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FOREWORD

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

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

The world-wide collection by ICAO of accident reports and aeronautical publications and documents relating to research and development work in the field of aircraft accident investigation, and publication of the material in condensed form, assists 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. It is hoped that States will co-operate to the fullest extent permitted by their national laws in the submission of material for inclusion in future issues of this Digest. It is recognized that investigations take a diversity of forms under the variety of constitutional and juridical systems that exist throughout the membership 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

*Provisional International Civil Aviation Organization 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 reports, 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.

The working languages of the Organization are English, French and Spanish. It would be helpful, therefore, if States, where possible, could submit their final reports on accidents in one of these languages as our translation facilities for other languages are limited.

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.

Whenever possible, photos and diagrams have been obtained for illustration purposes in order to give a clearer overall picture of the crash area, an idea of the probable flight paths of aircraft, the location of witnesses to the crash, and in general to make the reports more interesting to the reader.

Part II of this issue dealing with Aircraft Accident Statistics has been based on material derived from the Air Transport Reporting Forms G submitted by States and other sources. (For further review of material included refer to the Introduction, page 315).

Part III includes an article which discusses the power curve and sink rates as well as two Flight Safety Bulletins which warn pilots of the after effects of scuba diving and of the difficulties which may occur with instruments and systems supplied with static pressure.

Part IV presents the list of laws and regulations relating to aircraft accident investigation as published in Accident Digest No. 12 together with all amendments received by ICAO up to 31 May 1964.

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.

COMMENTS ON ACCIDENT SUMMARIES AND CLASSIFICATION TABLES - 1961

Reports of 54* aircraft accidents occurring during 1961 in commercial air transport operations have been received by ICAO and are summarized in this Digest. Also appearing are summaries of an accident in Sénégal (1960) 29 August, a training accident in Cameroon (1961) 13 June, and two incidents involving aircraft (1 July 1961 and 29 October 1961) which do not come within the ICAO classification of an accident. These last accidents are included in the Digest as they satisfy one or more of the following criteria:

1) World-wide interest in the accident, due to either
   a) major disaster aspect which resulted in wide publicity, or
   b) special nature of accident and possibility of remedial action;
2) Suitability of the original report for preparation of a summary;
3) Interest as an example of good accident investigation practice.

Although they do not appear in classification Tables A and B, they have been classified according to pages 16 - 20 of the ICAO Manual of Aircraft Accident Investigation - Doc 6920-AN/855/3 (Third Edition) and the classification appears at the end of each summary concerned.

The accidents occurring in commercial air transport operations may be classified as follows:

Scheduled operations	38
International	18
Domestic	20
Non-scheduled operations	16
International	11
Domestic	5

The classifications in Tables A and B follow closely the suggestions contained in the ICAO Manual of Aircraft Accident Investigation. They have, however, been based on accident reports founded on a variety of reporting and analysing techniques. Only a portion of the total number of accidents investigated by States is either released for general publication or sent to ICAO. Due to the smallness of the total samples (54) no attempt has been made in this publication to prepare classification tables according to the type of operation being conducted, for instance, whether scheduled or non-scheduled; and no differentiation is made between accidents occurring on domestic and on international flights. However, a notation on the type of operation being conducted, where known, is included in Table A. While the tables may serve a useful purpose in indicating causal trends, the numbers are too small to be significant for statistical purposes and readers are warned not to place too much reliance on the trends so indicated without comparison with other sources, such as those published by other international organizations and national administrations.

Although considerable care has been taken in drawing up Table A to ensure that the classification conforms with the findings of the reports from States, the very brevity of the table might give a wrong impression in some instances. The reader is, therefore, always invited to refer to the summary in the Digest and, if necessary, the report from which it is derived.

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* A ground collision, involving two aircraft, is counted as two accidents.

A survey of the commercial air *transport accident summaries for* 1961 suggests that the following features are worthy of attention:

i) 50% of the accidents summarized occurred during the approach and landing stages and of these 56% were collisions with terrain or objects thereon, (including 15% classified as undershoots). Another 18% were due to stall or loss of control and the remaining 26% were of various types, including one collision between a landing aircraft and another taking-off without clearance. It would appear from the above that pilots are experiencing difficulties in correctly determining their position and of correctly interpreting their height above the ground. The proportion of accidents occurring during the landing phase has slightly increased during the year under review;

ii) 29.6% of the accidents, including many serious ones, occurred during the en route phase. 37.5% of these were collisions with rising terrain confirming the comments above. Of the remainder 13% involved engine tearaway and another 13% wing failure. There was one in-flight fire due to a fuel leak, one engine bearing failure followed by overspeeding and turbine failure, one stall due to icing conditions and one instance of faulty navigation;

iii) 20.4% of the accidents reported occurred during the take-off and initial climb phase. This percentage is the same as for the previous year. Of these 27% involved control systems difficulties and in two cases the accident occurred when the aircraft stalled. Two other accidents were caused by a possible lack of coordination between the two pilots. One aircraft took off without clearance and collided with a landing aircraft.

Of particular interest in this issue is the summary of the Dag Hammarskjold accident which appears on page 183.

Unusual causes of accidents appearing in this issue include whirl mode, porpoising, and one instance, in Australia, of the pilot collapsing over the controls of the aircraft following a heart attack.

Improperly executed instrument approaches also contributed to the accident picture for 1961.

Manual of Accident Investigation

The ICAO Manual of Accident Investigation (Doc 6920-AN/855), which was first published in 1949, was completely revised in 1959, and the Third Edition is now available in English, French and Spanish. The Manual is designed to facilitate the proper training of investigators, without which many of the lessons that can be learned from the misfortune of accidents may be lost. In addition to the promotion of a higher technical standard of accident investigation, the Manual provides for a standard form of classification and reporting which will facilitate comparison of accident data and the international application of remedial measures arising from accident investigation.

TABLE A. - ACCIDENT CLASSIFICATION - 1961 (based on phase of operation)

Phase of Operation	No.	Type of Accident	No.	Description	ICAO Ref.	Type** of Operation	Page
Take-off (20.4%)*	11	Ground loop	1	Undetermined	AR/760	S	143
		Collision - aircraft - on ground	1	DC-6B commenced take-off without clearance from runway 9 and collided with Viscount landing on runway 4R.	AR/721	S	258
		Collision - object - trees	1	Co-pilot lost altitude after take-off. Pilot may have failed to supervise.	REP/GEN/8	S	282
		Collision - object - fence	1	Unnecessary discontinuing of take-off by check pilot.	AR/728	S	21
		Stall	2	Obstruction of pitch pointer in captain's director horizon. Made an excessively steep climb immediately following unstick.	AR/736	S	304
				Improperly executed take-off resulted in an inadvertent descent into the water. This produced a high-speed, low-angle porpoise.	AR/751	S	307
		Loss of control	3	Loss of a nickel steel bolt from parallelogram linkage of elevator boost system.	AR/737	S	163
				Mechanical failure in aileron primary control system ... improper replacement of aileron boost assembly.	AR/738	S	176
				Aircraft took off with full left rudder trim applied.	AR/710	NS	278
		Airframe - air	1	Action to recover control immediately after take-off imposed a load on the aircraft which with speed and turbulence produced forces greater than its structure was designed to bear. Starboard wing failed.	AR/749	S	287
		Undetermined	1	Undetermined.	AR/744	***	86
En route (29.6 %)*	16	Wheels-up landing	1	Faulty navigation.	AR/691	NS	147
		Collision - rising terrain	6	Pilot attempted to fly over mountainous terrain when unsure of his position and in poor weather conditions.	AR/761	S	31
				Navigation error.	AR/672 AR/717	S NS	59 214
				Aircraft drifted towards the mountain range. Lack of ground aids on the airway and strong wind contributed.	REP/GEN/24	S	65
				Pilot was probably unexpectedly confronted with severe carburettor icing conditions.	AR/671	NS	68
				Slightly off course because of prevailing winds - premature descent for unknown reasons.	AR/704	NS	72

* Percentages are based on the total number of 1961 accidents classified - 54

** S = Scheduled NS = Non-scheduled

*** KLM (operator and State of Registry) lists this as a charter-non-scheduled flight. VIASA (Venezuela) lists it as scheduled.

cont'd on next page

TABLE A:- ACCIDENT CLASSIFICATION - 1961 (based on phase of operation) (continued)

Phase of Operation	No.	Type of Accident	No.	Description	ICAO Ref.	Type of Operation**	Page
En route (cont'd)		Stall	1	Pilot failed to foresee the possibility of icing conditions and to assess the situation correctly.	AR/705	NS	225
		Airframe - air	2	Aircraft lost right wing following application of excessive loads - violent turbulence.	AR/715	S	133
				Aircraft was flown too close to summit of mountain and turbulence or some pilot manoeuvre caused the starboard propeller to strike the mountain. Starboard mainplane became detached.	REP/GEN/11	S	270
		Engine tearaway	2	Forced or unintentional descent during which structural stress factor was exceeded.	AR/752	S	61
				Whirl mode caused failure of forward propeller shaft bearing on No.1 engine.	AR/768	NS	92
		Turbulence	1	Undetermined.	AR/746	S	285
		Decompression	1	Oil starvation of the No.2 bearing caused its failure. Fracture of low-pressure compressor rear hub, overspeeding and disintegration of the low-pressure turbine section followed.	AR/719	S	245
		Emergency conditions - forced landing	1	A carburettor drain plug unscrewed and caused a fuel leak which started and sustained an in-flight fire.	AR/739	NS	160
		Undetermined	1	Undetermined.	AR/762	S	41
Landing* (50 %)	27	Ground loop	2	Failure of the thrust reversers on engines Nos. 1 and 2 when reverse thrust was selected resulted in asymmetric thrust, during hydraulic emergency.	AR/727	S	123
				Loss of directional control and aircraft struck snowbank.	REP/GEN/15	S	312
		Gear retracted	1	Co-pilot interfered with controls	AR/706	S	263
		Undershoot	4	Pilot concentrated on keeping runway lights in sight and failed to make adequate reference to his flight instruments.	AR/708	NS	170
				Pilot failed to follow instrument approach procedures.	AR/714	S	117
				Absence of approach and runway lights. Failure of GCA controller to give more positive guidance to pilot during last stages of approach.	AR/726	NS	138
				Pilot's improper execution of an instrument approach.	AR/720	S	299
		Overshoot	1	Pilot decided to land in variable weather conditions which precluded adequate orientation relative to location along the runway.	AR/759	S	202
		Collision - aircraft - on ground	1	DC-6B commenced take-off without clearance from runway 9 and collided with Viscount landing on runway 4R.	AR/721	S	258

* Percentages are based on the total number of 1961 accidents classified - 54
** S = Scheduled NS = Non-scheduled

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TABLE A:- ACCIDENT CLASSIFICATION - 1961 (based on phase of operation) (continued)

Phase of Operation	No.	Type of Accident	No.	Description	ICAO Ref.	Type of Operation**	Page
Landing (cont'd)		Collision - ground	7	Captain had heart attack and collapsed across engine controls bringing four throttle levers to closed position.	AR/709	S	78
				Pilot's inattention to his instruments.	AR/743	S	97
				May have attempted a fast let-down with partial visibility of the ground in unfavourable weather.	AR/725	S	129
				Pilot may have misread his altimeter which resulted in 1 000 ft error.	AR/723	S	169
				Pilot diverted his attention from his instruments to outside the aircraft thus allowing the aircraft to descend below the safe minimum altitude.	REP/GEN/19	S	206
				Flew below critical height during ILS approach and in surface visibility which was inadequate. Heavy landing beside runway.	AR/735	S	235
				Misjudged distance from ground.	REP/GEN/8	S	238
		Collision - rising terrain	2	Deviated from the prescribed flight path.	AR/724	NS	153
				The aircraft was not in the normal approach pattern and was below the normal altitude.	REP/GEN/22	S	201
		Collision - object - trees	2	Deviated from planned route - first time that the crew had flown into this airport.	AR/699	S	34
				Aircraft was allowed to descend too low and struck trees 9-1/2 miles before the runway.	AR/703	NS	183
		Stall	2	Wrong execution of left turn at low altitude at night. Contrib. factors - alcohol and lack of sleep.	AR/694	S	14
				Cargo displacement had occurred towards the rear of the aircraft during the take-off roll or immediately after take-off.	REP/GEN/21	S	302
		Loss of control	3	Material failure of the flight controls.	AR/763	S	43
				Sudden worsening of atmospheric conditions.	AR/684	NS	74
				Malfunctioning of the automatic pitch coarsening unit of the starboard propeller.	AR/740	NS	241
		Emergency conditions - forced landing	2	Incorrect management of fuel system resulted in partial loss of power and control.	AR/753	NS	194
				Lack of command, coordination, decision, judgement and knowledge of equipment.	AR/695	NS	251

* Percentages are based on the total number of 1961 accidents classified - 54
** S = Scheduled NS = Non-scheduled

TABLE B. - ACCIDENT CLASSIFICATION - 1961 (based on accident causes)

Causal Factor	No.	Description	No.
Pilot (53.8)*	29	- misjudged distance	4
		- failed to observe aircraft	1
		- exceeded stress limits, aircraft	1
		- inattentive, fuel supply	1
		- improper IFR operation	[illegible]
		- inadequate pre-flight inspection	1
		- improper in-flight planning	2
		- became lost IFR	1
		- continued VFR into unfavourable weather	1
		- continued IFR below minima	1
		- continued into known unfavourable conditions	1
		- operating recklessly - carelessly	1
		- improper training or supervision, flight	2
		- heart attack	1
		- other	2
Other personnel (11.1)	6	- check pilot	1
		- co-pilot	1
		- inadequate maintenance inspection	4
Power plant (5.6)	3	- propeller and propeller accessories	2
		- lubrication system	1
Airframe (3.7)	2	- flight control system	1
		- wing	1
Equipment and accessories (1.9)	1	- hydraulic system	1
Related equipment (1.9)	1	- airport facilities	1
Weather (5.6)	3	- icing conditions	1
		- whirlwind and downdraft	1
		- turbulence in flight	1
Airport terrain (1.9)	1	- snow	1
Miscellaneous (1.9)	1	- cargo displacement	1
Undetermined (13.0)	7	-	7

* the percentages are based on the total number of 1961 accidents classified (54)

PART I

No. 1

Air France, Super Constellation L-1049G, F-BHBC, crashed into the sea while approaching to land at Yoff Airport, Dakar, Sénégal, 29 August 1960. Report dated 12 December 1962, released in Le Journal Officiel de la République française, dated 10 September 1963.

Circumstances

F-BHBC was flying the Paris - Dakar stage of scheduled transport flight AF-343 between Paris - Dakar - Robertsfield and Abidjan. Aboard were 8 crew and 55 passengers. At approximately 0634 hours GMT, in unfavourable meteorological conditions, the aircraft carried out a baulked landing procedure on runway 01 at Yoff Airport. After declining runway 30 (equipped for instrument landing), the pilot reported that the aircraft still had an endurance of over two hours and that he had decided to postpone the landing until the meteorological conditions improved. Shortly after 0641 he announced that he intended to make another approach to runway 01. The aircraft overflew the aerodrome in an east-west direction and was seen at 0645 hours flying in the vicinity of the N'Gor hotel, positioning itself for the downwind approach. After reporting "downwind" at about 0647 hours, the aircraft disappeared in a rain squall and was not heard from again.

It crashed at sea shortly after 0647 hours, approximately 2 400 m, on a bearing of 252°, from the Mamelles lighthouse. The wreckage was located at a depth of 40 m. No one survived the accident.

Investigation and Evidence

The Aircraft

The aircraft was properly equipped and maintained and was operated in accordance with the regulations.

The load distribution and trim of the aircraft were satisfactory.

Flight crew

The pilot-in-command's licence was valid until 2 October 1960. He had type ratings for DC-3, DC-4, Lockheed 749, 1049 and 1649 aircraft. He had flown a total of 20 068 hours including a considerable number on L1049 aircraft which he had been flying since 1953. He knew Dakar Airport well and had operated in the area from July 1949 to January 1954, then again since January 1956.

The co-pilot also held a valid licence and had ratings on the DC-4 and the Lockheed 749, 1049 and 1649. His total experience amounted to 7 192 hours.

The other three members of the flight crew (a radio operator and two flight engineers) all held valid licences and had considerable flying experience.

Meteorological conditions at the time of the accident

Dakar was experiencing conditions similar to monsoon weather. Visibility varied considerably from one minute to the next. Fairly violent showers and storm phenomena raged over the aerodrome and in its vicinity. Distant lightning, at times, could also be seen.

The 0630 hour observation was as follows:

> "QAN 360/15 kt, QBA 6 km,
> QNY moderate showers,
> QBB 7/8 cumulonimbus,
> cumulus and stratus at 600/900 m,
> QFE 1009.5 mb, QNH 1012.7 for
> 27 m."

In his communications with F-BHBC the tower controller gave wind and ground pressure data as it was in the 0630 observation. Thereafter he modified the figures for the visibility and wind conditions as he observed them.

Sunrise at Dakar was at 0657 hours GMT on the day of the accident.

The Flight

Having filed a flight plan indicating a trip of approximately 9 hours 32 minutes duration, F-BHBC departed Paris on 28 August at 2038 hours. Following an uneventful flight, during which no difficulties were reported, the aircraft contacted the Dakar area control centre and reported that it was entering the area and expected to reach Yoff at 0630 hours.

The centre cleared it to descend to flight level 20 and asked it to report again over beacon DY. At 0627 the aircraft reported it was directly over the airport.

Following this, the flight's progress was established on the basis of tape recorder transcriptions between the aircraft and the Yoff tower, data entered in the tower log by the controller and his own testimony, as well as witness information.

At 0630 hours F-BHBC was told by the tower controller at Yoff that it was then No. 1 to land. The runway in service for visual landings, was runway 01, which was newly constructed and was the longest (2 900 m), the smoothest, and the best aligned in relation to the prevailing winds.

At 0634 hours the flight, which had not reported on final approach, advised that it was not aligned and the throttle had been re-opened. The flight was then downwind, going towards the range and was to stop climbing at 1 000 ft. The controller told the flight that the ILS was on as well as the three beacons.

Visibility was then poor on runway 01, and there was heavy rain. Therefore, the flight was to wait until conditions improved. The controller informed the aircraft that it could approach on runway 30. The wind speed at that time was 10 - 12 kt.

The pilot-in-command himself then notified the tower that he was not landing but would do so when the rain stopped. He also said that he was going to turn on Goree which was then clear.

Shortly after 0641 hours the flight asked whether it should try a landing on runway 01. The tower replied that the wind conditions were 020/05 kt, and visibility was still poor. The tower controller said he could only see the Mamelles lighthouse, situated 2 800 m away, when it flashed, and he could not see runway 01.

Following this communication the visibility conditions improved, and at 0645 hours the aircraft flew over the airport in an east-west direction.

Witnesses testified that the aircraft flew parallel to runway 30, banked to port behind the N'Gor hotel and then vanished in a violent rain squall. No one mentioned having seen lightning in that direction.

At 0647/0648 the aircraft acknowledged receipt of the last message from the tower and reported it was downwind for runway 01 at 1 000 ft. There was no further contact with the flight.

A witness stated later that at about the time of the accident he had seen two red flashes at an altitude of approximately 150 m about 2 km out to sea. These flashes were in the same direction as that calculated for the crash. The witness had noticed no lightning in the area.

The wreckage

The search of the crash area and locating and salvaging of the debris proved extremely difficult. Salvage operations yielded about 20% of the debris only.

The examination of the wreckage revealed that the impact forces were violent.

The configuration of the aircraft at the time of impact

Examination of the fragments of the aircraft and the workshop investigation established the following facts concerning the aircraft's configuration:

nose landing gear:	at start of extension
main starboard landing gear:	'down' position, near locking
main port landing gear:	locked in 'down' position
flaps:	extended 60%
propeller pitches:	close to 27-28°
engines:	2 200 rpm.

The damage suggested that the aircraft struck the water at a fairly sharp angle and most likely tilted to starboard. The sudden braking, caused by the impact on the propellers and then on the lower fuselage and engines nacelles, even if it only slightly affected the aircraft's trajectory, produced a rapid pitch rotation and lowered the nose of the aircraft.

Rapid deceleration increased this rotation, forcing the nose, with the forward nosewheel extending, and the open hatches to strike the water. The sudden loss of speed caused the load to be thrust forward. It is highly probable that the tail unit separated from the fuselage at this moment.

Regarding the speed at impact, and taking into account the engine power and propeller pitches at that time, one may accept the two following hypotheses in the absence of any indication as to the manifold pressures:

190 kt: in excess of 165 kt, the maximum speed authorized in this configuration;

140-150 kt: this suggests a violent increase of the manifold pressure without any movement of the propeller control towards the fine pitch. In this hypothesis, however, one cannot exclude voluntary or involuntary action on the throttle levers during impact.

Possible Causes of the Accident - Discussion

The aircraft carried no flight recorder. As it was not possible to recover all of the wreckage, the Commission envisaged certain hypotheses but no proof could be provided for any of them.

Meteorological conditions

Lightning - dazzle

Storm phenomena in the vicinity of the accident (rain, turbulence, and lightning) suggested that the aircraft might have been struck by lightning or the pilot was dazzled by it, and momentary loss of control resulted in the aircraft's hitting the water.

Evidence of witnesses with regard to to lightning flashes was contradictory.

However, magnetization of part of propellers Nos. 3 and 4 was established. Since the engines of F-BHBC had last been changed there had been no reports of lightning strikes on the aircraft. None of the other fragments recovered showed evidence of lightning strikes, and on examination, the discharge wicks were found to be in perfect condition.

Loss of control in turbulence

It was difficult to establish precisely the conditions which existed at the time of the accident in the vicinity of the aircraft's final flight path. The possibility of extreme turbulence or lightning could not be dismissed positively.

Sudden loss of control on this account was then considered. Data obtained from the landing gear, which was extending at that time, might suggest that having reported at 1 000 ft on the final turn the aircraft lost more altitude and might then have experienced a loss of control during the last seconds of flight.

Ground facilities

Deficiencies in ground facilities were not considered to have caused the accident. Landing instructions and altimeter setting were correctly transmitted to the pilot who chose the runway and the most appropriate procedure to be used.

No information of any sudden variation in the weather conditions was sent to the aircraft, and the observations at 0630 and 0700 hours did not entirely reflect the intervening developments. The fact remained, however, that the tower controller transmitted his own observations on ground conditions at regular intervals.

Equipment

Sabotage or explosion in flight

No evidence was found to support this hypothesis.

Failure of one or more power units

Investigation of the four engines, which were salvaged, did not reveal any damage except that resulting from impact. Examination of the propeller governors and pitches also indicated normal operation.

Propeller failure in flight

Almost all of the propeller blades were recovered following the accident, and there was no reason to believe that any of the propellers had failed in flight.

Faulty handling of flaps or landing gear

No data supported this hypothesis.

Malfunctioning of the flight controls

Examination of the vertical and horizontal controls revealed no defects. However, the remainder of the control gears, as well as the ailerons and wing flaps, were not recovered. It was not believed likely *that cables had broken, controls had disconnected* or that the high lift or pitch control systems had failed.

Structural failure

The breaks found on the tail assembly suggested total or partial rupture in flight. The Commission knew of only one such accident which occurred during a test flight. On the other hand, there had been several instances in ditchings of the tail separating from the fuselage.

Incidents in the cockpit

The possibility was also examined of cabin incidents having distracted the crew's attention momentarily.

In view of the undercarriage being in the process of extension, this would lead to the following conclusions:

a) the incident occurred during the last few seconds before impact and led to a sudden loss of control and to an impact configuration, which was not confirmed by observations;

b) the incident occurred two or three minutes prior to impact resulting in the pilot's unaware*ness of a 400 - 500 ft/min loss* of altitude. (The aircraft was last seen at 0645 hours at approximately 1 000 ft.)

Inaccurate indication of the altimeter or airspeed indicator

The possibility of interference with the static or dynamic pressure circuits of the aircraft following its entry into the rainstorm could not be entirely excluded.

However, the Commission was not aware of any significant precedent of this kind with regard to the operation of L1049's.

Taking into consideration the first approach made and the last flight of the aircraft over the aerodrome, this type of failure could have occurred suddenly during the last three minutes of flight, when a witness saw the aircraft disappear during a heavy downpour.

Although this was a remote possibility, a momentary "stiffness" in the instrument, showing a false reading of hundreds of feet, could not be ruled out.

Crew Error

Faulty reading of the altimeter

This possibility could not be excluded as this has occurred at times when the crew's attention was overtaxed. However, the statements of witnesses, who saw the aircraft pass over the aerodrome at 0645, i.e. just prior to the accident, stated that the aircraft's altitude at that time was about 1 000 ft. This agreed with the crew's last message.

Sensory illusion

The visibility conditions which existed when the aircraft made its second attempt to land, as based on witnesses' statements and data supplied by the tower controller, made sensory illusions a possibility.

The only visual point of reference the crew could have had during their next to last turn and downwind approach was the flashing of the Mamelles lighthouse. Also, the twilight provided no depth perspective of the seaward view. If there was a slight tilt of the aircraft to starboard, an assessment of his altitude by reference to this point alone would have given the pilot-in-command the illusion of having a sufficient margin above sea level, whereas, in fact, during his next to last turn and downwind passage he would have been losing height at a rate of 300 to 500 ft/min.

In this case he would have ordered extension of the undercarriage at a fairly high speed, and the impact with the water would have occurred shortly thereafter. Although this hypothesis cannot be ruled out, it presupposes insufficient attention to instruments or errors in the instruments themselves which are hardly admissible. Due to a lack of evidence, none of the above hypotheses could be verified.

Probable Cause

The cause of the accident could not be determined.

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ICAO Ref: AR/774

Scheduled International
Landing
Undetermined

No. 2

Aero O/Y, DC-3, OH-LCC, accident at Koivulahti, Finland, 3 January 1961. Summary report released by the Investigation Commission and the Commission for Investigation Control appointed by the Ministry for Communications and Public Works, Finland.

Circumstances

Flight AY 311 was scheduled to depart Kruununkyla for Vaasa at 0700 hours local time on 3 January, however, owing to a delay in pre-flight preparations the take-off did not take place until 0716 hours. The estimated duration for the Kruununkyla-Vaasa sector of the trip, a distance of about 100 km, was 30 minutes.

When approaching Vaasa the aircraft crashed in the woods in the village of Koivulahti at approximately 0740 hours, caught fire and was completely destroyed. The accident site is 10.5 km north of Vaasa Airport (direction 018°). All 22 passengers and 3 crew members aboard the aircraft were killed.

Investigation and Evidence

The Aircraft

Its last certificate of airworthiness issued 20 October 1960 was valid until 30 April 1961. Maintenance of the aircraft had been carried out as required.

On departure from Kruununkyla, OH-LCC's take-off weight of 11 252 kg was under the maximum permissible of 11 900 kg, and the aircraft's centre of gravity was within limits.

Crew Experience

The pilot-in-command of the aircraft had flown in that capacity on DC-3's with the company since July 1956. His airline transport pilot's licence was in order and valid until 9 June 1961. His total number of flying hours amounted to approximately 5 887.

The co-pilot held a valid commercial pilot's licence and had flown a total of 2 737 hours.

Weather

The preceding night a light snowfront was moving in the direction of Vaasa-Kruununkyla, followed by radiation fog on low-lying spots on the ground, such as fields and river valleys. The fog did not cover ridges and hills.

At the time of the accident (0740 hours) the weather conditions were:- visibility - 1 km in Vaasa; cloud 8/8, base 200 ft (60 m); temperature minus 2°C. The 0750 weather report transmitted to points including Helsinki and Tampere showed conditions which were similar to those existing at 0740 hours. There was also radiation fog in the river valley of Isokyrö, which lies near the place of the accident. The weather conditions were deteriorating. The temperature in Vaasa fell 7° within an hour, and the horizontal visibility at Vaasa Airport had deteriorated to 400 m by 0920 hours.

Activities of Flight Crew Prior to Final Flight - (Alcohol Discussion)

The pilot and co-pilot flew together on Friday, 30 December (1960) starting at 0805 hours on a scheduled flight Helsinki-Turku-Mariehamn-Stockholm. At 1535 hours on the same day they began the return flight Stockholm-Mariehamn-Turku-Pori. Owing to engine trouble an overnight stop at Pori was made, and the aircraft flew on to Helsinki at noon the next day (Saturday) without passengers. While at Pori the captain and co-pilot had liquor.

Both spent New Year's Eve and night in Helsinki at their homes and the following day, 1 January (Sunday), set out on a scheduled flight at 1850 hours for Turku-Mariehamn, returning Monday morning by the same route to Helsinki. No details are available as to how they spent their off-duty time in Mariehamn.

At 1805 hours on the Monday they commenced their joint working shift on a scheduled flight Helsinki-Pori-Vaasa-Kruununkyla. The landing at Kruununkyla was made at 2045 hours. On arrival at the town of Kokkola the captain and co-pilot went to the restaurant of the hotel where they were staying and had a meal with the local traffic officer, a representative of Aero O/Y, which included liquor (beer and gin).

After midnight the party had further liquor (cognac) for about half an hour in the pilots' hotel room. They then went to the traffic officer's residence for more drinks until about 0200 hours. Both crew members stayed there overnight.

Nex day the two flight crew did not arrive at the airline's office in Kokkola in time to catch the bus for the airport but went directly to the airport by taxi from the traffic officer's home.

On arrival at the airport, the pilot-in-command and the stewardess went straight to the aircraft whereas the co-pilot first reported to air traffic control.

Neither the taxi-driver nor any other persons questioned by police who had been performing duties at the airport, reported having noticed that the two flight crew members were intoxicated. However, the foreman doing construction work at the airport, who had a brother among the aircraft's passengers, stated that he suspected such a possibility.

On the basis of blood tests taken at the post-mortem examination it was established at the Institute for Medical Jurisprudence of the University of Helsinki that the pilot-in-command's blood contained at least 2 o/oo and the co-pilot's 1.56 o/oo of alcohol. Approximately the same result was obtained by calculating the crew's assumed share of the total quantity of alcohol consumed by the party of three persons the foregoing evening (16 bottles of beer, 7 gingrogs and about 900 g of cognac).

Regulation regarding alcohol consumption

Paragraph 18, point 3, of the agreement between Aero O/Y and the Finnish Airline Pilots Association in force at the time of the accident contains a regulation forbidding the consumption of alcoholic drinks when on duty and during the 12 hours before a flight. However, 1/3 litre of beer or 20 centilitres of light wine was allowed in connexion with a regular meal comprising a warm dish, but not during the flight.

Reconstruction of the flight of 3 January

The flight crew and traffic officer arrived at the airport only five minutes before the scheduled departure of the flight. The start was delayed as the tickets and luggage of passengers from Pietarsaari had to be checked at the airport.

The co-pilot made out the flight plan and obtained the necessary weather information. The pilot-in-command examined the aileron of the aircraft to ascertain that there was no snow or ice on it but did not perform an outer inspection of the aircraft.

The weather report given by the meteorological station at Kruununkyla indicated that the existing conditions at Vaasa were fairly good -

0650 wind 220°/6 kt; visibility 10 km;
clouds 8/8, cloud base 5 000 ft
clouds 2/8, cloud base 1 400 ft.

The forecast was also good.

The flight (AY 311) was to continue on from Vaasa to Pori, and the co-pilot was informed by the air traffic controller that the weather at Pori was not as good as at Vaasa. Pori is used as an alternate airport when flying from Kruununkyla to Vaasa.

Through ATC-Kruununkyla the co-pilot had requested permission from ACC Vaasa to fly at free altitude. This means that the aircraft is allowed to fly at or above the minimum altitude prescribed for the route in question. The lowest altitude allowed on the route Kruununkyla-Vaasa is 1 500 ft or 450 m. As there was no other traffic on the route, ACC Vaasa approved the request and the aircraft was informed, accordingly, before take-off.

The first part of the flight was normal except for the fact that it was carried out below the prescribed minimum altitude. The aircraft flew below the minimum the whole way, the last 30 - 40 km probably below 100 m.

At 0721, i.e. about 5 minutes after take-off, the aircraft was advised to change over to the radio frequency of Vaasa ATC. The radio communication between the aircraft and ATC Kruununkyla was normal and was probably done by the co-pilot. The air traffic controller (Vaasa) stated that the aircraft had thereafter called Vaasa ACC by radio several times, but it seemed that the answer from Vaasa could not be heard by the aircraft.

It was proved, during the reconstruction flights, that when flying at an altitude of 200 m, radio transmissions from Vaasa ACC could be heard aboard the aircraft beginning from a distance of about 50 km only, i.e. half the way from Kruununkyla to Vaasa. This also implies that the aircraft was flown at a low altitude.

Based on eye witnesses' statements and reconstruction flights it was concluded that the aircraft was flown within the prescribed airway, which is 18.5 km wide. Having maintained its initial climbing course as far as Ahtava, the aircraft turned somewhat to the right. At least from Oravainen to the accident site, a distance of about 30 km, it had apparently flown below 100 m. When passing Oravainen or thereabouts, about halfway, ATC Vaasa called the aircraft by radio at 0730 hours. The aircraft answered promptly and ATC Vaasa believed the co-pilot was operating the radio. The communication lasted about 4 minutes, and the Vaasa weather report was transmitted during this time. The report was the same as the one that the flight had received at Kruununkyla except that the weather had deteriorated and the clouds were now 8/8 600 ft. The aircraft was cleared for an approach to land on runway 16 for which an instrument approach must be carried out using the non-directional beacon "Seppa". The aircraft acknowledged the clearance. At the beginning of the communication the aircraft reported it was at 1 500 ft, above the clouds, and estimated it would be over Seppa at 0741 hours. The reported cruising level was obviously false. The aircraft was then about 20 km from the place of the accident and headed for the non-directional beacon at Seppa.

After the communication ended at 0734, ATC Vaasa received a message from the MET office stating that the cloud base was at 500 ft. This information was passed on to the aircraft immediately. The written 0735 weather report was then received, and according to it the Vaasa weather had deteriorated to such an extent that the horizontal visibility was only 1 km, clouds 8/8 200 ft and there was fog on the airport. The flight was again advised promptly, and it acknowledged receipt of the information. It was also told that conditions on the outskirts of the airport may even be worse. The aircraft then advised that it would be at the beacon in approximately two minutes time. This was the last radio communication with the aircraft, and it ended at 0739 hours. At this time the aircraft was about 3 - 6 km from the accident site. During this last communication the rpm of the engines was noticeably increased from 2350 - 2500 rpm. (This was established by comparing observations of persons who saw the actual flight with observations made by the same persons of reconstruction flights operated at different rpm's.) The increase indicates the pilots had begun the check required before landing. The aircraft was about to arrive at NDB Seppa.

When the flight did not advise that it had reached NDB Seppa the air traffic controller attempted to contact it several times on all the frequencies used by Vaasa ACC, but without success.

At about 0755 the police of Koivulahti reported to Vaasa ACC that they had been informed that an aircraft had crashed in woods nearby.

Subsequent to the last radio communication the aircraft flew for about 1.5 minutes over the open fields of Koivulahti at about 50 m, perhaps less, and then made a steep left turn during which it lost so much speed that a stall resulted. An unsuccessful attempt to regain control was made giving full throttle at the last moment; however, the aircraft went into a spin.

From the manner in which trees and branches were broken in the vicinity of the crash it was concluded that the aircraft had struck the ground, left wing first and at an angle of about 70°. On crashing to the ground it turned at least 60°. The direction of the aircraft on the ground was approximately the same as its heading before the turn. It is probable that the landing light had been switched on.

The accident site is about 400 m south of the aircraft's route. The time of the accident was fixed at about 0740:30 hours (0540:30 GMT).

Discussion of possible causes of the accident

Icing - this factor as the probable cause was considered and eliminated. Weather conditions existing were such that the forming of ice in sufficient quantity to impair the flight characteristics of the aircraft was not possible. The de-icing equipment aboard the aircraft had not been used, and ice accretion was not mentioned during any communications.

Collision with trees or other object - there was no evidence to support this as a possible cause of the accident. No traces were found on any of the aircraft's parts which indicated it had hit any obstacle prior to crashing to the ground.

Fire or explosion - eye witnesses, who had observed the aircraft prior to the accident, had observed nothing pointing to such a possibility. No objects had fallen from the aircraft away from the accident site. The fire extinguishing equipment had not been used.

Attempted forced landing - because in the last phase of flight the aircraft had turned back towards the open fields of Koivulahti, the possibility of an attempted forced landing was considered. No such intention was reported by radio. No other evidence was brought to light to support this theory.

Movement of passengers about the aircraft (centre of gravity) - the position of passengers in the cabin was studied following the accident. Most of the victims had been hurled forward and to the right. This resulted from the spin which the aircraft went into prior to hitting the ground. In order to change the centre of gravity through movements of passengers in the aircraft to such a degree that it would be sufficient to produce a noticeable change of the flight characteristics, it would be necessary for several to move from their places in the same direction at the same time. Having considered the location of the bodies and the contusions resulting from the accident, it was not believed that any general movement had occurred.

Argument between passenger and crew member - the theory that one of the passengers had gone forward to the cockpit to find out why the flight was being carried out at an abnormally low altitude and that an argument had arisen between him and the pilot was considered.

However, if this type of incident had occurred it cannot be assumed that the person in question would have been able to interfere with the piloting of the aircraft without the intervention of the co-pilot.

Other possibilities - The aircraft had entered into an unintentional spin. Two other possibilities were considered:

1) something had happened that had made the pilot incapable of action; or

2) an erroneous manoeuvre had been made.

1) Insanity, death, or a sudden case of illness were considered. The captain's medical record showed no mental diseases which would have pointed towards a possible sudden fit of insanity.

If the pilot had been suddenly taken ill the co-pilot was there to take over. It was not considered very likely that the pilot, who had his seatbelt fastened, could have collapsed in his seat and thereby have made it impossible for the co-pilot to use the right side controls.

Suicide was also considered and eliminated.

2) On the basis of the aforesaid, the remaining and most probable cause of the accident was thought to be an erroneous manoeuvre in the last phase of the flight. The captain had either begun turning the aircraft too sharply or endeavoured to increase the flying altitude too abruptly, whereby the aircraft crashed to the ground as a result of the decreased speed.

Reconstruction flights established that it is not possible to pilot the aircraft into a turn of such a small radius as the aircraft in question made without first considerably reducing the engine power. Witnesses did report that the engine noise had faded for a while. If the aircraft had stalled as a result of the decreased speed, the big increase in engine noise heard by observers could be explained as an attempt at the last moment to prevent the aircraft from crashing by increasing the engine power. A possible reason for the pilot's having made a steep turn to the left might have been that he had the erroneous impression that the aircraft had already come so near the Seppa NDB that he had begun to turn in the landing direction, which was almost at a right angle to the flight direction. As mentioned previously, the rpm and power of tne engines had already been adjusted to what they should be when preparing to land. The aircraft at that time was about 6 - 7 km from where the turn was begun. The erroneous conception of the aircraft's position may have been caused by a wrong estimation of its arrival time over the Seppa NDB by the similarity between the terrain outside Vaasa and that of Koivulahti, by the deceiving impression that the lights of Koivulahti village were the lights of the settled area near Vaasa (visibility was hampered by radiating fog on low-lying spots of the terrain), or by the directions of the radio compasses having been wrongly read.

One of the radio compasses was tuned to the frequents of the Seppa NDB and the other to the frequency of the locator serving as approach aid for runway 16. The estimation of the distance between the aircraft and the NDB is based amongst other things on the angle between the needles of these compasses. It was established, subsequently, that the Pori NDB*, which has the same frequency, is disturbing the above-mentioned locator and thus the position of the compass needles to each other may partly have misled the pilot. If such an error or some other erroneous reading of the radio compasses had occurred, the steepness of the turn could be explained by the fact that there is a radio mast with a height of about 114 m close to the approach from the Seppa NDB to the runway, which the aircraft would have had to be cautious of when flying at a low altitude.

A too sudden increase of the flying altitude may have caused the accident. If

* This new beacon was put into operation for tests only on 20 December 1960.

the aircraft was banked to the left at that moment it may have come into such an incorrect turning movement that it was no longer possible for the pilot to straighten it up. The momentary decrease of the engine noise, as heard by observers, could also have been due merely to the fact that the aircraft had drawn further away. The sudden increase of the engine noise may have been caused by a last minute attempt to regain control by applying more power. The eyewitness, who had followed the last phase of flight, did not report having noticed any increase in the flying altitude, at least no sudden increase, but exact observations were made difficult by the darkness, fog and the fact that he had not seen the aircraft from the side. His statement that the right wing was lower than the left and the green blinking light was visible may have been the attitude of the aircraft in its dive, when the green light on the right wing was already visible on account of the turning of the aircraft.

The aircraft was flying low over the open fields of Kouvulahti. The reason for the increase in altitude may have been the appearance ahead of a dark forest, probably free from fog, from the edge of which the terrain begins rising to more than 10 m for a distance of a few hundred metres and in which some trees are more than 20 m high. There may have been other reasons for increasing the flight's altitude. A sudden icing of the outside of the windshield may have occurred necessitating a change from night VFR to IFR. The change to IFR may also have been caused by the aircraft's entering cloud, the base of which was at an altitude of about 200 ft (60 m) in Vaasa and may have been at the same altitude at Koivulahti. The rapid deterioration of weather conditions at Vaasa Airport, which the pilot was aware of, may have made the pilot realize that the flight would not be continued VFR all the way to the airport and he, therefore, decided to climb higher. The sky had apparently been nearly free from clouds as far as Koivulahti and the flight was carried out during full moon in such a direction that the low-lying moon glared from straight ahead. This may have made the change to IFR more difficult and calls for rapid reading by the pilot of the indications of several instruments. If the increase of the aircraft's altitude had been too sudden and it was banked to the left, the apparent result was a series of movements which led to the crash.

Conclusions

Based on an examination of the wreckage and eye witnesses observations it was concluded that technical difficulty during the flight did not cause the accident.

The reason for low flying may at first have been that the cloud base was said to be 1 300 ft in the weather report and that flying in the clouds might have occasioned slight icing. That the flight was continued at a still lower altitude could not have been for any pertinent reason, which is evidenced by the fact that a false flying altitude was reported by the aircraft. The time lost by the delayed departure of the aircraft or reluctance to climb to a higher altitude because of the shortness of the route is no explanation for such low flying. It is, therefore, evident that during the flight in question regulations were wilfully and without reason violated by flying at too low an altitude. The navigation of the aircraft was, on the other hand, properly conducted.

