ICAO CIRCULAR

CIRCULAR 82-AN/69
Volume I

1968

AIRCRAFT ACCIDENT DIGEST No. 16

Volume I

Prepared by the Secretariat and published
by authority of the Secretary General

INTERNATIONAL
CIVIL AVIATION
ORGANIZATION
MONTREAL • CANADA

Published in separate English, French and Spanish editions by the International Civil Aviation Organization. All correspondence, except orders and subscriptions, should be addressed to the Secretary General of ICAO, International Aviation Building, 1080 University Street, Montreal 3 (Quebec), Canada.

Orders for this publication should be sent to one of the following addresses, together with the appropriate remittance (by bank draft or post office money order) in U.S. dollars or the currency of the country in which the order is placed or in a freely convertible currency:

Australia: Robertson and Mullens, 107 Elizabeth Street, Melbourne, C. 1.

Canada: Department of Public Printing and Stationery, Ottawa (Ontario).

France: Représentant de l'OACI, Bureau Europe, 3bis, villa Émile-Bergerat, Neuilly-sur-Seine (Seine).

India: Oxford Book and Stationery Co., Scindia House, New Delhi *or* 17 Park Street, Calcutta.

Japan: Japanese "ICAO" Society, Hikokan (Aviation Building), 1-18-1 Shimbashi, Minatoku, Tokyo.

Mexico: Editorial Hermes S.A., Ignacio Mariscal 41, México 4, D.F.

Peru: Representante de la OACI, Oficina Sudamérica, Apartado 4127, Lima.

Senegal: Représentant de l'OACI, Bureau Afrique, Boîte postale 2356, Dakar.

Sweden: C. E. Fritzes Kungl. Hovbokhandel, Fredsgatan 2, Box 16356, Stockholm 16.

Thailand: ICAO Representative, Far East and Pacific Office, P.O. Box 614, Bangkok.

United Arab Republic: ICAO Representative, Middle East and Eastern African Office, 16 Hassan Sabri, Zamalek, Cairo.

United Kingdom: Her Majesty's Stationery Office, P.O. Box 569, London, S.E. 1.

International Civil Aviation Organization (Attention: Distribution Officer), International Aviation Building, 1080 University Street, Montreal 3 (Quebec), Canada.

TABLE OF CONTENTS
OF VOLUME I

THIS PAGE INTENTIONALLY LEFT BLANK

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.

*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.

PART I

SUMMARIES OF AIRCRAFT ACCIDENT REPORTS PREPARED BY ICAO

No. 1

Austin Airways Ltd., DC-3C, CFILQ, accident near Rupert River, Quebec, on 9 January 1964. Report released by the Canadian Department of Transport (undated).

1. - Investigation

1.1 History of the flight

The aircraft was on a non-scheduled flight from Moosonee, Ontario, to Nemiscan Settlement with only two pilots on board. About 45 minutes after taking off the left engine failed, followed almost immediately by failure of the right engine, and the aircraft made a forced landing in thick forest. Both pilots were severely injured.

The location of the accident was lat. 51°20'N, long. 77°34'W. The time was 0818 hours, Eastern Standard Time.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal			
Non-fatal	2		
None			

1.3 Damage to aircraft

The aircraft was substantially damaged.

1.4 Other damage

None reported.

1.5 Crew information

The pilot-in-command held an airline transport pilot's licence with a valid instrument rating; he had flown a total of 9 500 hours including 400 hours on DC-3 aircraft, of which 50 hours had been flown during the 90 days prior to the accident.

The co-pilot held a senior commercial pilot's licence; he had flown a total of 15 000 hours, of which 100 hours were on DC-3 aircraft, including 5 hours on this type during the 90 days prior to the accident.

1.6 Aircraft information

A certificate of airworthiness had been issued for the aircraft, and there was no evidence to indicate any fault in the engines, airframe or controls prior to the accident.

The report gives no information on weight, centre of gravity and type of fuel used.

1.7 Weather information

Overcast cloud about 2 500 ft, no wind.

1.8 Aids to navigation

Not mentioned in the report.

1.9 Communications

Not mentioned in the report.

1.10 Aerodrome and ground facilities

Not relevant.

1.11 Flight recorders

Not mentioned in the report.

1.12 Wreckage

Not described in the report.

1.13 Fire

Not mentioned in the report.

1.14 Survival aspects

Not described in the report.

1.15 Tests and research

None mentioned in the report.

1.16 Other pertinent information

None.

2. - Analysis and Conclusions

2.1 Analysis

On refuelling the previous night, 281 gallons were loaded which filled the rear tanks. There were also about 40 gallons in each of the front tanks. The front tanks were used for starting and the pre-flight run in order to leave the rear tanks full for the flight.

The pilot stated that he used the rear tanks for take-off and cruise and that they contained about 150 gallons of fuel, with about 10 - 15 gallons in each of the front tanks. The power settings used for the flight were about 28 inches manifold pressure and 2 050 rpm with automatic lean mixture. About 50 minutes after take-off the left engine fuel pressure dropped to zero, and the engine failed. The booster pumps were switched on, and the tank selections were changed without effect. At this time the right engine fuel pressure dropped to zero, and the engine failed. Attempts to re-start were unsuccessful and when the aircraft was 200 ft above the ground the pilot realized he could not reach the Rupert River. A forced landing was made into trees about 1 000 ft from the river with the undercarriage down.

The co-pilot did not know which tanks were used during the flight nor which tanks were selected by the pilot after the engines failed.

Examination of the wreckage showed that the front fuel tanks were empty and no fuel had apparently been used from either of the rear tanks. Damage to the cockpit was such that it was not possible to tell which tanks had been selected at the time of impact.

2.2 Conclusions

Findings

Both pilots held appropriate licences and had considerable flying experience. The aircraft had a certificate of airworthiness and no evidence of defects prior to the accident was found in the engines, the airframe or controls.

It was found that both front fuel tanks were empty and that no fuel had apparently been used from either of the rear tanks.

Cause or Probable cause(s)

Engine failure due to fuel exhaustion.

ICAO Ref.: AR/839

No. 2

Aerotransportes Litoral Argentino S.A. (A.L.A.), DC-3, LV-FYJ, accident 9 km west of Zárate, Province of Buenos Aires, Argentina, on 9 January 1964. Report No. 1965 released by the National Directorate of Civil Aviation, Argentina

1. - Investigation

1.1 History of the flight

The aircraft was on a scheduled domestic flight from Santa Fé to Buenos Aires with an intermediate stop at Rosario. The flight from Santa Fé to Rosario was normal; the aircraft took off from Rosario at 0901 hours. The flight plan altitude was 1 200 m. At 0904 hours the pilot informed Ezeiza Control that he was climbing to 1 800 m because of turbulence, and at 0912 hours he requested - and was granted - clearance to 2 400 m. At 0936 hours the pilot reported overflying San Pedro, estimating Lima at 0948 h and Buenos Aires City Airport at 1008 hours. At 0943 hours the pilot reported a localized fire in the cabin to Ezeiza Control, and that he would try to land at Zárate. Having received no reply to this message a subsequent message was sent "Due to fire in aircraft cabin, I am going to land at Zárate". This was the last communication from the aircraft, which was subsequently seen by witnesses to be descending and trailing smoke. An emergency landing was attempted in a field 9 km from Zárate. The aircraft first struck the ground with its landing gear, left engine and left wing, which were torn off, then half of the right wing and the right engine were also torn off. Following these almost simultaneous impacts the aircraft travelled another 150 m before coming to an abrupt stop. The fuel tanks were torn open and a fire resulted which, however, did not spread over the entire aircraft. The accident occurred at approximately 0950 hours.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	3	27	
Non-fatal		1	
None			

1.3 Damage to aircraft

The aircraft was destroyed by the impact and the subsequent fire.

1.4 Other damage

None was reported.

1.5 Crew information

The pilot-in-command held a valid airline transport pilot's licence. He had flown a total of 7 032 hours, of which 5 070 hours were on DC-3 aircraft.

The co-pilot, who held a valid commercial pilot's licence,had flown a total of 1 851 hours, of which 1 330 hours were on DC-3 aircraft. He had also flown approximately 2 500 hours with the airline as a radio operator.

The stewardess was properly certificated.

1.6 Aircraft information

The aircraft's certificate of airworthiness was valid until 9 September 1964. It had flown a total of 31 545 hours; the engines had had 750 and 844 hours of flight time since their last overhauls, and both engines were certificated up to 1 200 hours.

The aircraft had no built-in heating system. Heat exchangers had been installed on the outside exhaust outlet of each engine, and these conducted hot air to the crew and passenger cabins.

The aircraft's weight and centre of gravity were both within the prescribed limits at the time of take-off from Rosario and at the time of the accident.

The type of fuel used was not mentioned in the report.

1.7 Meteorological information

Meteorological conditions throughout the flight were ceiling and visibility unlimited.

1.8 Aids to navigation

No mention of these is made in the report.

1.9 Communications

These were normal until the pilot-in-command reported the cabin fire and his intention to land at Zárate. No further communications were received.

1.10 Aerodrome and ground facilities

Not pertinent.

1.11 Flight recorders

Not mentioned in the report.

1.12 Wreckage

The wreckage was strewn over a distance of 280 by 50 m.

The cockpit emergency door was found 12 km from the site of the accident. One of the door's corners was scorched showing that it had been affected by slight heat but not by flames.

1.3 Fire

The cabin roof, passenger seats, radio equipment, etc. which were thrown from the aircraft on impact showed no evidence of fire. The remainder of the left side of the fuselage, the rear sector and tail unit were partly affected by the flames and the covering of all moveable surfaces was destroyed; the right side of the fuselage was unaffected and the paint unblistered. There were no signs of fire in the engines and the electrical cables. Two manual fire extinguishers were found with their contents almost intact.

1.14 Survival aspects

The sudden deceleration following the final impact broke off the bolts of the passenger seats, and these were thrown a distance of 20 m, tearing the cabin roof from the seventh window to the cockpit wall.

The report gives no indication of any fire-fighting or rescue activities.

1.15 Tests and research

A medico-legal examination of the body showed no evidence of a possible intoxication of the pilot-in-command caused by toxic gases.

The injuries sustained by the passengers showed the same characteristics as those of the co-pilot, and were entirely different from those of the pilot-in-command. This would indicate that the co-pilot was not in the cockpit at the time of the accident, and this is confirmed by the fact that his body was found together with the bodies of the passengers outside the aircraft.

2. - Analysis and Conclusions

2.1 Analysis

The field chosen by the pilot-in-command for the precautionary landing was quite suitable. It had a diagonal length of 1 500 m and was even and firm, with no obstructions.

Evidence showed that the precautionary landing was carried out with the landing gear extended and locked and the flaps extended to the 1/4 position. Grooves on the ground, spaced 28 cm apart, indicated that No. 1 engine was functioning normally, but there was evidence that No. 2 engine had been cut off and was windmilling. No evidence of malfunction or fire was found on the engines and the engine fire extinguishers were so badly destroyed that it was impossible to determine if they had been used.

The messages sent by the crew did not indicate where the fire took place. The eyewitnesses described black smoke escaping from the forward section which lead to the assumption that the fire might have come from the electrical system; however, no signs of fire damage were found on the electrical cables. Patches of oil on the right side of the fuselage indicated a considerable loss of oil in flight coming from No. 2 engine. The oil leak was attributed to a break in the external connexion of the oil line. The leaking oil probably came into contact with the hot exhaust pipes and produced fumes which were fed into the fuselage through cable openings.

Although the cockpit emergency door was scorched it was believed that the scorching was unrelated to the accident since a fire in this section of the cockpit would certainly have affected the pilot and no evidence of burns were found upon him.

The fact that the pilot-in-command reported a fire does not necessarily imply that this was the case, since a pilot would do so when noticing smoke or fumes entering the cockpit.

It was considered that if there was a fire prior to the first impact, it was not sufficiently serious to have affected the airworthiness of the aircraft.

No reason was found to explain why the precautionary landing had such a catastrophic ending.

2.2 Conclusions

Findings

The crew were well qualified for the flight.

The aircraft had been maintained properly and had a valid certificate of airworthiness.

The field which was selected by the pilot-in-command was quite suitable for a precautionary landing. The landing was carried out with undercarriage extended and locked, and flaps extended to the 1/4 position. At impact No. 1 engine was developing power, but No. 2 engine was shut off and its propeller windmilling.

An extensive oil leak on No. 2 engine was attributed to a break in the external connexion of the oil line. The resulting fumes might have entered the cabin and caused the pilot to believe there was a fire.

No reason was found to explain why the precautionary landing which seemed to be fully under control until the first impact with the ground had such a catastrophic ending.

Cause or Probable cause(s)

Impact with the ground, for reasons which could not be ascertained, during a precautionary landing. There were fumes or smoke in the cabin and No. 2 engine was cut and its propeller was windmilling, due to oil leakage.

3. - Recommendations

No recommendations were contained in the report.

ICAO Ref.: AR/895

No. 3

Swissair Caravelle III, HB-ICX, accident at Zurich-Kloten Airport, on 30 January 1964. Report No. 1964/4/155 dated 11 March 1964, released by Federal Board of Inquiry into Aircraft Accidents, Switzerland

1. - Investigation

1.1 History of the flight

Flight 101 was a scheduled international flight from London to Zurich. The flight was normal and the approach and landing on runway 16 at Zurich/Kloten were carried out in light snowfall and variable cross-wind. The runway was covered with a thin layer of wet snow and the aircraft landed about 5 m to the left of the centre line. After about 800 m the aircraft veered slightly to the left and, notwithstanding the pilot-in-command's efforts, ran off the left edge of the runway and destroyed four runway lights damaging its nose wheel and right landing gear. Then the aircraft swerved to the right, but was finally stopped on the runway close to the right edge after a total roll of 1 915 m. The accident took place in darkness at 2006 hours GMT.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal			
Non-fatal			
None	7	44	

1.3 Damage to aircraft

Damage to the landing gear amounted to about Swiss fr. 60 000.

1.4 Other damage

Four runway lights (value of Swiss fr. 3 600) were destroyed.

1.5 Crew information

The pilot-in-command, aged 34, held a valid airline transport pilot's licence with Caravelle rating. He had flown a total of 5 900 hours, including over 1 400 hours on Caravelles.

The pilot-in-command in training, aged 40, held a valid airline transport pilot's licence with Caravelle rating; he had flown a total of 4 800 hours, including 100 hours on Caravelles.

The co-pilot, aged 37, held a valid professional pilot's licence; he had flown a total of about 2 500 hours, including more than 1 000 hours on Caravelles. At the time of the accident the pilot-in-command was in the right-hand seat and a pilot being trained as pilot-in-command was in the left-hand seat; the co-pilot was seated behind.

There were four cabin attendants.

1.6 Aircraft information

The certificate of airworthiness for the aircraft was valid until 3 December 1964. At the time of landing the weight and centre of gravity of the aircraft were within prescribed limits.

1.7 Weather information

There was a light snowfall at Zurich-Kloten Airport between 1830 hours and 2330 hours. At 1950 hours the wind was 230/13, visibility was 1.5 km with snow, vertical visibility 1 000 ft, and the temperature ranged between 0^{o} and $-1^{o}C$. The wind chart for 2005 hours showed a clearly defined squall head $230^{o}/16$ kt.

At 1950 hours the air traffic controller reported to the flight that there was 5 mm of snow on the runway and that braking action was "medium". At 2001 hours he reported the wind as being $210^{o}/10$ kt to another flight and two minutes later to the subject flight as being $220^{o}/8$ kt. Finally at 2005 hours, when the flight was over the middle marker, the air traffic controller transmitted the following information without mentioning any addressee: "Surface wind 230^{o} strength 12 kt with gusts to 16 kt". This message was not received by either of the pilots at the controls.

1.8 Aids to navigation

Not mentioned in the report.

1.9 Communications

Communications were normal.

1.10 Aerodrome and ground facilities

Instrument runway 16 is 3 700 m long and 75 m wide. Taxiway 7 enters the runway from the left 1 700 m from the threshold; the west runway crosses it at 2 200 m from the threshold and the north runway at 2 600 m. The runway is illuminated by lights on both sides at intervals of 30 m. The left row of lights is interrupted for about 180 m at the place where the runway is joined by taxiway 7.

At the time of the accident a layer of snow slush, a few millimetres thick, covered the runway.

1.11 Flight recorders

The aircraft was equipped with a flight recorder.

1.12 Wreckage

Not applicable.

1.13 Fire

None.

1.14 Survival aspects

Not applicable.

1.15 Tests and research

None reported.

2. - Analysis and Conclusions

2.1 Analysis

According to the crew, the prescribed limitations regarding cross-winds and runway conditions were observed. However gusts up to 16 kt reported immediately prior to touchdown gave a cross-wind component of up to 14 kt, a value in excess of the 10 kt tolerance laid down for "medium" runway conditions. It was therefore considered that runway conditions had deteriorated below "medium" by the time of landing. Also, the flight recorder showed a maximum braking coefficient of 0.19 during the entire landing roll, which corresponded to a cross-wind limit of around 5 kt.

The fact that neither of the two pilots picked up the last wind report is understandable. They probably failed to hear the message on account of a conversation at the critical moment or to comprehend it owing to the passage of the aircraft through the middle marker signal at about the same time. The fact that the co-pilot, who had been the only one to hear the message, did not relay it to the pilots is explainable because he thought that the pilots had also heard the message and because he had no direct responsibility for the conduct of the flight at that time. The loss of directional control began near the entrance to taxiway 7 when the aircraft probably ran into substantially stronger cross-wind components as it lost the wind protection provided by the wood located on the west side of the runway. The snowfall, the fact that the centre line was covered with snow, and the lack of runway lights on the left-hand side of the runway at this particular point made it difficult to recognize the loss of directional control. It was not ascertained whether an earlier recognition would have prevented the deviation.

Also, in a roll through snow flurries and cross-wind, an optical illusion may arise and make it appear that the aircraft is moving sideways against the wind. Therefore the crew might tend to steer in the direction of the wind. There was, however, no evidence that this occurred.

The deviation might possibly have been avoided if the pilot-in-command had released the parabrake in the first phase of the landing roll. There was, however, no special reason for doing so in view of the fact that he did not get the last wind report. That he refrained from doing so when the aircraft was rolling towards the runway edge at a sharp angle was appropriate, since the effect might possibly have aggravated the situation.

2.2 Conclusions

Findings

The crew were properly certificated and had considerable flying experience. At the time of the accident the pilot-in-command was in the right-hand seat and a pilot being trained as pilot-in-command was in the left-hand seat; the co-pilot was seated behind.

The certificate of airworthiness of the aircraft was valid and the weight and centre of gravity were within prescribed limits at the time of landing. The last message of the air traffic controller indicating a cross-wind component in excess of the limit recommended in the Flight Manual was not received by the pilots.

After a straight landing roll of approximately 800 m, the aircraft encountered stronger gusts because of the terrain configuration and it started to veer to the left. Because the runway was covered with 5 mm of snow, adherence was considerably diminished and, notwithstanding the pilots' efforts, the aircraft ran slightly off the left side of the runway and the nose wheel and right landing gear struck some runway lights and were damaged.

Cause or Probable cause(s)

Loss of directional control during the landing roll because the aircraft ran into unexpected cross-wind gusts on a runway where snow had considerably diminished tire adherence.

ICAO Ref: AR/847

No. 4

British Overseas Airways Corporation, Comet 4, G-APDL, accident near Nairobi Airport, Kenya, on 2 February 1964. Report dated December 1964, released by the East African Common Services Organization

1. - Investigation

1.1 History of the flight

The aircraft left Johannesburg for Salisbury and Nairobi at 1523 hours Z on 2 February 1964. The aircraft arrived at Salisbury at 1700 hours, but take-off was delayed until 1926 hours because of unserviceability of the aircraft's weather radar. The flight from Salisbury was uneventful until 2200 hours; at this time the aircraft was flying at flight level 290, and approach control gave it QNH 1 020, QFE 839. A minute later the aircraft reported leaving flight level 290 and was instructed to report reaching flight level 95 and 18 NM DME for a straight-in ILS approach. When descent was begun the aircraft DME read 80 NM from Nairobi, and both altimeters were set at 1 013 mb.

Nairobi Radar identified the aircraft at 45 NM on the 210° VOR radial. Its heading at that time was 025°, and it was instructed by Radar to turn left to 015° to position for landing on runway 06. At about 20 NM DME at flight level 100 the co-pilot, who was flying the aircraft from the right-hand seat, called for the approach check and changed the setting on his altimeter to QFE, but stopped at a setting of "938 mb" instead of continuing until the correct setting of "839 mb". At 2209 hours Nairobi Radar cleared the aircraft to 2 000 ft, QFE 839; this was acknowledged and repeated by the aircraft. The pilot-in-command set up the correct QNH of 1 020 mb on his altimeter, checked the sub-scales on both altimeters but failed to check that the difference between the two altimeter readings corresponded to the aerodrome height. The co-pilot checked the setting of the left-hand altimeter at 1 020 mb, called for the landing check when approximately 12 NM out and closed the throttles to descend. He stated that at about 10 NM the ILS indicated "fly up" and his altimeter 4 500 ft. Looking ahead he saw the runway and approach lights almost fused into a continuous line and what appeared to be cloud between the aircraft and the lights. Realizing that he was too low, he applied power to check the descent. The aircraft then touched the ground and ran along it for about three seconds as the pilot-in-command opened the throttles to full power and the co-pilot lifted the aircraft off the ground. The pilot-in-command then retracted the undercarriage and requested clearance for a visual circuit and landing. The undercarriage was lowered on the down wind leg, and the co-pilot carried out the landing from the right-hand seat and taxied the aircraft to the apron. The point of premature touchdown was at latitude 1°24' S, longitude 36°48' E; elevation was approximately 5 500 ft.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal			
Non-fatal			
None	7	62	

1.3 Damage to aircraft

The aircraft was slightly damaged (two slashed tires, a brake line fractured and a tie rod damaged).

1.4 Other damage

None.

1.5 Crew information

The pilot-in-command held a valid airline transport pilot's licence with current instrument and Comet-4 ratings; he had flown a total of 13 467 hours including 12 864 hours as pilot-in-command. His experience on Comet-4 aircraft amounted to a total of 2 246 hours, of which 38 hours were flown as pilot-in-command during the 30 days prior to this incident. During the past three months he had operated through Nairobi Airport on three occasions.

The co-pilot held a valid commercial pilot's licence with Comet-4 and instrument ratings; he also held a valid flight navigator's licence. He had flown a total of 4 176 hours, of which 336 hours had been in command, 2 226 hours as co-pilot and 1 614 hours as navigator; these times included 68 hours under training as co-pilot and 84 hours under training as navigator on Comet 4s. During the past three months he had operated through Nairobi Airport on five occasions.

The flight engineer held a valid flight engineer's licence and had 2 344 hours as engineer, all on Comet 4s.

1.6 Aircraft information

The aircraft's certificate of airworthiness was valid until 3 May 1964, and the required checks had been performed. No indication of any deficiencies is given in the report.

The weight of the aircraft on taking off from Salisbury was 62 172 kg, and the centre of gravity was within the prescribed limits.

1.7 Meteorological information

Meteorological conditions at Nairobi Airport at the time of the incident were: surface wind 350°/2 kt, visibility 16 NM, cloud 2/8 at 2 000 ft. Between 2155 and 2225 hours, the QFE changed from 839.0 mb to 838.8 mb and the QNH from 1020.5 mb to 1020.3 mb.

At 2156 hours the approach controller passed the following weather information to the flight: "wind 020 velocity less than 5, visibility 16 NM, 2/8 at 2 000 feet, QNH 1021, QFE 839, temperature 14", and 4 minutes later "weather unchanged, QNH now 1020 mb QFE 839".

1.8 Aids to navigation

Nairobi Airport is equipped with the following navigational aids: ILS and outer and inner locators for runway 06; VOR; 10-cm surveillance radar; DME; VDF. All these aids were serviceable and operating normally.

1.9 Communications

No communications difficulty was indicated by the report except that a reply from the aircraft to the weather information at 2200 hours was very distorted and that the aircraft was unable to establish communication with Nairobi Radar on the appropriate 119.5 mc/s frequency but did on 119.7 mc/s, the approach frequency.

1.10 Aerodrome and ground facilities

Nairobi Airport had red-coded centre line approach lighting to runway 06, as well as VASIS set to a 3° glide path. This lighting was operating.

1.11 Flight recorders

Not mentioned in the report.

1.12 Wreckage

The scene of the premature touchdown could not be reached by motor transport because of difficult terrain and was visited by helicopter. It was in an open savannah with pigmy thorns and light dry grass. The soil was dry black cotton with outcrops of aged and mainly smoothed volcanic rocks. The wheel marks headed 020°M and were 195 yards long. The impact marks were initially 4 to 5 in. deep, becoming lighter and then again 4 to 5 in. deep towards the end of the tracks.

1.13 Fire

There was no fire.

1.14 Survival aspects

Not pertinent.

1.15 Test and research

Both altimeters were checked at Nairobi Airport for leakage and calibration and were found to be serviceable.

2. - Analysis and Conclusions

2.1 Analysis

At the time of the premature touchdown, the aircraft was being flown approximately 3 000 ft too low because the sub-scale of the right-hand altimeter had been incorrectly set by the co-pilot who was flying the aircraft from the right-hand seat to a QFE of 938 mb instead of 839 mb. This mistake was not discovered by either pilot until after the impact.

When the aircraft was cleared to descend to 2 000 ft at 2209 hours, the pilot-in-command set the correct QNH of 1 020 mb on his altimeter; he checked the sub-scale of the two altimeters but he did not read the two altimeters and did not check, as required, that their differences corresponded to the height of the airfield. The co-pilot checked the sub-scale of the starboard altimeter several times and each time he obtained what he later referred to as "a visual appreciation" of what he knew was the correct QFE of 839 mb. instead of the actual setting of 938. Subsequently, while cross-checking the altimeters he substituted for the airfield elevation the height to which he had been cleared (2 000 ft) which was, by sheer coincidence, the difference in reading between the two altimeters. This prevented him from detecting his error.

This incident stemmed from the transposition of figures made by the co-pilot when he set his altimeter sub-scale. This is the sort of human error which is difficult to prevent. This is why operators should ensure that if such an error is made it will become apparent through appropriate checks. Had the required checks been diligently carried out on this occasion, the error in setting would have been discovered. The pilot-in-command's failure to ensure that this was done indicated an unsatisfactory flight deck supervision.

It is the operator's normal practice that the pilot carrying out the landing should have his altimeter set to the QFE and the pilot acting as co-pilot to have his altimeter set to the QNH. On this occasion the QFE was set on the starboard altimeter and the QNH on the port. Although the pilot-in-command stated that he did not confuse the QNH set on his altimeter for the QFE, it is considered that the practice of changing the altimeter setting in this way might lead to confusion.

2.2 Conclusions

Findings

The aircraft was airworthy, properly maintained and correctly loaded.

The two pilots and the flight engineer were properly licensed.

There was no evidence of a technical defect which would have led to the premature touchdown.

At the time of the premature touchdown the port altimeter sub-scale was set to the QNH of 1 020 mb and the starboard altimeter was set to read 3 000 ft too high.

The approach to landing was carried out from the right-hand seat.

The incorrect altimeter setting was not discovered by the crew until after the impact.

Cause or Probable cause(s)

The incident stemmed from an error by the co-pilot in setting his altimeter which resulted in the instrument reading 3 000 ft too high. Failure by the pilot-in-command and the co-pilot to carry out diligently all the essential checks allowed this error to pass unnoticed.

3. - Recommendations

The operator should examine the flight check procedures laid down.

ICAO Ref.: AR/851

No. 5

South Central Airlines Inc. Beech D-18S, N 2999, accident at Gainesville Municipal Airport, Florida, on 3 February 1964. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 2-0001, released 5 January 1965

1. - Investigation

1.1 History of the flight

Flight 510/3 was a scheduled domestic air taxi service from Ocala to Tallahassee, with stops at Gainesville and Jacksonville. The aircraft departed Ocala at 0720 hours Eastern Standard Time and the 13-minute flight to Gainesville was uneventful. At Gainesville nine passengers boarded the aircraft; three of their bags were placed in the nose baggage compartment and the remainder in the aft baggage compartment.

The aircraft took off from Gainesville on runway 6 at 0800 hours. Witnesses who observed the take-off stated that the aircraft made a steep climb to an altitude of 200 ft with flaps in the extended position. At this altitude the aircraft appeared to stall and dive in a left-wing-down attitude to the end of runway 6. Initial impact was 79 ft from the end of this runway and 10 ft to the left of the centre line.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	1	9	
Non-fatal			
None			

1.3 Damage to aircraft

The aircraft was destroyed by impact and subsequent fire.

1.4 Other damage

None reported.

1.5 Crew information

The pilot, aged 47, had a total of 16 647 flying hours, including 486 hours on Twin-Beech type aircraft. He held a valid commercial pilot's certificate, endorsed for single and multi-engine land aircraft with instrument and flight instructor ratings. He also held an FAA second-class medical certificate with the following limitation: "Holder shall possess correcting glasses for near vision while exercising the privileges of his airman certificate". In 1954 he had been discharged from the United States Navy with a disability rating of 100%, and in 1959 he was placed on the Navy's permanent disability retirement list with a disability rating of 100%; his condition at that time was classified as "arthritis due to trauma rated as severe limitation of the lumbar spine, rheumatoid arthritis and slight impairment of auditory acuity".

1.6 Aircraft information

The aircraft was originally manufactured as a Beech D-18S certificated in accordance with FAA Aircraft Specifications. In 1962 a Supplemental Type Certificate (STC) was issued authorizing conversion of certain models of Beech aircraft to allow a take-off weight of 10 200 lb and to extend the aft centre-of-gravity limits to 120.5 in. In December 1963 the converting firm applied for FAA approval of an "economy version" allowing a maximum gross take-off weight of 9 360 lb and extending the rear centre-of-gravity limit from 117.7 to 120.5 in.; this conversion application was treated by the Engineering and Manufacturing District Office of the FAA at Miami as an amendment to the original STC rather than as a new STC and a Flight Manual Supplement for the "9 360" conversion was approved prior to completion of the FAA's conformity inspection and flight testing. In the meantime, with the approved Flight Manual Supplement and an STC number only, but without approval of the amended STC, the converting firm contracted for modification of at least two aircraft of which one was the subject aircraft. These aircraft were modified in accordance with the unapproved application for an amended STC. However, this modification was never approved by the FAA due to the absence of an elevator-down spring. Since the modification included the extension of the aft centre-of-gravity limit of the Beech D-18S the down-spring was required in order that the control inputs during all regimes of flight would be in accordance with the certification requirements under Part 3, Civil Air Regulations. Such a spring does not affect elevator power or authority of the pilot but merely keeps the stick forces within a normal envelope of acceptable limits.

This aircraft had eight passenger seats and two pilot seats installed. The empty weight and centre of gravity and the requirements of Part 3 of the Civil Air Regulations indicated that it was not possible to put a 170-lb passenger in each seat without exceeding the aft centre-of-gravity limit. Addition of any fuel to the aircraft moved the centre-of-gravity further aft. It was not possible to operate this aircraft with eight passengers unless ballast was carried in the nose compartment. There were no placards to warn of these dangerous loading restrictions, nor were any required by the provisions of Part 3 of the Civil Air Regulations.

An aft baggage compartment was installed on the right side opposite the most rearward seat. When the rear seat was not occupied it was limited to 276 lb and further limited to 106 lb when the rear seat was occupied. Placards were required in both the nose and aft baggage compartments indicating their maximum load capacity. There was conflicting testimony as to whether these placards were installed.

1.7 Meteorological information

Not significant in this accident.

1.8 Aids to navigation

Not significant in this accident.

1.9 Communications

Not significant in this accident.

1.10 Aerodrome and ground facilities

Runway 6 is an asphalt runway 150 ft wide and 5 027 ft in length.

1.11 Flight recorders

Not mentioned in the report.

1.12 Wreckage

The left wing and engine separated from the aircraft at impact and the fuselage, right wing, right engine and tail assembly bounced and slid approximately 100 ft, before coming to rest on a 220° magnetic heading.

1.13 Fire

The aircraft caught fire on impact and the fuselage structure from the nose through the passenger compartment was almost entirely consumed by fire.

1.14 Survival aspect

Intense heat and door jamming prevented rescuers from opening the rear compartment door. No signs of life were observed inside the passenger compartment.

1.15 Tests and research

None mentioned in the report.

2. - Analysis and Conclusions

2.1 Analysis

No evidence of malfunction or failure of the airframe or the engines prior to impact was found. The flight controls were found intact, the elevator trim tab in the full nose-down position and the rudder trim tab in neutral.

The landing gear was fully retracted and the flaps fully extended at impact.

There was no indication that the pilot's physical disability contributed to the accident.

Take-off appeared to be normal until gear retraction when uncontrolled manoeuvres were observed. These were typical of an aircraft which was unstable because of an excessive aft centre of gravity.

The pilot and all the passengers were identified and their respective positions in the aircraft located. The airline's records revealed that ten pieces of luggage weighing a total of 209 lb were placed aboard the aircraft.

Computations of the weight and centre-of-gravity position at the time of take-off, based on conservative estimates, revealed that the aircraft was overloaded and tail heavy. The aircraft's weight was computed to be 9 402 lb, i.e. 652 lb in excess of the maximum allowable take-off weight for the basic D-18S type and 42 lb in excess of the proposed maximum take-off weight for the "9 360 lb conversion type". The centre of gravity was computed as being 124.7 in. aft of datum with gear extended and 125.9 in. aft of datum with gear retracted. The proposed rearward centre-of-gravity limit for this type of aircraft was 120.5 in. and the centre of gravity (gear retracted) was located 5.4 in. behind that limit. Furthermore, due to the lack of the elevator-down spring, the allowable rear centre-of-gravity limit for this particular aircraft was in fact 117.7 in. and therefore the centre of gravity (gear retracted) was actually located 8.2 in. behind the limit.

This placed the aircraft outside its aerodynamic control parameter with insufficient elevator effectiveness to prevent an excessively nose-high attitude which resulted in a low altitude stall from which recovery was not possible. Furthermore, when the flaps are fully extended on this aircraft the centre-of-lift moves aft, and a slower-than-normal lift-off speed and increased drag are obtained. However, the centre of gravity was so far aft of the aircraft's controllability limits that the effect of full flaps was negligible.

The full nose-down elevator trim position confirmed the tail heavy loading of the aircraft at the time of the accident and indicated an attempt by the pilot to lower the nose by use of trim in addition to the use of the elevator.

According to regulations, the pilot-in-command was responsible for proper loading of the aircraft. It could not be established whether the pilot computed the weight and balance of the aircraft at Gainesville. The Flight Manual, which is required aboard aircraft over 6 000 lb by the Civil Air Regulations and which contains important information for safe operations (including weight and balance data) was not found in the wreckage. A copy of a Flight Manual identical to the copy allegedly aboard did not contain information or charts on the seat locations or baggage compartments of this aircraft.

Also no evidence of a cockpit check-list was found in the wreckage and the presence of such a check-list aboard was not established. Neither of the two check-lists for Twin Beech aircraft presented by the company after the accident was applicable to the subject aircraft.

2.2 Conclusions

Findings

The pilot was properly certificated and had considerable flying experience.

The aircraft,which was originally a type D-18S had been modified in accordance with a proposed Supplement Type Certificate to increase the maximum take-off weight to 9360 lb and the aft centre-of-gravity limit to 120.5 in. The Flight Manual Supplement was approved on 10 January 1964 and the Supplemental Type Certificate on 24 February 1964. The practice of back-dating the ITC opened the door to operation of an unairworthy aircraft.

No evidence of malfunction or failure of the airframe, the controls or the engines prior to impact was found. The undercarriage was fully retracted, the flaps fully extended and the elevator trim tab in the full "nose-down" position at impact.

Computations of the weight and position of the centre of gravity of the aircraft revealed that it was overloaded and tail heavy at the time of take-off.

As a result the aircraft was unstable, the elevator was not effective enough to prevent an excessively nose-high attitude and the aircraft stalled at low altitude.

Cause or
Probable cause(s)

Failure of the pilot to load the aircraft properly, resulting in insufficient elevator effectiveness to reverse an unwanted pitching motion.

3. - Recommendations

1. That urgent consideration be given by the FAA to the drafting of a sub-part of the Federal Aviation Regulations governing air taxi operations and covering matters such as flight time limitations, requirements for initial and recurrent training and proficiency checks as well as company records regarding them, definition of flight deck and conditions under which a passenger may be carried in the pilot's cabin, development, maintenance and approval of a company operations manual. The operations to be affected would be those in which a certificate of public convenience and necessity was not involved.

2. That existing Supplemental Type Certificates should only be amended for such purposes as improvement of the existing approved modification or correction of data. The process should not be used for an application for a different modification, particularly where there are changes in maximum weight, centre of gravity, travel, performance, or handling characteristics.

3. That the FAA re-examine the entire Supplemental Type Certificate towards the goal of tightening the control over approved Supplemental Type Certificates and surveillance of aircraft and component modification.

4. That the FAA consider an amendment to either paragraph 3.74 or 3.76 of the Civil Air Regulations which will require a placard if the centre of gravity falls outside the established limits when loaded according to paragraph 3.74 (b)(1).

ICAO Ref.: AR/853

No. 6

Turkish Airlines, Douglas DC-3 (C47A) TC-ETI, accident near Ankara, Turkey, on 3 February 1964. Report released by the Turkish Ministry of Communications

1. - Investigation

1.1 History of the flight

The aircraft took off from Istanbul at 1710 hours GMT on a non-scheduled domestic flight to Ankara (Esenboğa Airport) with three crew members and 841 kg of freight aboard. At 1809 hours the pilot-in-command asked for - and received - weather conditions at Esenboğa. At 1826 hours the aircraft passed the ZIR beacon and began a descent from FL90 to FL80. Its estimated time of arrival at the AN beacon in the Ankara control area was 1835 hours. At 1830 hours the aircraft reported that it could not receive AN. The beacon was checked and found to be operating normally. The aircraft was so informed. By that time the aircraft had reached the ANK radio beacon, and began its descent to reach AN at 6 500 ft. The Ankara control tower told the pilot-in-command that he was cleared for an ILS approach to runway 03 immediately after passing the AN beacon and asked him to report when the runway was in sight. After this point, no further contact could be established with the aircraft.

The aircraft wreckage was subsequently found 12 km from Esenboğa Airport. The accident took place at night.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	3		
Non-fatal			
None			

1.3 Damage to aircraft

The aircraft was destroyed.

1.4 Other damage

None.

1.5 Crew information

The pilot-in-command, aged 36, had a valid licence with a DC-3 rating, and had flown a total of 4 372 hours.

The co-pilot, aged 45, had a valid licence with a DC-3 rating, and a total flight time of 9 946 hours. Both had flown 1.35 hours during the previous 24 hours.

The third crew member was a stewardess.

1.6 Aircraft information

The aircraft was properly certificated, and its certificate of airworthiness was valid until 1 November 1964.

Weight and centre of gravity were within prescribed limits.

1.7 Meteorological information

Actual weather conditions at the time of the accident were as follows:

Visibility:	3 km
Clouds:	6/8 st. at 8 000 ft 7/8 dc. at 2 000 ft 8/8 ns. 5 000 ft
Temperature:	0°C (snowing)
Wind:	020°/15 kt

The accident took place at night.

1.8 Navigational aids

The aircraft carried 2 VFH R/T
1 HF R/T
2 ADF
1 Z marker

1.9 Communications

Radio communications were normal until the pilot was cleared to the ILS approach.

1.10 Aerodrome and ground facilities

All airport facilities functioned normally.

1.11 Flight recorders

Not carried by the aircraft.

1.12 Wreckage

The aircraft struck the ground at an inclination of 10°. Wreckage was scattered over a distance of 110 m.

1.13 Fire

There was no fire.

1.14 Survival aspects

The lower parts of the fuselage up to the end of the passenger compartment were torn off. The upper part of the cockpit was opened; the pilot-in-command and the hostess were thrown 8-10 m forward, while the co-pilot's body was found under the wreckage.

1.15 Tests and research

None.

2. - Analysis and Conclusions

2.1 Analysis

During take-off and cruising from Istanbul to Ankara, no abnormality was reported.

At 1809 hours when the aircraft was between Beypazari and the ZIR beacon, at Flight Level 90, the weather at Esenboğa was passed to the pilot-in-command at his request and a QNH of 29.94 in. was given to him. Examination of the two altimeters after the accident revealed that neither was set at that value.

2.2 Conclusions

Findings

Both pilots were properly certificated and had considerable flying experience.

The aircraft had a valid certificate of airworthiness and no evidence of structural or engine failure prior to impact was found.

Although a QNH of 29.94 in. had been given to the pilot-in-command, neither of the two altimeters was set at that value.

Cause or
Probable cause(s)

The probable cause was the fact that the aircraft got below the prescribed altitude limits as a consequence of having deviated from the instrument flight rules.

3. - Recommendations

None given.

ICAO Ref.: AR/890

No. 7

AVIANCA DC-3, HK-326, accident at Orocué Airport, Colombia, on 5 February 1964. Report, dated 17 March 1964, released by the Colombian Administrative Department of Civil Aeronautics

1. - Investigation

1.1 History of the flight

Flight 636 was a scheduled domestic flight Villavicencio - El Yopal - San Luis de Palenque - Trinidad - Orocué - and return to Villavicencio, via the same route with another stop at Mare-Mare to disembark two passengers. Having departed Villavicencio at 0558 hours (local time) the flight arrived at Orocué at 0810 hours according to schedule. At 0912 hours the aircraft began its take-off roll for the return journey on runway 26; it covered the first 285 m without incident, after which it veered first to the right and then to the left, then continued along the runway to a point 400 m from the end of runway 26. At this point the left wheel dropped into a ditch at the side of the runway and the left wing struck the wind-sock mast. The aircraft then swung further to the left and continued across the field for another 210 m where the wind-sock came to rest. Then the aircraft began to disintegrate, losing its right wheel, its propellers with part of the nose cones and its right engine. The left propeller cut through the pilot's cabin and destroyed part of the instrument panel and the pilot-in-command's control pedals. After rolling over the right engine, the aircraft finally came to rest 349 m from the point where it had left the runway on a heading of 316°.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal			
Non-fatal	1	3	
None	2	27	

1.3 Damage to aircraft

The aircraft was severely damaged.

1.4 Other damage

None reported.

1.5 Crew information

The pilot-in-command held a current airline transport pilot's licence with a DC-3 instrument restriction and a valid medical certificate; he had been involved in a previous accident in 1961 the cause of which was attributed by the Air Safety Division to "pilot error in that he entered the runway at excessive speed".

The co-pilot, who did not serve in that capacity during the take-off, held a valid commercial pilot's licence with C47/PB4 co-pilot restriction, and a valid medical certificate.

The steward also held a valid licence and medical certificate.

1.6 Aircraft information

The aircraft's certificate of airworthiness was valid until 13 January 1965. All inspections and repairs had been carried out in accordance with the maintenance plan of the airline.

The aircraft's operating permit was valid until 30 April 1964 for a maximum gross weight of 12 202 kg. The passenger and weight-and-balance manifests were not correctly filed for the Orocué - Mare-Mare flight. One passenger was not listed on the manifest and 152 kg of baggage or cargo were in excess. Centre-of-gravity information was not given in the report.

The type of fuel used was not mentioned in the report.

1.7 Meteorological information

At take-off time the weather was reported as "good" except for a 90° cross-wind component of 20 to 30 kt.

1.8 Aids to navigation

Not relevant.

1.9 Communications

Not mentioned in the report.

1.10 Aerodrome and ground facilities

The airport has triangles and a wind-sock 440 m from the left boundary. The runway is bordered on both sides by drainage ditches 1.5 m wide by 0.6 m deep.

1.11 Flight recorders

Not mentioned in the report.

1.12 Wreckage

See 1.1.

1.13 Fire

There was no fire.

1.14 Survival aspects

In the passenger cabin, seat no. 6 on the left side was wrenched from the floor.

1.15 Tests and research

None reported.

2. - Analysis and Conclusions

2.1 Analysis

The pilot-in-command invited a passenger to take the place of the co-pilot, who was ordered to vacate his seat. Engine run-up was carried out on the left engine by the pilot-in-command, and on the right engine by the passenger, with no abnormality being noted. The pilot-in-command stated that the check-list was performed before take-off and that, after having first released the parking brake, the passenger, serving as co-pilot, increased power progressively up to 48 in., as instructed.

