled. They are prepared primarily for the use of personnel engaged in operations in the field, as a service to those Contracting States who do not find it practicable, for various reasons, to prepare them for their own use.

TECHNICAL MANUALS provide guidance and information in amplification of the International Standards, Recommended Practices and PANS, the implementation of which they are designed to facilitate.

AIR NAVIGATION PLANS detail requirements for facilities and services for international air navigation in the respective ICAO Air Navigation Regions. They are prepared on the authority of the Secretary General on the basis of recommendations of regional air navigation meetings and of the Council action thereon. The plans are amended periodically to reflect changes in requirements and in the status of implementation of the recommended facilities and services.

ICAO CIRCULARS make available specialized information of interest to Contracting States. This includes studies on technical subjects as well as texts of Provisional Acceptable Means of Compliance.

EXTRACT FROM THE CATALOGUE

ICAO SALABLE PUBLICATIONS

ANNEX

	U.S.$
Annex 13 - Aircraft accident inquiry. 2nd edition, March 1966. 16 pp.	$0.50

MANUAL

Manual of aircraft accident investigation. (Doc 6920-AN/855/3). 3rd edition, 1959. 257 pp.	$4.00

ICAO CIRCULARS

18-AN/15 - Aircraft Accident Digest No. 1. June 1951. 116 pp.	$2.00
24-AN/21 - Aircraft Accident Digest No. 2. 1952. 170 pp.	$0.85
31-AN/26 - Aircraft Accident Digest No. 3. 1952. 190 pp.	$1.00
38-AN/33 - Aircraft Accident Digest No. 4. 1954. 186 pp.	$3.00
39-AN/34 - Aircraft Accident Digest No. 5. 1955. 186 pp.	$2.00
47-AN/42 - Aircraft Accident Digest No. 6. 1956. 237 pp.	$2.50
50-AN/45 - Aircraft Accident Digest No. 7. 1957. 245 pp.	$2.50
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