The aircraft was piloted, at least in the last phase of the flight by the captain. The position of the bodies of the crew showed that the pilot had been sitting in his own seat on the left-hand side and that he had his seat belt fastened, whereas the seatbelt of the co-pilot was not fastened. According to the company's operations manual, one of the pilots must be at the controls with his seat belt fastened during the entire flight. According to the air traffic controller it was the co-pilot who had been in charge of the radio communications, which would also indicate that he was not piloting the aircraft.

According to the regulations the pilot-in-command is responsible during the flight for the operation and handling of the aircraft as well as for its safety and for the safety of all persons on board. The co-pilot is under the command of the responsible pilot. The regulations concerning the use of alcoholics before a flight, however, concerned both of them.

The physical and mental conditions of the pilots were not normal because of a lack of sleep the night before the final flight and because of alcoholic drinks which had been consumed contrary to regulations.

The air traffic controller at Kruununkyla, whose responsibility it was to supervise the safety of the flight, had not had the opportunity of verifying the captain's condition, since the latter did not come to air traffic control. As for the co-pilot, only one of the persons who had seen him in the morning in question reported that his conduct gave reason to suspect that he had taken alcoholic drinks.

The duties of the company's traffic officer at Kokkola were to take care of the passengers and to check that the aircraft was properly loaded, therefore, his position did not involve any obligation to interfere with the course of events in this case.

Regarding the operations of the Vaasa meteorological office, it was established that the written reports passed to Vaasa ATC concerning the local weather conditions for the morning in question were incomplete and erroneous. It was on the basis of these reports that weather information was provided to OH-LCC.

Probable Cause

The probable cause of the accident was the wrong execution of a left turn at low altitude at night, as a result of which the aircraft stalled, lost its manoeuvrability and went into a spin.

Contributing factor

As a consequence of having had alcoholic drinks and insufficient sleep the night before, the pilot was not considered to be in a satisfactory mental and physical condition to undertake the flight. For the same reason, the co-pilot should not have been allowed to start on the flight in question.

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ICAO Ref: AR/694

No. 3

Aeronaves de Mexico, Douglas DC-8, XA-XAX, accident at New York International Airport, New York, N. Y. on 19 January 1961. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. F-100-61, released 1 August 1962.

Circumstances

Following a discontinued take-off from runway 7R, XA-XAX crashed and burned at 2017 hours eastern standard time killing 4 of the 9 crew members. All 97 passengers survived, but some were injured.

Investigation and Evidence

The Aircraft

At time of take-off the aircraft's gross weight (272 171 lb) and the location of its centre of gravity were within the permissible limits.

Its total airframe time was 529 hours 24 minutes at the time of the accident. Four hours and 19 minutes were accumulated the day of the accident on the trip from Mexico to New York.

The time since the last phase check (No. 2) was 120 hours 11 minutes and it was completed on 3 January 1961 by Eastern Air Lines at Miami, Florida. The time since the last interphase check was 12 hours 54 minutes and it was completed 17 January 1961 in Mexico. The last trip check was completed at (Idlewild) International Airport, New York, on the day of the accident.

The maintenance history of the aircraft was without any item which could be significantly related to this accident.

Crew information

The pilot-in-command held a currently effective Mexican airline transport certificate and was checked out as a DC-8 captain in November 1960 at Miami, Florida. His total pilot time was 15 210 hours, of which 94 hours were in DC-8's. His total night time in DC-8 aircraft was about 47 hours, and his total instrument time in the last three years was 182 hours.

The co-pilot also held a currently effective Mexican airline transport certificate and was rated as a captain in the DC-3 and as first and second officer in the DC-8. His total pilot time was 8 261 hours, of which about 126 hours were in the DC-8. He had flown a total of 54 hours by night in DC-8 aircraft, and his total instrument time in the last three years was 160 hours.

The check pilot, a United States national, was a designated Eastern Air Lines DC-8 check pilot and held a valid airline transport pilot certificate with various ratings. He had a total of 19 495 flying hours, of which 285 were in the DC-8. His total flight time by night was 4 800 hours, with a total instrument time of 2 124 hours.

Operating and Training Agreement between Aeronaves and Eastern Air Lines

A joint training agreement between Aeronaves de Mexico, Eastern Air Lines, and the Douglas Aircraft Company, provided that Aeronaves flight crews receive DC-8 training, using Eastern Air Lines ground and simulator facilities and Douglas Company flight instructors for check-out in the DC-8 aircraft. Eastern Air Lines provided DC-8 ground school classes between 3 October 1960 and 4 November 1960 for five Aeronaves DC-8 captains and eight Aeronaves pilots, including the crew of Flight 401/19. All three flight crew members graduated from the DC-8 ground school with high grades. They also received flight simulator training from

Eastern Air Lines and completed their courses satisfactorily. All three were flight-trained in the DC-8 at Miami, Florida, by Douglas Aircraft Company flight instructors. The pilot-in-command was checked out as "captain" and both first officers were checked out as both "first and second officers", and qualified at the systems panel.

Eastern loaned Aeronaves qualified check pilots to assist in the early stages of Aeronaves jet operation between Mexico and New York. This assistance was for approximately two months so that EAL check pilots could accompany each Aeronaves DC-8 captain for at least three round trips and each Aeronaves first officer for a maximum of twelve round trips over the New York - Mexico City route. In accordance with agreement to assist Aeronaves in any proper and practical manner, EAL arranged to assign to Aeronaves four of its senior check pilots qualified on the DC-8. These check pilots on this assignment would specifically perform the following functions:

1. Observe and monitor the performance of Aeronaves flight personnel.

2. Coach and familiarize Aeronaves flight personnel with standard procedures for the DC-8, and particularly to familiarize Aeronaves flight crews with air traffic control procedures in the New York area.

3. To assist Aeronaves flight crews in any other possible way which, in the knowledge and experience of our check pilots, would contribute to the safe, efficient conduct of the Aeronaves operation.

The check pilot on the subject flight was aboard in accordance with the above.

The Flight

The aircraft had arrived from Mexico City at 1515, that day, and snow had accumulated on it. Glycol was used to remove the snow from the aircraft including the pitot heads, and the process was continued until time to start the engines for taxying out. The second officer and the check pilot conducted a walkaround inspection of the aircraft.

The crew boarded the aircraft at 1935 hours. The aircraft subsequently received an IFR clearance, and at 2012 hours it was cleared to taxi to the westerly end of runway 7R, where it stopped and was then cleared for take-off. The latest airport weather was given to the flight as: "precipitation ceiling 300 ft; sky obscured; visibility 1/4 mile; light snow; fog; wind east-northeast 18; gusts to 24; altimeter 29.64". While the aircraft was being taxied to take-off position it was given "runway 4R (because 4R is equipped with a transmissometer) visual range less than 2 000 ft." The weather minima for domestic jet take-offs are ceiling 200 ft, visibility 1/2 mile. However, the weather minima for the take-off of this flight, with high intensity lights operating, were ceiling 100 ft, visibility 1/4 mile in accordance with Part 27(b) of the FAA-approved Foreign Air Carrier Operating Specifications of Aeronaves de Mexico, S.A. as amended on 6 December 1957.

The first approximate 6 200 ft of take-off roll was observed by control tower personnel, visually, until the aircraft was lost to view by obscuring snow, approximately 3 800 ft from the control tower. At that time the aircraft had not taken off or rotated.

The check pilot was the only survivor of the four cockpit occupants. He was occupying the jump seat directly behind the pilot-in-command and stated that the checklist was accomplished normally. The runway condition was good, and everything apparently occurred in a routine manner through the 100 kt time check when the first officer called out "cien" (Spanish for 100). Upon reaching approximately 130 kt (the V_1 speed) the first officer called out V_1 and V_R in rapid succession. The aircraft was then rotated quickly and somewhat excessively. The check pilot did not see the airspeed go over 130 kt and as rotation started he saw the airspeed start to drop back quite rapidly to about 110 kt. At this time the Aeronaves captain called or pointed to the airspeed indicator. The check pilot felt that the aircraft could not become airborne under these conditions and that the runway remaining was not long enough to put the nose back down to start the take-off again from that speed. His only choice, so he stated, was to try to get the aircraft stopped on the runway. He unfastened his safety belt, stood to gauge progress down the runway, moved forward, shoved the throttles forward briefly, noted a normal and uniform response from the engine instruments (the EPR - engine pressure ratio - gauges were reading normally from 2.52 to 2.54), and then pulled the throttles full back. The pilot-in-command "immediately" pulled the reverse throttles back into reverse thrust and used wheel brakes. The check pilot extended the spoilers and then sat down on the jump seat without refastening his seat belt. He believed that the aircraft did not take off. /His actions would have taken about three seconds, as shown by later test./

The aircraft continued ahead the full length of the 10 000-foot runway, beyond it, through a blast fence*, catching on fire, through the airport boundary fence and across a boulevard where it struck an automobile, injuring the driver and sole occupant. Many parts of the aircraft were shed before it came to rest in flames 830 ft beyond the end of the runway. Destruction of the aircraft was extensive.

Weather

1900-2100	precipitation ceiling 500 ft or less due to snow; visibility - less than 1 mile and gradually dropped to 1/4 mile in snow and fog. Runway visual range - less than 2 000 ft at the time of the accident.

The snow consisted of small dry flakes and was blown and drifted by surface winds which averaged 15 to 22 kt with gusts up to 27 kt.

1900-2000 snow on runway 7R

1st quarter of runway	- mostly clear with some patches of compacted snow
2nd " " "	- scattered patches of snow 1 - 2 in deep
3rd " " "	- snow patches 2 - 3 in deep
last quarter	- scattered snow finger drifts 4 - 6 in deep

Runway 7R remained open and available for use until closed by the airport management immediately after the accident.

Eastern Air Lines Flight Manual prescribes six inches of snow depth as maximum for DC-8 take-off. There is nothing in the record to indicate a depth of more than six inches anywhere on runway 7R, although it was probably close to that figure at the upwind end of the runway.

Virtually continuous light dry snow had fallen, and the temperature had remained at about 20°F during the several hours the aircraft was parked on the airport between flights.

* This fence is of 10-foot sections of steel, each 10 ft high, designed to withstand and deflect the blast of jet engines. The sections are bolted sufficiently frangible to fail readily if struck by a landing aircraft, i.e. from the opposite direction.

Witnesses

The take-off roll was timed by one passenger, a highly qualified employee of an aircraft manufacturer. He estimated that rotation should start in 35 - 40 seconds. When 50 seconds passed and the aircraft was still on the runway, he thought the roll was too long and tightened his seat belt. One or two seconds later the aircraft lifted off the runway with a "thump", stayed airborne no longer than a count of three, and was back on the runway with brakes and reverse thrust being applied. He believed that the "thump" was caused by the normal rapid extension of the landing gear struts as the aircraft left the runway.

Most of the passengers believed that the aircraft did leave the ground briefly. This opinion was shared by two Aeronaves DC-8 pilots, who were riding as passengers, and one stewardess, who was seated aft in the cabin.

Blowing and drifting snow obliterated tire tracks made during the take-off roll before measurements could be made. This precluded any possibility of learning definitely the precise point at which the aircraft may have left the runway.

Systems

Investigation of the systems was hampered by covering snow and cold weather. Fire destroyed most of the structure, including a majority of the systems components. There was no evidence of fire in any system prior to the accident. No evidence could be found to indicate any system had been malfunctioning. As far as could be determined no circuit breakers were opened during the time the aircraft was on the ground at New York. The switch controlling the pitot and stall warning anti-ice heaters was found in the "off" position. There was no evidence of impact to this switch or to the surrounding structure.

The flight recorder was inoperative at the time of the accident.

Power plants

The examination of the four power plants yielded no indication of any power plant distress and indicated that they had been producing power as selected.

Structures

The wreckage came to rest in marshy, frozen and snow-covered terrain on a heading of 105°M and slightly to the right of the extended centreline of runway 7R.

Tire marks of the normal intermittent anti-skid type were found beginning 7 535 ft down the 10 000-foot runway. They extended 2 235 ft farther down the runway and ended approximately 230 ft from the runway end.

All four engines separated from the aircraft.

Fire broke out early during the sequence of events after the airplane struck the blast fence. The majority of the destruction of the wings and the fuselage was the result of the intense and prolonged fire which persisted after the accident.

The fuselage was almost completely destroyed by the prolonged fire following the accident. Only portions of the flight deck upper structure, the belly and lower side panels, and the extreme aft area were unmelted. The fuselage had remained reasonably intact throughout the accident sequence except for a partial separation of the flight deck section. The heat destruction following impact precluded any establishment as to the extent of this damage.

The cockpit area, including the instruments, controls, and circuit breaker panels, was almost totally consumed by fire.

Human factors

The deaths of the four crew members were caused by multiple burns or generalized third and fourth degree burns. Tests for toxicity produced negative results on all four, and there was no significant level of carbon monoxide in any of the four.

As stated, the check pilot was the only flight deck survivor. He was thrown several feet clear of the wreckage, as was his seat.

Twenty-eight of the cabin occupants, both passengers and attendants, were injured in diverse manners and varying degrees. As far as can be determined, these persons, as well as all other cabin attendants, did have their seat belts fastened as directed.

Take-off Performance

The manufacturers of the aircraft furnished the Board with certain take-off data. All of it is predicated on the following conditions, which are those prevailing, or assumed, at the time and place of the accident.

Aircraft nose 300 ft from southwest end of runway 7R at start of take-off roll

Take-off gross weight	270 671
Flaps set	15°
Engine anti-ice	On
EPR - according to testimony of checkpilot (Brakes released after take-off power is set and blowaway jets off 5 seconds after brake release)	2.52 - 96% thrust 4 engines
Wind	18 kt, east-northeast
Temperature	20°F
Runway	7R Idlewild
MAC	26°
Runway gradient	Zero

Because there are no known data applicable to snow-covered runways, the following is based on a dry, concrete runway.

(A) Normal Take-off Profile

	Airspeed (Knots)	Distance (Feet)	Time (Sec.)	Thrust (EPR)	Attitude (Degrees)	Altitude (Feet)
100 K Ck	100.0	2000	21.3	2.52	-1	0
V_1	130.8	3270	29.6	2.52	-1	0
V_R	143.0	3994	33.6	2.52	-1	0
Liftoff	154.6	4801	37.0	2.52	+9 to +11	0
V_2	160.56	5950	42.18	2.52	+9 to +11	35
35 Ft alt	160.56	5950	42.18	2.52	+9 to +11	35

(Distance in feet is in relation to western end of runway 7R)

(B) Profile for an Abort (Balk) at V1

	Airspeed (Knots)	Distance (Feet)	Time (Sec.)	Thrust (EPR)	Attitude (Degrees)	Altitude (Feet)
100 K Ck	100.0	2000	21.3	2.52	-1	0
V_1	130.8	3270	29.6	2.52	-1	0
Brakes	130.8+	3720	33.26	Forward Idle		

1. Accelerate Stop Distance (Brakes only)

		6350		Forward Idle	-1	0

2. Accelerate Stop Distance (Brakes plus # 2 and # 3 engines in reverse thrust take-off power and # 1 and # 4 engines in forward idle thrust)

		5965		2.52 # 2 and # 3	-1	0

3. Accelerate Stop Distance (Brakes plus all four engines in reverse thrust take-off power)

		5660		2.52	-1	0

(C) Abort (Balk) at VR (No rotation started)

100 K Ck	100.0	2000	21.3	2.52	-1	0
V_1	130.8	3270	29.6	2.52	-1	0
V_R	143.0	3994	33.6	2.52	-1	0
Brakes	143.0+			Forward Idle	-1	0

1. Accelerate Stop Distance (Brakes only)

		8185		Forward Idle	-1	0

2. Accelerate Stop Distance (Brakes plus # 2 and # 3 engines in reverse thrust take-off power and # 1 and # 4 engines in forward idle thrust)

		7710		2.52 # 2 and # 3	-1	0

3. Accelerate Stop Distance (Brakes plus all four engines in reverse thrust take-off power)

		7445		2.52	-1	0

(D) Accelerate to Time of 50 Seconds and 52 Seconds without Rotation

100 K CK	100.0	2000	21.3	2.52	-1	0
V_1	130.8	3270	29.6	2.52	-1	0
V_R	143.0	3994	33.6	2.52	-1	0
50 Sec Run	200.01	7470	50.0	2.52	-1	0
52 Sec Run	208	8170	52.0	2.52	-1	0

Note: Estimated distance to stop aircraft after reaching 208 and 8170 ft on runway is 5 300 ft additional if brakes are used and all four engines are in reverse thrust at take-off power.

(E) VMU (the minimum speed at which this aircraft could have left the runway) was 137.8 kt.

Runway lighting

Changes had been made in the runway lighting on the last half of the runway. At the time the check pilot pulled the throttles the aircraft was still on that portion of the runway which was lighted, as originally prescribed, and he did not ascribe any irregularity in lighting on the far end as a factor in discontinuing the take-off.

Analysis

The methods for measuring visibility and snow depth leave much to be desired. They are not properly representative of pertinent runway conditions. The transmissometer cannot measure runway visual range values below 2 000 ft and the prevailing visibility, reported at 1/4 mile at the time of the accident, was observed at a point well removed horizontally and vertically from runway 7R. The procedures used for measuring snow depth are not precise as to the permissible length of time in advance of a take-off that runway measurements of snow depth can be made, the points along the runway at which measurements should be made, and the means for establishing density. However, the weather and runway conditions, though marginal, are not considered to have been prohibitive or critical.

The facts disclosed by the parts of the aircraft which were examinable make extremely unlikely the possibility of failure or mechanical malfunctioning of any part of the aircraft or of fire prior to impact.

When the pilot-in-command called or pointed to the airspeed indicator, the check pilot felt that the 130 kt which the indicator was then showing was insufficient for take-off and, after gauging progress, quickly pulled the power. What remains unknown is the pilot-in-command's motive in pointing toward or calling attention to the airspeed indicator. He may have been drawing the check pilot's attention to an indication which was too low (as the check pilot believed), or he may have been conveying the idea that the airspeed indicator was not to be trusted and should be ignored. Whether the latter is the case or not, after the check pilot pulled the throttles, the aircraft was committed to a balked take-off, irrespective of what was in store at the end of the runway.

There is no way of positively establishing the dependability of this airspeed indicator. According to the maintenance records, it should have been functioning properly. The switch controlling the heat to the pitot tubes was found "off". Whether it was not "on" during take-off or was knocked to "off" at impact cannot be established, although the latter is unlikely. If it was not "on" during take-off, an erroneous airspeed indication may have resulted.

The engines were capable of developing full power and were not damaged prior to impact. One of the check pilot's observations during the brief period when he was weighing a balk was that of the four EPR gauges, and he stated that they were reading normally. These gauges could read erroneously if their probe ends were iced up. These ends are electrically heated and can be turned off only by means of the circuit breakers (which was not done as far as can be ascertained during the period that the aircraft was on the ground between flights at New York International Airport). Thus, there is no reason to suspect that there may have been an erroneous power indication by the EPR gauges.

According to the check pilot, V_1 and V_R were called in rapid succession by the first officer. However, the aircraft could not have accelerated from the 129 kt V_1 speed previously calculated by the flight crew to the calculated 143 kt V_R speed without an appreciable time interval. The captain's airspeed was at the time indicating 130 kt, also according to the check pilot, and shortly thereafter quickly reduced to 110 kt during rotation at which time the pilot-in-command pointed to or mentioned his airspeed. All three of these conditions were obviously abnormal.

The check pilot felt that the aircraft did not become airborne and was not accelerating properly after rotation, although he felt that the rotation was abrupt and excessive. Therefore, he reduced engine power without cross-checking with the first officer's airspeed. The stewardess in the aft cabin could not have noticed the runway lights becoming farther away unless the aircraft was airborne, as rotation only would have lowered the tail and caused the lights to become closer. Also, the aircraft's lights were seen to rise for a short time coincident with reduction of engine power at about the 6 400-foot point on the runway. The landing lights are located in the trailing edges of the wings and the navigation lights are at the tips; both of which would lower slightly during rotation since they are somewhat aft of the main landing gear and would not rise except after the aircraft became airborne. The two DC-8 pilots and the well-qualified passenger, all of whom were seated well forward, believed the aircraft to have been airborne, as do two lay groundwitnesses. Additionally, the lifting sensation described by passengers in the aft part of the cabin (which should have lowered if rotation only had occurred), the stopping of runway roughness, the smooth feeling of flight, the thump normally coincident with extension of the landing gear oleo struts on becoming airborne quickly, a touchdown bump, and the preponderance of other witness' evidence, establish the aircraft being airborne for a few seconds.

According to the Douglas Aircraft Company performance data, the aircraft, under existing conditions but on a snow-free runway, would normally have been rotated after a 3 994-foot roll in 33.6 seconds at 143 kt and become airborne at 4 801 ft in 37 seconds at 154.6 kt. But the evidence of five persons on the ground indicates that the aircraft was not airborne by the time it had rolled 6 200 ft down the runway.

According to the same performance data the aircraft, in 50 seconds, should have travelled 7 040 ft along the runway and reached a speed of 200 kt. But it did not travel 7 040 ft in that time. At 50 seconds (by calculation, Table D), with uniform acceleration, it should have passed the 6 200-foot point at an airspeed of 163.8 kt. It became airborne two or three seconds later, touched down, and caused intermittent skid marks beyond the 7 040-foot point (at 7 535 ft). Actually the take-off roll started about 300 ft from the threshold where a normal turn from the taxiway would place the aircraft. It is, therefore, obvious that the aircraft was not accelerating properly.

The aircraft could not have become airborne at less than 137.8 kt. It must have been appreciably greater than that figure because an abrupt and excessive rotation, as apparently did occur, is not possible at that minimum take-off speed due to the relatively slower elevator effect at that speed.

The tested three-second average time required for the check pilot to unfasten his seat belt, stand up, estimate progress, move the throttles ahead slightly, then close them, when applied to a DC-8 simulator rotated at a 163-kt airspeed, resulted in a simulated 150-foot climb.

This altitude could not have been possible as the aircraft could not have touched down again in a maximum 1 335-foot distance, and indicates that the airspeed at becoming airborne must have been considerably less than 163 kt.

Thus, the take-off speed could not be less than 137.8 kt and not as much as 163 kt. A uniform acceleration to 130 kt, then a constant speed to the end of the 50-second period, would require 16 seconds at 130 kt (which no captain is likely to allow). This indicates that acceleration was probably normal to the 100-knot point, but not normal thereafter. The probability exists that after the 100-knot point the speed continued to increase, but more slowly, to the 143-knot airspeed at liftoff, since this was the airspeed that the first officer should and probably did call as V_R.

From this it is clear that either the captain's airspeed indication was erroneous or the check pilot was mistaken in stating that it read 130 kt.

On the basis of the following evidence, it is concluded that the captain's airspeed indicator was giving an erroneous low reading at the time take-off was aborted. The first officer, observing his airspeed indicator, had called out V_R (143 kt). Immediately thereafter, the pilot-in-command had pointed to his airspeed indicator and the check pilot in checking the airspeed on the captain's instrument had read 130 kt and advanced, then closed the throttles.

At the time of the accident the sustained wind velocity was 19 kt with gusts to 24 kt. Such gusts might account for a slight change but not a 13-kt increase (130 to 143) or 20-kt decrease (130 to 110) in the airspeed indications. It is evident, therefore, that the captain's airspeed must have been indicating erroneously for some other reason.

The possibility of Glycol entering the airspeed systems through the pitot heads during anti-icing and de-icing of the aircraft was explored. However, because both pitot sumps were drained after use of Glycol, the possibility of Glycol having affected the airspeed systems appears to be most unlikely.

It cannot be definitely shown, due to impact and fire damage, that no mechanical malfunction of the captain's airspeed system occurred. However, a review of the aircraft's records revealed no uncorrected airspeed items and indicated a satisfactory leak test of the airspeed systems on 4 January 1961, with no malfunctioning noted thereafter. In addition, the left airspeed indicator was evidently slow by at least 13 kt up to the rotation point. Similar leaks simultaneously affecting both systems are extremely unlikely.

It could not definitely be substantiated that the pitot heat selector was not moved by impact to the "off" position, where it was found. This is so because the copper pitot heads and the transducer heating elements were not found despite extensive effort by investigators and considerable expense for earthmoving equipment.

The pitot heat selector furnishes current for the heating elements in the captain's and first officer's pitot heads and for the stall-warning transducer. Current is supplied to all three when the selector is in any one of the four positions except "off". The ammeter indicates current drawn by whichever one of these three elements is selected. The proper amperage is 1.75 to 2.75 for each airspeed pitot, and 1.25 to 2.75 for the stall-warning transducer. The ammeter indicated 1.1 amperes when found (probably moved to that figure from zero by fire). Neither the knob of the pitot heat selector nor the assembly in the immediate vicinity bore any marks of impact, although there was marked fire damage. Moreover, there were no marks of overtravel within the selector switch, and it is unlikely that impact would move the selector knob due to the internal spring followup design of the switch. This strongly indicates that the selector was not moved by impact.

Thus, it appears that the left airspeed indicator was slow to the 130-kt point and then suddenly changed. Since leaks are unlikely, the cause could only have been of a type that was changeable with increased airspeed. The probable cause for such an erroneous reading could not be determined. However, the possibility exists that failure to apply pitot heat during snow conditions may have played a part in the erroneous indication.

There was no decay in engine power and, consequently, the slow acceleration must have been due to snow on the runway. The amount of this lessening of acceleration is not subject to precise and specific quantitative analysis. If there had been no impairment of acceleration, the aircraft would normally have been only 3 994 ft down the runway rather than 6 200 or more feet at time for rotation.

It was established that the aircraft was capable of continuing the take-off if power had not been reduced by the check pilot. Eastern's Operations Manual, utilized by Aeronaves, authorizes the check pilot to take over control at his discretion. Whether or not the pilot-in-command would have continued the take-off if the check pilot had not reduced power will never be known.

In an effort to determine whether or not continuation of such a take-off as that involved in the accident (with one or both airspeed indicators malfunctioning) is safer than discontinuing the take-off, arrangements were made with two air carriers for tests in their DC-8 flight simulators. These tests indicated that

1) such a take-off by a qualified DC-8 captain could be completed with a reasonable degree of safety, and

2) captains normally do crosscheck with the first officer's airspeed under such conditions.

Any small amount of snow which may have remained on the aircraft after de-snowing or any small amount which may have accrued while taxying did not palpably, have any significant effect on the aircraft's take-off capability. Therefore, snow on the structure is not considered to be a factor in this abnormal take-off.

Aeronaves de Mexico utilizes Eastern's checklists and, since the accident, Eastern has changed its cockpit checklist to eliminate turning off the pitot heat selector once it is turned on prior to engine starting. At the time of the accident the procedure was to turn it "off" and "on" again before take-off.

The DC-8-21 aircraft has the capability of being rotated to its physical limits (until the bottom of the empennage almost touches the runway) and continuing to accelerate until becoming airborne. Once it becomes airborne, even though rotation has continued to the maximum physical limits, airspeed continues to increase, assuming there are no malfunctions or failures. It is not possible in a DC-8-21 to "get on the back side of the power curve," i.e., to enter the region of operation wherein the power required is greater than the power available, while the aircraft is on the ground. If the angle of attack is not further increased following liftoff, the aircraft would continue to accelerate. Flight tests have proven that maximum rotation at the minimum speed will result in a positive rate of climb and the shortest runway distance to liftoff. Once airborne, the take-off performance characteristics will be much the same as if rotation had been made at the pre-determined flight manual V_R, taking into consideration, of course, the differences in elapsed time, distance, and airspeed.

A question has been raised as to the possibility of decreasing the speed of the aircraft from 130 to 110 kt very quickly - say within 5 seconds - during or immediately after rotation, as the check pilot believed. To achieve such a decrease in airspeed the deceleration would have to be 8.44 ft/sec^2 (0.26g) which, at the take-off gross weight of 270 000 lb, would require a drag force of 70 500 lb. Thrust available from the four engines, at between 110 and 130 kt, is approximately 59 000 lb. Assuming conservatively that 59 000 lb of thrust is in balance with the drag (no acceleration), an additional 11 000 lb of drag would be needed upon retarding power to idle to produce a 0.26g deceleration. Actually, with the throttles in "idle", the engines are still producing some forward thrust. To determine the effect of the increased drag on the aircraft, due to the rotated attitude, a series of calculations was made. Assuming that the aircraft's speed was stabilized at about 130 kt (thrust = drag), and then rotated, the time necessary to decelerate to 110 kt is:

6.9°	rotation = 45.7	seconds
8°	rotation = 34	seconds
12°	rotation = 18	seconds

These times are obviously too long to be considered in this case. In addition, the assumption that the aircraft was stabilized at 130 kt is false because the engines were apparently operating properly and producing the proper amount of thrust for continued acceleration. Thus, it can be seen that it is not possible for the aircraft to have accelerated from 130 kt to 110 kt in five seconds.

Conclusion

The Board concluded that the aircraft did become airborne. Investigation pointed out that the check pilot erroneously believed that if the speed of rotation were appreciably below the calculated V_R speed , a longer take-off run would result.

Probable Cause

The probable cause of the accident was the unnecessary discontinuing of the take-off as a result of the action by the check pilot, who was not in either pilot seat, in reaching forward without warning and pulling the throttles back. This action caused power to be decreased on all four engines.

Contributing factors were the marginally poor weather, snow on the runway, and the possibility of the pitot head heat not having been on.

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ICAO Ref: AR/728

No. 4

Garuda Indonesian Airways, Douglas DC-3C, PK-GDI, struck mountain ridge of Burangrang, 53 NM southeast of Djakarta, Indonesia on 24 January 1961. Report released by the Ministry of Air Communications, Indonesia.

Circumstances

PK-GDI, owned and operated by Garuda Indonesian Airways was flying a scheduled domestic service between Djakarta and Surabaia with stops at Bandung and Djokjakarta. It departed Kemajoran Airport (Djakarta) at 0209 Z, climbing to a cruising altitude of 3 500 ft to fly below clouds. At Purwakarta, a point approximately 43 NM from Kemajoran, the captain asked to leave flight level 35 and to climb to flight level 95. The call was made at 0243 Z and acknowledged by Djakarta control. The flight was then instructed to contact Husein tower at Bandung. The flight was heard at approximately 0245 Z calling Husein tower, however, the latter did not acknowledge. When the aircraft failed to report to Husein tower at the estimated time of arrival, Djakarta control was informed that it was overdue. It crashed at approximately 0248 Z.

The wreckage of the aircraft was sighted at 0230 hours on 28 January on the western slope of Mount Burangrang at an altitude of 5 400 ft. None of the 5 crew and 16 passengers survived the accident. The aircraft was destroyed by impact and fire.

Investigation and Evidence

The crew, the aircraft and the operator were currently certificated.

Maintenance requirements for the aircraft had been met.

Preparations for the flight were satisfactorily completed, and an instrument flight rules flight plan was filed. At time of take-off the aircraft's gross weight (11 778 Kg) was within the maximum allowable, and the load was properly distributed.

Reconstruction of the flight

Prior to departure from Kemajoran Airport the available en route and terminal weather forecasts were reviewed by the captain.

The Garuda procedure was to fly VMC (visual meteorological conditions) if conditions permitted or to climb and maintain flight level 95 to clear the mountains.

The flight (GA 424) attempted to contact Husein tower at 0244Z, as overheard by Kalidjati and Kemajoran towers, and again at 0245 Z, as heard by a Garuda pilot on a training flight. In the 0245 call the aircraft was requesting weather information from Husein, however, the calls were not received.

Other pilots flying at the same time observed westerly winds of 20 - 30 kt. According to the weather forecast the winds were expected to be about 16 kt.

The investigating committee felt that the flight proceeded normally from Kemajoran to Purwakarta. It is difficult to believe that the captain attempted to make a direct flight from the Purwakarta area to Husein considering the hazardous terrain south of Purwakarta over which he had to fly. Assuming that his position at 0243 Z over Purwakarta was correct and considering his request to climb to 9 500 ft, he must have flown VMC (according to the Company's procedure) until he reached a point where he was forced to climb to 9 500 ft. Purwakarta beacon was declared unreliable by the Company during the last six-month period.

The distance from Kemajoran to Purwakarta was flown in twenty-one minutes, whereas it should have been covered, in view of the prevailing winds, in seventeen minutes. Four extra minutes may possibly have been used in making turns to avoid clouds. Assuming that the wind was 300/20 kt, the possible positions of the aircraft before commencing the climb to 9 500 ft would more likely be past Purwakarta by one or two minutes.

It appeared most probable that the flight encountered poor visibility and bad weather, for if the visibility were good the crew would be aware of the surrounding terrain.

The actual weather conditions on the route, according to pilots flying before flight GA-424, were generally scattered cumulus clouds with showers north of the track. Cloud base was 1 500 - 2 000 ft. Over the Sanggabuana and Burangrang areas there was heavy rain, and the visibility over these areas was zero. During this time of year the mean position of the inter-tropical front was over Java. On that date the inter-tropical front was active over West Java.

According to the fact that a climb was made to 9 500 ft at 0243 Z, the captain was supposed to be fully aware of his position somewhere over Purwakarta and was encountering bad weather. The Company's instructions are that a pilot should make a spiral climb to 9 500 ft if he is certain of his position, or climb to the north to reach flight level 95 before crossing the mountains if he is not sure of his position. The accident site showed that he was 6 NM east of the track. The question was how he could have arrived at that spot.

The captain knew that he was somewhere over Purwakarta but probably could not determine with certainty the exact position and was proceeding presumably by dead reckoning. Or, he must have made an error in determining his position. Nevertheless, he proceeded to climb, without visual reference. Considering the winds of 20 - 30 kt and the weather conditions, he could have drifted to the east causing errors in the determination of his position.

A climb from this position to the south, as was shown by the direction of the accident, would be very critical. From the time of the captain's call to Djakarta control at 0243 Z, requesting to climb to flight level 95, to the time of the accident at 0248 (as indicated by the co-pilot's watch), the aircraft had climbed from an altitude of 3 500 to 5 400 ft. The only procedure which could be justified in this condition was a climb in a northerly direction. The possibility that the captain had used his radio compass to determine his position and, in so doing, obtained an erroneous position should not be completely ruled out. However, even so, the climb procedure adopted by the captain cannot be justified, and was not in accordance with the Company's instructions.

The possibility of engine malfunction cannot be eliminated, although this would not be compatible with the fact that the aircraft at this gross weight climbed 1 900 ft in approximately 5 minutes. Also, if an engine had been lost or the aircraft had been changed to a northerly heading, the captain would have radioed as he was fully aware of the hazardous terrain. His last attempted contact with Husein tower was for the purpose of obtaining weather information, and at that time the captain did not report having encountered any difficulty with the aircraft's engines or components. There was no evidence of a bomb explosion.

The Investigating Committee concluded that the aircraft after departing from Kemajoran attempted to fly VMC. It also believed that as the flight progressed towards the mountainous area the overcast lowered and intermittently the aircraft had to fly through cloud finally going completely on instruments several minutes before the crash.

Probable Cause

The probable cause of the accident was the attempt by the pilot to fly over mountainous terrain when unsure of his position and in weather conditions which severely restricted visibility.

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ICAO Ref: AR/761

No. 5

British Overseas Airways Corporation, de Havilland Comet IV, G-APDM hit treetops at Case Nuove, San Martino al Cimino, (Viterbo), Italy on 25 January 1961. Report of the Commission appointed by the Ministry of Defence and Aviation, Italy. This summary is based on the translation of the Italian report released by the Ministry of Aviation (United Kingdom) as C.A.P. 185.

Circumstances

G-APDM was flying the first portion of scheduled flight BA/115 from London, England to Rome, Khartoum, Nairobi, Salisbury and Johannesburg. It had departed London at 1821 hours GMT for Fiumicino (Leonardo da Vinci) Airport, Rome, carrying 8 crew and 44 passengers. About two hours and twelve minutes later, between 2033 and 2035 hours GMT, during what was presumed to be the instrument approach procedure for Fiumicino Airport, the aircraft struck the tops of trees at Case Nuove. Although damaged, it continued the flight and landed at its destination at 2121 hours. The aircraft was damaged, but no one aboard was injured.

Investigation and Evidence

The Aircraft

G-APDM's certificate of airworthiness was valid until 9 June 1961. It had flown a total of 5 633 hours, 55 hours of which had been flown since the airframe and engines' last inspection during the period 17 - 20 January 1961.

At the time of the accident the aircraft's gross weight was 49 200 kg, well under the maximum permitted for landing (52 618 kg). Its centre of gravity position was also within the required limit.

No defects were reported in instruments or equipment during the 10 days preceding the accident, and no replacements had been made.

The Crew Members

The crew consisted of two captains, a flight navigator, a flight engineer, two stewards and two hostesses.

The pilot-in-command holds the following valid licences: airline transport pilot, general flight radio telephony operator and flight navigator. He has flown a total of 9 454 hours - 3 354 hours as aircraft commander and 6 100 hours as co-pilot. Of his total number of hours flown, 1 223 were on Comet IV aircraft. Since January 1960 he has carried out three take-offs and landings as aircraft commander in the Rome area (Ciampino Airport). Regarding Fiumicino Airport, this captain only had a briefing on the airport procedures and let-down. However, BOAC considered he had the necessary ability, skill, and experience to complete the approach flight to this airport which, moreover, in the opinion of the airline itself, presents no special difficulty.

The co-pilot is also a well-qualified captain. He has flown approximately 10 442 hours, including 4 392 as aircraft commander and 5 874 as co-pilot. His total flight time aboard Comet aircraft is 1 006 hours.

The flight navigator has flown 10 270 hours, 771 hours of which were on Comets.

The flight engineer has flown 8 666 hours, including 1 247 aboard Comet aircraft.

Weather conditions

Over the area Giglio-Elba-Civitavecchia-Rome, the conditions entailed much cloud or complete cloud cover with local precipitation possibly of a thundery nature. The conditions were liable to give rise to extensive phenomena due to the instability of the very moist air masses causing electrical discharges and ice formation between 1 800 m and 4 000 m. Regarding turbulence, its intensity was not expected to be such as to have any appreciable effect on air navigation.

There was an incursion of cold air into the western basin of the Mediterranean as far as Sardinia, while over the accident area there were very moist and unstable warm air masses.

Navigation Aids

In the Rome area there are numerous radio aids available for instrument approach to Fiumicino Airport.

The aircraft was fitted with the following radio, navigation and communication equipment:

2 ADF *systems;* 2 VOR *systems;*
1 Doppler navigator; 1 DME;

1 radar; 1 marker receiver; 2 VHF receiver/transmitters;

1 receiver which can be operated on HF; 2 HF receiver/transmitters.

Communications

The communications between G-APDM and the Air Traffic Control units (Rome Control, Rome Approach and Fiume Tower) were made in the appropriate phraseology, on the special channels, and the clearances given were in accordance with current regulations.

Ground installations

The radio beacon NF is associated with the ILS installation which serves runway 16 at Fiumicino. This beacon is, therefore, used by aircraft which land at Fiumicino, inbound from Civitavecchia radio beacon (NR) in the case of jet aircraft and from Bracciano radio beacon in the case of piston-engined aircraft.

The installation of this radio beacon and the frequency assignment conform to the standards and recommended practices of ICAO's Annex 10.

The flight testing of the radio beacon inside the area where it is used has been carried out by a radio facility testing aircraft fitted with an ARN 6 radio compass. In the course of these flights, made both by day and by night during the months preceding the opening of Fiumicino Airport to traffic and since the accident, no interference has been recorded of such a nature as to make the use of the assigned frequency inadvisable.

In particular, the Radio Prague transmission was not observed in the area of coverage of the radio beacon NF. Furthermore, it has not been possible to make calculations regarding such interference because the necessary data are not available.

Reconstruction of the flight

1821 hours	Take-off from London. Reached cruising altitude, flight level 330 over Dieppe. Up to this stage the times were deduced from the flight plan. Subsequent times are derived from tape recordings of Fiumicino (Tower) and of Ciampino (Rome Control and Rome Approach).
2012 hours	Start of descent.
2013:30	Flight over Elba at 2013 hours at flight level 290. This flight level was maintained on the instructions of the Control because a Caravelle aircraft was

flying at flight level 280 over the same route in the opposite direction.

2014:30 The aircraft was cleared to descend from Giglio direct to Civitavecchia without passing via Punto Tango and was also cleared for flight over Civitavecchia at flight level 100.

2017:30 Mutual sighting of the two aircraft, so the Comet obtained clearance to descend to flight level 100.

2020:30 Over Giglio at 2019, descending, passing through flight level 260.

2026:30 Descending through flight level 160.

2027:30 Was cleared to establish radio contact with Rome Approach.

2028 Informed Rome Approach that it had flown over Civitavecchia at 2027 and was now descending through flight level 135 heading for Fiumicino NDB, estimating it would reach it at 2031. The aircraft was cleared for flight over Fiumicino NDB at 1 300 ft, for a direct approach and was to establish radio contact with Fiumicino Tower.

2029:30 *Having contacted Fiumicino* it reported it was passing through flight level 90, estimating it would be over Fiumicino NDB (NF) in one minute and would report over the outer marker on finals.

2037 Informed Tower it was at 4 000 ft, heading for Ostia NDB.

Between Giglio and the point of impact (see Figure 1)

From the chronological data it is not possible to derive sufficient information to establish accurately the aircraft's track between Giglio and the point at which it struck the treetops.

However, based on the recording of the radio communications and on the statements *of the pilots and witnesses*, the following considerations are put forward regarding the area over which the aircraft probably flew on this stage of its flight.

The aircraft flew over Giglio NDB at 2019 hours. This is derived from the communication recorded on the magnetic tape at 2020:30 hours. From this communication and subsequent messages, it is found that there was a difference of about one minute between the aircraft clock and the clocks of Rome Control, Rome Approach and Fiumicino Tower. In fact, the message recorded on tape at 2020:30 reports passage over Giglio at 2019, and the message reporting flight over Civitavecchia, which is said to have occurred* at 2027 hours, was sent at 2028 hours.