It is noted that, for the sake of practising his English, the pilot-in-command conducted his conversation in that language with the passenger, who was a United States citizen. According to the passenger, there was a moment when he thought the pilot-in-command was in control of the aircraft, but when he considered this after the accident he came to the conclusion that neither he nor the pilot-in-command had been controlling the aircraft during the events which resulted in the accident.

Evidence was found that both engines were developing power at the time of the accident.

2.2 Conclusions

Findings

All crew members had valid licences with ratings for the subject type and valid medical certificates.

The aircraft had valid airworthiness, registration and radio certificates. The aircraft's maintenance record showed that all the scheduled overhauls had been carried out normally and that the aircraft, its engines and other components were within the limits laid down by the manufacturers.

The runway at Orocué was in good condition. The prevailing wind at 0912 hours (local time) had a 90° cross-wind component of 20 to 30 kts. It is probable that, if it had not been for the ditch and the mast of the wind-sock, the aircraft might have sustained much less damage.

The passenger and weight-and-balance manifests for the flight Orocué - Mare-Mare show that there was one excess passenger and an excess of 152 kg of baggage and cargo.

The preliminary reports submitted by the pilot-in-command and co-pilot did not correspond to the actual facts.

The state of the propellers and the subsequent reports of the crew make it clear that at the time of the accident there was no failure of the engines or airframe.

At the time of the accident the left station in the crew cabin was occupied by the pilot-in-command. At the pilot-in-command's suggestion, a person who was neither an airline employee nor the holder of a licence or permit issued by the Administrative Department of Civil Aeronautics was acting as co-pilot.

It was stated in the pilot-in-command's report and the declaration made by the passenger that during take-off there was a point at which neither of them was controlling the aircraft, and the accident resulted.

Cause or
Probable cause(s)

The primary causal factor of the accident was pilot error. The pilot-in-command committed a grave breach of flight discipline in giving control of the aircraft to a person outside the airline who was not familiar with its operating technique and did not hold a licence or permit from the Administrative Department of Civil Aeronautics to fly over Colombian territory.

3. - Recommendations

No obstruction should be authorized within 300 ft of the runway centre line; ditches on either side of the Orocué runway should be eliminated and the orientation of the runway changed, as in summer it is exposed to a 90° cross-wind.

A Penalties Committee should be convened to consider penalties to be imposed on the pilot-in-command for the grave breach of flight discipline, on the co-pilot for not having respected the truth in his original statement and on the airline for incorrect filing of the passenger and weight-and-balance manifest.

ICAO Ref.: AR/908

No. 8

Philippine Air Lines, Inc., DC-3C, PI-C97, accident at Barrio Bangi Mamaan, Municipality of Piagapo, Lanao del Sur, on 21 February 1964. Report, dated 11 March 1964, released by the Civil Aeronautics Administration, Department of Public Works and Communications, Republic of the Philippines

1. - Investigation

1.1 History of the flight

Flight 946 was a scheduled domestic flight from Cotabato to Cayagan de Oro, with intermediate stops at Malabang and Iligan. It took off from Malabang at 1540 hours Philippine Standard Time*. The pilot-in-command was in the right-hand seat and the co-pilot was in the left. The pilot flew VFR for about 10 minutes towards the Lake Lanao (elevation 2 300 ft) area on a heading of approximately 030°. Over the lake the weather was turning from bad to worse. However, it is believed that for this portion of the flight the pilot was able to maintain VFR. From Lake Lanao the pilot turned to a northerly direction trying to look for breaks in the weather. The pilot cleared the high ground north of the lake, which is approximately 3 000 ft: during this portion of the flight he encountered instrument meteorological conditions. He flew on instruments from there on. At 1557 hours he requested the Iligan Airport weather, and it was given to him by the PAL Iligan radio operator. He acknowledged. Shortly afterwards, the aircraft hit a clump of trees located on a ridge apprcximately 2 700 ft amsl and went out of control. The aircraft instantly lost altitude and the pilot shut off the engines. The aircraft crashed and burned 400 ft from the point of initial impact at an elevation of approximately 2 650 ft. Although the time of the crash could not be exactly determined it was believed that it occurred somewhere around 1600 hours.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	3	25	
Non-fatal		1	
None			

1.3 Damage to aircraft

The aircraft was destroyed by impact and fire.

---

* Philippine Standard Time is GMT + 8 hours.

1.4 Other damage

None reported.

1.5 Crew information

The pilot-in-command, aged 43, held a current airline transport pilot's licence with type ratings for DC-3 and F-27. He had flown a total of 13 402 hours, including 10 987 hours on the DC-3, 278 of which were flown during the last 90 days. He was a regular DC-3 pilot-in-command and flight instructor. The CAA had no record of any violation of regulations or accident on him.

The co-pilot, aged 30, held a current airline transport pilot's licence with type ratings for DC-3. He had flown a total of 3 419 hours, including 3 156 hours on the DC-3, 279 of which were flown in the last 90 days. He recently completed 100 hours on cargo flights as pilot-in-command and was undergoing the required route qualification prior to flying as a regular pilot-in-command.

The flight steward was substituting for the assigned flight stewardess who was taken ill at Cotabato.

1.6 Aircraft information

The aircraft had flown a total of 24 938 hours. Its last overhaul was on 23 January 1964. Its certificate of airworthiness was valid until 19 July 1964. At the commencement of the flight the aircraft's actual centre of gravity was 19.1% which was within the permissible limits. The gross weight at the time of the accident was computed as 24 248 lb, well under the maximum permissible of 26 000 lb for the flight.

The type of fuel being used was not stated in the report.

1.7 Meteorological information

Throughout the day the weather in the Iligan area was marginal. The weather report which was passed to the flight at 1557 hours gave: ceiling 200-300 ft overcast, visibility to N-NW 8 miles, wind N/8-12 kts, QNH 29.87. The pilot of another flight, who was flying from Iligan to Cotabato at the time of the accident, testified later that the weather was below VFR minima. He observed the ceiling in the Lake Lanao area to be 100 to 200 ft with rain showers and some of the hills between the lake and the airport were hidden by low clouds. For this reason he flew the longer route from Iligan to Cotabato via Ozamis.

1.8 Aids to navigation

No navigational aids are available at the Iligan/Maria Cristina Airport. However, there is a broadcasting station at Iligan City located 9.4 NM north-northeast of the airport. There is also a broadcasting station at Ozamis City about 25 NM west of the airport. Cagayan de Oro Airport, which is about 30 NM north-east, is equipped with a VOR and a NDB. The aircraft was equipped with two radio compasses and one VOR set. What aids were used during the flight were not known.

1.9 Communications

The aircraft was equipped with a VHF transceiver and an HF transceiver. Radio logs at Iligan and Cotabato indicated that no communication difficulties were experienced by the crew.

1.10 Aerodrome and ground facilities

Not relevant to the accident.

1.11 Flight recorders

Not mentioned in the report.

1.12 Wreckage

The aircraft was found in a small bowl on a cultivated hill, at an elevation of 2 650 ft. The wreckage was concentrated in a small area around the aircraft. The aircraft was destroyed except for the vertical stabilizer, rudder, right horizontal stabilizer and right elevator.

1.13 Fire

The fuselage from the nose section to the aft lavatory was burned to the floor. Readings of the flight and engine instruments were unreliable due to the impact and intense fire.

1.14 Survival aspects

Most of the passenger seats were broken from their mountings and found piled in the forward section. The lone survivor, who did not have his seat belt attached, was thrown out of the aircraft.

1.15 Tests and research

None mentioned in the report.

2. - Analysis and Conclusions

2.1 Analysis

According to the testimony of the pilot who flew from Iligan to Cotabato at the time of the accident, and to the testimony of the lone survivor, the Board concluded that the aircraft flew for five minutes inside clouds with moderate turbulence before the crash. The route of the aircraft was established as having been from Malabang to Lake Lanao on a northeasterly direction and then northwesterly to Iligan, as shown by the fact that the clump of trees hit by the aircraft was southeast of the crash site. A direct route from Malabang to Iligan was impossible during marginal weather due to the high mountains (6 200 ft) west of Lake Lanao.

There was no evidence to show that there was engine failure, accessory failure or material failure that might have caused or contributed to the accident.

Strip examination of the left propeller revealed that it had a 28° blade angle of attack at the time of final impact.

Two witnesses, who were near the crash site and the lone survivor, stated that they heard explosions similar to fireworks while the aircraft was still airborne, and that the crash occurred immediately afterwards. This led the Board to believe that the engines were backfiring, because the pilot shut off the master ignition switch when he realized that the aircraft, after hitting trees, was out of control and was going to crash. The condition of the recovered left propeller, which had one blade more badly bent than the other two and no scratches on all three blade tips, confirmed that the engine was shut off prior to final impact.

The extent of damage caused by the initial impact with the tree tops was not determined due to the condition of the wreckage but it was considered that it probably resulted in a loss of control, otherwise the pilot would have applied power and climbed.

2.2 Conclusions

Findings

The crew members were satisfactorily certificated.

The aircraft was airworthy and properly loaded at the time of departure. No evidence of airframe, systems or engine malfunction or failure prior to the accident was found.

The pilot flew the route in weather below VFR minima. In spite of the low ceiling he was overconfident since he had flown the route for ten years and was familiar with the terrain and the weather in the area.

However, when the aircraft reached the Lake Lanao area the weather turned from bad to worse and the ceiling became lower until it became impossible to maintain VMC. He then flew on instruments in the general direction of Iligan until the aircraft hit a clump of trees on a ridge 2 700 ft amsl. The aircraft went out of control. Sensing an imminent crash the pilot put off the master ignition switch. Four hundred feet from the point of initial impact the aircraft hit the ground left wing first in a nose-down attitude of about 30°, exploded and burned.

Cause or Probable cause(s)

Pilot factor

The pilot continued to fly VFR into unfavourable weather. The weather en route and at the destination was below VFR minima.

The pilot flew at low altitude over mountainous terrain in instrument meteorological conditions.

Weather factor

Low ceiling, limited visibility and rain contributed to the accident.

Turbulence characterized by downdraughts or updraughts was prevalent over the mountainous area at low altitudes.

3. - Recommendations

PAL should make a thorough study of hourly weather reports in the Cotabato-Iligan area and flights should be scheduled only during periods when weather conditions are generally favourable for VFR flights.

PAL pilots should be reminded to adhere strictly to Civil Air Regulations, particularly those that deal with visual flight rules.

PAL should exercise closer supervision over flights in the Mindanao area. (The last fatal accident involving PAL aircraft was in that region and due to similar causes.)

The CAA should evaluate more thoroughly the policy of the Philippine Air Lines in the matter of supervision of their senior pilots. Records show that the last four PAL aircraft involved in fatal accidents were flown by veteran pilots. Three of these pilots had more than 10 000 hours flying time, and one had 8 900 hours. Reports on all four accidents listed pilot factor as one of the probable causes.

ICAO Ref.: AR/904

No. 9

United Arab Airlines Viscount SU-AFX, accident at Beirut International Airport, Lebanon, on 23 February 1964. Report released by the Directorate of Civil Aviation, Lebanon

1. - Investigation

1.1 History of the flight

The aircraft was on a non-scheduled international flight from Cairo to Beirut. No abnormalities were reported during the flight. At approximately 1718 hours GMT the aircraft began its final approach to runway 21 at Beirut International Airport, all cockpit checks having been completed. Prior to touchdown, the aircraft encountered a downdraught and heavy rain over the runway, which suddenly reduced the visibility. The aircraft touched down very heavily, then became airborne again and reached a height of 20 to 30 ft before hitting the ground again, first with the starboard undercarriage and then with the nose wheel. The impact caused a failure of the starboard main spar and the starboard wing, together with Nos. 4 and 3 propellers, then hit the ground. Propellers 1 and 2 also made contact with the runway. The nose wheel structure was also broken, and the aircraft then began a turn to starboard, coming to rest just off the runway on soft ground.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal			
Non-fatal			
None	5	48	

1.3 Damage to aircraft

The aircraft was destroyed.

1.4 Other damage

None reported.

1.5 Crew information

The pilot-in-command, aged 25, held a valid commercial pilot's licence with an endorsement in Group 2 for Viscount aircraft. He had flown a total of 3 215 hours, of which 475 hours were as pilot-in-command on the Viscount. He was first appointed as pilot-in-command on Viscounts on 30 March 1963, but was subsequently suspended from flying as pilot-in-command on two occasions as a result of two minor landing accidents, one on a

DC-3 at Cairo Airport, on 19 April 1963, and the other on a Viscount at Nozha Airport, on 22 August 1963. After appropriate flying checks, on 23 September and 1 October 1963, he was regraded as pilot-in-command. He had been checked on various routes including the Cairo-Beirut route, on 30 July 1963, and had previously flown to Beirut by night on four occasions.

The co-pilot, aged 37, also held a valid commercial pilot's licence with Viscount endorsement. He had flown a total of 5 270 hours.

An extra crew member was the holder of a valid commercial pilot's licence.

A hostess and a steward were also aboard.

1.6 Aircraft information

The aircraft's certificate of airworthiness was valid until 11 March 1964. All Viscount modifications had been carried out and the aircraft had a valid certificate of maintenance.

No information was given in the report concerning weight, centre of gravity or type of fuel used.*

1.7 Meteorological information

As given by the meteorological service:

Surface wind:	230°/15 kts
Visibility:	8 km
Actual weather:	thunderstorm and showers
Cloud:	3/8 Cb 2 000 ft
	6/8 Cw 2 300 ft

1.8 Aids to navigation

Not mentioned in the report.

1.9 Communications

Not pertinent.

1.10 Aerodrome and ground facilities

Not mentioned in the report.

1.11 Flight recorders

Not mentioned in the report.

* The load sheet appeared as an annex to the report, but the annexes were not received by the Secretariat.

1.12 Wreckage

See 1.1.

1.13 Fire

None.

1.14 Survival aspects

Not mentioned in the report.

1.15 Tests and research

None mentioned in the report.

2. - Analysis and conclusions

2.1 Analysis

Evidence was found that the nose wheel struck the ground at almost the same time as Nos. 4 and 3 propellers and that Nos. 2 and 1 propellers also hit the ground some 10 m and 17 m respectively farther down the runway. There was also evidence that the nose wheel door came into contact with the runway. This proved that the nose wheel structure failed and began to collapse gradually after its first impact with the runway. The pilot-in-command stated that when the aircraft made its first contact with the runway, the flaps were at a setting of 40° and the throttles in the idle position. He also stated that when the aircraft bounced after the first impact, he did not think it appropriate to initiate an overshoot procedure because of the poor weather conditions and also because he was afraid that the aircraft had sustained considerable damage during the first impact. Therefore, he just pushed the control column forward.

The pilot showed both lack of judgement and poor technique in failing to take appropriate action to counteract a downdraught on final approach. As a result the aircraft struck the ground heavily and bounced to an approximate height of 30 ft. Adequate corrective action (such as the application of power) was not taken then, resulting in a second and extremely heavy impact with the runway causing extensive damage to the maniplane, the failure of the nose wheel structure and considerable resultant damage.

2.2 Conclusions

Findings

The crew were properly licensed and well qualified for the flight, although the pilot-in-command had two previous minor landing accidents.

The aircraft had been properly maintained and had a valid certificate of airworthiness.

The aircraft encountered a downdraught during the final part of the approach. No action was taken to counteract the downdraught and the aircraft touched down very heavily and bounced to a height of 20 to 30 feet above the runway. Power was not applied and the control column was pushed forward. As a result of this the second impact on the runway was extremely heavy and caused extensive structural damage to the aircraft.

Cause or
Probable cause(s)

Failure of the pilot-in-command to take action: firstly, to counteract the effect of a downdraught on final approach and, secondly, to react correctly to a bounce to a height of approximately thirty feet.

ICAO Ref.: AR/848

No. 10

Eastern Air Lines, Inc., Douglas DC-8, N 8607, accident at New Orleans, Louisiana, USA on 25 February 1964. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0006, released 1 July 1966.

1. - Investigation

1.1 History of the flight

The aircraft arrived at Mexico City at 2212 hours Central Standard Time on 24 February 1964 and the pilot-in-command reported that the pitch trim compensator (PTC) was inoperative. Flight 304 was a scheduled international flight originating in Mexico City for New York with intermediate stops at New Orleans, Atlanta and Washington.

The pilot-in-command filed an instrument flight rules flight plan for a reduced airspeed, in accordance with company procedures for flights with the PTC inoperative. The landing was made at New Orleans International (Moisant) Airport at 0051 hours. The flight attendants, who were scheduled for a crew change at New Orleans, and the deplaning passengers indicated that the flight Mexico-New Orleans was routine except for light to moderate turbulence experienced during the last 30 minutes. One flight attendant also stated that the pilot-in-command was flying the aircraft.

At 0159:46 hours the local controller in the tower observed the take-off, which appeared to be normal. At approximately 0201 hours he advised the flight to contact Departure Control, and this was acknowledged. He estimated that the flight was two or three miles north of the airport when the lights disappeared into the overcast. Voice communication and radar contact were established immediately between the flight and the departure controller who advised it to turn right to a heading of 030. The departure controller then contacted the New Orleans Air Route Traffic Control Centre (ARTCC). The radar target was identified five miles north of the New Orleans VORTAC and a radar handoff was effected at 0202:38 hours. The flight was then instructed to contact New Orleans Centre radar and this was acknowledged at 0203:15 hours. This was the last transmission from the flight. At 0205:40 hours, when no transmissions had been received from the flight by the ARTCC controller, he contacted the departure controller to verify that proper instructions had been given.

During this conversation, both controllers confirmed that the radar target associated with the flight had disappeared from both scopes, and emergency procedures were initiated shortly thereafter. The last position noted by the controllers was approximately 8 miles from the New Orleans VORTAC on the 030-degree radial. The aircraft crashed at 14.5 miles on the 034 degree radial in Lake Pontchartrain. The accident occurred at about 0205 hours. (Fig. 10-1)

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	7	51	
Non-fatal			
None			

1.3 Damage to aircraft

The aircraft was destroyed.

1.4 Other damage

None.

1.5 Crew information

The pilot-in-command, aged 47, held an airline transport pilot's certificate with ratings for several aircraft, including the DC-8. He had a total pilot time of 19 160 hours, including 916 hours in the DC-8. He had been rated in the DC-8 on 8 January 1962 and passed his last proficiency check on 24 January 1964.

The co-pilot, aged 39, also held an airline transport pilot's certificate. He had a total pilot time of 10 734 hours, including 2 404 hours in the DC-8. His last proficiency check was accomplished on 4 December 1963. He was involved in an incident on 9 November 1963. He was restored to flying status on 21 November 1963 and flew 214 hours on 20 separate trips since then.

The pilot/engineer, aged 39, held an airline transport pilot's certificate. He was a certificated flight instructor and also held a flight engineer's certificate. He had flown a total pilot time of 8 300 hours including 1 069 in the DC-8 as pilot/engineer.

The flight crew accumulated 5:42 hours flight time and 8:35 hours duty time on 23 February and then had 24:55 hours rest before the subject flight. They had not exceeded the allowable monthly flight time.

There were four flight attendants aboard.

1.6 Aircraft information

At the time of the accident the aircraft had been flown 11 340 hours. The DC-8 aircraft can be controlled longitudinally by use of the elevators or variable incidence horizontal stabilizer. The nose-down pitching moment encountered in high-speed flight is offset in the DC-8 by the Pitch Trim Compensator (PTC) system which applies nose-up control through the elevator system. This system consists of an electrical computer, an electrical actuator, spring loaded linkages, and a mechanical indicator. The computer senses Mach effect at high altitude and dynamic pressure below 20 000 feet, and provides the electrical signals to the actuator which actually moves the co-pilot's control column. The actuation begins at either Mach 70 or 310 knots and increases in displacement and rate up to Mach 88 or 410 knots. Actuation of the PTC is indicated by the extension of a plunger from a flexible cable housing attached to the left side of the co-pilot's control column. There is no measurable correlation between the amount of indicator showing and the degree of actuator extension.

Longitudinal trimming of the aircraft is accomplished by hydraulic or electric motors which actuate the horizontal stabilizer through a range of 10 degrees aircraft nose-up (ANU) to 2 degrees aircraft nose-down (AND). Both motors provide power through differential gearing to a drive shaft on which a dual sprocket assembly is mounted. The sprocket are connected to the common drive shaft by shear rivets, and each transmits rotation of the drive unit through roller chains to an irreversible jackscrew. Failure of either set of shear rivets freezes the stabilizer in the last selected position. The indication of stabilizer position is provided by fore and aft movement of a small "bug" along a scale on the left side of the centre console.

Longitudinal control of the aircraft may also be accomplished through the autopilot. Any "runaway" or contradiction in the system results in the interruption of power to the autopilot and the illumination of a warning light.

The flight maintenance logs of the aircraft revealed that on 20 August, 1963, the aircraft was subjected to abnormal flight conditions during flight in severe turbulence. A Severe Turbulence Mechanical Check of the aircraft at that time revealed only minor damage. On 11 September, 1963, the stabilizer jammed in the full ANU position during a landing at San Juan, Puerto Rico. An inspection at that time revealed that power from the drive unit was not transmitted through the sprockets to the jackscrews. The dual sprocket assembly was replaced, but the rivets sheared again during the ground test operation and both the jackscrews and sprocket assembly were replaced this time. One of the removed jackscrews had a rusted thread and the lubrication on the bearing was poor. There was no further maintenance work recorded on the stabilizer drive unit until the accident.

The review of the aircraft records disclosed a recent history of PTC difficulties. The PTC computer on this aircraft had been changed eight times, and four had been used during the last week of operation. On 18 February, although the PTC was reported as operative, the indicator failed to show extension. There was no maintenance performed on the indicator mechanism following this write-up. Computer S/N 268D, installed at the time of the accident, had been removed from various aircraft 13 times, beginning in April, 1960. Six of these removals were for unwanted extensions. No discrepancies were ever found during the shop inspection of this component. Following the accident it was discovered that functional tests by EAL and other operators could not detect certain computer malfunctions. The PTC computer was changed the last time on 24 February, in Miami. The aircraft was flown to Philadelphia and no flight crew complaints on the PTC were entered in the log. The flight engineer on the outbound flight to Mexico City noted that the PTC failed to check on the ground. Maintenance personnel performed a ground check of the system and confirmed the engineer's findings. The check performed was: activation of the test circuit and watching for movement of the indicator or control yoke. No inspection of the actuator position or operating capability of the indicator system was made. The aircraft was dispatched with a request that the crew check the PTC operation during the flight. This check was performed at cruising speed and altitude between Washington and Atlanta. It was determined that the PTC was inoperative.

The flight maintenance logs also revealed 11 autopilot malfunctions in the last 30 days of operation. Two discrepancies involved yaw, six referred to longitudinal control problems, and three reported automatic disconnects.

Attitude information in N 8607 was provided by a Collins 105 Approach Horizon through movement of the "miniature airplane" in reference to the all-black face of the instrument. It has no indices for the degree of pitch, and the displayed rate of pitch change varies as follows:

Attitude Range	Display Ratio
0-20 degrees	0.033 inch/degree change
20-70 degrees	0.012 inch/degree change
70-85 degrees	0.006 inch/degree change

Thus it is possible for the instrument to indicate a reduced rate of pitch when attitude changes through 20 degrees of pitch, even though the actual rate of change is constant. In a corresponding manner, if the attitude has exceeded 20 degrees, the displayed rate of aircraft response to control inputs will be slower than the actual response.

The review disclosed that both artificial horizons failed simultaneously on February 18, 1964. This was corrected by replacement of the instrument switching unit, which is a common point in the wiring of both instruments.

There were five discrepancies on the continuous maintenance log: (1) Fuel totalizer reading wrong, (2) Outer pane centre windshield heat inoperative, (3) No. 3 engine ejector light blinks, (4) No. 3 main fuel gauge reads 2-4 000 pounds high, and (5) PTC inoperative.

The aircraft's computed take-off gross weight of 213 871 pounds was less than the 215 000 maximum allowable for the airport, and the centre of gravity (c.g.) of 25.2 per cent was within the allowable limits of 16.5 to 32 per cent.

The type of fuel being used was not mentioned in the report.

1.7 Meteorological information

The U.S. Weather Bureau (USWB) aviation area forecast, valid 0100-1300, indicated a surface wave off the Louisiana coast was expected to move eastward at 30-35 knots, with ceilings at 400-800 feet and moderate to occasionally heavy rain. A north-south line of showers and embedded thunderstorms north of the wave crest was expected to produce moderate to severe turbulence in the thunderstorms and heavier showers, and moderate or greater clear air turbulence was forecast from 24 000 to 40 000 feet, throughout the area. The EAL system forecast, valid 0000-1200, predicted ceilings below 1 000 feet, light rain in the Pensacola-New Orleans area, improving to 1 200-2 500 feet as the low centre moved eastward. Turbulence* was forecast at scale 6 in occasional thunderstorms, and light to moderate wind shear turbulence above 14 000 feet.

The 0146 New Orleans Radar weather observation showed an area of scattered echoes containing light rain showers, with the closest showers at 260 degrees, 60 miles. The top of detectable moisture was 18 000 feet. The 0210 Moisant special surface weather observation was: ceiling measured 1 000 feet overcast, visibility 7 miles, wind direction 020 degrees at 12 knots.

* EAL utilizes a numerical scale to delineate the severity of turbulence within a given classification, i.e., 4-6 is moderate, 7-9 is severe, and 10 is extreme.

A C-46 took off at 0146 and proceeded on a similar departure pattern as Flight 304 towards the north-east. The crew reported moderate to severe turbulence from lift-off to 9 000 feet. A second aircraft, a large jet, departed at 0202 and was vectored to the north-west. The pilot-in-command of this flight observed Flight 304 make a normal take-off and disappear into the overcast at approximately 1 200 feet. He also reported light to moderate turbulence almost immediately after entering the overcast at approximately 1 200 feet, until on top at approximately 5 000 feet. The existing turbulence was also confirmed by the readout of the flight recorder tape from this flight.

1.8 Aid to navigation

A Notice to Airmen advised that the VOR portion of the New Orleans VORTAC was inoperative from 2259 to 0458. However, maintenance workers reported that the malfunction was in the monitoring system, and the facility was actually operating normally throughout the period.

1.9 Communications

There were no discrepancies in air-ground communications, except the failure of the flight to contact the ARTCC. No emergency or distress was exhibited in any transmissions. It was determined from recordings of transmissions that the first officer made all ground transmissions, and the captain made all those after take-off.

1.10 Aerodrome and ground facilities

Not applicable.

1.11 Flight recorder

The aircraft was equipped with a Fairchild Model 5424 flight data recorder. The recorder magazine with the record spool and approximately 50 feet of loose unused tape were recovered. The take-off portion of the tape was not recovered.

1.12 Wreckage

Initial attempts to locate the wreckage of Flight 304 were conducted by helicopter. The discovery of an oil slick and floating debris on the lake prompted a systematic dragging operation commencing simultaneously in this area and also at the point of last radar contact. This search rapidly assumed enormous proportions as additional electronic and sonic underwater detection gear became available. Discovery of the wreckage was finally confirmed late in the afternoon, 13 March. Salvage operation commenced immediately and continued on a 24-hour basis until 16 April, at which time approximately 60 per cent of the wreckage, by weight, had been recovered. No portion of the PTC actuator was recovered. The operation involved raising the pieces from deep in the mud and silt bottom of the lake, and placing them on a barge. The parts were examined and the condition noted by Board investigators. After being washed, all parts were then transferred to shuttle barges, and taken to a hangar at the New Orleans Lakefront Airport, where a layout was made for further study.

1.13 Fire

There was no evidence of in-flight fire.

1.14 Survival aspects

The extreme disintegration of the aircraft structure precluded any crash/injury study. The crash was non-survivable.

1.15 Tests and research

The Douglas Aircraft Company (DACO) performed a functional test of a stabilizer drive unit to determine what effect the omission of the drive sprocket support bushing P/N 2652666 would have on the operation of the unit. The report indicated that while full stabilizer trim capability existed, a wear pattern comparable to the one found in the subject aircraft (see para. 2.1) was reproduced on the test assembly. On June 1, 1964, the FAA issued a telegraphic alert recommending, "(1) Operators perform a one-time inspection of stabilizer adjusting mechanism to determine proper installation of bushing P/N 2652666 and shim P/N 2648310; (2) Operators' maintenance procedures be reviewed regarding adequate assembly and installation instructions of stabilizer drive mechanism ....." The DACO DC-8 Overhaul Manual instructions pertaining to the drive sprocket support bushing of the sprocket assembly were revised on 1 August 1964, to incorporate the additional information, "Make certain bushing (104) is installed with flange up."

During initial certification of the DC-8 satisfactory stability characteristics were demonstrated in high speed cruise (350 knots) configurations and also at the best rate of climb speed (220 knots). However, it was found in flight testing subsequent to the accident that with the aircraft trimmed at 300 knots in an aft c.g. climb configuration with maximum continuous thrust (MCT), and the PTC inoperative, the slope of the stick force curve remained essentially zero as the aircraft accelerated to 390 knots. This stick force relationship to airspeed conflicted with then existing regulations which specified that speed changes be perceptible to the pilot through a change in the stick force. The criterion generally used at that time was at least one pound of force/seven knots of airspeed change.

Further flight tests were conducted to evaluate the controllability of the aircraft with unprogrammed PTC extensions or retractions. The final determination was that adequate elevator control was available to overpower the PTC input even though the time delays for pilot response were actually longer than those used during autopilot "hardover" testing. However, with an aircraft loaded to an equivalent c.g. of 24% it was stated that, during manoeuvering with a fully extended PTC at a velocity of approximately 220 knots and the aeroplane trimmed to full AND (2.0 degrees) any attempt to manoeuvre the aeroplane by applying either nose-up or nose-down control with the elevator system resulted in sharp reversals in the aeroplane's manoeuvering stability. In these conditions a pilot would be presented with a very difficult control problem in turbulent atmosphere. When the nose-down trim was adjusted to 0.5 degrees AND the aeroplane demonstrated less tendency towards manoeuvering instability.

Flight testing of the DC-8 handling characteristics under abnormal conditions, i.e., PTC extended to offset a 0.5 AND stabilizer setting, in a cruise configuration at 220 knots, revealed that the aircraft exhibited no stick force stability. This lack of stick force is caused by a shifting of the stick neutral position to a very flat portion of the load feel spring when PTC is extended. The low gradient of the load feel spring in this area is masked by the control system friction which necessitates flying the aircraft by stick position only. The aircraft is neutrally stable at small airspeed increments about the trim point in any normal attitude, including 45 degrees turning flight.

The investigation also focused on the aerodynamic stability of large swept wing jet aircraft, with particular emphasis on the longitudinal natural frequencies.

Data developed by an independent research agency, under government contract, revealed that the rate of response to elevator deflection has a profound effect on the behaviour of the aircraft from the pilot viewpoint. This mode of motion has a one to five second period and as the short-period frequency decreases a slower response is experienced and the initial motion is not a good indicator of the final response. This leads the pilot to overcorrect, especially when flying in turbulence, and consequently produce a pilot-induced oscillation (PIO). Flight testing demonstrated that with the frequency adjusted between 0.2 and 0.3 cycles per second (cps), with a damping ratio of 0.4 to 0.7, the aircraft could be flown with no difficulty as long as the pilot flew gently, accepting the slow response. The optimum longitudinal short period frequency from a pilot standpoint was found to be 0.6 to 0.7 cps. The DC-8 has a longitudinal short-period frequency of approximately 0.28 cps in cruise, with a damping ratio of 0.6.

During the investigation the Board discovered several incidents of misrigging in the longitudinal control system of other DC-8 aircraft. One incident involved an aircraft leased by EAL from 15 January 1964 to 4 March 1964. Pilot write-ups on this aircraft resulted in the installation of a PTC actuator on 13 February, and a new indicator on the following trip the same day. There was no further action by EAL in this area, and following 225 hours of accumulated flight time from this date, the aircraft was returned to the owner. The aircraft was then operated by the owner from 5 March until 31 March, when the pilot suggested that the elevator load-feel mechanism be checked for proper adjustment. Following a check of the load-feel mechanism and a visual inspection of the PTC the aircraft was cleared to continue. On 1 April, the crew of a training flight reported that at times it was necessary to crank trim to full nose-down and still necessary to hold forward control. A thorough examination of the various components of the system revealed that:

1. The actuator arm of the PTC was extended 1/2 inch too far (this displaces the control column neutral, introducing a nose-up input at all times). This was installed with zero time since modification by the manufacturer.

2. The pitch trim compensation spring (providing nose-up control input when the PTC operates) was reset from 56 to 36 pounds. This adjustment bolt still retained the original DACO factory seal.

3. The right elevator control tab was found 3/8 inch out of rig in the nose-down direction. This item had last been adjusted by the owner on 11 November 1963.

4. The PTC indicator was found to have excessive play in the mechanical linkage, which resulted in erroneous or no indication. The indicator neutral position had also been displaced to indicate PTC retraction with 1/2 inch of actuator input into the system.

The aircraft had been flown 238 hours by the owner, including three training flights, following its return by EAL.

2. - Analysis and Conclusions

2.1 Analysis

Portions of all extremities of the aircraft were recovered from the main impact area. The general pattern of break-up showed extreme fragmentation of all structure with the largest piece being the upper five feet of rudder. The flaps and landing gear were determined to be in the "up" position.

The Nos. 1 and 2 powerplants were recovered approximately 45 feet from the Nos. 3 and 4. All four received similar damage, and evidenced severe disintegration at impact. The diffuser and combustion cases of all four engines accordioned between the 3 and 9 o'clock positions, and the ejector assemblies were extended. No evidence of pre-impact operating distress was found. The recovered reverser assemblies indicated use of reverse thrust at impact. The fuel system was capable of functioning normally.

The recovery of all powerplants and portions of all extremities of the aircraft from a closely confined area indicated that the aircraft was structurally intact at the time of contact with the water. No evidence of in-flight fire or explosion was found. Based on observations over the years, the attitude of a diving aircraft tends to flatten between the times of nose and wing contact, therefore it was assumed that the aircraft struck the water at some dive angle in excess of the 20° indicated by the damage pattern of the powerplants. The fact that the engines were being operated in the reverse thrust regime was indicative of an attempt by the crew to recover from a diving attitude. The co-pilot, following a previous upset into a steep dive, attributed the successful recovery to the use of reverse thrust which, in addition to providing drag forces, produces a nose-up pitching moment. Furthermore, it was concluded from the symmetry of the powerplant damage pattern and from the small wreckage area that the aircraft was essentially level, laterally, at impact.

Although none of the aircraft systems was recovered completely, there was no indication of fire or heat damage on the components available. The left and right stabilizer jackscrews were within one turn of the full AND trim setting. This setting is equivalent to the stabilizer being in the full AND position.

Examination of the drive gear assembly of the stabilizer drive unit revealed normal wear patterns on the planetary gears and the male spline extension which transmits power down to the dual sprocket assembly. In addition, another wear pattern was found 1/4 inch below the normal engagement point of the extension. This abnormal wear pattern continued to the end of the splined shaft. The flanks of the splines in this area were highly polished around the entire periphery of the shaft, indicating the wear occurred over an extended period of time, and could not have occurred during break-up. There was also considerable spalling of the case hardened surface at the end of the splined shaft. The mating female splines, in the top of the dual sprocket assembly portion of the stabilizer drive unit, exhibited a similar severe wear pattern. The wear had produced convex surfaces lengthwise on both flanks and left a lune-shaped area on the crest of each tooth. This damage from misalignment of the mating splines resulted from oscillation of the sprocket assembly since the planetary gears at the top of the shaft had no abnormal wear. The case hardened male splines at the bottom of the shaft did not develop the lune-shaped wear. A bearing seat at the top of the dual sprocket assembly also exhibited the abnormal wear from a 1/4 inch displacement, and oscillation of the assembly. The lower support bushing P/N 2652666 for the sprocket shaft, which supports the sprocket assembly in the vertical plane for proper spline engagement and also restrains it in the lateral direction, was not recovered. Other sprocket assemblies used for comparison showed bright polishing on the lower shaft where it fits into the lower bearing support bushing and showed polishing on the bottom sprocket hub where it rests on and is supported by this same bushing. The sprocket and shaft assembly from N 8607 showed none of this. The lower support bushing has a flange on its outer circumference and when installed properly (flange up) it overlaps the lower bearing and thus provides the vertical and lateral support for the sprocket shaft assembly. The three rivets attaching the lower sprocket to the assembly sheared circumferentially from loads applied in the ANU direction, but the needle bearings from this sprocket scored the shaft axially as the sprocket and shaft separated.

No portion of the PTC actuator was recovered.

To assess properly the evidence at hand, the Board found it necessary to construct by analytical methods a facsimile of the type of plot normally gained from the flight recorder. This was done by utilizing a DC-8 flight simulator programmed to duplicate the weight and c.g. of the aircraft and the take-off conditions at Moisant Airport. The simulated accelerations and climb data were corroborated by observations of actual DC-8 take-offs. Integration of the data produced the plot shown at Figure 10-2, which gives an envelope within which this flight operated.

The maximum altitude which could have been attained was about 7 000 feet for a normal climb at 310 knots. It could have been lower depending on possible power and speed reductions because of turbulence and on the time of onset of difficulties, their nature, and the crew reaction thereto. Within certain limitations there is also latitude for variation in airspeed. An acceleration to, and climb at 310 knots, presented the most plausible flight profile; however, the unaccountability of a period of 40 seconds allows for possible airspeed reduction which could have been drastic, say to 220 knots, for a short period of time, or in the order of 280 knots for a relatively prolonged period. Assuming impact to be as late as 0205:40 (later than the Board believed the accident occurred) the average climb speed could not have been less than about 250 knots.

In view of the weather situation that prevailed at the time pronounced vertical and horizontal wind shear existed in the accident area. Therefore, it is believed that moderate and probably severe wind shear turbulence was encountered by the flight while in the clouds below 6 000 feet. An analysis of the flight recorder of the jet which departed New Orleans immediately afterwards substantiated the severity of the turbulence in the area. Accelerations to +0.2 and +1.9-g between 2 000 and 6 000 feet, recorded on the tape, indicated severe turbulence. Since known or forecast turbulence along the climb path is the prime criterion for selection of the climb speed, it is probable that the crew, unconcerned about turbulence below 14 000 feet, chose 310 knots rather than the lower rough airspeeds depicted in their flight manual.

Examination of the horizontal stabilizer lower sprocket failure reflects that the sprocket rivets sheared during rotation of the sprocket in the sense of ANU. The rotational pattern of rivet shear and the previously mentioned abnormal, displaced wear pattern of the unit, together with the positions of the two irreversible-action stabilizer jackscrews, reflected that the stabilizer drive unit had been operating in an abnormal condition over a period of time, then failed while being operated in an ANU direction from the full, or near full, AND position.

The Douglas tests indicated that the unit in this abnormal condition would be capable of operating throughout the normal required range. However, since the test rig had no means to introduce appropriate air loads, neither the torque forces required to start and sustain rotation of the unit, nor the actual rate of drive were realistic when compared with the normal design values. It was believed that operation of the unit varied from these normal values; however, the variation would be nominal. The geometry of the drive system and the wear patterns in evidence strongly suggested a unit which would not attract attention to its abnormal condition until it failed completely.

Based on the evidence contained in the recovered horizontal stabilizer drive unit, and the tests performed by DACO, the Board concluded that the drive unit was installed by EAL maintenance personnel in September 1963, with the support bushing in the inverted position. This would allow the bushing to fall free at some point in time after installation and the drive shaft to drop down from its normal position. In this instance it dropped 1/4 inch and was operated in this position for an extended period of time. Since the wear rate would be dependent on the number of actuations, as well as the associated loads imposed, there was no way to determine when this occurred.

It is logical to assume that the drive unit was functioning prior to departure from New Orleans since the crew would have to position the stabilizer for take-off. If the drive unit failed prior to take-off, the crew would have had the difficulty corrected. The EAL DC-8 Flight Manual in use at the time of the accident indicated a stabilizer setting of one degree ANU for take-off and since a normal trim correction towards AND is experienced as the aircraft is rotated and then "cleaned up," the drive unit was operating after the aircraft became airborne and started to climb to the assigned cruise level.

The stabilizer position of two degrees AND, whether intentional or unintentional, is symptomatic of an abnormal flight condition. Consequently, the Board has focused on the possible reasons for the stabilizer position and the attendant conditions produced by this setting.

On at least two occasions tobacco tar, dust, and other material from the cabin have collected in the fairleads of DC-8 rear pressure bulkheads. On these occasions when actuation of the stabilizer was initiated by the pilot, the cables stuck in the fairleads and the pilot was unable to stop the stabilizer at an intermediate position and this resulted in the control running to the full travel position. Maintenance records showed that this area was cleaned a week before the accident. If the stabilizer cable fairleads were in fact cleaned at that time, it is doubtful that the full AND position was produced by fairlead contamination.

Testimony by a DACO Aerodynamicist revealed that the extreme AND range of the stabilizer was provided to allow pilots to maintain a pull force under certain loading conditions during acceleration after take-off. While it is doubtful that the 2-degree position would normally have been reached following the take-off at New Orleans, the Board believed that the history of this aircraft reflected a possible condition which could have caused trim positions more AND than usual.

In connexion with this, it was found that on another DC-8 belonging to another operator, the crew of a training flight noted control difficulties following take-off on 1 April 1964. An inspection of the control system subsequently revealed that the PTC actuator on installation had been adjusted so that it was extended 1/2 inch when at its most retracted position. Normally this amount of extension would have caused the indicator on the first officer's column to be partially extended. In this case the sleeve from which the indicator plunger extends had been raised to the degree that it was flush with the plunger at the minimum position of the actuator as installed. Additionally, because of a mechanical malfunction in the linkage as found, the indicator was inoperative. A check into the maintenance records showed that on 13 February, while the aircraft was on lease to EAL, the PTC actuator was replaced because of a failure by a new actuator obtained by EAL from the owner's stock, and installed in the aircraft by EAL maintenance personnel. The foreman in charge of this work testified that he had examined the old and new units, assuring that the replacement actuator measured the same as the old one with respect to "eye-bolt to eye-bolt" length and to number of threads showing on the rod end-fitting. Investigation has revealed, however, that both of these conditions could not exist simultaneously since the old unit, DACO P/N 17989-2, and the new one, DACO P/N 17989-3, differed in configuration. With the same number of threads showing on a -2 as on a -3, the eye-bolt to eye-bolt distance will differ by about 1/2 inch, the -3 being the longer. So installed, the fully retracted position would be the equivalent of the programmed extension for 386 knots EAS below 20 000 feet or at 0.84 Mach number at higher altitudes.

It is extremely interesting to note the effects this misrigged PTC system had on the aircraft which had a c.g. of 26% (nearly the same as on the subject aircraft). Pilots commented that nose-down trim was required following take-off to the point that the warning light was illuminated.* There was no reference made to how much additional AND trim was used.

It was found that the PTC actuator in the aircraft at the time of the accident had been installed on 6 May 1963, as a replacement for a malfunctioning actuator. As with the leased DC-8, the new unit was a -3, whereas the one removed was a -2, and the change had likewise been accomplished by EAL maintenance personnel. With reference to the PTC problems encountered at Philadelphia on the day before the accident, the Board did not find evidence that either maintenance or flight personnel ascertained that the actuator was in fact retracted. The only determination made was that the unit was inoperative, and it was decided to utilize the aeroplane in that condition until the following day. Failure to ascertain positively the true position of the actuator was most probably brought on by its inaccessibility; removal of the first officer's seat was necessary to view the actuator. (This has since been corrected by the installation of an access panel in the nose wheel well.) The pilot-in-command of the flight to Mexico City testified that the PTC was also checked in flight after departure from Washington and found to be still inoperative. While this information further verified the static condition of the system, it offered no enlightenment on the PTC actuator position.

Further, the Board believed that a partially extended PTC would give an explanation for the many autopilot difficulties which remained, for the most part, uncorrected. Several write-ups had been for automatic disconnects. The autopilot trim system is limited in positioning the stabilizer in the AND sense (1.25 to about 1.5 degrees AND) and if more nose-down moment is required to keep the aircraft in trim while utilizing the autopilot, the attendant loads must then be carried by the elevator servo. The circuitry of the autopilot is such that if these holding loads by servos become excessive, the autopilot will automatically disengage. The recorded history of autopilot disconnects and other longitudinal problems, despite repeated autopilot component replacements, indicated a problem lying without the autopilot system.