The communication at 2029:30 hours, made by the second pilot, was based on an inaccurate estimate in that it is impossible for the aircraft to lose 7 700 ft (difference between flight level 90 and the height of 1 300 ft cleared for NF) in one minute only. Furthermore, at the end of the estimated minute the aircraft would not only have had to have come down to this height but also to have already assumed the configuration for final approach.

The moment of impact with the trees may have occurred between 2033 and 2035 hours. The *first time of impact was*

* "avvenuta" which is feminine and therefore relates back grammatically to "message" and not to "flight over". Translator.

obtained from the navigation log and the pilots' statements, whereas the second time was deduced from the recordings of the radio communications, on the assumption that the aircraft took two minutes to reach 4 000 ft at 2037 hours (climb of 2 260 ft above the point of impact). The two times are the minimum and maximum limits between which the impact undoubtedly occurred.

Points B and B_1, almost coincident, have been taken as different points for the beginning of the right-hand turns which would have brought the aircraft over the town of Viterbo, as appeared from evidence of a prison guard, or which, according to the pilots, would have excluded flight over the town.

The time taken by the aircraft to arrive at the point of impact from the position near Viterbo where it began the right-hand turn was about 2 minutes, i.e. one minute to make the turn and one minute, in the configuration for final approach, to reach the point of impact.

The time taken to fly from Giglio to the point at which the turn was begun, a time during which the indicated air speed was maintained at 240 kt, was, therefore, 12 minutes if the impact is considered to have taken place at 2033 hours or 14 minutes if the impact is considered to have taken place at 2035 hours.

The indicated airspeed of 240 kt corresponds to a mean TAS of 292 kt which in standard atmosphere and with no wind is the same as the ground speed. These figures have been provided by the crew and the flight navigation officer (BOAC). On the basis of a ground speed of 292 kt, the distance covered by the aircraft would be between 58 NM and 68 NM.

If the temperature (5^{o} below standard) and the winds in the area are taken into consideration, the IAS of 240 kt will be found to correspond to a mean groundspeed of 310 kt, and the distance covered would be between 62 NM and 72 NM.

A comparison of the four distances established in this way shows that the minimum distance is 58 NM and the maximum 72 NM.

The routes drawn (see Figure 1) depict the minimum and maximum limits within which the actual track made good by the aircraft must certainly be contained.

The testing in flight of NF before and after the accident, both by day and night, gave satisfactory results. A flight was also made at the same time of day as that of the accident and with the same aircraft. This test consisted of three consecutive approaches from Giglio, in accordance with the specified procedures. Nothing abnormal was experienced during two approaches between NR and NF. As soon as NR had been left and the radio compass tuned to NF, the call sign NF was clearly received, and the indications of the radio compass gave correct bearings. In one of the three approaches, after flight over NR and after assuming a magnetic heading to bring the aircraft over NF, it was necessary to wait for 1 minute 40 seconds before obtaining a clear identification signal and having an accurate and stable bearing on the radio compass.

On this approach, interference by the Prague station, which transmits on 272 kc/sec, was experienced on the frequency of the NF beacon.

At a low altitude and a short distance from NF, however, the interference of the Prague transmitter became practically negligible.

It follows, from the above, that abeam Tarquinia, and in any event before reaching Civitavecchia, the pilot must have tuned one of the radio compasses to NF and on the basis of the indications obtained he left the track he had been following up to that moment. It is very probable that with the setting of the other radio compass unchanged, NR was seen to go round to starboard at about 2027 hours. Subsequently, this radio compass was also tuned to NF.

As a result, indications agreeing with one another, caused by the interference of the more powerful station on the weak NF transmission, were erroneously accepted and a false QDM was used.

On reaching point C, the pilot deviated from the track between Giglio NDB and Civitavecchia NDB and followed the indications of the radio compass needle. In so doing he thought he was on the route which is shown by a dotted line on Figure 1) beginning at point C' and ending over Fiumicino NDB. This route is the same as C B A but displaced in a direction parallel to the latter by a distance of 60 NM. A superficial critical examination of the situation could have revealed the erroneous conviction. In fact:

a) The time required to reach point C' from Giglio would have been about twice that required to reach point C and the heading some 25 to 30° greater in magnitude.

b) The whole of the route would have been flown over the sea, whereas it was observed both with the aircraft radar and by direct observation that the aircraft passed over the coastline and subsequently flew over land.

c) If the aircraft had followed the route C' to Fiumicino NDB, Civitavecchia NDB would always have been observed on the port side, whereas the crew saw it "go round" to starboard.

From the whole of the above considerations, it is deduced that the aircraft did not in any event fly over Civitavecchia NDB and therefore the communication made at 2028 hours relating to such overflight is without foundation on fact.

If the crew had applied the prescribed procedure:

a) flight over NR

b) flight away from NR on a track between 115° and 122°

c) use of NF indications only after flight over NR

the indications obtained would have made possible the regular continuation of the flight under consideration.

Ample proof of this is also provided by the regular completion of thousands of flights to Fiumicino Airport with use of the radio aids existing at the time of the accident.

Probable Cause

The accident was attributed to the following causes:

1. Exercises for familiarization, as recommended by ICAO, with the approach procedure for Fiumicino were not carried out. These exercises were all the more necessary as it was the first time that this crew had flown to the airport.

2. The aircraft did not fly over NR and did not follow a QDR (magnetic heading) between 115° and 122° from NR.

3. The two radio compasses were tuned to the same frequency. As a result, only one "double" erroneous indication was available, whereas it would have been possible to have had useful indications from different sources for a "fix", by using the bearings of pairs of radio beacons.

4. After both radio compasses had been tuned to the NF frequency, and their indications agreed with one another, they were accepted as reliable.

5. For the final navigation phase only the radio compasses were used. More importance should have been attached to the contemporaneous indications of the compass and clock after appreciable differences had been noted between information

shown in the flight log and data which could have been obtained subsequently by observation and measurement.

6. Inaccuracy in radio communications on the part of the second pilot, (as shown in communication at 2029:30 hours).

7. The Prague transmitter interfered with radio beacon NF.

Recommendations

In view of the findings, the Commission recommends the following:

a) To Pilots

Follow the procedures set forth in the ATC documents. In case of doubt, use all navigation aids available in order to check the position before coming down below the safety height, particularly if there are fixed obstructions in the area and visibility is poor.

b) To Airlines

Before pilots use an airport with which they are unfamiliar, arrange for them to carry out a familiarization flight or at least flight simulator tests for the purpose of training in the air traffic and approach procedures established for the airport in question.

c) To the Inspectorate of Telecommunications

Study the possibility of replacing the working frequency of Fiumicino radio beacon by another frequency not subject to interference from other high power transmitters.

ICAO Ref: AR/699

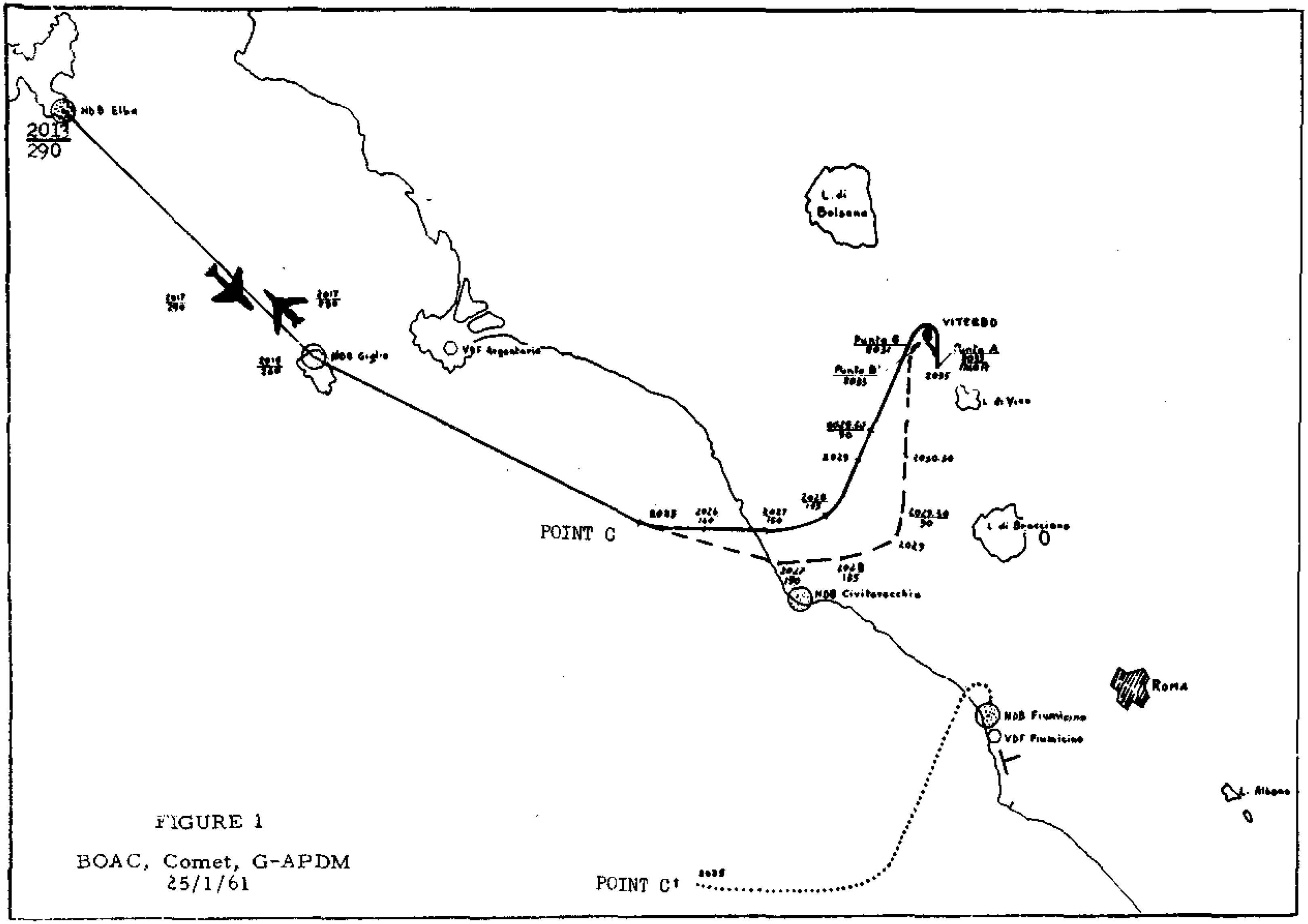

FIGURE 1

BOAC, Comet, G-APDM
25/1/61

No. 6

Garuda Indonesian Airways, Douglas DC-3, PK-GDY, crashed into the sea near the north coast of the Island of Madura, on 3 February 1961. Aircraft Accident Report released by the Ministry of Air Communications, Republic of Indonesia.

Circumstances

Flight GA-542 took off at 2335 hours from Perak Airfield, Surabaia on a scheduled flight to Balikpapan. Aboard were 5 crew and 21 passengers. The aircraft and crew were on the third day of a four day trip.

At approximately noon on 4 February the aircraft was reported missing. Efforts by a search and rescue team to locate the aircraft were unsuccessful, however, it was believed that the aircraft had crashed into the sea off the Island of Madura. No trace of the occupants was found.

Investigation and Evidence

The Aircraft

The aircraft was sent to Hongkong for a complete overhaul in March 1957 at which time all required modifications were incorporated.

The maintenance of the aircraft had been accomplished according to a progressive maintenance schedule. During the last major (500 hours) inspection, carried out between 26 and 31 December 1960, both engines were changed. Since then engines Nos. 1 and 2 had flown 44:45 hours each, during which time maintenance records showed a history of engine vibrations. Trouble rectification included change of the automatic mixture control, change of the spark plugs, a valve timing check, oil check for metal particles and retightening of the propeller nut.

The airframe had a total of 18 829 hours.

The Crew

All crew members were correctly certificated.

Weather conditions

The weather conditions en route (between Surabaia and 50 NM out) were fair to cloudy. The wind was 10°/10 kt; strato-cumulus cloud from 7 000 to 9 000 ft, 3/8 - 5/8 cloud coverage, a base of 1 500 - 2 500 ft cumulus cloud with tops of 5 - 7 000 ft becoming cloudier to the north with signs of precipitation.

Reconstruction of the flight

The flight departed Perak at 2335 hours. It first contacted Surabaia control on 119.3 Mc/s and reported it was on course at 2338 hours, climbing to (cruising) flight level 90 on a northwesterly heading. At that time it estimated the boundary of the control area at 0022 hours. This message was acknowledged by air traffic control, and the captain was instructed to report when reaching flight level 90.

At 2346 the flight advised that it estimated its arrival at Balikpapan at 0242, was climbing to flight level 90 and estimated the boundary at 0022, Masalembo at 0041, abeam Bandjarmasin at 0126 and Warukin at 0201 hours. The flight reported reaching flight level 90 at 2355 hours and was then instructed to report over the boundary. Nothing more was heard from the aircraft. It sent no emergency message.

Findings

The flight had been properly planned and dispatched. At the time of take-off its gross weight was 36 lb under the maximum permissible take-off weight, and the centre of gravity was within limits. No discrepancies were found in the maintenance of the aircraft. There were no records of the aircraft carrying dangerous materials or explosives. Samples of fuel were checked and found to be normal. There were no indications of foul play.

Due to a lack of evidence, the investigating committee could not come to a positive conclusion as to what actually happened to the aircraft. A strong lead was some aircraft items found on the day the aircraft was reported missing. From these items it was deduced that the aircraft may have crashed not too far from Surabaia. However, none of the items found showed positive proof that it belonged to the aircraft in question. A reconstruction of the accident, using the items and the people that found them, indicated that the probable site of the accident could have been about 33 NM northeast of Surabaia. This spot coincides with the normal track of the aircraft. Every effort was made with the assistance of the Navy to locate more positive evidence in the area. A weak echo was detected by the Navy's sonar equipment in that area. Due to circumstances, no further efforts could be made to locate the source of the echo coming from the bottom of the sea.

Probable Cause

The probable cause of the accident was not determined as the aircraft could not be found.

Follow-up action

Following the accident a fleet inspection of Garuda's Dakotas was carried out, which included wing attach angle checks, flight control system checks, electrical wiring checks, a corrosion check of the aircrafts' primary structures. No serious discrepancies could be found.

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ICAO Ref: AR/762

No. 7

SABENA, Boeing 703-329, OO-SJB, accident at Berg, 2 km northeast of the threshold of runway 20 at Brussels National Airport, Belgium on 15 February 1961. Report released by the Minister of Communications, Belgium.

Circumstances

The accident occurred at the conclusion of a normal scheduled non-stop flight from New York to Brussels. The aircraft was on long final approach to runway 20 and had been cleared to land. When near the runway threshold, instead of landing, the pilot increased power and retracted the undercarriage. The aircraft gained height and made several circles in a left turn. During these turns the bank angle, while decreasing several times for short periods, increased more and more until finally the aircraft was in a near vertical bank. It then crashed and fire broke out on impact. All 11 crew members and the 61 passengers aboard were fatally injured in the accident, and the aircraft was completely destroyed. One person on the ground was killed and another seriously injured. The accident happened at 0905 hours GMT.

Investigation and Evidence

The Crew

The aircraft's crew consisted of a captain, co-pilot, navigator, flight engineer, 5 stewards and 2 stewardesses.

The captain held an airline transport pilot's licence valid until 30 July 1961. His licence was endorsed for the Boeing 707 instrument and night flight, and he had a restricted radiotelephony licence. As of February 1961 he had a total of 15 384 hours flying time. His experience on the Boeing 707 was:-

- simulator training: 6 hr
- flight training: 13 hr 51 min day
  1 hr 15 min night

He was declared proficient on Boeing aircraft on 27 February 1960 and had a proficiency check on 17 October 1960. He was fully qualified on the route New York - Brussels.

The co-pilot was also the holder of a valid airline transport pilot's licence which was endorsed for DC-6, DC-7 and Boeing 707 aircraft. As of February 1961 he had a total of 16 231 hours flying time to his credit, and was also fully qualified on the route New York - Brussels. He had the following experience:

- simulator training: 6 hr
- flight training: 14 hr - min day
  \- 45 min night

Examination of the personal files of the crew members showed them to have received a thorough indoctrination and training on this type of aircraft and their qualifications and experience were established. From the medical point of view, they had undergone the required medical examinations, and the results had always been favourable. The minimum required rest periods were observed and even exceeded, while the total flying times were within the limits authorized.

Nothing in the post mortem examination indicated any reduction in the physical capabilities of the crew.

The Aircraft

The airframe had 3 038 hours of flying time. Between a type II overhaul (11/1/61 to 9/2/61) and the accident, the airframe had accumulated 37 hours of flying time.

The aircraft held a certificate of airworthiness valid until 8 August 1961 which was revalidated on 9 February 1961 at the conclusion of a test flight in which a delegate of the technical services of the "Administration de l'Aéronautique" participated.

The aircraft was maintained by the technical services of Sabena. These operations are supervised by the control services of that company. The maintenance programme is laid down by the technical services of the "Administration de l'Aéronautique" which also approves the Sabena controllers and makes its own supplementary independent checks.

As the maintenance and work cards concerning the aircraft did not show any abnormalities, the Commission felt that OO-SJB had been correctly maintained in accordance with the approved programme.

At the time of take-off from New York the aircraft's all-up weight was 119 500 kg of which 50 000 kg were JP. 1 fuel. The centre of gravity was 26% MAC. According to the flight plan the aircraft's estimated all-up weight on arrival was to be 79 230 kg.

At the time of the accident the aircraft was at an all-up weight of 77 500 kg, and the centre of gravity was 25.5% MAC.

Trouble reports

It was found that OO-SJB, as well as other Sabena Boeing 707s, had been affected by blockings or hard spots in the aileron control. Examination showed that the reason for these difficulties was jamming, at low temperatures, in the aileron trim mechanism. The two trim assemblies of OO-SJB, left and right, were removed and replaced during the overhaul carried out on 11 January 1961. They were examined and tested by the Boeing Company. It was possible to reproduce complete jamming of one of the mechanisms by cooling to a low temperature. A considerable force, equivalent to 90 lb at the wheel, was necessary to unjam the mechanism.

No other significant remark was noted in the trouble reports of OO-SJB. However, two difficulties were found which affected the flight controls after overhaul.

1) The pilot noted that during the first test flight on 9 February 1961 the trim button had to be pushed harder than normal. A second test flight was made to confirm the fault, after which the pilot noted "abnormal response of the stabilizer particularly after trimming nose down; slight nose up impulses give no result."

The corrective action taken by maintenance consisted of replacement of the stabilizer trim motor. A ground test gave normal responses in both directions.

2) The second incident was observed during the same flight. The pilot noted: "At the beginning of the flight there was a strong tendency of the aircraft to roll to the right. In level flight, the two left wing spoilers are 1 inch out."

"After descent, speed brakes out, at the moment of their retraction there was a marked roll to the right - it did not recur afterwards."

"At the end of the flight, the tendency to roll to the right was considerably diminished."

An inspection on the ground did not reveal anything abnormal. This fault did not recur during subsequent flights.

Examination of the trouble report, already signed by the captain, for the flight during which the accident occurred, and a message to the company at 0848 hours established clearly that there was no malfunctioning of the aircraft during this flight, and the crew considered it was airworthy for a subsequent flight.

Weather conditions at Brussels National Airport

They were as follows:
visibility: 3 500 m; cloud: 7/8 at 6 000 m; wind: 190°/2 kt; dry bulb temperature: +7.4°C; dewpoint: +4.6°C; relative humidity: 82%.

The weather conditions were good and had no bearing on the accident.

Reconstruction of the trajectory

1. According to ATC information and radio communications

Figure 2 shows this trajectory from the point of entry into Belgian territory until the break in radio communications.

2. According to the testimony of witnesses

The trajectory was also reconstructed from the turn onto a long final approach until impact. The trace of this trajectory figures as Points A, B, C, D and I on Figure 3. These witnesses included persons spaced along the trajectory, Air Force personnel stationed at the airport, personnel of the Air Traffic Control Services and aircrew and technical personnel of Sabena.

The witness located at Point B saw the undercarriage in the "down" position. Point C is the last point at which the aircraft reported its position (Hofstade). Up until Point D, all witnesses saw the aircraft flying normally. It then started its "overshoot". It overflew the runway threshold at an approximate height of 300 ft, climbed whilst turning to the left along an apparently steep trajectory. Traces of smoke were observed coming from the four engines. At an estimated height of approximately 1 500 ft it levelled off, reducing power. The aircraft then described three 360° left turns relative to the approach direction. During this trajectory it started first a descent, then several climbs followed by small descents; power was reapplied and cut several times. The left bank angle, while considerably reduced during short periods, increased more and more. The last 90° of turn were accomplished at slow speed, engines idle, with a large bank angle (close to 90° according to certain witnesses). The aircraft then nosed down and crashed. Fire broke out on impact.

3. According to the indications of the flight recorder

The trajectory is shown as Points E, F and G on Figure 3. It is based on information extracted every 12 or 15 seconds on the time scale of a graph. It is to be noted that the flight recorder was an experimental model and, moreover, it was found in an area where the fire was particularly intense. For this reason, the value of the information furnished by the graph during the last 4 or 5 minutes of flight is uncertain or worthless. The recorder does not give points of the trajectory directly. It provides for the airspeed and heading of the aircraft at each instant. From these observations and supposing that the speed vector has the same direction as the heading, a series of tangents can be traced for which the envelope constitutes the trajectory. There is no correlation between the times of the testimonies and the times of the recorder, however, one may attempt to place the curve established according to the witnesses' testimony over the curve established according to the elements of the flight recorder by displacing the latter and by taking into account its orientation, which is determined by the indications of successive headings.

By doing so, as the two trajectories nearly superimpose, the time scale can be deduced and Point D can be located 4 minutes prior to the impact time.

Examination of the wreckage

The wreckage was minutely examined.

The assistance of experts from the Civil Aeronautics Board, the Federal Aviation Agency and the Boeing Airplane Company was obtained for different phases of the technical investigation.

Structure

The aircraft's structure was nearly completely destroyed by impact and the subsequent fire. A major part of the wings was burned, but it was possible to rebuild the essential part of the controls. The breaks, in the different parts of the airframe, revealed nothing abnormal.

The debris found at the site of the accident confirmed that the aircraft's structure was intact before impact. The cockpit debris, projected outside the fire zone, presented no trace of fire.

Although two witnesses believed they had seen some objects become detached from the aircraft at different times, an extensive search in the particular areas did not reveal anything.

Controls

Inboard ailerons

Nothing on the surfaces, the structure, the hinge supports, the control tabs, the snubbers, nor on the balance panels indicated any defect prior to impact. The pressure seals on the passage of the control cables into the fuselage were found burned in their lodgings. Examination of the markings observed on the structure determined that at the moment of impact the inboard ailerons were in a position for a right turn. The left-hand inboard aileron was in a 10° down position, while the right-hand inboard aileron was in a 14° up position. The control pulleys, located below the captain's control column, were found in position for a left turn while those below the co-pilot's control column were found in position for a right turn. These pulleys control the displacement of the aileron control tabs but not the ailerons directly. They are interconnected by a cable which was found broken.

Aileron trim

The positions of the aileron trim control drums showed that the aileron trim was in the neutral position on impact.

Outboard ailerons

It was not possible to determine with certainty the position of the outboard ailerons on impact. However, the measurement of the extension of the control rods of the lock-out mechanism showed that they must have functioned and that the ailerons should normally have been in the neutral position. The control system of the left-hand outboard aileron was intact with the exception of the quadrant which was broken. The quadrant is a casting which permits the control of the outboard ailerons through a cable link with the inboard ailerons.

Apart from deformations, due to impact, nothing abnormal was found amongst the remaining parts of the structure, the balance panels, and the hinges of the left aileron. The right-hand aileron control system was badly damaged.

In the case of jamming of an outboard aileron

a) flaps down: the inboard ailerons will also be blocked;

b) flaps retracted: the inboard aileron adjacent to the jammed outboard aileron will be forced in the same direction as the position of the jammed aileron until such moment as the inboard aileron reaches its full displacement. For example, the inboard aileron will be forced upwards if the outboard aileron is jammed in an "up" position, and vice versa. When the inboard aileron reaches its stop the jamming of the outboard aileron has to give sufficiently or one of the parts in the mechanism will be deformed or broken. If the outboard aileron is jammed in the neutral position the inboard aileron will, after a momentary "up" displacement, return to neutral.

Tests were made in order to clarify the reasons for the fracture of the steel extremity of the outboard aileron control rod under the possible action of flap retraction, ailerons jammed in the down position.

These tests showed that the weakest component in the mechanism is the attachment bolt of the upper outboard part fixing the bell crank driven by the actuator. This bolt breaks by shearing. The blocking torque of the aileron at the moment of rupture is of the order of 250 Kgm.

None of the four bolts, left and right-hand, were found sheared, and it was, therefore, presumed that the breaking of the aileron control rod was due to the impact force.

Spoilers

The position of the spoilers on impact was difficult to determine. The spoilers were all found retracted. However, according to the marks on the structure and rods, it seems that the position on impact might have been as follows:

left-hand outboard spoiler	: undetermined
left-hand inboard spoiler	: probably : retracted
right-hand inboard spoiler	: out (approxi- : mately 40°)
right-hand outboard spoiler	: undetermined.

The position of the spoilers could, therefore, correspond to a right turn control demand.

The "speed brake" control lever was in the neutral position at the moment of impact.

There was no visible indication on what remained of the structure, controls, spoiler actuators and control valves that could lead to the conclusion of a failure prior to impact.

However, it was noted that all shear rivets on the control follow-up mechanism were sheared.

The three by-pass valves of the system were found in the normal position (hydraulic pressure "on").

The by-pass valves of the left and right-hand outboard spoilers were contaminated by fire. The inboard spoilers' by-pass valve was intact.

Bench tests of these valves gave the following results:

inboard valve	: functioned normally
right-hand outboard valve	: functioned normally after reconditioning (replaced seals and springs).
left-hand outboard valve	: functioned abnormally, even after reconditioning. The valve remained stuck in the "open" position.

The overhead panel on which the control switches of the spoiler by-pass valves are located was considerably damaged by impact. The cover of the inboard spoilers' by-pass valve switch was intact and in the normal (down) position but imprisoning part of the panel normally situated outside the switch cover. The cover of the outboard spoilers' switch was in the "up" position but with one of its corners broken off.

Flaps

The flaps were in the retracted position on impact. The selector lever was in the 0° position.

Apart from multiple breaks due to the impact forces, nothing abnormal was found in the structure or control systems.

Rudder and vertical fin

They were not damaged by fire and were relatively intact. Traces on the structure showed that there was a 20° right rudder position on impact. The traces left on the quadrants controlled by the rudder pedals also showed a 20° right rudder position on impact. No abnormality was found on the structure, hinges, balance panels, tabs, snubbers, or in the power-assisted control system, and the whole control rod system was correctly assembled and safety wired.

The trim was found with a one unit right setting.

The split pins of the centring spring mechanism of the rudder trim were incorrectly installed. Also, the cable which slackens on right rudder application was outside of its lodging. For large rudder movements these split pins, when incorrectly installed, will hit the central support arm of the pulleys of the rudder centring mechanism, and the corresponding cable will slacken and may jump out of its lodging on the drum. When the rudder returns to the neutral position or beyond, this cable may then roll up in the neighbouring lodging. This will result in a displacement of the neutral position of the rudder which, when measured on the ground, has been found to be of the order of 3°. This displacement will remain constant as long as the rudder is not displaced beyond the angle where split pins will again hit the support arm.

Elevator

There were no indications of failure prior to impact on the structure, hinges, balance panels, control tabs, stabilizer actuated tabs or snubbers. At impact the elevators were in the "up" position.

Stabilizer

It was in a position corresponding to 10 - 10.5 units nose up trim, close to the maximum of 11 units. The marks left by the index on the pedestal indicated 8 - 8.5 units nose up trim, but the cable connecting the front drum and the indicating mechanism was broken.

The stabilizer control mechanism was examined for electrical and mechanical failure. The only significant discrepancies were:

a) A relatively important quantity of water condensation was found in the lower housing and in the input shaft well for the electric actuator;

b) The locking nut of the input shaft of the electric trim actuator was excessively tightened and the locking washer was sheared;

c) A piece of fibre was jammed between the rear drum and the cable. The cable had rubbed considerably on the protective covering.

The remains of the electrical parts of the control were strip examined and revealed nothing.

Tests were made to determine the influence of certain faults and to ensure the correct operation of the trim mechanism taking into account the stabilizer's position. Low temperature tests indicated that water in sufficient quantity in the input shaft well of the electric actuator may cause the jamming of the electric trim motor control. While the motor continues turning, water can also cause excessive tightening of the locking nut and shearing of the locking washer.

Other low temperature tests were made to determine the influence of contamination while the mechanism is in operation.

This contamination is a result, partly, of the humidity in the atmosphere which infiltrates during each flight when the mechanism is no longer airtight, and partly because grease on the screw is sucked inside the topcasing during the movements of the screw. The contamination of the lower casing could result from the grease packed inside the mechanism's roller bearings.

The screw is reversible and when operating normally, this reversibility is prevented by two brakes: the primary brake (containing brake plates) and a secondary brake (shoe brake). Tests were made to ascertain whether or not the brakes would slip due to contamination by humidity, ice, grease, or a combination thereof. The possibility of slipping, especially in the case of the secondary brake, was established. However, conditions of prolonged slipping were not apparent. The fibre found between the rear drum and the cable wound upon it could have caused the disconnect clutch to operate due to the friction of this cable on the protective cover, rendering the electrical trim inoperative. The tests made at ambiant temperature, with the squashed fibre and a new assembly, did not operate the disconnect clutch mechanism.

Power plants and systems

Nothing abnormal was found in the power plants, electrical and hydraulic systems, mach-trim, radio or autopilot.

Discussion of the data established during the investigation

Results of the examination of communications exchanged between the aircraft and ground stations during the flight and also from flight recorder tape analysis showed nothing abnormal until 0859:30 hours when approach control cleared the flight to land at Brussels and requested that the tower be contacted on frequency 118.6 Mc/s. The aircraft replied: "All right 118.6 JB". At that moment it was at 1 500 ft, near Hofstade, 5.5 NM from the threshold of runway 20 on which it was to land.

It did not contact the tower. After appearing close to the runway threshold at an altitude and in an attitude which seemed normal, it began a series of abnormal manoeuvres and crashed at 0905 hours, 2 km northeast of the runway threshold.

The flight recorder indicated that 0859:30 hours the aircraft was at a speed of about 220 kt, a magnetic heading of 185° and a pressure altitude of 1 400 ft which corresponds to an altitude of 1 560 ft(QFE). It also indicated a loss of altitude of 1 000 ft/min with a reduction in airspeed from 215 kt to 145 kt between 0900 and 0901 hours. To obtain this loss of altitude and speed reduction the pilot probably took the following action in quick succession:

1) power reduction
2) lowered flaps to 30°
3) lowered landing gear
4) lowered flaps to 40°
5) lowered flaps to 50°

It the aircraft was trimmed longitudinally at the beginning of this manoeuvring and if the pilot continued to maintain his longitudinal trim during the reduction in speed and altitude, the number of units of trim would have passed from one unit nose up to 5 units nose up, which represents approximately 8 seconds of trim motor action. The aircraft would, therefore, have been in the landing configuration and at a height of 560 ft above the airport elevation, which would have made it possible to continue and land normally on the runway. Contrary to all expectations, the aircraft started a manoeuvre which, in the beginning, resembled an overshoot. This changed almost immediately into "an abnormal sequence of evolutions", characterized by left-hand banks and sharp left turns.

The investigation was limited to a technical failure which showed up clearly between the end of communications with approach control and the beginning of the overshoot. This covered a period of 1 min 30 sec during which the flight recorder registered a rapid decrease in speed and altitude, which could only be explained if the crew took the actions stated above over a one minute period.

As the evolutions observed thereafter showed clearly that it was not possible to control the attitude of the aircraft, the Commission looked for the causes of the accident in a failure or combination of technical failures and tried to establish a correlation between the appearance of this or these failures with one of the manoeuvres made by the crew during the minute preceding these evolutions.

The engine thrust produces a certain effect on the aircraft's attitude, determines the speed and is, therefore, closely related to the use of the flying controls. Therefore, the possibilities and conditions of operation of the engines immediately prior to the accident were examined.

Stripping of the engines showed no abnormal conditions, and all four of them were running at impact but probably at reduced thrust. The reverser shells were in the normal in-flight condition, which excludes the possibility of untimely reversing of one or more of the engines. The reverse thrust controls were in the forward position. All four engines were idling and each was developing from 1 000 to 1 500 lb of thrust. It was concluded that the engines did not prevent controlling the aircraft's attitude, and the examination of possible causes of the accident was therefore limited to a flight controls failure.

Rudder, Elevator and Horizontal Stabilizer

The possibility of rudder, elevator or elevator control being causal factors in the accident due to failure or jamming was carefully examined and rejected as highly improbable.

The horizontal stabilizer was then considered. It was in a 10 unit nose up position. In the landing configuration and at the reference speed (V ref = 1.3Vs, Vs = stall speed) the position of the stabilizer should have been 5.9 units nose up with the engines at take-off thrust.

The position of the horizontal stabilizer increasing linearly with the lift coefficient should reach approximately 8 units nose up at 105 kt in level flight and landing configuration (lift coefficient at Vs = 1.7 times the lift coefficient at 1.3 Vs).

It was, therefore, concluded that the stabilizer's position was abnormal for the approach.

If the protective coverings of the spoiler by-pass switches were lifted before the crash, it indicates that the pilot wished to by-pass one of the two spoiler systems either to eliminate a defective spoiler system or to obtain a nose down pitch movement in order to compensate for the exaggerated nose up stabilizer position.

The stabilizer position can only be explained if:

1) one of the control systems of the stabilizer ran away;

2) there was an untimely slipping of the horizontal stabilizer due to unbalanced aerodynamic loads upon it; or

3) failure of one of the other flight controls required increased action of the stabilizer.

Assumptions - 1st hypothesis

"The position was the consequence of a failure in the control system of the stabilizer."

The stabilizer can be controlled by the autopilot, by the mach trim system and by the electric motor of the manual system.

The autopilot was disconnected on impact. The servo motor was recovered completely destroyed but the mach trim may be eliminated as the switch inside the KIFIS was intact and in the open position. (It is normally open below 0.83 Mach.) A short circuit or a faulty toggle switch might have caused a continuous displacement of the stabilizer.

This is, however, anticipated in the emergency procedures, by operating the cut-out switch on the pedestal to cut off the electrical supply to the motor and the clutches. The switch and the relay were recovered damaged, but nothing indicated that they did not function correctly before impact. Furthermore, the Commission considered it difficult to believe that during the 8 to 10 seconds that the runaway would have lasted, the pilots did not have an opportunity to operate the cut-out switch.

2nd hypothesis

"The position was the consequence of a slipping stabilizer."

The uncontrolled slipping of the horizontal stabilizer under the influence of unbalanced aerodynamic loads is prevented by two friction brakes. Tests were made on these. The tests showed that in certain conditions, which may be encountered in normal operations, one of these brakes slips at high speed and is, therefore, inefficient, whereas the other brake slips but at a slow rate. Therefore, some doubt as to the efficiency under all circumstances of the braking device remains. This would be a possible explanation of the accident. Once the stabilizer is out of trim, the aerodynamic loads which act upon it have an unfavourable influence which increases with the slipping.

The Commission felt, however, that it was difficult to admit this explanation because it would then have been necessary for -

1) the two brakes to become inoperative;

2) the slipping of the primary brake to be rapid, when the tests under conditions of severe contamination produced only a slow creep.

Finally, a rapid slipping due to aerodynamic loads would most probably have brought the screw nut in contact with the mechanical stop, whilst in actual fact, it was found one to two turns away from this stop. It was admitted that the crew could have partly returned the stabilizer, but no certain indication whatsoever of the use of the manual trim could be found.

3rd hypothesis

"The position was necessary to compensate for the failure of one of the other flight controls."

The efficiency of the elevator decreases during turns. The pitching component of the angular rotation speed causes a relative air flow which tends to create a nose down movement. This is due to the distance existing between the stabilizer and the centre of gravity.

Under these conditions the nose up tendency of the stabilizer must be increased. A 10 unit nose up position could be necessary to trim the aircraft for a coordinated turn at speeds between 120 and 155 kt (40° to 60° bank, flaps down).

The requirement is less in the flaps up configuration (the maximum lift coefficient is reduced). It should not be more than 7 units for a turn at 60° of bank and at the buffet speed. The effect of the elevator being equal to 5.5 units of trim, it follows that, in the final configuration, the equilibrium of the aircraft was only possible within tight limits of speed and bank angle.

No figures are available for speed lower than the buffet speed but if a linear variation of the coefficient of aerodynamic pitching moment as a function of the lift coefficient is admitted, then a setting in the order of 10 units nose up is found.

The Commission concluded that the probable cause of the accident could hardly be attributed to a malfunctioning of the stabilizer as it could have been used for a steep turn close to stalling speed.

Lateral controls

Inboard ailerons

In normal flight, i.e. flaps retracted, the outboard ailerons are inoperative, and only the inboard ailerons are used.

Numerous cases of in-flight jamming of the inboard ailerons were found in the trouble reports. Wreckage examination disclosed that the inboard ailerons were deflected in such a direction as to produce a right bank. However, it was not possible to determine whether the position was such before impact or had been caused by it.

The aileron trim cartridge showed a point where jamming had occurred. This jamming was due to corrosion combined with insufficient clearance.

The cartridge corrosion deposit analysis conducted by Boeing indicated that the corrosion was due to the effects of the fire which followed the crash.

This point was so located as to permit a full displacement of the control for a left bank but only allowed a very limited displacement past neutral for a right bank. Assuming that the pilot decided to overshoot and started a turn to the left, the Commission found it difficult to understand why he did not maintain the wings level by using later on whatever remained of lateral control and with the help of the rudder. Moreover, there are shear rivets on the connecting rod between the jammed aileron trim cartridge and the aileron tab control mechanism. Once these rivets are sheared, the aileron control is free. The theoretical shear force to be applied on the control wheel is 105 lb. A test made on the recovered part produced a shear force of 152 lb. Notwithstanding the 50% increase over the theoretical force, such a force could have been applied, especially by two pilots. These rivets were actually intact.

The Commission, therefore, concluded that this point of jamming in the aileron trim cartridge could not explain the accident.

Outboard ailerons

If the outboard ailerons are jammed in a position near neutral but not exactly neutral, the extension of the flaps will create a temporary displacement of the control wheel; displacement which could be unnoticed by the pilot or to which he may attach no importance. The entire aileron system, both inboard and outboard, will be jammed if flaps are lowered partially or fully under those conditions.

The kinematics of the system are such that, if the pilot then decides to raise the flaps, the inboard ailerons will be carried along in an opposite movement of an amplitude corresponding to several times the amount of offset from neutral of the outboard ailerons. This operation could set up large internal stresses within the control system, stresses which could cause permanent distortion or breaking of some of the control elements.

However, the inboard ailerons can be freed if there is no permanent distortion during this manoeuvre and if the flaps are fully retracted.

Due to the construction of the linking mechanism between the outboard and inboard ailerons and the flaps, several possibilities of bringing the inboard ailerons to full deflection exist if the outboard ailerons were jammed before or after flap extension. This could have been a possible explanation of the accident, however,

1) as far as is known by the Commission, no case of jamming of the outboard ailerons has ever been reported;

2) there was nothing in the examination of the debris to support this hypothesis;

3) the inboard ailerons were in a position for a right bank which, due to the presence of the snubbers, can hardly be attributed to impact forces.

Spoilers

Examination of the spoilers and their control mechanism showed that the shear rivets on the follow-up mechanism between the spoilers and the hydraulic valves were sheared on all four pairs of spoilers. Also, the hydraulic by-pass valve of the left-hand outboard spoilers was deficient; it remained locked in the 'open' position.

If the rivets on certain spoilers were sheared before impact, this means that if these spoilers were used they could have gone to the fully extended position. Furthermore, if the lateral controls were then moved, the spoilers could either remain fully extended or could retract depending upon the friction existing in the system.

As the friction between the axis and the differential of the sheared follow-up mechanism is modified during the relative displacement of the two parts, a progressive loss of alignment of the follow-up mechanism of the corresponding hydraulic valve can ensue, bringing differences in the extension of the corresponding spoilers.

However, in the most unfavourable case they will retract for a rotation of the control wheel exceeding 17° to 20° in the opposite direction.

A pair of outside spoilers completely extended causes a torque which will result in a roll rate of 13°/sec at 150 kt.

To counterbalance this torque a displacement of the control wheel far superior to 20° in the opposite direction is necessary. When the amount of control wheel exceeds this value, the spoilers will retract and the control wheel movement will produce a roll rate in the opposite direction of approximately 4°/sec with flaps up and spoilers extended and of the order of 2°/sec with flaps up and no spoilers.

The spoilers can normally be put out of action by activating the corresponding spoiler by-pass valve switches.

The spoilers cannot be put out of action if the corresponding by-pass valve remains jammed in the open position. As the left-hand outboard spoilers' by-pass valve was deficient, it follows that, if the shear rivets on the follow-up mechanism were sheared on these same spoilers, the pilot could not overcome the defect in the lateral control system by the action foreseen. The only possible solution in this case would be to cut out the hydraulic utility system.

The Commission expressed the opinion that such critical flight conditions would quickly lead to an accident.

Interpretation of the investigation results

Examination of the wreckage showed that the positions of the control surfaces at impact were:

- stabilizer	up to 10.5 units nose up
- elevator	up
- rudder	20° right
- ailerons	inboard - set for a right turn
	outboard - probably neutral
- spoilers	left-hand outboard - undetermined
	left-hand inboard - probably retracted
	right-hand inboard - extended (40°)
	right-hand outboard - position undetermined
- flaps	up

Analysis of these observations showed that the pilot must have had normal use of the elevator, rudder and aileron controls. It was established that the aircraft, during its abnormal manoeuvres made only left-hand turns with variable bank up to 60°. Without being able to confirm that the positions in which the various controls were found corresponded necessarily to their position in flight, they all indicated an attempt to turn or bank to the right. At the same time, the elevator was pointing upwards when the stabilizer was already 10 - 10.5 units nose up.

It was concluded that an important abnormality, in spite of the use of the flying controls and engines, forced the aircraft to the left and prevented the pilot from re-establishing level flight and manoeuvring with a view to landing.

Consequently, in order to establish a sequence of events compatible with the facts, all factors which could influence the lateral stability were examined. As no evidence of engine failure was found, attention was drawn to the fact that all shear rivets on the entire follow-up system were sheared and that during tests the left-hand outboard spoiler valve remained jammed in the 'open' position several times.

Observations made as to the position of the safety covers of the switches operating the spoiler by-pass valves led to the assumption that the pilot had envisaged their use in connexion with the lateral control difficulties he encountered.

The use of these switches is only justified in two instances:

1) abnormal functioning of the stabilizer;

2) abnormal functioning of the spoilers.

As malfunctioning of the stabilizer was eliminated, the Commission assumed that the pilot wanted to correct a spoiler malfunction. This assumption is supported by the fact that at that time other cases of shearing of rivets on the spoiler follow-up system were found. Shearing of these rivets results in abnormal and erratic behaviour of the spoilers. While it has been proved that a spoiler, following its separation from its follow-up system, may go to the fully extended (60°) position even for a relatively small aileron control wheel movement (3 to 5°) it has also been proved:

1) that it is necessary, in case of the most unfavourable displacement of the spoiler control valve, to apply 17 to 20° of wheel in the opposite direction to retract the spoiler completely;

2) that it is impossible for the pilot to bring back all lateral control surfaces to neutral simultaneously and that, therefore, he is confronted with a lateral control system modified in such a way that it is no longer possible to find a position of the controls where the roll torque can be cancelled.

Having admitted the foregoing, and if the pilot arrived at the conclusion that his difficulties came from the spoiler system, the fact of by-passing them could only aggravate the situation in the present case, as the left-hand outboard by-pass valve was not functioning.

The pilot would then be in a situation where the aircraft had lost all lateral stability. The use of rudder to remedy such a situation would result in a violent dutch roll, difficult to stop because of the abnormal functioning of the lateral controls and also because of the tendency of the nose to drop. In addition to this the possibility of a displaced neutral position of the rudder, which could have occurred precisely at this phase, would thereby have created a further difficulty for the pilot.

Considering the foregoing, the Commission tried to reconstruct the sequence of events which led to the accident.

The flight recorder indicated that the approach appeared normal until 0900:30 hours. At that time the trace showed a rapid variation of 15° to the left immediately followed by an equal variation to the right. Unfortunately, the trace stopped immediately after 0901 hours.

These variations in reading may coincide with the beginning of the difficulties of OO-SJB, which were such as to prevent the co-pilot from establishing communications for which he normally is responsible. This would explain the aircraft's silence on frequency 118.6 Mc/s.

At 0901 hours, as the aircraft was not aligned with the runway, the pilot started his overshoot.

If it is admitted that the cause of the trouble was the shearing of the rivets in the follow-up system of the left-hand outboard spoilers, the difficulties could then only increase.

Confronted by a lateral control problem the pilot had only one possibility, that was to by-pass the spoilers. The use of the by-pass switches seems confirmed by the position of their covers as found in the wreckage. Whatever they were used for, the situation became worse as the left-hand outboard spoiler was not working properly.

Under certain conditions, this would result in severe lateral instability. If this was the situation in OO-SJB it is most probable that it led to the final loss of the aircraft.

The Commission admitted that the above account, while very plausible and based on certain material elements and observations, had not a character of certainty. It felt, however, that it could not be excluded.

The Commission had no indication as to when the flaps were retracted or the reasons which led the pilot to retract them completely. It noted that although the flaps and landing gear were found in the retracted position, that fact was not connected in any way with the accident sequence as here presented. The lateral instability of the aircraft with the modulated extension of the spoilers is always a fact no matter what the configuration may be.

Supposing an erratic functioning of the spoilers, the Commission considered:

1) What actions could the pilot have taken to correct it?

The only possibility was to suppress the hydraulic pressure activating the spoilers. In order to accomplish this, the pressure in the utility system could have been dropped by activating the pressure control switches of the hydraulic pumps.

2) Why did the crew not take this action?

The Commission was of the opinion that, if the sequence of events as explained previously was admitted, it was impossible in the time available, and under the circumstances in which the crew found itself, to identify with certainty the failures with which it was confronted. Moreover, the identification of such failure is complicated by the fact that it is nearly impossible to observe the spoilers from the cockpit.

Probable Cause

Having carried out all possible reasonable investigations, the Commission concluded that the cause of the accident had to be looked for in the material failure of the flying controls.

However, while it was possible to advance certain hypotheses regarding the possible causes, they could not be considered as entirely satisfactory. Only the material failure of two systems could lead to a complete explanation, but left the way open to an arbitrary choice because there was not sufficient evidence to corroborate it.

Recommendations

With regard to modifications that the Commission could recommend, it noted that the following Service Bulletins sent out by Boeing and by Sabena cover the suggestions that could have been made:

No. 1117	Spoiler follow-up crank shear joint modification (18 January 1961)
No. 1336	Outboard spoiler shut off valve consolidation (18 September 1961)
No. 1344	Inboard aileron centring spring cartridge modification (27 July 1961)

No. 1410 Control wheel stabilizer trim switch replacement (5 September 1961)

No. 1484 Hydraulic system solenoid valve replacement spoiler system (15 December 1961)

No. 1635 Stabilizer trim electrical limit revision (15 June 1962)

No. 1680 Rudder control centring spring cable guard installation (25 May 1962)

No. 114 Sabena Bulletin - Installation of a supplementary brake for stabilizer trim actuator (7 May 1962)

Moreover, the introduction of a spoilers' position indicator would facilitate the detection of any abnormality in their operation and would permit adequate corrective action to be taken.

Comments of the State of Manufacture (United States of America)

The Administrator of the FAA (Federal Aviation Agency) has sent the following comments to the Director General of Civil Aviation, Belgium.

"Several possible causal factors for this accident are mentioned in the report."

"With respect to the spoiler malfunction hypothesis, we cannot agree that such a malfunction as described in the report would have been responsible for the flight path described by witnesses. Flight test data in our file indicate that the Boeing 707 aircraft is readily controllable with an outboard spoiler blocked in the fully open (60 degrees) position and the flaps positioned to 30 degrees or to zero degrees."

"Of the several hypotheses evolving from findings in the accident report, we believe the most plausible to be that concerned with a malfunction of the stabilizer adjusting mechanism permitting the stabilizer to run to the 10.5-degree aircraft nose up position. If such a malfunction occurred and the split flaps and spoilers procedure (inboard spoilers and outboard flaps extended) not employed, the only means to prevent the aircraft from pitching up into a stall would be to apply full forward column and enter a turn in either direction."

"It is apparent from the recorded impact positions of the controls that the split flaps and spoilers technique was not used. The wing flaps were found in the up position and had the inboard spoilers been extended both would have been up at impact and the speed brake handle would not have been in the neutral position as found."

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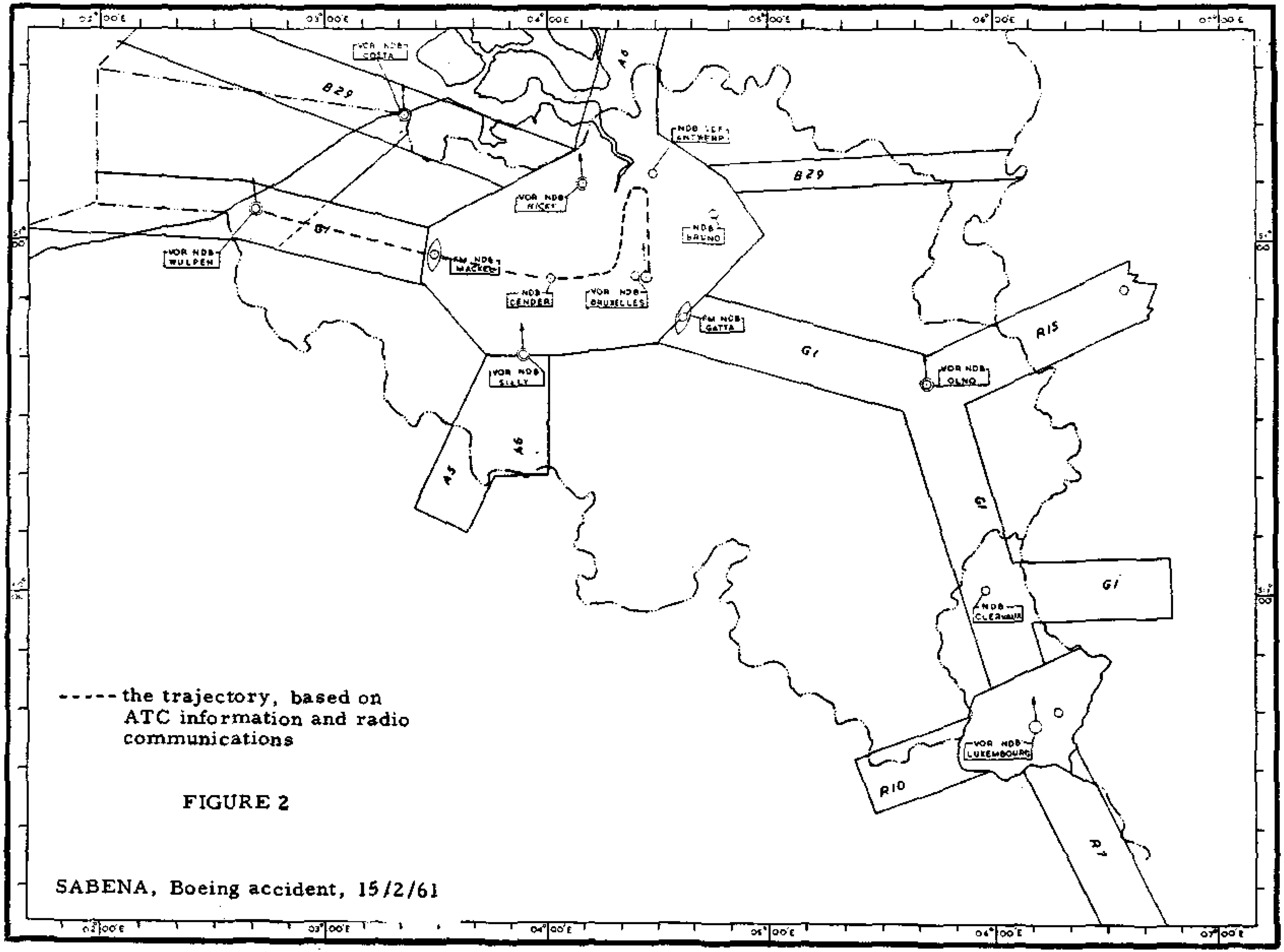
ICAO Ref: AR/763



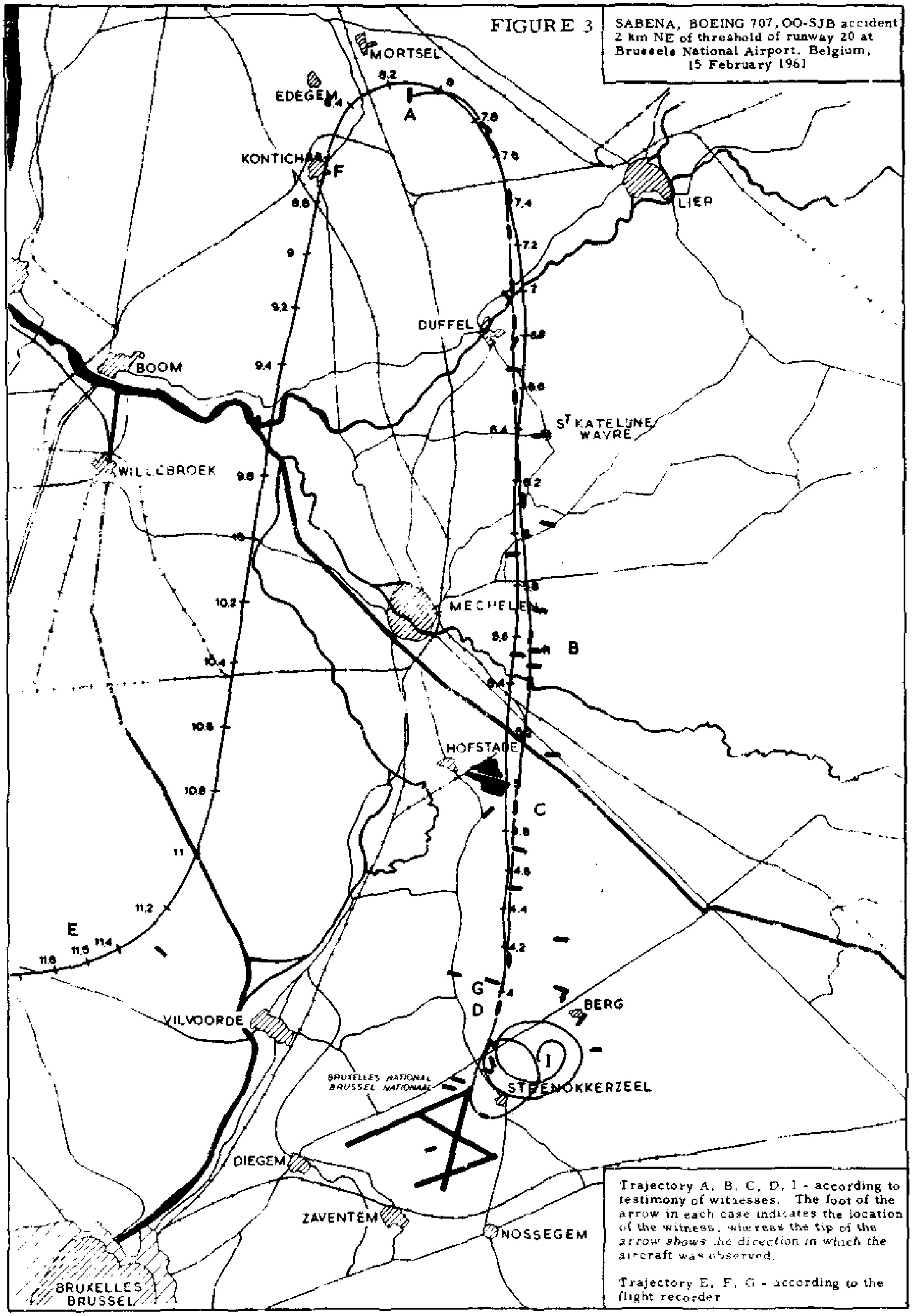
----- the trajectory, based on ATC information and radio communications

FIGURE 2

SABENA, Boeing accident, 15/2/61

FIGURE 3

SABENA, BOEING 707, OO-SJB accident 2 km NE of threshold of runway 20 at Brussels National Airport, Belgium, 15 February 1961



Trajectory A, B, C, D, I - according to testimony of witnesses. The foot of the arrow in each case indicates the location of the witness, whereas the tip of the arrow shows the direction in which the aircraft was observed.

Trajectory E, F, G - according to the flight recorder

No. 8

Línea Aeropostal Venezolana, DC-3C, YV-C-AZQ, accident at Páramo Turmal, Venezuela on 9 March 1961. Report released by the Directorate of Civil Aviation, Venezuela.

Circumstances

The aircraft took off from San Antonio del Táchira on 9 March on a flight to Maiquetía carrying 4 crew and 8 passengers. The duration of the flight was estimated at 2 hours 45 minutes with the landing at Maiquetía to be made at 1515 hours. Thirty minutes after the estimated time of arrival the Maiquetía Air Traffic Control notified the Director of Civil Aviation that an alert phase had been declared. Word was subsequently received from the Trujillo area that the aircraft had been found at Páramo Turmal. All aboard the aircraft had been instantly killed.

Investigation and Evidence

The aircraft had flown a total of 23 352 hours and had last been inspected on 16 February 1961.

The port and starboard engines had total times of 1 672 and 7 782 hours respectively.

The pilot held a valid airline transport pilot's licence (Class I) for aircraft up to 4 400 hp which had been issued in July 1959. The co-pilot had an airline transport pilot's licence (Class III) for aircraft up to 2 400 hp, issued in November 1959. Both the pilot and co-pilot held valid medical certificates.

Study of the wreckage

Examination of the front part of the fuselage showed that the aircraft struck the hill in a fairly level flight attitude. Two of the propeller blades and the hub were buried in the ground, only 50 cm remaining visible. The left propeller was turned slightly to the right, which was due to the left engine being more powerful than the right at the time of the accident. The fact that the distance between the hubs of the propellers was 5 m 56 cm instead of the original 5 m 66 cm indicated that the deceleration was extremely violent, bringing the remains of the aircraft to a stop 50 or 60 cm after the impact. The violent deceleration, which was absorbed by the engines, undercarriage and right wing, resulted in the upper part of the fuselage and the left side of the aircraft being thrown forwards. The objects contained in the fuselage followed the same path as part of of the cabin and were strewn over a distance with a radius of 300 m from the aircraft. Contact occurred at a bank angle of 5 to 6° to the right. Fire broke out through gasoline combustion.

The aircraft did not touch the trees which appeared to be close to the elevator before the impact but did so when the tail was lowered after the aircraft came to rest. Since the height of the trees was more than 2 m this shows that the tail passed over them implying a level flight attitude.

In short, at the time of the accident the following conditions existed:

1) undercarriage and flaps retracted;
2) flight height approximately 9 200 ft;
3) cruising power slightly increased on left engine;
4) radio compass No. 1 (red) tuned to Radio Barquisimeto;
5) radio transmitter between channels 3 and 4;
6) controls set on cruising flight;
7) time: estimated time of accident;
8) rudder trim tab 0°;
9) elevator trim tab: normal;
10) orientation of accident: 60° approximately (track angle).

The technical investigation did not reveal any malfunctioning of the engines, structures or controls.

Witnesses' Statements

The IFR flight plan for this flight is San Antonio del Táchira-Orope-W-6-Bobures-W-7-Carora-Siquisique-W-2-W-1-Maiquetía.

The manager of Valera Airport indicated that the aircraft flew over that airport. Residents of Carache indicated that they heard the aircraft pass to the south of their village over Concepción. Furthermore, the left radio compass at the time of the accident was on 680 kc/s, the frequency of a commercial radio station in Barquisimeto. If the two points indicated by the witnesses are joined with the town of Barquisimeto, a straight line 60° north is obtained, joining Orope with Barquisimeto and passing through the site of the accident. The wreckage pattern of the aircraft coincides with the theoretical track Orope-Barquisimeto.

Probable Cause

A navigational error in the course of an instrument flight at insufficient altitude caused the accident.

Contributing factors were:

1) failure to follow the route San Antonio-Maiquetía as called for by the LAV Operations Manual;
2) the flight took place outside of the route established by the National Airways Division;
3) overconfidence of the pilot in his knowledge of the route;
4) instrument flight which prevented visual checking of the position of the aircraft.

Recommendations

As a result of this accident the following recommendations are made:

a) that flight recorders be installed on 3 out of every 8 commercial aircraft as a means of checking flight operations;
b) that VOR or at least a radio beacon be installed at Carora to afford increased flight protection;
c) that appropriate measures be taken to ensure that flight reports are transmitted regularly at the required intervals.

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ICAO Ref: AR/672

No. 9

Ceskoslovenské Aérolinie, Ilyushin 18, OK-OAD, accident northeast of Nürnberg, Germany on 28 March 1961. Report dated 22 March 1963 released by the Federal Republic of Germany.

Circumstances

The aircraft was on a scheduled flight from Prague to Bamako/Mali with intermediate stops at Zurich, Rabat, Dakar and Conakry. It disintegrated in the air and subsequently crashed in flames* while on the Prague-Zurich flight leg, at a point approximately 22 km northeast of Nürnberg. The 8 crew and 44 passengers on board the aircraft were killed in the accident. The last contact with the aircraft prior to the accident was at 2006 hours. The crash is believed to have occurred at about 2009 hours.**

Investigation and Evidence

The Aircraft

An operating licence for the aircraft, issued on 13 June 1960, was valid at the time of the accident.

The aircraft was equipped with an automatic pilot but not with automatic elevator trim adjustment (trim servo). A 3-axes trim indicator for the automatic pilot was not installed. The elevator trim was adjusted manually. The aircraft was also equipped with an automatic signalling device which enabled the crew to ascertain whether the aircraft was properly trimmed. Rudder and aileron trim adjustment was electrical.

The aircraft was not equipped with a rapid fuel cut-off device. The fuel used was kerosene LRX 53.

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

The Crew

The licences of all crew members were valid at the time of the accident, and their flying experience was considerable. The pilot-in-command had flown a total of 8 572 hours, 354 of which were on the Ilyushin 18. The co-pilot had flown a total of 11 019 hours including 179 on the Ilyushin 18.

Weather

The Nürnberg station of the German Meteorological Service gave the following report of local conditions at Nürnberg at 2011 hours:

wind 250/7 kt
clouds 7/8 sc in 5 000 ft, 8/8 cs in 25 000 ft
visibility 20 km
QNH 2000 h 1021.5 mb
no precipitation (VFR weather)

The Flight

The aircraft left Prague at 1941 hours and climbed on a heading direct to the Rakovnik radio beacon which it crossed at 1949 hours at an altitude of 14 400 ft in climbing configuration. At 1951 hours the aircraft climbed further to 19 000 ft and estimated crossing the Eger radio beacon at 2001 hours. It was cleared by Prague area control to 20 000 ft and reached this

* based on statements of several eyewitnesses
** All times in this report are MEZ = Central European Time = GMT + one hour

altitude at 1952 hours. Because of damage to the antenna of the Prague area radar installation, which could not be repaired because of the strong wind, the flight was subsequently monitored by DF equipment. Thus, it was observed that the aircraft was slightly to the right of its course. According to the crew the DF was inaccurate. At 1956 hours the aircraft was observed on the radar scope for a short time and was on course. Four minutes later it reported that it would be crossing the Eger radio beacon at 1959 hours and gave the estimated time for crossing the Bayreuth radio beacon as 2005 hours. The aircraft was then transferred to the "Rhein-Control" upper control area.

In the German sector ATC radio communication was carried on with the aircraft by Rhein-Control until 2006 hours when the aircraft gave its estimated overflight of Nürnberg as 2010 hours. No further contacts were made.

At 2020 hours Nürnberg ATC received a telephone message that an aircraft had crashed and was burning some 20 km north-northeast of Nürnberg Airport.

At the Accident Site

The point of impact of the aircraft's fuselage was 510 m above sea level in open agricultural terrain. The angle of impact was about 60° at which a rotation around the transversal axis occurred. The fuselage section was so heavily damaged by the impact and ensuing fire that no reliable information could be obtained from the pieces of instrument found. The left wing, the right wing tip, parts of the tail assembly and the four engines were not found at the point of impact.

The four engines with their propellers lay south to east of the fuselage impact point at a distance of 150 to 600 m from the fuselage and were clustered closely together. The left wing with empty engine housing was found in a wood, 1.3 km ahead of the fuselage impact point. This wing was torn off on the inner side of engine No. 2. Further to the rear, in the direction opposite to the flight direction, lay the right wing tip measuring some 4 m in length; parts of the tail, skin, upper side of the fuselage, a firewall and two large sections of the engine housing were found at a distance of up to 5 km from the fuselage impact point. The direction of dispersion of these fragments and the impact direction of the fuselage was approximately 285°. None of the fragments found outside of the fuselage impact point revealed traces of fire. According to the findings, the landing gear and landing flaps were retracted at the moment of impact.

Findings

The testimony of the witnesses, the position of the wreckage and the examination of the wreckage all indicated the following pattern of circumstances:

The aircraft, which was flying normally at flight level 200 (approximately 6 000 m), went into a steep descent (plunging flight path) during which the engine performance was apparently not reduced.

According to information furnished by the operator, the true airspeed in horizontal cruising flight was 635 km/hr. According to the documentation of the manufacturer, the equivalent airspeed at cruising was approximately 145 km/hr higher than the design manoeuvring speed for full rudder control (V_A approximately 325 km/hr EAS), approximately 180 km/hr higher than the design speed for maximum gust intensity (V_B approximately 290 km/hr EAS) and, at an ambient air temperature of -32°C, approximately 70 km/hr below the permissible Mach number M_{NE} = 0.65).

At an altitude of presumably 2 000 to 2 500 m asl, the aircraft fell apart. All four power units were torn from their mounts in the engine housings on the upper side of the wing.

The deformation of the engine mounts indicated that a moment of forces to the right must have acted on the axis of the power units (propellers turned counter-clockwise). The forces produced when the engines were wrenched out, as it appeared from the deformation of the engine mounts, were directed downwards in the case of engines 1 and 2, and in a more lateral direction towards the wing tip in the case of engines 3 and 4. From their position on the ground it was concluded that the four engines were wrenched out at approximately the same time. A propeller blade, presumably from No. 4 engine, struck the right wing on the outer side of No. 4 engine when the engine was torn off sideways and cut through its leading edge, two stringers and the forward beam. The wing, which had broken off in the air, had sustained between point of breakage and the wing tip, three additional cuts from propeller blades. On the left wing, on the inner side of engine housing 2, in the area of the inner fuel tank on the edge of the landing gear recess, there was a rather long break running in a straight line from front to rear. The wing broke off in a down-to-up direction (folding break). The rudder was destroyed by a force applied from left to right and was detached from the tail fin. The tail fin was broken off in the same direction while still in the air. The left elevator trim flap with the elevator had separated from the aircraft in a down-to-up direction. The trim flap and elevator were found at different points. No parts of the fuselage were found outside of its point of impact. It must, therefore, be concluded that the fuselage was still intact in the air. All four propellers, each with its four blades, were found on the corresponding engines. Examination of the engines and propellers gave no indication as to the cause of the accident. All propeller blades were in the feathered or almost feathered position.* This is attributable to the built-in automatic control system. When fuel feed fails, the feathering mechanism automatically becomes operative.

With respect to the chronological sequence of events, it is difficult to reconstruct the breaking-up of the aircraft in the air. According to the reports of eye witnesses and ear witnesses and in view of the circumstance that all four engines were wrenched out at approximately the same time, it must be assumed that the aircraft was abruptly pulled up in the course of a dive at high speed and that it thereby broke up. Two pieces of the engine housings were found furthest from the fuselage impact point (opposite the flight direction), and then fragments were found of the tail assembly and skin. It can be concluded therefrom that the engines were wrenched out, and the left wing broke off first. The aircraft broke up evidently as a result and not as a cause of the dive.

The flight from take-off until the final dive was observed by a Czechoslovakian radar station on the radar scope. No other aircraft was observed in the vicinity of the aircraft at the time of the accident.

Witnesses were unanimous that the sound of the aircraft changed gradually from that of an aircraft flying at normal speed to that of an aircraft flying at high speed and that only at the end of the steep descent could detonations be heard at approximately the same time as the pulling-out noise.

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* Comment by the State of Registry (Czechoslovak Socialist Republic)

"This contradicts our findings. The propeller feathering mechanism investigation proved the following positions of the propeller blades:

the first engine	-	angle of propeller setting 45°
the second engine	-	" " " " 34° 30'
the third engine	-	" " " " 38°
the fourth engine	-	" " " " 47° 30'

As the angle of propeller setting in the feathered position is equivalent to 83°, the above verified setting of blades proves that the blades were in working position."

The steep descent was, therefore, most probably not the result of any explosion.

The Board of Inquiry carefully studied analyses by the aircraft's manufacturer of a number of flight incidents in which the flight movements were impaired after damage to various structural elements. It was also explained how damage to other parts of the aircraft would occur following destruction of the rudder assembly by an external force. It could not, however, consider the evidence submitted in support of the above hypothesis as admissible.

Probable Cause

In the light of the investigations undertaken, it is probable that the accident occurred in one of the following ways, although the possibility of other causes cannot be ruled out:

a) Forced descent causing the aircraft to exceed the structural stress factor in the approach manoeuvre or during the pull-out owing to:

1) the aircraft falling into an uncontrollable flight position because of a defect in an artificial horizon or an electronic instrument of equal importance. In air transport flight incidents throughout the world, where unintentional steep dives have occurred, such incidents can be explained by a defect in an artificial horizon.

2) an unnoticed overcontrol of the electrical rudder or aileron trim adjustment occurring when the automatic pilot was operating with flight movements resulting therefrom after the automatic pilot was disconnected. The automatic pilot was not equipped with a trim servo-indicator to give warning of excessive trim adjustment.

3) physical incapacity of one or both pilots.

b) Intentional descent owing to the presence of smoke, fire or similar emergency, during which the structural stress factor was exceeded in the approach manoeuvre or in the pull-out.

Further comments of the State of Registry

Para. a) 1/ We do not consider it probable that a defective artificial horizon would result in the aircraft's being placed in an uncontrollable flight position as the Ilyushin 18 is equipped with other instruments which would permit control of its attitude.

Para. b) In view of the statement that "None of the fragments found outside of the fuselage impact point revealed traces of fire", we do not consider the presence of smoke or fire on board the aircraft to be the probable cause of the 'intentional descent'. Insofar as a 'similar emergency' is concerned, this is a very general statement. We are convinced that the aircraft, which exchanged messages with Rhein Control up until the time of the accident, would have advised the latter if it intended to descend.

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ICAO Ref: AR/752

No. 10

Línea Aérea Nacional, DC-3, CC-CLDP, crashed into Lástima-Pejerrey Hill, 44 km southeast of Linares, Chile on 3 April 1961. Report, dated 8 May 1963, released by the Directorate of Aviation - Chilean Air Force Headquarters, Chile.

Circumstances

The aircraft was on a scheduled passenger and cargo flight (LAN 210) from Castro (Chiloé) to Santiago, with stops at Puerto Montt and Temuco. Departure from Temuco on the last segment of the flight was at 2230 hours GMT in IFR conditions. The flight was to follow airway 45 or 40 south at an altitude of 8 500 ft and the trip was estimated to be of 2 hours 30 minutes duration.

At 2345 hours the pilot requested clearance from Santiago Control, through Concepción radio and Santiago radio, to descend to a lower altitude due to icing. Santiago Control did not authorize descent in view of conflicting traffic (LAN 205) on airway 45, and the aircraft maintained 8 500 ft, estimating Curicó at 2357 hours.

Santiago control cleared LAN 210 to turn back on airway 45 and then descend to 6 500 ft on the same airway, pass over Curicó at 6 500 ft and continue on airway 40 south at the Santo Domingo radio beacon.

Santiago radio failed to establish direct communication with the aircraft, and the instructions were transmitted to Concepción radio, which relayed them to the aircraft, but no acknowledgement was received.

The descent clearance request was the last communication heard from LAN 210, and contact with the aircraft was lost.

On 10 April it was confirmed that the aircraft had crashed and was completely destroyed. All 24 persons aboard (4 crew and 20 passengers) were killed.

There were no eyewitnesses to the accident.

Investigation and Evidence

The Aircraft

Its certificate of airworthiness was valid, and maintenance work on the aircraft had been routine. The aircraft was authorized to operate with a total of 32 seats, including crew, and with a maximum take-off weight of 26 200 lb. Its total flight time was 18 299 hours.

The aircraft's de-icing equipment, fitted to the leading edges of the wings and the fixed tailplanes, had been removed because of maintenance difficulties. The airline's operations manual clearly stipulates that no aircraft may operate under icing conditions.

The airborne radio equipment had been repaired, and it is considered that, owing to the weather prevailing on the day of the accident, this equipment may have failed.

The Crew

The pilot-in-command held a senior commercial pilot's licence and had flown a total of 6 012 hours, of which 714 were on instruments and 364 hours by night.

The co-pilot held a commercial pilot's licence with a total of 489 hours, of which 8 were on instrument flight.

The flight radio operator's licence had expired.

Airway 45

It begins in the south at Victoria and extends towards Chillán, Curicó, Melipilla and Santiago through the central part of the country. Radio beacons are located in

Victoria, Curicó, Melipilla and Santiago, in addition to the Los Angeles beacon, 48 miles north of Victoria and the Concepción beacon on the coast, a quarter of a mile from Chillán and about 50 miles from Los Angeles.

A radio beacon, which should be located at Chillán, is lacking on the 205-mile Victoria-Curicó leg. The distance from Curicó to Melipilla is 75 miles, and from Melipilla to Santiago about 28 miles.

Investigation showed that military aircraft were not using this airway because the range of the Curicó and Victoria radio beacons and the receiving conditions of the aircraft radio compasses were not sufficiently reliable for adequate flight control. In addition, the commercial radio stations used as a control supplement were not sufficiently reliable for continued operations, and the prevailing winds were westerly - all of which made this airway unsafe.

A check revealed that the range of the Victoria and Curicó beacons is some 50 miles.

Hypothesis - reconstruction of the flight

The aircraft took off from Temuco at 2230 hours and engaged on airway 45 at an altitude of 9 500 ft. Because of icing on the wings, which were not fitted with de-icing equipment, the pilot requested clearance through Concepción radio to descend because his equipment, through failure or lack of power, failed to establish direct communication with Santiago Control. Clearance to descend was not granted owing to the presence of another aircraft (LAN 205) on a lower level, but the aircraft was authorized to turn back and descend to 6 500 ft.

The aircraft was flying the 205-mile Victoria-Curicó leg. It may be assumed that the radio beacons did not fully cover the area and, therefore, the aircraft either lost contact with them or their signals were too weak to be perceived. These circumstances, together with the strong westerly wind blowing at that altitude contributed to the aircraft's drift towards the mountain range. On receiving the authorization to turn back, the pilot initiated a turn to the right, i.e. towards the mountains into which the aircraft crashed at 7 000 ft.

Support for this hypothesis

Before impact the aircraft made a turn to proceed on a southwesterly heading, followed by descent, a manoeuvre attributed to the following:

a) decision by the pilot in order to counter the ice formation;

b) compulsory manoeuvre resulting from the aircraft's loss of aerodynamic properties through ice formation;

c) possibility of direct reception of Santiago radio during its transmission of the authorization requested by the pilot;

d) compulsory manoeuvre caused by a downward current in the Andes.

The position and orientation of the wreckage proved that the aircraft was on a southwesterly heading.

Factors which may have affected the airborne compass bearings -

- the distance separating the radio beacons along the segment
- cloudy sky with tendency to ice formation
- impending storm

The 50-mile range of the radio beacons left a distance of about 105 miles over which the pilot flew IFR without any ground aids.

Concepción radio, which was in touch with the aircraft, heard no reports of mechanical failures or emergency calls.

Transmissions reached the aircraft after a 14-minute delay.

The upper wind conditions were:

at 7 500 ft	240°/25 kt
at 9 500 ft	250°/35 kt

Reasons against the hypothesis

Airway 45 had been regularly used by this airline, and no comments had been sent to the Directorate of Aviation.

There are two radio beacons in the Victoria-Curicó segment of airway 45, and both functioned normally on the day of the accident.

Wreckage examination

The aircraft crashed on La Gotera Hill, which is part of the Lástima-Pejerrey range.

From the wreckage's position it was determined that the flight was on a south-west heading, although owing to the aircraft's being entirely destroyed and burnt out it was not possible to state its speed or altitude, or whether the left engine had failed. At impact it appeared that the right engine was functioning normally.

It was not possible to determine the cause of the accident from the navigation instruments or the wreckage.

ICAO Ref: AIG/ACC/REP/GEN/No. 24 - Chile

No. 11

Air Taxi Company, Aero Commander 500, EP-ABA, accident in mountainous terrain 21 km from Zafarkand Village, Iran, 17 April 1961. Report released by the Department General of Civil Aviation, Iran.

Circumstances

On 16 April the aircraft departed Mehrabad Airport at 0228 Z on a charter flight to Yazd and Bandar Abbas. On the same day the first stage of the return flight was made to Shiraz where an overnight stop was made. Next day EP-ABA left Shiraz at 0245 Z to pick up four passengers at Marvdasht. At 0515 Z it departed Marvdasht on a direct flight to Mehrabad Airport, Tehran, ETA 0800 Z. A last contact was made with Esfahan at 0630 Z reporting its position as 20 miles east of Esfahan - VFR, flight level 150, ETA Mehrabad 0800 Z. This was the last message received from the aircraft.

On 19 April word was received at Mehrabad Airport that the aircraft had crashed on the mountains 40 km south of Ardestan and 18 km west of Zafarkand Village. The pilot and four passengers were killed in the accident, and the aircraft was destroyed.

Investigation and Evidence

The Aircraft

The aircraft's certificate of airworthiness was valid until 27 May 1961. The actual gross weight of EP-ABA at take-off was approximately 5 802 lb - the maximum allowable being 6 000 lb. It was assumed that the position of the aircraft's centre of gravity was within limits at the time of the accident. All log books and maintenance records of the aircraft were found to be satisfactory.

The Crew

The pilot, the sole crew member, held a commercial pilot's licence issued on 27 April 1957 and ratings for DC-3, DC-4 and Aero Commander aircraft. He had satisfactorily completed the U. S. A. F. Instrument Pilot Instructor School Course and was last checked on 16 September 1960. He had flown T28, B-25-NA, T-29B, CV-240, DC-3, DC-4, Aero Commander and IL-14 aircraft. On the Aero Commander he had flown 26 hours as co-pilot and 477 hours as captain. His total in flying hours was 2 866 hours, night flying 51 hours and blind flying 156 hours. Besides these recorded times he had flown (after 21 March 1961) a further 32 to 40 hours. In addition to his normal duties as a pilot in the Air Force he was commander on the Russian IL-14 aircraft owned by H. I. M. The Shahanshah. His commercial pilot duties with Air Taxi Company were supplementary to those with the I. I. A. F. and his satisfactory medical, training standards etc. are assured from this source.

Weather conditions

From various reports and statements of persons living in the accident area it was determined that the aircraft, during its flight from Marvdasht to the accident site, encountered the following weather:

wind :	South of Esfahan 245° - 18 kt North of Esfahan 325° - 20 kt
clouds:	South of Esfahan: CU, SC and AS clouds with tops at 14 000 ft North of Esfahan: 4/8 SC and AS tops at 15 000 ft and 4/8 CB with tops at over 20 000 ft
general:	North of Esfahan: moderate to severe icing and turbulence.

The site of the accident and its surroundings

EP-ABA crashed approximately 21 km WSW of Zafarkand Village at a height of 6 996 ft. The wreckage was located in a narrow gorge. The aircraft came to rest approximately 80 ft below the crest of the gorge, between the steep slope of two mountain peaks. The centreline of the narrow gorge runs in a direction 068° -248° M whereas the aircraft came to rest in a direction of 225°M. The centreline of the gorge shows an average up-slope of 40°, whereas the enclosing mountain walls show up-slope of 35-15°. The entire gorge is covered with large and small rocks, rendering vegetation extremely scarce. The crest opens a passage of approximately 100 ft wide at the bottom and 1 000 ft wide at the enclosing mountain peaks. During the investigation at the site of the crash it was found that a moderate wind from a westerly direction caused a strong venturi effect over the crest, with an extremely strong downdraft into the gorge.

Approximately 1 500 ft to the east, the northern wall of the gorge is interrupted by a pinnacle of isolated rock formation, rising vertically up from its base. The top of this formation reaches to a height of about 7 140 ft or 144 ft higher than the location of the wreckage. An investigation of this rock formation revealed that protruding pieces have recently been broken off from the extreme top and, furthermore, that traces of paint similar to the type of paint applied to the aircraft wings, were present.

Analysis of the flight

The aircraft had departed Marvdasht at 0515 Z and had reported its position to Esfahan as 20 miles east of that station, cruising at flight level 150. From the time of its last departure to the time of position reporting, 1 hour and 15 minutes had elapsed during which time a straightline distance of 169 NM was covered. In accordance with the instructions of the operator, a true airspeed of 150 kt was to be maintained at the normal cruising level of 15 000 ft. Allowing 9 minutes additional time for take-off and reaching cruising level, an average groundspeed of 154 kt between Marvdasht and the position 20 miles east of Esfahan was maintained. This groundspeed indicated an average wind component of plus 4 kt.

During his flight from Marvdasht to a point 20 miles east of Esfahan, the pilot had ample opportunity to fix his position and, consequently, to be aware of the progress of the flight. In other words, the fact that during that portion of the flight, a tailwind component increased his groundspeed slightly, must have been known to him. Due to the fact that prior to departing from Shiraz and Marvdasht he had neither requested nor received a weather forecast, he could hardly be aware of the fact that there was a windshift from WSW to NNW after passing Esfahan, changing the tailwind component of approximately 4 kt into a headwind component of approximately 17 kt. After passing Esfahan, a closed overcast and lack of ground facilities to fix his position prevented him from obtaining a picture of the changed wind conditions. In view of this, the pilot might well have been under the impression that the groundspeed of his aircraft continued to be 154 kt instead of a now reduced groundspeed of approximately 133 kt. Apart from this, the top of the closed overcast had risen to 15 000 ft with approximately 4/8 cb with tops over 20 000 ft. At a flight level of 150 the aircraft was most probably "skimming" over the overcast or, flying in and out of protruding cloud tops.

The weather analysis prepared by the Aeronautical Forecasting Office at Mehrabad indicated moderate to severe icing conditions in the area where EP-ABA was now operating. The very character of its operation offered ideal conditions for carburettor icing.

The manufacturer of the engines installed on the aircraft gives the following instruction in its Operator's Manual:-

> "On damp days, especially cloudy, foggy, or hazy days, regardless of temperature, keep a sharp lookout for loss of power and manifold pressure. If ice begins to accumulate, it may be melted out by turning air heat on full."