* This warning light is peculiar to this company's aircraft and is illuminated at about one degree AND.

In summary, the work performed by EAL maintenance personnel on the leased DC-8 and the similar change in actuator models on the subject aircraft established the possibility of a partially extended PTC actuator, and the autopilot difficulties encountered are symptomatic of this condition. Furthermore, if the indicator system failed, as occurred on the leased aircraft and on this one earlier in the day preceding the accident, the PTC actuator could have become inoperative at any position. Apparently the indicator was the only basis used at Philadelphia to determine that the actuator was retracted, therefore it was possible that the aircraft, at departure from New Orleans, as well as earlier, was being operated with a PTC actuator extension (although inoperative) ranging from 0.5 inch to 2.15 inches (normal full extension of 1.65 inches plus the 0.15 inch misrigging).

If this condition existed, full AND stabilizer might have been used shortly after take-off. Failure of the chain sprocket on the next attempt to trim nose-up would have resulted in ever increasing pull forces on the column as airspeed was accelerated toward en route climb.

Data available* indicated that for the 2-degree AND condition the stick forces necessary to hold the aircraft in steady-state 1-g flight range from 33 pounds (PTC retracte and zero pounds (PTC extended) at 242 knots, to 55 pounds (PTC retracted) and 22 pounds (PTC extended) at 320 knots. Accordingly, the force characteristics should have become noticeable to the crew at speed above 220-240 knots, depending on extent of PTC extension, and they would not have accelerated much beyond this speed band. Rather, they would have elected to return to New Orleans and would have made their intentions known to departure control. The facsimile airspeed trace (see Figure 10-2) showed that this speed range would have been reached at about 0201:36 to 0201:46 and yet a simple acknowledgment of "OK" was made about a minute and a half later. That time interval might have been a period of problem and troubleshooting, during which no decision had been reached as to whether the flight should continue or return to New Orleans. The difficulty could have degenerated to an emergency and, ultimately, to catastrophe after the final transmission.

However, the Board found it difficult to conclude that this condition alone, PTC extension and AND stabilizer, could have precipitated the complete loss of longitudinal control evidenced by the condition of the wreckage. It was established that under any condition whereby the aircraft is placed in trim by using AND stabilizer to counteract unprogrammed PTC actuation, the overall effect is to shift the zero-force point of the control column away from its normal position in relation to the dual rate feel spring to a point where the stick force per g becomes relatively light. This is depicted in Figure 10-3, wherein the characteristic force pattern is reflected. The values on the abscissa and ordinate will vary depending on speed, altitude, and c.g. location, but the shape of the curve does reflect the pattern for any regime. Normally trimmed, the control column will be centred about Area A and any column displacement from that area will follow the curve shown so that reasonable and expected stick force per g or per degree of surface deflection will be felt by the pilot. Excessive nose-down stabilizer positions, on the other hand, require up elevator to keep the aircraft in trim. The new column centre position is in Area B where pilot inputs in the pull direction are at a considerably lower gradient. Here the primary concern is the gradient and not the actual force itself. The gradient is the same whether the pilot holds the aircraft in trim against an unwanted AND stabilizer position by applying a stick pull force, or the control forces are in balance through the medium of using AND stabilizer to counteract unprogrammed PTC, or extension of the PTC by use of the "test" position to balance out unwanted AND stabilizer settings.

* For 213 000 pounds, c.g. at 26 per cent and MCT.

Of course, if it becomes necessary for the pilot to hold a pull force against AND stabilizer, the magnitude of the force necessary does become a factor in so far as physical capability and pilot fatigue are concerned.

One very interesting aspect in the leased aircraft occurrence was the discovery that one elevator control tab had been rigged in such a manner that it partially offset the effect of the PTC extension, i.e., the compensating stabilizer deflection moved the controls into or toward Area B, and the tab rigging tended to shift them back toward Area A, but to a lesser degree. Tabs misrigged in the opposite direction, or for that matter correctly rigged, would have worsened the control difficulties of the aircraft.

The variation of stick force per g versus speed for the 2-degree AND case, shown in Figure 10-4, is also significant; while the stick force per g is light but at a reasonable level at 310 knots, it degenerates to about 13 pounds at 220 knots. This level of force gradient is extremely light* and is to a large extent masked by the friction forces of the system, which are about ± 5 to 6 pounds. Thus, at 220 knots a pilot could maintain a 1.5-g manoeuvre without feeling any resistive force, or he could hold limit load (2.5-g) by feeling out only about 14 pounds, considerably less than required for a similar manoeuvre in a military fighter aircraft.

In this regard a highly qualified FAA test pilot testified that with PTC extended and at approximately 220 knots he trimmed the aircraft to two degrees nose-down and started doing some nominal manoeuvering with the aeroplane in this configuration. He found that any time he attempted to depart from the trim point, either in nose-up or nose-down direction, he received reversals in the aeroplane's manoeuvering stability: the rate of pitch increased and the stick force went to the opposite direction to check the manoeuvre. He also indicated that after a few manoeuvres the tests were discontinued because of the nervousness of all the crew.

By presuming an acceleration after take-off to speeds where stick forces against a jammed AND stabilizer would become noticeable, and also a continued acceleration while trying to reactivate the stabilizer, say to 260 or 270 knots, one can account for the speed element necessary to place the aircraft near the region of the accident. Further, if the pilot then reduced his airspeed to 220 knots to relieve the stick force necessary for trim and then encountered moderate to severe turbulence, he could conceivably, because of the low stick force gradient, have overcontrolled the aircraft to the extent that on one of the oscillations the aircraft reached a nose-down attitude for which the altitude did not permit recovery.

Figure 10-5 has been constructed from available data, principally DC-8, by superimposing on the altitude required to recover from given dive angles (utilizing a 2-g recovery), the altitude lost in getting from level to these dive attitudes. Not included is altitude dissipated during the time required for situation analysis, decision and reaction, and the time necessary to apply the stick force for a 2-g manoeuvre. Examination of the graph shows that recovery becomes problematical if a pushover to 30 degrees is initiated at any altitude below 5 000 feet. If one considers the additional altitude losses referred to above, the limiting altitude would be considerably higher or, conversely,

---

* The Civil Air Regulations under which the DC-8 and other transport aircraft were certificated do not specify stick force per g values. For the superscripted statement the Board relied on general consensus of opinion and on MIL-F-8785 (ASG) which specifies maximum and minimum gradients by formula. Applying the formula to the DC-8, the stick force per g values are a maximum of 80 and a minimum of 30 pounds.

the maximum dive angle for recovery would be less. Calculations based on flight recorder data of the DC-8 turbulence upset which occurred with the same co-pilot at the controls showed that the aircraft reached a nose-down attitude of about 40 degrees and that 13 000 feet were required to resume level flight.

Some of the preliminary results of the extensive NASA intercentre rough air penetration studies were of considerable assistance to the Board in its assessment of this accident and subsequent similar accidents. Of particular interest is NASA's finding that pilot workload, flight deck acceleration environment, aircraft characteristics, instrumentation displays, and piloting technique can all be factors in precipitating upsets in some cases. In the work completed it has been shown that the simulator, without any pilot control inputs, can fly through the most severe National Severe Storms Project (NSSP) gust/draught history without excessive g excursions, large airspeed variations or great altitude changes but with, in many cases, large changes in pitch attitude. The inherent or augmented stability of the simulated aircraft provides the restoring forces necessary to maintain the trim condition. In most of the trials with a pilot control input, the simulator could be flown successfully through the "storm" and the extent of the g, airspeed, and altitude excursions depended largely on how close the pilot tried to maintain the desired pitch attitude. Some of the trials revealed oscillations quite large in amplitude, indicating pilot control input out-of-phase with the simulator motions induced by the imposed gust/draught history. In a few trials the oscillations became divergent and an upset occurred. When the pilot was told to deliberately ignore the pitch attitude display and to rely chiefly on controlling airspeed during the simulated penetration, large oscillations of all parameters invariably resulted.

In line with the accepted concept that the attitude indicator becomes the primary instrument in turbulence flying, it is important to recall that in the Collins 105 the gearing of the pitch bar is such that when the aircraft is being rotated to high pitch attitudes (more than 20 degrees), the ratio of actual aircraft deck angle to indicated pitch attitude increases. The result, of course, is that unless the pilot is familiar with this phenomenon, he will view the aircraft as being in a less severe attitude than it really is, or he may allow the aircraft to stray farther in pitch simply because his attitude instrument is presenting him with conservative data. If the attitude indicator presents "geared-down" pitch attitude information to the pilot, it likewise presents "geared-down" pitch rate information and could cause a degree of over-control when the pilot attempts to restore the aircraft to normal attitudes. Coupled with this is the small physical size of the instrument face and its solid black background, which does not display to the pilot the immediately interpretive picture of the two-coloured instruments.

The Board heard testimony concerning the miscues presented to pilots by their flight instruments during turbulence flying, and several papers have been written on the subject. Generally conceded is the fact that airspeed, rate of climb, and altitude presentations could lack accuracy and, even more, could present completely erroneous information as to longitudinal attitude, i.e., trends exactly opposite to that expected of a given attitude.*
The Board then found that the primary instrument, the attitude indicator, presents to the pilot information which, while not illogical, is certainly not optimum.

---

* Secretariat note: Of particular interest in this connexion was Northwest Airlines Flight Standards Bulletin No. 3-65, which was reproduced with the kind permission of the author, Mr. Paul Soderlind, as an attachment to ICAO State Letter AN 11/10-65/116 dated 16 August 1965.

Additionally, the Board gathered information on the subject of speed stability* Flight tests have shown that the DC-8 speed stability in the climb configuration approaches neutral at speeds above 300 knots when the PTC fails to extend the programmed amount. Speed stability characteristics were explored with a research pilot who had considerable experience in experimentation with specially adapted variable stability aircraft. He indicated, as did other test pilots, that neutral speed stability in itself does not pose a serious problem to the pilot, and, in fact, under normal flying conditions, makes an aircraft quite pleasant to fly. He further pointed out, however, that what is dangerous about a situation like this is a distraction. If the pilot, for example, is distracted for any reason and allows the aircraft to start diverging from its trim condition, especially if he is in turbulence and he is faced with a fairly substantial change in his trim or his attitude, the tendency usually is to make a large input, and this is where the trouble begins.

The Board conducted studies pertaining to aircraft characteristics in turbulence. This information revealed that turbulence has known energies broad enough to excite aircraft natural frequencies between 0.2 cps and 4.0 cps. An example of this was illustrated by the pilot-in-command who was involved with that same aircraft in a turbulence incident on 20 August 1963 at Dulles. He stated that he encountered the most violent jolt ever experienced in over 20 000 hours of flying, and that he felt as though an extremely severe positive, upward acceleration had triggered off a buffeting, not a pitch, that increased in frequency and magnitude. Not an instrument on any panel was readable to its full scale, but they appeared as white blurs against their dark background and it could have been 10, 20, 60 or 100 seconds, with no idea of attitude, altitude, airspeed or heading. Briefcases, manuals, ash trays, suitcases, pencils, cigarettes, flashlights were flying about like unguided missiles. It sounded and felt as if pods were leaving and the structure disintegrating.

The objects that were thrashing about the cockpit seemed to settle momentarily on the ceiling which made it impossible to trust one's senses, although he had a feeling that the aircraft was inverted as his seat belt was tight and had stretched considerably and his briefcase was on the ceiling. Both he and the co-pilot applied as much force as they could gather to roll aileron control to the left. The horizon bar at this time started to stabilize and showed the aircraft coming back through 90 degrees vertical to a level attitude laterally. At this time, he had his first airspeed reading decaying through 250 knots; the air smoothed out and the aircraft gently levelled off at between 1 400-1 500 feet.

In its attempts to assess the combination of turbulence and handling characteristic elements of the man-machine-environment triangle, the Board found of considerable value the conclusions reached by the independent research agency (see paragraph 1.15) regarding the tendency of pilots to overcorrect, thus producing a pilot induced oscillation (PIO).

Based on the information available to the Board, the DC-8 exhibited very low speed-stability characteristics, particularly at higher climb speeds when the PTC does not operate as programmed, and the question was raised whether these stability aspects were within the requirements of the Civil Air Regulations. As a matter of fact, the regulations did not cover stability in the event of a mistrimmed condition or a system malfunction; under such conditions, the regulations required only that the aircraft be safely controllable.

* Speed or static stick-free stability is the measure of the aircraft's ability to return to trim speed if momentarily disturbed to a lesser or greater speed. An aircraft which has positive speed stability will likewise require pull forces to maintain altitude if the speed decreases and push forces if the speed increases from trim speed.

However, what was of primary interest was the fact that at lower speeds (220 knots) the aeroplane could, under certain mistrim conditions, exhibit low to neutral stick force per g and stick force versus elevator deflection; and at the higher climb speeds (310 knots) it could have very low speed stability.

Earlier the Board discussed the possibility of a partially or fully extended but inoperative PTC. This would have contributed to reduced manoeuvering stability at lower speeds but would have improved to a small extent the speed stability at the higher speeds. On the other hand a retracted, inoperative PTC would have had no effect at lower speeds but would have produced marginal speed stability at speeds in excess of 300 knots. As stated before, the possibility existed that the PTC actuator was extended. This condition, while it could have worsened the situation, was not a necessary prerequisite to a PIO situation. The Board investigated several PIO accidents and incidents in which the PTC was not involved, including aircraft which did not have this type of compensating system. One element, however, common to almost all PIO occurrences, was the application of nose-down stabilizer trim at some point during the oscillatory cycles.

In other words, the pilot, finding his aircraft in an excessively nose-high attitude, pushed the column forward and, when the aircraft did not respond to his satisfaction, he also actuated the trim switch. He then suddenly found the aircraft responding more rapidly than anticipated, and this motion could also have been aggravated by a gust reversal which became additive to the elevator and stabilizer inputs. At this point, in all probability, the PIO conditions have ended for all practical purposes, and the aircraft was in a dive. Whether or not the aircraft could have recovered from the dive was mainly a question of dive angle and altitude. However, other factors more subtle and difficult to assess, but greatly affecting the seriousness of angle and altitude, were pilot response times, his use of reverse thrust, whether he attempted to retrim and perhaps the most important of all, how much load he was willing or able to place on the airframe in the pull-out.

The failure of the stabilizer drive system at the full AND position, whether it occurred during a PIO or earlier, automatically established a lower limit to the pilot's ability to recover from a diving condition. The larger size of the stabilizer makes it approximately three times as powerful as the elevator, and therefore about six degrees of up elevator is required to counteract the effect of an unwanted 2-degree AND stabilizer position. This amount of elevator deflection was lost in so far as recovery was concerned. Also, as speed increased, the ability to get any recovery action from the elevator diminished, and disappeared completely at about 470 knots. Several PIO incidents also established the fact that high stick forces (about 80 pounds or more) produced moments on the stabilizer which exceeded the trim motor capability, and that under these circumstances it was necessary to relax some of the pull force in order to reposition the stabilizer. If the drive system failed during a PIO rather than earlier, the pilots had no way of knowing the real reason for its failure to operate in the ANU direction. In the split seconds available to them for analysis they could easily have concluded that the failure was due to heavy stick forces. Reverse thrust, in addition to drag, produces a nose-up pitching moment; however, during the time, no matter how short, required to go from forward thrust to reverse, the nose-up pitching moment of forward thrust had been removed and therefore contributed to the severity of the dive. Small as it may be, this factor becomes more significant at very low initiating altitudes.

Based on voice identification and crew practices, it was believed that the co-pilot was at the controls during and following take-off from New Orleans. This same pilot, during the development of a longitudinal upset in another DC-8, did not hesitate to apply full forward control column and additional nose-down trim when faced with an unusual attitude in turbulence. The result was a dive reaching about 40 degrees nose-down, and about 13 000 feet were required for recovering. The Board, however, fully recognized that what this pilot did in one situation at one time was not necessarily indicative of his actions in another, even similar, situation at another time.

2.2 Conclusions

Findings

The crew were properly certificated.

The aircraft's gross weight and centre of gravity were within allowable limits.

Night, instrument conditions prevailed.

Moderate to severe turbulence was encountered.

The PTC was inoperative and may have been partially or fully extended.

The stabilizer drive system failed in the 2-degree AND position at some time during the flight.

The attitude indicator, which was small with a solid black background, was difficult to interpret at night.

The pitch indication of the attitude indicator was "geared-down" but not indexed as to degrees.

The aircraft exhibited marginal to non-existent speed stability and a stick force per g characteristic which test pilots have interpreted as unstable.

None of these factors in itself constituted a hazard or even a serious situation; however, several or all of them in combination could have created conditions under which control of the aircraft could have been lost, partially or completely.

The Board concluded that, although the exact time of trim failure could not be established, such failure did occur and either contributed to the introduction of a PIO in turbulence or was contributory to the failure to recover therefrom, and that the inoperative PTC also contributed whether retracted or extended, and that there was a strong possibility that it was at least partially extended. The histories of this and other DC-8 aircraft suggested also that some degree of control system misrigging might have added to any other control difficulties.

Cause or
Probable cause(s)

The Board determines the probable cause of this accident was the degradation of aircraft stability characteristics in turbulence, because of abnormal longitudinal trim component positions.

3. - Recommendations

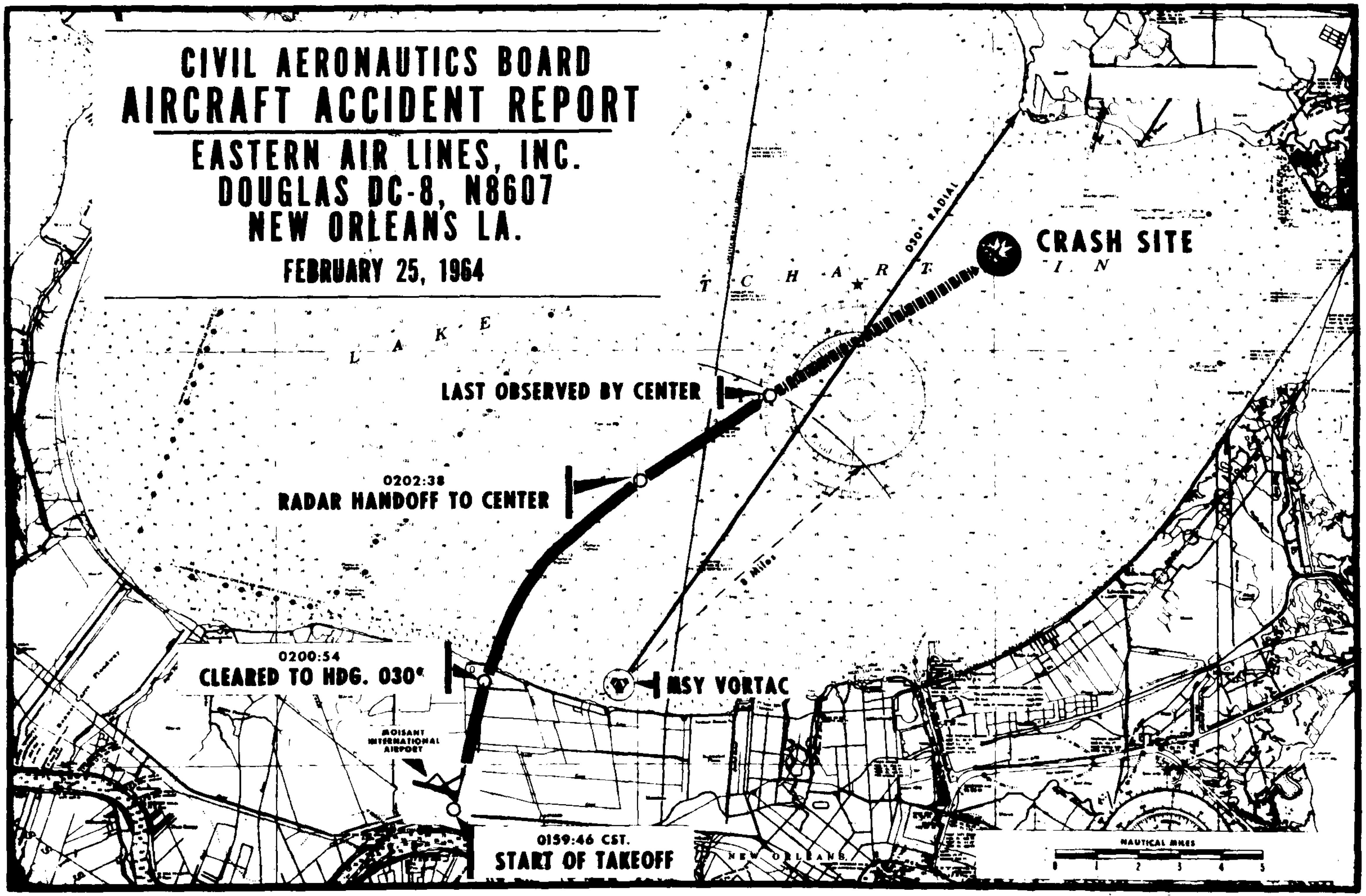
None were contained in the report.

4. - Action taken

Following this accident, and as a result of further testing of the DC-8, the FAA approved several aircraft modifications, and new maintenance and operating procedures. The AND travel limit of the horizontal stabilizer was reduced from two degrees to one-half degree to minimize the effects of mistrimming. The elevator load-feel and centring spring assembly was modified to adjust tolerances properly, and eliminate the possibility of a heavy compression spring in the assembly producing a preset in the assembly. The PTC actuator bellcrank arm was replaced to modify the aft force on the control column to provide an increase in longitudinal stability under all flight conditions, and an amber warning light was installed to warn of 80 per cent of full extension. The operating procedures for the aircraft were also changed to restrict the climb speed to 250 knots maximum when the PTC was inoperative and the aircraft c.g. exceeded 30 per cent. Because trimming against an unwanted PTC extension will result in (1) decreasing the elevator available for landing, and (2) decreasing the stability of the aeroplane the procedure for overcoming this condition was changed to: "... the elevator should not be trimmed to zero, but the stabilizer should be positioned to maintain a slight push force (approximately 10 pounds) ..."

Also, EAL modified their Collins 105 Approach Horizon to provide a more realistic presentation of attitude to the pilot.

ICAO Ref: AR/910



CIVIL AERONAUTICS BOARD
AIRCRAFT ACCIDENT REPORT
EASTERN AIR LINES, INC.
DOUGLAS DC-8, N8607
NEW ORLEANS LA.
FEBRUARY 25, 1964
CRASH SITE
LAST OBSERVED BY CENTER
0202:38
RADAR HANDOFF TO CENTER
0200:54
CLEARED TO HDG. 030°
MSY VORTAC
030° RADIAL
0159:46 CST.
START OF TAKEOFF
NAUTICAL MILES
0 1 2 3 4 5

FIGURE 10-1

FIGURE 10-2

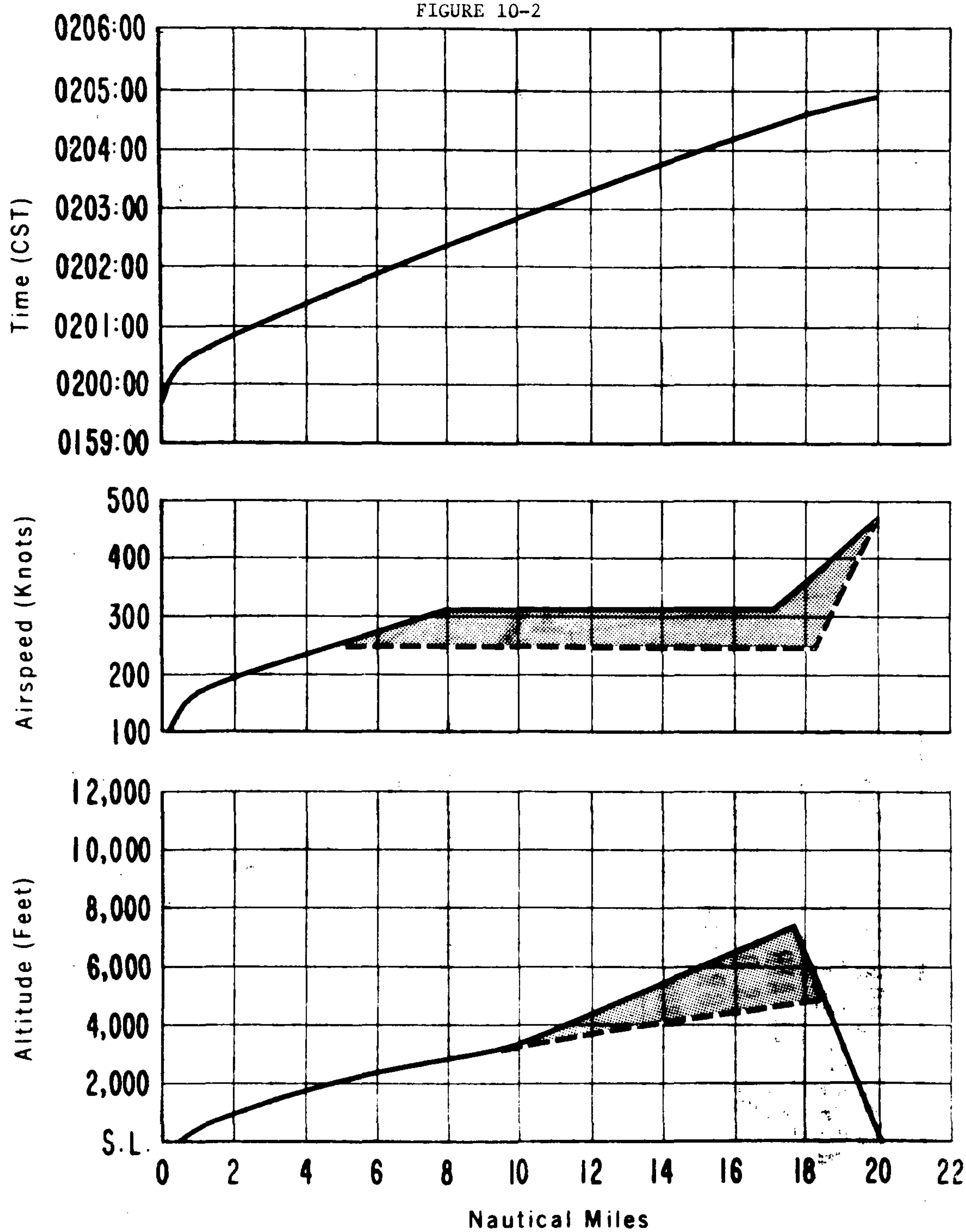

0206:00
0205:00
0204:00
0203:00
0202:00
0201:00
0200:00
0159:00
Time (CST)
500
400
300
200
100
Airspeed (Knots)
12,000
10,000
8,000
6,000
4,000
2,000
S.L.
Altitude (Feet)
0
2
4
6
8
10
12
14
16
18
20
22
Nautical Miles

FIGURE 10-3

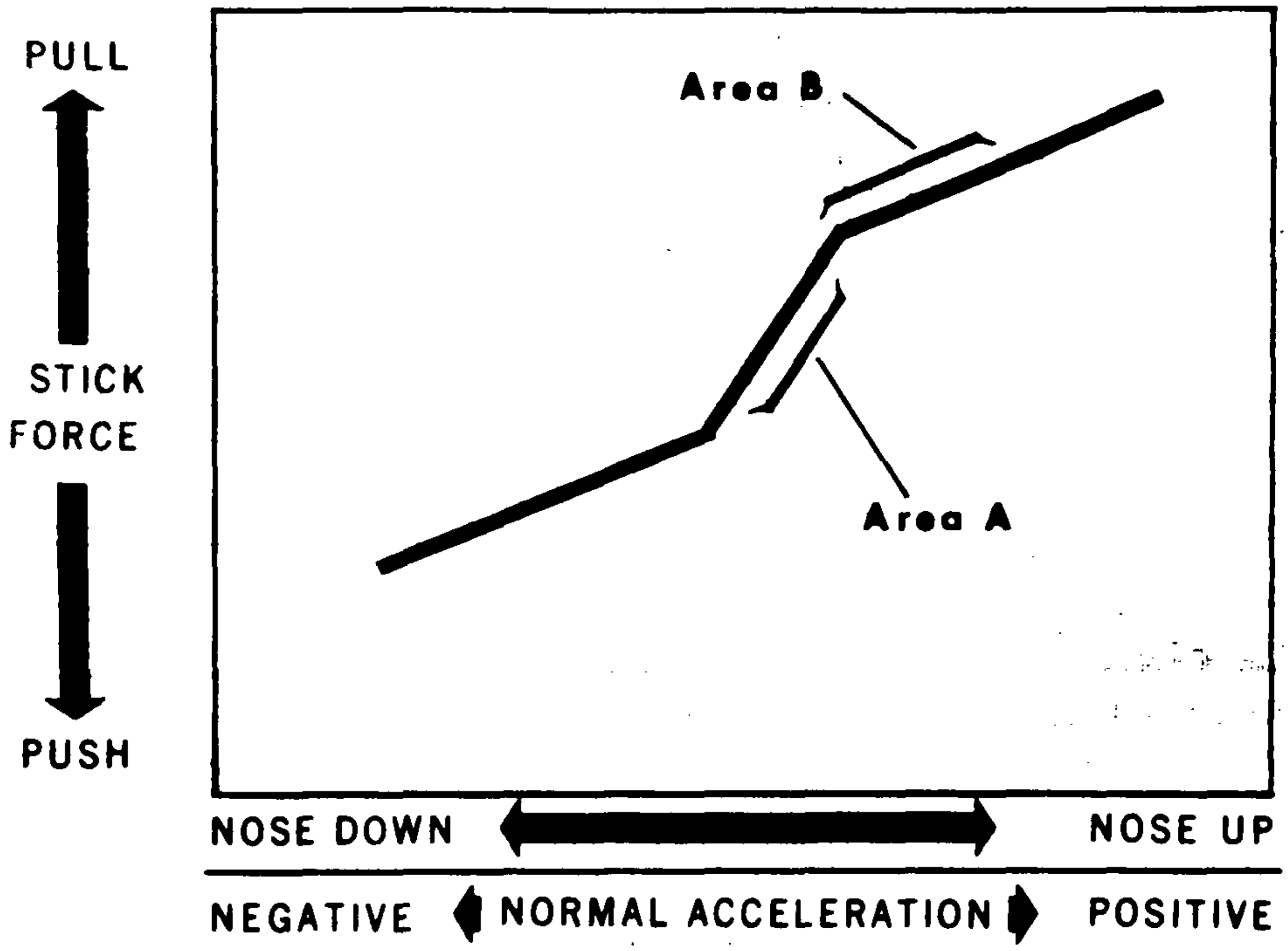


FIGURE 10-4

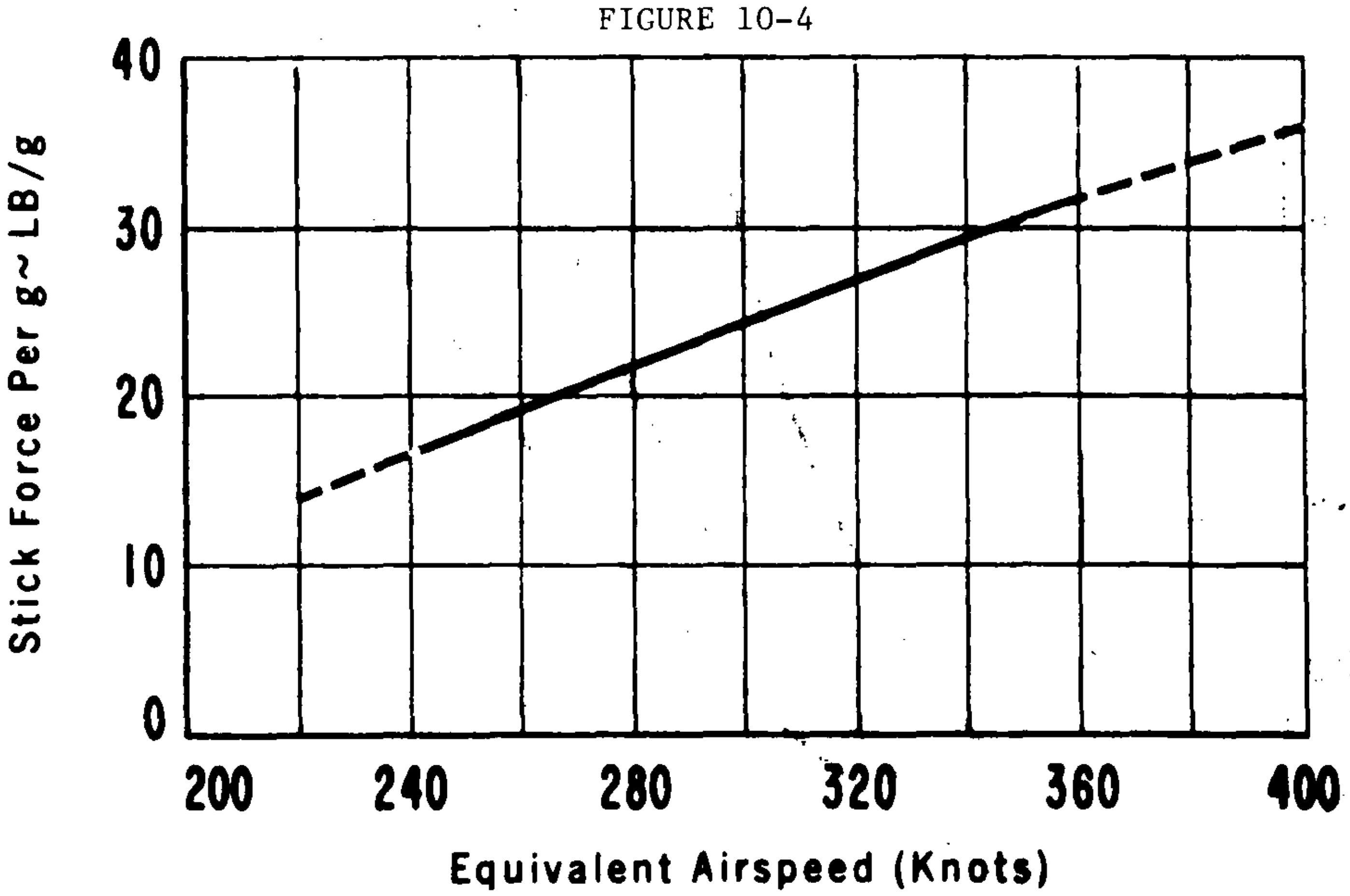
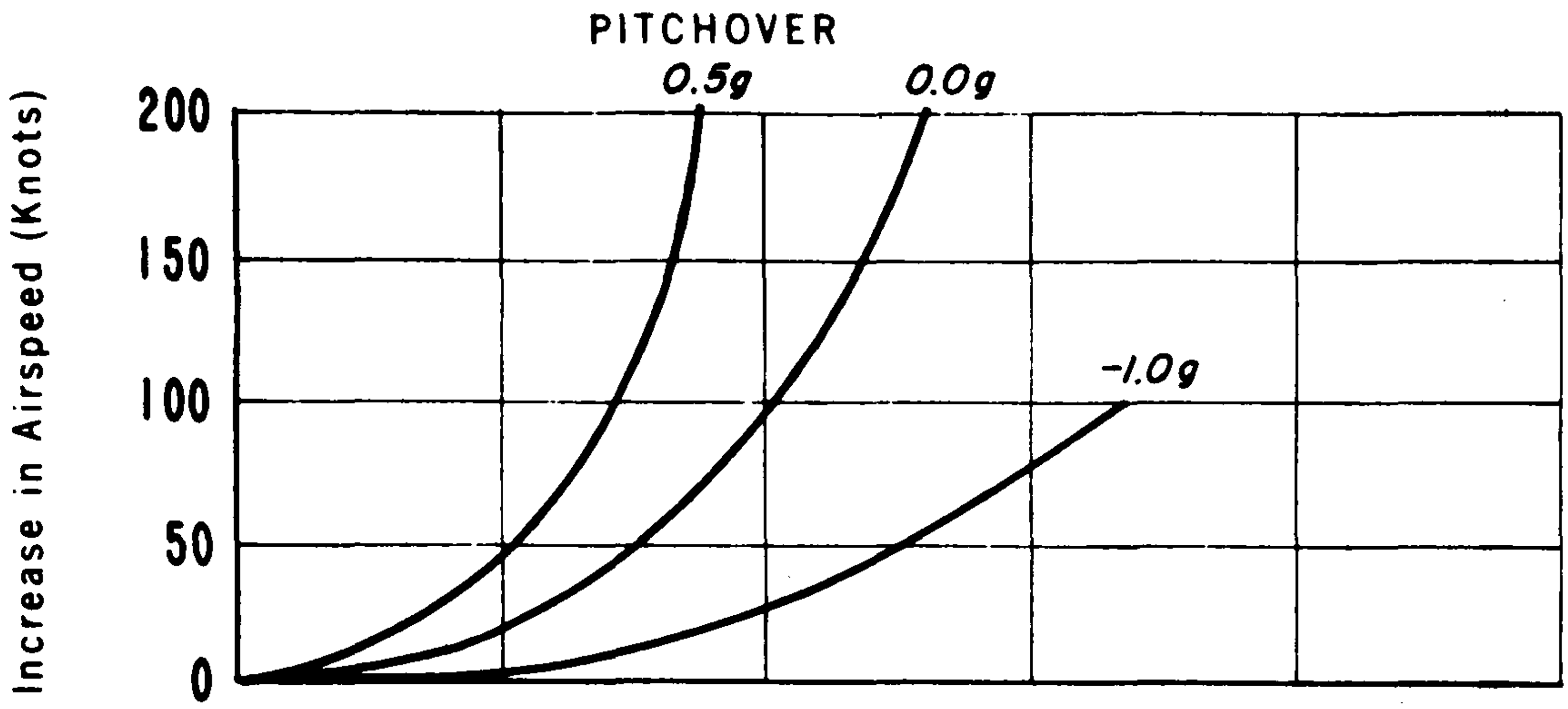
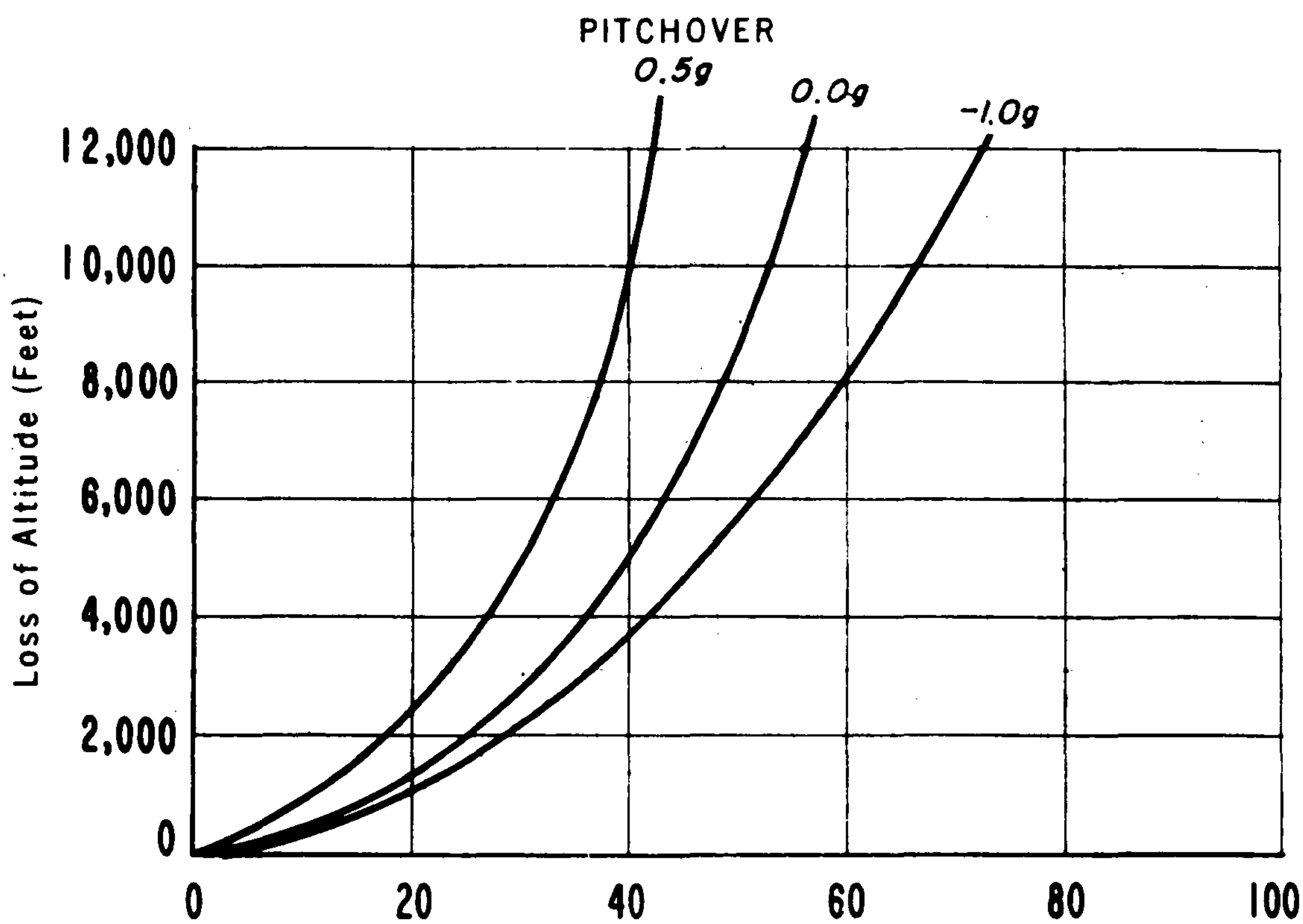


FIGURE 10-5



Airspeed Gained and Altitude Lost in a Pitchover Manoeuvre to a Dive Angle, Followed by a 2.0-g Pull-up to Level Flight.

FIGURE 10-6



No. 11

Fuji Koku Co. Convair 240 JA5098, accident at Oita Airport, Japan, on 27 February 1964. Report released by the Japan Civil Aviation Bureau on 1 July 1966

1. - Investigation

1.1 History of the flight

Flight 902 was a scheduled domestic flight. It departed Kagoshima at 0546 GMT* and flew VFR to Oita with a crew of 5 and 37 passengers aboard the aircraft. At 0614 hours it made radio contact with the Oita Control Tower and was given weather information. The co-pilot, who was flying the aircraft from the left-hand seat, landed the aircraft on runway 02 but was unable to reduce the speed of the aircraft and the aircraft over-ran the runway. Its left wheel hit a 62-cm-high airport boundary marking stone 96.6 metres beyond the end of the runway on the extended centre line. The aircraft then collided with lumber piled up 124 m from the runway end, and fell into the dried-up bed of the Urakawa River.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	2	18	
Non-fatal	3	9	1
None			

1.3 Damage to aircraft

The aircraft was destroyed by the impacts and subsequent fire.

1.4 Other damage

None.

1.5 Crew information

The pilot-in-command held an airline transport pilot's licence, valid until 26 April 1964. He had flown a total of 5 387 hours, including 982 hours on Convair aircraft.

The co-pilot also held a valid airline transport pilot's licence, valid until 16 June 1964. He had flown a total of 2 810 hours, including 529 on Convair aircraft.

*Local time = GMT + 9 hours.

A third pilot, not on duty during this leg of the trip, was sitting on the jump seat. He also had a valid airline transport pilot's licence.

Nothing in their recent flying activities indicated anything which could have prevented them from normal operation of the aircraft.

1.6 Aircraft information

Inspection and maintenance had been carried out according to established procedures. The aircraft had flown 836 hours since the last inspection. There was no report of any deficiency prior to and during the flight. No indications of weight and centre of gravity are given in the report. The fuel used was ESSO 100/130.

1.7 Meteorological information

Meteorological conditions permitted VFR operation. The accident took place in sunlight.

1.8 Aids to navigation

Not pertinent.

1.9 Communications

Both aircraft and ground station communications were normal.

1.10 Aerodrome and ground facilities

Runway 12/30 is 1 080 m long and 30 m wide. The airport is 2 m amsl.

1.11 Flight recorders

Not installed.