There hardly exists reason to believe that the pilot was aware of prevailing icing conditions at first. Only after these conditions manifested themselves by a drop in engine power might he have taken steps to melt the ice out. By the time he had applied carburettor heat, he had probably lost some altitude which implies that he had descended into cloud. From this moment on, icing conditions became considerably worse, rendering quick melting of carburettor ice problematic. Under conditions of reduced engine power, turbulent air and instrument meteorological conditions, the pilot may have been unable to climb back into the clear sky on top of the overcast. Apart from this, the chance of flying into one of the cumulonimbus clouds surrounding him, had greatly increased. The pilot must soon have become aware of the seriousness of the situation. Having no reason to assume that his groundspeed had considerably reduced since passing abeam Esfahan, he might have supposed that a gradual descent had brought him completely clear of the high mountain range which he had to pass before entering the large plain located north of the high range. However, his considerably reduced groundspeed was the cause of this breaking cloud over the plateau of Zafarkand, only a few miles distant from the last high mountain peaks that were to be surmounted. After breaking cloud, extremely poor visibility was prevalent, due to heavy downpour and cloud patches. Immediately in front of the descending aircraft a steep mountain wall blocked its passage. The pilot, flying on a northerly heading, made a sharp turn to port to avoid this mountain, soon to be confronted again with another mountain range, running in a North-South direction. The pilot's only chance was to endeavour to force his way over this new obstruction and in doing so he attempted to pass through the narrow gorge, its centre line running in a direction of 248°M. When turning left into this gorge the undersurface of the port outer mainplane and probably the port propeller hit the isolated rock formation aforementioned. Unfortunately due to interference with the wreckage before investigation had commenced, it was not possible to determine precisely at what stage the port aileron and propeller blade tip were shed. But if perchance the aircraft remained controllable after this impact, the pilot might have banked his aircraft more sharply to the left and also tried to make a steep pull-up in order to pass over the crest of the gorge a few hundred feet ahead. Furthermore, a strong downdraft coming over the crest could have contributed greatly to a stalled position. In such a position the port wing tip area of the aircraft next hit the rocky surface of the gorge followed immediately by the final impact of the front fuselage on the steep rocky slope, and the aircraft came to rest only 45 ft from where the port wing tip hit the ground.

Discussion of the evidence

It being recognized that the cause and events leading up to the accident could chiefly only be resolved on hypothetical lines, considerable study was made of the several aspects pertaining to the following:

1) reconstruction of the flight up to the accident;

2) icing conditions and preventive processes, especially as affecting this particular type of aircraft;

3) the weather conditions that could only be assumed to have prevailed on the basis of the weather analysis prepared by the aeronautical forecasting office together with the pilot's report.

A major with the Iranian Air Force was able to contribute considerable useful information as he had made several simulated flights over the scene of the crash in a Harvard aircraft and was, therefore, able to confirm that:

1) the climb required would be too steep to get through the gorge and over the crest under the existing conditions;

2) tremendous down draughts were encountered from the venturi formation of the mountain terrain at the crest of the gorge;

3) the chipped pinnacle of isolated rock formation as mentioned previously was easily identified, and his observations were compatible with the accident pattern submitted;

4) it was determined from discussion of the available information that the EP-ABA flight route conditions were undoubtedly conducive to icing. If a pilot on this type of aircraft does not take timely application of the carburettor hot air anti-icing system as a precaution against such effects, then it is unlikely that this particular system would be efficient later for purposes of de-icing;

5) the Air Taxi Company representatives informed the Board that they had already taken expedient measures to safeguard themselves against the aforementioned in the following manner:

   a) company pilots have been fully briefed on the implication of carburettor icing and the preventive measures to be taken;

   b) carburettor air intake temperature gauges are being installed in this type aircraft;

   c) pilots have been issued strict instructions to only operate under visual meteorological conditions.

6) in studying the reports on weather conditions it became apparent that the meteorological department was not fully aware of the actual conditions over the route area at the time the aircraft departed from Shiraz; under these circumstances it was thought that even if the pilot had received a forecast which denoted VFR conditions it would not have influenced him against making this particular flight.

Probable Cause

The pilot was unexpectedly confronted with severe carburettor icing conditions. A loss of engine power resulting from this impelled him to descend through the cloud layer when possibly the icing conditions became considerably worse, thus rendering a quick melting of the carburettor ice problematic.

His already serious situation was intensified due to breaking cloud over mountainous terrain under conditions of bad visibility.

In an effort to avoid the mountain barriers confronting him, he endeavoured to fly through a narrow gorge and a visible gap at the top. Due, however, to a still greatly diminished power from the persistent effects of carburettor icing, together with the most imposing turbulence and down draught effects that he would undoubtedly encounter in the crest area, his attempt failed. Unfortunately, the protruding rock formation which he first hit presented a further great obstruction at the most critical point of his passage.

Recommendations

The attention of the manufacturer and also Iranian owners of this type of aircraft should be directed to the real icing hazards as depicted by this accident. Recommendations should at the same time be made to install some early warning device such as by the introduction of carburettor air-intake temperature gauges.

Operators should be further advised to always ensure that the co-pilot's seat is adjusted fully rearwards when it is occupied by a passenger in order to ensure that the pilot has unrestricted access to the carburettor heater controls in the area of the co-pilot's instrument panel.

Instructions should be issued to all authorities and persons that are most likely to be concerned when an aircraft accident occurs, so that no interference with the aircraft or disturbance of any wreckage is permitted until the investigation has been taken over by the Airworthiness Department of the Directorate General of Civil Aviation and clearance has been granted from the Chief of Airworthiness.

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ICAO Ref: AR/671

No. 12

LACSA, DC-3,TI-1006-C, accident at Monte Arenal, Costa Rica, 12 May 1961. Report dated 6 September 1961 released by the Directorate General of Aviation, Costa Rica.

Circumstances

Departure from La Sabana Airport, San José was at 1205 hours GMT on the route San José - Upala - San José. The last radio contact with the aircraft was made at 1220 hours, and no further reports of its position were received. The accident occurred at approximately 1225 hours GMT.

The aircraft's wreckage was found at 1620 hours the same day at Cerro del Arenal. The two crew, the sole occupants of the aircraft, died prior to the outbreak of the intense fire which followed the accident.

Investigation and Evidence

The Aircraft

At the time of the accident the aircraft had a certificate of airworthiness valid until 6 October 1961. The aircraft had logged a total of 30 385:51 hours. In August 1960 a No. 5 service was performed on the aircraft at which time the altimeter settings were tested, and the instrument panel unit was overhauled. At the same time the compass was compensated and the deviation card installed. The radio compasses were frequently checked by the airline's radio technicians.

The times shown for the engines and propellers since the last overhaul were as follows:

	starboard	port
Engines	793:32 hours	18:20 hours
Propellers	1 994:31 hours	1 120:54 hours

The weight of the aircraft at take-off was 20 768 lb, well within the maximum permissible limit, and was estimated at 20 024 lb at the time of the accident.

The Crew Members

Two crew were aboard the aircraft on the subject flight.

The pilot held an airline pilot's licence and had flown a total of 12 950 hours with this airline. His last medical examination was in April 1961.

The first officer had a commercial pilot's licence and had also obtained a flight instructor's licence on 20 April 1960. His last medical examination was in February 1961. His total flying experience amounted to 2 300 hours.

The Subject Flight

The flight to Upala was being made on a visual flight rules flight plan, and the estimated time of arrival there was 1240 hours.

The aircraft was airborne at 1206 hours. Several communications concerning the cargo to be picked up in Upala, were exchanged with the aircraft on the airline frequency. The last such message was at 1220 hours. This was the last radio contact with the flight.

As the aircraft had not arrived at Upala by 1243 hours (i.e. 3 minutes after its estimated time of arrival there) the airline attempted to obtain information concerning its whereabouts, and the weather conditions, from Upala and Los Chiles. Inquiries were also made at Canas and Liberia, two stations on the other side of the mountains. All five stations continued to call the flight without results. As no word was received by 1330 hours, an emergency was declared.

The wreckage of the aircraft was located at Monte del Arenal at 1620 hours on the same day. As the flight time between San José and Monte del Arenal is approximately 19 minutes, and the aircraft took off at 1206 hours, it was assumed that the accident occurred at 1225 hours. This was confirmed by a wristwatch belonging to one of the crew members.

At the accident site

Several expeditions were made to Cerro del Arenal. Some were unsuccessful because of the difficulties presented by the terrain and the steep slope. However, the site of the accident was finally reached. A fairly large number of people had previously been at the site, and the investigating commission noted that many parts had been removed or damaged, and pieces of the wreckage had been taken away as souvenirs.

The main part of the wreckage was found in an area of about 60 m radius, while the right wing with the engine and landing wheel were about 40 m away in a cleft formed by vegetation and volcanic stone formations. From this information and the position of the other parts it was assumed that the right wing made the first impact with the ground and continued its path along the ground turned slightly upwards at about 30°.

The stabilizer and right elevator were torn from their mountings, and it was, therefore, impossible to determine the position of the tabs on that side. Because of the total destruction of the controls along the fuselage, it could not be determined whether any cable in the main components had broken before the accident. The ailerons of both wings were destroyed by impact and fire. The rudder's position corresponded to the prevailing wind at Cerro del Arenal. Examination of the wings showed that the flaps were 'up'. The landing gear was retracted. There was no apparent separation of components which could have caused an uncontrollable flight situation. The instrument panel was located but was so damaged that no reading was possible, except that the aircraft's clock had stopped at 1757, and the cylinder heat temperature indicator showed zero in both engines. All other instruments had been destroyed.

From the evidence available, it was believed that at the moment of the accident the engines were developing power. The oil filters in the engines were found to be completely clean and contained no metal particles, so that the possibility of mechanical failure in the engines can be excluded.

As the last radio contact with the aircraft was at 1220 hours, i.e. 5 minutes before the accident, this shows that the radio was in good condition, and the conversations exchanged indicated no abnormalities in the operation of the aircraft.

The Weather Situation

Information from various sources, including other airlines and pilots that had flown the same route the day of the accident, showed the following conditions:

San José:	ceiling and visibility unlimited
Upala:	ceiling 1 500 ft, visibility 10 - 12 miles, wind calm, ground wet
Los Chiles:	ceiling and visibility unlimited
Route between san José and Upala:	in the areas near Cerro del Arenal stratus clouds between 3 000 and 7 000 ft. The prevailing winds were from the northeast with fair intensity.

Probable Causes

The aircraft was a little off course at the time of the accident, possibly because of the strong northeast winds in the area. A slightly premature descent had been made apparently without the crew noticing the hill, because of a stratus formation.

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ICAO Ref: AR/704

No. 13

Aigle Azur Extrême-Orient, Boeing SA-307-BI, F-BHHR, accident 900 m from the intersection of the two runways, Tan-Son-Nhut Airport, Saigon, Viet-Nam, on 22 May 1961. Report released by the Director of Civil Aviation, Viet-Nam.

Circumstances

F-BHHR departed Tan-Son-Nhut Airport at 0340 hours GMT for Vientiane (Laos) on an IFR flight plan. Four crew and 24 passengers were aboard. At 0410 hours the pilot advised that he was returning to Saigon with No. 4 engine out. The airfield was sighted at 0436 hours, and descent was commenced in visual meteorological conditions. Six minutes later the last turn was made, and the aircraft was aligned on radio beacon SG, runway 25 - long final. Sight of the field was lost and on contacting the tower the flight was advised that the aerodrome was QBI (IFR flight compulsory) ceiling 200 m, visibility 500 to 1 000 m, wind 270°, 16 kt.

On short final the weather conditions deteriorated, and visibility dropped to 50 to 80 m. The pilot decided to go around and reapplied power on three engines, at an airspeed of 118 kt, and the landing gear and flaps were retracted. The aircraft then entered a violent squall, running into heavy rain and turbulence. It was blown to the right, dipped, touched the ground and crashed on the airfield at 0448 GMT. No one was injured, but the aircraft was 90% damaged.

Investigation and Evidence

The Aircraft

The aircraft had valid certificates of registry and airworthiness. Its last maintenance check was made on 5 April 1961 by the Bureau Véritas.

The maximum gross weights permitted by the certificate of airworthiness for this flight were 24 495 kg for take-off and 23 154 kg for landing. The trim sheet presented by the Aigle Azur Company mentions a total weight of 22 640 kg.

Following the accident, the Board recalculated the gross weight of the aircraft at take-off and at the time of the accident. The results were 23 386 kg and 22 466 kg respectively. The latter was close to the maximum authorized landing weight.

The Crew

The pilot-in-command, out of a total of 20 251 hours flying, had flown 19 594 as pilot-in-command and 2 274 at night: his experience on this type of aircraft amounted to 3 000 hours.

The flight engineer had approximately 8 000 hours on Boeing 307's out of a total of about 15 000 hours.

Weather Situation

At the pilot's request, the Saigon tower passed on the following weather information to F-BHHR at 0443:

visibility 500 to 1 000 m; 3/8 stratus at 200 m; wind 270°/16 kt.

Two minutes later the flight advised that it was going around having missed the runway. The accident occurred at 0448.

The details of the deteriorating conditions released by the MET service were as follows:

0455 - cloud 4/8 Fs/60m, 6/8 Cb/300 m, 6/8 As/3 300 m visibility - 100 m; wind 280°, 15 kt; maximum gust speed - 20 kt; thundershowers
(after the accident)

On the day of the accident the squall came onto the aerodrome very quickly, at the time when the aircraft was on long final.

An eyewitness affirmed that the rain, which started coming down shortly before the accident, penetrated inside the trailer where he was; in view of the orientation of the trailer, this seemed to indicate that the wind was whirling at that point.

Furthermore, the engineer aboard the aircraft stated that the airspeed indicator suddenly fell from 118 to 85 when the aircraft entered the squall. It was, therefore, submitted to strong turbulence that forced it into the ground before the pilot had time to react.

During the monsoon season from May to October violent thunder squalls with strong gusts of west wind are very frequent over Saigon/Tan-Son-Nhut, and winds may reach a force of 35 kt.

Reconstruction of the flight

Twenty minutes after taking-off from Saigon the aircraft's No. 4 engine started vibrating as the flight was passing through cumulonimbus cloud at 7 900 ft. The propeller was feathered, and the aircraft climbed to flight level 85 on three engines. No. 4 engine was restarted but vibrated again, so it was stopped, and its propeller was again feathered. Tan-Son-Nhut was then advised that the flight was returning with No. 4 engine out. The stewardess reported that smoke was coming from the hold. The engineer took the necessary action.

At 0436 the aircraft was over the station at 4 500 ft in 50% visual meteorological conditions, and was cleared to descend to 2 500 ft and instructed to call over SG. The radio operator advised that the radio compass was not operating correctly and requested landing instructions. The tower gave him the following information: "surface wind 260°/16 kt, runway 25, QNH 29.77". It also told the flight (at 0440) that it was then "QBI at the aerodrome."

Two minutes later, at 1 500 ft with rear wind, the aircraft made its procedure turn in sight of the ground, (the radio operator seeing the field during the turn), and lined up on radio beacon SG on a heading of 248°, flaps out to 24°, indicated airspeed 125 kt. The aircraft was on long final, and the crew had lost sight of the runway.

Shortly thereafter the visibility decreased, and the pilot decided to re-apply power. It was re-applied on three engines at an indicated airspeed of 118 kt, at an altitude of about 300 ft and a distance of 1 370 m from the threshold of runway 25, when the aircraft was over beacon SG, the radio compass needle moving to heading 180°. The engineer retracted the landing gear and flaps at the same time. All three engines responded normally and developed full power.

One to two seconds later, the aircraft entered a violent squall, within which it encountered whirling downdrafts, first full crosswind then full rearwind, accompanied by violent rain that reduced visibility to nil.

It was blown to the right and dropped, the indicated airspeed falling to 85 kt. The stewardess advised the crew that smoke was again entering the cabin.

The aircraft touched the ground at 0445 and the pilot closed the throttles, the engineer cut the ignition, and the aircraft crashlanded. Its position on the ground was normal, approximately in the line of flight. The feathered propeller of No. 4 engine broke off a wooden marking post 2 m from the ground. The lower part of the fuselage touched the ground, and the propellers of No. 3 and 4 engines dragged along the ground. No. 4 propeller and engine hit a gravel heap 1m20 in height, and the whole unit fell off. After that impact the aircraft inclined onto the left wing, and the aileron was torn off and thrown rearwards. The aircraft came to a halt as it reached a heap of stones 1m60 in height, which was rammed by the lower part of the fuselage, from the right wing to the level of No. 4 engine, and by No. 3 engine.

Technical examinations

It was ascertained by dismantling No. 4 engine, which had been stopped at 0405 hours, that the rods of Nos. 5, 6 and 7 lower cylinders were broken. The damage was apparently caused by breakage of the rod on cylinder No. 6 following *failure of the piston gudgeon-pin.*

There was no sign of jamming or lack of oil.

It was possible to determine the origin of smoke that issued into the cabin shortly after the pilot had advised he was returning to Saigon. The electric motor controlling the hydraulic pump (both being mounted in the hydraulic hold) heated abnormally causing the interior varnishing, the solder of the wires to the collector, the wires and varnishes of the rotor, etc. to melt. The overheating was due to breakage of one of the screws fixing the brush-holder plate. This screw moved into a slightly sideways position, thus causing bonding by electric arc.

As the electric motor and auxiliary pump are not vital elements for the aircraft's flight, the failure of that electric motor may be eliminated as a direct cause of the accident.

Special technical tests conducted one week after the accident by the Bureau Véritas (Saigon Branch), in the presence of the Board of Inquiry, also included the checking on the ground and in flight of landing gear retraction time for another aircraft of the same type and checking of the conditions for regaining altitude following re-application of power on three engines. The objective of this last-mentioned test was to discover whether the performance of the aeroplane was notably affected by retracting the flaps and landing gear at the moment when power is re-applied (possibility of loss of altitude).

Conditions for the in-flight tests were kept as similar as possible to those prevailing at the time of the accident: same load, same trim; only the altitude at which the tests were conducted was different (3 500 ft).

The tests showed that full retraction of the landing gear, had it been possible, would have occurred in a time between 31 and 38 seconds.

On the basis of the position of the landing gear at the time of the accident, and taking into account a maximum duration of 5 seconds between the time when the pilot ordered re-application of power and retraction of landing gear, and the start of that manoeuvre, it may be assumed that the pilot's order was given about 24 seconds ± 2 seconds before contact with the ground.

Thence it may be deduced that the order to re-apply power was given at an altitude of 250 to 300 ft, above radio beacon SG. This was confirmed by the testimony of the engineer, who saw the road that passes near that beacon and the testimony of the pilot, who observed the turn-around of his radio compass needle at that time. It was contradicted by the report of the pilot asserting he read the altimeter at about 450 ft.

In his report the pilot mentioned "the hasty action on the part of the engineer in automatically retracting the flaps at the same time as the landing gear when power was re-applied", an action that apparently increased the rate of descent.

On the other hand, the airline's operations manual stipulates that in case of climb-out on three engines, the flaps and landing gear must be retracted as soon as possible.

The in-flight tests showed that the influence of flap retraction on possible loss of altitude was not great, a difference of 30 ft. It may, therefore, be assumed that the flap retraction was not a determining cause of the accident.

Probable Causes

The direct cause seems to derive mainly from the sudden worsening of the atmospheric conditions. The violence of the storm was definitely localized in the approach of the squall and in the squall. Whirling winds, three quarters front and then full cross, were the cause of the displacement of the aircraft to the right in spite of the efforts of the pilot, who felt that No. 3 engine was not yielding its full power. The subsequent downdrafts and rain forced the aircraft down, caused it to lose altitude and brought it to the ground.

The re-application of power, effected at an altitude of approximately 250 to 300 ft, and 25 to 30 seconds from the beginning of the runway, occurred late.

In identical weather conditions, if the pilot had re-applied power as soon as he received the QBI and QAM (latest MET observation) he had requested from the tower, the aircraft would have been at an altitude of approximately 560 to 600 ft and one minute and twenty seconds from the runway, at a distance of 4 km. It would have met the squall in higher altitude and speed conditions that would have avoided the aircraft's being brought to the ground.

The following factors had an aggravating effect although they were not direct causes of the accident:

- QBI was first announced by the tower while the aircraft was at 1 500 ft in a rear wind. The pilot and the radio operator stated that they did not hear it at that time. However, a playback of the recorded tape definitely included the voice of the radio operator answering: "Aerodrome is QBI; all right". Had the pilot known of the QBI condition at that time, he would probably have requested a QAM and would have been in a better position to make a prompt decision to re-apply power.

- The second report of appearance of smoke, the origin of which could not be detected on board, distracted the attention of the crew from the controls for a fraction of a second, causing them to apprehend danger from the holds.

- The load was 660 kg heavier than that submitted by the company. The airline should have re-weighed the baggage instead of relying on the weights shown on the packages and on the manifest drawn up and filed.

Recommendations

It was recommended:

a) that carriers, and in particular non-scheduled carriers, check weights and trim on departure, and not rely on the statements of users; that a warning be issued to the company to that effect;

b) that the Tan-Son-Nhut control tower be enabled to advise pilots of possible worsening of the weather before it occurs, by direct observation from the tower. A meteorological rating for controllers is very useful in such cases, particularly in the rainy season.

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ICAO Ref: AR/684

No. 14

Trans Australia Airlines, DC-4, VH-TAA, accident on Bulwer Island, 2.5 miles NE of Brisbane Airport, Australia on 24 May 1961. Report released in Aviation Safety Digest No. 29 (March 1962) of Department of Civil Aviation, Australia.

Circumstances

Flight 1902 departed Sydney for Brisbane at 0229 hours eastern standard time on the final stage of a regular freight service from Melbourne to Brisbane. At 0425 hours when it reported 30 miles south of Brisbane Airport, it was given landing information by Brisbane Tower. Nine minutes later the captain reported that the field was in sight, and the aircraft was observed by the airport controller. At 0441 hours when the aircraft had not landed, it was found that communication with it had been lost.

The aircraft's wreckage was found 2 hours 15 minutes later on Bulwer Island. It had crashed in a tidal mangrove-covered mud flat, killing the two crew members. The aircraft was destroyed.

Investigation and Evidence

The Aircraft

It had flown a total of 46 006 hours and during the last two and a half years had been used almost exclusively for the carriage of freight between major airports in Australia. Since the last complete overhaul, the aircraft had flown 4 576 hours.

No unserviceabilities of the aircraft were reported by the crew at Sydney nor were any known to have developed during the flight. Maintenance inspections had been carried out as required.

Its Loading

The aircraft's cargo consisted of 11 151 lb of mixed freight and 1 158 lb of mail. According to a load distribution sheet compiled at Sydney, the aircraft's centre of gravity was within limits.

At the time of the accident it was estimated that the all-up-weight of the aircraft was 58 771 lb, i.e. 4 729 lb less than the maximum permissible landing weight for Brisbane.

The Crew Members

The Captain

The captain had flown a total of 13 019 hours including 11 367 hours in command. Of the latter, 378 hours were flown when in command of DC-4 aircraft. His last proficiency check on DC-4 aircraft was satisfactorily completed in March 1961. He held a current first class airline transport pilot's licence and a first class instrument rating.

Medical Aspects

With one exception it may be said that the medical history of the captain contained no evidence which might be significant in the consideration of this accident. It was found, however, in the post-mortem examination that his death was due to a cardiac failure arising from a condition of myocarditis or inflammation of the heart muscle. The injuries sustained by the captain in the impact were not such that immediate death would be expected from these injuries alone.

No obvious cause for the myocarditis was found in this instance, but it was of relatively recent onset and would have been virtually impossible to detect during life.

The cardiac failure arising from this condition may have occurred before or after impact, and the premonitory symptoms of the attack may range from none at all to a vague feeling of discomfort for any period up to 30 minutes before the attack followed by breathlessness or coughing for a short period of minutes prior to the cardiac failure. In the circumstances of this accident it is perhaps most significant that the attack can occur at any time without warning and can involve an almost immediate loss of consciousness. It is also significant that, if there was any period of time between the onset of the attack and the loss of consciousness, one of the measures adopted for relief might be the undoing of the safety belt or the pushing back of the seat or both these actions as well as an attempt to stand up.

There was some evidence that only two months prior to this accident the captain was observed to become distressed by minor exertion. The medical evidence is insufficient to establish whether this was symptomatic of the condition which ultimately caused his death. The last electrocardiogram examination undertaken by the captain was in September 1960, and it was quite normal, but the condition of myocarditis cannot be detected in this form of examination. The captain is not known to have suffered any ailment likely to have generated or accelerated the condition. There is no evidence that the captain's performance was affected by fatigue, and the medical opinion is that fatigue cannot be associated with the captain's heart condition or with the time at which the heart failure occurred.

Although the medical evidence was insufficient to establish conclusively whether the captain died before or after the impact it was the opinion of medical specialists that the relatively minor degree of haemorrhage was very slightly suggestive of cardiac failure before the impact. The medical evidence left no doubt, however, that the captain suffered a cardiac failure, and it pointed strongly to the conclusion that this was the cause of his death.

The First Officer

The first officer had 3 132 hours of flying experience including 821 hours of command experience on DC-3 and Convair 440 aircraft as well as 406 hours as first officer on DC-4 type aircraft. In August 1960 he was issued a second class airline transport pilot's licence endorsed for DC-4's. This licence was current at the time of the accident as was his second class instrument rating. His last flight proficiency check on DC-4 aircraft was satisfactorily completed in January 1961.

Medical Aspects

There was no evidence in the medical history or in the post-mortem examination of the first officer to suggest that he was, or was likely to have been, incapacitated by any pathological condition or that his physical and mental responses were affected by any circumstance occurring during this flight. His death was due to an injury sustained in the impact.

Weather Conditions

The flight segment Melbourne-Sydney was flown in fine, clear conditions. Before leaving Sydney for Brisbane the captain obtained a meteorological briefing at the Avmet Office.

The forecast indicated that en route conditions would be fine with no cloud or turbulence at the planned cruising flight level 90. In the Brisbane terminal area smoke haze was expected with a visibility of 8 miles and a ground wind of 6 kt from the southwest. Only a slight trace of cloud at 5 000 ft was forecast. The actual conditions encountered at Brisbane were not significantly different.

Brisbane Airport

It is situated 4 miles northeast of the city of Brisbane on a flat plain 2 miles from the coast, and its southern boundary is skirted by the Brisbane River, within which Bulwer Island is located.

The airport is 7 ft amsl, and its density altitude at the time of the accident was minus 360 ft.

Both runways at Brisbane are equipped with low intensity, omni-directional lighting. The radio navigation aids available consist of a visual-aural range transmitting on a frequency of 110.9 Mc/s, distance measuring equipment on a frequency of 206/224 Mc/s, an approach localizer serving runway 22 transmitting on a frequency of 109.9 Mc/s and a non-directional beacon transmitting on 216 kc/s. All of these radio navigation aids are located on the airport and were functioning correctly at the time of the accident.

Reconstruction of the flight

The flight plan for the Sydney-Brisbane portion of the trip indicated the aircraft would take 129 minutes to reach its destination via West Maitland, Point Lookout and Casino. The aircraft carried enough fuel to reach Brisbane plus sufficient for a further 3-1/2 hours cruising flight or 4-1/2 hours of holding.

Following take-off from Sydney at 0227 hours, the flight proceeded along the prescribed track reaching Casino at 0406 hours at which time it estimated its arrival at Brisbane at 0435 hours. A clearance was then issued by Brisbane area control for the descent from cruising level. Landing was to be on runway 22. The wind was 5 kt from the south, and the altimeter setting (QNH) was 1023 mb. At 0434 when the aircraft was sighted, apparently in the normal position, it was cleared for a visual approach and was to report again when on base leg. The clearance was acknowledged. When nothing more was heard from the aircraft, and the airport controller could not see its navigation lights in the circuit area or on the ground, it was called at 0441 on 118.1 Mc/s. There was no response, so the distress phase of search and rescue procedures was instituted at 0443 hours.

The accident occurred 1.65 miles, on a bearing of 081° magnetic, from the threshold of runway 22 at Brisbane Airport.

Evidence of witnesses - Discussion

Evidence was obtained from seventeen witnesses who saw the aircraft during the last six miles of its flight. Twenty-eight other persons heard the aircraft in the Brisbane area shortly before the accident. They also gave evidence. A series of simulation flights were conducted in Brisbane in order to test the reliability of the observations made by significant witnesses and to crystallize the conclusions which might be drawn from this evidence.

The track followed by the aircraft in the vicinity of Brisbane Airport involved no significant departure from the track normally followed by aircraft arriving from the south and carrying out a visual left-hand circuit for a landing on runway 22. Although it entered the circuit area and turned on to the downwind leg at the normal height of 1 000 - 1 200 ft, the impact occurred only three miles beyond this point. During the last 1-1/2 miles of its flight eyewitnesses noticed it because it was abnormally low and continued a high-rate descent with little or no engine noise apparent. Although the precise point at which the descent below normal circuit height commenced was not established from the witness evidence, the range was narrowed to a small segment of flight path 1-1/4 miles in length. Special test descents at idling engine power were conducted in a DC-4 aircraft similarly loaded, and the results of these tests pointed to the probability that the descent of VH-TAA commenced 1.8 miles short of the impact point assuming this was the power condition which pertained. All possible commencing points within the established range succeed the point at which the last transmission was made from the aircraft.

It was deduced from witness evidence that the impact probably occurred between 0436 and 0437 hours. This implies that the aircraft was four miles south of the airport and five miles from the impact point when the "field-in-sight" report was given to the airport controller. It was determined beyond reasonable doubt that this transmission, which seems to have been quite normal in every respect, was made by the captain as were all the previous transmissions from the aircraft during the flight from Sydney. Having regard to the normal division of cockpit duties on this flight, it is most probable, therefore, that the aircraft was being flown by the first officer during the approach to Brisbane Airport.

The descent path was quite similar to the expected power-off glide path for this type of aircraft, but it apparently remained under adequate aerodynamic control right up to the point of impact. In the final stages of flight there was some evidence that the aircraft was banked to port and turned left some 40° from the downwind heading. There are several possible explanations of this circumstance, but it occurred at such a low height that it can only be regarded as incidental to the accident.

Wreckage Examination

Attempts to operate vehicles to the accident for the removal of components were unsuccessful because of the nature of the surface. The early activity was, therefore, concentrated on accurately establishing the configuration of the wreckage and raising the movable components above the level of the peak tides which were expected to cover the area three days after the accident. All of the components required for testing or for workshop examination were ultimately extricated by manhandling or, in the case of heavier items, by winching the components on specially constructed sleds across mud areas cleared of mangrove vegetation. Although the extremely difficult condition of soft mud and dense mangroves at the accident site was accentuated by tidal action and by heavy rain, the early precautionary action taken was successful in that the engineering conclusions were unhampered by salt water corrosion, by weathering or by an unpremeditated disturbance of the wreckage.

The functional state of the aircraft immediately prior to the impact was established with a reasonable degree of certainty. The undercarriage and wing flaps were in their fully retracted positions whilst the landing lights were extended but not switched on. All four propellers were rotating, but none of the engines were delivering power. The heading of the aircraft at the time of impact was 358° magnetic, and the forward speed was probably between 115 and 125 kt. The aircraft was banked some 10° to port, and the flight path angle was approximately 7° below the horizontal. This evidence carries no suggestion that there was a complete loss of control in the aerodynamic sense prior to this accident.

All major components were located in the area of the principal impact, and there was no evidence of any structural failure, fire, explosion or of any other event which would have affected the integrity of the aircraft in flight. There was no evidence to suggest that any of the flight control systems were not functioning correctly or that any of the hydraulic, electric, radio or other systems required for safe flight were not capable of normal operation. The most significant feature in this area, perhaps, was the evidence that all electrical and radio systems had been disconnected from the aircraft's electrical power sources prior to the impact by movement of the emergency disconnect switch, which is located in the cockpit overhead panel.

A careful examination of the engines and propellers together with their associated control systems and the ignition, fuel and lubrication services failed to reveal any circumstances which might have prevented the crew from utilizing up to full power on all four engines. Uncontaminated fuel of the correct grade was found in the fuel lines leading to the fuel feed valve where fuel enters the induction section of the engine, and it is apparent that, with the propellers windmilling, some fuel must have been circulating through all four engines. It was concluded, however, that all four of the engine ignition switches were probably in the "off" position at the time of impact.

As the aircraft's flight deck was severely damaged in the impact, practically no significant information was obtained from the cockpit dial indicators and only corroborated evidence can be accepted in respect of the positions of most cockpit controls. Both crew seats were severely damaged and had separated from the floor. The first officer was found strapped into the right-hand seat, which had been adjusted prior to the accident to the lowest available position and fully forward. The captain was found about 5 ft from his seat, the belt of which was unfastened. The chair had been adjusted prior to impact to the second lowest position and although the fore-and-aft adjustment could not be reliably determined, it is probable that it was positioned against the aft stop at impact.

Analysis

In considering the cause of the accident three conclusions arose from the evidence on which to focus:

a) Although the aircraft was fully airworthy and, in the engineering sense, capable of being operated normally, it struck the ground with no engine power being delivered and with some crash/fire precautions having been taken.

b) The aircraft was operating normally until it reached the mid-position of the downwind leg where a rapid power-off descent was commenced and continued without loss of aerodynamic control until the accident occurred.

c) The captain's safety belt was not fastened at the time of the impact, and he had suffered a cardiac failure.

Although the engineering conclusion does not completely explain the accident, it does contain two significant points. It is clear that no power was being delivered by any engine at the time of impact although there was no reason why full power on all four engines could not have been utilized by the crew right up to this point. This fact supports the witness evidence of a descent without any audible engine noise. It was also clear that the aircraft was prepared for the impact at least to the extent that all electrical power and ignition were switched off. This dispels any view that neither crew member was aware of the seriousness of the situation. It also shows that although there was no means, in the time available, to overcome the emergency, at least one member of the crew was still capable of rational action. The proposition that the aircraft remained under control in the aerodynamic sense during this descent is also consistent with this view.

Various hypotheses were examined to try and provide an operational reason why an aircraft would suddenly enter a rapid but apparently controlled descent on the downwind leg of a visual circuit and strike the ground without there being any evidence of recovery action. There was no support for the proposition that this was a landing approach on to an illusory runway since there were no lights in the immediate area of the impact, and the undercarriage and flaps were not extended. It is also highly improbable that any reference to inadequate visual cues or any misreading or malfunction of the altimeter deceived the crew as to the real height of the aircraft since it passed over a large and brightly illuminated oil storage depot at a height of some 300 ft only 3/4 mile before impact. A simulation of the flight path in similar circumstances showed clearly that this was a dominant and unambiguous point of reference. The evidence of preparations in the cockpit for the impact supports the view that the crew were well aware of the dangerously low height which had been reached.

A wide range of emergency situations which might have induced loss of control, errors of judgement or serious distractions sufficient to cause this accident was examined and, in each hypothetical situation, it was found that the proposition either ran contrary to the evidence or was unsupported in any way. It is difficult to envisage any emergency situation arising at this point in the preparation for landing which would induce the crew to avoid using engine power, either in the recovery action itself, or, in the last resort, to avoid an accident, unless that emergency itself involved the complete loss of power on all four engines.

The medical conclusion alone also afforded no ready explanation of this accident. Accepting the probability that the captain's death occurred suddenly in flight, the presence of a competent and experienced first officer should have been an adequate safeguard against an accident of this nature. There is no suggestion that the first officer was also incapacitated, but there is little doubt that a sudden collapse by the captain would have induced a major distraction of his attention for some period. The evidence that aerodynamic control of the aircraft was retained and that it was prepared for the impact indicates that this distraction did not persist for sufficiently long to cause the accident.

In the light of all the evidence it is entirely reasonable to believe that this accident was associated with events arising from the heart attack suffered by the captain. His seal belt was unfastened and a premonitory symptom of the attack might be a desire to stand up for some relief. This led to a consideration of the ways in which collapse of the captain could deprive the first officer of the ability to utilize engine power. After discussion and experiment, a quite feasible mode of collapse which would have just this effect became clear. It envisages the captain moving his seat to the rear, unfastening his seat belt, standing and turning half-right in the normal actions to leave the seat and then collapsing across the engine control console with his body falling so as to bring all throttles to the fully closed position and moving all pitch control levers towards the full fine position. The experiments also confirmed that, with a body in this position, it would be impossible for the first officer to remove the obstruction so as to regain engine power control without leaving his seat and abandoning control of the aircraft for an intolerable period of time. There would also be some forward pressure on the control column from the captain's legs which could be overriden without difficulty by the first officer but, nevertheless, would be sufficient to cause nose down pitching if counteracting pressure was not continuously applied.

The period within which the collapse of the captain must have occurred can be narrowed to the half minute of 1-1/4 miles of flight path between the turn on to the downwind leg and the mid-position of this leg where the abnormal descent commenced. The fact that the captain himself gave the field-in-sight report only 4 miles south of the airport indicates that there was little or no warning of his collapse. This is completely consistent with the range of possibilities described in the medical evidence. The proposition of a collapse in this segment of the flight path also introduces a logical explanation of the undercarriage and flaps being in their retracted positions at impact. The evidence indicates that the emergency situation arose at or prior to the aircraft reaching the mid-downwind position. In the known circumstances of this aircraft's approach to the airport it could not be expected that the undercarriage would be extended until after this position had been passed.

Although the first stage of flap extension is often taken prior to this point, it is by no means unusual for this action to be delayed until a later point in the flight path is reached when there is no excess height or speed to be lost. It is reasonable to assume, therefore, that the emergency arose before the extension of either flaps or undercarriage had been carried out and, in view of the nature of the emergency which is postulated, it could not be expected that the first officer would take these actions subsequently.

The mode of collapse envisaged offers a complete explanation of the otherwise inexplicable evidence, that this descent occurred without engine power being applied at any time. It is compatible with the evidence that, in the engineering sense, this power was available at all times. It explains why no feathering action was taken despite the apparent lack of power, and it clarifies the apparent resignation of the first officer to the inevitability of an accident as is reflected in the actions to switch off the electrical power and engine ignition before the impact. It is compatible with the evidence that the aircraft remained under control throughout the descent and it gives a ready explanation of the fact that no emergency call was made on the radio. If both crew members had been competent to jointly deal with the emergency which arose, the first officer, during the 55 seconds which the descent would occupy, would have had time to give some indication to the airport controller that an emergency existed although it is by no means certain that he would do so. If the first officer was obliged to cope with this emergency alone, however, he could not be expected to make any transmission in the time available.

Another feature of the evidence which puzzled the investigators until this proposition had been developed was the fact that the landing lights were in the extended position at impact and yet even the closest eyewitnesses denied that they were illuminated at any time during the descent. It is most difficult to conceive of any pilot attempting a crashlanding at night on unknown terrain without, at some point in the descent, using the landing lights to gain some appreciation of the terrain or to select the most favourable terrain within the usable area. The landing light extension and illumination switches for this aircraft are situated in the ceiling panel immediately above the captain's position and they cannot be reached by the first officer whilst he is in his seat with the belt fastened. It is feasible that the captain had extended the lights earlier in the approach when he was capable of doing so in order that they would be ready for immediate use when required for the normal landing. The fact that they were not subsequently used despite a pressing need can only be attributed to the fact that the captain was then incapable of actuating the switches, and the first officer was unable to take the steps necessary to reach them.

Several other possible ways in which the operation of the aircraft might have been affected by the captain under the influence of a disordered cardiac function were also examined. It was concluded that the evidence did not admit any possibility that a physical collapse by the captain could have affected any other engine controls such as the mixture levers or the fuel tank selector levers so as to produce the known circumstances of the final flight path. It was shown by experiment to be extremely unlikely that any mode of collapse in or from a seated position, even with the safety belt unfastened, would affect control of the aircraft or of the engine power in a manner consistent with the evidence in this accident. The investigators also considered the possibility of irrational behaviour of the captain in the premonitory stages of his cardiac failure, being a causal factor in the accident. This hypothesis was not supported by any evidence, and it is difficult to believe that any irrational act affecting the operation of the engines could go unnoticed or could remain long undetected by the first officer. There was no evidence of any conflict between the captain and the first officer in the control of the aircraft, and it is considered that the possibility of irrational behaviour by the captain cannot be supported as a significant factor in this accident.

The opinion formed as to the cause of this accident was only reached after careful examination of a wide range of hypotheses. None of the alternative explanations were acceptable in the light of the firmly established evidence, and none of them were supported so strongly by circumstantial evidence as was the view that the captain's heart failure occurred on the downwind leg of the circuit and that his collapse deprived the first officer of all engine power. This in turn provided a reasonable explanation of some items of evidence which could not be explained in any other way. Some minor variations of the accepted mode of collapse are equally feasible, but they all involve closing of the engine power levers and the forming of a complete obstruction to their further movement. There was no suggestion in the evidence that the captain, whilst in normal health, undertook any action likely to endanger his aircraft, and it is probable that the first officer, without warning, was presented with an emergency situation which was beyond the capacity of one person alone to rectify under the circumstances. The evidence points to the fact that he took action to minimize the dangers of the imminent impact.

Probable Cause

The accident occurred during the pre-landing circuit when the captain tried to leave his seat under the influence of a disordered cardiac function and, in the course of so doing, collapsed across the engine control console in such a way as to bring all four throttle levers to the closed position depriving the first officer of the throttle movement necessary to avoid a crashlanding off the airport.

ICAO Ref: AR/709

No. 15

KLM/VIASA, DC-8, PH-DCL, crashed into the Atlantic Ocean 3 km off the coast of Fonte da Telha, Almada District, Portugal, on 30 May 1961. Report, dated 1 March 1963, released by the Director General of Civil Aviation, Portugal.

Circumstances

Flight VA 897 was a scheduled* flight from Rome to Madrid, Lisbon, Santa Maria (Azores) and Caracas, Venezuela. It landed at Lisbon Airport at 0006 hours where it was inspected by KLM maintenance personnel. Following a crew change, the aircraft left for Santa Maria at 0115 hours. Four minutes later it reported passing over Caparica radio beacon (LS) and climbing through flight level 60 (1 800 m). This message ended with two quickly spoken sentences. There was no further contact with the aircraft which crashed into the sea to the left of the original track at about 0120 hours GMT killing all 14 crew and 47 passengers aboard. The aircraft was destroyed.

The wreckage was located on 31 May in the Bay of Caparica, 7 km south of the beacon, 3 km off the coast and at a depth of 30 m.

Investigation and Evidence

The Aircraft

Certificates of registration and airworthiness were issued for PH-DCL on 1 May 1961. The aircraft had a category A licence. On 2 May 1961 it was issued a maintenance certificate valid until the next periodic inspection after 300 hours of flight time. During the aircraft's life several transit inspections had been carried out after each landing as well as four more extensive inspections. Its total flight time upon arrival in Lisbon on 30 May was 209:30 hours, i.e. less than 300 hours. Therefore, no block inspection had been carried out on the aircraft. It had flown 32 hours since its last type 1 inspection.

An extensive investigation was made of the aircraft's maintenance history. No serious malfunctions had occurred. Although the logs for the flights Rome - Madrid - Lisbon showed no complaints, the statements of the incoming crew indicated that there were minor deficiencies, however, they did not affect the airworthiness of PH-DCL.