1.12 Wreckage

Wreckage was scattered over the area from 96.6 m to approximately 144 m in a line beyond the end of runway 30. The right wing, right engine, fuselage and tail all fell into the dry bed of the Urakawa River, and the central part of the fuselage then burned out.

1.13 Fire

Fire-fighting equipment at the aircraft consisted of three tank trucks, two pump trucks and two other vehicles. No information is given on the effectiveness of the fire fighting.

1.14 Survival aspects

The front of the fuselage was broken off, allowing passengers sitting forward to escape; those seated in the rear were burned to death.

1.15 Tests and research

None.

2. - Analysis and Conclusions

2.1 Analysis

Before departure from Kagoshima, the pilot-in-command told the co-pilot that threshold speed at Oita should be 115 kt, i.e. 12 kt greater than stipulated for the landing weight, which was estimated to be 38 000 lb.

Touchdown point was assumed to have been at approximately 250-300 m after the threshold. The nose wheel contact took place at approximately 500 m and the co-pilot probably applied reverse pitch at this point. However, he felt an acceleration instead of deceleration and found that the reverse warning light was off. He then pushed the reverse level back to the "off" position and reported the ineffectiveness of the reversing to the pilot-in-command who was already alerted because, as the nose wheel touched down, the aircraft veered to the left. The flight engineer testified that, according to the sound he heard, the left propeller went into reverse but not the right one; this caused the aircraft to veer to the left. Both pilots then applied the foot-brake simultaneously but found that the brakes did not work as well as usual. The co-pilot then applied the emergency brake, while the pilot-in-command applied full reverse pitch. All this, however, was insufficient to stop the aircraft before the end of the runway.

The reverse system circuit breaker was found in "Trip" position when all other circuit breakers were found in "Normal" position. It was believed that this breaker went into the "Trip" position when reverse was first applied. This might have been caused either by a greater-than-specified flow of current through the circuit breaker resistance, or by an internal failure of the circuit breaker itself.

Traces of normal braking were hardly identifiable, but traces of emergency braking were found starting approximately 250 m before the end of the runway. The left wheel traces started first and were heavier than those of the right wheel. No definite evidence of serious defect in the brake system was found.

The pilot-in-command's and the co-pilot's explanation that the response of the foot brake was not as good as usual could be explained by one or more of the following reasons:

(i) Malfunction or failure of the hydraulic pump,

(ii) Hydraulic fluid leakage,

(iii) Mechanical failure of the brake control valve in the hydraulic system,

(iv) Insufficient hydraulic fluid.

Ineffectiveness of the brakes was considered as a possibility.

2.2 Conclusions

Findings

The pilots were properly certificated.

The aircraft had been properly maintained and was airworthy at the time of take-off from Kagoshima.

The landing at Oita appeared normal although the threshold speed was slightly higher than normal for the aircraft's weight.

Touchdown was between 250 and 300 m after the threshold and the nose wheel touched down some 200 m farther down the runway. Reverse pitch was then applied; however, only the left propeller went into reverse. The reverse system breaker was found in the "Trip" position after the accident. According to pilots' testimony normal foot braking appeared to have been less effective than normal. Although no definite evidence of serious defects in the brake system was found, ineffectiveness of the brakes was considered as a possibility.

Cause or Probable cause(s)

The overlapping effects of excessive air speed in touchdown, inoperative propeller reversing, insufficient effect of the foot brake and the counter effect of the second reversing operations, although it is very difficult to judge to what degree any of the above-mentioned causes affect this accident.

No. 12

British Eagle International Airlines Britannia 312, G-AOVO, accident near Innsbruck, Austria, on 29 February 1964. Report released by the Federal Ministry of Transport and Electricity of Austria on 8 April 1965

1. - Investigation

1.1 History of the flight

Flight EG-802/6 was a scheduled international flight from London/Heathrow to Innsbruck, via Dover, Spangdalem Stuttgart, Munich, Tolz and Walchen.

It took off from London at 1204 hours GMT, with a crew of 8 and 75 passengers, on an IFR flight plan. As far as Stuttgart the flight proceeded in accordance with its flight plan at flight level 210. Thereafter it departed from the flight plan and followed the shorter route direct to NDB Kempten and Innsbruck, a saving of approximately 35 NM (about 6½ min. flight time). Clearance for this was granted by Rhein and Munich ATC units.

At 1320 hours the flight contacted Innsbruck tower and was given the latest weather information for Innsbruck, Seefeld and Kufstein; however, this was not acknowledged. AT 1335 hours the flight made contact with Munich ATC and reported over Kempten NDB at 1344 hours changing its IFR flight plan to VFR from Kempten to Innsbruck. Contact was again established with Innsbruck tower at 1346 hours. The flight reported having passed Kempten and descending VMC directly to Seefeld. It was given the 1330 weather report for Seefeld and a few minutes later the 1350 weather report for Innsbruck. The flight reported that it could not get underneath the clouds at Seefeld and was proceeding to Innsbruck VOR at 12 000 ft. Later on, it reported over the VOR at 11 000 ft, unable to break cloud. At approximately 1412 hours, on a request from Innsbruck tower, the flight reported at an altitude of 10 000 ft. This was the last message from the aircraft.

The wreckage of the aircraft was subsequently found on the steep eastern flank of the Glungezer Mountain (2 677 m). The aircraft struck the mountain at an altitude of about 2 600 m, approximately 65 m below the ridge running to the Gamslanerspitze and 300 m SSE of the Glungezerspitze, and disintegrated. The impact, which occurred at approximately 1414 hours, precipitated an avalanche which carried most of the aircraft debris and most of the bodies downhill for about 400 m and buried them.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	8	75	
Non-fatal			
None			

1.3 Damage to aircraft

The aircraft was destroyed.

1.4 Other damage

None reported.

1.5 Crew information

The pilot-in-command, aged 41, held a valid airline transport pilot's licence with type rating for Britannia 100/300 in Group 1 and had flown a total of 10 290 hours, of which 3 320 were in Britannia aircraft. His last instrument rating test was on 13 April 1963 and during the last seven months preceding the accident he had made nine flights to Innsbruck as pilot-in-command.

The co-pilot, aged 42, held a valid airline transport pilot's licence with type rating for Britannia 100/300 in Group 1, and had flown a total of 14 073 hours, of which 303 hours were on Britannia aircraft. His last instrument rating test was on 29 August 1963 and he had made three familiarization flights on the London-Innsbruck route during the month of the accident and was to have served on this route as pilot-in-command after a final check on 1 March 1964. Both pilots had their last medical examination in December 1963.

The flight engineer, aged 34, held a valid flight engineer's licence with type rating for Britannia 300; he had a total of 2 080 hours as flight engineer in Britannia aircraft.

The other five crew members were stewardesses.

1.6 Aircraft information

The aircraft's certificate of airworthiness was valid until 10 July 1964. All maintenance work had been carried out in accordance with the (UK) Air Registration Board's maintenance schedule; on 29 January 1964, British Eagle International Airlines issued their own certificate of maintenance in accordance with the approved maintenance schedule. Examination of the aircraft's records showed that all the British airworthiness authority's mandatory modifications and inspections had been satisfied.

On departure from London the aircraft was properly loaded, and carried 13 946 kg of fuel corresponding to an endurance of more than 4 hours. The type of fuel used was not mentioned in the report.

1.7 Meteorological information

The following weather forecast, valid from 1000 to 1900 hours, was prepared at 0901 hours by the meteorological office at London/Heathrow:

Innsbruck		between 1100 and 1500 hours
wind variable	/03 kt	30% probable improvement
visibility	1.5 NM	4 NM
cloud	3/8 st at 1 500 ft 3/8 sc at 3 500 ft	1/8 st at 1 800 ft 4/8 sc at 5 000 ft

Munich		Temporarily
wind	120/07 kt	
visibility	1 600 yards	1.5 NM
cloud	8/8 st at 300 ft	6/8 st at 500 ft 8/8 sc at 2 000 ft

Zurich		Gradually from 1000 to 1200 hours	Temporarily between 1200 and 1900 hours
wind variable	/03 kt		
visibility	2.5 NM	2 NM	1 NM
cloud	2/8 st at 1 000 ft 8/8 sc at 1 500 ft	4/8 st at 1 000 ft 8/8 sc at 2 000 ft	6/8 st at 1 000 ft 8/8 sc at 1 500 ft

During the weather briefing, which took place at 0920 hours, the crew was informed that heavy rainfall might be met en route and that fog and low stratus clouds, clearing slowly, covered extensive areas of Germany and the Alps. It was further stated that it would be possible to use Zurich as an alternate. No actual weather for Innsbruck was requested by the crew from the meteorological office; however, the operator inquired directly of its representative in Innsbruck and was informed that the weather was improving there and that landing should be possible.

At about 1320 and 1332 hours weather reports were transmitted to the flight by Innsbruck tower; however, they were not acknowledged. At about 1346 hours Innsbruck tower supplied the following information to the flight:

Seefeld: (1330 hours weather report) wind calm, visibility five zero kilometers, 8/8 stratus at 3 000 ft.

and about five minutes later:

Innsbruck: (1350 hours weather report) wind 120 degrees, 7 knots, visibility three decimal zero kilometers, 5/8 stratocumulus at 4 700 ft, 7/8 altostratus at 10 000 ft, temperature 7^{o}, dew point 2^{o}, QNH 1004.6 mb, QFE 937.2 mb.

This was acknowledged by the aircraft, without repeating the QNH and QFE as was usually done.

Around the time of the accident the actual weather conditions were:

Innsbruck: (1420 hours weather report) wind 110°/7 kt, visibility 3.0 km, rain, cloud 6/8 sc at 4 000 ft, 7/8 at 9 000 ft, QNH 1005 mb.

Seefeld: (1400 hours weather report) wind 030°/2 kt, visibility 30 km, rain, cloud 8/8 st at 3 000 ft.

Patscherkafel*: (1400 hours weather report) wind 010°/4 kt, visibility less than 100 m, snow, vertical visibility less than 100 ft, temperature -3°, dew point -3°.

Furthermore, witnesses revealed that, around the time of the accident, the eastern flank of the Glungezer Mountain was covered with cloud, thick mist and moderate to heavy snow fall.

1.8 Aids to navigation

The following aids were available on the day of the accident:

- An NDB (OEJ) 3 NM southeast of Igls Aerodrome
- A VOR (OEJ) located on the Patscherkofel Mountain at an altitude of 7 448 ft amsl, 5.7 NM south-east of Innsbruck Airport
- Locator west (JW) 6.75 km west of the threshold of runway 08 and on the runway centre line
- Locator east (JE) 6.4 km east of the threshold of runway 26 and on the runway centre line.

The VOR and the two locators were on test at the time of the accident. The VOR was not authorized for use as an aid to navigation and could in no circumstance be used as a landing aid.

Also a VHF-D/F was installed on a trial basis but was not available for use by aircraft.

The aircraft was equipped with the following aids:

2 ADF equipment

1 ILS/VOR equipment

1 DME

1 Loran

1 Airborne search radar

1 Marker receiver

* The altitude of the weather station is 1 909 m.

1.9 Communications

Communications between the aircraft and ground stations were normal through the flight except for the period from 1320 to 1346 GMT; at 1320 hours the aircraft attempted to get in touch with Innsbruck tower, but the conversation was not completed; at 1332 hours Innsbruck requested the aircraft to switch over from 118.3 Mc/s to 124.4 Mc/s but was unable to establish communication with the aircraft on this frequency.

1.10 Aerodrome and ground facilities

Innsbruck Airport lies outside controlled airspace, 2.3 NM west of the city. The aerodrome elevation is 579 m. Runway 08/26 is 1 880 m long and 40 m wide.

The runway lighting consists of white high and low intensity lights and green threshold lights which were switched on and working at the time of the accident.

On account of its location in the Inn Valley bounded on both sides by mountain ranges rising up to an altitude of 9 300 ft within 10 NM of the airport, approach to and departure from the airport are only authorized by day and under visual meteorological conditions (see AIP Austria, AGA 2-1-6, 29a).

1.11 Flight recorders

Not mentioned in the report.

1.12 Wreckage

The aircraft struck the mountain with its port wing and the port side of the forward section of the fuselage first, on a heading of approximately 280°. The propeller and reduction gearing of the port outer engine remained wedged in the rock face. Further parts of the aircraft lay scattered ahead on the rocks along the original line of flight. The greater part of the wreckage was carried down some 400 m by an avalanche.

1.13 Fire

There was no fire.

1.14 Survival aspects

The flight deck and the passenger cabin were completely demolished; seats were scattered in the lower region of the accident site. Almost all the safety belts were found undamaged (although two were found torn from their attachments) indicating that passengers were not strapped in at the time of impact. All occupants were instantly killed on impact.

1.15 Tests and research

All instruments, engines, propellers and other components recovered at the accident site were sent to the Institute of Technology, Vienna, for detailed examination. Nothing abnormal was found (see 2.1).

1.16 Approach and landing at Innsbruck

In view of the particular situation of the airport and of the fact that, according to the AIP Austria, approaches to and departures from the aerodrome must be made in accordance with VFR and in VMC only, the Company had laid down in its Operations Manual rules even more restrictive than those established by the Austrian authorities for operations at Innsbruck.

In accordance with the Austrian meteorological minima for VFR flights, approach to Innsbruck can be made with a visibility of 5 km (2.5 NM) at a minimum height of 1 000 ft above the ground and with a visibility of 1.5 km (1 600 yards) at a height less than 1 000 ft. The Company's "Innsbruck Standard Operating Instructions - Britannia Aircraft" prescribes:

"In the event of uncertainty about the weather, or if there is any communication difficulty, the aircraft must not enter the valleys and the flight must terminate at Munich. Divert to Munich unless the Innsbruck forecast obtained within 1 hour before entering the valleys indicates without doubt that the weather will permit a visual approach and landing to be made and the weather in the valley is not worse than 8/8 at 8 000 ft amsl for approaches from the west and 8/8 at 6 000 ft amsl for approaches from the east, with a flight visibility of 5 nautical miles".

Two alternative VFR approaches are provided in the Manual, one from the west from Kempten NDB via Walchen along the valleys to Seefeld and Innsbruck at an altitude of 6 000 ft QNH, the other from the east via Rosenheim, along the Inn Valley via Kufstein and Schutinz to Innsbruck at an altitude of 4 000 to 4 500 ft QNH.

A third approach was described during the investigation as often used. This is from Tolz NDB or from Kempten NDB direct to "OJE" NDB above minimum safe altitude and clouds, descending in the Innsbruck area if visual contact with terrain and VMC are obtained. The approach is then carried out along the Inn Valley either from the east or from the west depending on wind and visibility. A holding pattern may be flown in VMC above Innsbruck to await improvement of the weather.

Furthermore, the Company's Operations Manual prescribes that, in order to avoid large radius turn, all manoeuvring within the valleys must be at no more than 160 kt TAS with 15° flap selected, and that minimum RVR is 5 NM for both take-off and landing at Innsbruck.

2. - Analysis and Conclusions

2.1 Analysis

Examination of the wreckage at the site of the accident and by the Institute of Technology at Vienna revealed that:

- the aircraft was nearly horizontal, in a nose-up attitude and in a slight climb when it struck the mountain port side first;
- all four engines were running normally;
- the flaps were in the 15° position and the landing gear retracted;
- the auto[illegible] ot in use;

- the elevator trim was almost at "neutral";

- the total fuel remaining in the aircraft at the time of impact was between 9 150 and 10 000 kg;

- the pilot-in-command's altimeter was at a setting of 1005 mb (QNH at the time 1004.6 mb) and the co-pilot's altimeter at a setting of 1013.5 mb.

No evidence of malfunction or failure of the aircraft's structure, systems or instruments was found.

It was not possible to ascertain which of the pilots was occupying the left-hand seat. However, it was assumed that the pilot-in-command, who was checking the co-pilot as pilot-in-command on the Innsbruck route, was occupying the right-hand seat.

The weather forecast, prepared at 0901 hours at London and given to the crew at 0920 hours, gave a visibility of 1.5 NM at Innsbruck with a 30% probability of improvement to 4 NM. This was clearly below the minimum 5 NM RVR stipulated in the Company's Operations Manual.

From 1320 hours onward the flight could have listened to the Volmet weather reports. Weather reports were transmitted to the flight by Innsbruck tower at 1320 hours and at 1350 hours. The 7/8 altostratus at 10 000 ft reported in both cases corresponded to about 12 000 ft QNH. The crew could therefore have assumed that they would be able to obtain visual contact with terrain in the Innsbruck area at least from 11 000 ft, the minimum safe altitude in the holding pattern and to make an approach if the visibility improved.

Approach to Innsbruck at a minimum safe altitude of 11 000 ft, or below this in VMC, was therefore justifiable, particularly since there was adequate fuel available for approach to an alternate aerodrome or for reaching Innsbruck by another route.

The cloud cover actually encountered in the Innsbruck area was almost unbroken and there was no break large enough to allow penetration. Cloud base in the neighbourhood of the Patscherkofel (VOR) and the Glungezer was not at 10 000 ft but considerably lower.

After Kempten the flight approached VOR Innsbruck direct, in a descent. It was assumed that it arrived over Innsbruck at 1356 hours without immediately reporting its arrival. In the Seefeld area the flight reported at 12 000 ft and it was already at 11 000 ft when it reported over VOR Innsbruck, adding that it could not at present break cloud. The figures given must be assumed to be altitudes above sea level, since the left-hand altimeter was set to QNH Innsbruck and the right-hand one to 1013.2 mb and they were given in reply to the tower operator's request for "altitude".

In order to help the pilot to locate the aerodrome, the tower operator switched on the runway edge lighting at maximum intensity.

The pilot-in-command's intention of breaking cloud and landing at Innsbruck was indicated not only by the relatively long period spent in the vicinity of the VOR but also by his question to Innsbruck tower: "Can you see any breaks in the cloud in any direction, please?". This was also confirmed by the fact that, when the tower had replied to this inquiry in the negative, the pilot did not leave the Innsbruck area in order to approach

Innsbruck Airport by another route or to make an approach to an alternate aerodrome, but remained in the vicinity of the VOR and further reduced his altitude. Descent below the minimum safe altitude of 11 000 ft amounts to entering the Valley from above and is only justifiable in VMC.

While the flight was in the holding pattern at about 11 000 ft in the vicinity of VOR Innsbruck, another flight reported that the higher clouds were only over and not north of the Alps. Thus the crew knew of the possibility of making an approach from Rosenheim along the Lower Inn Valley, although, admittedly, this would fail to take into account the low ground visibility reported at Innsbruck. However, flying north above cloud, with radar-assisted descent from Munich via Rosenheim and making a fresh approach along the Lower Inn Valley at reduced airspeed would have resulted in an increased flight time of 25 to 30 minutes.

Innsbruck tower informed the flight that the highest cloud base was in the centre of the Valley, above the runway, and informed it of the location, frequencies and identification of the two runway locators, in order to help the crew to find the centre of the Valley. After the accident, a setting corresponding to locator JE, frequency 303kc/s, was found on one of the ADF receivers. It is unlikely that the crew made use of this locator (which was in the centre of the Valley, east of the aerodrome) for navigation, but it is probable that they used the VOR on the Patscherkofel to ascertain their position during holding and descent. This is indicated by their own reports and by the fact that, for quite some time, various people heard the aircraft time and again in the neighbourhood of the Patscherkofel. From this it appears that the crew planned to break cloud when they had visual contact with terrain (which was only to be found in patches and only above the centre of the Valley) and with the help of the VOR. The mountains over which the aircraft had to fly in order to do this, however, were covered in cloud a long way down.

In accordance with the Austrian State minima of 1.5 km, landing and take-off were permitted at Innsbruck Airport on 29 February 1964. The meteorological minima in the Company's Operations Manual, however, did not permit the pilot to land at Innsbruck on 29 February 1964. The minimum visibility of 5 NM was not attained either in TAF or in AERO (forecast or actual weather) at any time during the day. In addition, the Company's Aircraft Operations Manual lays down that visibility only, and not cloudiness, forms the criterion for initiating an approach to land. In accordance with these rules, the crew ought not to have approached Innsbruck but should have flown to an alternate aerodrome. Disregarding the limits imposed by the Operations Manual, other criteria permitted take-off and landing, although the visibility reported by the meteorological office amounted to less than 5 NM. Thus on 8 February 1964, this same crew landed and took off at Innsbruck in visibility reported by the meteorological office as 2.5 NM.

Since the pilot-in-command had received the weather forecast for Innsbruck at London Airport in writing and acknowledged it, and the visibility at Innsbruck Airport was passed to him repeatedly during his approach, it cannot be assumed that he mistook the 3 km visibility reported to him for 30 km.

Flights made for purposes of comparison in the Glungezer - Patscherkofel area and neighbouring area showed that, in bad visibility through cloud gaps, persons familiar with the area can, in places, confuse the southern medium-high mountains of the Inn Valley and the Stubai Valley with the Inn Valley. On the other hand, it is hardly possible to confuse the Wipptal with the Inntal in this area.

At approximately 1410 hours the aircraft was seen west of the Patscherkofel, turning southwards in a normal flight attitude. About two minutes later the last R/T contact took place. At that time it must have been in the area between the Patscherkofel and the Glungezer, near the Patscherkofel, coming from west-south-west and flying in an east-north-easterly direction. According to the pilot-in-command's report, the aircraft was flying at an altitude of 10 000 ft. As it flew over the ridge between the Patscherkofel and the Glungezer, the aircraft was thus approximately 2 500 ft above the Patscherkofel and approximately 1 200 ft higher than the ridge above the subsequent accident site, which is lower than the adjacent mountains. Its distance from this ridge was about 4 to 5 km. The last R/T contact made no reference to any technical defect in the aircraft which might have forced it to fly at a lower height. It must therefore be assumed that, at the time of the last R/T contact, at an altitude of 10 000 ft and about 2 minutes before impact, no technical defect had developed.

The flight beyond this point was heard very clearly by some mountaineers. The engine noise was normal. The aircraft first continued in an easterly direction and then turned south. The location and elevation of the accident site, the flight time of about two minutes (viz. approximately one minute's straight flight and about 1½ minutes' turning) after the last R/T contact and a rate of descent of 500 to 600 fpm, are compatible with these observations. The UK pathological report states that it is fairly certain that no sudden drop preceded the impact. According to the technical report, no deviation from normal flight operation occurred prior to the impact. All four engines were running at the time of impact. Altimeter readings and settings were correct. According to ear-witnesses, the aircraft had already carried out the same manoeuvre in the Glungezer area before (viz. approach from the south-west followed by a right turn to the south) with steady loss of height - as can be concluded from the reported flight altitudes of 12 000, 11 000 and 10 000 ft. According to the meteorological expert's report, icing may be ruled out as a cause of the accident.

On the basis of these facts it must be assumed that up to the time of impact there was no technical defect in the aircraft and that even during the last two minutes it was under the control of the crew.

The various weather observations made in the Patscherkofel - Glungezer area establish the fact that, when flying over this area, the crew could not see either the Patscherkofel or the Glungezer. It is possible that they saw the rock face shortly before impact and attempted to avoid collision with it by pulling up the nose of the aircraft.

It was not possible to ascertain the time and place at which the crew changed over to instrument flight. It is, however, certain that the final stage of the flight, up to the crash, or until just before it, was flown without visual contact with terrain. If the crew had known that the mountains to the east of the VOR are considerably higher than the site of the VOR, they would certainly not have lost height there.

In this connexion it was noted that:

- The Innsbruck Approach Chart (International Aeradio Ltd., London, dated 4.9.63) was not very clear and did not give a complete picture of the mountains and obstructions in the Innsbruck area. For example, it did not show clearly that the VOR is on a mountain peak at 7 450 ft.

- Aerad Flight Guide of 18.2.64, No. 109, p. 48, gives the bearing from the VOR to Innsbruck Airport as 123° which is a 180° error. But even on the basis of this information, the VOR would lie in mountains which would render descent below the minimum safe altitude of 11 000 ft impermissible.

- Neither an ICAO 1:500,000 chart of Europe, Bolzano (N.E. 46/10), 1953 Edition, nor a second one, extending as far south as Trient, gives spot heights for the Patscherkofel and Glungezer. These charts were adequate only if the Company's instructions, based strictly on VFR and absolute safety, were complied with.

2.2 Conclusions

Findings

The technical investigation brought to light no evidence of any technical defect in the aircraft:

(a) the aircraft was airworthy, properly maintained and loaded as prescribed;

(b) the engines were operating normally up to the moment of the impact with the rock face;

(c) all the instruments and equipment recovered had, so far as their condition after the impact allows such a statement, functioned properly; the altimeters were correctly set and showed the correct height;

(d) no defect could be found in the parts of the control system which were recovered. The autopilot was not engaged at the time of the accident; consequently, there is no reason to believe that any misapplication of control by the autopilot took place;

(e) fuel remaining at the time of the accident was sufficient for more than two hours' flight;

(f) no evidence could be found to suggest that the accident was caused by an explosion or fire on board.

The two pilots and the flight engineer held the necessary licences and had extensive experience in Britannia aircraft.

The medical examination showed that, at the time of the accident, neither of the pilots was under the influence of alcohol and no pathological organic changes were found. The examination of blood produced no evidence to suggest carbon monoxide poisoning.

According to what has been established regarding the progress of the flight, the aircraft was neither in the aerodrome traffic circuit nor on an approach to Innsbruck Airport, which is only authorized for approach and departure in VMC in accordance with VFR. The accident occurred outside controlled airspace, 15.5 km east-south-east of the aerodrome reference point, at an altitude of 2 601 m (8 535 ft) amsl.

The pilot-in-command had not requested any clearance from Innsbruck Aerodrome Control (TWR), nor was any clearance granted to him. Nor did he report any abnormal flight condition or an emergency before the accident.

The meteorological report on the accident indicates that there was 7/8 cloud at Innsbruck at the time of the accident, with tops at about 11 000 ft and base down to 7 000 ft in precipitation. The accident site itself was covered in a cloud layer in which visibility was considerably reduced, in places, by heavy snow showers.

From this it is to be concluded that, at the time of the accident, the aircraft was flying in IMC, although at 1344 GMT, over Kempten, the pilot had changed his IFR flight plan to VFR and ought therefore to have been flying in accordance with VFR from Kempten onwards.

In view of the weather situation prevailing on the day of the accident, icing can be eliminated as a cause. It is also to be assumed that turbulence exerted no decisive influence on the progress of the flight since, as a result of the shallow distribution of pressure, winds were only light.

On the basis of the results of the investigation it can be assumed that the pilot, presumably misled by:

(a) the high cloud base of 7/8 altostratus at 10 000 ft passed to him (which, however, did not apply to the Glungezer area) and

(b) the fact that, below the clouds, a Swissair aircraft was departing from Innsbruck Airport and an Austrian Airlines aircraft was approaching it,

attempted to break cloud. This assumption is confirmed by the fact that 15° flap had been selected, as prescribed in the Operations Manual for entry into the Valley.

In doing this the pilot obviously reduced his altitude (reported first as 12 000 ft, then 11 000 ft and finally 10 000 ft) to such an extent, while making several left-hand and right-hand turns above the mountains in the area of Innsbruck VOR, that he finally got into cloud and, as a result of insufficient visibility, struck the steep eastern flank of the Glungezer (2 677 m) at an altitude of 2 601 m, while heading approximately west.

Cause or
Probable cause(s)

The primary cause was the erroneous decision of the pilot-in-command to descend below the stipulated minimum safe altitude in the weather conditions prevailing at the time, as a result of which he was unable to conduct the flight in accordance with visual flight rules.

3. - Recommendations

Two members of the Commission made the following recommendations:

1. Operators should be required to exercise a closer supervision of the conduct of flights with regard to compliance with operating regulations, particularly compliance with the meteorological minima laid down by them.

2. In the case of VFR flights, aircraft may not, in any circumstances, be flown in IMC. This fundamental rule applies particularly in the Alpine region.

3. In order to avoid possible errors in the R/T transmission of visibility values, whole values should be transmitted as whole numbers without the use of decimals; e.g., a visibility of 3 km as "three kilometres" and not as "three decimal zero kilometres".

ICAO Ref.: AR/865

No. 13

Paradise Airlines, Inc., Lockheed Constellation L-049, N 86504, accident near Zephyr Cove, Nevada, USA, on 1 March 1964. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0002, released 15 July 1965

1. - Investigation

1.1 History of the flight

Flight 901A was a scheduled domestic flight from Oakland, California, to Tahoe Valley Airport, with intermediate stops at Salinas and San José, California. At Oakland the company prepared a VFR flight plan to Tahoe Valley Airport because there was no approved IFR approach procedure for the destination. Although the United States Weather Bureau had forecast poor flying conditions at the destination, the company dispatcher had forecast more favourable conditions based on his own evaluation of the available data and on his own special knowledge of local conditions. The flight was uneventful up to San José where it arrived at 0946. It took off from San José at 1040 hours on a VFR flight plan. It then requested and received an IFR clearance via airways Victor 6 South to Sacramento, and Victor 6 to the Lake Tahoe VOR at 11 000 ft. At 1057 the aircraft made radio contact with flight 802 which was outbound from the Tahoe Valley Airport. The pilot-in-command of that flight reported icing at 12 000 ft, snow showers over the lake and clouds topping the mountains in the area. Flight 901A then requested and was cleared to climb to 13 000 ft amsl and 9 minutes later to 15 000 ft. Estimated arrival time at Tahoe was 1129 hours. At 1114 hours, when the Constellation was about 25 miles southwest of the Lake Tahoe VOR, Oakland ARTCC lost radar contact with the aircraft due to precipitation clutter. Four minutes later the ARTCC controller instructed the flight to hold southwest of the Lake Tahoe VOR and expect further clearance at 1131 hours. The crew acknowledged and reported over the VOR at 15 000 ft. After having contacted the company they advised the controller that they were on top and were going to the south end of the lake as some holes were reported there. The flight also asked for its IFR clearance to be held in case it had to return to the VOR. At 1121 the flight cancelled the IFR clearance as it "could see the south shore". The airline passenger agent stated that the flight did not contact him until 1127 when he gave it the 1100 Tahoe Valley weather which was: estimated ceiling 2 000 ft overcast, 3 miles visibility, snow showers, temperature 32°F, wind 10 kt, altimeter 29.97 in. The agent heard a call from the aircraft at 1129 but could not make contact. This was the last known signal.

A number of witnesses saw or heard the Constellation between 1100 and 11?? . It appeared from testimony that the aircraft made an unsuccessful approach and then disappeared in a snow storm northeast of Lake Tahoe. Other witnesses, including an airline captain and another commercial pilot, stated that the ceiling in the vicinity of the airport was 300 to 700 ft with wind up to 30 kt.

The aircraft crashed at 1129 hours 9 nautical miles northeast of th. airport near the crest of a ridge 8 900 ft high. The first impact was at 8 675 ft amsl on trees and the final impact 120 ft farther at 8 695 ft amsl.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	4	81	
Non-fatal			
None			

1.3 Damage to aircraft

The aircraft was destroyed.

1.4 Other damage

None reported.

1.5 Crew information

The pilot-in-command, aged 45, held a currently effective ATR FAA airline transport certificate with numerous type ratings including Lockheed Constellation aircraft. He also held a flight engineer's certificate and a flight dispatcher's certificate and was the chief pilot of the company. His last proficiency check in Lockheed Constellation was on 13 November 1963. At the time of the accident he had flown a total of 15 391 hours, including 3 266 hours on Lockheed Constellation type aircraft, and had a total instrument time of 1 414 hours. He satisfactorily passed a first-class FAA physical, on 2 November 1963, and had flown 113 hours in the last 90 days.

The co-pilot, aged 28, held a currently effective FAA commercial pilot licence and instrument rating. His last line check was in a Lockheed L-049, on 6 October 1963, and his last 12-month check was on 14 June 1963. He had flown a total of 3 553 hours, including 1 533 hours in Lockheed Constellations, and had a total instrument time of 149 hours. He satisfactorily passed a first-class FAA physical, on 16 January 1963, and his flight time in the last 90 days was 182 hours.

Both pilots were fully qualified for the flight; while the pilot-in-command had made approximately a dozen trips into the Tahoe Valley Airport, including one the day preceding the accident, the co-pilot had made hundreds of flights into that airport and knew the terrain in the area quite well.

The flight engineer held a currently effective FAA flight engineer's certificate and A and P (airframe and powerplant) mechanic's certificate. He had accumulated a total of 3 700 hours as a flight engineer, including 912 hours on Lockheed Constellation aircraft, and he had flown 161 hours in the last 90 days. His last line check was on 4 October 1963 and his last first-class physical was on 1 January 1964.

The flight stewardess, aged 29, had her last line check on 29 September 963.

1.6 Aircraft information

The aircraft's certificate of airworthiness was not mentioned in the report.

Examination of the maintenance records of the subject aircraft revealed 11 reports of malfunctions in the flux gate compass system during the period from 14 June 1963 to 29 February 1964. Discrepancies were reported on both altimeters on the day preceding the accident. Additionally, flight crews said later that they did not always enter in-flight discrepancies on the aircraft log sheets.

Maintenance was performed on both altimeters and the No. 2 flux gate compass transmitter the night before the accident. This work was performed by maintenance personnel who inspected and signed off their own work.

The mechanic who worked on the flux gate compass had performed no previous maintenance on this type of transmitter and did not refer to any available technical publication for guidance. He did not check the complete system or swing the compass after re-installation as required by the maintenance manual. This work was accomplished because the compass had been reported as unreliable in turns on the day preceding the flight.

The day before the accident, the pilot-in-command's altimeter was reported as "sticky", and the co-pilot's altimeter as indicating approximately 100 ft low on the ground. Both altimeters were brought to the maintenance facility where they were checked on a test stand and adjusted. The mechanic who performed this work did not recall securing the barometric scale adjusting screw that he unscrewed as part of the adjustment of the pilot-in-command's altimeter. Both altimeters were installed in the aircraft by a radio mechanic who had never done this kind of work before. He did not pressure check or leak check the Pitot static system after this installation as required by the appropriate maintenance manual.

The anti-icing equipment installed on the aircraft did not comply with the conditions set out in the criteria for operation in icing conditions.

At the time of the accident the aircraft had accumulated a total flying time of 45 629 hours and had flown 104 hours since its last major inspection.

The aircraft's gross weight and centre of gravity were within the allowable limits at the time of departure from San José.

The type of fuel being used was not stated in the report.

1.7 Meteorological information

All of the weather information was available to the Paradise Oakland dispatcher before and during the flight, both at the USWB office at Oakland Airport and on his own service "A" teletype receiver.

The dispatcher testified that he used the current weather sequences and area weather forecast in his briefing of the crew before their departure from Oakland. He stated that he was not aware of an Advisory for Light Aircraft which warned of brief moderate icing in the area the flight would traverse. The dispatcher provided the pilot-in-command with the area weather forecast and current sequences to study during the briefing. No warnings or advisory messages regarding the weather in the Lake Tahoe area were forwarded to the crew while the aircraft was en route. The dispatcher did not notify the crew when information was made available to him indicating that the Tahoe Valley Airport was below company minima.

Evidence indicated that the procedures for reporting the Lake Tahoe weather were unsatisfactory. There was inadequate control over the transmission of weather reports from Lake Tahoe and the Oakland dispatch centre. This, in turn, was reflected in inadequate transmission of Tahoe Valley Airport weather over the service "A" teletype circuit.

Icing was forecast and did exist in the Lake Tahoe area. This was substantiated by pilot reports including the report a company pilot made to the flight while en route to Lake Tahoe. Snow showers were also forecast and reported in the Tahoe area with associated low visibility.

Most of this weather information was available to the crew while en route to the Tahoe area via the scheduled radio broadcasts the FAA makes at 15 and 45 minutes after each hour over en-route navigational radio aids. Finally, the latest Tahoe Valley Airport weather was available to the crew while they were over the Tahoe VOR before they started their descent.

Although the crew indicated they were going to call the company radio station at Tahoe Valley Airport to get the weather, they were off the centre frequency only about 40 seconds. Further, the company agent at the airport testified that they did not call for the weather until approximately two minutes before the crash. Therefore, it is believed that the crew had already attempted an approach at the time this call for weather was made.

1.8 Aids to navigation

There was a VOR at Lake Tahoe. Both of the automatic direction finder (ADF) receivers were tuned to 375 kilocycles. The only navigational aid , with this assigned frequency in the Lake Tahoe area, was the Donner Summit non-directional radio beacon located approximately 8¾ miles northwest of the Lake Tahoe VOR. The VOR receivers were both tuned to the Lake Tahoe VOR frequency.

1.9 Communications

The Paradise Airlines passenger agent at the Tahoe Valley Airport was responsible for communications from the airport to company aircraft. He stated that the crew did not contact him until 1127 hours. At 1129 he heard a radio call from the flight but was unable to establish communications with them. This was the last known transmission from the flight.

1.10 Aerodrome and ground facilities

Not relevant to the accident.

1.11 Flight recorders

Not mentioned in the report.

1.12 Wreckage

The wreckage was located at 0730 hours, on 2 March 1964, by a US Air Force search and rescue helicopter. The wreckage area was 9 NM northeast of the Tahoe Valley Airport near the crest of a ridge of Genoa Peak, Nevada. The crest was approximately 8 900 ft amsl in the wreckage area. This mountain forms the north side of Daggett Pass. The elevation of the top of the pass is approximately 7 300 ft amsl, and it is several miles wide in this area.

The aircraft initially struck several trees on the west slope of the ridge, at approximately 8 675 ft amsl, slightly right-wing-low in a nearly level flight attitude. First ground contact, 120 ft beyond the initial impact point, was at an elevation of 8 695 ft amsl. The wreckage pattern was approximately 900 ft long oriented along a 077° magnetic bearing.

The aircraft sustained extensive breakup, but all major components were accounted for in the primary wreckage area.

1.13 Fire

There was no fire.

1.14 Survival aspects

There were no survivors.

1.15 Tests and research

Ultraviolet light tests were made of recovered instruments in an attempt to determine instrument readings at impact.

2. - Analysis and Conclusions

2.1 Analysis

No pre-impact defects were found in the flight control system.

At the time of impact the landing gear was retracted and the landing flaps were extended 60%. The Paradise Airlines Operations Manual specified 60% flaps for take-off, maximum angle climb performance and when reducing speed for holding or manoeuvring. The elevator, aileron, and rudder boost were on.

The cockpit trim indicators read: elevator trim 3° nose up; rudder trim 3° nose right; and aileron trim 5° right-wing-down.

Due to crash damage, information gained from examination of the flight instruments was limited to the following: the pilot's master direction indicator (MDI) was indicating 217°. The pilot's radio magnetic indicator (RMI) revealed a reading of 086°. The co-pilot's MDI read 092°. The automatic pilot directional gyroscope cards read 145° on the upper card and 315° on the lower card. The flux gate compass transmitters which provide heading information to the MDIs, RMIs, and the automatic pilot were recovered and bench checked. No discrepancies were discovered.

The pilot-in-command's altimeter was recovered with the barometric scale set at 29.93. The internal mechanism and pointers were detached from the gear train and no pointer marks on the instrument face could be observed under black light. (Ultraviolet light tests were made of recovered instruments in an attempt to determine instrument readings at impact. The fluorescent compound on the instrument needles or hands will occasionally leave an imprint on the instrument face which can be detected on exposure to an ultraviolet light.) The barometric scale adjustment screw was found unscrewed sufficiently to prevent locking with the shoulder on the adjusting shaft. If this adjusting screw is not properly seated it is possible to rotate the barometric scale of the altimeter without moving the hands on the instrument to reflect a corresponding change in indicated altitude.

The differences between the RMI and MDI indications and the aircraft's track during the crash suggest an error of 15 or more degrees in the compass system. If this error did exist, prior to impact, it would indicate that the aircraft's actual heading was more northerly (farther left) than the compasses indicated to the pilots. Another factor that could have affected the aircraft was the high velocity wind over the lake which would have pushed the aircraft towards the mountains at a high ground speed. There was no evidence to indicate that the crew was aware of this wind.

The condition of the pilot-in-command's altimeter, as recovered from the wreckage, indicated a pre-impact discrepancy. With the barometric adjusting screw disengaged, it would have been possible for the pilot-in-command to set the barometric dial of the altimeter without affecting the position of the instrument hands. If the aircraft were in a descent at this time, the failure of the rotating hands to properly reposition themselves might easily be overlooked, particularly when the pilot-in-command knew that the altimeter had been sticking and then jumping the previous day. The difference between the barometric setting at San José and that found on the recovered altimeter would have been approximately 280 ft and would have indicated to the pilot that the aircraft was 280 ft higher than its actual altitude.

The installation of one flux gate compass transmitter and the two altimeters was done by mechanics who worked without reference to available, approved maintenance manuals; the compasses were not swung, the Pitot static system was not checked for leaks, and unauthorized personnel "inspected" their own work. The condition of the captain's altimeter, as recovered from the wreckage, with the barometric adjusting screw backed out, indicates that the maintenance man who checked it did not complete his work.

The flight crew's decision to proceed from the VOR to the airport either without, or despite, knowledge of the existing weather was in violation of the company's operating procedures.

If the crew were aware of the weather at Tahoe Valley Airport they should have remained at the VOR awaiting better weather or diverted to Reno. They had been informed of the icing situation encountered by another flight that had departed the airport about one hour earlier. They knew their aircraft was neither authorized nor equipped to fly in any icing condition. It is apparent that after the crew arrived in the vicinity of the Tahoe Valley Airport they were either unable to locate it or if they located it they decided not to land. The decision not to land could have been based on the weather as they observed it or on the below minimum weather reported to them at 1127 hours by the company agent at the airport. The dispatcher's negligence played a part in this sequence also. He did not recommend or urge a diversion of the flight to Reno when he had the 1100 hours Tahoe Valley Airport weather available to him shortly after that time.

When the crew decided to abandon the approach, they took up a heading which they must have known would take them towards the high terrain east of the lake. It is very likely that from their position over the Tahoe VOR they were able to observe the VFR conditions that existed east of Lake Tahoe on the leeward side of the mountains. Additionally, it is assumed that the co-pilot was aware of the existence of Daggett Pass and considered it an access to VFR conditions beyond the Pass. It is further assumed that he knew an altitude of 9 000 ft would provide about 1 500 ft terrain clearance through the centre of the Pass. Further, an easterly heading from the south end of the lake would take the aircraft through the Pass which is several miles wide.

The heading and altitude of the wreckage suggest that the crew established an easterly heading and climbed to an altitude of 9 000 ft. Then, either because they believed they had sufficient altitude to clear the terrain or because they were unable to climb higher due to structural ice, the aircraft levelled off. At that time they struck the first trees and were unable to avoid the final impact with the mountain. Had the flight been 300 ft higher, or 300 yards farther south, they would have cleared the existing terrain and proceeded into VFR conditions. The last factor that could have affected the situation was that the crew could not accurately determine the position relative to the Pass when they took up the final heading. They were in a heavy snow shower over the lake and would have had to depend on some visual observation of the east shoreline to determine their position.

The customary procedure of company pilots in getting out of the Tahoe area after abandoning the landing approach was to climb to a safe altitude and return to the Tahoe VOR, refile an IFR flight plan, and proceed to an alternate airport. The Board could assign no logical reason for the crew's failure to carry out this course of action unless it was an attempt by the crew to avoid a known area of icing through which they had let down on their descent from the VOR.

2.2 Conclusions

Findings

The crew were satisfactorily certificated.

The aircraft was airworthy and properly loaded.

The crew was inadequately briefed on the forecast weather en route to and at the Lake Tahoe area. The crew was released for, and proceeded with, a flight on the basis of an inaccurate weather report. The crew made an approach to the Tahoe Valley Airport without adequate weather information or despite their knowledge of existing weather. The crew operated the aircraft in an area of forecast and reported icing without required anti-icing and de-icing equipment.

Finally, the crew undertook to fly their aircraft over a mountainous area without ensuring themselves of the 2 000 ft terrain clearance required by FAA regulations.

The possibility exists that there was a heading error, an altimeter error and a tail wind that had an effect on the flight which was not detected by the crew.

The fact remains, however, that once having decided to leave the Tahoe Airport area on an easterly heading, the accident would have been avoided had the crew climbed to an altitude of 2 000 ft above the terrain along their intended flight path.

Cause or
Probable cause(s)

The probable cause of this accident was the pilot's deviation from prescribed VFR flight procedures in attempting a visual landing approach in adverse weather conditions. This resulted in an abandoned approach and geographical disorientation while flying below the minimum altitude prescribed for operations in mountainous areas.

3. - Recommendations

No recommendations were contained in the report.

ICAO Ref.: AR/869

No. 14

Hansen Air Activities, DC-3A, N 410D, accident on 8 March 1964 near Chicago-O'Hare International Airport, Chicago, Illinois, USA
Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 2-0002, released 24 February 1965

1. - Investigation

1.1 History of the flight

The aircraft was on a non-scheduled domestic flight from Chicago, Illinois, to Pellston, Michigan, and return. It arrived at Pellston, Michigan, at approximately 2057 hours Central Standard Time for the purpose of returning 28 passengers to Chicago, Illinois. After arrival, the pilot visited the Federal Aviation Agency Flight Service Station (FSS) at the Emmet County Airport/Pellston. He was provided with the 2100-hour sequence weather observations for several points along the route including Chicago-O'Hare International Airport, and filed an instrument flight rules flight plan requesting a cruising altitude of 5 000 ft, via V-193 to White Cloud VOR, V-215 to Muskegon VOR, V-55 to Pullman VOR, V-84 to Northbrook VOR, direct to the Chicago-O'Hare International Airport. Prior to departure the flight received an IFR clearance issued by the Minneapolis Air Route Traffic Control Centre (ARTCC) to the Chicago-O'Hare Airport. It departed Pellston at 2132 hours with 28 passengers and the two-pilot crew. The flight to the vicinity of the Chicago-O'Hare terminal area was described by the pilot as being smooth and uneventful. At 2335:15 hours the control of the flight was transferred from Chicago ARTCC to Chicago Approach Control while the aircraft was at 5 000 ft. At this time radar indicated the aircraft was 7 miles east of the Sturgeon Intersection, and the crew was instructed by Chicago Approach Control to descend to 3 500 ft 15 miles east of the Northbrook VOR. The pilot stated that he then established a 500 ft/min descent utilizing engine power settings of 2 000 rpm and manifold pressure of 21 to 23 Hg. The flight was then informed that it would be provided radar vectors for an ILS approach to runway 14R. After the aircraft departed the Northbrook VOR, the landing gear was extended, power was increased and an indicated airspeed of approximately 115 kt was maintained.

Several other aircraft were also being vectored to land on runway 14R. Among these a Boeing 707 (TWA Flight 83) was being vectored in a turn from 270° to 220° and then to 170°. At 2350:56 hours the Boeing 707 was 2½ miles north of the Romeo Outer Marker descending to 2 500 ft in a left turn to 170°, when the subject aircraft was at 2 500 ft, 4 miles from the Romeo Outer Marker on a heading of 190° until intercepting the ILS localizer course. At 2353:05 hours the crew reported "in a blast of air" and that they would attempt another approach. They were instructed to turn right to 270° and to maintain 2 500 ft. At this time the crew reported they were at 1 500 ft. The approach controller advised the crew of the existence of high radio towers west of the airport and instructed the flight to climb to 2 500 ft. At 2354:40 hours the aircraft was observed on radar to depart the localizer course and reported it was in "very bad air ... almost going down". At approximately 2354:50 the crew reported "... we're coming out of it now but it's very, very bad air". No further communications were heard and at 2356:15 the aircraft disappeared from the radar scope. The aircraft struck the ground in a flat, open area 756 ft amsl and slid on a heading of 238°. The right wing struck a telephone pole and the aircraft finally came to rest against a house. The accident occurred at approximately 2356 hours, 7.5 miles west-northwest of the Chicago-O'Hare International Airport.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	1		
Non-fatal		3	
None	1	25	

1.3 Damage to aircraft

The aircraft was substantially damaged.

1.4 Other damage

The aircraft slid into an occupied dwelling coming to rest with the nose in the rear wall of the attached garage and the left wing embedded in the rear wall of the house.

1.5 Crew information

The pilot-in-command, age 39, held a currently effective airline transport pilot certificate with multi-engine land and DC-3 type ratings. He also held a currently effective airplane and power plant mechanic's certificate. He had flown a total of 5 232 hours flight time including 924 hours in DC-3 aircraft. Of the hours flown on DC-3s, 101 hours were flown as pilot-in-command and 34 hours within the last 90 days.

The co-pilot, age 21, held a currently effective commercial pilot's certificate with single and multi-engine land and instruments ratings and a mechanic's certificate. He had flown a total of 550 hours flight time of which 15 hours were as co-pilot in DC-3 aircraft.

Both crew members held first-class medical certificates with no limitations indicated.

1.6 Aircraft information

No mention is made in the report regarding the aircraft's certificate of airworthiness.

The aircraft had flown a total time of 37 744 hours.

An examination of the aircraft's records indicated that flight time computations and records were incomplete and inaccurate after 26 October 1962 when the aircraft was sold by a scheduled air carrier and registration subsequently passed through five successive owners. The log-books did not reflect the actual engine operating times for the aircraft. Available records indicated the left and right engines had accumulated totals of 1 624 and 1 640 hours, respectively.

At take-off from Pellston the gross weight of the aircraft, as computed during the investigation, was approximately 26 440 lb, i.e. 1 094 lb over the maximum allowable certificated take-off weight, but its centre of gravity was within permissible limits. However, the weight and centre of gravity of the aircraft were both within limits at the time of the accident and therefore were not considered a factor in the accident.

The type of fuel being used was not mentioned in the report.

1.7 Meteorological information

The 2100-hour sequence weather observations indicated ceilings ranging from 1 500 ft obscured in the Traverse City area to 700 ft in the Grand Rapids and Muskegon areas. In the South Bend and Chicago areas the ceilings were 300 to 700 ft. Visibilities were 1.5 miles at Joliet and 4 to 6 miles in rain, fog and smoke at Chicago Midway and Chicago-O'Hare International Airports. The temperature and dew point at Chicago-O'Hare were 35°F and 33°F, respectively.

The briefer at Pellston indicated that the area forecast included a forecast for moderate to heavy icing in clouds. An Aviation Severe Weather Forecast indicated severe thunderstorms along a 60-mile front either side of a line from Vandalia, Illinois, to Jackson, Michigan. Also a SIGMET effective from 1830 to 2230 hours forecast intermittent moderate to heavy mixed icing for central and southern Wisconsin and southwestern Lake Michigan and also possibility of moderate to heavy icing over northern Illinois and south-eastern Lake Michigan. All the above weather information was made available to the pilot-in-command, although he testified he did not recall a forecast of moderate to heavy icing.

The Chicago-O'Hare International Airport special weather observation at 2358 hours was in part as follows: ceiling measured 400 ft overcast, visibility 7 miles in very light drizzle, temperature 34°F, dew point 30°F, wind from 350° at 10 kt.

1.8 Aids to navigation

Not relevant to the accident.

1.9 Communications

Communications were normal until approximately one minute prior to the accident.

1.10 Aerodrome and ground facilities

Not relevant to the accident.

1.11 Flight recorders

Not mentioned in the report.

1.12 Wreckage

The aircraft struck the ground in a flat, open area 756 ft amsl, on a flight path of 238°. The right wing struck a 40-ft telephone pole 3 ft above ground causing damage inboard of the right engine. Contact with the pole caused the aircraft to turn right to a heading of 285° while continuing to travel in a 238° direction.

All major aircraft components were located within the immediate confines of the wreckage site and those components which had separated from the main structure did so as a result of impact.

1.13 Fire

There was no fire.

1.14 Survival aspects

All 28 cabin seats were occupied at the time of impact and remained secured to the floor mountings. None of the seat belts failed. Passengers exited through the main cabin door and the emergency exits.

1.15 Tests and research

None mentioned in the report.

1.16 Vortex turbulence

Vortex turbulence is a part of the air disturbance created by a lifting airfoil. It exists in the wake of all fixed-wing aircraft and is generated at the wing tips by spanwise flow of air from the high pressure side of the wing around the tip toward the low pressure side. Vortex intensity is dependent on airspeed, wing angle of attack, wing span and area, weight, and distance downstream of the wing tip. Persistence of vortex turbulence at a given point, after passage of an airplane, is dependent also on the natural air turbulence at the place and time, persistence decreasing with increased natural turbulence. (See Aircraft Accident Digest No. 11, Part III - "Hazards of the Wake".)

2. - Analysis and Conclusions

2.1 Analysis

Examination of all rudder, elevator and aileron control systems and their associated trim systems revealed no evidence of pre-impact failures or malfunction. Examination of the leading edges of the right wing, right and left horizontal stabilizers, approximately 90 minutes after the accident, revealed an accumulation of mixed rime and clear ice which was extremely rough textured. The base of the ice was approximately three-eighths of an inch thick and there were many projections extending approximately one inch from the airfoil leading edges. An examination of the inner surface of the ice revealed that it was smoothly contoured to fit the leading edge with no cracks or irregularities that would be indicative of de-ice boot actuation.

Examination of both power plants disclosed discrepancies in valve clearance adjustments and improper retaining screws on one propeller dome stop ring.

The electric pump which provides the pressure to pump alcohol to the propeller, carburettor and cockpit windshield de-icing systems was found to be inoperative. Examination of the pump motor after the accident indicated massive corrosion and complete seizure.

Examination of the flight instruments disclosed that the captain's artificial horizon did not meet manufacturer's specifications for setting time limits from pitch attitude of 20° above the horizon to 0°.

During examination of the flight control system, it was found that the two castellated nuts securing clevis bolts, which connect the left aileron main control cables at the left wing to centre section attach point, contained no cotter pins.

With the exception of the condition of the pilot-in-command's artificial horizon, which could have provided the pilot with an inaccurate portrayal of his flight attitude and thus contributed to his inability to maintain flight, no causal relationship between the other potentially hazardous maintenance discrepancies and the occurrence of the accident appears to exist; this notwithstanding the inoperative alcohol pump, for the pilot-in-command testified that he did not attempt to utilize any de-icing or anti-icing system during the approach. However, the above discrepancies reflect the absence of an adequate inspection and maintenance system, and the weather briefing received by the pilot-in-command, prior to departure from Pellston, should have alerted the crew to the possibility of encountering freezing precipitation. Both the subject Dakota and the Boeing 707 were being vectored from the left to runway 14R. The Boeing 707 intercepted the glide slope at 2351:38, while at 2 700 to 2 800 ft amsl, 5 NM from touchdown and 1 NM from the Romeo Outer Marker.

At the same time the Dakota intercepted the localizer course approximately 3.5 NM northwest of the Romeo Outer Marker while at 2 500 ft. At 2352:38 it was at the same geographical position and at an altitude approximately 250 ft lower than the jet had been one minute earlier.

Considering the atmospheric condition just prior to the accident, the velocity within the jet's vortex trails, one minute after the vortex was shed, would be approximately 10 ft/sec or 600 ft/min. The rate at which the vortices would move downward perpendicular to the wing would be 4.4 ft/sec or 264 ft/min.

The vortices created by the jet aircraft would have settled about 260 ft by 2352:38. At the same time, because of the light wind from the northwest, they would have drifted southeast along the localizer course approximately 1 500 ft or one-quarter nautical mile. As a result, the turbulence would be at the altitude of the Dakota and along a course where it would be penetrated approximately 1.25 to 1.5 nautical miles northwest of the Romeo Outer Marker. At this point, vortex turbulence caused the Dakota to make an abrupt roll to the right with a subsequent loss of altitude.

It was apparent that during this approach the aircraft was accumulating airframe ice. Below-freezing temperatures existed from approximately 1 000 to 2 500 ft amsl and at altitudes above 5 000 ft amsl. Moderate icing would have been encountered in clouds in the sub-freezing zones. The pilot of another aircraft approximately 4 minutes behind the Dakota testified that northwest of the Romeo Outer Marker at 2 500 ft he experienced fast accumulation of from 1 to 1½ inches of rime ice between a point 8 NM northwest of the Romeo Outer Marker at 2 500 ft and the middle marker at 1 100 ft.

No anti-icing or de-icing equipment was activated by the crew of the Dakota since they were unaware of the ice accumulation. Since the crew failed to recognize the icing situation they did not correct for the increase in stall speed which resulted. It is difficult to determine when ice began to accumulate on the airframe, but its effect began when vortex turbulence was encountered. While the icing was a factor in aircraft control, the amount accumulated would not have prevented operation of the aircraft if power had been added and airspeed maintained. The ice could have been removed w the use of wing de-icing boots.

The transition from the rolling condition caused by the vortex turbulence and low airspeed to the rolling resulting from the partial stall was not recognized by the pilot-in-command. Statements by him indicated that attempts to utilize more engine power resulted in control difficulties. However, the Board was unable to reconcile these statements with known aircraft response.

Both engines were operating at impact and, if utilized in conjunction with the proper aircraft attitude/airspeed combination, sufficient power should have been available to sustain normal flight. The short distance travelled after ground impact confirmed an extremely low ground speed at impact and the lack of appreciable surface wind resulted in the airspeed and ground speed being nearly the same.

2.2 Conclusions

Findings

The crew members were properly certificated.

No mention was made in the report of the aircraft's certificate of airworthiness. The aircraft was over the maximum allowable certificated take-off weight of 26 346 by 1 094 lb. However, the weight and centre of gravity were not considered factors in the accident.

The weather briefing received by the pilot-in-command prior to departure from Pellston should have alerted the crew to the possibility of encountering freezing precipitation. During the approach the aircraft accumulated airframe ice and entered vortex turbulence from a Boeing 707.

Although the pilot-in-command possessed the required FAA certificate, his actions showed a lack of familiarity with flight in icing conditions. He apparently became confused because of the vortices, the effect of the unknown accumulation of airframe ice, and the difficulty in maintaining airspeed. As a result, he failed to take proper action to stop the aircraft's descent prior to ground impact.

Cause or Probable cause(s)

The probable cause of this accident was the failure of the crew to utilize available de-icing equipment and engine power to maintain positive control of the aircraft under conditions of rapid airframe ice accretion and vortex-induced turbulence.

3. - Recommendations

No recommendations were made in the report.

ICAO Ref.: AR/875

No. 15

Líneas Aéreas Taxader, DC-3, HK-862, accident near Facatativá, Colombia, on 8 March 1964. Report, dated 12 November 1964, released by the Administrative Department of Civil Aeronautics, Colombia

1. - Investigation

1.1 History of the flight

The aircraft took off on a scheduled domestic flight at 1724 hours local time from Matecaña Airport at Pereira City for Eldorado Airport carrying 33 persons including 3 flight crew members. At 1727 hours the crew informed Route Control that it was climbing in the Pereira area and expected to pass El Paso at 1745 hours at an altitude of 13 500 ft. At 1751 hours it reported over El Paso estimating Girardot at 1809. At 1810 hours it reported over Girardot. It was then cleared by Bogotá Control to proceed to La Esperanza intersection, maintaining 13 000 ft with an altimeter setting of 30.18 in. This was acknowledged by the aircraft which reported over La Esperanza intersection at 1818 hours, and was instructed to hold over the intersection at that altitude. It was cleared to leave La Esperanza intersection at 1833 hours maintaining 13 000 ft and to report over the Bogotá VOR. This was acknowledged by the aircraft and two minutes later it reported that it had left the intersection and was estimating over the VOR at 1844. It was then instructed to descend from 13 000 to 12 000 ft and cleared to make an ADF approach to Eldorado Airport reporting over Bogotá VOR at 12 000 ft and over the outer marker at 9 800 ft. At 1839:30 hours Bogotá Control asked the aircraft if it still estimated the VOR at 1844 and was given a new ETA of 1841. Bogotá Control requested the aircraft to try to be "inbound" at 1844 hours in order to initiate descent. At 1841:45 the flight reported abeam Bogotá VOR at 12 000 ft. Bogotá Control acknowledged and instructed it to maintain 12 000 ft until 1844 hours. At 1842:15 hours the flight reported sighting what appeared to be a DC-4. This was in fact a Curtiss C-46 which had been cleared for final approach about 4 minutes earlier. Nothing further was heard from the aircraft despite repeated calls from Bogotá Control. The aircraft was subsequently found in a field near the town of Facatativá, 3 miles from the Bogotá VOR on a bearing of 140°. The accident occurred between 1842:30 and 1845 hours local time.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	5	28	
Non-fatal			
None			

1.3 Damage to aircraft

The aircraft was completely destroyed by fire.

1.4 Other damage

None mentioned.

1.5 Crew information

The pilot-in-command had a valid pilot's licence with an instrument rating on DC-3 aircraft. He had flown as pilot-in-command on DC-3s during the preceding 90, 30 and 10 days and also on DC-4s and C-46s prior to the accident. Examination of the records showed that he tended to neglect flight discipline. His medical certificate was valid up to 2 December 1964.

The co-pilot also held a valid pilot's licence with an instrument rating on DC-3 aircraft. His medical certificate was valid until 3 September 1964.

The flying experience of the pilots was not mentioned in the report.

There was also a stewardess aboard the aircraft. A 30-day permit had been issued for her to fly for 30 hours as observer and receive instruction in emergency equipment with a view to obtaining a flight auxiliary licence. She could only discharge flight duties under the supervision of duly licensed staff.

1.6 Aircraft information

The aircraft had a valid certificate of airworthiness. It had flown a total of 23 533 hours, including 802 hours since the last overhaul which was completed on 28 October 1963. The maintenance records of the powerplants indicated that the period of operation since last major overhaul was within the limits.

The gross weight of the aircraft at take-off was 11 503 kg, i.e. 72 kg in excess of the maximum take-off weight authorized for passenger transport operations.

The centre of gravity was 27.8% of the MAC which is within the permitted limits but near the aft limit of 28%.

The type of fuel being used was not stated in the report.

1.7 Meteorological information

None contained in the report.

1.8 Aids to navigation

The only aid mentioned in the report was a VOR at Bogotá. There was no indication that it was not operating normally at the time of the accident.

1.9 Communications

All communications between Bogotá Control and the aircraft were normal and clear until the last message at 1842:30 hours. No distress call was received from the aircraft.

1.10 Aerodrome and ground facilities

Not relevant to the accident.

1.11 Flight recorders

None mentioned in the report.

1.12 Wreckage

The accident site was located near the municipality of Facatativá, 3 miles from the Bogotá VOR on a bearing of 140°. The site was 8 497 ft amsl and located in flat, cultivated land. The wreckage was scattered in a straight line over a distance of 170 m on a bearing of 340° from the point of initial impact.

1.13 Fire

There was a fire after impact as a result of escaping fuel.

1.14 Survival aspects

No information contained in the report.

1.15 Tests and research

On 14 May 1964 the circumstances of the flight were reconstructed with a C-46 and a DC-3 commencing at about 1700 hours. In this exercise the flights made on 8 March were simulated with due observance of the times at which the various events occurred. Two trials were made. The first went through all the normal procedures and the second simulated the normal situation as it occurred on 8 March. The conclusion reached was that the separation had been adequate. In both trials the C-46 only took one minute and 15 seconds to execute the 180° turn on the VOR BOG and align itself on the outer marker.

2. - Analysis and Conclusions

2.1 Analysis

A study of the distribution of the debris showed that the aircraft struck the ground in an attitude of descent at high speed and with a steep bank to the right.

The powerplants were completely destroyed on impact. However, the state of the interior of the cylinder heads and associated spark plugs as well as the piston heads indicated that the engines were functioning normally. No evidence was found of pre-ignition or detonation. None of the witnesses in the vicinity of the accident heard any explosion or detonation of engines, and they all agreed that the engine noise was normal or similar to the characteristic noise of aircraft flying over that area. Also, none of them remembered having seen flames or fire in the aircraft and/or engines prior to collision with the ground. Most of the cylinder heads were detached from the cylinders which indicated that the engines were developing more than normal cruise power. The rpm corresponded to normal cruise with a little more manifold than was required.

The way in which the propeller blades were broken and the reduction gear stripped on both propellers indicated that they were functioning normally at the time of the accident.

No evidence was found indicating a failure of the control surfaces.

According to the statements of eyewitnesses, the navigation lights of the aircraft were on at the time of the accident and it was, therefore, concluded that there was no failure of the electrical system prior to the accident.

The ADF equipment of the aircraft was not recovered from the wreckage. However, the course of the flight suggested that this equipment was functioning normally until the aircraft was abeam the Bogotá VOR, and it was concluded that the ADF equipment functioned normally up to the time of the accident.

Careful consideration of the damage sustained by the aircraft, in conjunction with the fact that the angle of dive was approximately 30°, appeared to indicate that the speed of the aircraft just prior to impact was probably close to maximum.

When the pilot saw another aircraft slightly below and to the left of his own glide path he made a sharp turn to the right, probably in a climbing attitude. During this turn the aircraft lost speed and it was assumed that the pilot not only decreased the angle of attack of the aircraft but also increased power. There was evidence at the accident site that the engines were functioning at a higher rate than normal cruise before the accident.

Bearing in mind that the turn must have been initiated fairly abruptly, this sudden change of attitude in instrument meteorological conditions could hardly fail to produce some dizziness of the pilot. Under these conditions, it was believed that the aircraft assumed an abnormal nose-down attitude in a right turn and that the pilot was unable to recover in time to avoid collision with the ground.

In addition the fact that the pilot had been flying on other types of aircraft, such as C-46s and DC-4s, must have had a psychological effect on the pilot who reacted in a way which brought the aircraft into an abnormal attitude when he initiated the turn.

In the opinion of other DC-3 pilots of the Company, the location of the artificial horizon makes instrument flying difficult since this instrument is virtually hidden by the control column. This factor must also be included among the difficulties which faced the pilot in his efforts to control the attitude of the aircraft during the initial phase of the turn.

2.2 Conclusions

Findings

The crew were satisfactorily certificated.

The aircraft was airworthy and properly loaded.

No evidence of malfunctioning or failure of the aircraft, its engines and its ADF equipment was found.

The pilot-in-command, seeing another aircraft in close proximity and not knowing that the other aircraft had him under visual control, took abrupt evasive action, making a climbing turn to the right. Realizing that he was losing speed he probably increased engine power and, at the same time, he decreased the angle of attack of the aircraft. This resulted in an abnormal position (right turn with nose down below the horizon) which was not recognized and/or rectified in time to prevent a collision with the ground.

Cause or
Probable cause(s)

The pilot of the aircraft in observing the presence of another aircraft abruptly initiated a right turn which ended in an abnormal "nose below the horizon" attitude, which he was unable to rectify in time.

Contributing factors:

Error of other personnel - The pilot of the other aircraft initiated the instrument descent from 12 000 ft after 2 min 55 sec, when the normal time would have been 1 min 15 or 20 sec, in accordance with the procedures laid down in the Bogotá approach-to-land chart and the Manual of Colombian Air Routes approved by the Administrative Directorate of Civil Aeronautics, thereby creating a risk of collision in the air.

Other causes - The pilot of the subject aircraft had been flying on DC-4s and C-46s as well as DC-3s. The psychological reaction of the pilot at a critical moment was certainly affected by habits acquired on DC-4 and C-46 aircraft.

Possible failure of equipment - (faulty distribution of flight instruments in the cockpit). This is a design effect, since the artificial horizon in the subject type of aircraft was hidden behind the pilot's control column, which made it more difficult to control the flight posture of the machine.

3. - Recommendations

The Board recommended:

1) that the Administrative Department of Civil Aeronautics instruct commercial airlines, flying schools, aeroclubs, etc. to include in their instrument flight manuals techniques and procedures for recognizing and recovering an aircraft from an abnormal attitude;

2) that the Administrative Department of Civil Aeronautics notify all airlines operating in the country to stress to their pilots the need for strict observance of the Standards and Procedures of approach-to-land charts established in the Manual of Colombian Air Routes;

3) that civilian pilots engaged in the transport of passengers and cargo be restricted to fly on one aircraft type only;

4) that airlines be recommended to position the flight instruments on the instrument panel in such a way as to facilitate reference to them;

5) that a copy of the narrative part of the inquiry report be transmitted to Taxader.

ICAO Ref.: AR/898

No. 16

Slick Airways Division, Douglas C-54B-DC, N 384, accident at Castle Island, Boston, Massachusetts, USA, on 10 March 1964. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0003, released 5 November 1964.

1. - Investigation

1.1 History of the flight

Flight 12 was a scheduled domestic cargo flight from John F. Kennedy International Airport, New York to Logan International Airport, Boston, with a stop at Bradley Field, Windsor Locks, Connecticut. The trip to Bradley Field was routine. While on the ground, a crew member telephoned the FAA Flight Service Station at the airport and requested and received the Bradley and Boston sequence reports and the Boston terminal forecast. The flight departed Bradley Field at 0735 hours Eastern Standard Time. At 0801:49 hours it contacted Boston Approach Control and was cleared to the Walpole Intersection via Franklin and Victor 16 to maintain 3 000 ft and to expect a clearance for an approach to runway 4R. At 0803:27 it reported that it was encountering rain and moderate rime icing at 3 000 ft and that the outside temperature was about 4°. Three minutes later the flight reported at the Franklin Intersection and was instructed by Approach Control to turn to 090° for a radar vector for an ILS approach. A new heading of 070° was given to the flight at 0809:36 hours and, in acknowledging this, the crew requested a lower altitude. The aircraft was immediately cleared to descend to and maintain 2 000 ft. The flight reported leaving 3 000 ft and that there was "moderate to heavy" rime icing. At 0811:34 hours the flight reported reaching 2 000 ft whereupon the controller advised it that radar contact had been established 18 miles southwest and cleared the flight for an ILS approach to runway 4R. At 0813:56 the flight was vectored to 050° and its position was given as being 9 miles southwest of the outer marker. At 0815:05 the air traffic controller advised the approach controller that the visibility was 1½ miles, but this information was not relayed to the aircraft. At 0816:29 hours the flight was advised that its position was 5 miles southwest of the outer marker; that radar advisory services would be provided on 110.3 mc and was instructed to contact the tower on 118.1 mc. Ten seconds later contact was established with the air traffic controller who instructed the flight to report passing the outer marker and provided information concerning field conditions and braking action.

After reporting the outer marker inbound at 0818:52 hours the flight was cleared to land and was requested to report when the field was in sight. The following advisory information was transmitted by the Precision Approach Radar (PAR) controller on 110.3 mc to the flight at the times indicated: passing outer marker course and glide path OK (0818:57); 5 miles from touchdown 125 ft above glide path (0819:12); 4 miles from touchdown, 100 ft above glide path (0819:42); 3 miles from touchdown, course and glide path OK (0820:11); 2 miles from touchdown, 150 ft right of course, 50 ft above glide path (0820:46). At 0821:09 the PAR controller advised the flight that it was "passing the stacks at Castle Island.*" The controller later stated that at this point in time and space, the aircraft was on course and glide path. At about 1 to 1½ miles from touchdown the aircraft's target disappeared from both the elevation and azimuth radar scopes. At 0821:20 the PAR controller transmitted the following: "Slick 384, I've lost radar contact with you. Radar advisories terminated." The local controller then observed a large ball of flame emanating from the

* A well-known landmark, tall stacks on an industrial plant.

ground at Castle Island. The aircraft crashed at 0821:35 hours in a lumberyard approximately 7 000 ft from the displaced threshold of runway 4R and on the extended centre line of that runway.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	3		
Non-fatal			
None			

1.3 Damage to aircraft

The aircraft was demolished by impact forces and the ensuing fire.

1.4 Other damage

None.

1.5 Crew information

The pilot-in-command, aged 39, held a currently effective airline transport pilot's certificate. He was qualified in Curtiss-Wright C-46, DC-4, DC-6, DC-7 and Lockheed Constellation aircraft. He had flown a total of 6 000 hours, including 814 hours on DC-4 aircraft. His last first-class FAA physical examination was successfully taken on 13 February 1964. His last line check was accomplished on 30 April 1963 and his last proficiency check was accomplished 5 October 1963.

The co-pilot, aged 35, held a currently effective commercial pilot's certificate with airplane single and multi-engine land and instrument ratings. He had flown a total of 5 824 hours including 4 340 hours on DC-4 aircraft. His last first-class physical examination was accomplished 14 August 1963. His last proficiency check was accomplished on 17 September 1963. He was in the pilot-in-command's seat at the time of the accident.

The third crew member was a freight handler.

The activities of the crew prior to and during the flight did not indicate anything out of the ordinary other than that their on-duty time had been 15 hours and 33 minutes. According to Civil Air Regulations a pilot cannot be on duty more than 16 hours in any 24-hour period.

1.6 Aircraft information

Maintenance had been performed in accordance with approved company and FAA procedures and the aircraft was in an airworthy condition at the start of this flight.

The gross take-off weight of the aircraft was 57 048 lb, well below the maximum allowable gross take-off weight of 73 000 lb. The cargo was properly secured. The centre of gravity of the aircraft was within prescribed limits.

The type of fuel being used was not stated in the report.

1.7 Meteorological information

In preparing for the flight at New York a crew member was briefed by telephone from the U.S. Weather Bureau. This briefing included the Boston terminal forecast for the period 0200 to 1200 which indicated expected ceilings 400 - 600 ft, overcast, visibilities 1 - 3 miles, fog, light drizzle or rain. The weather briefer said that he also included the latest pertinent weather sequences and advised that freezing or frozen precipitation would occur north of the intended route. The company's station clearance and flight plan form for this flight contained weather sequence reports and forecasts; no mention of freezing or frozen precipitation was made.

It was believed that the Boston terminal forecast received by the crew at Bradley Field was the same as the aforementioned.

The 0800 Boston weather observation passed to the flight at 0801:49 hours was: 400 ft scattered, measured 700 ft overcast, visibility $2\frac{1}{2}$ miles, light sleet and fog, temperature 32°, dew point 32°, wind 050° 20 kt, gusts to 30 kt, altimeter 29.73. This message was acknowledged.

The Boston weather just after the accident was: scattered clouds at 400 ft, overcast at 700 ft, surface visibility $1\frac{1}{2}$ miles in moderate sleet and fog, wind 050° (true), 22 kt, gusts to 28 kt, temperature 32°, dew point 32°.

1.8 Aids to navigation

All navigational equipment was operating within prescribed tolerances.

1.9 Communications

The PAR controller was in contact with the flight up until the time of the accident.

1.10 Aerodrome and ground facilities

No information contained in the report.

1.11 Flight recorders

No information contained in the report.

1.12 Wreckage

The wreckage was spread over an area 375 ft long and 200 ft wide.

1.13 Fire

There was heavy fire damage.

1.14 Survival aspects

No information contained in the report.

1.15 Tests and research

The medical examiner did not find any indication that the crew was incapacitated prior to the accident.

2. - Analysis and Conclusions

2.1 Analysis

Evidence revealed that the co-pilot was seated in the left-hand seat at the time of the accident and that the aircraft struck the ground in a 60° nose-down attitude approximately, on a magnetic course of 48°. All of the aircraft and its components were found on the accident site.

From the extension of the elevator jackscrew it was determined that the elevator trim was 5 - 6° nose-down at time of impact. The extension of the flap and its actuating strut pistons indicated that the flaps were extended about 30°. The full-down position of the flaps is 45°.

The landing gear was down and locked. No evidence was found to indicate any malfunction or failure prior to the accident.

The pilot-in-command of another flight who was obliged to hold at the outer marker at 2 000 ft altitude, because of the accident, testified that he met icing conditions in the holding pattern. On each of four or five complete circuits he made the side windows of the aircraft became covered with ice when approaching the outer marker, but on the southwest end of the pattern the ice on the unheated side windows slid off and the windows were clear.

It was believed that the subject aircraft began to accumulate airframe icing of moderate intensity because of freezing precipitation in the clouds at 3 000 ft between Putnam and the Franklin intersection shortly before 0800. At about 0803 the flight reported moderate icing. A short time after 0809 this icing condition would have increased in intensity from moderate to heavy rime ice and was so reported by the aircraft when leaving the 3 000 ft level for 2 000 ft. From this time until the aircraft was over Castle Island it was believed that moderate to heavy rime icing conditions continued.

A propeller slash mark in the lumber stack indicated that the aircraft struck the ground at a nose-down pitch angle of approximately 60° with the horizontal; also, that the aircraft was approximately 480 ft amsl when the pitch-over began and that the horizontal distance from this point in space to the point of impact was approximately 780 ft. Timing of certain known investigative data produced a ground speed of about 108 kt from the outer marker inbound. Applying the wind, the true airspeed was about 130 kt and with the existing temperature, calibrated airspeed would also be about 130 kt.

It was calculated that the aircraft, in order to attain a pitch attitude of 60° in the vertical and horizontal distance available, had to execute a pitch-over manoeuvre at or near its maximum capability. It was further calculated that this manoeuvre, a negative accelerated stall, produces about -1.4g.

From witnesses' statements and physical evidence it was concluded that the aircraft did not just get too low on the approach. It was also concluded that the aircraft did not execute a 1.0g stall or experience serious power failure because a stable aircraft would not, from such causes, assume the attitude it did. Furthermore, the aircraft struck the ground near the heading necessary to fly from the outer marker to runway 4R, thus ruling out any appreciable roll or yaw in the final manoeuvre.

While changes in centre of pressure of the wing may cause small perturbations in pitch, only changes in horizontal tail load can produce sustained and/or high normal accelerations (angular velocities). Since this aircraft was not equipped with sophisticated systems such as electric or hydraulic trim, pitch trim compensators, control boost or auto-pilot, the possible sources of the manoeuvre can be reduced to three:

1. Pilot action.

2. Separation or serious and widespread distortion of the horizontal tail.

3. Loss of lift (negative) on the horizontal tail by disturbance of the airflow.

A complete lack of motive eliminated No. 1, and physical evidence in the examination of the wreckage eliminated any possibility of No. 2.

There are several ways in which airflow on the stabilizer can be disturbed to the point of destroying lift, but ice accretion seems to be the only one which fits the circumstances.

In general, icing of an airfoil at low angles of attack is detrimental to the aerodynamic characteristics. Icing causes large increases in section drag coefficient (increases as high as 350% in 8 minutes of heavy glaze icing have been recorded), reductions in section lift coefficients (up to 13%) and changes in the pitching moment coefficient from diving to climbing moments. Rotation of an airfoil to angles of attack higher than that at which icing occurred generally creates an even greater loss of lift than if the airfoil iced when at higher angles of attack.

Testimony of the company's Eastern Division Chief Pilot was elicited with respect to procedures and techniques which would be employed when flying under conditions similar to those encountered by the flight. A build-up of ice on the wings would necessitate additional airspeed. This accounted for the excessive 130 kt airspeed held throughout the approach. He further said that ice of any magnitude on the wings would also cause the aircraft's nose to pitch up, and accordingly a nose-down trim would be in order. This condition was reflected by the position of the elevator trim jackscrew of the aircraft. He also said that it is entirely possible that the crew of the subject aircraft lowered flaps to 15° at the outer marker and may not have lowered them further until assured of a completed approach by seeing the approach lights. Since the visibility at the time of the approach was reported to be 1½ miles, the Board believed that the pilot could have seen the approach lights from over Castle Island and in all probability did lower the flaps as suggested by the Chief Pilot.

With ice on the stabilizers, the increased negative angle of attack caused by flap extension to 30° could have been sufficient to destroy tail load. This would induce a serious nose-down pitching moment. If the ensuing aircraft rotation is severe enough, or for sufficient duration, recovery at low altitude would be impossible.

2.2 Conclusions

Findings

The crew members were satisfactorily certificated.

The aircraft was airworthy and properly loaded. No evidence of malfunction or failure of the aircraft prior to the accident was found.

The aircraft collected ice, particularly on its tail, during the flight to Boston and especially during the approach.

15° of flap extension was used from the outer marker inbound and "abeam the stacks" the flaps were further extended to 30°.

The increased downwash resulting from the latter flap extension changed the stabilizer angle of attack to a position which, coupled with ice formation, destroyed the tail lift, thereby disrupting the aircraft's necessary balancing tail loads.

The resultant pitch-over was too severe at the aircraft's altitude for the crew to effect recovery.

Cause or Probable cause(s)

The probable cause of this accident was loss of balancing forces on the horizontal surface of the aircraft's empennage, due to ice accretion, causing the aircraft to pitch nose-down at an altitude too low to effect recovery.

3. - Recommendations

None were contained in the report.

ICAO Ref.: AR/849

No. 17

KLM, DC-7C, PH-DSN, accident at Geneva/Cointrin Airport, Switzerland, on 11 March 1964. Report No. 1964/8/172, dated 13 August 1964, released by the Federal Board of Inquiry into Aircraft Accidents, Switzerland

1. - Investigation

1.1 History of the flight

Flight KL 331 was a scheduled international flight from Amsterdam to Geneva. The flight took off from Amsterdam at 1028 hours GMT, half an hour behind schedule, with a crew of six and twenty-five passengers on board. The flight was uneventful and at 1201 hours it passed over the Jura range at an altitude of 7 000 ft. At this point the flight was cleared to descend for an instrument approach to runway 23 and was given the latest Geneva weather report as at 1150 hours. The pilot-in-command who was steering towards Gland NDB on a magnetic heading of 140° decided to cut short the normal descent procedure in an attempt to gain time. Just before Gland NDB he initiated a slight turn to the right and intercepted the ILS glide path beam between 7 000 and 6 000 ft at an angle of approximately 60°. Although perfect in azimuth, the approach was initiated about 2 000 ft too high, with the result that the aircraft failed entirely to find the glide path beam despite the information supplied by the precision radar (see Figure 17-1). Having reached the minimum altitude, the pilot ordered re-application of power to execute a missed approach, but shortly afterwards the co-pilot reported the runway in sight. The pilot then throttled back and landed on the last segment of the runway. As a result of this the aircraft over-ran, collided with the blast fence and came to rest 20 m beyond. The accident happened at approximately 1209 hours in fog.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal			
Non-fatal			
None	6	25	

1.3 Damage to aircraft

The aircraft was seriously damaged by the collision with the blast fence. The cost of repairs was estimated at 175 000 Swiss francs.

1.4 Other damage

The blast fence was destroyed (5 000 Swiss francs).

1.5 Crew information

The pilot-in-command, aged 40, held an airline transport pilot's licence valid until 16 July 1964 and a DC-7 rating. He had flown a total of more than 13 000 hours, including about 2 300 hours on DC-7Cs. His last proficiency test was on 14 December 1963.

The co-pilot, aged 32, held an airline transport pilot's licence valid until 24 April 1964 and a DC-7 rating. He had flown a total of more than 8 000 hours including about 2 900 hours on DC-7s.

The flight engineer was 36 years old. No information regarding his experience or training was included in the report.

Also aboard were 3 cabin staff.

1.6 Aircraft information

The aircraft had an airworthiness certificate which was valid until 9 October 1964. There was no reason to suppose that the aircraft was not airworthy at the time of the accident.

The maximum allowable landing weight was 50 394 kg, and the actual landing weight was approximately 45 800 kg. The centre of gravity was within the prescribed limits.

The type of fuel being used was not stated in the report.

1.7 Meteorological information

The local situation at Geneva was characterized by thick cloud, snow and rain precipitation, little or no wind. The 1150 GMT weather report was: wind calm, horizontal visibility 600 m, snow precipitation, vertical visibility 300 ft, temperature +1, QNH 1013, QFE 962, runway visual range 1 200 m.

1.8 Aids to navigation

Runway 23 is equipped with an ILS consisting of a localizer and glide path transmitter as well as middle and outer markers. The glide path transmitter beam is set for an approach angle of 3^{o}. The outer marker is located 3.93 NM from the threshold of runway 23, and the middle marker 0.53 NM from the same point. Versoix (OG) NDB is situated half-way between the outer and middle markers.

The perpendicular from an NDB located 11.7 NM from the threshold of runway 23, in the vicinity of Gland, intercepts the extended runway centre line at "Point Papa" (initial approach datum) at a distance of 3 NM from the beacon.

Runway 23 is served by a precision approach radar working on a wavelength of 3 cm and equipped with two screens having ranges of 12.5 and 2.5 NM. The 2.5-NM screen is fitted with a camera, which is switched on whenever an approach is executed in conditions of visibility and ceiling below 2.5 NM or 600 ft, respectively.

1.9 Communications

The crew was in contact with the PAR operator up until the time of the accident.

1.10 Aerodrome and ground facilities

Runway 23 is 3 900 m long and 50 m wide, and the elevation of the threshold is 416 m. The theoretical point of impact is located 300 m after the threshold.

A wooden blast fence, painted red and white, equal in length to the width of the runway and comprising a triangular section 160 cm high at 210 cm along the base, is located on the grass 40 m beyond the end of runway 23.

Approach area 23 is equipped with a 5-bar Calvert lighting system 750 m long, consisting of high-intensity unidirectional white lights and low-intensity omnidirectional red lights. The first bar of 16 lights is located 200 m southwest of the middle marker.

The runway is illuminated by a combination of adjustable high-intensity bidirectional and low-intensity omnidirectional lights. These lights are 30 m apart and are white, except for the final 600 m of the runway where they are yellow.

The threshold and end of the runway are marked respectively by a row of green, and a row of red, lights which are likewise high-intensity bidirectional and low-intensity omnidirectional.

The touchdown zone is also equipped with two rows of inset lights on either side of the centre line over a distance of 900 m. These lights are white and have a lateral spacing of 22 m and a longitudinal spacing of 62 m.

1.11 Flight recorders

Not mentioned in the report.

1.12 Wreckage

Not relevant.

1.13 Fire

There was no fire.

1.14 Survival aspects

Not mentioned in the report.

1.15 Tests and research

None mentioned in the report.

1.16 Regulations

When visibility is less than 5 km or the ceiling below 1 000 ft, ILS approaches are monitored by precision approach radar (AIP RAC 1-4-5).

Pilots are advised of deviations from the descent path if the following tolerances are exceeded:

- azimuth displacement of 2° (424 ft at 2 NM) to left or right of the runway centre line;

- displacement of 1/2° above or below the nominal glide path (the maximum tolerated deviation is 265 ft at 5 NM and 106 ft at 2 NM).

The obstacle clearance limit for runway 23 at Geneva/Cointrin Airport is established at 230 ft (70 m) above the touchdown zone (416 m amsl) (AIP RAC 3-1-11).

The Company's meteorological minima for an ILS approach at Geneva are visibility 600 m, ceiling 60 m (measured from the reference elevation of the airport: 430 m asl).

2. - Analysis and Conclusions

2.1 Analysis

During the approach the co-pilot, who had the task of monitoring the instruments and informing the pilot-in-command as soon as visual contact was made with the ground, had a first glimpse of the ground - but not of the Calvert lighting system - in the vicinity of the middle marker. When the pointer of his altimeter, set at QNH 1013 mb, reached the 1 600 ft (230 ft/ground) mark, he shouted "Limit" and at the same time heard the word "Overshooting" in his headset. As the ground was not yet in sight, the pilot-in-command gave the order to the flight engineer: "Take-off power". The flight engineer then re-applied power, but just as he was completing this manoeuvre the co-pilot announced "I see lights". The pilot-in-command then turned away from his instruments and saw the runway in front of him, bounded by two rows of lights. Believing that he was at the head of the runway, he himself pulled back the throttle and landed. Assuming that he had sufficient length of runway available, he was suddenly surprised to see the end of the runway appear 300-400 m in front of him. He tried by every possible means to brake the aircraft in time, but the manoeuvre did not succeed.

According to the aircraft flight manual the landing distances of the DC-7C with a normal weight of 45 800 kg and with normal braking conditions on runway 23 at Geneva Airport in weather conditions similar to those prevailing on the day of the accident were estimated as follows:

- total distance on dry runway from a height of 50 ft: 900 m

- distance of ground roll on dry runway: 420 m

- distance of roll on wet runway: 500 m

It was not possible to establish accurately at what point the aircraft touched the ground. The distance of roll to be expected (500 m) and the evidence showing that the aircraft when it was opposite the control tower, i.e. about 700 m from the end of the runway, had not yet touched down, make it very probable that the point of impact was located in the final 500 m.

The decision to land taken by the pilot-in-command on merely observing the edge of the runway was unjustified. He could count on a long stretch of runway, but having executed the entire approach too high and bearing in mind that neither he nor the co-pilot had seen the threshold lights, he should have realized that a considerable portion of the runway was already behind him. He could not possibly have known exactly where he was; as the instrument approach had been missed, the preferred course of action would have been to stick to his earlier decision to go around.

The fact that throughout the instrument approach the aircraft at no time entered the glide path transmitter beam must be attributed primarily to the pilot's desire to gain time by curtailing the prescribed descent procedure. The critical meteorological conditions should have also been taken into consideration. If the attempt was nevertheless made, the very utmost prudence should have been observed in the subsequent stages.