At take-off the weight and centre of gravity of the aircraft were within the authorized limits.

The Crew

The crew complement was as follows: 3 pilots, a radio operator, 2 flight engineers, 2 pursers, 3 stewards and 3 stewardesses.

The flight crew had had a two-day rest in Lisbon, and there was no indication that any crew member was fatigued on the day of the accident.

The pilot-in-command, who was acting as check pilot on the subject flight, had been flying with KLM as pilot since 1946. His Netherlands airline transport pilot's licence was last renewed on 26 April 1961, and he was authorized to fly as pilot-in-command on DC-6, Convair 340, Constellation 749 and 1049 and DC-8 aircraft. The DC-8 rating was endorsed on 16 March 1961. He had flown a total of 12 886 hours including 9 040 hours in command. On the DC-8 his experience was as follows:

pilot-in-command	60 hours	These hours had all been flown during the 90 days prior to the accident.
first officer	75:30 hours	
type training	16:50 hours	
DC-8 simulator	37:30 hours	

* KLM (operator) lists this as a charter (non-scheduled) flight. VIASA (Venezuela) lists this as a scheduled flight.

On 27 May he had made one flight from Amsterdam to Lisbon.

The co-pilot had a lengthy career as captain on Constellation aircraft over the Atlantic. His route qualifications in this respect were still valid. He had various licences including an airline transport pilot's licence last renewed in March 1961 and valid until September 1961. His training as a DC-8 captain was satisfactorily completed in April 1961, and he was granted a DC-8 rating. He had made several flights as co-pilot of DC-8 aircraft on the Mid-Atlantic route. In April 1961 he had carried out two application training flights on this route with satisfactory results. On the subject flight he was to have his route application check. His experience on DC-8 aircraft was:

DC-8 simulator	62 -	hours instead of the normal 36 hours He had difficulty with the use of the integrated instrument system.
flight training	16:55 -	hours (during the previous 90 days)

The results of his type rating examination were above standard.

He had a total of 12 913 flying hours to his credit of which 10 578 hours were when in command and 55 hours were as first officer on the DC-8. The week prior to the accident he had flown one trip on the DC-8 from Amsterdam to Lisbon.

All other crew members were fully qualified, had considerable experience and were medically fit.

Meteorological situation

The actual conditions existing at the scene of the accident around 0120 hours are not known. There is no meteorological station at that location. However, the conditions must have been similar to those at Lisbon Airport. The following are considered to be most probable:

> ceiling 600 m; visibility 8 km; wind 270°/18 kt; temperature 13.5°C; dew point 12°C; clouds 4/8 stratocumulus at 600 m 8/8 altostratus; light rain; light to moderate turbulence; no thunderstorms or icing had been observed.

The crew were properly briefed on the conditions before departure. The weather conditions were not believed to have contributed to the accident.

The Flight

As the ground engineers were not present when the aircraft arrived from Madrid the transit inspection was carried out by the second flight engineer under the supervision of the first flight engineer, a licensed ground engineer and some mechanics.

The flight plan, prepared by the flight operations officer, was checked and signed by the captain. The aircraft was to take a magnetic track of 273° after passing the LS beacon at Caparica. An Air Traffic Control instrument flight rules flight plan was also filed for flight level 310 with Lisbon and Lajes as alternates.

At take-off from Lisbon the pilot-in-command was probably in the right-hand seat, and the co-pilot was in the left-hand seat.

Departure from runway 23 was at 0115 hours on course to NDB "LS". The pilot had been asked to report the cloud base and to call over the LS beacon. At 0118:37 the aircraft advised that the cloud base was at 3 700 ft and changed to the Lisbon area control frequency. It reported again at 0119:25 to Lisbon Control that it was "over LS at 19 climbing through FL 60", but the communications were suddenly interrupted, after two quickly spoken sentences; the first one, not definitely established, could have been "eh ... take care of" and the second one was "we are climbing out". Last contact with the flight was at 0119:50 hours.

Witnesses at Caparica stated that they had heard a loud noise, like an explosion, shortly after the aircraft had passed over.

As a result of salvage action during the period 14 June to 6 July, approximately 40 000 kg of wreckage were recovered from the sea. About 75% of the total structural weight of the aircraft and 60% of the aircraft's skin were recovered during 375 dives covering a total diving time of 260 hours.

Configuration of the aircraft at impact

Evidence showed that the aircraft hit the water in a northwesterly direction. Its pitch angle was approximately 25° nose down, and it was probably banking 30° to the right. Indications were that the aircraft was intact and flying at a speed of 450 - 500 kt when it crashed. No small parts had broken off in flight. The rudder, ailerons and elevator were in the neutral position. The aircraft's configuration was normal for a climb to cruising level.

The hydraulic system was functioning normally, and there was electric power on all four buses. At the time of impact the engines were operating far below cruising power. However, engine power might have been reduced some seconds before impact, possibly when the aircraft came out of the clouds.

Reconstruction of flight path based on evidence

Although there was little data available, a flight path consistent with all evidence was calculated connecting a point about 6 000 ft above Caparica with the place of the wreckage. According to this flight path, the aircraft would have started a spiral dive to the left during the last message, banking to the left to 90° within about 20 seconds and ending in the water after another 15 seconds. During the last 15 seconds, the bank was overcorrected to the right, and the steep dive was checked to some extent. This calculated flight path was tested on a DC-8 flight simulator and checked by analogous computations. The flight path was such that during the vital initial phase the deviations could only be noticed by the pilots on the instruments.

Somewhat steeper or somewhat flatter and longer flight paths may have been possible. With a steeper dive there was a chance that the overspeed warning signal had sounded during the radio communications. Tests showed that the overspeed warning can be heard clearly through normal radio communications. It was not heard. Moreover, the course deviation cannot have been sufficient to put the aircraft in a northerly direction at impact. Therefore, a much steeper dive was not possible.

A flatter flight path would have taken more time. It cannot have been too flat as that would have been inconsistent with the statements of witnesses.

Investigation of unintentional flight path deviations

At the beginning of the investigation the Commission's attention was drawn to some cases in which jet aircraft were unintentionally brought into a dive or a spiral dive. The main characteristic of these cases was that the deviation became large within a short time before it was noticed by the crew. In a few cases the pilots were initially misled by a defective artificial horizon. The possibility was considered that the accident to PH-DCL might have been caused by such a flight path deviation.

Discussion of evidence

No parts of the aircraft were found outside the wreckage area.

No pre-crash defects were found. However, the possibility that they existed could not be excluded. Structural failure due to turbulence was excluded because there was only light to moderate turbulence in the vicinity of the accident site. Fatigue failure was considered unlikely. The aircraft was practically new, and no indications of this type of failure were found. It was definitely established that the engines operated properly up until the time of the accident. Although no indications were found of failures or malfunctions, they could not be definitely excluded because insufficient parts were recovered, especially of the systems, and all recovered parts were heavily damaged at impact.

There was no indication of fire in the air or of a lightning strike. Although there was no evidence of sabotage, the possibility of explosion or a malicious act could not be definitely excluded. Collision with another aircraft was also excluded, no other aircraft being present in that area at the time.

During the investigation several cases of loss of control became known. The loss of control had resulted in a dive or a diving spiral because of the pilot's inattention. Another accident had occurred because during the take-off climb the pilot concentrated on a blocked artificial horizon bar. A stall had resulted.

During tests made in a DC-8 simulator the PH-DCL flight was simulated. It was proved that, due to a failure of the artificial horizon in bank, a pilot could be misled in such a way that he would lose control of the aircraft.

If it is assumed that the pilot began to lose control of PH-DCL during the last message, the last sentences heard over the radio could be interpreted as a warning coming from the pilot-in-command to the pilot at the controls. The uncertainty of the exact wording and meaning of the last two sentences gives, however, insufficient grounds for considering such a pilot error as a probable cause of the accident.

There was no evidence regarding the possibility of other crew errors.

Probable Cause

Notwithstanding a very thorough, time-consuming investigation, in which many authorities and experts co-operated, it was not possible to establish a probable cause of the accident.

Recommendations

PH-DCL was not equipped with a flight recorder. A recorder would have been of considerable assistance to the investigators and would probably have provided some indication as to the cause of the accident. Follow-up action in the field of air safety might have been taken. It was, therefore, strongly recommended that turbine-powered transport aircraft should be equipped with crashproof flight recorders.

The possibility that the aircraft crashed into the sea following an unintentional spiral dive could not be excluded. The flight characteristics of modern jet aircraft with swept back wings require continuous alertness on the part of crew members. More attention should be given to making aircraft and flying procedures safe from human errors. International co-operation of all interested parties in this field should be promoted.

Additional comments by the State of Registry (Netherlands)

It may be assumed that the flight proceeded normally as far as the LS beacon and that the aircraft was being flown manually.

On passing the beacon the course had to be altered to the right, i.e. from 225° M to 273° M, and this can only be done by means of the ailerons. About one minute after passing the beacon the aircraft crashed not to the right of the original heading, which would have tallied with the change of heading, but to the left of it.

In view of these facts, the Board was inclined to believe that there must have been some connexion between the actions necessary to effect the alteration in course and the introductory cause of the accident.

It is possible that after the aircraft changed course the ailerons remained slightly deflected so that a slow rolling movement to the left commenced, which was not noticed by the pilot in time and/or could not be observed in time due to the possible failure of the artificial horizon.

The aircraft got into a steep bank which sent it into a spiral dive during which it lost altitude so rapidly that the aircraft struck the water before the attitude for level flight could be restored.

The foregoing hypothesis is supported by flight simulator tests made after the accident. Nevertheless, it is by no means certain that the accident occurred in this way.

In view of the fact that nothing in the investigation points to disintegration having occurred during flight or intentional descent, for instance, to make a forced landing or to return to the airport, the pilot must have lost control of the aircraft through unknown causes.

Though there are no direct indications in this respect, the Board regards it as possible that the accident was due to the pilot or pilots being misled by instrument failure, in particular of the artificial horizon, or to the pilot having been distracted, so that a serious deviation from the normal flight path was not discovered in time.

Recommendations

It is more essential than ever that the entire complex of cockpit equipment and cockpit procedures should be such as to ensure the timely detection of any defects in vital instruments or of pilot errors. Accordingly, the Board has noted with pleasure that KLM puts more emphasis than ever before on training pilots in the timely detection of instrument failures.

The Board was of the opinion that in view of the dangers inherent in the failure of the artificial horizon, a system should be designed and installed which immediately detects differences in the pilot's and co-pilot's horizon readings and gives warning by means of a visible and audible signal. A comparison with the "stand-by" horizon would then reveal which horizon has gone wrong.

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ICAO Ref: AR/744

KLM/VIASA, DC-8, PH-DCL accident off the coast of Portugal, 30 May 1961

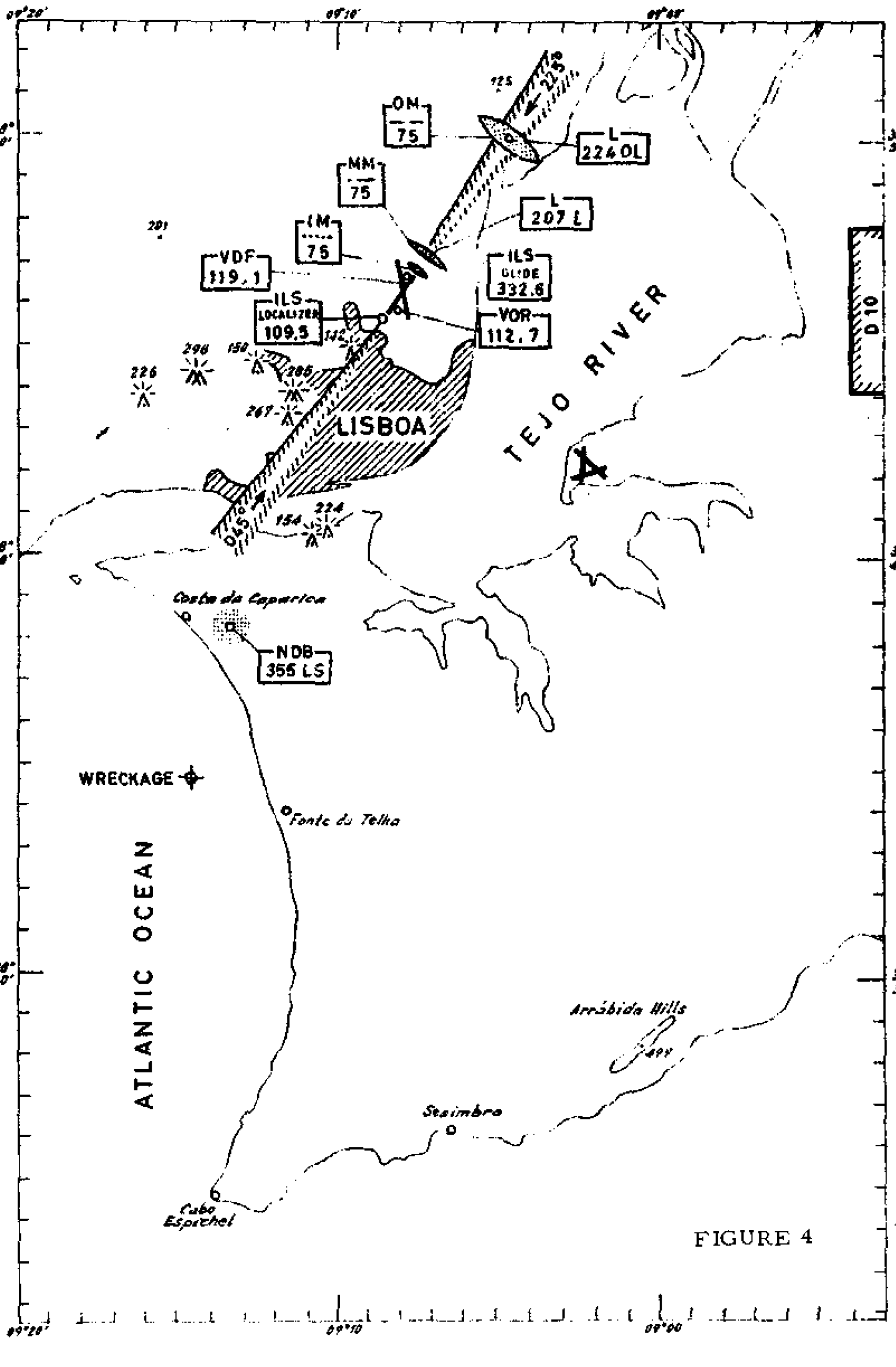

FIGURE 4

No. 16

KLM, DC-7C, PH-DSN accident over the Atlantic Ocean on 11 June 1961. Preliminary report No. 61-09, dated 3 December 1962, of the Chief of the Air Inspection Division of the National Aeronautical Service, the Netherlands.

Circumstances

The aircraft departed Idlewild, New York, for Bradley Field, Windsor Locks, Connecticut at 1943 hours on 10 June where 73 passengers boarded the aircraft for Prestwick, Scotland and Amsterdam, the Netherlands. The charter flight carried a crew of 8. Take-off from Windsor Locks was commenced at 2226 hours, and the aircraft followed the Boston - Moncton - Sydney airway to Gander, Newfoundland, at an altitude of 3 900 m (13 000 ft). At approximately 0715 hours GMT, while cruising at an altitude of 5 000 m (17 000 ft) over the Atlantic Ocean, the aircraft began to shake violently. The heavy vibration occurred in the port outboard engine and propeller. The pilot issued an emergency call and reported that he was descending and losing speed. The crew were unable to feather the propeller and fire was then reported at 0718 hours near the propeller hub. Ditching procedures were carried out and completed by 0730 hours at which time No. 1 engine and its propeller broke loose and fell into the sea. A landing was made at Prestwick at 0845 hours. There were no fatalities.

Except for the detachment of the No. 1 power unit, the damage was limited to one dent in the metal cover of No. 2 engine and another in the underside of the nacelle of No. 1 engine.

Investigation and Evidence

The Aircraft

The aircraft's certificate of airworthiness was valid until 9 October 1961.

A No. 10 inspection was carried out at Schiphol on 7 June 1961. The No. 11 inspection was due on completion of 9 565 flying hours. When the aircraft landed at Prestwick Airport it had flown a total of 9 318 hours since manufacture.

The two flight engineers made a transit check at Idlewild in the presence of a KLM technician, and no anomaly was found at that time. No complaints were entered in the maintenance log concerning the trip to Windsor Locks.

On departure, the aircraft weighed 62 190 kg, i.e. 2 732 kg below the maximum limit. The estimated landing weight, 48 071 kg, was also below the maximum allowable of 50 394 kg.

From the flight log it was deduced that at the time of the accident the aircraft weighed about 49 626 kg (109 550 lb).

The centre of gravity limits for the flight were not exceeded.

Crew information

The crew was made up of three pilots, two flight engineers and three cabin crew.

The pilot-in-command held a valid B1 pilot's licence which carried type ratings for DC-6 and DC-7 aircraft. He had flown a total of 14 750 hours including 326 hours on the DC-7C. Two hundred and forty-one of these had been flown as pilot-in-command. His last proficiency test was carried out in January 1961.

The second pilot held a valid B3 licence with instrument and co-pilot ratings for Convair 340, Lockheed 749 and 1049 and DC-7C aircraft. His total flight time amounted to 6 205 hours including over 1 000 hours on DC-7C aircraft as co-pilot. He underwent his last proficiency test in May 1961.

The first flight engineer had flown a total of 18 340 hours as of 1 June 1961. This total included 7 478 hours on DC-6/7C aircraft.

Reconstruction of the flight

At approximately 0715 hours the aircraft was cruising at 5 100 m (17 000 ft) the engine rpm was 2 400, and the blower was running at a high rate of rotation. The pilot-in-command was in the left seat. Without any warning the aircraft suddenly began to vibrate with steadily increasing violence. A heavy up-and-down tremor was felt throughout, however, the instruments showed no abnormal deviation. The second flight engineer began to check the engines with the analyzer, starting with No. 1, but this likewise showed no anomaly. The pilot, who had been watching the port engines at about the same time, saw No. 1 shudder violently and gave orders to switch it off.

The second flight engineer depressed the cut-out button of this engine and closed the fuel supply with the idle cut-off. The interval between the start of the vibration and depression of the cut-out button must have been about 8 to 10 seconds. During the cut-off procedure the feathering button was depressed, and the red control lamp came on. The rpm decreased, but not below 2 100.

When the pilot saw that the feathering operation had not been successful he called for reduction in speed and at the same time closed the right throttle lever. He put the aircraft into a climb and speed decreased immediately. The first engineer again operated the cut-off button to No. 1 engine. As this gave no result he pressed it a third time and the rpm increased rapidly reaching 3 500 on the indicator. The engineer pressed the button out again immediately and held it there for a short time. The rpm then returned to 2 000 and stayed there until the engine fell off (at 0730 hours).

As soon as the vibration began the pilot put out an emergency call and reported the aircraft was descending and losing speed. It began to sink at a speed of 130 - 135 kt and a rate of descent of 7.5 to 10 m/sec (1 500 to 2 000 ft/min). A fire near the propeller of No. 1 engine was reported shortly thereafter. By 0720 hours the aircraft was at 1 200 m (4 000 ft) so it must have descended 3 900 m (13 000 ft) in about five minutes. Three minutes later it was at 300 m (1 000 ft), and the pilot advised he was going to try and maintain this altitude.

Once the engine had separated from the aircraft at 0730 the vibration ceased, and the pilot was able to put the aircraft into a climb at a speed of about 140 kt, starting with METO power which was reduced afterwards to 1 850 hp. The climb was made to 1 500 m (5 000 ft) with 20% flaps and 2 400 rpm. With an indicated speed of 150 kt, 2 400 rpm and 180 BMEP the pilot headed for Prestwick where a landing roll, in which Nos. 2 and 3 engines were reversed, took place normally. After the landing it was found that the propeller feathering pump corresponding to No. 1 engine was still turning.

Discussion

No. 1 engine and its propeller shaft

Following the installation of this engine after a 8 271-hour check on 24 February 1961, a complaint had been reported. A check revealed no anomaly which could be connected with the trouble that led to loss of the engine. The propeller shaft had a total of 5 230 hours of service.

The hub and propeller blades

The hub and propeller blades had been in service 10 620 and 10 801 hours respectively. No oversight in maintenance was brought to light during the investigation.

While the blades were fitted to PH-DSN, they had been damaged at New York. A complete overhaul by the manufacturer followed. Since that time the propeller had been in service for 572 hours on the subject aircraft. Nothing in the evidence available connected the propeller to the engine loss.

The feathering pump

Those parts of the feathering system which were left behind on PH-DSN after loss of the engine were examined. No defects were found that might have prevented normal functioning of the feathering system. After the landing at Prestwick, the engines were stopped. The feathering pump of No. 1 engine was observed to be still turning despite the fact that during the breakdown the crew had taken action to stop it. From the data available, it appears that the circuit breaker, which was connected to the pump, was probably still on after the landing. The rotation of the pump after landing can be satisfactorily explained by assuming that, as a result of the distortion produced by the separation of No. 1 engine, this pump continued to receive current due to the throttle lever of No. 1 engine being moved to the reverse blade position at the time of landing. When the throttle levers were returned to normal, the engine feathering pumps were stopped by the signal from the appropriate blade switches. As No. 1 engine and propeller had broken loose, the signal to its feathering pump was never transmitted, and the pump continued functioning.

The engine mounting

It has been in service a total of 7 469 hours and was due for a major overhaul after 8 000 hours. It had several minor overhauls including a check for flaws, however, its maintenance history gave no occasion for comment.

The oil shut-off valve

After the oil supply to No. 1 engine had been shut off it continued to run about 9 minutes without seizing up. Although this seems rather a long interval, the data about so-called "engine freeze" in certain accident reports indicates that it is by no means improbable.

The question arose as to whether the oil supply was, in fact completely shut off. The oil valve itself could not be checked as it had fallen away with the engine. Witnesses said that the length of the flames from the spinner decreased after the oil supply had been disconnected.

It is probable that the valve was functioning properly and there is no reason to doubt the proper functioning of the accessory.

Propeller whirl motion*

Propeller whirl is a precession-like motion of the propeller and part of the nacelle and engine. When flexibilities in the engine and/or in the engine mount are present, the propeller-nacelle combination is able to perform pitching and yawing deflections coupled together by gyroscopic and aerodynamic moments. The motion is in reverse to the direction of propeller rotation; its frequency is lower than the lowest coupled natural frequency of the propeller-nacelle combination.

NAARL (National Aero and Astronautical Research Laboratory) conducted an inquiry into the possibility of the engine having broken loose as a result of propeller whirl flutter or whirl motion. The report of the inquiry contained the following findings:

1) The possibility of propeller whirl flutter, caused by failure of the forward propeller shaft bearing, exists.

2) The whirling propeller causes a load great enough to bring the aircraft into a violent oscillating motion.

3) The oscillating aircraft motion may be a rigid body motion.

* Summaries of two other accidents attributed to "whirl mode" and discussion of this phenomenon appear in Aircraft Accident Digest No. 12 - Circular 64-AN/58. (Braniff Airways, Electra, nr. Buffalo, Texas, 20 September 1959 and Northwest Airlines, Electra, nr. Cannelton, Indiana on 17 March 1960.)

4) When after damage the yaw frequency of the propeller-nacelle combination comes very close to a natural wing vibration, a dangerous co-operation of these frequencies may arise.

5) Correct operation of the propeller feathering mechanism should have limited the extent of the incident.

Power unit failure

The history of the power unit prior to the accident and the condition of the aircraft thereafter failed to suggest anything which might be related to the breakdown or provide an explanation thereof. Engine No. 1 was not recovered.

The crew stated that there were no abnormalities in the engine or propeller prior to the flutter which increased gradually.

The pilot-in-command's observations showed that the spinner gyrated in a circle contrary to the direction of the propeller at a rate of 1 to 2 cycles per second. He also reported a loss of oil and a fire at the blade roots. The flight engineers mentioned reverse action of the feathering system and overspeeding of the propeller.

The movements reported by the pilot-in-command were characteristic of a well-defined oscillating motion of the propeller designated as "whirl mode". No major centrifugal forces are generated by this motion, and the disequilibrium is located close to the propeller shaft. In the subject case the engine was not lost until fifteen minutes after the trouble started.

A prerequisite of "whirl motion" is a diminution of rigidity in the supporting structure of components of the power unit installation. This diminution is only apparent in the engine mounting or propeller shaft bearings. A photograph which was taken, giving the view from the pilot's seat, showed that the supporting structure of the components still formed a single whole, and the spinner was swinging outwards in relation to the engine cowl. This suggested that the loss of rigidity most probably occurre in the forward propeller shaft bearing and was due to its failure.

The propeller hub is so constructed that if failure of the forward shaft bearing occurs, oil is lost from the component and ejected near the blade root. As a result of the disalignment of the oil supply passages a reverse action may have been set up in the feathering system and pollution of the oil in the dome, by metal fragments from the ruptured bearing, could have put the overspeed safety coupling out of action. The brushes of the electric de-icer in front of the propeller blades may then have overheated through excessive racing and ignited the oil just emitted at this point.

There was nothing in the observations of the crew or in the instrument readings before or during the breakdown to suggest any other cause. The NAARL report gave support to the hypothesis that whirl mode motion may have occurred in engine No. 1 through loss of stiffness resulting from failure of the forward propeller shaft bearing.

Loss of the entire power unit installation must be ascribed to fatigue of the upper engine mount suspension points, such as occurs with exceptionally high loads.

KLM has had earlier bearing trouble with this engine type (TC18EA). No uncontrollable situation arose, and the effects were kept to a minimum. Between 1960 and 1962 KLM registered three breakdowns of the TC18DA type (on Lockheed 1049C's) in 297 780 flying hours, while no trouble has occurred with the TC18EA (on DC-7C's) in 470 844 flying hours. This shows the fortuitous character of the failure on PH-DSN. The NAARL report states that the forward propeller shaft bearings have given regular cause for complaint. This, as can be seen, is incorrect.

In short, the cause of the failure cannot be attributed with certainty to engine breakdown, but the depositions of the crew contained sufficient indication to make failure of the forward propeller shaft bearing the probable cause.

No special instructions had been provided to crews on this type of failure as it was unknown to KLM. When the first signs appeared the pilot and two flight engineers took action calculated to reduce the effects. Ignorance of this type of difficulty and uncertainty as to the behaviour of the propeller must have influenced the actions of the pilot at the time. The further course of the flight and the disappointing performance of the aircraft at a lower altitude point out that the decision to make a rapid descent is only to be taken with great caution.

Probable Cause

The accident was attributed to failure of the forward propeller shaft bearing on No. 1 engine. Violent vibration, which could not be stopped, arose in No. 1 propeller and resulted in fire and separation of the entire No. 1 power unit.

Follow-up action

Following the accident, KLM analyzed the situation in the passenger cabin from the point of view of emergency procedures and the personnel involved. The existing procedures however provide the best arrangement and were, therefore, not modified.

As for the situation in the cockpit, particularly with regard to the presence there of the co-pilot and the flight engineers during an emergency, the procedures were modified. The regulations in force at the time of the accident stipulated that the co-pilot must remain in the passenger cabin to take charge there after ditching. The procedures now allow the captain to retain the co-pilot or flight engineer in the cockpit if the circumstances so require.

As stated, correct operation of the propeller feathering mechanism should have limited the extent of the incident. It must be noted that the supply and return of oil to and from the propeller governor was effected via the passages in the propeller shaft and engine nose section. If the propeller shifts in relation to the nose section, on account of bearing failure, these passages cease either wholly or in part to coincide, with the result that proper functioning of the feathering mechanism is no longer assured. It has not, apparently, been possible to find a constructive solution to this problem. Moreover, with the propeller oscillating, a compact seal between the propeller axle and the nose section is no longer assured.

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ICAO Ref: AR/768

No. 17

KLM, Lockheed Electra L-188C, PH-LLM, accident near Cairo Airport, United Arab Republic on 12 June 1961. This summary is based on a translation of the report, dated 6 March 1963, of the Aircraft Accident Investigation Board The Netherlands.

Circumstances

Flight KL 823 departed Amsterdam at 1850 hours local time (11 June) on a scheduled air service to Cairo via Munich, Germany and Rome, Italy. It was then to continue to Kuala Lumpur via Karachi, Pakistan. Aboard were a crew of 7 and 29 passengers. During the approach to land at Cairo the aircraft crashed at 0411 hours local time (12 June) 4 km southeast of the threshold of runway 34 at a point 60 m above the level of the runway threshold. The aircraft was destroyed. Three crew members and seventeen passengers were killed in the accident, and four additional crew members and twelve passengers sustained injuries.

Investigation and Evidence

The Aircraft

By virtue of an American Certificate of Airworthiness for Export, a Netherlands Certificate of Validation, valid until 13 December 1961, was issued to the aircraft on 14 December 1960. It also had a valid maintenance release.

The Loading of the Aircraft

The take-off weight and centre of gravity of the aircraft were 45 310 kg and 24.8% of the mean aerodynamic chord, respectively. At the time of the accident the aircraft's total weight would have been 39 120 kg, and the centre of gravity at 22%, i.e. they were both well within the limits.

Crew information

The crew consisted of the pilot-in-command, a co-pilot, a flight engineer, a flight navigator/flight radio operator, a purser, steward and stewardess.

The pilot-in-command was acting in this capacity for the first time on the subject flight. He held a valid airline transport pilot's licence on which were entered ratings entitling him to act as pilot-in-command on Convair 340's and on the Electra. His flying experience amounted to 11 489 hours, 4 955 of which were as pilot-in-command. He had about 100 hours experience on the Electra L-188C, i.e. 87 hours as co-pilot, 6 hours of pilot-in-command training and 7 hours as pilot-in-command. Though the pilot-in-command had little experience on this type of aircraft and was acting as pilot-in-command on this type of aircraft for the first time, he should in view of his extensive airline transport piloting experience be considered sufficiently competent to execute the landing at Cairo safely.

The co-pilot had flown 3 821 hours in all, including 747 hours as co-pilot on the Lockheed L-188C.

Weather

The conditions at Cairo Airport at 0411 hours (the time of the accident) were as follows:

surface wind	330°/8 kt
visibility	10 km
clouds	4/8 stratocumulus
base of clouds	600 m
air pressure	1014.4 mb
temperature	20°C
weather conditions	favourable

Runway 34 - Cairo - Landing Chart

KLM Nav.11/5/60 (visual manoeuvring chart) concerns the visual approach procedure for runway 34.

The chart which was on board the aircraft contained the following information:

a) landing runway 34 is not equipped with special landing aids, e.g. ILS; the runway length is 2 500 m, the threshold is situated at an altitude of 333 ft (100 m); the runway has a downslope of 1.6%;

b) during the approach to runway 34 a right-hand circuit must be flown; the visual manoeuvring chart recommends that the downwind leg of the circuit be flown at 1 200 ft (365 m), that the descent be commenced during the right-hand turn and that a glide path of 3° be maintained during the final approach;

c) to the south of the airport the area slopes upwards in a series of sand dunes. On the chart the level is marked by lines indicating differences in height of 100 ft;

d) about 4-1/2 km from the beginning of runway 34, at an altitude of 636 ft (193 m), a red obstruction light has been placed on the ridge of a hill; this light is an occulting light and is of low intensity;

e) the aerodrome has been provided with the usual night lighting; only runway 23 is equipped with approach lighting.

A KLM Notam, dated 9 June 1961, promulgated the following information concerning runway 34 at Cairo:

"Runway 16/34 available length 2 500 m. Threshold runway 34 marked by gooseneck flares on each side and the first 500 m ICAO marked.

Take-off distance 8 200 ft, 1.6% downslope."

The pilot-in-command knew of this data. He also knew that instrument runway 05 was not in use because of repairs.

Reconstruction of the flight

The flight was uneventful until the approach at Cairo. The aircraft contacted Cairo Approach when about 35 NM out and was cleared to continue its descent to 610 m to the radio beacon near the airport. It also received the latest information on the air pressure (QNH 1014.6 mb), the prevailing surface wind (350°/6 kt) and the landing runway to be used (runway 34).

The captain had familiarized himself with the approach procedure as shown in the KLM route manual. He understood from the chart that a right-hand circuit had to be made.

He intended to fly to Cairo Range first and then to approach the airport along the southern leg of this beacon. As soon as the airport was sighted he would change his heading 45° to the left to enter the circuit, and would then carry out a normal right-hand circuit to runway 34 visually. He intended to maintain an altitude of 610 m (2 000 ft) during the flight on the downwind leg and on base leg until he had obtained visual contact with the runway. He would then reduce power and lower his landing gear to carry out a steep approach to the runway. He realized that the approach procedures would have to be carried out over an up-sloping hilly area and that when carrying out this left-hand turn to downwind leg he would, from his position in the left-hand seat, lose sight of the runway. Therefore, he would ask the co-pilot to tell him when the right-hand turn to the runway, following the downwind leg, would have to be started.

At 0409 hours (local time) the pilot reported that the aircraft had passed the range beacon at 610 m (2 000 ft). It probably passed it within one mile. The aircraft was then cleared for the approach procedure. The exact wording of the clearance is not known. The radio log-book entry reads: "you are cleared for a standard beacon approach runway 34". However, the air traffic controller on duty declared that the aircraft was cleared "for a visual contact approach".

At 610 m the aircraft was levelled at a speed of 150 - 160 kt; the engine power being about 1 000 hp per engine. Not until quite close to the airport and nearly over it did the captain see the airport lighting, and changed his heading about 40° to the left to make the right-hand circuit. Prior to passing the range beacon the wing flaps were put in the approach position at an altitude of about 1 830 m (6 000 ft). The aircraft then continued to fly horizontally following the new heading. The co-pilot was requested to "keep the runway in sight".

Applying normal procedure, the aircraft would enter the right-hand turn for the final approach about 30 seconds after passing the runway threshold. Although the captain knew from experience approximately when he would have to initiate the circuit he waited for a sign from his co-pilot.

In the meantime, at 0410 hours local time the co-pilot reported to the Cairo Tower that the aircraft was downwind. The tower gave the surface wind as 330°/8 kt and instructed the flight to report on final.

Shortly thereafter the pilot-in-command commenced the right-hand turn and before he sighted the runway, gave the order for the lowering of the landing gear and reduced the engine power to 100 - 200 hp per engine.

The aircraft struck the ground (at 0411 hours local time) and caught fire.

At the site of the accident

Pieces of wreckage were scattered over a distance of 360 m, over three hills and the valleys in between. The fuselage had fallen into three parts. An attempt was made to establish the positions and indications of the instruments, levers, switches and the controls. The readings of the power indicators and the damage to the propellers led to the conclusion that the engine power was low, i.e. probably less than 170 hp. Examination of the altimeters did not provide any definite conclusion as to their condition prior to impact. It was believed likely that they did function correctly at that time. The airspeed indicator on the left-hand instrument panel was still in good condition after the accident and functioned within the appropriate limits at the examination.

The right-hand circuit

As runway 34 was not equipped with radio navigation aids, a visual approach had to be made. It was a dark night and there were no means of orientation other than the airport lighting and the runway lighting. The red light, 4.5 km southeast of the runway was of too low an intensity to be considered reliable as a means of orientation.

The fact that the runway had to be approached in a right-hand circuit was a disadvantage to the pilot-in-command (in the left seat). The pilot had to rely on instruments until immediately before the end of the right-hand turn, i.e. the moment when he would get sight of the runway.

The pilot had instructed the co-pilot to "keep the runway in sight" and was positive in his statement that the co-pilot had indicated the moment when the right-hand turn should be commenced. This statement was not confirmed by the flight engineer nor by the flight navigator/flight radio operator.

Reconstruction of the flight path
(see Figures 5 and 6)

From the marks on the ground it was inferred that at impact the aircraft was on a 225° heading, the angle of bank was 22° and the ground speed was 159 kt. The flaps were in the approach position, and the landing gear was down. The wind was 330°/8 kt.

This data gives a flying speed and a heading at time of impact of 81 m/sec and 228° respectively. From the angle of bank at this flying speed follows a rate of turn of 2.80° per second, so that the duration of a turn of 180° was 64 seconds, which is in accordance with the duration of the normal procedure, which takes 60 seconds. From the speed and the bank a radius of 1 650 m in front of the runway and in respect of the air can be inferred. Assuming that speed and bank were kept the same during the turn and taking due account of the wind, it follows from this radius, from the heading at the moment of impact, and from the probable point where the downwind leg of the circuit was commenced that on the track prior to the turn the track was 123° and the heading 122°. This heading differs 40° from the direction of runway 16, the opposite of runway 34, which concurs with the statement of the pilot-in-command that he changed his heading about 45° to the left, after he reached the airport.

The change of heading between the beginning of the circuit until the moment of the crash was 228° - 122° = 106°, at the rate of turn as reconstructed, reached in 38 seconds.

If the aircraft had not lost height, it would have come right in front of the runway when continuing the circuit. This shows that the pilot-in-command flew the circuit correctly.

The intended approach procedure

When planning the landing the pilot consulted KLM visual manoeuvring chart No. 11/5-60 which gives the following procedure as an example:

> "Downwind leg at an altitude of 1 200 ft (365 m) during 30 seconds after passing the runway threshold at a speed of 150 kt; descend to 700 ft (213 m) during the right-hand turn at a rate of descent of 152:60= 2.5 m per second; approach to the runway under an angle of 3°, at a rate of descent of 4 m/sec."

The pilot of PH-LLM intended to deviate from this example, because with the up-sloping area south of the runway, he preferred to fly at a greater altitude on the downwind leg. He intended to maintain an altitude of 2 000 ft (610 m) on the downwind leg and not to commence the descent before he had the runway in sight when turning and to then approach the runway in a steep descent. In the turn he would not be able to see the runway through the side windows because of the bank of the aircraft. He would only be able to have the runway in sight through the front windows when his heading would be about 280°; the runway would then be about 55° to the right of his heading.

Reconstruction of the flight path showed that at that time the aircraft would have been about 3.4 km from the runway threshold. Reckoning with the wind, it would have taken about 45 seconds to reach the runway threshold.

The pilot stated, during the investigation, that he had calculated that decreasing his engine power to between 100 and 200 hp per engine, he would have a speed descent of 2 000 fpm (10m/sec). Over the runway threshold, therefore, he would have lost about 450 m of height, and his altitude would then have been reduced to a good 150 m. The runway threshold is at an altitude of 333 ft (about 100 m). Also due to the fact that the steep flight path for the landing had to be completed it follows that a rate of descent higher than 10 m/sec would have been required during the first part of the final approach to be able to fly the aircraft over the runway threshold at an appropriate altitude.

This could have been achieved by fully lowering the wing flaps. A final approach thus executed, with a rate of descent of about 10 m/sec, deviated greatly from normal practice and also from the rate of descent of about 4 m/sec as recommended by the KLM manoeuvring chart. The Board wondered whether the pilot had realized that his intended procedure had to lead to a rate of descent which would be considerably higher than that which is usual for landings.

Actual final approach procedure

The pilot carried out the procedure in another way to that planned. At the time the aircraft contacted the ground it was at an altitude of 520 ft (158 m). It should have been at an altitude of 2 000 ft (610 m). The landing gear had already been lowered, and the engine power had been reduced. From the statement of the flight engineer it appeared that before impact the pilot had reduced the engine power from 1 000 hp to between 100 and 200 hp per engine. The flight engineer was positive on this point because he had for some time been expecting to have to suppress a possible negative power. The aircraft's loss of height and the flight engineer's statement prove, undoubtedly, that the pilot deviated from his plan not to lower the landing gear nor to reduce power until he was in sight of the runway.

Trials were made with the Lockheed Electra at Schiphol Airport on 12 July 1961. The aircraft was loaded the same as the subject aircraft. The trials showed that with flaps in the approach position and the landing gear lowered, the rate of descent at an engine power of 100 hp and a designated speed of 160 kt in a right-hand turn and banks of 15°, 20° and 30° was 10.6 m/sec (between 2 000 and 2 200 fpm). This is a similar situation to that in which PH-LLM was at the time of the accident.

The difference in height between the aircraft's altitude on the downwind leg (2 000 ft) and that at the point of the crash (520 ft) is 450 m, so that it must have been descending for 42 seconds. As the turn took 38 seconds, it can be concluded that the power reduction and the lowering of the landing gear must have taken place about simultaneously with the initiating of the right-hand turn.

The pilot appears to have initiated the steep descent about one minute before the time he intended. He initiated the descent in accordance with the recommended procedure of the KLM manoeuvring chart but at a rate of descent in accord with his planned procedure which was 2.5 to 4 times the rate of descent of the procedure of the manoeuvring chart.

The discord between intention and execution did not make the collision unavoidable because the pilot, who was flying mainly IFR, should have been warned of the dangerous situation which was developing by reading the rate-of-descent indicator and more particularly the altimeter, so that he could have taken corrective action. The fact that he did not notice this warning indicates that he did not pay adequate attention to these instrument readings for more than half a minute and during a flight which he had to carry out mainly on instruments.

Considering the accuracy with which the circuit was flown, he would have paid due attention to the airspeed indicator and the turn indicator.

The neglect of the altimeter and the rate-of-descent indicator gives the impression that not only after the accident but also during the approach, the pilot was unaware that he had commenced the descent that steeply.

The fact that the descent was made over an up-sloping area cannot be considered as the direct cause of the accident.

If the accident area had been at the same altitude as the runway threshold the collision would have occurred 6 seconds later, the difference in altitude only being 187 ft (i.e. 57 m). The heading of the aircraft would then have been 245° so that the pilot-in-command would not have had sight of the runway either, and would not have had occasion to take corrective action during these six seconds.

Conclusions

The pilot-in-command deviated without known reason from his intended approach procedure, which included a steep descent. He actually commenced this descent one minute earlier than intended.

His intended approach procedure meant that a rate of descent of more than 10 m/sec had to be applied, which rate of descent is considerably higher than the usual one under normal circumstances and than the rate of descent recommended for

Cairo Airport on the KLM manoeuvring chart. The Board did not believe that a right-hand circuit carried out by a pilot in the left-hand seat was dangerous. This accident was not caused by this circumstance.

Probable Cause

The accident was caused by the pilot-in-command's inattention to his instruments.