2.2 Conclusions

Findings

The crew were satisfactorily certificated and experienced.

The aircraft was airworthy. Its weight and centre of gravity were within the prescribed limits.

There was fog at the time of the accident.

The approach was initiated too high so the aircraft failed to find the glide path beam despite the information supplied by the precision approach radar.

Having reached the minimum altitude the pilot ordered re-application of power to abandon the approach and to overshoot. The co-pilot then reported runway in sight. The pilot-in-command landed the aircraft on the last segment of the runway and over-ran, crashing into a blast fence.

Cause or
Probable cause(s)

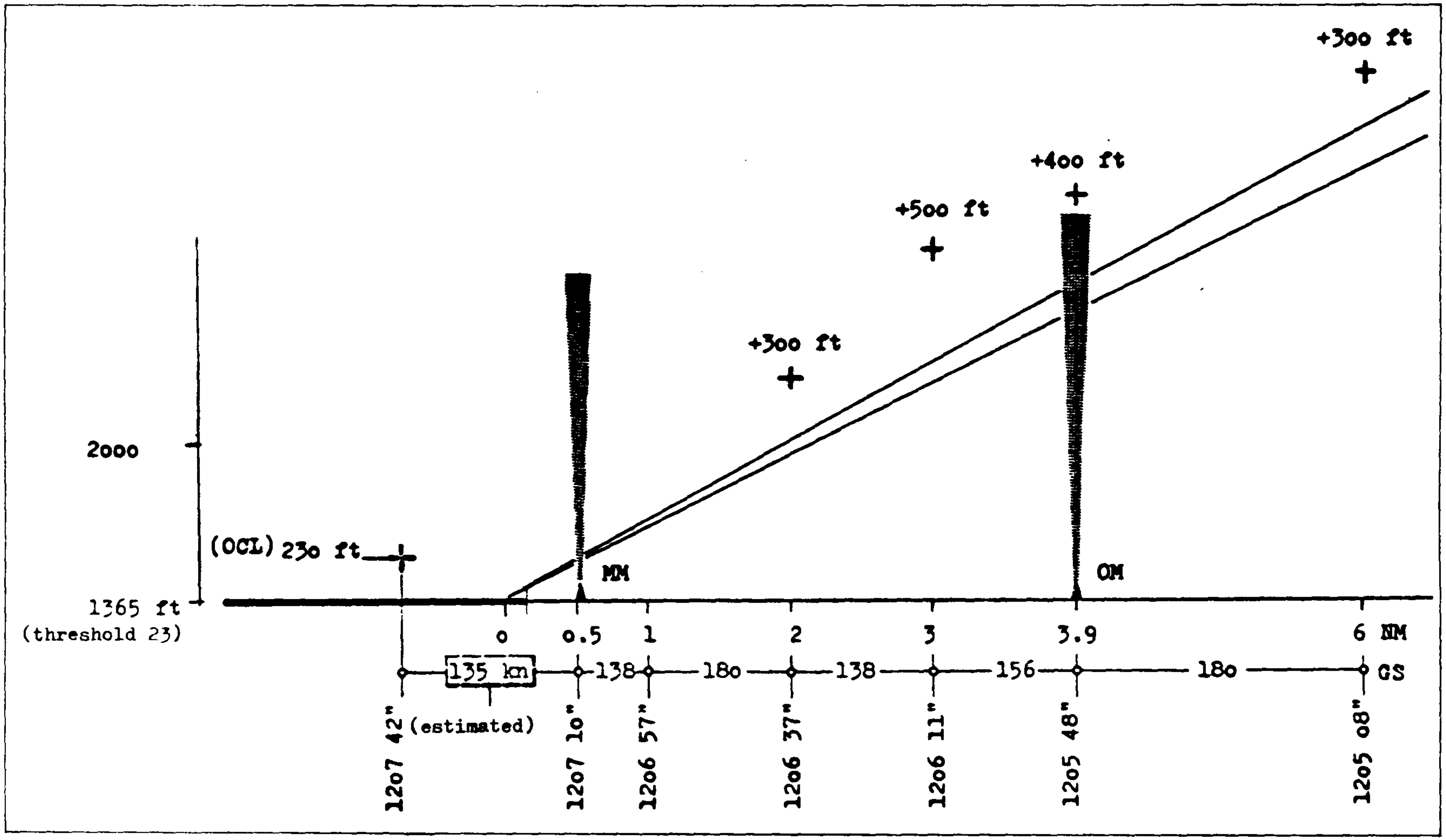
The accident was due to the fact that the pilot-in-command insisted on making the landing without knowing his position relative to the length of the runway, in a situation where the instrument approach had been objectively missed.

3. - Recommendations

No recommendations were contained in the report.

FIGURE 17-1

GRAPH RECONSTRUCTION OF THE APPROACH OF PH-DSN BASED ON THE PRECISION APPROACH RADAR TAPE RECORDING (PAR - KLM 331)



No. 18

Scandinavian Airlines System, SE 210 Caravelle, OY-KRD, accident at Copenhagen Airport, Denmark, on 17 March 1964. Report, dated January 1965, released by the Directorate of Civil Aviation, Denmark

1. - Investigation

1.1 History of the flight

Flight SK 566 was a scheduled international flight from Paris to Copenhagen/ Kastrup. The entire flight, including the landing at Kastrup at 1551 hours GMT on runway 04, was normal. However, during the landing roll the aircraft lost its starboard nose wheel at a speed of about 40 kt shortly after the intersection with runway 17/35. The starboard nose wheel, together with a short piece of the axle, worked loose from the nose gear and rolled out upon the grass to the left of runway 35 where it remained at a distance of about 30 m from the runway lights and about 125 m from the intersection of runways 04/22 and 17/35. The aircraft continued its landing run straight ahead under smooth and non-vibratory braking. Shortly thereafter the flight was requested to clear the runway as soon as possible and when commencing a turn to the left at a speed of about 20 kt towards the exit of the runway the port nose wheel also came off. The aircraft sank down on the shock absorber of the nose gear, sliding thereon for about 70 m before coming to a stop. The engines were stopped at approximately 1552 hours and the crew notified "Taxi Control" that they were stopped just clear of the runway and 2 minutes later that they had lost a wheel on the runway.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal			
Non-fatal			
None	8	not stated	

1.3 Damage to aircraft

The axle housing of the shock absorber was heavily worn by the friction on the concrete.

1.4 Other damage

No other damage was incurred.

1.5 Crew information

The crew consisted of 4 flight crew and 4 cabin crew.

The pilot-in-command, aged 41, held a valid licence and had flown 11 085 hours with SAS including 898 hours on Caravelle aircraft.

The co-pilot, aged 42, also held a valid licence. He was flying the aircraft at the time of the landing. He had flown 10 051 hours with SAS including 406 hours on the Caravelle.

The second officer, aged 34, also held a valid licence. He had flown a total of 3 467 hours with SAS including 2 190 hours on Caravelles.

Also aboard was a radio operator, aged 29, whose licence was valid until 31 August 1964. He had flown 2 991 hours with SAS including 87 hours on Caravelles.

1.6 Aircraft information

The aircraft's certificate of airworthiness was valid until 5 August 1964. The aircraft had a total of 7 890 hours, including 303 hours since last overhaul. The nose gear had been in service 3 241 hours.

The maximum permissible landing weight was 43 800 kg. According to the load sheet the aircraft's actual landing weight was 38 757 kg. With a landing weight of 39 000 kg the permissible limit of the centre of gravity was 25-38% of AMC. According to the load sheet the actual centre of gravity at landing was 33± 3% of AMC.

The type of fuel being used was not stated in the report.

1.7 Meteorological information

The weather en route and in the landing area was fair without risk of ice or turbulence. Immediately before the landing, the wind, as reported by the Control Tower, was 070°/18 kt. Temperature was -2°C.

1.8 Aids to navigation

Not pertinent.

1.9 Communications

No difficulties reported. About 20 minutes after the accident the pilots in the cockpit noted that radio contact on SAS frequency 131.3 Mc/s was poor. SAS could not hear the aircraft since the batteries had become nearly exhausted.

1.10 Aerodrome and ground facilities

No information was contained in the report.

1.11 Flight recorders

Not mentioned in the report.

1.12 Wreckage

See 1.3.

1.13 Fire

There was no fire.

1.14 Survival aspects

As there was no smoke from the nose gear and there did not appear to be any risk of fire, the pilot-in-command, in consideration of the actual weather conditions (low temperature and strong wind), found an immediate evacuation of the passengers unnecessary.

One of the airport's fire trucks arrived on the scene at 1602 hours and remained there until evacuation of the passengers had been completed.

1.15 Tests and research

The broken axle was turned over to the Laboratory for Metallurgy of the Technical University of Denmark. It was concluded that the fracture was caused by fatigue cracks originating from cracks in the chromium plating.

Further examination in the "Statens Prävningsanstalt" in Stockholm established that a large number of cracks existed in the chromium plating and that fatigue cracks in the steel originated from a number of these cracks.

The axle was finally forwarded to the manufacturer - Hispano Suiza - in Paris who reported that the fracture was caused by a fatigue crack which had arisen in connexion with the repair of the chromium plating.

All three laboratory reports concur that the cause of the fracture of the axle was fatigue cracks in the steel, arising in connexion with cracks in the chromium plating.

2. - Analysis and Conclusions

2.1 Analysis

The landing was normal. The co-pilot did not know that he had lost one of the nose wheels and he turned into the taxiway to save taxiing time and to comply with the request of Control Tower to leave the take-off runway as soon as possible. On request he switched over to the frequency of "Taxi Control". The accident took place immediately afterwards. At 1552 the crew notified "Taxi Control" that the aircraft was clear of the runway but had lost one wheel. At the same time another aircraft advised the Tower that OY-KRD was practically clear of the runway and that in their opinion take-off could now be made. Two minutes later they advised that a wheel was lying on the runway and that, therefore, no take-offs should be permitted from this runway. This was further confirmed by two other aircraft. At 1600 hours Control Tower transferred all traffic to runway 12.

2.2 Conclusions

Findings

The crew were properly certificated and had considerable experience on the SE 210 Caravelle.

The aircraft had a valid certificate of airworthiness. Its weight and centre of gravity were within the permissible limits.

The landing was normal until the aircraft lost both nose wheels because of the rupture of the nose gear wheel axle. The aircraft then sank down on the shock absorber of the nose gear and slid thereon for about 70 m before coming to a halt on the taxiway.

Laboratory examination revealed that the fatigue fracture of the axle originated from cracks in the chromium plating.

Cause or
Probable cause(s)

The cause of the accident was a fatigue fracture in the nose wheel axle. Cracks in the chromium plating of the axle were the origin of fatigue cracks in the steel.

3. - Recommendations

The necessity should be considered of alerting fire trucks as well as ambulances in case an aircraft suddenly stops under apparently vigorous retardation.

It should be determined through instructions that direct radio contact between control tower and aircraft be maintained until it is absolutely certain that the aircraft has left the runway.

The expediency of the dispositions of ATC, in so far as continued operations on runway 04 after the accident had happened should be further considered.

4. - Action Taken

(a) All nose wheel axles installed in SE 210 aircraft were dismounted during the period 17 - 19 March 1964 for magnaflux control.

(b) All nose wheel axles were, until 1 June 1964, the subject of a main overhaul at the Linta Workshop, Stockholm. The axles were microscopically examined and provided with a new chromium coating.

(c) All axles, which had been subjected to a major overhaul, were individually marked and their hours in service put on record.

(d) Nose wheel axles installed in SAS aircraft were to be magnaflux controlled every 750 hours.

(e) The major overhaul interval was reduced from 6 000 hours to 3 500 hours.

(f) New reinforced axles (p/n 279.362) have been introduced in all aircraft.

The major overhaul interval for these axles has likewise been fixed at 3 500 hours.

(g) The Aeroplane Flight Manual for SAS, SE-210 aircraft, para. 3.4.3, has been revised for the purpose of giving clearer instructions to the crew on how to obtain the longest possible function time of the radio when both engines have been shut down.

ICAO Ref.: AR/877

No. 19

Malaysian Airways, Comet DH 106, Series 4, G-APDH, accident at Singapore Airport, on 22 March 1964. Report, undated, released by the Department of Civil Aviation, Singapore

1. - Investigation

1.1 History of the flight

The aircraft, operating on charter from BOAC to its associate company Malaysian Airways, was completing the last stage of a scheduled international flight (ML 511) on the route Singapore/Kuala Lumpur/Bangkok/Kuala Lumpur/Singapore, a total flying time of 5 hours 35 minutes. The only incident reported occurred at Bangkok where a starboard main wheel was changed when the tire was found to be punctured by a large metal pin. The aircraft took off from Kuala Lumpur at 0835 hours and the flight to Singapore was uneventful. At 0915 hours GMT the aircraft was over SINJON NDB and the co-pilot commenced the approach to runway 02 from the right-hand seat. A QNH of 1007 mb and surface wind of 060°/10 kt gusting to 15 was passed to the crew. The landing checks were completed and a normal visual approach in VMC, with good visibility, was commenced at the recommended approach speed of 131 kt for the landing weight of 51 000 kg with a threshold speed of 121 kt being aimed at. At 0917 hours the flight was given clearance to land, and a revised surface wind of 030°/10 kt. The approach continued normally but the flare to land was started a little late and the aircraft touched down firmly on the runway, first with the starboard wheels 218 ft from the runway threshold, followed by the port wheels 33 ft farther down. The aircraft then bounced and floated a few feet above the runway. During the bounce the starboard wheel bogie and part of the landing gear leg dropped off. After the aircraft settled gently back onto the runway the starboard wing began to drop slowly towards the ground. The wing was lifted several times during the landing roll by means of the flying controls, but eventually the wing appendages, starting with the fuel dumping and vent pipes, then the flaps, and finally the pod tank, began scraping along the runway surface. About this time the pilot-in-command took the controls and had the engines shut down. He also applied left wheel brakes and steered the aircraft using the nose-wheel steering keeping it close to the runway centre line until just before it stopped when it swung about 20° to the right. The accident occurred at 0919 hours.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal			
Non-fatal		36	
None	8	24	

The only injuries to passengers were sustained whilst escaping from the aircraft and consisted mainly of sprained or twisted ankles, and burns on the hands from sliding down the escape ropes. The injured were transported to the airport health section for treatment.

1.3 Damage to aircraft

The aircraft was substantially damaged by the ensuing fire.

1.4 Other damage

No object other than the aircraft was damaged.

1.5 Crew information

The pilot-in-command, aged 40, held airline transport pilot's licences of both the United Kingdom and Singapore with type rating for the Comet 4 in Group 1. He was first issued with a certificate of operational competency as pilot-in-command in Comet 4 aircraft on 15 May 1963, and was last checked in this capacity on 20 August 1963 by BOAC.

He was last checked for his instrument rating on 16 August 1963. The date of his last medical examination was 25 November 1963. Both licences, to which were attached appropriate radiotelephony licences, were valid until 2 June 1964.

His total flying experience amounted to 13 172 hours of which 614 hours were in Comet aircraft as pilot-in-command. During the last 90 days, he had flown 169 hours as pilot-in-command in Comet aircraft.

The co-pilot, aged 43, held airline transport pilot's licences of both the United Kingdom and Singapore with type rating for the Comet 4 in Group 1. He was first certified as qualified to undertake the duties of co-pilot on Comet 4 aircraft on 22 February 1963. He was issued with an operations certificate in this capacity on 30 April 1963. He was last checked and issued with a certificate of operational competency on 10 December 1963. He was last checked for his instrument rating on 10 December 1963. The date of his last medical examination was 10 February 1964. Both licences, to which were attached appropriate radiotelephony licences, were valid until 26 August 1964.

His total flying experience amounted to 13 450 hours of which his experience in Comet aircraft included 7½ hours as pilot under training, 582 hours as co-pilot, 24 hours as pilot-in-command under supervision, and 13½ hours as pilot-in-command. During the last 90 days he had flown 4½ hours as pilot-in-command under supervision and 134 hours as co-pilot in Comet aircraft.

The flight engineer, aged 35, held a United Kingdom flight engineer's licence which included ratings for DC-7C and Comet 4 aircraft. The date of his last medical examination was 11 April 1963. His licence was valid until 20 April 1964.

His total flying experience amounted to 5 458 hours of which his experience in Comet aircraft, as the responsible flight engineer, was 765 hours, and in the last 90 days, in the same capacity, he had completed 168 hours.

1.6 Aircraft information

The aircraft had a certificate of airworthiness valid until 27 November 1964 and a valid certificate of maintenance. Its gross weight and centre of gravity were within the permissible limits at the time of the accident.

At Kuala Lumpur 3 850 kg of fuel were uplifted. The type of fuel being used was not stated in the report.

1.7 Meteorological information

The weather was not considered as a factor in this accident.

The visibility was 19 miles and the wind 040°/10 kt to 060°/8 kt. Clouds were 1/8 at 2 300 ft and 6/8 at 30 000 ft. QNH was 1007.1 mb and QFE 1005.2 mb.

1.8 Aids to navigation

The following aids were available at Singapore:

Approach - NDB (SINJON) position 0113N, 10351E
- VOR (SINJON)

Aerodrome - NDB locator beacon, bearing 021° M/1.1 NM from threshold of 02 runway

No aids were used after passing the SINJON NDB.

1.9 Communications

The aircraft was in contact with Singapore tower up until the time of the accident.

1.10 Aerodrome and ground facilities

Singapore Airport - Position : 01° 21' 12"N 103° 54' 15"E
Elevation : 59 feet

Dimensions of 02 runway	Take-off run	Take-off distance	Accelerate/ Stop distance	Landing distance	Width	Threshold elevation
	7 600 ft	9 200 ft	9 200 ft	9 000 ft	200 ft	41 ft

Runway surface - Bituminous concrete

Obstructions - Nil

1.11 Flight recorders

Not mentioned in the report.

1.12 Wreckage

The starboard bogie was found.

1.13 Fire

The duty air traffic controller, while watching the aircraft land, saw it bounce and lose some of its wheels; he immediately advised the pilot on R/T while, at the same time, his assistant sounded the airport crash alarm.

The Airport Fire Service turned out 7 seconds after the alarm was given and followed the aircraft along the runway; they were in action within a minute of the aircraft's coming to a stop. Three foam tenders, two water tenders and two rescue tenders were used, and it is estimated that the fire was under control within three minutes and extinguished within five minutes.

The fire in the aircraft was confined to its starboard side. The sequence of events leading up to the main fire in the starboard wing appeared to have developed from the time when the pod tank commenced to leak. About 900 ft before the aircraft stopped, the bottom of the pod tank was already worn through after the safety wheel and its mounting had first worn away. The tank began to leak leaving a trail of fuel along the runway behind the aircraft. Just before the aircraft stopped (and at a position about 550 ft from where it stopped) this fuel trail ignited and set fire to the tank. The fire spread to the wing and caused explosions in the three integral tanks, No. 3 which was empty and Nos. 2 and 4 from which some fuel had been used. The burning fuel escaping from the damaged tanks ran down the sloping surface of the runway under the aircraft, scorched the main fuselage skin and burned away part of the starboard tail plane and rudder assembly. Burning fuel also entered the drainage ducts alongside the runway, causing flames to issue from several manhole covers at other parts of the runway and in a nearby village outside the airport boundary and about 1 000 ft from the main fire.

The secondary fires developed when burning fuel flowed into the drainage ducts running alongside and crossing underneath the runway and out into a stream in a village just alongside the airport boundary. The first of these secondary fires, which was burning in the ducts inside the airport boundary, was controlled and extinguished by the Singapore City Fire Service. The second fire, caused by burning fuel floating along on the surface of the village stream and burning trees and foliage on the banks, was brought under control and extinguished by the combined action of the Airport Fire Service and Royal Air Force Changi Fire Service.

It was estimated that 2 650 gallons of water, 50 000 gallons of produced foam and 300 lb of dry chemical powder were used by the AFS in extinguishing the aircraft fire. The RAF Changi Fire Service made use of 700 gallons of water, 5 000 gallons of produced foam, 25 lb of dry chemical powder and 12 lb of CO_2 in extinguishing fires caused by the burning fuel from the drainage ducts. The Singapore City Fire Service used water appliances only and apart from their other activities maintained a water supply for the Airport Fire Service.

1.14 Survival aspects

Evacuation of the aircraft was initiated by the crew as soon as the aircraft came to a stop. The front crew door on the starboard side, the forward port overwing escape hatch and the rear main door on the port side were opened. An escape chute was attached to the rear main door, but this chute, which was made of a synthetic material, deteriorated very quickly under the effect of the heat and flames being wafted under the fuselage, so that only three passengers were able to escape by its use. Thereafter, they escaped either by jumping from the door sill, which was about seven feet above the ground, or by using the escape rope which was hanging from an attachment close to the top of the doorway. An attempt by the firemen to use a ladder at the doorway was abandoned when it was realized that this would considerably slow down the rate of evacuation. Evacuation through the forward crew door had started before an escape chute could be carried forward from its stowage position and attached. The chute was abandoned and escape was effected by jumping and by using the escape rope assisted by persons on the ground. One stewardess and several passengers escaped through the overwing escape hatch. The stewardess stood on the wing and pulled the passengers through the hatch after having had difficulty in helping them through from the inside of the aircraft.

The total evacuation of the aircraft took about three to three and a half minutes; some delay was caused when it became necessary for passengers to wait and avoid the flames which wafted under the rear door from time to time. Apart from three or four passengers who escaped through the overwing escape hatch, it was estimated that 60% escaped through the rear door, and 40% through the front door of the aircraft.

1.15 Tests and research

The damaged parts of the starboard main landing gear leg forging were removed and subjected to laboratory examination. This examination subsequently revealed the presence of a fatigue crack which had initiated the ultimate failure of the forging.

Fig. 19-1 is a general view of the piece of the leg that was received first and arrow 'O' indicates the origin of fracture. Figs. 19-2 and 19-3 show this area of initial fracture at a higher magnification and its appearance suggested failure by fatigue. A smaller secondary fracture nucleus was also observed immediately adjacent to the main origin (arrow 'A', Figs. 19-2 and 19-3). Fatigue failure was confirmed by high-power microscopic examination of the failure surface which showed many areas of the striated pattern, characteristic of this mode of failure (Figs. 19-4 and 19-5). This technique also confirmed that the dark crescent shaped area of fracture (area 'B', Figs. 19-2 and 19-3) was produced by a single burst of tensible failure. The staining of this portion of the fracture suggested some element of atmospheric attack during crack growth and it is possible that the crack was full of water at this stage.

The fatigue crack had not originated at any obviously severe geometric stress concentrator and the area of fatigue that had produced catastrophic failure was small. The anodic film on the component was in good condition considering its age and no evidence of other than very superficial corrosion was detected by visual or metallographic examination. Failure was not associated with any transverse weakness in the material since the fatigue failure was at about 45^{o} to the local direction of grain flow. Some small pits in the anodic film were observed on the inside surface of the component adjacent to the region of fatigue (Fig. 19-6).

Some secondary fatigue cracks, parallel to the main one, were noted in this region and they were usually associated with faint shallow machining marks (Fig. 19-7). The main fatigue area probably followed such a mark and certainly began at a pit as shown by arrow 'C' in Fig. 19-8.

Examination of the remaining portions of the undercarriage leg has not suggested that the fatigue crack grew beyond the extent indicated in Figs. 19-2 and 19-3 prior to final failure which was probably by tensile bending.

It is concluded that this component failed by fatigue. Although the failure was associated with some very slight machining marks and small pits, the component was in good condition so far as corrosion was concerned and the surface finish was in accordance with good engineering practice.

A test programme was carried out by the manufacturers on a landing gear leg with a similar service history to that of the failed leg on G-APDH. In this test the leg, which had a service history of 6 165 flights, closely approximating that of the failed leg of G-APDH, was subjected to 21 335 simulated flights under test, making a total of 27 000 flights, before a crack was detected in the critical section. These figures compare favourably with the design life of 8 000 flights which was in force at the time of the accident. The simulated flight tests were not directly comparable with normal service conditions, but they were made as representative as possible in the light of experience and of tests conducted by other manufacturers. The results of their tests, together with the total service history of all similar legs in which no similar fracture had occurred, indicate that the failure on G-APDH was an isolated case.

2. - Analysis and Conclusions

2.1 Analysis

Examination of the groups of tire marks on the runway showed that the starboard tires had made contact first, followed by the port 33 ft further along. A second group of marks, left by the port tires only, at a position about 750 ft from the first group, showed where the aircraft had finally touched down. There were no further tire marks on the starboard side, but there were marks made by the detached bogie. Metallic marks and holes gouged out of the runway surface indicated that the starboard landing gear failed during the first impact. It then broke away from the aircraft and came to rest about 1 600 ft further along the runway.

Examination of the starboard main landing gear showed that the main leg forging had fractured at a point immediately below the section cut out for the rocker arm at the forward inboard corner and running to the bottom of the damper strut attachment lug at the rear of the leg. The main shock absorber strut parted at the joint between the piston and the piston cap. The damper strut parted at the joint between the cylinder and the top cap. The rocker arm was twisted at the attachment point for the balance strut. The bottom half of the main leg had become detached and was found complete with both axle beams, brake torque rods, balance strut, rocker arm and the remainder of the main strut and damper strut, on the runway.

From the evidence of the pilot-in-command, the co-pilot and eyewitnesses, it was concluded that the approach was made in visual conditions according to standard procedures and was perfectly normal until the commencement of the flare, which was initiated a little late.

The evidence, including the manufacturers' assessment of an analysis of a cine film taken of the landing by an eyewitness from a position near the runway threshold, indicated that the landing was well within normal operating tolerances.

The technical evidence showed that the failure of the main forging of the undercarriage leg resulted from a fatigue in the material (D.T.D. 683) which had been initiated by a fatigue crack. This crack created a condition whereby failure could have occurred at any time after its inception.

2.2 Conclusions

Findings

The aircraft had a current certificate of airworthiness and had been maintained in accordance with an approved maintenance schedule.

Its gross weight and centre of gravity were within the permissible limits.

The crew were properly licensed and had attained the approved standard of competency.

The forces involved in the landing were within normal operating limits.

There was pre-crash fatigue in the landing gear forging which failed.

Cause or Probable cause(s)

The landing gear leg, which had previously been weakened by fatigue, failed on first impact during the landing.

3. - Recommendations

No recommendations were contained in the report.

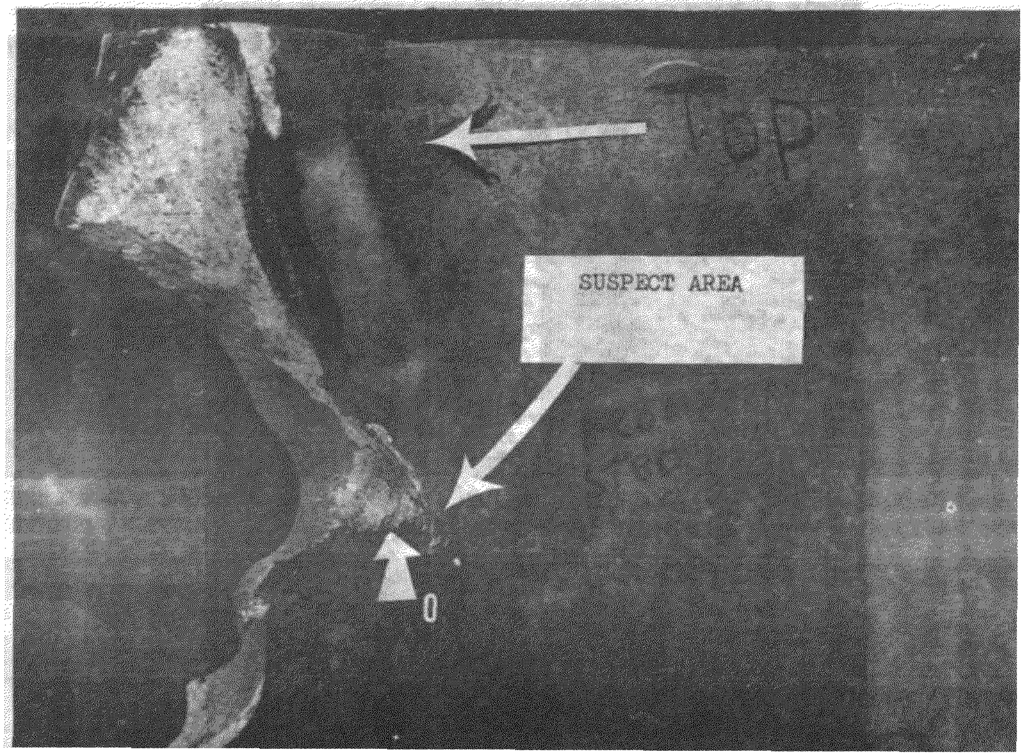
4. - Action taken

Immediately after the accident the approved operating life of all Comet 4 undercarriage legs was reduced from 8 000 to 4 500 landings; at the same time an extensive programme of ultrasonic testing was introduced.

The approved life of 8 000 landings was later re-introduced, subject to the legs having undergone modification, including shot peening and ultrasonic testing, in conformity with a mandatory directive issued by the Air Registration Board.

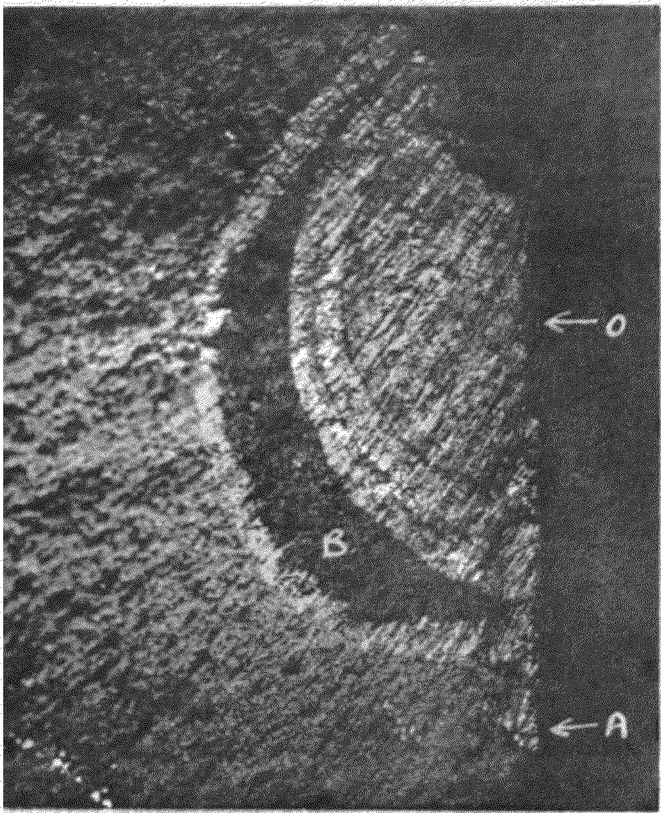
ICAO Ref.: AR/894

FIGURE 19-1



FRACTURED MAIN UNDERCARRIAGE LEG WITH ARROW "O" SHOWING ORIGIN OF FRACTURE

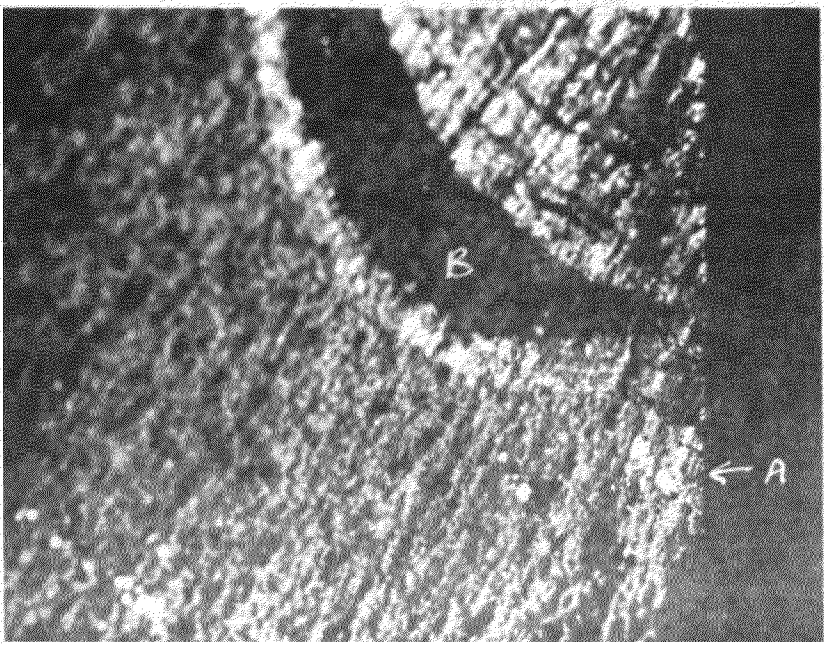
FIGURE 19-2



ARROW "A" - SECONDARY FRACTURE NUCLEUS

AREA "B" - FATIGUE FRACTURE AREA

FIGURE 19-3



ARROW "A" - SECONDARY FRACTURE NUCLEUS

AREA "B" - FATIGUE FRACTURE AREA

FIGURES 19-4 TO 19-8

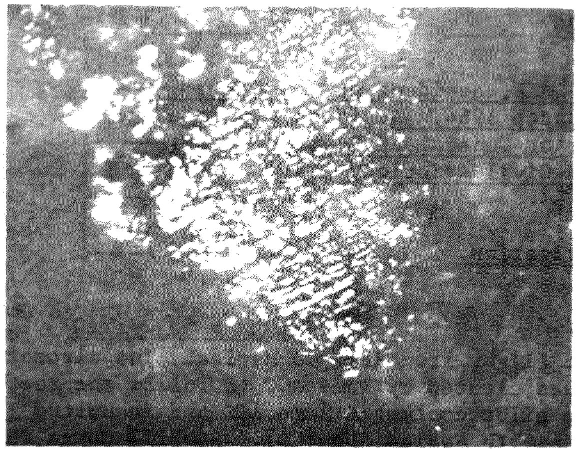


FIGURE 19-4.- 500X MICROPHOTO SHOWING STRIATED PATTERN OF FRACTURE SURFACE

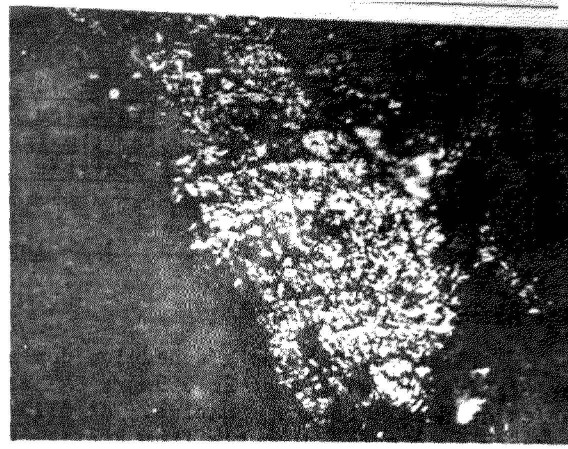


FIGURE 19-5.- 500X MICROPHOTO SHOWING STRIATED PATTERN OF FRACTURE SURFACE

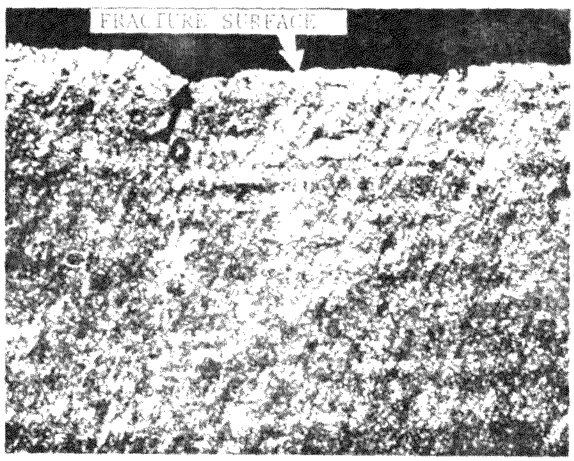


FIGURE 19-6.- 25X MICROPHOTO OF SMALL PITS IN ANODIC FILM

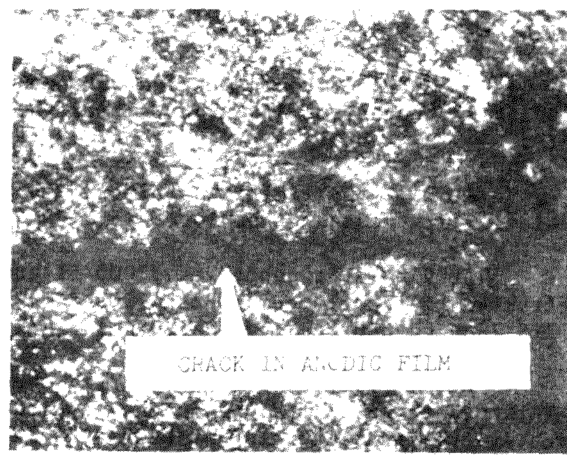


FIGURE 19-7.- 200X MICROPHOTO OF CRACK IN ANODIC FILM

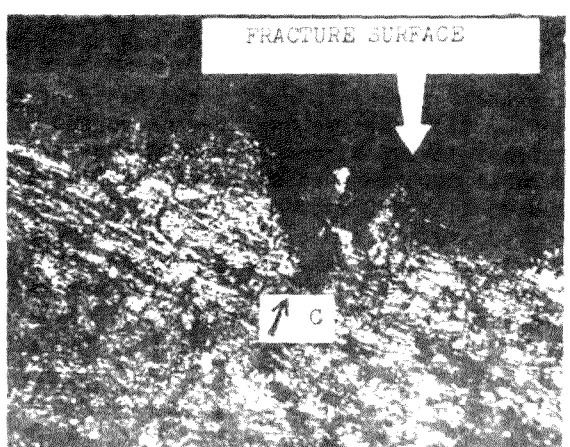


FIGURE 19-8.- 200X MICROPHO[illegible]
ORIGIN OF FATIGUE - [illegible]

No. 20

Alitalia, Vickers Viscount 785, I-LAKE, accident on Monte Somma - Vesuvius, Naples, Italy, on 28 March 1964. Accident report, not dated, released by the Inspector General of Civil Aviation, Ministry of Transport and Civil Aviation, Italy

1. - Investigation

1.1 History of the flight

Flight AZ/045 was a scheduled domestic flight from Rome to Naples. The aircraft took off from Fiumicino at 2110 hours GMT and was cleared by Rome ACC to follow the route Pratica di Mare - Latina - Naples. At 2115 the pilot contacted Rome ACC and requested clearance to proceed directly from Pratica di Mare to Naples NDB (LD). At 2117 hours the flight reached flight level 70. At 2129 GMT it reported abeam of Teano estimating Naples at 2137 GMT and was cleared to contact Naples APP. The flight immediately contacted Naples APP and reported departing Teano at 2129, maintaining level 70 and estimating arrival over NDB LD at 2137.

At 2130, it requested and obtained from Naples APP the local QNH given as 29.65; immediately thereafter it asked whether the ILS was operating and received an affirmative reply.

At 2132 the flight was cleared to descend to 5 000 ft and reported that it was initiating its descent from 7 000 to 5 000 ft.

At 2134 it reported at 5 000 ft and was then cleared to descend to 4 000 ft and instructed to report over LD at 4 000 ft. It was also asked whether it intended to make an ILS landing and replied: "We do not think so, because we can see".

At 2135:30 the flight reported over LD. Naples APP asked what type of approach it intended to make, and the flight replied: "We can see, we are now leaving 4 000 ft directly on visual, turning on down wind leg".

At 2136 Naples answered: "Roger. Since you can see the runway from LD, you are cleared on visual. Report down wind and on final - wind 180/210°, 12 kt".

At 2137 the pilot reported leaving LD. This was the last contact with the flight.

According to witnesses' statements and on the basis of the evidence gathered, the last phase of the flight, from 2137 onwards, was reconstructed as follows. Immediately after 2137 hours the aircraft left the airspace above Naples and flew directly towards the sea at an estimated altitude of 500-600 m on a course roughly SE and through an area of heavy showers. At 2139 hours, i.e., 30 seconds prior to impact, the aircraft flew over the town of S. Sebastiano (Vesuvius) at an estimated altitude of about 500-600 m on a heading of about 90° with undercarriage retracted, engines running steady, landing lights on, in heavy showers. At approximately 2139:30 hours the aircraft crashed in cloud-shrouded Monte Somma. The impact occurred at an elevation of about 610 m while the aircraft was on a heading of approximately 90° and banked about 20° left. The site of the accident was 40°45'21"N - 14°20'32"E.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	5	40	
Non-fatal			
None			

1.3 Damage to aircraft

The aircraft was destroyed.

1.4 Other damage

No other damage was incurred.

1.5 Crew information

The pilot-in-command, aged 53, held a Class 3 pilot's licence, a first-class navigator's licence and a radio telephone operator's certificate. He held ratings for DC-3 and Viscount 785 aircraft and an instrument rating. He had flown a total of 14 923 hours including 1 669 hours on Viscounts. He had never been involved in an accident. He held a valid medical certificate although he had been declared temporarily "unfit" for flying during the period 27 June 1960 to 2 September 1960 because of an unspecified illness.

The co-pilot, aged 25, held a Class 3 pilot's licence and a radio telephone operator's certificate. He had a rating for Viscount 785 aircraft and an instrument rating. He had flown a total of 1 555 hours including 1 417 hours on the Viscount 785. He was not directly involved with the piloting of the flight.

The navigator, aged 32, had valid Class 3 pilot and navigator licences and had flown a total of 7 178 hours without an accident including 8 hours on the Viscount.

The flight crew's flying times during the last 3 months and the last 48 hours were within specified limits.

Also aboard were a steward and a hostess.

1.6 Aircraft information

The certificate of airworthiness of the aircraft was valid until 21 July 1964. The aircraft had flown a total of 13 028 hours. Its last maintenance was carried out on 23 March 1964. Prior to take-off the aircraft had undergone the routine station transit inspection.

At the time of the accident the estimated gross weight of the aircraft (24 836 kg) and its centre of gravity (21.5%) were within the permissible limits.

1.7 Meteorological information

Prior to departure from Fiumicino the crew received the following weather forecast:

En route:
- very cloudy with cumulus formations up to 16 000 ft scattered cumulonimbus base 2 000 ft top 2 500 ft
- moderate turbulence
- moderate icing conditions
- freezing level at about 7 000 ft
- wind at 10 000 ft from NW moderate

Capodichino Airport (from 28/3 1800 hours to 29/3 0300 hours)
- surface wind 180° 16 kt, with gusts up to 25 kt
- forward surface visibility 6 km, hazy
- 3/8 cumulus 2 000 ft
- 5/8 stratocumulus 2 500 ft
- 6/8 altocumulus 7 000 ft
- raining with visibility reduced to 4 km

At 2128 hours GMT the aircraft contacted Naples APP and was provided with the following weather report:

"6/8 cover - 2/8 CU 2 000 ft - 3/8 SC 3 000 ft - 2/8 AC 7 000 ft visibility 6 km - QNH 29.65 - runway in use 24 - QFE 29.41 - wind S 180/210° 12kt runway 24 - temperature 11°"

At the time of the accident the weather conditions in the area Naples, Gulf of Naples and Vesuvius were:

Cloud cover mostly at low altitudes consisting of small and average-size cumulus and stratocumulus which had not yet consolidated into a system;

Cloud amount variable; complete overcast along windward slopes of Vesuvius which were completely covered by clouds that had merged together; along the line Vomero-Capodichino, sky cover 4/8 - 6/8 ; over the western part of the Gulf of Naples, sky cover 5/8 - 6/8; over the eastern part of the Gulf and in the area between Naples and the Vesuvius, sky cover 6/8 - 8/8;

The first cloud layer, the lowest, consisted of 2/8 - 3/8 cumulus at approximately 2 000 ft; these small isolated cumulus clouds were descending towards the 1 000 ft level in the Vesuvius area; the second cloud layer consisted of 3/8 - 5/8 cumulus and stratocumulus with the base around the 3 000 ft level; this second layer was also moving downwards and increasing in quantity towards the Vesuvius area; a third layer consisted of 2/8 - 4/8 altocumulus, with base around 7 000 ft;

A steady light rain was falling along the slopes of the Vesuvius; in the Gulf zone heavy showers moving towards the city; in the eastern part, showers;

Upper visibility was very variable and closely related to the presence or absence of clouds or showers along field of vision.

Possibility of turbulence, particularly in vicinity of showers and Vesuvius;

Estimated freezing level approximately 1 500 m;

Estimated wind:	surface	180-210°/12 - 15 kt
	1 000 ft	210°/15 - 20 kt
	2 000 ft	230°/20 kt
	3 000 ft	260°/20 kt
	4 000 ft	270°/20 kt
	5 000 ft	290°/20 kt.

1.8 Aids to navigation

Approach and landing aids available at Naples/Capodichino were:

Holding
- NDB LD

Procedure
- NDB IP
  VDF/NAV
  ILS
  GCA

All the equipment was operating normally between 2100 and 2400 hours on the day of the accident.

1.9 Communications

All communications were normal until 2137 hours, when Naples approach received the last message from the aircraft.

1.10 Aerodrome and ground facilities

No bearing on the accident.

1.11 Flight recorders

No flight recorder was carried by the aircraft.

1.12 Wreckage

The impact occurred against steep sloped ground broken by furrows in an area covered with scarce vegetation and with trees from 2 to 4 m high. The wreckage of the aircraft was scattered over an area approximately 80 m in length.

1.13 Fire

There was fire damage on engines Nos. 1 and 2 which indicated that the engines were operating at the time of impact. The impact and ensuing fire resulted in the near total destruction of the wing structures. The tires were completely burned.

1.14 Survival aspects

No information was contained in the report.

1.15 Tests and research

The flap control gear box was examined to further determine the position of the flaps at time of impact and to check its proper functioning and the mechanical condition of the gears. The examination confirmed that the flaps were retracted at the time of impact and showed that the gear mechanism was still in excellent operating condition.

The domes of engines Nos. 1 and 3 were opened and the position of the pitch setting locks was examined. It was found that the two propellers were set slightly above fine pitch with the corresponding locks engaged and slightly below feathering pitch.

2. - Analysis and Conclusions

2.1 Analysis

The flight appeared to be normal until passing over LD. At 2128 the pilot had reported his ETA over LD as 2137 hours; this estimate was subsequently confirmed by the pilot at 2129:30 and 2134.

At 2134 he indicated he did not intend to follow the ILS procedure because "he could see". At 2135:30, i.e. 1½ minutes earlier than his ETA, the pilot reported over LD and at 2137 that he was leaving LD. Therefore 90 seconds elapsed between arrival over LD and departure from LD. This time was probably used for losing height, since the pilot was at 5 000 ft at 2134 and reported 90 seconds later that he was about to leave 4 000 ft for a visual approach. According to witnesses the loss of height for visual approach was most likely achieved by a 360° turn carried out to the right in order to make use of a sector that was more free from cloud and the aircraft then flew towards the sea on a SE heading approximately, passing over Via Caracciolo in the city of Naples.

During the right turn to lose height, the pilot presumably put the aircraft in the approach configuration as prescribed by the Alitalia Viscount procedure (undercarriage down, flaps 20°), and flew out over the sea on a roughly SE heading at 2137. It was probably at the end of the turn that he reported leaving LD (at 2137).

Considering the following facts:

- the 2½ minutes that elapsed between the last contact (at 2137) and the moment of impact;

- the SE flight over the sea passing approximately over Castel dell'Ovo;

- the lack of witnesses' statements concerning the exact point of over-flight when the aircraft returned inland;

- the last segment flown on a 90° heading;

- the weather situation with heavy showers over the entire area between the Vesuvius, the runway and the eastern part of the Bay of Naples;

- the switching on of the landing lights over S. Sebastiano;

- the clean configuration of the aircraft over S. Sebastiano and at the time of impact;

- the altitude of the aircraft when it flew over Via Cilea, S. Sebastiano, and the elevation of the point of impact;

- the distance of some 15 km travelled in 2½ minutes;

- the surface wind 180/210°, 12 kt; the wind at 2 000 ft, 230°, 20 kt; at 3 000 ft, 260°, 20 kt;

it was concluded that the pilot was flying south of the intended path because he had in mind the 2128-hour aerodrome weather report giving a wind of 180-210°/12 kt. This was supported by a sketch which was found at the accident site and upon which an arrow drawn in pencil indicated a south wind.

It was further believed that between the segment over the sea flown on a SE heading, and the last segment flown on a 90° heading, a rather short intermediate segment was flown possibly on a 60° heading, i.e. the heading corresponding to the down wind leg.

Up to that point the manoeuvres could be considered as normal for the visual approach procedure.

The aircraft then banked to the right to get on a heading of 90°. Two assumptions were made with respect to this manoeuvre:

1. it was intentionally carried out to avoid an area of heavy showers in the conviction that the aircraft was farther to the north and to the west than it actually was;

2. it was performed because of an inaccurate course indication of the instruments, which might have been unnoticed by the crew because they were:

   - carrying out other tasks (retraction of undercarriage and flaps, power increase, change of altitude, etc.);

   - flying the aircraft in adverse weather conditions;

   - exchanging views concerning the action to take;

   - observing the weather radar screen;

   - observing the weather outside.

While flying over the town of S. Sebastiano, near the Vesuvius, with his landing lights on, the pilot noticed a cloud formation ahead and at the same moment suddenly realized, on seeing the lights of the town of S. Sebastiano, that he was at a much lower altitude than the 2 000 ft indicated on the altimeter, with the ground "rising fast".

He then initiated a left turn to find an escape route, entered the cloud that shrouded Monte Somma and crashed into the mountain.

2.2 Conclusions

Findings

The crew were satisfactorily certificated and had considerable experience on Viscount aircraft.

The aircraft had a valid certificate of airworthiness, and the maintenance of the aircraft had been properly carried out. Its estimated gross weight and centre of gravity at the time of the accident were within the permissible limits.

At the time of the accident the slopes of Vesuvius were covered with clouds and steady light rain was falling with a possibility of turbulence in the vicinity of the showers.

There was no evidence that any technical difficulty was the cause of the accident.

The flight of I-LAKE up to the Naples Airport holding beacon (LD) was normal and in accordance with flight and control procedures.

Reconstruction of the flight and examination of the facts and evidence for the period of time between 2135:30 GMT (time at which the aircraft reported to Naples APP that it intended to continue the flight on visual) and the time of impact with the ground (2139:30 GMT) led the Board to conclude that the accident was probably caused by a variety of factors, some human and others purely environmental, which induced the pilot to continue an unsafe approach. The Board, however, did not rule out the possibility of a concomitant technical factor.

Cause or Probable cause(s)

The Board concluded that the causes of the accident were the following:

1. Delayed interruption of, or failure to interrupt, visual approach in the absence of minimum visibility conditions required for the type of manoeuvre involved.

2. Abnormally wide initiation of down wind leg which brought the aircraft considerably south of the circuit for visual descent to the airport and along an unsafe path in relation to the terrain in the area.

3. Inaccurate estimate of position of aircraft as a result of which the left turn manoeuvre was initiated too late for completion of the required manoeuvre.

The Board concluded that the pilot's behaviour and his manoeuvres were conditioned by the following factors:

1. The meteorological situation in the area surrounding the airport (cloudy with precipitation), which was variable and worse than that existing at the airport as reported to the pilot by the aerodrome services.

2. A west wind component which carried the aircraft towards the Vesuvius whereas the pilot had most likely planned his approach taking into account the south wind component indicated in the aerodrome reports.

3. Possibly excessive confidence of the pilot in his knowledge of the terrain characteristics in the area, explained by the fact that he had carried out a large number of regular flights with stops at the Naples airport.

3. - Recommendations

On the basis of the evidence gathered during the inquiry, the Board made the following recommendations:

a) The "on visual" procedure should be strictly avoided in marginal weather conditions.

b) The rules governing visual flight should be strictly adhered to by pilots.

c) In the case of airports located in difficult terrain the air traffic services should not accept VFR flight plans or the cancellation of IFR flight plans, or alternatively VFR flights should only be permitted along routes which do not cause interference with flight paths used for instrument flights.

d) Bearing in mind that airline pilots have already expressed their concern about the particular conditions in the Naples approach zone and the navigational aids available to them, particularly in adverse weather conditions, the general problem of the radio aids to navigation in the Naples control zone should be re-examined by the component authorities.

e) Flight recorders should be installed in all aircraft used in scheduled services.

ICAO Ref.: AR/392

No. 21

Cimber Air, Piper Apache, OY-AIK, emergency landing near Skelskør, Denmark, on 30 March 1964. Report, dated 10 September 1964, released by the Directorate of Civil Aviation, Denmark

1. - Investigation

1.1 History of the flight

The aircraft took off from Sønderborg Aerodrome at 1956 hours GMT on a non-scheduled domestic flight to Copenhagen Airport, Kastrup. It climbed to flight level 50 and flew normally for 10 minutes at this altitude. The port engine then ceased to run smoothly. On detecting that the oil pressure on the engine had fallen to "0" the pilot feathered the propeller and increased the power on the starboard engine to 2 500 rpm/25" (maximum continuous power). As the pilot could not maintain height with a speed of 90 mph he informed the ACC accordingly and requested a lower flight level. He was then cleared to between flight levels 45 and 35. When the aircraft reached flight level 35 it was still not possible to maintain height so the pilot tried to raise the nose of the aircraft slightly and to keep a speed of 85 mph. This, however, resulted in a stall with a loss of 150 ft, so the pilot lowered the nose of the aircraft increasing the speed to 90 mph. At this speed the average rate of descent was still 300 ft/min. When reaching flight level 30 the pilot reported to ACC accordingly and received a clearance to flight level 25. However, he was also unable to maintain this flight level, advised the ACC and requested that the lights of Ringsted and Avnø aerodromes be switched on. The aircraft stalled three times at 1 500 ft at a speed of 90 mph and once at 400 ft at a speed of 100 mph. AT 400 ft he got visual contact with the ground through rain and sleet. The distance to Dalmos was then 20 NM. As the aircraft continued to stall at speeds of 90 - 100 mph and as the pilot knew that the terrain was rather favourable in this area, he decided to make an immediate emergency landing. During the landing the pilot saw some high tension wires in the landing lights. He then pushed on the control column; however, the aircraft struck the lowest wire and touched down in a near level attitude with the undercarriage and flaps retracted and with maximum power on the starboard engine. The aircraft slid a short distance in a ploughed field and then made an abrupt turn to the left of about 90° before coming to rest.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal			
Non-fatal			
None	1	4	

1.3 Damage to aircraft

The aircraft was substantially damaged.

1.4 Other damage

The lowest high tension line, nearly 2 cm in diameter, was broken and a piece of line, 60 cm long, was found on the ground.

1.5 Crew information

The pilot-in-command held a senior commercial pilot's licence and a flight radio operator's licence both valid until 6 November 1964. He had flown a total of 4 800 hours including about 350 hours on Piper Apache aircraft.

There were no other crew members aboard.

1.6 Aircraft information

The aircraft's certificate of airworthiness was valid until 18 July 1964. The aircraft had flown a total of 2 188 hours, including 61 hours since the latest 100-hour overhaul.

The maximum permissible take-off weight was 1 724 kg. The load sheet was not properly filled in. It showed a take-off weight of 1 710 kg; however, the take-off weight was computed as being 1 727 kg, slightly in excess of the maximum permissible. The centre of gravity was within the allowable limits.

The type of fuel being used was not stated in the report.

1.7 Meteorological information

At 1914 hours the pilot called the MET office in Kastrup and was given the following information:

Actual weather in Kastrup: 15 km visibility and 6 000 ft cloud base; no significant changes.

Wind at 5 000 ft between Sønderborg and Kastrup 110°/20 kt.

Malmø forecast a possibility of snow, but visibility not expected to get below 7 km and cloud base not below 1 500 ft. Malmø could, therefore, be used as alternate.

There was a possibility of light icing depending on temperature. Only at a slight rise in temperature at 6 000 ft would icing set in.

Freezing level was very low, but there was practically isothermy right up to about 6 000 ft, which was described as "most embarrassing".

Temperature was expected to be -2 to -3°C up to about 6 000 ft, thereafter rising to -1° and again falling higher up. The penetration of a little more warm air would cause danger.

No icing had occurred and no precipitation had been observed during the flight from Kastrup to Sønderborg on the afternoon of the same day.

Not until the landing at Sønderborg did precipitation occur as sleet.

1.8 Aids to navigation

Not relevant.

1.9 Communications

No difficulties were reported.

1.10 Aerodrome and ground facilities

Not relevant.

1.11 Flight recorders

Not mentioned in the report.

1.12 Wreckage

The wrecked aircraft was found lying at the northeastern end of a ploughed field at a distance of about 10 m from the field path running in a northeasterly direction and about 25 m from the hedge surrounding the garden of a small holding.

The aircraft was lying in practically normal flight attitude, its nose pointing towards northeast so that its longitudinal axis was parallel with the field path. It was resting on the underside of the fuselage, the underside of the wings and engine nacelles.

1.13 Fire

There was no fire.

1.14 Survival aspects

Not relevant.

1.15 Tests and research

According to Owners' Handbook this type of aircraft has the following performance on one engine at maximum permissible take-off weight:

Climbing power	180 ft/min
Absolute ceiling	5 500 ft
Service ceiling	2 400 ft

The Handbook also gives the recommended climb speed on one engine as 95 mph, and minimum speed for safe control as 72 mph. Normal cruising speed on one engine is 110 mph. These values apply to aircraft not equipped with de-icing equipment. Such equipment reduces the performance of the aircraft and the cruising speed is about 5 mph less. The aircraft had such equipment.

According to the Handbook the carburettor heat is able to increase the air inlet temperature by 96°C (200°F). This reduces engine power by about 20%.

The use of 100°F heat reduces engine power by approximately 8 - 10%.

In order to test the one-engine performance of the Piper Apache a test flight was carried out on 14 April 1964 with another aircraft which had no de-icing installation. The aircraft was loaded to 1 669 kg, i.e. about 55 kg below the maximum permissible take-off weight.

The test flight was carried out as a simulated instrument flight, the propeller of the port engine being feathered. A power setting of 2450/24.5" was maintained during the entire flight and the carburettor heat was kept at 100°F.

The test flight was commenced at 1206 hours at 5 000 ft, outer temperature being -4°C, IAS 90 mph. Under these conditions the variometer indicated a rate of descent between 50 and 200 ft/min. At 1215 the aircraft had got down to 4 440 ft, the temperature there being still -4°C. The rate of descent varied between 0 and 150 ft. IAS was still kept at 90 mph.

At 1220 the altitude was 4 250 ft, the outer temperature -2°C, the variometer indicating a rate of descent of 0 to 150 ft/min. IAS still 90 mph.

During these manoeuvres the aircraft was in trim and trim indicators showed one point tail heavy and 3½ points starboard wing down. At 4 000 ft speed was increased to 105 mph without alteration of power setting. Under these conditions the variometer indicated an average rate of descent of 100 ft/min.

At about 2 500 ft it was just about possible to maintain altitude at IAS 105 mph, but even very small alterations in speed, positive as well as negative, resulted in a rate of descent of about 50 ft/min.

2. - Analysis and Conclusions

2.1 Analysis

The flight plan had been correctly filled in. Although there was a possibility of icing this did not justify the cancellation of the flight. All messages had been correctly dispatched.

As regards the OPS flight plan, the pilot as well as the company maintained that one of the normal OPS flight plans, approved by the Directorate of Civil Aviation, had been filled in and that a copy had been carried on board during the flight, another copy being filed at Sønderborg. Neither copy could, however, be traced.

When questioned at the site of the accident the pilot did not even mention the OPS flight plan when the Accident Investigators expressed their surprise that the company had introduced an abbreviated OPS flight plan. The pilot later stated that an ordinary as well as an abbreviated OPS flight plan was carried aboard the aircraft because the abbreviated plan had not yet been approved by the Directorate. The abbreviated plan was carried on board only to train the pilot in its use.

The company was repeatedly asked by the investigators for a copy of the ordinary OPS flight plan but was unable to produce it. It produced only a photocopy of the abbreviated OPS flight plan which was left behind in Sønderborg and which differed from the copy handed over by the pilot at the site of the accident.

The pilot explained that he had used the wrong side of the carbon paper when filling in the form and that he had to prepare two forms.

Furthermore, many deficiencies in the filling in of this abbreviated OPS plan were found.

At the site of the accident the port engine, the port flap and the port side of the fuselage were found heavily smeared with oil. The port propeller was feathered and undamaged.

By running the engine it was found that the oil leak was caused by a crack in the rubber tube connecting the engine to the oil cooler. This crack was the result of a slightly twisted mounting of the tube to the oil cooler inlet and of engine vibrations.

The oil leak occurred after about 12 minutes of flight when the aircraft had reached flight level 50 and was in the area of Avernakø at a distance of about 17 NM from Sønderborg.

It would therefore have been reasonable to return to Sønderborg Aerodrome which could have been reached even with a rate of descent of about 475 ft/min at an IAS of about 100 mph.

This rate of descent is considerably higher than the rate of about 300 ft/min that the pilot was actually able to maintain. If he had returned to Sønderborg with this latter rate of descent his height above the aerodrome would have been about 1 850 ft.

The pilot decided not to do so because he had comparatively little experience in instrument landings on the Sønderborg Aerodrome and was fully familiar with approach procedures at Kastrup where better radio landing facilities were available.

Light icing did probably occur. In normal circumstances this would not have noticeably affected the flight; however, this considerably reduced the performance of the aircraft on one engine. Weather was therefore considered as having a bearing on this accident.

The action of the pilot when the oil pressure on the port engine went down to "0", as well as his approach and landing were considered as normal in the extremely difficult situation encountered.

2.2 Conclusions

Findings

The pilot held a valid licence and valid ratings entitling him to carry out the subject flight.

The aircraft had a valid certificate of airworthiness and was authorized to carry out non-scheduled commercial air traffic under instrument meteorological conditions. The prescribed overhauls of the aircraft had been performed. The aircraft's load sheet had not been correctly filled in. The aircraft weighed slightly more than the maximum permissible. The aircraft's centre of gravity was within limits.

The flight was entirely justified with regard to the weather situation forecast.

Only an abbreviated OPS flight plan was produced to the Board and many deficiencies were found in the way it was filled in.

After about 12 minutes of flight the port engine's oil pressure dropped to "0", and the pilot had to feather the propeller. The one-engine performance of the aircraft, probably reduced by icing, was such that the pilot had to carry out a forced landing in extremely difficult conditions.

An oil leakage was found on the port engine. It was caused by a crack in the tube connecting the engine to the oil cooler. This crack was the result of a slightly twisted mounting of the tube to the oil cooler inlet and of engine vibrations. It was not possible to establish with certainty when this twisted mounting was made.

Cause or
Probable cause(s)

The cause of the falling oil pressure, which made it necessary to shut down the port engine, was a crack of the oil pipe which connects the engine to the oil cooler.

The shutdown of the engine necessitated an emergency landing because various unfortunate circumstances (reduced engine power when carburettor heating was switched on and probably some icing) made it impossible for the pilot to maintain his flight level.

3. - Recommendations

It is recommended that airline companies ensure that pilots during future checks on multi-engined aircraft perform at least part of the checks with one propeller feathered. The opinion of the Directorate was that many pilots are usually not trained in this manner but only in flying with a power setting on one engine corresponding to a feathered propeller.

As regards aircraft whose propellers cannot be feathered, the ignition shall be cut off on one engine.

Greater accuracy in the preparation and filing of OPS flight plans and load sheets should be emphasized upon Cimber Air.

The presumed inaccurate mounting of the tube, connecting engine and oil cooler, should be pointed out to the maintenance service of Cimber Air.

ICAO Ref.: AR/878

No. 22

Kenting Aviation Ltd., Aero Commander 680E, CF-JOK, accident at Thompson, Manitoba, on 1 April 1964. Report Serial No. 2206, undated, released by the Department of Transport, Canada

1. - Investigation

1.1 History of the flight

The aircraft departed Thompson for a flight to Toronto, Ontario via Winnipeg, Manitoba. The aircraft took off from runway 05 and after a left procedure turn returned across the airport parallel to runway 23 at low altitude. The right wing was observed to fold upward, and the aircraft collided with the ground. Some of the material which separated from the aircraft before impact was from the left wing; it is therefore considered that some deformation of that wing must have occurred before impact although the failure observed by witnesses involved the right wing. The accident occurred at 0826 hours Central Standard Time. The co-ordinates of the accident site were 55°48'N, 97°52'W.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	1	3	
Non-fatal			
None			

1.3 Damage to aircraft

The aircraft was destroyed by impact and fire.

1.4 Other damage

No object other than the aircraft was damaged.

1.5 Crew information

The pilot held a commercial pilot's licence and his total flying experience amounted to 7 600 hours, including about 500 hours on Aero Commander aircraft, of which 125 hours had been flown during the 90 days prior to the accident.

1.6 Aircraft information

The aircraft held a valid certificate of airworthiness. At the time of the accident it had flown a total of 5 949 hours including about 5 000 hours since 1958 when it had been imported into Canada. In October 1963, the aircraft was converted to a model 680E by the addition of extended wing tips and additional fuel tanks. As a result of this, the all-up weight was increased by 500 lb to 7 500 lb.

At the time of the installation of the extended wing tips and additional fuel tanks, an inspection of the internal wing structure centre section was conducted, and the rear spar was modified and strengthened. It has been confirmed, however, that this inspection did not include X-ray examination of those areas of the front spar at Stations 24 left and 24 right forward of the spar web. At these points a "cutout" of the forward side of the lower spar flange occurs and in aircraft of serial number series before and for some time after that of CF-JOK, the "cutout" is of a quarter-circle form. An engineering change on later model aircraft made this "cutout" at a 60° angle, which has materially increased the amount of metal in the affected area. In this same area a change to the spar plan form occurs and the wing dihedral starts.

A perusal of the history of the aircraft revealed that it had been free of any major incidents and the only two minor incidents in which the aircraft was known to have been involved were not considered significant in relation to the accident under investigation.

The aircraft was loaded near the maximum permissible weight.

The type of fuel being used was not stated in the report.

1.7 Meteorological information

The weather at the time of the accident was reported to have been overcast cloud at 2 000 ft, visibility 15 miles, temperature 20°F and the wind from the north-east at 10 mph.

1.8 Aids to navigation

Not relevant to the accident.

1.9 Communications

No information was contained in the report.

1.10 Aerodrome and ground facilities

Runway 05 at Thompson had a gravel surface and was 5 100 ft long and 150 ft wide.

1.11 Flight recorders

Not mentioned in the report.

1.12 Wreckage

The accident occurred in an area roughly cleared of trees, where bulldozer operations had left snow-covered ridges. The following significant factors were found:

(a) the left engine was to the right of the wreckage path;

(b) the aircraft wreckage was located longitudinally in the following sequence - centre section, propellers, the left wing, then the main wreckage and the right wing, which had apparently remained attached to the fuselage.

1.13 Fire

Fire followed impact.

1.14 Survival aspects

No information was contained in the report.

1.15 Tests and research

Eight significant portions of the front spar were salvaged from the wreckage and were given detailed examination by the National Aeronautical Establishment. The report on this examination states that fatigue cracks extended over 40.5% of the lower spar cap at wing Station 24 right and over 30.5% at wing Station 24 left.

2. - Analysis and conclusions

2.1 Analysis

There was no evidence of any fault in the engines or controls prior to the accident.

A short section of the wing front lower spar cap, which extends from Station 24 left outboard, exhibited evidence of a fatigue crack of large proportions extending rearwards.

The laboratory examination failed to reveal any material defect which could account for the initiation of the fatigue cracks. The fracture surfaces exhibited characteristic fatigue striations which were of very fine spacing and indicative of high frequency moderate load conditions. These would most likely be the result of gust loading, and while the number of cycles probably exceeded 300 000, it was not possible to estimate the time involved for the cracks to propagate.

The remaining spar fractures on the right side indicate that the wing failed from upload forces. The left wing, however, indicated a failure from downloads.

Evidence indicated that the initial impact areas were around the nose of the aircraft and that at some point it was inverted. There was considerable impact damage to the left wing. Many items from the front section were located in the initial part of the wreckage trail, and the tail and rudder were sheared off early in the disintegration process. Assembly of the empennage items and the extensive damage to the top and outer portions of the left wing confirmed this sequence.

The right wing apparently remained with the main wreckage and actually came to rest somewhat beyond it. It landed inverted and the whole of the underskin and its integral parts were burned out. The condition of the upper skin surface of this wing did not show any significant bending or distortion of the skin.

2.2 Conclusions

Findings

The crew were properly certificated.

The aircraft had a valid certificate of airworthiness. It was loaded near the maximum permissible, which would in the circumstances impose higher stresses than those found in flight with lighter loads. However,the extent of this loading would not approach design failure loads.

The manoeuvres which immediately preceded the accident should not have resulted in any problem had the aircraft structure been normal.

Failure of the main spar wing structure occurred in the air prior to impact.

It was determined that the failure originated from fatigue cracks.

No direct cause for the initiation of the fatigue cracks at the front spar wing Stations 24 left and 24 right could be determined. The aircraft history did not record abnormally heavy landings or other incidents which might have started them. Visible tool marks were found on the forward flange "cutout" radius on the left side, but since the greatest crack was on the right, the marks were not considered significant.

The length of time taken for the fatigue cracks to propagate could not be ascertained.

The fact that fatigue cracks existed indicated that a considerable stress riser had been generated in the configuration of the spar caps at the milled-out radius in the front flange.

The type of flying which had been performed by the aircraft (magnetometer and other survey flights at low altitude) suggested an accelerated fatigue life. It was not possible to estimate the amount by which this may have been accelerated.

Cause or
Probable cause(s)

Material failure of the wing main spar occurred under flight loads as a result of weakness caused by fatigue cracks.

3. - Recommendations

None were contained in the report.

ICAO Ref.: AR/855

No. 23

Pan American World Airways, Boeing 707-139, N 779PA, accident at John F. Kennedy International Airport, Jamaica, New York on 7 April 1964. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0052, released 16 February 1965

1. - Investigation

1.1 History of the flight

Flight 212 was a scheduled domestic passenger flight from San Juan, Puerto Rico to JFK International Airport, New York. It took off from San Juan at 1514 hours Eastern Standard Time and was routine until arrival in the New York area. After descending and entering the holding pattern at the Colts Neck VOR at 1838 hours the flight received the latest JFK weather, which was below landing minima. It therefore proceeded to its alternate, Dulles International Airport, Chantilly, Virginia and landed there at 1937 hours. The weather having improved at New York, the flight departed Dulles Airport at 2221 hours with the same crew of 9 and 136 passengers.

The flight was conducted under instrument conditions and was routine until arrival in the New York area. At 2239 hours the New York Centre controller transmitted the JFK weather to the flight. The runway visual range (RVR) on runway 4R at JFK was reported to be 1 600 ft. At 2250 hours JFK Approach Control established radar and radio contact with the flight and advised: "Depart Colts Neck heading zero nine zero for vectors to the final approach course; Kennedy weather is three hundred thin broken, measured ceiling one thousand five hundred overcast; visibility one and one-half miles fog; and the runway visual range runway four right more than six thousand feet, stand by." This was acknowledged by the flight. The flight reported over the Colts Neck VOR at 2253:35 hours and was cleared to descend from 6 000 to 1 500 ft. Several vectors were given to the flight on the inbound heading to the outer marker (OM). At 2256:15 hours, while on a heading of 040^{o}, the crew reported reaching 1 500 ft, airspeed 180 kt. Several delaying vectors were given to position the aircraft 3½ miles behind a DC-8 which was landing ahead. At 2259:45 hours the JFK local controller transmitted: "Clipper two one two this is Kennedy tower, report passing outer marker, straight in four right, wind calm, runway visual range, all aircraft copy, four right is more than six thousand."

Prevailing visibility at the JFK Airport was less than three miles, therefore the Precision Approach Radar (PAR) controller was monitoring all ILS approaches to runway 4R as prescribed by procedures.

At 2301:10 hours the PAR controller advised: "Clipper two twelve, Kennedy radar on localizer one mile from outer marker course and glide path OK." At 2301:40 hours the flight reported passing the outer marker and the PAR controller advised, "Clipper two twelve two miles from touchdown." The local controller transmitted at 2301:45 hours:"Clipper two one two, Kennedy tower cleared to land four right, traffic will be clear in five seconds." PAR at 2302:10 hours advised:"Clipper two twelve, Kennedy radar, execute a missed approach if you do not have the runway in sight." Immediately following this transmission the flight acknowledged:"Uh ... Roger two one two." The next radio transmission was at 2303:10 hours when the local controller called the flight but was unable to establish radio contact.

After touchdown the aircraft continued down and off the runway across the asphalt overrun and through a sandy area before coming to rest in the shallow water of Thurston Basin approximately 800 ft from the far end of runway 4R. The accident occurred at 2303 hours Eastern Standard Time.

1.2 Injuries to persons

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

* Of a total of 9 crew and 136 passengers, 33 persons aboard the aircraft received minor injuries and 7 were seriously injured. The report does not state how many were crew and how many were passengers.

1.3 Damage to aircraft

The aircraft sustained major structural damage.

1.4 Other damage

No object other than the aircraft was damaged.

1.5 Crew information

The pilot-in-command, aged 47, held a currently effective FAA airline transport pilot's certificate with numerous ratings including one for the Boeing 707. His last line check in Boeing 707 aircraft was on 9 January 1964. His last proficiency check in Boeing 707 aircraft was on 26 December 1963. He had flown a total of 14 629 hours, including 711 hours on Boeing 707 aircraft.

The co-pilot, aged 47, also held a currently effective FAA airline transport pilot's certificate with a rating for Boeing 707 aircraft. His last line and proficiency check was accomplished in Boeing 707-720 aircraft on 21 October 1963. He had flown a total of 10 433 hours, including 141 hours on the Boeing 707.

The second officer, aged 36, held a currently effective commercial pilot's certificate with aeroplane single and multi-engine land, flight instructor aeroplane and instrument ratings. He had flown a total of 5 000 hours, including 33 hours on the Boeing 707.

The flight engineer, aged 44, held a currently effective engineer's certificate. He received his last recurrent flight check on 18 February 1964 and on 19 February 1964 was designated by FAA as a check airman on Boeing 707 aircraft. He had flown a total of 11 303 hours as engineer, of which 192 hours were on Boeing 707 aircraft.

Also aboard were 5 stewardesses, all of whom had received the company jet emergency training course during the previous six months.

1.6 Aircraft information

The aircraft had flown a total of 11 094 hours, of which 563 had been accumulated since the last major inspection.

The only maintenance required at Dulles was the replacement of No. 1 VOR receiver and refuelling.

A total of 5 117 gallons of fuel were added to the aircraft as shown by the fuelling tickets. The Jet Fuel Loading Instructions sheet for the aircraft at Dulles showed the following:

Station fuel, kerosene, density 6.80 lb/gal	
On aircraft before fuelling -	28 000 lb of JP-4, density 6.42 lb/gal
Mixed fuel density	6.65 lb/gal
Total fuel load	9 140 gal
	60 780 lb

The maximum take-off gross weight of 202 000 lb of this particular flight was limited by the aircraft design maximum landing weight of 190 000 at Kennedy Airport and based on a 12 000 lb fuel burn-off in flight.

An error in the dispatching of the flight at Dulles Airport resulted in an actual take-off gross weight of 208 282 lb, which was 6 282 lb greater than that specified in the company's release from New York for the Dulles departure. Predicated on the computed dry tank weight of the aircraft (149 502 lb) and the amount of fuel removed from the aircraft (46 986 lb) the gross weight of the aircraft at the time of the accident was 196 488 lb. This was 6 488 lb in excess of the maximum allowable gross weight for landing at JFK Airport. The 46 986 lb of fuel removed from the aircraft, subtracted from the fuel aboard at take-off from Dulles, 58 780 lb, was 11 794 lb, the amount burned off in flight. This was compatible with the 12 000 lb estimated to be burned off.

Computations on the weight and balance sheet revealed the centre of gravity was within the allowable limits.

1.7 Meteorological information

A weather observation taken by the U.S. Weather Bureau at 2254 hours (9 minutes prior to the accident) in part contained the following: 300 ft thin broken, measured 1 400 ft overcast, visibility 1½ miles, fog, temperature 47°F, dew point 47°F, wind 210°, 4 kt, altimeter setting 29.72 inches, runway 31L RVR 2 000, runway 4R RVR 6 000 +. The next observation taken at 2314 hours (11 minutes after the accident) in part contained the following: 100 ft thin broken, measured 1 400 ft overcast, visibility 1½ miles, fog, temperature 47°F, dew point 47°F, wind 230°, 6 kt, altimeter setting 29.73 inches, runway 4R RVR 2 600. The 2300 hours upper wind observation at JFK Airport showed the wind at the 1 000 ft altitude to be from 280° true at a velocity of 26 kt.

1.8 Aids to navigation

Not pertinent to this accident.

1.9 Communications

No difficulties were reported.

1.10 Aerodrome and ground facilities

JFK Airport is 12 ft AMSL. At the time of the accident runway 4R was 8 400 ft long and 150 ft wide. The runway surface was paved concrete with a 120 ft asphalt overrun extending beyond the far end of the runway. The lighting system included approach lights with sequence flashers, high intensity runway lights and touchdown zone lights. The touchdown zone lights extended along the first 3 000 ft of the runway with runway centre line lights starting at the 3 000 ft mark and continuing to the far end of the runway. The high intensity lights extended along the entire length of the runway on both sides. All lights were on and operating normally at the time of the flight's approach and landing.

Following notification of the accident, Federal Aviation Agency Systems Maintenance Service personnel performed required ground checks on facility radar equipment and the ILS serving runway 4R at JFK Airport. The equipment was found to be functioning normally. A flight check of the ILS was made by the FAA on 8 April 1964 and it too was found to be operating normally.

1.11 Flight recorders (See Figure 23-1)

A readout of the flight recorder was conducted on that portion of the tape representing approximately the five-minute period before touchdown. During this time period the parameters showed no evidence of abnormality in their functioning. The readout shows that approximately 12 seconds prior to touchdown the aircraft was at an altitude of 400 ft AMSL and at an indicated airspeed of 178 kt; the IAS at touchdown was 160 kt.

1.12 Wreckage

Examination of the aircraft revealed that the forward section of the fuselage was practically severed from the remainder of the aircraft around the entire circumference at approximately fuselage station 600. General distribution and orientation of shear wrinkles in the skin forward of the fracture and structural components at the fracture indicate a compressive load was exerted on the forward fuselage section at the time of impact with the water. Other parts of the aircraft received varying degrees of damage. All spoilers remained intact with the exception of the inboard ends of the inboard spoilers which were damaged by the adjacent trailing edge structure when the trailing edge structure was pushed upward by the inboard flap carriages and tracks, causing the inboard foreflaps to contact the spoilers. Matching interference marks correspond to the spoilers being in the retracted position at the time of occurrence of the accident.

1.13 Fire

There was no fire.

1.14 Survival aspects

When the aircraft came to rest,the crew proceeded aft to assist the passengers. The main forward (left) cabin door was opened and the passengers in this section of the aircraft left through this door. The passengers in the aft section left through the over-wing exits on to the wings; and others left through the two rear doors and got into two life rafts that had been launched. Evacuation of the aft section of the aircraft was completed in approximately five minutes. After seats and débris had been removed from the first-class compartment aisle, some of the persons who had been in the aft section of the aircraft re-entered the aircraft and left through the main forward cabin door.

1.15 Tests and research

The aircraft brake system, including the anti-skid device, was examined and functional tests were conducted on the components. This examination disclosed no evidence that would have precluded normal brake operation prior to impact with, and submersion in, the salt water of Thurston Basin.

2. - Analysis and Conclusions

2.1 Analysis

The aircraft, its powerplants and systems were operating normally at the time the accident occurred. The undercarriage was down and locked, flaps were extended at 50°, but although the pilot-in-command stated that he extended the speed brake (spoilers) after touchdown, and in all probability believed that he did, the physical evidence showed that the spoilers were retracted at the time of impact with the water.

Based on the reported surface wind of 210° at 4 kt 9 minutes prior to the accident and 230° at 6 kt 11 minutes after the accident, it is believed that the aircraft landed at JFK Airport with an average tail wind component of 5 kt. The only wind information given to the crew by FAA ATC personnel was by the local controller approximately 2 minutes prior to touchdown when he reported the wind "calm".*

The PAR controller stated that PAA 212's approach was routine until approximately one mile from touchdown. At that point the aircraft appeared to level off or climb. Shortly thereafter the aircraft's radar target rapidly left the glide slope, and appeared outside the safety zone line above the glide slope. The PAR controller said he then transmitted an advisory to execute a missed approach if runway was not in sight. The target thereafter appeared to descend rapidly towards the touchdown point on the glide slope, remaining above the glide slope until it disappeared into the ground clutter surrounding the touchdown point on the runway.

* AT P 7110.1A, paragraph 417.1B stated in part: "When the surface wind velocity is less than 5 kt, the runway prescribed or normally used is the 'calm' runway, due to length, better approach, shorter taxiing distance or other reasons, in which case the wind direction and velocity shall be stated since some aircraft are not approved for take-off or landing when a tail wind component is present."

The local controller stated that no visual contact was established with PAA 212 during the approach or landing as no portion of runway 4R was visible from the tower cab due to low visibility in that direction. The traffic on the runway was being observed on the Airport Surface Detection Equipment radar (ASDE). Following observation of the DC-8 turn off at the far end of runway 4R, a fast-moving target was observed on the runway briefly but disappeared at the far end.

The pilot-in-command of Flight 212 stated ... "At approximately the outer marker I glanced up and could observe the runway and the glow of the 'strobe' lights associated with the approach light system. It was apparent that the fog stopped at about the shoreline and also that the RVR of 6 000 plus was accurate for all practical purposes. I could see the entire runway. I elected to discontinue the approach on instruments and to continue visually. I levelled the aircraft so as to get over the fog bank overlying the approach light system. Shortly thereafter I called for and received 50° flap. As we crossed the threshold I pushed the aeroplane down and squared away for the landing. The aeroplane went on smoothly, speed brakes were applied immediately, reverse thrust and brakes were applied after the spoilers were raised. Brakes were applied and were without effect. Power in reverse was increased to maximum available. Deceleration was not satisfactory, and the aeroplane continued down the runway. It became apparent that we would go off the end ..."

The fog bank involved extended at least to the approach end of runway 4R, as shown by the RVR on runway 31L of 2 000 ft at 2254 hours and 2 600 ft on runway 4 R at 2314 hours. Reduction to these distances could only have occurred as a result of the fog. The extended centre line of the approach end of runway 31L is in proximity and crosses the approach end of runway 4R.

The initial touchdown of the aircraft could not be determined by visual examination of the runway surface. The first discernible marks that could be associated with the aircraft were identified as those made by the left main landing gear (MLG) tires. These were whiteish scrub marks and began at a point 7 600 ft from the approach end of runway 4R and continued to a point on the asphalt overrun 14 ft beyond the end of the runway. Whiteish scrub marks identified with the right MLG could be distinguished as commencing 8 300 ft from the approach end of runway 4R and also continuing 14 ft beyond the end of the runway. These marks showed that the aircraft veered slightly to the left of the runway centre line shortly before passing over the macadam blast pad at the end of the runway. No nose gear tire marks could be detected on the runway.

The wet runway surface afforded fair to poor braking at best as attested to by the crew, the captain of a DC-8 that landed one minute before, and from examination of the whiteish scrub marks left by the MLG tires of the subject aircraft. The lack of nose gear tire marks, coupled with the whiteish scrub marks made by the left and right MLG tires, shows that there was some braking effect although poor.

For all practical purposes the tires on the right MLG were smooth as opposed to relatively new ribbed tires on the left MLG. The rear tires of tandem installations produce most of the braking on wet runways. Where directional control was maintained as the aircraft proceeded down the runway, braking efficiency would have been limited by the effectiveness of the right MLG tires. The new ribbed tires on the left MLG probably accounted for the swerve to the left near the end of the runway as these tires would brake more effectively than the right tires as the aircraft slowed.

The pilot-in-command stated "... As we crossed the threshold I pushed the aeroplane down ..." An analysis of the flight recorder readout shows this push-over occurred at an altitude of 400 ft and 12 seconds prior to touchdown. Using the average airspeed from threshold to touchdown of 169 kt and adding a 5 kt tail wind, the aircraft was making a ground speed of 174 kt for the 12 seconds prior to touchdown. At this speed, and for this length of time, computations show that this aircraft would have touched down about 3 516 ft from the threshold, and would have left the surface of the runway at an indicated airspeed of approximately 82 kt. An increase in the magnitude of "G" trace deflections occurred 23 seconds after touchdown when the trace went from -0.025Gs to + 2.52Gs.

At the average ground speed of 132 kt (127 kt IAS plus 5 kt tail wind) for the 23 seconds following touchdown, the aircraft would have travelled 5 120 ft on the runway. This distance subtracted from the length of the runway shows that the touchdown point was 3 280 ft from the approach end of runway 4R. From a touchdown ground speed of 165 kt (160 kt IAS plus 5 kt tail wind), the aircraft decelerated to 142 kt ground speed during the next 10 seconds at an average speed of 151 kt. At this average speed for 10 seconds, the aircraft would have travelled 2 543 ft. This distance, added to the lesser of the computed touchdown points (3 280 ft) and subtracted from the length of runway 4R (8 400 ft), shows that when the aircraft reached a ground speed of 142 kt, there was only 2 577 ft of remaining runway.

Boeing test data indicate that under conditions of wet runway at sea level zero wind, 196 000 lb gross weight, anti-skid brakes on, attainment of maximum reverse thrust within 10 seconds after touchdown, spoilers retracted, smooth tires, and a touchdown speed of 142.2 kt IAS, 4 350 ft of runway is required to stop the aircraft.

Examination of these data further shows that the elimination of any of the adverse factors related above would not have prevented the aircraft from overrunning the runway.

2.2 Conclusions

Findings

The crew were properly certificated and had considerable experience.

No mention is made in the report regarding the aircraft's certificate of airworthiness. Due to an error in the dispatching at Dulles the aircraft's gross weight at the time of landing was 6 488 lb in excess of the maximum allowable for JFK Airport.

The approach was normal until approximately one mile from touchdown. Then the aircraft appeared to level off and was continuously above the glide slope. It was estimated that it passed the threshold of runway 4R at an altitude of 400 ft and touched down 3 280 ft after the threshold at a ground speed of 165 kt. During the next 10 seconds the aircraft decelerated to 142 kt at an average speed of 151 kt. At this average speed the aircraft would have travelled 2 543 ft. This distance, added to the lesser of the computed touchdown points (3 280 ft) and subtracted from the length of runway 4R (8 400 ft), showed that when the aircraft reached a ground speed of 142 kt, there was only 2 577 ft of runway remaining. The aircraft therefore overran the runway.

Cause or
Probable cause(s)

The Board determined that the probable cause of this accident was the pilot-in-command's deviation from the glide slope during an ILS approach resulting in a touchdown on the runway at a point and speed which precluded stopping the aircraft on the remaining runway.

3. - Recommendations

None were contained in the report.