Follow-up disciplinary action

The pilot-in-command sustained such injuries in this accident that it is assumed that he will not be able to act as a commercial pilot again. The seriousness of the mistake which was made and the grave consequences thereof have the inevitable result, however, that the pilot-in-command had to be punished disciplinarily. Therefore, his licence (entitling him to act as pilot-in-command of an aircraft) was withdrawn for a period of three months.

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ICAO Ref: AR/743

KLM, ELECTRA, PH-LLM, 12/6/61

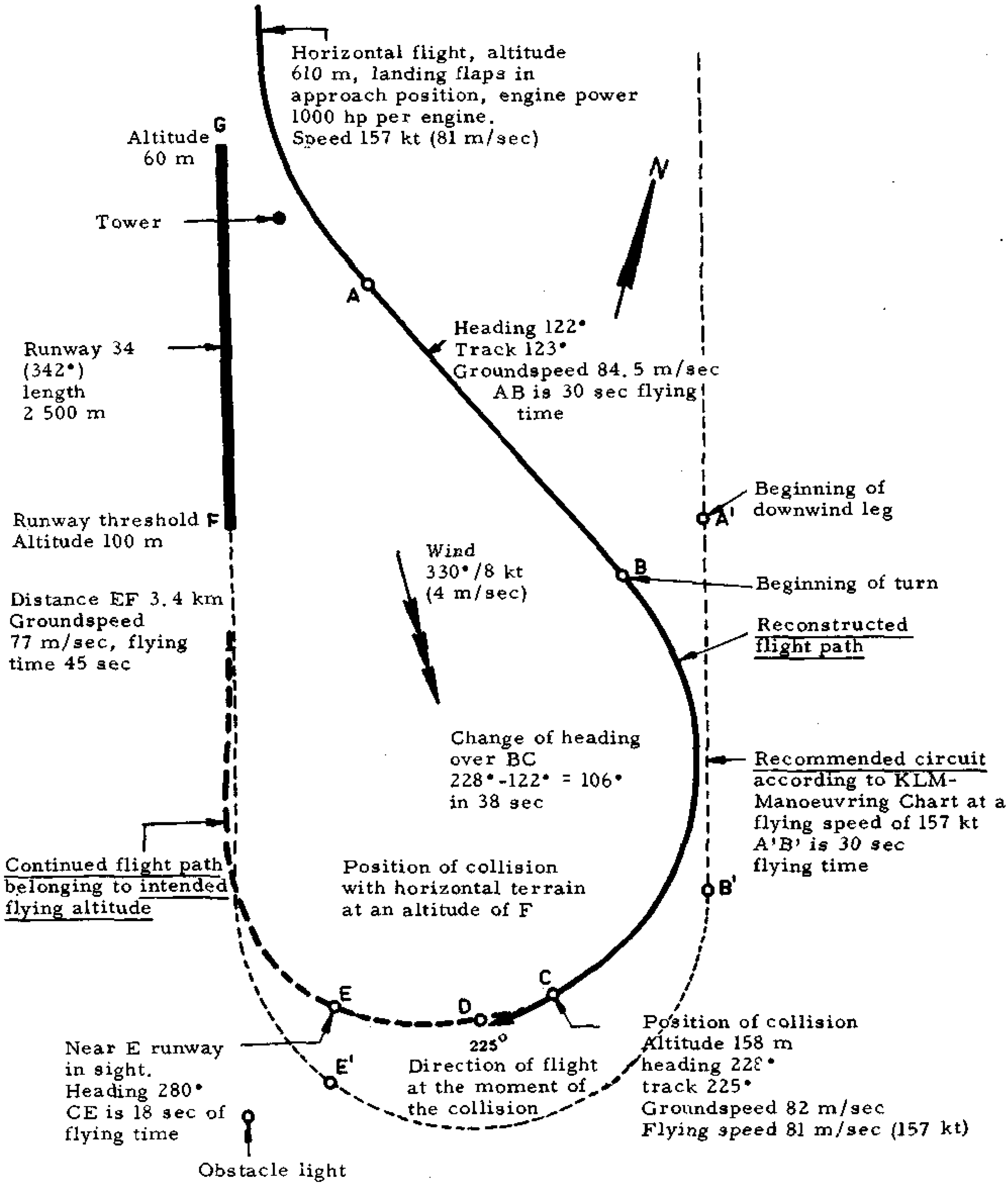

FIGURE 5

KLM, ELECTRA, PH-LLM, 12/6/61

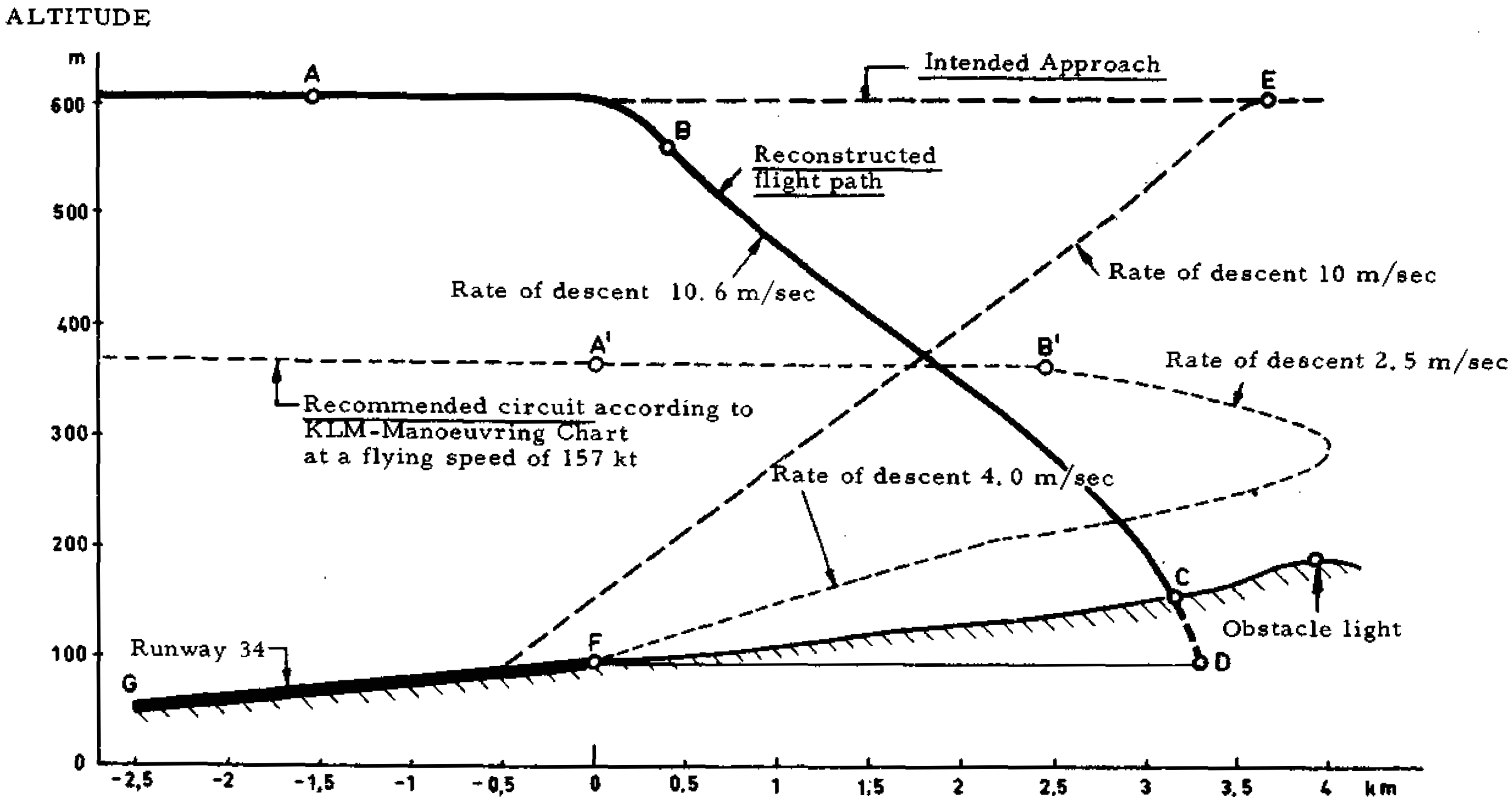

FIGURE 6

No. 18

Air Cameroun, Douglas C-54, TJ-ABC, accident at Douala Airport, Cameroon, 13 June 1961. Report released by the Director of Civil Aviation, Cameroon.

Circumstances

The flight was the last being made in order to complete the pilot's training for a DC-4 type rating. The crew consisted of an instructor, the trainee-pilot, a radio operator and an engineer.

The first training session of the day had taken place during the afternoon from 1638 - 1755 hours at which time the pilot had performed ten take-offs and landings for the instructor including several with one engine inoperative and the propeller feathered. Circuits had been flown at heights between 150 and 200 ft.

The second part of the session was to include take-offs with one engine on reduced power.

Following a twenty-minute break, the aircraft took off from runway 12 at 1816 hours (i.e. at night), flew along its extended centreline, made a 180° turn and landed in the opposite direction on runway 30 at 1826 hours. After making a half-turn at the end of the runway, the aircraft took off at 1831 hours from runway 12. According to the controller in the tower and to witnesses, the aircraft lifted off only in the last quarter of the runway in a very shallow climb. Twenty seconds after take-off and slightly to the left of the runway centreline, a ball of fire was seen. This was followed by a ground fire. The four crew were killed instantly, and the sole passenger aboard was fatally injured in the accident which occurred at 1833 hours GMT.

The wreckage was located about 1 500 m from the end of runway 12 and 500 m to the left of its centreline amid trees 50 m or more above the aerodrome level.

The Aircraft

The certificate of airworthiness delivered 24 April 1961 for the aircraft was marked "provisional document" being the "equivalent of a permit". The last airframe inspection had also taken place on 24 April 1961.

Since the last periodic inspection of the power plants they had flown -

No. 1	37.55 hours	No. 3	37.55 hours
2	33.55 hours	4	37.55 hours

The propellers, since the last overhaul and periodic check, had completed the following number of hours service:

No. 1	3 547.24 hours	No. 3	1 849.40
2	869.09 hours	4	1 183.11

Crew Information

The instructor held a valid airline transport pilot's licence, an assistant-instructor's rating valid until 29 July 1961 and was authorized to check the ability of the company's pilots on DC-4 aircraft. He had flown a total of 13 412 hours including 2 750 at night. During the two months preceding the accident he had flown 192 hours on this aircraft type. His total hours flown on this type (as entered in his log book) was 212 since October 1958.

The trainee-pilot held a valid airline transport pilot's licence with a type rating for C-46 aircraft issued on 1 June 1961.

His total number of hours flown amounted to about 14 965 of which 1 142 hours had been flown by night. On the DC-4 aircraft he had flown 62.35 hours (dual controls), two hours having been flown within the 48 hours preceding the accident.

The two other crew members aboard, i.e. the radio operator and flight mechanic, also held valid licences and had the following experience:

radio operator	10 380 hr by day 474 hr (partial night)	

He had flown 53 hours on this aircraft type during the two months preceding the accident.

flight mechanic	11 523 hr by day 650 hr (by night)

During the two months prior to the accident he had flown 333 hours on the DC-4.

Reconstruction of the final flight

The afternoon's training session was interrupted by an incident with a hydraulic lock of No. 4 engine. Because of this the engine could not be restarted, and the oil of the lower cylinder had to be emptied by counter-rotating the propeller. However, according to the chief engineer for Air Cameroun, engine No. 4 was operating normally before the last take-off.

Power on No. 4 engine was reduced during the take-off which took place at 1831. The aircraft had difficulty in lifting off the ground but finally became airborne on the last third of the runway. The landing gear and flaps were retracted immediately. It also may be assumed that the take-off was performed without flaps as the instructor had informed the pilot during the afternoon that the nose wheel tended to shimmy at high speed. Because the shimmy made it difficult to read the instruments, the instructor intended to have them read off to the trainee-pilot. The aircraft took off in a very shallow climb because of the braking of engine No. 4 and the immediate flap retraction, and a left turn was initiated before reaching 150 ft.

Approximately 1 200 m from the end of runway 30, the propeller of engine No. 2 slashed a tree, severing it and smashing the propeller to pieces. The aircraft was then nosed up but struck a second tree. Momentum was lost, course was altered and the aircraft broke up, cutting a swath in the trees. Following the second impact the fuel tanks burst and caught fire. Propellers 1, 3 and 4 and engines Nos. 1, 2 and 3 were projected forward; the left wing and left wing root ripped from the fuselage which continued on its path. The right wing then smashed against a tree 200 m from the first point of impact and fell in front of the fuselage after losing engine No. 4 in its fall.

Findings at the accident site

The wreckage of the aircraft was located 1 459 m from the approach end of runway 30, its direction forming an angle of 20° with the extended runway centreline.

A tree, 274 m from the farthest piece of wreckage (the right wing), was severed at a height of 40 m. Forty-five metres closer in, the top of a very large tree, more than 50 m high, was broken off. A third point of impact was found 150 m from the first on a tree 80 cm in diameter. Its trunk was broken at a height of about 15 m. From that point, the path of the aircraft, which had followed the edge of the forest, entered into an area consisting mostly of soft wood. The path of the machine was thus visible for 274 m. Debris was scattered along the axis of the aeroplane's path over a rectangular zone about 270 m by 150 m.

Two hundred metres from the machine's first impact and 15 m to the left of the track the three engines Nos. 1, 2, and 3 were grouped in a radius of 6m. Engine No. 4 was lying 7 m ahead and to the right of the wreckage of the cabin.

The propellers seemed to be all at fine pitch, but the stops of the blades were damaged.

The fuselage, entirely destroyed by fire, was 240 m from the first point of impact. It had not crashed into the ground but slid and tilted to the left.

The two wings were found with most of the ailerons and flaps, the latter being in the retracted position. The left wing was lying a few metres to the left of the path of the aircraft, 125 m from the first tree. The right wing was to the right and ahead of the fuselage, 274 m from the point of first impact.

The indications of the aircraft's instruments could not be considered as primary evidence but merely as data in support of other positive evidence.

Probable Causes

The accident was caused by flight at too low an altitude during a night training exercise.

According to witnesses, the instructor had directed the pilot to circle the runway at an altitude of 150 ft during the first training exercise; it appears that this instruction was maintained for the same exercise by night.

Assuming that take-off was made with flaps extended, it so happened that complete retraction of the flaps occurred practically at the time of impact with the first tree. In fact, it can be estimated that the flight lasted 30 - 40 seconds from the time of take-off to impact with the first tree. Retraction of the landing gear takes 15 seconds and of the flaps approximately 10 seconds. Rapid retraction of the flaps at low speed causes the aircraft to nose down. It is possible that the loss of altitude occurred just before reaching the curtain of trees. Flaps are normally retracted gradually after reaching an altitude of 200 ft in visual meteorological conditions and 400 ft in instrument meteorological conditions or at night. The normal path of a DC-4 with one engine on reduced power at take-off, climbing speed 400 - 500 ft/min, made it impossible for the aircraft to clear the tops of the trees which it struck.

Assuming the take-off was made without flaps - a manoeuvre not recommended during night flights at Douala - the path followed would have inevitably brought the aircraft into the trees.

It should be noted that the Air France DC-4 Manual prohibits counter-rotating the engine propeller in case of hydraulic lock; this manoeuvre merely forces the oil into the intake pipe and can render the engine inoperative. Even though this prohibited manoeuvre was followed, it does not appear that it was one of the causes of the accident; the incident would most certainly have occurred during the first aerodrome circuit after the return to the parking area.

In conclusion, it appears that the accident should be ascribed to lack of seriousness and judgement on the part of the instructor.

Pilot fatigue may also be invoked after a two-hour training flight at very low altitude under the constant supervision of the instructor. The pilot was a very serious, methodic and calm flier, but he did not have sufficient authority to disregard the unduly risky manoeuvres urged upon him, as confirmed orally by a flight mechanic who had flown with the crew involved in the accident.

Recommendations

Instructor ratings

It is essential that instructor ratings, even provisional ones, be issued with the greatest caution.

Search and rescue services

Considering the difficulties of access to the accident site, the search and rescue services arrived without undue delay. No vehicle was able to reach the wreckage. The passenger, who was still alive, was transported under extremely difficult conditions.

In order to provide for more rapid assistance to aircraft that may crash along one of the sides of the extended runway centreline (road usable over 1 800 m), it is recommended that 500 m access ways, which can be used by jeeps, be provided at right angles to the extended centreline at approximately 300 m intervals i.e. up to the edge of the take-off flight path.

Fire fighting services

The fire fighting services should be provided with strap-on portable extinguishers and powerful lighting equipment.

ICAO Ref: AR/711

Training
Take-off
Collision - trees
Pilot - operating recklessly - carelessly (unsafe manoeuvres at low altitudes)

C-54, TJ-ABC, 13/6/61

FIGURE 7

(Georges Prunet)

FLOOR OF PASSENGER COMPARTMENT WITH UPPER PART MISSING

FIGURE 8

(Georges Prunet)

FORWARD FUSELAGE AND NOSE WHEEL

No. 19

Continentale Deutsche Luftreederei, G.m.b.H., Douglas C-54 (B-DC), D-ABEB, accident 2 NM from the threshold of runway 07, Kano Airport, Nigeria on 17 June 1961. Report released by The Ministry of Transport and Aviation, Nigeria.

Circumstances

The aircraft was on a charter flight from Hamburg, Germany to Leopoldville, Congo via Luxembourg, Tripoli and Kano. It carried a pilot-in-command, two co-pilots, two mechanics and two passengers. The passengers boarded the flight at Luxembourg when some cargo was taken on as well.

During a night approach to Kano Airport the aircraft undershot runway 07 and crashed at 2223 hours GMT about 2 NM from its threshold. Fire broke out. One of the passengers was killed, and a mechanic was seriously injured.

Investigation and Evidence

The Crew

The pilot-in-command has considerable flying experience. His log book was lost in the accident, but he states that his total flying hours amount to about 13 000 of which 3 500 - 4 000 hours were as pilot-in-command and co-pilot on DC-4 (C-54) aircraft. In the last six months he has flown 500 - 600 hours and in June, the month of the accident, he had flown 80 hours up to the time of the accident.

He holds a German Airline Transport Pilot's Licence valid until 1 October 1961, which contains a current instrument rating renewed on 30 April 1961 and is endorsed for DC-4 aircraft as pilot-in-command.

The co-pilots

Both first officers, who shared the duties of co-pilot during this flight, have valid German Commercial Pilot Licences with current instrument ratings and are endorsed as first officers on DC-4's. They have flown 3 000 and 1 100 hours in all, of which 600 and 300 hours respectively were flown on DC-4's.

The Aircraft

Since manufacture the aircraft had flown 32 850 hours, 800 of which had been flown since last overhaul for the renewal of the Certificate of Airworthiness. About 18 hours had been flown since the issue of a Certificate of Maintenance on 16 June 1961. The aircraft had been maintained in accordance with the maintenance schedules.

Loading

The distribution and securement of the cargo had been supervised by one of the co-pilots and checked by the captain. The latter had refused to load a ground power unit and two wing jacks, totalling 950 kg, at Luxembourg.

No arms or ammunition were carried on the flight.

On take-off from Idris Airport for Kano the aircraft's weight was 32 845 kg, approximately 335 kg below the maximum gross take-off weight of 33 180 kg. Fuel for the trip was calculated as 4 765 kg, and the landing weight at Kano as 28 080 kg. Because of the extra 1 hr 23 min which the flight took, the landing weight at the time of the accident was estimated as 27 540 kg. The centre of gravity was calculated as being within the prescribed limits.

Weather Conditions

At 1800 hours a line squall, about 120 miles east of Kano, was observed on the storm warning radar screen at Kano Airport. Its rate of movement westwards was approximately 30 kt at this time, but by 2000 hours it became clear that the line was speeding up, and it was then estimated that it would reach Kano at 2100 hours.

When the squall was about 20 miles east of Kano it appeared that about a 10-mile section of the line east to northeast of the station was weakening. At 2110 hours active storm cells passed about 5 miles north and 5 miles south of the airport with squally winds at the station gusting to 45 kt from the southeast, and the visibility was reduced to 300 yd by dust. When it became clear that the more active storms had bypassed the station, an amorphous radar echo could be seen, whose western edge was 7 miles east of the airport. This precipitation area moved slowly to affect the field at about 2153 hours. Although the echo of this precipitation area was tracked on the radar screen, visual observation of the area was only possible during lightning flashes from surrounding storms; no electrical activity was observed from the area itself. The precipitation area produced very little rain at the station.

It was clear from Air Traffic Control tape recordings that the aircraft was kept fully informed of the development and movement of the storms in the Kano area. As a result, the aircraft turned back when some 40 miles from the airport to await an improvement in the Kano weather.

The rain area that moved in from the east to affect the airport at about 2153 hours produced 0.04 inches of rain in 20 minutes with the wind swinging between east and south at speeds of 6 - 33 kt. The intensity of the rain was 0.12 inches per hour and, therefore, relatively light. It seems likely that this rain area was over the scene of the crash at the relevant time.

At the time of the procedure approach to runway 07 (about 2210 hours) the weather conditions were believed to be:

cloud	2/8 St 1 500 ft, 4/8 Sc 1 800 ft 3/8 Cb 2 000 ft, 8/8 As 9 000 ft
visibility	6 NM
wind	120° - 150°/15 - 20 kt
QNH	29.92"

slight thunderstorm, turbulent conditions, rain.

The turbulent conditions did not constitute a hazard to an aircraft making a correct angle of approach.

None of the reports of the meteorological conditions at the time of the accident as seen from the airport makes any reference to an active cumulonimbus cloud in the vicinity of the airport, although there were active storms in the distance in several directions, and there was high level cumulonimbus overhead.

The following report was made by the pilot of a United States Air Force C-124 aircraft flying in the area around the time of of the accident:

> "When we turned inbound on our finals at about 2 000 ft QFE we had quite a turbulent ride. This was within 3 minutes of the crash. The visibility from 2 000 ft was good - over 10 miles - and I could clearly see the runway and approach lighting. There was no cloud at all on the approach, in fact, we encountered no cloud whatsoever from 5 000 ft QNH down to the ground."

The Flight

The aircraft had been chartered to carry spare engines, equipment and two passengers of Inter-Ocean Airlines Ltd. from Luxembourg to Leopoldville, Congo. It departed Hamburg at 2111 hours (16 June) for Luxembourg where it landed at 2311 hours on the same day. The duties of co-pilot were shared by the two first officers. During take-offs and landings one occupied the co-pilot's right-hand seat and the other the 'jump' seat opposite the central control pedestal. The co-pilot in the right-hand seat read out the check list, and the other took the executive action. At Luxembourg the aircraft was refuelled and cargo was loaded.

It took off at 0449 hours for Tripoli, where it landed at 1201 hours and remained there for 1-3/4 hours for refuelling and customs inspection. The co-pilots prepared the flight plan and obtained the meteorological forecast for the flight to Kano. The forecast showed good weather to Kano with isolated thunderstorms en route. Zinder was to be the alternate as the captain had been advised at Luxembourg that he should use it. He did not know that Zinder had only emergency lighting at 6 hours' notice and says there was no mention of this fact in the flight guide carried in the aircraft.

The aircraft left Tripoli at 1346 hours and the greater part of the flight was flown at flight level 100 (10 000 ft) instead of the planned flight level 80 (8 000 ft).

At 2044 hours the aircraft communicated with Kano Tower on 118.1 Mc/s giving its estimated time of arrival at Kano as 2124 hours. It continued its approach to Kano until about 2111 hours when it was advised to turn north and hold 60 - 70 miles from the airport until a storm passed through. At 2137 it was given permission from Kano ATC to make another approach to the KA beacon and turned south again.

After approaching the airfield on a VOR radial of 201°, the procedure approach to runway 07 was commenced over the KA beacon outbound at 5 000 ft QNH at 2214 hours. Runway 07 at Kano is 8 610 ft. The conditions were very turbulent, and a rate of descent of 300 - 500 ft per minute was maintained until the procedure turn was completed. The captain steered 246°M for 1-1/2 minutes instead of two minutes because of the tailwind. He then turned onto a track of 291°M and had to steer 270 - 280° to maintain it. After tracking 291° M for one minute he commenced a rate one turn to the left. At 2216, just before this turn was commenced, the aircraft reported "beacon outbound" and shortly after the turn was started "leaving 4 000 ft now". When the procedure turn was completed the aircraft reported "beacon inbound" at 2219, and the captain states that they were at 3 500 ft QNH. He ordered the "gear down" and the final landing check.

Although the aircraft was equipped with both VOR and a radio compass, it obtained four true bearings from Kano VDF during the inbound approach. The radio compass was unreliable as the electrical storm was moving the needle in all directions, and the VDF bearings were requested in order to check the aircraft's VOR heading.

During the final approach a power setting of 2 250 rpm and 28" MP was used; 15° flaps and indicated airspeed 125 kt. The captain estimated that it would take 3-1/2 to 4 minutes on the final approach to the runway threshold.

After the tower had switched on the high intensity lights, the aircraft reported that the runway lights were in sight. There was heavy rain, and the windshield wipers were switched on. The captain reached up to put on the landing lights, but heavy turbulence made him desist in order to control the aircraft.

The captain described the final part of the flight as follows: "Suddenly it was dark, it seemed as though we were in cloud, the altimeter was showing 2 200 ft (i.e. about 637 ft above Kano Airport elevation)... I had a feeling of being forced down and a strong light was in the cockpit. I pushed the throttles forward, and this was my last action." The captain's last recollection after the aircraft had struck and just before it came to rest was the altimeter reading 1 850 ft.

Evacuation and Rescue

When the aircraft came to rest the captain, the two co-pilots and one mechanic got out through the right-hand cockpit sliding window. The two passengers had been sitting in adjoining seats in the second row port side forward of the passenger cabin. The port inner propeller had pierced the fuselage and struck one of the passengers. The other passenger, after trying in vain to extricate his fellow passenger, was finally forced to break down the door leading to the flight deck and got out through the port cockpit sliding window. Later he, the captain and one of the first officers re-entered the aircraft and attempted to rescue the injured passenger but were driven back by the flames. The captain and the uninjured passenger then tried to reach him through the hole torn in the fuselage side but found it impossible.

The second mechanic, who was sitting in a rear seat on the port side of the passenger cabin, had been flung out when the fuselage broke open and was severely burned by an exploding fuel tank.

The airport fire and rescue vehicles were alerted by the Kano Air Traffic Controller when the accident occurred and proceeded to the scene of the accident as quickly as possible. Civilian rescuers were first to arrive.

The Scene of the Accident

The first point of impact was two trees 12 100 ft from the threshold of runway 07 and 1 925 ft to the north of the extended centreline. The point of impact was measured and found to be 60 ft above the official aerodrome elevation of Kano Airport (1 563 ft amsl) and the wreckage trail was on a heading of 97°T. The wreckage trail extended for about 230 yd. The two trees had been struck by both landing gear legs about 6 ft above ground level and indicated that the aircraft had been banked slightly to starboard at the time. The starboard wing had afterwards been severed outboard of No. 4 engine by striking another tree, and this had caused the aircraft to slew round with the result that the tail had been severed from the fuselage when it struck a tree 120 yd further on. The remaining forward section of the fuselage, with the port wing still attached, had finally come to rest in an upright position. When the starboard wing became ruptured fire broke out immediately, and there were traces of fire the full length of the wreckage trail. The main wreckage sustained extensive fire damage, and the main forward fuselage and cockpit were burned out. The length of the wreckage trail indicated that the impact speed had been of a comparatively low order - probably less than 120 kt.

All the instruments were severely damaged by fire and, with the exception of the two altimeters which were both found set to 29.92 in. Hg. provided little useful evidence.

The domes of the four propellers were removed, and their blade settings on impact were checked. They were found to be in the fine pitch range about 30° and their damage indicated that they were operating under a high degree of power on impact.

The Final Approach - Discussion of Evidence

Because of the tape recorded messages between Kano Tower and the aircraft it was possible to plot with reasonable accuracy the position of the aircraft along the final approach.

Considering all available evidence, the Board was of the opinion that the rate of descent of the aircraft during the final approach was around 470 ft per minute, which agreed with the pilot's statement "between 300 and 500 ft per minute", and that the accident occurred within a few seconds of 2223:25 hours.

The procedure approach carried out by the aircraft was not in accordance with the standard procedure laid down by the State. The aircraft, having elected to carry out a procedure approach, was instructed by the tower to report outbound over the KA beacon at 4 000 ft, heading 246° magnetic. At this time the aircraft had already passed the KA beacon at 5 000 ft having approached on a VOR radial of 201°. It had then turned onto 246° magnetic to commence the procedure approach and its descent. It actually reported "beacon outbound" two minutes later, immediately followed by "leaving 4 000 ft" when it was in the procedure turn. This careless reporting meant that the aircraft was not where the tower controller had been led to believe it was, at a time when the controller was having to use the positions and heights reported to effect separation between D-ABEB and another aircraft.

It has been found impossible to plot the outbound track of the aircraft with any reasonable accuracy. At the time it completed its procedure turn, it should have been 7-1/2 NM from the KA beacon; in actuality, at the time it reported "beacon inbound" at 2219:28 hours it was approximately 8-1/2 NM from the KA beacon and 1 mile north of the extended centreline of runway 07; but before this, at 2218:06 hours, when it obtained a bearing of 240°T it was approximately 10-1/2 NM from the KA beacon and just south of the extended centreline. (See Figure 9).

Due to the bearings that the aircraft obtained during its final approach it has been possible to plot its inbound track. (See Figure 9). It will be seen that the aircraft tracked away from the centreline until it was about 1-1/2 NM north of the centreline at a distance of 4-3/4 NM from the threshold of runway 07. It later appears that the aircraft did not turn in towards runway 07 until just after the last bearing 255°T, when it reported it had the runway lights in sight. This evidence is in accord with that of eyewitnesses of its final approach, and with the heading of the aircraft when it first impacted.

The Board examined the captain's and co-pilot's claim that just before the accident the altimeter read 2 200 ft QNH (i.e. about 637 ft above official aerodrome level at Kano); they entered cloud; a down-draught affected the aircraft, and that they were struck by lightning.

As both altimeters were found set at the correct QNH (29.92 in. Hg.) after the accident, the Board cannot accept the possibility that both instruments malfunctioned at the same time. Technical considerations render the possibility too remote. It is more than likely, however, that the captain saw this height indicated just before he saw the runway lights, and that he then concentrated on keeping the lights in view, and did not refer to his flight instruments again.

The darkness or cloud that the aircraft is said to have entered just before the accident was probably a simulated effect caused by it descending to the level of the trees and out of sight of the runway lights.

That there was lightning about during the final approach is not questioned. After considering the evidence of witnesses who watched the aircraft approach, and those on board the aircraft, the Board thinks that it is unlikely that the aircraft was struck when it was at a very dangerously low height. They consider that the light that illuminated the cockpit was very possibly caused by fuel igniting after the integral wing fuel tanks had been ruptured by the trees.

The Board accepts as a fact that the flying conditions on the final approach were turbulent and sufficient to vary the rate of descent to the amounts claimed by the captain and the co-pilots. But the captain did not have to vary his power during the final approach until just before the impact. At this point the aircraft was critically low as noticed by a senior airline captain who watched the approach from a position in front of Kano Airport and stated: "... Large cumulonimbus with continuous lightning to port of approach path Runway 07 at a distance of approximately 5 to 6 miles. The aircraft anti-collision light first appeared beneath this Cb and shortly afterwards the port light came into view. It was immediately apparent that the aircraft was very low and this drew my attention to it ... The aircraft was descending in a very shallow descent the whole time, and it was obvious that it would hit the ground if it continued in the same direction without checking the rate of descent (possibly about 200 ft per minute)..." At such a low altitude the aircraft may have been affected by additional turbulence from ground obstructions, and it may well be that a down-draught occurred during the last few seconds before the impact.

Fatigue

Consideration was given to whether the captain's judgement may have been affected by tiredness during the procedure approach brought about by the length of his flying duty period since leaving Hamburg. In considering this question, the Board has taken into account the fact that the crew stated that the aircraft carried a bunk for their use and that there were two co-pilots, though neither of them was qualified by his licence to act as commander of the aircraft during the captain's absence from the cockpit.

Allowing one hour for pre-flight preparation at Hamburg, the flying duty period before the accident was 26 hours 12 minutes and, making allowance for the captain's claim that he slept for 4 hours at Luxembourg in the airport building while the aircraft was being loaded, the flight duty period after leaving Luxembourg was 17 hours 34 minutes including the 1-3/4 hours stop at Idris Airport during which he was with the customs officials when they searched the aircraft.

The captain maintains that he was not tired. It is, however, well-known that a pilot's reactions become progressively slower the longer he is subjected to mental and physical strain.

In the captain's case he had been subjected to over an hour's flying in turbulent conditions at the end of a very long flying duty period (26 hours), and the Board considers that the procedure approach carried out by the captain was not of the quality that would have been acceptable for an instrument rating test, and was not of the type that the captain would have carried out if he had not been tired, bearing in mind that he had been an instrument flying instructor. The Board was of the opinion, therefore, that the captain's tiredness was a contributory factor to the accident.

Landing lights

It is left to the discretion of the pilot-in-command whether or not he uses his landing lights during a final approach to land. On this final approach, it was clearly the intention of the captain to use them after he had the runway lights in sight, for he reached up to switch them on but was prevented from doing so as he had to control the aircraft in the turbulence. There was no reason, however, why he did not instruct the co-pilot to illuminate them, and had he done so there is a possibility that the accident would not have occurred as he would have obtained ground reference.

Probable Cause

The accident was the result of an error of judgement on the part of the captain who, after sighting the runway lights, concentrated on keeping them in sight and failed to make adequate reference to his flight instruments. As a result, he allowed the aircraft to descend below the obstacle clearance limit of 360 ft. In the darkness with no ground reference, the distant runway lights gave him insufficient guidance as to his height and angle of approach, and he was unaware that the aircraft had descended to ground level. The fatigue of the captain and the failure to illuminate the aircraft's landing lights were contributing factors.

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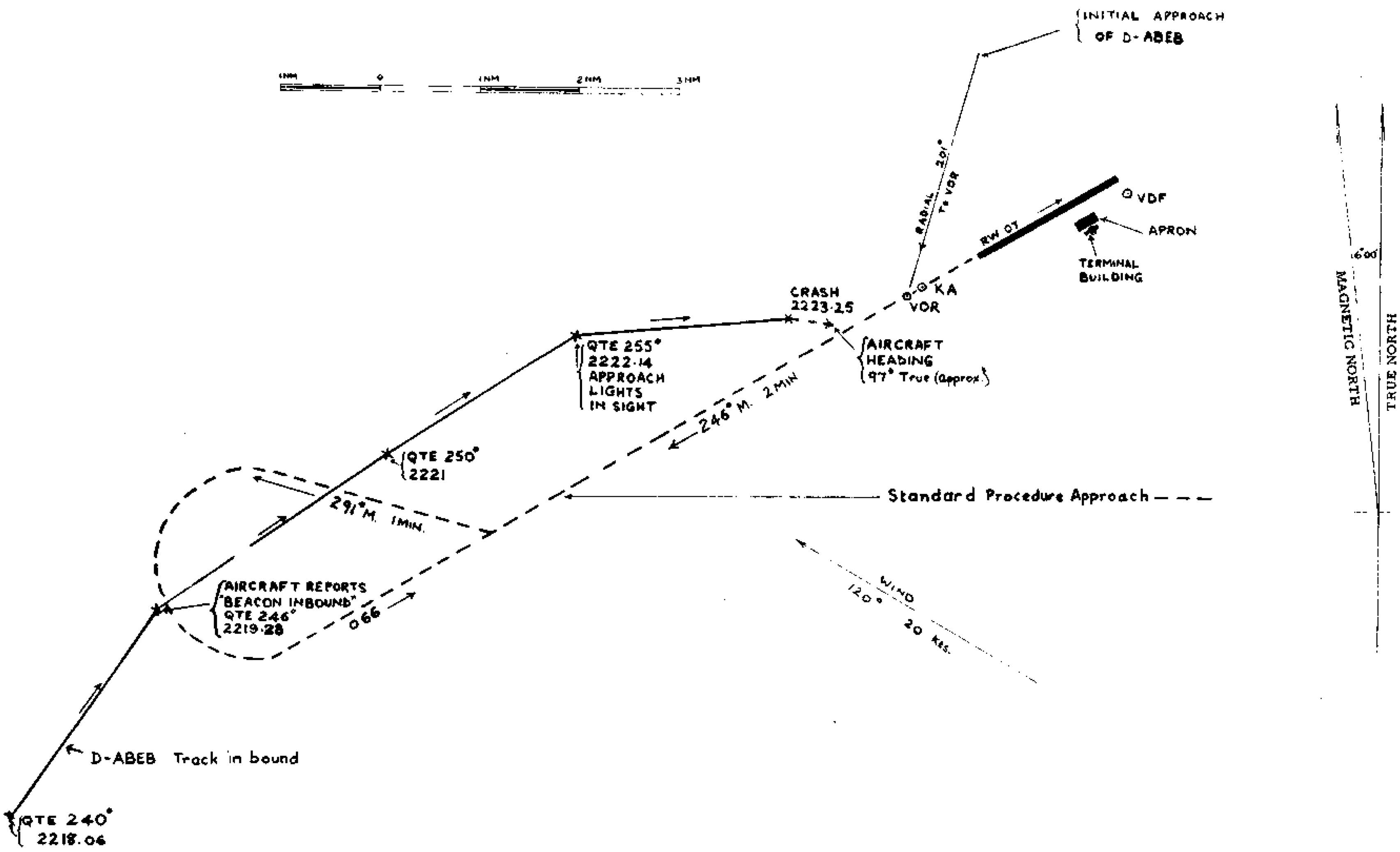
ICAO Ref: AR/708

C-54 (B-DC), D-ABEB
17/6/61

FIGURE 9



No. 20

Transcontinental S.A. de Transportes C. é I., C-46, LV-FTO accident near Buenos Aires Airport, Argentina, on 30 June 1961. Report No. 1477 released by The National Director of Civil Aviation, Argentina.

Circumstances

The aircraft was flying the last segment of a scheduled flight between Salta and Buenos Aires (Aeroparque) Airport with a stop in Córdoba. It carried 4 crew and 31 passengers. Departure from Pajas Blancas Airport, Córdoba was at 1846 hours*, and the aircraft flew at an altitude of 2 700 m making routine contacts until it approached Buenos Aires Airport where it was cleared for an instrument approach to runway 12. During the approach, approximately 1 300 m from the threshold of the runway and 175 m to the right of the extended runway centreline the aircraft hit a railway signal mounted on top of an 8 m support, which caused it to lose the outer part of its right wing. The aircraft turned about 45° to the right, hit a group of trees and telegraph lines with its propellers and left wing and fell in a public area where it caught fire due to fuel spillage. The time of the accident was about 2057 hours. Twenty-two passengers and the 2 pilots perished in the accident. The aircraft was destroyed.

Investigation and Evidence

The Aircraft

A 6 000-hour inspection was carried out on the aircraft in February 1961, and the aircraft's airworthiness certificate was re-validated until 30 September 1961.

On 28 May 1961 another inspection was made at the time of the left engine change. The aircraft continued flying until the date of the accident. All the required periodic inspections were fully recorded and on 30 June 1961 the aircraft had a total of 8 926:40 hours, of which 6 780 hours had been logged since the last major overhaul.

The authorized maximum take-off weight for this aircraft was 21 614 kg, and its maximum landing weight was 21 546 kg. The aircraft's actual gross weight at time of take-off from Pajas Blancas was 20 658 kg, i.e. within the permissible limits.

The Crew

Four crew members were aboard the flight - the pilot, co-pilot and two stewardesses. Only the two stewardesses survived the accident.

Both pilots held valid airline transport pilot licences. The captain had flown a total of 6 772 hours, and the co-pilot had logged a total of 3 816 hours. From various statements it appeared that the co-pilot was occupying the left-hand seat at take-off and was still in this position ten minutes before the accident. At no time had either pilot exceeded the maximum number of hours permitted.

Weather conditions

The weather forecast given at time of take-off (1846 hours) from Pajas Blancas, which was to cover the duration of the flight, was:-

> overcast; rain 8/8; cloud type: stratus and numbostratus with a 100 m to 200 m ceiling; at 2 500 m there was an 8/8 overcast of altostratus; visibility was from 2 to 4 km. No turbulence was forecast.

* All times are local.

The conditions at Buenos Aires which were passed to the aircraft at 2042 were as follows:-

2000 hours wind ESE 15/20 kt; visibility 4 km; present weáther, rain, overcast 8/8 fractostratus at 100 m; barometric pressure 1021.1; temperature 10°C; dewpoint 9°C.

The instrument approach chart valid at the time of the accident was issued on 15 May 1961 and was in use by the company. It showed as minimum values for runway 12 at night a ceiling of 130 m and a visibility of 1 500 m.

Transcontinental S.A. had raised the minimum ceiling to 150 m but retained the figure of 1 500 m for visibility.

The weather conditions at Buenos Aires were below the minima laid down by Transcontinental S.A. and also below those laid down by the official authority.

The Approach to Buenos Aires Airport

From the time the flight contacted the control tower and started its approach procedure the conversation exchanged between the aircraft and the tower was recorded on magnetic tape.

First contact with the tower was at 2042 hours when the aircraft advised that it was over El Mundo radio station at 900 m. The flight was cleared to descend to 600 m and head for the outer marker "OP". At this time the 2000 hour weather observation was passed to the aircraft.

At 2048 the flight reported it was over the inner marker "P" and would start its turn to fly the outbound leg and would return over the same marker "P" to check the passage. Three minutes later it was over the outer marker "OP" on the outbound leg at an altitude of 600 m. At 2054, still on its approach, LV-FTO advised it was making a procedure turn for approach to the aerodrome and would inform when over the outer marker "OP". Two minutes later it was over the outer marker "OP", in partial contact, with visibility reduced by showers. The tower cleared it to final approach requesting the aircraft to report again over the inner marker "P". Nothing more was heard from the aircraft.