ICAO Ref.: AR/874

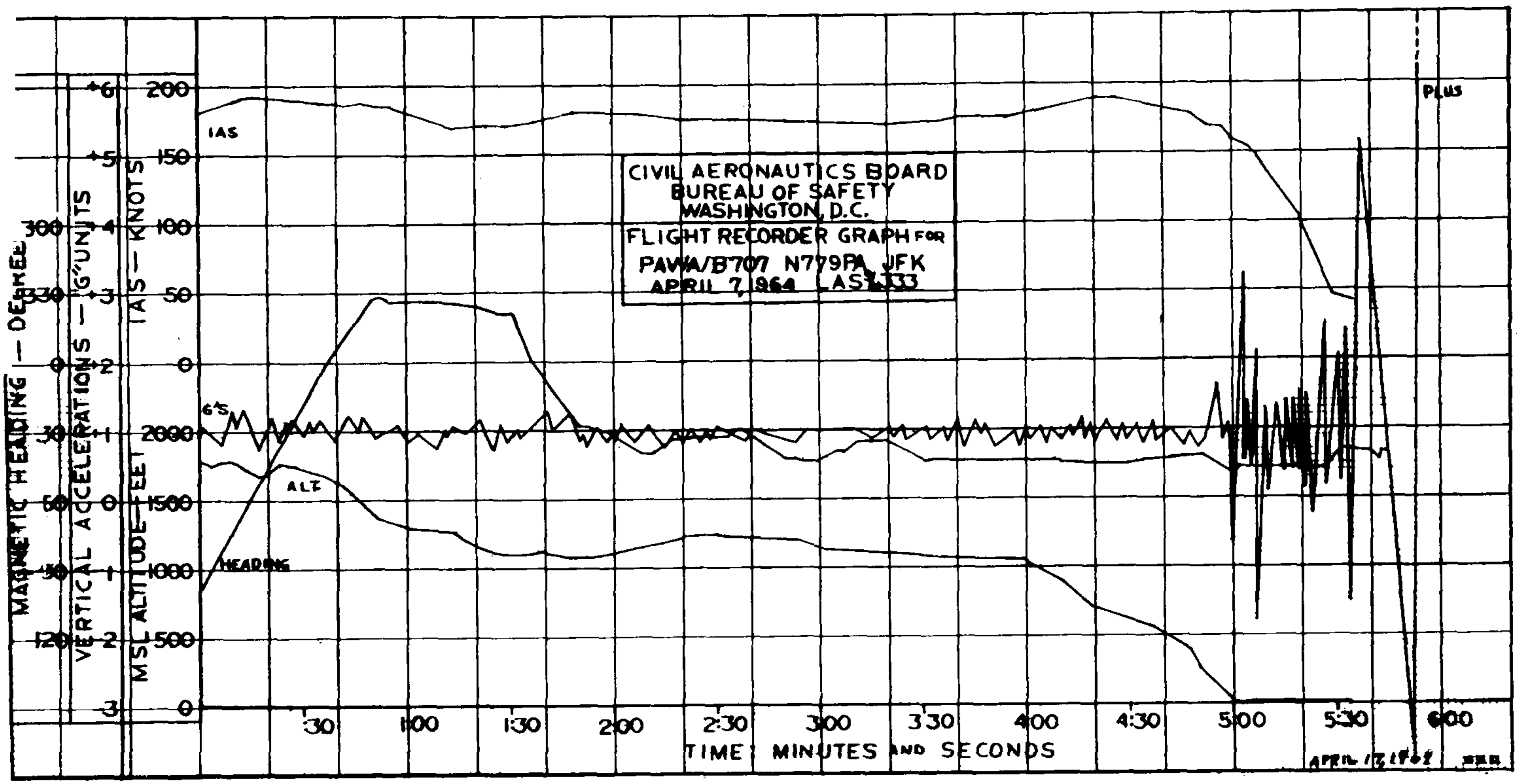

CIVIL AERONAUTICS BOARD
BUREAU OF SAFETY
WASHINGTON, D.C.
FLIGHT RECORDER GRAPH FOR
PAA/B707 N779PA JFK
APRIL 7, 1964 LAS
IAS
ALT
HEADING
G'S
PLUS
MAGNETIC HEADING — DEGREE
VERTICAL ACCELERATIONS — "G" UNITS
IAS — KNOTS
MSL ALTITUDE — FEET
TIME: MINUTES AND SECONDS
30
1:00
1:30
2:00
2:30
3:00
3:30
4:00
4:30
5:00
5:30
6:00

FIGURE 23-1

No. 24

Middle East Airlines, SE 210 Caravelle III, OD-AEM, accident at sea 10 NM SSE of Dhahran Airport, Saudi Arabia on 17 April 1964. Report dated July 1964 of the Committee of Accident Investigation convened by the Superintendent Director General of Civil Aviation, Saudi Arabia

1. - Investigation

1.1 History of the flight

Flight ME 444 was a scheduled international flight from Beirut to Dhahran Airport. It departed Beirut at 1709 hours GMT and proceeded in accordance with its flight plan to Dhahran at flight level 300. At 1904 hours the aircraft reported to Bahrain Control that it was estimating Dhahran at 1928 hours, and was cleared to descend to reach flight level 50 over the Dhahran beacon. At 1906 hours it contacted Dhahran Tower and requested the latest wind and visibility, which were given as NNE/10 kt, gusting to 16,and ½ NM (reported 110 yd in suspended dust). At 1909 hours the flight reported to Bahrain that it was leaving FL 300, and at 1926 hours that it was estimating the Dhahran NDB in two minutes. At 1928 hours it contacted Dhahran and reported "5 000 ft descending". It was cleared for an ADF approach and requested to report at 4 000 ft and outbound at 2 000 ft, QNH 1 006 mb. At 1929 hours it reported leaving 4 000 ft and at 1930 hours passing 2 500 ft and turning inbound. It was then cleared to final approach and requested to report reaching minimum and runway in sight. At approximately 1932 hours a short loud transmission noise was recorded by the Tower. No further message was received from the flight. It was subsequently found that the aircraft struck the sea at the completion of the procedure turn 4 NM off shore and 10 NM south of Dhahran Airport (26°05'55"N - 50°13'36"E). The accident occurred at 1932 hours GMT.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	7	42	-
Non-fatal	-	-	-
None	-	-	

1.3 Damage to aircraft

The aircraft was destroyed.

1.4 Other damage

None.

1.5 Crew information

The pilot-in-command, aged 33, held a valid airline transport pilot's licence with a Group 1 rating for Caravelle aircraft. He had flown a total of 9 193 hours, including 3 425 hours as pilot-in-command and 235 hours on Caravelles, of which 10:35 were in OD-AEM*.

The co-pilot, aged 36, also held a valid airline transport pilot's licence with a Group 2 rating for Caravelle aircraft. He had flown a total of 7 691 hours, including 1 680 hours as pilot-in-command and 70 hours on Caravelles, of which 29 hours were in OD-AEM*.

The flight engineer, aged 42, held Lebanese and French flight engineer licences with a Class I rating for the Caravelle SE 210. He had flown a total of 15 000 hours, including more than 1 500 hours on Caravelles, mostly on Caravelle III aircraft.

1.6 Aircraft information

The aircraft was a Caravelle III. It had a valid Lebanese certificate of registration and a certificate of airworthiness valid until 29 January 1965. A certificate of maintenance, valid for 350 hours, had been issued for the aircraft on 5 April 1964.

At the completion of a flight Beirut-Ankara-Beirut on that same day some technical defects were reported and were corrected prior to the departure of the aircraft for Dhahran.

The maximum gross weight allowed for this flight was 46 000 kg. At the time of the accident the aircraft weight was estimated as being approximately 37 250 kg. At the commencement of the flight the centre of gravity was at 32.2%, well within the limits (25% - 39% MAC).

---

* OD-AEM was the only Caravelle III of the MEA fleet. The pilot's instrument panel of this aircraft differed from the instrument panel of Caravelle VI N aircraft as follows:

Instrument	Caravelle III	Caravelle VI N
Altimeter	Kollsman single pointer drum	Smiths two pointers
Airspeed Indicator	Smiths two pointers	Kollsman single pointer (100's) drum (10's)
Radio Altimeter	Yes	None
RMI	Separated by radio altimeter	Adjacent
Director Horizon	Different presentation	
Standby Horizon	Below radio altimeter	Below stop-watch
Turn & Bank Indicator	Below ILS indicator	Below VOR RMI

The co-pilot's instrument panel of this aircraft also differed in many instances from the instrument panel of Caravelles VI N.

1.7 Meteorological information

The forecast for Dhahran supplied to the flight at 1025 hours at Beirut was as follows:

Valid from 18 - 2400 hours - visibility 15 NM, intermittently 2 NM falling to 01 NM in sandstorm; wind, 140°/15 kt, gusting 25 kt; intermittently, 340°/25 kt, gusting 40 kt; cloud 4/8 Sc 3 500 ft, 5/8 Ac 15 000 ft; temporarily 1/8 Cb 3 500 ft.

At the time of the accident the weather conditions at Dhahran Airport were:

cloud ceiling, sky obscured; visibility 110 yd in dust haze; wind 10-20°/16 kt, gusting 22 kt; temperature 28½°C; dew point 8½°C.

1.8 Aids to navigation

Aids fitted to the aircraft were: VOR, ADF, ILS and a radar scope.

The ADF and VOR both appear to have been indicating correctly.

Aids available at Dhahran: VOR situated on the aerodrome about 500 yd east of runway 34/16 and 2 000 yd north of the threshold of runway 34. NDB (DH) situated 1.2 NM SSE of the threshold of runway 34, with which it was aligned.

1.9 Communications

All radio communications between the aircraft and air traffic control at Bahrain and Dhahran were normal.

1.10 Aerodrome and ground facilities

Dhahran Airport was fully operational throughout the aircraft's approach. The main runway was in use - 34/16, 10 000 ft by 200 ft. The approach lights were not illuminated as they were under repair.

1.11 Flight recorders

Not mentioned in the report.

1.12 Wreckage

Salvage operations were commenced the day following the accident and about 95% of the aircraft structure was recovered in an area of about 250 ft radius from the main body of the aircraft. At the moment of impact the aircraft was slightly nose-down and banked to the right. The attitude, together with the nature and extent of the airframe damage, appeared consistent with striking the water at approach speed.

The front and rear fuselage sections, although disconnected structurally, were still loosely held by control and electrical cables and were separated during salvage operations.

1.13 Fire

There was no fire.

1.14 Survival aspects

There were no survivors. Seventy passenger seats were recovered out of a total of 80. No evidence was found to indicate that any seat had suffered damage due to displacement by inertia loads during impact. The release of seats from the forward first class compartment was due to the break-up and displacement of the cabin floor as the front fuselage broke up following impact with the water. The seats in the centre part of the fuselage, which remained attached to the left wing, were still securely fixed in position and virtually undamaged. There was evidence that most of the passengers had been strapped in their seats.

1.15 Tests and research

The following equipment was removed from the aircraft and examined by Air France at Orly under the general direction of the Ministère des Travaux Publics et des Transports:

a) pilot's and co-pilot's altimeters, air speed indicators and vertical speed indicators;

b) both gyro units with pilot's and co-pilot's HZ4 horizon indicators;

c) the radio altimeter, indicator and switch unit;

d) the elevator and rudder feel system;

e) the four servodyne units operating the aircraft's flying control surfaces.

It was not possible to calibrate either of the altimeters, the airspeed indicators or the vertical speed indicators due to corrosion of the mechanism following their immersion in sea water. Strip examination of the mechanisms revealed that all barometric capsules were serviceable and no evidence of pre-crash failure or defect was found in these instruments. Both altimeters were set to 1 006 mb.

Complete functional testing of the gyro units and computer could not be carried out owing to the effects of salt deposition and corrosion on electrical components. The directional and vertical gyros and the HZ4 indicator units were tested individually and found to be capable of normal operation.

The radio altimeter transmitter and receiver could not be bench checked due to damage and corrosion. The selector was at 400 ft and functioned correctly at this position. The indicator was selected to "small scale" with the switch in the "on" position.

Examination and checking of the mechanical portion of the rudder and elevator feel systems revealed no evidence of any pre-crash defect or malfunction, and the setting of the torsion bars of the springload system were correct. The pitch-corrector actuator was in the "normal" position. Strip examination of the hydraulic components of the system, i.e. the actuators, the pressure reducing valve and the on/off selector revealed no evidence of any pre-crash defect or malfunction. The pre-crash position of the on/off selector could not be determined.

The four servodyne units operating ailerons, elevator and rudder were bench tested and found to operate normally. No evidence was found of any pre-crash defect or malfunction.

2. - Analysis and Conclusions

2.1 Analysis

It was believed that the time at which the loud transmission noise was tape recorded by Bhahran Tower, 64 seconds after the aircraft had informed the Tower that it was "turning inbound", was the time of the accident. Since the aircraft had been cleared by Bahrain control to 5 000 ft over the Dhahran NDB, it was believed that it was over the beacon at about the time it reported "5 000 ft descending". At normal instrument approach speed the aircraft could have descended to the position where the accident took place in the 3 minutes 26 seconds interval between these two transmissions.

As the Jeppesen NDB Instrument Approach Chart was found loose in the cockpit after the accident, it was presumed that the procedure laid down in the chart was being carried out. The Operator drew attention to the fact that the pilot-in-command was very familiar with the "teardrop" pattern approach procedure which was prescribed for Dhahran. The Jeppesen Instrument Approach Chart indicates among other things that the procedure turn should be made in level flight or completed at 1 600 ft QNH. After the completion of the procedure turn the aircraft may descend to the OCL of 648 ft (MEA's minimum is 700 ft) and continue at this height inbound until it arrives overhead the NDB.

Evidences indicated that at the time the aircraft struck the water it was in an approach configuration (10° flap setting and undercarriage extended). Its speed could not be accurately established, although it was probably in excess of 154 kt and may have been in the range of 170 - 180 kt. Its attitude on impact was slightly nose-down and banked to the right, which indicated that the aircraft was completing or had just completed the procedure turn. At this point the aircraft should have been at an altitude of at least 1 600 ft. The technical examination of the wreckage failed to produce any evidence of malfunction or failure of the aircraft, its engines or its equipment. No evidence of explosion or bird strike in flight were found and the manner in which the aircraft struck the water supported the conclusion that the aircraft was operating normally at the time of the accident.

In considering whether the accident might have been the result of the pilot-in-command misreading his primary altimeter or being confused over his flight instruments, the Committee appreciated that under the conditions prevailing during an instrument approach and the environment created by night and sandstorm, both pilots would have been concentrating on their flight instruments. As the co-pilot was known for his mental alertness and habit of closely monitoring and commenting upon any variations from the correct conduct of a flight, and the experienced flight engineer had a reputation for closely monitoring the approach phase of a flight, it was difficult to conceive that if the pilot-in-command had permitted the aircraft to descend dangerously low as a result of misreading his altimeter or being confused over his flight instruments, it could have passed unnoticed by the other crew members. However, the Committee examined these possibilities.

Misreading of the Altimeter

The Committee considered the possibility that the pilot-in-command misread his primary altimeter (pressure drum with single pointer type) by 1 000 ft high and then decided to descend to the OCL during the procedure turn.

The Committee noted the similarities between the subject accident and two previous Caravelle III accidents, one at Augara (Esenboga) on 19 January, 1960*, and the other at Rabat on 12 September, 1961**. The two aircraft involved in these accidents had similar instrumentation and were carrying out ADF instrument approaches at night. In neither of these accidents was any evidence found of technical failure or malfunction which could have caused the accidents. In both cases the aircraft were flown by experienced pilots, and the investigating authority stated that the possibility of the pilot misreading his altimeter could not be ruled out.

Following the Rabat accident, the top portion of the altimeter's window was blanked off so that only one complete numeral of the drum could be seen at a time. While the Committee accepted that this measure should have made it impossible for a pilot to misread the instrument by 1 000 ft high, nevertheless the Committee did not rule out this possibility. It also considered it possible that the crew might have been misled into a misinterpretation of the height by a false indication on the radio altimeter.

Following trials carried out in the Sahara in 1958, Air France issued the following technical instruction:

"1. These radio altimeters (RCA AVQ 6 and CSF AM 210) are frequency modulated. Measurements in the Saharan laboratory and simulated trials on these radio altimeters have shown that.

- The electric fields surrounding the aircraft are of the order of 1 volt/cm in calm weather, but they exceed 150 volts/cm in violent sandstorms.

- Under these conditions, the static discharge wicks can no longer ensure the continuous discharge of the aircraft and series of rapid discharges arise in those areas of the airframe which have a small radius of curvature; the phenomenon is maintained by the continuous electrification produced by the grains of sand and by a state of partial ionization near the disruption points.

- The rate of repetition of the discharges comes within the range of action of the computing circuits of the radio altimeter, so that interference pulses are added to the normal pulses resulting from the beating of the emitted and received waves. <u>For this reason, there is sometimes an indication of height greater than the actual height above the ground</u>.

2. Under these conditions, the radio altimeter must be used only with the greatest caution. <u>The pressure altimeter must be regarded as the basic instrument for measuring the aircraft's altitude and the radio altimeter should be used only as a cross check of this basic information</u>.

3. It is only in extreme cases of very strong sandstorms that the pressure altimeter may also give erroneous indications (sand in the intakes etc.). Under these rare and special conditions:

---

* Aircraft Accident Digest No. 12, page 108

** Aircraft Accident Digest No. 13, page 169

- The indications of the instruments must be cross checked and the instrument giving the lowest altitude must be used.

- The approach must not be continued below 500 ft; at that altitude, there is not sufficient visibility of the ground to continue the approach visually."

After the accident the radio altimeter was found switched "on" and the range selector set at 400 ft. There was no mention in the Air France operations manual found in the aircraft of the above technical instruction. The operator stated that he was unaware of the technical instruction and, consequently, had taken no action to warn pilots not to rely on the radio altimeter in sandstorm conditions.

Confusion of ASI with Altimeter

The Committee then considered the possibility that the pilot-in-command mistook the ASI for the altimeter. It was noted that his experience on the subject aircraft (Caravelle III) was only about 10 hours compared with approximately 225 hours on the Caravelle VI N. The VI N is equipped with double-pointer altimeters and single-pointer ASIs, whereas the Caravalle III had single-pointer altimeters and double-pointer ASIs (see Figure 24-2). Thus, when the pointers of the altimeter in the VI N are (say) indicating 1 600 ft, they are in the same positions as the pointers of the ASI in a III.

In the past, accidents have occurred as the result of a panel having two different instruments with similar presentation, with the result that the pilot had mistaken one for the other. Pilots have been found to make such mistakes when making instrument approaches in simulators when the workload is high and the conditions under which an instrument approach was carried out were difficult.

In the subject accident, however, the method of presenting information on the airspeed indicator was different from the method of presentation of information on the altimeter. It is to be noted also that the airspeed indicator and the altimeter in both the Caravelle III and Caravelle VI N occupy respectively the same geographical position on the instrument panels, thus making a possibility of error unlikely.

The Committee found it difficult to conceive how such a mistake could have occurred and remained unnoticed by the other crew members, unless they had been reassured by the height being erroneously indicated by the radio altimeter.

The Committee also considered whether the NDB radio navigational facility may have provided inaccurate guidance due to night effect or the adverse effect of a static build-up in the sandstorm conditions. However, in view of the use of the facility by other aircraft immediately before and shortly after the accident, the Committee was satisfied that the facility operated efficiently. The Committee was also satisfied that the lack of approach lighting for runway 34 in no way contributed to the accident.

High Velocity Gust

The Committee also considered whether at the time of the accident there was a possibility of vertical or horizontal gusts sufficiently strong to increase considerably the rate of descent of the aircraft. It was suggested that this situation could have been aggravated by the aircraft being in its approach configuration, and that it might have been beyond the pilot's capability to control the ensuing rapid descent in the limited height available for full recovery to be effected.

The Senior Meteorological Officer at Bahrain stated that the most severe turbulence in the area of the crash would have occurred between 1700 and 1730 hours GMT and that at the time of the crash he did not believe that any unusually severe turbulence might have existed.

On the other hand, the chief of the Forecasting Centre at Beirut considered that in view of the conditions in the general area, there was a very distinct possibility of horizontal and vertical wind shear in the Dhahran local area before and after 1930Z in the region from ground level up to 3 000 ft.

At the same time, the department of the Ministry of Aviation, London, was requested to indicate what magnitude and type of gust would be required to cause a Caravelle III aircraft, in approach configuration, to enter an uncontrollable descent. The Ministry of Aviation gave the following opinion:

"According to our calculations, only a gust which led to the aircraft stalling could cause an uncontrollable descent. The aircraft would have been able to recover easily after any smaller gust, and in fact since it was above its minimum drag speed quite a large gust would have been needed even to increase the rate of descent at constant thrust.

The minimum gust which would cause the Caravelle to stall at an airspeed of 154 kt would be an up-gust of about 90 fps EAS. Alternatively, a horizontal gust of about 100 fps could have reduced the airspeed and hence have led to the aircraft stalling. Either of these is, of course, an extremely violent gust."

In view of these opinions, the Committee was unable to determine whether or not a wind shear of sufficient magnitude to cause the aircraft to enter a pronounced rate of descent was present in the area.

2.2 Conclusions

Findings

The crew were properly licensed and qualified to conduct the flight and had had adequate rest.

The pilot-in-command was more familiar with the manner in which the airspeed and altitude information was presented in the Caravelle VI N, compared with that in the subject aircraft, but the Committee was unable to conclude that this contributed to the accident.

The aircraft had been properly maintained, and was correctly documented, equipped, fuelled and loaded for the flight from Beirut to Dhahran. At the time of the accident the engines were running normally, and there was no mechanical defect or malfunction in the aircraft, its systems or instruments.

Although the reported weather conditions for landing were unfavourable, they did not preclude the pilot-in-command from making an approach to his critical height to determine whether a landing could be carried out in accordance with the operator's weather minima.

It was not possible to determine whether or not there was a local disturbance in the area which produced a high velocity vertical or horizontal gust sufficient to have caused the aircraft to enter a phase in which there was a pronounced increase in the rate of descent.

The air traffic control at Dhahran Airport rendered the aircraft all necessary assistance during its instrument approach, and the NDB and VOR radio navigation aids functioned normally.

The aircraft flew into the sea when descending and slightly banked to the right in an approach configuration. It was completing, or had completed, the procedure turn of the NDB instrument approach pattern.

Cause or
Probable Cause(s)

The probable cause of this accident cannot be ascertained.

3. - Recommendation

That an instrument landing system (ILS) should be installed at Dhahran International Airport.

ICAO Ref.: AR/888

FIGURE 24-1

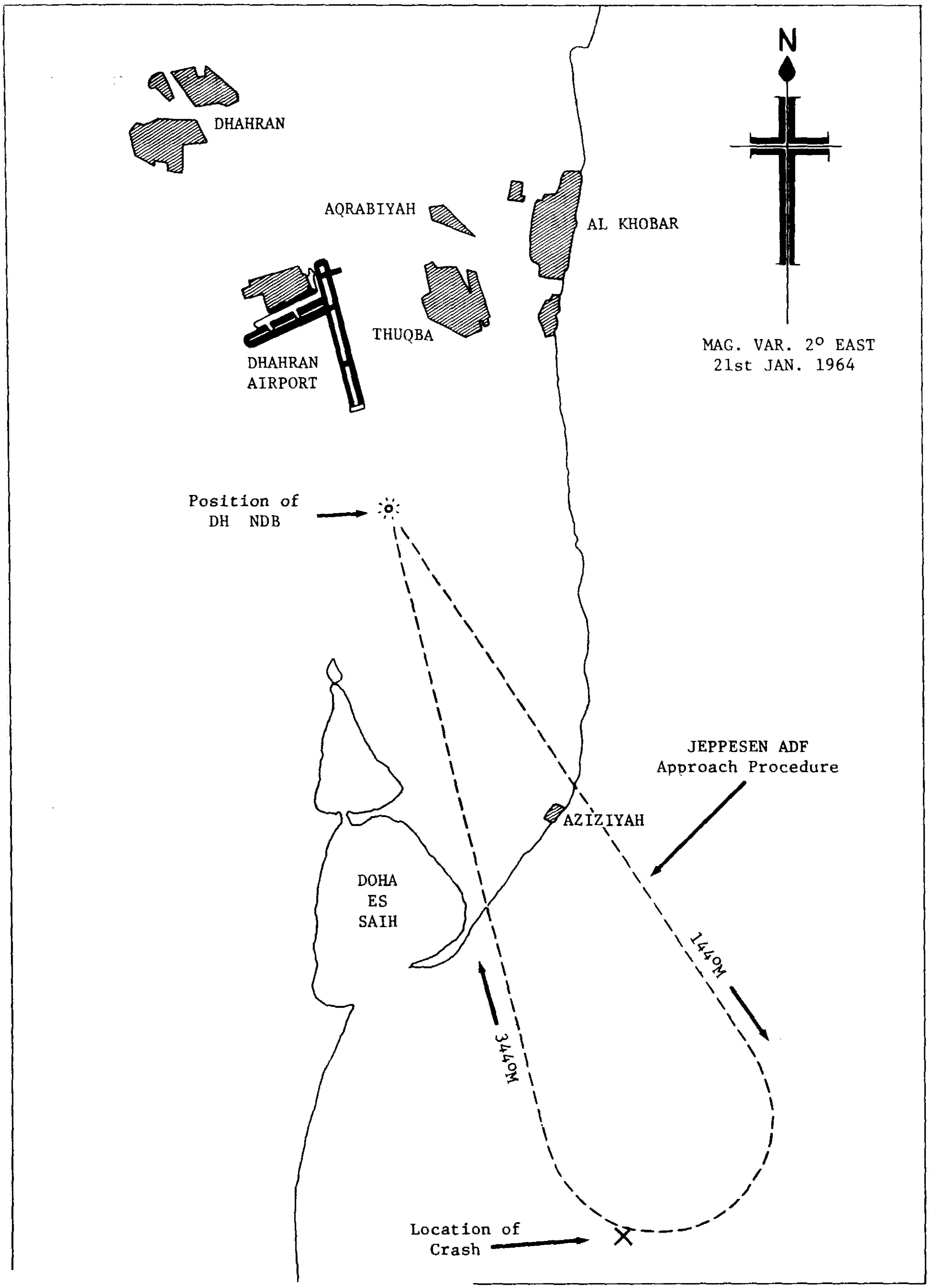

N
DHAHRAN
AQRABIYAH
AL KHOBAR
THUQBA
DHAHRAN
AIRPORT
MAG. VAR. 2° EAST
21st JAN. 1964
Position of
DH NDB
JEPPESEN ADF
Approach Procedure
AZIZIYAH
DOHA
ES
SAIH
144°M
344°M
Location of
Crash

FIGURE 24-2

CARAVELLE III

AIRSPEED INDICATOR

ALTIMETER

CARAVELLE VI N

AIRSPEED INDICATOR

ALTIMETER

No. 25

United Arab Airlines, Comet 4C, SU-ALL accident at Khartoum International Airport, Republic of the Sudan on 22 April 1964. Report No. CA.7.E.120, dated 2 May 1964, released by the Department of Civil Aviation, Ministry of Communications, Republic of the Sudan

1. - Investigation

1.1 History of the flight

Flight 767 was a scheduled international flight. It departed Cairo at 2207 hours GMT and arrived at Khartoum at 0320 hours GMT. It departed Khartoum at 0415 with 8 crew and 10 passengers. The undercarriage was selected to the "up" position after take-off and all indications were usual. Approximately seven minutes after take-off the green system pressure warning light came on and a rapid loss of hydraulic pressure occurred. An inspection by the flight engineer revealed that the corresponding tank was empty. At 0430 hours the pilot requested authorization from Khartoum to return because of a failure in the green hydraulic system. Approaching the airport the landing gear was lowered using the red system, but an abnormal sound was heard combined with a sudden shock coming from the right-hand side of the aircraft. The nose and port wheels were then down and locked, while starboard was showing red and its mechanical indicator was up. Since a warning horn sounded when closing the throttles, the crew were convinced that the starboard wheel was not locked down. At 0516 hours the pilot-in-command requested authorization to jettison fuel and to make an emergency landing. Fuel was reduced to a minimum, leaving in the port tank 400 kg more than in the starboard one. At 0624 hours the aircraft flew low over the runway and the pilot advised Control that the starboard undercarriage was not fully locked and that he would land the aircraft on runway 36, the main runway. During the final approach engines 1 and 4 were stopped, and the approach was normal. At 0632 hours the aircraft touched down on the port main landing gear first, then levelled off, but during the initial stage of the landing roll it leaned violently to starboard and veered slightly to the right of the centre line of the runway. The starboard undercarriage had collapsed. At this stage 800 metres of the landing roll had been completed. The aircraft came to rest on the runway about 1 260 metres from the threshold. The co-ordinates of the site were 15°36'00"N - 32°33'30"E.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal			
Non-fatal			
None	8	10	

1.3 Damage to aircraft

The aircraft was substantially damaged. The damage was confined to interchangeable items, i.e. main undercarriage door, inner and outer split flaps, inner and outer plain flaps, pod tank wheel and fairing and the undercarriage door operating lever. Repair of the aircraft was completed on 26 April and the aircraft was flown back to Cairo on that same day.

1.4 Other damage

No objects other than the aircraft were damaged.

1.5 Crew information

The crew consisted of 4 operating crew and 4 cabin attendants. No information regarding the crew was contained in the report.

1.6 Aircraft information

No information was contained in the report. The aircraft carried 1 000 kg of fuel at the time of the landing.

1.7 Meteorological information

Weather conditions were good.

1.8 Aids to navigation

Not pertinent.

1.9 Communications

No communication difficulties were mentioned in the report.

1.10 Aerodrome and ground facilities

Runway 36 is 2 134 metres long and 45 metres wide. Its elevation is 1 256 ft AMSL.

1.11 Flight recorders

Not mentioned.

1.12 Wreckage

See paragraph 1.3.

1.13 Fire

There was no fire. The fire rescue services were positioned to ensure no further incident.

1.14 Survival aspects

Crew and passengers disembarked in an orderly manner.

1.15 Tests and research

Laboratory examination of the fixed head of the main retraction jack of the starboard landing gear showed that it was one of a batch of 24 manufactured from a zinc-based alloy (DTD 683), an approved alternative for copper-based alloy (DTD 364). All other heads were manufactured from DTD 364. Every effort was made to locate the 23 remaining heads in order to withdraw them from service.

Further tests were initiated in order to establish if any further action may be required on copper-based alloy heads.

2. - Analysis and conclusions

2.1 Analysis

Investigation showed that failure of the fixed head of the main retraction jack had occurred, after which the jack was no longer attached to the retraction lever. The fracture was initiated by fatigue and was 3 inches long. The stress levels at the ends of this crack eventually resulted in a tension failure which extended past the end seal and produced a loss of pressure and fluid. At this stage the jack was still in one piece, although the fixed head was cracked for about half its circumference. On selecting undercarriage down on the red system, sufficient material remained to carry the load required to unlock the radius rod, but as the system pressure built up, the final severance of the jack occurred allowing a free fall of the undercarriage leg and preventing its locking in the down position.

2.2 Conclusions

Findings

No information was contained in the report regarding the crew and the aircraft. Fatigue caused fracture of the fixed head of the main retraction jack of the starboard undercarriage. A tension failure resulted producing a loss of pressure and fluid in the green system. Final severance of the jack allowed a free fall of the leg and prevented locking of the starboard undercarriage in the down position.

Cause or Probable cause(s)

Fatigue fracture of the fixed head of the main retraction jack of the starboard undercarriage.

3. - Recommendations

None were contained in the report.

ICAO Ref.: AR/812

PART II

AIR SAFETY ARTICLES

Excerpts from Flight Safety Focus
May, No. 3/1966, issued by
The Flight Safety Committee,
United Kingdom

THE FLYING QUALITIES OF JET TRANSPORTS

Large C.G. Range

All civil transports need a reasonable range of centre of gravity positions in order to cater for the loading of passengers and freight. On a piston-engine aeroplane, because of its straight wing, fuel loading is not normally a limiting parameter in establishing C.G. travel. On a big jet transport, however, two factors demand a larger C.G. range than previously:

1. The use of fuel in the wing due to the sweep of the wing results in a large change in the centre of gravity, the C.G. moving forward as the fuel is consumed. Similarly for use of the centre tank fuel: this is usually a little forward and with the use of this fuel the C.G. will move aft;

2. Because of the extremely long passenger compartments the effect of indiscriminate passenger loading and freight loading is exaggerated: hence the need for a large C.G. range.

The effects of extremes of C.G. positions, of course, are the same in a big jet as in a piston-engine transport - only more so; they reflect primarily in the stability and controllability qualities in the longitudinal plane.

At a very forward C.G. -

- the stability of the aeroplane is increased and the static and manoeuvre margins are large. Stick forces for manoeuvring are relatively high, larger stick movements are required for a given manoeuvre and larger trim changes are necessary for, for example, a given speed change. The aeroplane is generally heavy and less responsive to handling in flight, and larger and heavier forces are necessary for take-off and landing.

At a very aft C.G. -

- the stability of the aeroplane is decreased and the static and manoeuvre margins are smaller. Stick forces are comparatively light, stick movements are smaller and a smaller amount of trim is necessary for any given change. The aeroplane is generally lighter and more responsive.

All aeroplanes, of course, have acceptable handling qualities throughout the certificated C.G. range and no special briefing should be necessary. However, because of the domestic limits inside the certificated limits which most operators prudently impose, it is rare for a line pilot to experience the change in handling qualities which go with extremes of C.G. positions. Broadly, it is worth high-lighting the high stick forces which can be required to flare at forward C.G. and the comparative delicacy with which the elevator control should be used at aft C.G.: it is particularly important not to overtrim the tail when manoeuvring on aft C.G. at high speeds.

Variable Incidence Tailplanes

The fixed tail/elevator configuration can become rather limited when dealing with a very large C.G. range. For an aeroplane in balance longitudinally in ideal cruising flight the weight acts downwards through the same point as the lift acts upwards on the wing and the tail is not called upon to provide any balancing force. If the C.G. is now moved a long way forward there will be a nose-down tendency which is counteracted by 'up'-elevator producing the required balancing force downwards from the tailplane: for a significant aft movement of the C.G. the reverse would apply. For large changes of C.G., positions could be arrived at, at which the elevator would be fully deflected - and no further control in the pitching sense would be available.

With a variable incidence tail, however, as the C.G. is moved over comparatively large distances, the incidence of the tail is altered to provide the balancing force and the elevator remains in the streamlined position. Because the tail area is much larger than the elevator area the tail needs to move through a smaller angle to produce the required balancing force and, the elevator always being "neutral" to the tailplane, full elevator control remains available at all times. This large increase in balancing forces available from a V.I. tail makes a large C.G. range a practicable proposition.

There are other advantages of a V.I. tail:

- In practice a fixed tail carries a small down load in the cruise in order not to limit the amount of 'up'-elevator required for, say, a forward C.G. landing; a V.I. tail can be set to be at an optimum incidence for the cruise, thus reducing the drag;

- While drag is proportional to lift, the profile drag of a fixed tail with a grossly deflected elevator is much more than the profile drag of a V.I. tail with a slipstreamed elevator producing the same balancing force.

In dealing with the consequences of having a V.I. tail, this basic fact must be kept in mind - it is very powerful. Because the elevator, when in trim, is always slip-streaming the tail, it remains available over its full range and can be smaller than the elevator on a fixed tail aircraft - simply because the V.I. tail can be set to meet the bulk of the demand and the elevator remains to look after the rest. On a V.I. tail aeroplane, therefore, the elevator is smaller, and less effective in isolation than it is on a fixed tail aeroplane. This enormous power in a V.I. tail can be a good servant when required but an impossible master when not required. Normal manoeuvres should be carried out on the elevator alone and the tail trimmed to remove the residual stick force after the manoeuvre has been completed. If, in an extreme case, the tail is needed to assist in a manoeuvre, it should be used slowly and carefully and its effect on the aeroplane monitored all the time; at very high speeds, particularly, a V.I. tail should be used only in short bursts and the full effect be appreciated before any more tail change is made. If a V.I. tail should be grossly mis-set, e.g., before take-off, there is every likelihood that not only will the resulting stick forces be too high to hold but, even if they could be held, full elevator deflection would be insufficient to control the aeroplane. For take-off it is vital that the V.I. tail be set pretty closely to the proper setting according to the C.G. position.

Variable incidence tailplanes can fail in two ways: (a) a simple stuck tail and (b) a runaway tail.

(a) A simple stuck tail is no trouble. Some aeroplanes make provision for handwinding or slow standby electrical operation of a failed power system to the tail; in this case it is only necessary to make changes of configuration, power and speed in plenty of time to allow for the very slow rate of tailplane change. On those aeroplanes where no such provision is made and in a real 'stuck tail' condition, life is a little more difficult - but not much, so long as you know what to do. If you enjoy the facility of split flaps or spoilers to alter the basic pitch trim of the aeroplane, take advantage of them, of course. If not, remember that, <u>so long as you maintain the speed at which the tail stuck you will remain substantially in trim</u>.

This should be sufficient reason to declare an emergency and fly the remainder of the flight as closely as possible to this original speed. Plan for a long final and reduce the speed as late as prudently possible in order to keep to a minimum the length of time for which high stick forces will have to be held. Use a reduced flap setting or a higher speed for landing if distance is not at all limiting. Guard against the tendency to come below the glide path because of the subconscious relaxing of the high pull forces involved over an appreciable length of time. With tails stuck within the normal flight settings there should be no lack of elevator available for the landing. It is also possible, of course, to vary the C.G. of the aeroplane in order to make life easier: if the tail has stuck in the cruise, any speed reduction or flap extension will need a pull force on the control column; this can be alleviated by getting the C.G. further aft - either by moving the passengers, if possible, and/or a nonstandard fuel usage.

(b) A runaway tail must be stopped as soon as possible. There are approved drills for this emergency for every aeroplane. If the runaway is arrested, either handwind back, or proceed as for a stuck tail above for a nose-down stuck tail; for a nose-up stuck tail, or course, one should get the C.G. more forward. If the runaway is not arrested, life is going to be very difficult. The fact that some aeroplanes can be flown under some conditions of configuration and speed with a full runaway tail is only of academic interest. If this should occur at high speed, the aeroplane is almost bound to be lost - the only hope is to get the speed off. There is no point in taking this analysis any further: the design of aeroplanes is such that the failure to stop the runaway will not occur. So, if the tail starts off on its own or doesn't stop moving when the input is removed, take the required emergency action immediately.

Excerpts from Flight Safety Focus
June, No. 4/1966, issued by
The Flight Safety Committee,
United Kingdom

1. AIR MISSES

At present there is no common definition of an Air Miss. Several expressions, such as "risk of collision", "hazardous situation", etc., are used but as the most important single factor is safety, then it is considered that if the man on the spot, the pilot, makes an air miss report then an incident has occurred. This may not necessarily mean that an air miss has been experienced but even when two aircraft come into close proximity without the risk of collision it is possible that a lesson can be learnt in the hope of preventing a repetition.

The basis of an Air Miss investigation is that it is:

(a) first reported;

(b) investigated and analysed by the appropriate authorities to produce facts;

(c) replied to in full to the Operator concerned within a reasonable time;

(d) followed up if necessary and lessons learnt.

In this respect it is necessary that States should have a system for the reporting and analysing of air misses. This would then provide valuable information for the review of Air Traffic Control procedures and separation criteria, as well as highlight where specific problems lie.

Although investigating authorities will not always agree as to whether a report constitutes an air miss, definition is not considered important, reporting must not be inhibited and the flow must be kept going through to them so that any disturbing trends may be uncovered.

When a report is made, it is followed up by the Operator concerned with the appropriate agency in the country where the accident occurred. This system works quite well and depends on friendly co-operation, but in cases where a satisfactory reply is not forthcoming then the Ministry of Aviation can be asked to assist.

Having looked at the reporting procedure for air misses it is necessary to look at why they occur. There are a number of factors which contribute to this problem, amongst which are:

(a) IFR/VFR mixed. In the past much value has been attached to 'look-out'. However, in the jet age the value of this has been reduced to a minimum and there is a case for civil aircraft flying at all times in a controlled airspace on an IFR plan.

(b) Civil/military conflicts. More instances of air misses from civil/military conflict occur in West European airspace than anywhere else. Significantly, fewer cases due to this conflict occur in United States airspace since the introduction of a single controlling agency for all airspace users. Action should be taken to improve the situation in Western Europe where there is so much military traffic by many national air forces.

(c) Air Traffic Control. The quality of Air Traffic Controllers and the equipment with which they are provided especially in the undeveloped countries contributes to the problem. Much remains to be done in the facilitation of training and the provision of the technical means to provide a modern, efficient Air Traffic Service.

(d) Air Discipline. In this respect strict adherence to clearances, rules and regulations etc., by all airspace users is the important factor.

No doubt there are other factors but it can be anticipated that while future civil aircraft will require to operate at even higher altitudes than hitherto, the amount of airspace available is basically of fixed dimension. Forecast and planned traffic growths during the next decade mean even greater crowding in the airspace with an inevitable significant rise in risk of collision unless remedial action is taken. This warrants the attention of all concerned with aviation operations, and improvements should be foremost in the minds of all responsible authorities.

2. THE FLIGHT SAFETY OFFICER

Notes on the function, the personal qualities necessary and the duties involved.

Safety and Economy

The prosperity and growth of an airline, or an aviation industry, is directly related to safety achievement; but whereas profit or deficit must be accounted for annually, money invested in safety cannot normally bring benefit in a short time scale. It is said that safety costs money. It should be an aim, therefore, that a Flight Safety function should account for its effectiveness by contributing to management efficiency.

Characteristics of a Flight Safety function

A Flight Safety function should not attempt to replace primary basic organisational responsibility. It should be co-operative, remedial, advisory and non-punitive. Its aim must be to monitor all experience and, through a systematic process of recording, investigation, correlation and review, to advise upon any changes considered necessary to maintain or improve safety.

The qualities desirable in a Flight Safety Officer

He should possess a good background of flying experience. His basic purpose is to communicate efficiently. He should cultivate an atmosphere of confidence which will enable him to establish and maintain continuously good liaison with the operations and engineering divisions of his airline at every level to ensure effective safety coverage of the whole operation.

The organizational place of a Flight Safety Officer

In order to maintain the integrity of responsibility in the normal management structure, the function should be advisory only.

The Flight Safety Officer should have direct access and be responsible to the chief executive.

The appointment should, if possible, be on a full-time basis to ensure that the officer can work independently of flight operations and engineering divisions.

Where it is not possible to make a full-time appointment and it is combined with other duties, the person appointed should not be financially penalised. In this case the person appointed should be of sufficient seniority to have access to and be able to discuss problems at every level within his organisation.

In the absence of any other independent investigating body within the organization, the Flight Safety Officer should conduct any internal investigation into the airline's incidents/accidents. (In this context investigation means fact-finding only in accordance with the ICAO definition, differentiating between this and an inquiry.)

The Flight Safety Officer should have an office at the main operations base.

The duties of a Flight Safety Officer

He should be familiar with those procedures and practices of his airline which have a bearing on safety. He should also be as familiar as possible in this respect with the procedures and practices of other airlines to the end that he will suggest consideration of any procedures different from those in use which might benefit safety.

The setting up, within his organization, of an accurate reporting and recording system for incidents and accidents.

- Incidents/accidents must be reported on a prescribed form designed for the purpose of establishing basic factual and environmental information.

- The record should include all reportable incidents/accidents as defined in the airline operations manual.

- It is essential to encourage the *discretionary* reporting of incidents which could have led to accidents or which have a bearing on the safety of operations generally.

The information recorded from reports should be surveyed and analysed to establish trends, and any necessary recommendations to management should be formulated.

The assembly and selective dissemination of flight safety information from all sources within his own organization and its correlation with that provided by external agencies such as the UKFSC, FSF, ICAO, IATA, ARB, MoA, BOAC, BEA, BIATA, manufacturers, the Press, etc.

The provision of flight safety information to UK Incident/Accident Exchange Scheme.

The arrangement of periodic meetings with his executive and representatives of operational and engineering management for the purpose of reviewing systematically the overall safety of the airline's operation.

The provision of adequate publicity for flight safety matters within his airline.

Attending those national and international meetings on flight safety at which his airline decides to be represented.

The maintenance of a reference library of flight safety information conveniently accessible to flight crew members and others who will wish to keep up to date with current flight safety matters.

- END -

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

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
54-AN/49 - Aircraft Accident Digest No. 8. 1958. 212 pp.	$2.25
56-AN/51 - Aircraft Accident Digest No. 9. 1959. 290 pp.	$3.00
59-AN/54 - Aircraft Accident Digest No. 10. 1961. 286 pp.	$3.00
62-AN/57 - Aircraft Accident Digest No. 11. 1961. 266 pp.	$4.25
64-AN/58 - Aircraft Accident Digest No. 12. 1963. 376 pp.	$5.75
69-AN/61 - Aircraft Accident Digest No. 13. 1964. 359 pp.	$5.50
71-AN/63 - Aircraft Accident Digest No. 14.	
Volume I. 1965. 115 pp.	$2.00
Volume II. 1966. 202 pp.	$3.25
78-AN/66 - Aircraft Accident Digest No. 15.	
Volume I. 1966. 156 pp.	$2.50
Volume II. 1967. 256 pp.	$4.00
82-AN/69 - Aircraft Accident Digest No. 16.	
Volume I. 1968. 171 pp.	$2.75

N.B.—*Cash remittance should accompany each order.*
Catalogue sent free on request.

PRICE: U.S. $2.75
(or equivalent in other currencies)