Site of the Accident

The accident site was at an elevation of 6 m asl, in front of the Balneario railway station. Railway tracks which start at Retiro Central Station pass in front of the airport and run parallel to the runway for its entire length to serve Balneario Station. In the station there is a building, 10 m high, which is used as a signal cabin. It is surrounded by trees which vary from 10 to 20 m in height. A few metres from the station, still in the same direction and at the side of the tracks, there is a semaphore signal which is mounted at the top of an 8 m mast.

The aircraft hit the metal mast, its right wing's outer portion was cut off about 7 m from the tip. The severed portion of the wing was carried forward by its own momentum and landed upside down about 50 m from the point of impact. The aircraft continued onward, veering to the right and after hitting several trees with its left propeller and wing, turned on its back and struck the ground with the cockpit roof, propellers and engines. The fuel tanks were ruptured, and the aircraft was totally destroyed in the subsequent fire.

Both engines were functioning, and increased power was applied a few moments before the crash. It was presumed that both engines were stopped following the loss of lateral stability which was impossible to counter at the time the portion of wing and corresponding aileron were torn off.

Witness information

One witness on the ground, an engine driver, was leaving the Balneario Station at 2056 hours driving a passenger train. About

150 m in front of the locomotive he observed the landing lights of an aircraft which was flying above the railway tracks; the lights were shining directly on the train. At first, the witness thought it was a low-flying aircraft in normal flight; then he observed that, as it approached, it was also losing altitude as if to land. For that reason, he turned off the train's headlight in order not to blind the pilot of the aircraft which, at that moment, passed about 3 m above the roof of the train cabin. He saw the aircraft tilt from left to right as though it had struck an obstacle, and then it straightened out, but he heard a sharp noise and felt sure that the aircraft had hit something.

The engine driver and the fireman on the same train declared that the weather was bad at the time. It was drizzling, and visibility was 300 m.

Some of the surviving passengers stated that the aircraft was flying very low before reaching the River Plate stadium. They could see the lights of the Vicente Lopez area. They then passed very low in front of the stadium and further along they could see the streets of the city, vehicles and people. At the same time, they observed that the engines were working perfectly, that the undercarriage and flaps had been lowered, and the landing lights were on. Later they heard an acceleration of the engines, followed by a hard jolt on the right side of the aircraft, and had the impression of making "an about face". They stated that there was neither fire nor explosion in the aircraft before the accident.

This was confirmed by the statements of the two stewardesses.

Instrument Approach Procedure

a) Official approach procedure for runway 12 as stated was published on 15 May 1961 and will remain a temporary document until the inner marker "P" is located in its final position, i.e. in line with the axis of the runway. It was 130 m to the left of that line.

When making the approach, after authorization has been received from the tower, the outer marker "OP" must be passed over at an altitude of 310 m, on a heading of 123°. The inner marker must be passed over at a minimum altitude of 130 m if visual contact has not already been established with the runway threshold. The climb-out should then be made on a heading of 90°. The minimum altitude in the area is 600 m.

b) Performance of the markers and of the control tower

The markers "OP" and "P" were working perfectly on the day of the accident according to the statements of the operator in the control tower. This was confirmed by the pilots of four aircraft who used the airport previously. They landed between 1950 hours and 2035 hours, i.e. a few minutes before the arrival of LV-FTO. The pilot of LV-FTO appeared to have some difficulty in recognizing the identification signal of the marker "P" during his procedure approach. However, despite this, he heard its emission and identified it correctly. He then decided to make another pass over it to complete identification, after which he made a turn to locate the "OP" marker.

c) Application of the procedure by the aircraft involved

If one plots, graphically, the instrument approach made by the aircraft in accordance with the communications which were sent to the control tower, the location of the aircraft would be above the outer marker "OP" in partial contact flight, with visibility reduced by rain. (No altitude specified). That marker is located in line with runway 12, at a distance of 7 km from its threshold.

If the aircraft had flown over the outer marker "OP" at the altitude prescribed by the procedure 310 m in a slowly descending trajectory 2.5 m/sec it should have climbed out if the threshold of runway 12 was not visible at the time it reached an altitude of 130 m (critical altitude) still heading for the inner marker "P". How then could it be explained that the aircraft struck a railway signal 8 m above the ground and located 305 m to one side of the inner marker "P"? It should be remembered that this obstacle is not in line with the runway, but offset 175 m from its centreline. This means that the aircraft was flying to the right of the runway, at an altitude lower than that prescribed by the regulations covering instrument approach procedures.

From this, it is obvious that the pilot abandoned instrument flying, and did not comply with the indications of the approach chart. Another aircraft captain who landed on the same runway at 2035 hours, just a few minutes before the accident to LV-FTO, encountered a ceiling of 180 m and said it was necessary to make the approach on instruments for this landing.

As to whether he should have attempted an instrument approach procedure under the weather conditions which prevailed at the time, the data reveal that these conditions were below permissible limits authorized by the Government office and even more below those authorized by Transcontinental S.A. for a night landing on runway 12.

It cannot be doubted that the pilot came down lower than the prescribed critical altitude of 130 m during the instrument approach, as he hit an obstruction 8 m in height.

Supposing that the captain actually crossed the outer marker "OP" at the prescribed altitude of 310 m, not only did he descend lower than the critical altitude of 130 m without establishing normal visual contact with the runway threshold and without having passed the inner marker "P", but he did not make a descent at the prescribed rate of 2.5 m/sec. If he had done this after passing the outer marker at 310 m and then descended below the critical altitude, his altitude would have been 68 m at the railway signal.

After reading the statements of the aircraft's passengers, it was obvious that they identified lights in the Vicente Lopez area, and vehicles and people in the area of the River Plate stadium. In view of the weather conditions, low ceiling, and, at times, heavy rain, it must be admitted that the identification of such objects could not have been possible unless the aircraft passed the outer marker "OP" at an altitude lower than that prescribed (310 m).

Passing the outer marker at a low altitude, attempting to continue contact flying when weather conditions did not permit, *and abandoning the protection of the inner* marker as a control caused the aircraft to hit the railway signal.

Actions of the control tower operator and the Transcontinental S.A. dispatcher at Buenos Aires

The tower operator cleared the aircraft to make an instrument approach but did not clear it to land.

As required by the regulations, the dispatcher forwarded complete weather information to the Operations Office in Córdoba so that the aircraft captain could be given the weather situation for the route and for Buenos Aires Airport as well as for the Mar del Plata Airport, the alternate. He could have suggested to the captain that the alternate be used, since the weather minima at Buenos Aires Airport were below those authorized by Transcontinental S.A.

However, the explanation he gave in his testimony was accepted, i.e. that he spoke to a captain who landed a few minutes before LV-FTO arrived. This pilot had stated that the actual weather conditions were better than those reported officially. On the other hand, the dispatcher knew that the control tower had passed the necessary weather information to the aircraft in question. It showed values lower than those authorized. The dispatcher also knew that the pilot was aware of this fact, as his operations manual gave the values applicable to the various airports. Furthermore, the pilot was familiar with the airport.

In short, the dispatcher knew that a procedure approach only had been authorized and that no clearance had been given for landing. He also knew that, although the pilot had a partial visual contact, he had to follow the procedure which, if carried out correctly made for a safe landing. He said that for this reason he did not suggest that the captain change his destination, as he (the dispatcher) did not wish to interrupt him while he was working out his problem. However, he would have done so if the aircraft had been unable to land.

Probable Cause

The pilot failed to follow the instrument approach chart during the approach.

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ICAO Ref: AR/714

No. 21

KLM, DC-8, PH-DCG went into a steep climb when cruising over the Atlantic Ocean, 1 July 1961. Report, dated 30 July 1963, of the Aeronautical Board, the Netherlands.

(Note of ICAO Secretariat:

Although the following does not actually come within the ICAO definition of an accident and, therefore, does not appear in the classification tables, the summary is included in the Digest to point out the need for pilots to monitor their flights continuously.)

Circumstances

At 0710 hours GMT on 1 July 1961 the aircraft left Idlewild Airport, New York, on scheduled flight KL 622 for Amsterdam, with an intermediate stop at Prestwick, Scotland. Around 1010 hours, while the aircraft was cruising at about 11 300 m (flight level 370) on the automatic pilot, it suddently went into a steep climb. The pilot-in-command, who had one hand on the control column, felt a backward blow on the column and at the same time saw that the artificial horizon on the left instrument panel had tumbled. He immediately disconnected the automatic pilot and throttled down, whereupon the aircraft, which had climbed 1 200 ft in the meantime, resumed a horizontal attitude. As a result of the rotation produced by this manoeuvre the people in the aft end of the passenger cabin were thrown against the ceiling and four passengers and a stewardess received minor injuries.

The aircraft headed for Prestwick with the automatic pilot switched off and landed there at 1258 hours. A check at the airport showed that no damage had been sustained by the aircraft.

Probable Cause

The accident occurred as the result of jamming of the vertical gyro (through rupture of the bottom bearing) which led to the automatic pilot giving the hard-over signal on the elevator control and sending the aircraft into a steep climb. The recovery, which was effected by the captain switching off the automatic pilot without - in accordance with the regulations in force at the time - first putting the control column into neutral. This provoked such a violent rotation of the aft end of the cabin that some of the occupants were thrown against the ceiling and injured on the rebound.

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ICAO Ref: AIG/ACC/REP/GEN/No. 2 - The Netherlands

Scheduled International
En route
Other - failure of autopilot
Equipment and accessories - instruments

No. 22

United Air Lines, Inc., Douglas DC-8, N8040U, accident at Stapleton Airfield, Denver, Colorado, 11 July 1961. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0003, released 20 July 1962.

Circumstances

On arrival at Stapleton Airfield from Omaha, Nebraska, the aircraft crashed during its landing roll at 1136 hours mountain standard time. None of the 122 occupants of the aircraft (i.e. 7 crew and 115 passengers) was severely injured as an immediate result of the impact; however there were 16 passenger fatalities as a result of carbon monoxide poisoning when the aircraft burned. One other passenger, an elderly woman, broke both ankles during evacuation of the airplane and later succumbed to shock. In addition, the driver of a panel truck, which the aircraft struck after leaving the runway, also suffered fatal injuries.

Investigation and Evidence

The Flight

Flight 859 originated in Philadelphia and was scheduled to proceed to Chicago, Omaha and Denver. The first two stages were completed without incident. During taxi, take-off and climb out of Omaha the operation of the aircraft and its systems was normal.

At about 20 000 ft the crew noticed that the manual reversion lights in the flight control system were indicating that the hydraulic boost controls had reverted to manual system, and the hydraulic fluid quantity gauge indication was decreasing rapidly. They immediately isolated all hydraulic systems by placing the system selector lever in the No. 1 position, and placed engine-driven hydraulic pump bypass switches to the "off" position. The reading of the hydraulic quantity gauge stabilized at the midpoint of the low range of the instrument.

The captain, who had been flying the aircraft manually, turned the controls over to the first officer while he and the second officer evaluated the situation, consulting the aircraft manuals and an operator's training bulletin. They decided that they had an abnormal rather than an emergency hydraulic situation and, therefore, elected to continue to Denver rather than return and take advantage of the longer runway at Chicago.

During the time the flight was continuing to Denver the crew contacted the company dispatcher and discussed the situation.

As it progressed the crew monitored the situation, reviewing the procedures to be followed during the landing. As a precaution, after starting descent into Denver, the flight was cleared to hold at 14 000 ft in order to check out the hydraulic system in preparation for landing.

The crew then tried to extend the ejectors (engine thrust reversing assemblies) by letting the airstream blow them back. This was unsuccessful even when they increased speed from about 180 kt to 260 kt. This action undertaken by the crew was of no value because the system is designed to prevent, by mechanical means, blowback of the ejectors under aerodynamic loads. After reducing speed again, they turned on the auxiliary hydraulic pump. Pressure built up to 3 000 psi, steady blue lights indicated the ejectors had extended properly, and the hydraulic fluid quantity indicator remained constant.

The captain then called for 15° of flap. At the same time the slot extend indicator light came on and then went out, indicating that the wing slots were open and locked. The hydraulic pressure gauge indicated 3 000 psi, and the quantity remained constant. After completing the approach descent checklist and receiving a clearance to the airport, 25° of flap was selected. At this time, the hydraulic pressure fluctuated rapidly and then fell to zero. The hydraulic fluid quantity gauge indication fell to a point about 1/8" from the bottom of the scale, whereupon the flap selector lever was returned to the 15° detent, and the auxiliary pump was turned off.

It was then decided to allow the gear to free-fall. The three green landing gear indicator lights came on, indicating that the gear was down and locked. Throughout this operation the hydraulic quantity indication remained constant. The hydraulic system selector control was then placed in position No. 3, the auxiliary pump was turned on, and the flaps were selected to 25° and extended normally.

The captain decided to use runway 26L so as to avoid flying over the city and because he could make a flatter approach to the fields. After the final checklist was completed 40° of flap was obtained. The approach speed was kept at about 155 kt in case the aerodynamic loads forced the flaps to return toward their retracted position. About one-half mile from the threshold, airspeed was reduced and 50° of flap were called for. The aircraft crossed the threshold at a speed of 125-128 kt, and a normal touchdown was made at about 120 kt. It was later determined from flight recorder data that touchdown occurred about 1 650 ft from the threshold.

The crew stated that their normal procedure after touchdown as to place all four power levers in the idle reverse position, without command, prior to touchdown of the nose gear. When the first officer felt the nose gear on the runway, and on the captain's command, he would apply reverse power to Nos. 2 and 3 engines and then to Nos. 1 and 4 which could be used differentially for directional control. This, according to testimony, was the procedure followed.

The crew subsequently stated that the touchdown was normal,the power levers were brought to the idle reverse position, and all four amber reverse indicator lights came on. As the nose gear touched the captain called for reverse and felt the aircraft swerve to the right. He immediately applied full left brake and left rudder. When this action failed to prevent the aircraft leaving the runway he used the emergency airbrakes to slow the aircraft as much as possible. Soon after the aircraft left the runway a loud snap was heard, and the right wing dropped sharply. The aircraft continued to skid off the runway, turning onto a northeasterly heading before hitting a newly constructed raised concrete taxiway.

The first officer stated that as the nosewheel touched down he applied reverse power to Nos. 2 and 3 engines and was reaching for power levers Nos. 1 and 4 when he felt the aircraft lurch to the right off the runway. He then advanced the power levers for Nos. 3 and 4 to the forward thrust range. He subsequently stated, however, that he had not noticed the amber reverse indicator lights and did not apply reverse thrust on any engine.

The second officer had been instructed to monitor the flap indicator during the approach and warn the captain immediately if the flaps started to move toward "up". He was further instructed to swivel his seat immediately on landing and call out brake accumulator pressures. He confirmed that the approach and landing were normal but was unable to place in sequence, with any degree of certainty, his observations regarding the series of events which occurred immediately after touchdown. As the aircraft skidded across the grass he vacated his seat and started back to the passenger cabin, anticipating an emergency evacuation. By the time the aircraft came to rest on its belly he had opened the forward passenger loading door and installed the emergency slide. He noticed that fire had broken out on the left side of the aircraft and that the cabin was beginning to fill with smoke as he began to assist passengers to the exit.

The first officer and two male passengers held the uninflated evacuation slide at the forward door and assisted passengers from the aircraft. Meanwhile, the captain and second officer were making repeated trips into the smoke-filled cabin to assist passengers. Finally, no more passengers could be found in the first class section, by which time flames completely covered the forward door.

The senior stewardess in the first class section opened the forward galley door, but as flames were already present on the right-hand side of the fuselage she did not attempt to use this exit. After ensuring that the divider door between the first class and tourist sections was open, she proceeded to assist passengers through the emergency exits until she too was instructed to leave the aircraft. The other stewardesses opened the rear galley exit and installed and inflated the emergency slide. They then assisted passengers out and away from the burning wreckage.

Several ground witnesses, some of them pilots, confirmed that the approach and touchdown were normal and that the aircraft rolled straight down the runway for a distance of 700 to 800 ft. Their evidence indicates that the left wing lifted quite high as the aircraft swerved off the runway.

One passenger, who was seated in the forward lounge, stated positively that the thrust reverser buckets on both Nos. 1 and 2 engines did not close. He heard the power cut, and the aircraft touched down with a hard landing. He also felt the nose gear touch down and immediately thereafter he heard power reapplied. At the time of the sound of power he had the impression of acceleration and thought the pilot was executing a go-around. The aircraft then swerved, and he could see they were going off the runway.

Several fire fighting crews attended the aircraft. There was substantial variation in the estimated elapsed time between the accident and the fire fighting personnel being in position to fight the fire. It was estimated that the fire was brought under control in about 30 minutes.

Accident Site

Investigation revealed that the airplane had slid in a curved path to the right, off the runway, across a grass strip, hit the raised edge of a newly constructed concrete taxistrip, and had come to rest on the taxistrip about 4 950 ft from the threshold of runway 26L and 400 ft to the right of its centreline. Tire marks on the runway were clearly visible as were the tracks across the intervening grass strip. It could be seen that the path of the aircraft over the ground curved from a westerly to a northwesterly heading while the aircraft's heading changed from about 260 to 026° magnetic.

All four tires on the right main gear were blown out. The skid marks left by these tires were visible continuously, curving off the runway and across the grass to the point where the gear failed and separated from the aircraft. The marks left by the left main gear tires were intermittent and were not discernible as the aircraft curved off the runway and across the grass. Three of the tires blew out during the skid, whilst the fourth ruptured on impact with the raised taxiway. The nose gear failed during the skid and separated from the aircraft.

Technical Examination - Results

Three of the four engines were torn out of the aircraft and suffered varying degrees of damage. No evidence of any pre-impact malfunctioning was detected in the subsequent examination.

The extensive fire after impact destroyed a major portion of the left wing and left side of the fuselage, from the flight deck area aft to the rear passenger loading door. In addition, the entire inside of the cabin was gutted. The fuselage area aft of the rear passenger door was crushed inward by contact with a surveyor's panel truck which was parked 300 ft from the runway centreline. The force of this impact distorted the rear door lower frame, thus preventing the door from being opened from the inside.

Fire damage on the right-hand side of the aircraft was confined to the wing trailing edge and flap. The empennage was intact, and the control surfaces were undamaged.

Apart from establishing the position of the significant controls and confirming that the various systems were capable of normal operation, the technical investigation was centred on the hydraulic system. An extensive investigation was also conducted into the crash injury and emergency evacuation aspects. It was learned from the survivors and from the pathological study of bodies that the deceleration of the aeroplane was not excessively high and that no apparent traumatic injuries were sustained by the crew or passengers as a result thereof.

Evacuation

The crew members opened the forward left main entrance door and the aft right galley door, while passengers opened both of the overwing exits on the right side of the cabin. Through these exits 106 of the occupants evacuated the airplane. All of the 39 first class passengers, three flight crew members, and two stewardesses evacuated through the forward left-hand door or through the overwing exits. Sixty-two of the 78 occupants of the tourist section evacuated the airplane utilizing the two door exits and the aft overwing exit on the right side. The entire evacuation was complicated by the dense smoke throughout the cabin.

Analysis

The damage to the aircraft was such that it was not possible to determine the source of the initial loss of hydraulic fluid, although some sections of the system could be eliminated from consideration either because they were not utilized during the flight or were isolated by crew actions.

Following the initial loss of fluid the crew reported that the hydraulic quantity indicator was about 1/8" from the bottom of the gauge. The hydraulic reservoir holds 10 gal of fluid but the minimum fluid level which the float transmitter in the tank will sense is 3.5 gal. The quantity gauge dial presentation consists of an arc of 120° with a "low" and "normal" segment, the low end representing the 3.5 gal-level and the high end representing the 10-gal level. A change of one gallon of fluid within these limits would be reflected by 18.5° of movement of the quantity indicating needle.

When the crew extended the ejectors no change occurred in the indicated fluid quantity level, although about 3/4 gal of fluid would be removed from the reservoir. Also, when the landing gear was allowed to free fall, about 1.6 gal of fluid would have been returned to the reservoir, yet no increase was registered on the quantity gauge. From these indications it appears that the hydraulic fluid level must have been below the lowest level measurable by the float transmitter.

It also appears that the inability to get 25° of flap was because the fluid level at that time was below the taller standpipe supplying fluid to the auxiliary hydraulic pump inlet.

The procedures followed by the crew to prepare the aircraft for landing were the approved procedures based on the information available to them during the flight. The shift to the No. 3 position of the hydraulic system selector was proper and necessary to ensure positive flap actuation during the approach. In this position there was no pressure available to the general hydraulic system, which powered, among others, the ground spoilers, nosewheel steering, and the rudder. Hydraulic braking was available from the brake accumulator.

Evidence indicated that after touchdown the thrust reverser buckets on the left side of the aircraft did not rotate to the closed position. These buckets must be closed to deflect engine thrust in a forward direction. They are actuated by an engine air bleed which is connected to the bucket only when the ejectors are fully extended. If an ejector does not extend fully or if it should move forward as much as 3/8", its gland coupling will not engage, and the thrust reverser buckets will not close.

The ejectors are hydraulically operated. There is also an emergency provision for extending the ejectors by use of the air bottle system. That system was not used. Each ejector mechanism has a control valve which ports system pressure to its actuating cylinder to extend or retract the ejector. Each control valve incorporates two spring-loaded poppet plunger type valves which are solenoid actuated alternately to either extend or retract. These valves are tested prior to service to operate with 3 000 psi applied and the leakage rate, after a three-minute seating time, to be within specific limits. During this test, leakage is greater at low pressure and decreases as higher pressures tend to seat the poppet valves more solidly. For this reason, following loss of system pressure, the unseating tendency will permit internal leakage to the return lines. Any internal leakage of an ejector control valve, under these conditions, has the same effect on the adjacent system. This is because both ejector control valves, on either side of the aircraft, are supplied by a common pressure line which incorporates two opposing one-way check valves. One check valve permits the introduction of fluid pressure, and the other permits high pressure air to be introduced as an alternate method of ejector operation. Any leakage by either the one-way check valves or the ejector control valves will relieve the hydraulic lock feature which is designed to hold the ejectors in the extend position when system pressure is lost, and permit both ejectors on the same side of the aircraft to move forward from applied forces. These forces include pressure in the system return lines, aerodynamic loads, and the forward shifting tendency upon touchdown and during rollout.

The ejectors were fully extended and remained in this position during the approach, as evidenced by the four steady blue lights of the position indicating system. At the moment of touchdown, however, the second officer recalled seeing ejector lights blinking, indicating that one or more were in transit.

The Board believed that the ejectors for engines Nos. 1 and 2 did shift forward after touchdown and prior to the positioning of the power levers in the reverse idle detent. As a result, when the crew positioned the power levers for reverse thrust, the thrust reverser buckets were not closed. This allowed engines Nos. 1 and 2 to develop forward thrust while engines Nos. 3 and 4 were producing reverse thrust during power applications.

Evidence of asymmetric thrust was found in the flight recorder trace, which contained unusual fluctuation in indicated altitude beginning about six seconds after touchdown. Detailed studies of two other recorder traces of DC-8 landings in which asymmetric thrust occurred showed almost identical trace patterns, whilst study of the traces of normal landings disclosed no evidence of similar aberrations.

The rapidly fluctuating indicated altitude, while the airplane is at constant altitude, obviously results from the asymmetrically disturbed airflow at the static ports during asymmetric reversing.

In order to understand clearly the sequence of events which took place during this landing, a comprehensive analysis was made utilizing flight recorder data, tire skid marks, and crew statements.

Based on the results of the analysis the following conclusions were reached:

1. All four engines were at or near idle forward thrust at touchdown.

2. All four power levers were placed in their reverse idle detents 2.5 to 3 seconds after touchdown.

3. The thrust reversers for engines Nos. 1 and 2 were inoperative.

4. Maximum continuous thrust was initiated on the inboard engines 5 seconds after touchdown.

5. Full manual rudder control and differential braking were initiated 5 to 6.5 seconds after touchdown.

6. Maximum continuous thrust was initiated on the outboard engines 5.5 to 6 seconds after touchdown.

7. The application of maximum continuous power to all engines resulted in high asymmetric thrust forces causing an uncontrollable lateral deviation from the runway.

From all the evidence it was concluded that in the subject case the first officer applied reverse thrust without checking to see if the amber thrust reverser indicator lights were on. The normal procedure for reversing requires that these lights be on before increasing power for reverse. Subsequent to the accident the need for close monitoring of these lights was re-emphasized by the company.

The crew's original diagnosis of the trouble was correct in that an abnormal hydraulic situation existed. Very shortly after departing the holding pattern (at Strasburg) en route to runway 26L, the abnormal situation abruptly developed into an emergency condition. This occurred when 25° of flap was selected. When the complete loss of hydraulic pressure occurred, the crew should have been aware that an emergency situation had developed and that a normal landing could not be expected.

Probable Cause

The probable cause of this accident was the asymmetric thrust which, during hydraulic emergency, resulted from the failure of the thrust reversers on engines Nos. 1 and 2 when reverse thrust was selected.

A contributing factor was the failure of the first officer to monitor the thrust reverse indicator lights when applying reverse thrust.

Follow-up Action

As a result of this accident the manufacturer made several modifications to the DC-8 systems. These modifications, some of which were instigated by the Civil Aeronautics Board, were made mandatory by the Federal Aviation Agency through the issuance of Airworthiness Directives. These included: a dual source of hydraulic power for actuation of all wing spoilers during landing roll; increased brake accumulator capacity; a dual source of hydraulic power for the rudder power system; a source of power to actuate nosewheel steering when the airplane hydraulic system is being operated with the hydraulic system selector handle in the No. 3 position; additional hydraulic fluid reserve capacity with changes in the fluid reservoir quantity indicating system; dampers wherever necessary in the hydraulic system to limit pressure surges to acceptable levels; and the installation of a power lever thrust-brake interlock system to prevent application of reverse thrust until the thrust reverse buckets are in the reverse thrust position. This interlock also is designed to return a power lever to the idle detent position should the corresponding buckets move from the reverse thrust position.

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ICAO Ref: AR/727

No. 23

Ceskoslovenské Aerolinie, Ilyushin 18, OK-PAF, accident south of Anfa Airport, Morocco, on 12 July 1961. Report released by The Directorate of Aviation, Morocco.

Circumstances

The aircraft was on a scheduled flight from Zurich, Switzerland to Rabat, Morocco carrying 8 crew and 64 passengers. At 0101 hours GMT the pilot signalled that he was going to Casablanca - Anfa because of unfavourable weather over Rabat - Sale.

After a balked landing following his first approach at Casablanca - Anfa and climb back to the safe altitude of 1 300 ft, the pilot requested permission from Anfa Airport to land at Nouasseur. During the time Anfa control was transmitting this request to the American authorities in Nouasseur, the aircraft crashed at 0125 hours GMT, in line with runway 03 about 8 miles from its threshold. Ground elevation at the point of impact was 450 ft. All occupants of the aircraft were killed, and it was completely destroyed by the crash and the ensuing fire.

Investigation and Evidence

The Aircraft

The aircraft, built in the U.S.S.R., held a certificate of airworthiness, valid until 22 April 1962. It had flown about 268 hours since manufacture.

Airframe checks had been made within the prescribed periods.

The aircraft was equipped with a complete set of instruments, allowing day and night, bad visibility and poor weather IFR flights.

The maximum allowable take-off weight of the Ilyushin 18 is 61 000 kg (135 000 lb). At the time of take-off from Zurich OK-PAF weighed 59 723 kg (132 000 lb). Its centre of gravity was within the permissible limits. From the foregoing it was concluded that the aircraft's gross weight and centre of gravity at the time of the accident were within the allowable limits.

When leaving Zurich the aircraft was carrying 15 500 kg (34 200 lb) of fuel. Consumption during the flight was about 9 000 kg (20 000 lb) dependent on altitude, speed and weather conditions, which would leave 6 000 to 6 500 kg (13 200 to 14 300 lb) at the time of the landing at Casablanca.

Crew information

The flight carried a pilot-in-command, a co-pilot, a navigator, a radio operator, a flight engineer, two stewardesses and a steward.

The pilot-in-command held a first class licence valid up to 26 July 1961. He had a total of 10 560 flying hours, of which 826 were on the Ilyushin 18. During the last three months he had flown a total of 100 hours. He had a total of 208 hours' experience on African routes and had made four landings at Casablanca - Anfa.

The co-pilot held a second class commercial transport pilot's licence valid until 23 November 1961 and was qualified for day and night flights on the Ilyushin 18. His total number of flying hours amounted to 6 301 of which 223 were on the Ilyushin 18. He had flown 125 hours during the last three months and 57 hours on African routes but had made no landings at Casablanca.

The navigator, radio operator and flight engineer also had considerable flying experience and valid licences.

C.S.A. weather minima for instrument approaches at Casablanca - Anfa

They were as follows:

horizontal visibility	1 000 m (3 280 ft)
cloud base (amount, type and height above official aerodrome elevation)	150 m (490 ft)

These minima, used by the pilot during his first approach, had not been communicated to the Moroccan authorities for approval.

Note. - The above minima were lower than those currently applicable at Casablanca-Anfa, which were as follows:

3 200 m (10 500 ft)
200 m (650 ft)

Weather information

General weather situation and forecast at 0000 hr (midnight) GMT, 11/12 July

"The generally stable weather which has prevailed for several days over North Africa, including Morocco, will be disturbed by a mass of polar air, rather extensive for this period of the year. Isobars are changing position relatively quickly."

"The maritime air masses which have been stationary above the Atlantic Ocean will be set in motion by this cold mass, and should cross over Morocco during the latter part of the night of 11 12 July and the morning of 12 July, bringing in banks of stratocumulus."

The weather in Kenitra on 12 July at 0000 hours GMT explains the fog in Sale.

In Casablanca there was low stratus. The ceiling at Anfa was 150 m (500 ft) as measured by a nephoscope.

Weather conditions between 0100 - 0200 hours on 12 July

Casablanca - Anfa

at 0100 hr	155-70000-60031-87705	at 0130 hr	155-70000-60831-87705
QNH:	1017	QNH:	1017
QAN:	calm	QAN:	calm
QBA:	10 km (6.2 mi)	QBA:	10 km (6.2 mi)
QNY:	No	QNY:	No
QBB:	7/8 St 150 m (500 ft)	QBB:	7/8 St 150 m (500 ft)

Rabat - Sale

at 0100 hr	135-00000-00460	at 0130 hr	135-00000-0044
QNH:	1017	QNH:	1017
QAN:	calm	QAN:	calm
QBA:	zero	QBA:	No
QNY:	fog (sky visible)	QNY:	fog (sky visible)
QBB:	clear	QBB:	clear

Special meteorological report:

Deteriorating conditions at Rabat - Sale:

0050 hr QAN: calm; QBA: zero; QNY: fog, sky visible; QBB: clear

0150 hr QAN: calm; QBA: 100 m (300 ft); QNY: fog, visible sky; QBB: zero

The Flight

It departed Zurich at 2043 hours on 11 July and the trip was uneventful up to the time of contact with Rabat - Sale control tower. At 0036 hours (12 July) it gave its position as over Fez and its estimated time of arrival in Sale as 0055 hours. At 0100 hours the aircraft contacted Sale Tower on 118.3 Mc/s and requested weather information. The tower replied: "visibility 10 m (30 ft), ground fog, clear sky." The flight then advised it was heading for Casablanca.

At 0106 the aircraft gave its position as 5 miles from Casablanca - Anfa, requested permission to descend and asked for landing instructions. The aircraft was asked to call when on the downwind leg.

Four minutes later the flight was asked to call when on final approach and was told that he was No. 1 for landing, the surface wind was 040°, 4 kt. The pilot replied that he would call when over the range station. The aircraft flew over the field at 0113, and three minutes later the pilot gave his altitude as 400 m (1 300 ft) and indicated a ceiling of 150 m (500 ft). The flight was advised that cloud was 7/8, ceiling 140 - 150 m (450 to 500 ft). Three minutes later conditions were 7/8, 100 m (330 ft). At 0122 the aircraft requested permission to land in Nouasseur if possible, and the tower asked him to wait. Two minutes later the aircraft was asked how much fuel it had remaining. It replied it had enough for 90 minutes. Subsequent calls from the tower remained unanswered as the aircraft had hit the ground.

The Scene of the Accident

OK-PAF crashed in line with runway 03, 13 km from its threshold, at an elevation of 140 m (452 ft).

When the police arrived at the scene at 0150 hours, i.e. 25 minutes after the crash, they found that one passenger had been thrown clear of the aircraft but was seriously injured. Calls for help were heard coming from the wreckage, and an attempt was made to rescue the passengers, but a fire started, and it was impossible to continue operations.

All persons aboard perished in the accident; the injured man succumbed to his injuries.

The Wreckage

The main wreckage was composed of the fuselage, almost complete, with part of the stabilizer and the elevator, the fin and rudder, the No. 3 engine, and one half of the main gear twisted towards the rear.

The fuselage was on its back, in a direction which was perpendicular to its path, and the underside had been opened to remove the victims. On the right rear side, level with the fin, were traces of scraping by high voltage wires. The cockpit had been entirely destroyed by fire.

None of the flight or engine instruments could be recovered. Fire damage on the main part of the wreckage showed that, at the outset, the fire was not fed by fuel. It looked like an electrical fire, which could have run along some short-circuited electric wires in the aircraft, becoming more intense at certain points where it was fed by other combustible material (such as hydraulic fluid). Some highly inflammable objects (e.g. films and records) did not burn. It does not, however, seem possible to eliminate the leakage of fuel onto No. 3 engine as a contributory cause of the fire.

Results of examination of the wreckage

The four engines, all propeller parts, some radio equipment and other equipment located at the rear of the aircraft were sent to Czechoslovakia for examination. Representatives from Czechoslovakia and Morocco were present.

The results of the analysis did not point to any facts which would have assisted the investigation.

Assumptions

Material failure

Neither the aircraft nor the radio communications gave any indication of failure.

Electrical failure

This was considered but rejected for the following reasons:

1) a complete DC failure could only have occurred if:

   a) the four engines had stopped when the batteries were already exhausted, or

   b) if shorts occurred in four separate points of the electrical circuits.

2) a complete AC failure could only have been caused by some major disturbance, such as the simultaneous failure of engines Nos. 2 and 4, with failure of the PO 1500 converter, or two simultaneous short circuits in separate sections of the main lead feeding the radio equipment.

Abrupt manoeuvre to avoid another aircraft

This would be difficult to check. It is, however, very unlikely that such a thing occurred, as neither the area control centre nor the approach control centre reported any aircraft in the vicinity of the aerodrome at the time of the accident.

Unfavourable weather conditions

The Commission assumed that the pilot may have been in a hurry to land because the Anfa control tower had warned him of deteriorating weather conditions. This is also unlikely, since the pilot had not received an answer to his request for a landing in Nouasseur, and the fuel remaining (90 minutes) would have allowed him to fly to an alternate aerodrome.

Probable Cause

None of the above assumptions satisfied the investigating commission as being a definite cause of the accident.

The last one, however, although unlikely at first sight, as explained above, could account for the accident if the crew, warned of deteriorating weather by the Anfa tower, had decided to take advantage of the partial visibility (of the ground) between stratus cloud and had attempted a fast let-down in unfavourable conditions.

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ICAO Ref: AR/725

No. 24

Aerolíneas Argentinas, Douglas DC-6, LV-ADW, accident at "La Maria Eugenia" field, Azul, Province of Buenos Aires, Argentina on 19 July 1961. Accident Investigation Report No. 1526 dated 2 February 1962, released by the National Director of Civil Aviation, Argentina.

Circumstances

LV-ADW departed Ezeiza Airport (Buenos Aires) at 0731 hours* on a scheduled non-stop flight to Comodoro Rivadavia carrying a crew of 7 and 60 passengers. The trip was being made on an approved instrument flight rules flight plan. Routine communications were exchanged with the airport control tower and with the control of Baires terminal. When over Gorchs the aircraft made its last contact. Having been authorized to leave the Baires control frequency and change to the route frequency, it acknowledged the message. No further information was received concerning the flight until it was learned that the aircraft had crashed 12 km west of Pardo Station (General Roca Railway) in the Province of Buenos Aires. All persons aboard were killed, and the aircraft was totally destroyed by the impact and ensuing fire. The accident occurred at 0800 hours.

Investigation and Evidence

The Aircraft

The aircraft's certificate of airworthiness was valid until 13 December 1961. At the time of the accident it had flown a total of 20 211 hours.

Gross weight at take-off was 38 682 kg, i.e. within permissible limits.

The Crew

The crew of seven was made up of the following: the captain, a co-pilot, a flight engineer, a radio operator, a flight attendant and two stewardesses.

The captain held a valid airline transport pilot's licence and had flown a total of 17 705 hours with Aerolineas Argentinas. Of this total he had flown 3 320 hours as DC-6 captain and 1 532 hours on instruments.

The co-pilot also held a valid airline transport pilot's licence and had flown 9 724 hours including 2 113 hours as co-pilot on DC-6's.

Neither the captain nor the co-pilot had exceeded the flight time limitations prior to the accident.

Reconstruction of the flight

Having acquainted himself with detailed weather information and all documents relative to the clearance having been approved, the captain took off at 0731 hours. From Ezeiza to Azul he was to climb to the maximum altitude of 4 800 m. This altitude was to be maintained until arrival in the Comodoro Rivadavia Airport control zone. The airway to be used was Amber 45 with the following contact points: Lobos, Azul, Bahia Blanca, San Antonio, Trelew and Comodoro Rivadavia. At 0733 he called on VHF to say that he "estimated Lobos at 0745 hours". The Baires terminal area control authorized him to climb to 4 800 m, in accordance with his flight plan and re requested him to give his position over Lobos. He acknowledged this and added that he was flying between cloud layers. At 0742 hours he notified his position as over Lobos at 2 200 m, climbing in visual flight, over layers of cloud; he estimated Gorchs at 0750 hours. At 0750 hours he sent another message on VHF, stating that he was leaving the terminal area, adding that he was

* all times are local unless otherwise specified.

over Gorchs at 3 400 m, climbing to 4 800 m and expected to reach that altitude at 0757 hours and would call when over Azul at 0819 hours. Following authorization to leave the Baires terminal radio frequency and to switch to the route frequency, he acknowledged the message and switched off VHF. The aircraft crashed shortly thereafter.

Wreckage - General

The accident site was at an altitude of 128 m above sea level, and the terrain was flat and swampy. The total area covered by the aircraft wreckage was plotted on a survey map and was 3 km long by 1.5 km wide.

Inspection of the wreckage was made by helicopter the day after the accident. The right wing had separated from the aircraft and had fallen 850 m away from the main wreckage. Its structure was destroyed in various places. The tail surfaces were missing from the fuselage. Engine and propeller No. 3 with the engine mounting had separated from the right wing. These main elements were spread over an area not wider than 1 000 m, and the complete power plant was found 900 m from the right wing.

Wreckage - detailed inspection

An impact had torn the skin on the right side of the fin, near its base, where it joins the fuselage cone. On the right half of the horizontal stabilizer there was a large hole, also due to impact. The leading edge was torn, as well as the attachments to the fuselage cone. The damage extended as far as the structure of the longerons. The separation of these two surfaces, as well as that of the movable surfaces was apparently simultaneous, since the heavier elements among them were found in a relatively small area.

The right wing had multiple fractures between the fuselage and engine No. 3 due to the break-up. Power plant No. 3 must have separated from the wing at the same time the wing separated from the fuselage for the following reason: examination of the break which followed the front spar and the two longitudinal ruptures at either end of this break, showed that the latter two correspond to the longitudinal beams which support the engine.

Examination of the engines revealed that No. 1 and 2 engines, which were still attached to the left wing, were feathered. No signs of malfunction or overheating were found, and No. 3 and 4 engines, which separated from the right wing, were in fine pitch.

Engine No. 3 showed a rupture line on the stressed panel which forms the top of the engine support. This line coincided with the front spar of the wing. The spar, in turn, showed vertical fractures on both sides of the wheel well. The beams and frames of the engine support were broken and torn off. This led to the assumption that strong engine vibrations could have torn the top panel in two and then broken the engine supports at the front spar, weakening the latter. Another assumption was that the front spar ruptured at the same time as the wing, thus freeing the power plant, which broke away while still under power.

It was not possible to find any indication of malfunction in engine No. 3 neither was there evidence of loss of parts capable of causing abnormal vibrations of the kind which could result in ruptures and separation. The breaks were caused by downward bending - resulting in traction at the top of the power plant structure. The supports broke at the junctions with the front spar. They showed folds which confirm the downward movement. This movement could have been a reaction of the structure to an upward acceleration or to a positive pitching movement of the aircraft.

Taking into consideration the resistance of the Douglas aircraft's structure, the reports of weather conditions in the area at the time of the accident and evidence from the wreckage, it is estimated that the break-up of the aircraft was a consequence of stresses generated by a pull-out at a positive angle of incidence, combined with an upward gust. Movements of this type occur during flights in heavy turbulence.

From the shape of the wing and empennage breaks, it is estimated that the right wing broke first. It started with the underside tearing under tension, in a direction perpendicular to the span. The rupture affected all the structural elements. The wing structure was made of three spars, with stressed wing panels reinforced with omega type stringers. The top caps of the three spars showed a break due to flexion.

The lower caps of the wing spars had broken in traction. The bottom wing panels were torn along a line of rivets. All breaks were of the type which occur in static tests, and in none of them could any indication of fatigue cracks be found.

Weather information

When the dispatcher arrived at Ezeiza Airport around 0500 he learned that there was a warm front over Buenos Aires Province producing low stratus, fog, cumulonimbus and violent showers. Between Buenos Aires and Las Flores moderate to heavy turbulence existed.

The conditions at Bahia Blanca, the alternate in the flight plan, were also examined. The dispatcher was informed the the ceiling would be low there.

The captain arrived at the meteorological office at 0620 hours and was informed by the forecaster on duty that there was a warm front over the northeast of Buenos Aires Province and a cold front in the vicinity of Bahia Blanca. The forecaster added that practically the whole province would have a ceiling of 100 to 200 m, with mist and fog, and that there was instability in both warm and cold sectors. With regard to the warm front, the forecaster said that there would be 2/8 to 4/8 cumulonimbus, with light to heavy turbulence between Ezeiza and Bahia Blanca. The captain obtained the following forecasts for Comodoro Rivadavia and Ezeiza Airport based on the 0300 hour weather map:

Comodoro Rivadavia:
partial to complete overcast at medium altitudes, cloud bases at 3 000 m; low broken clouds at 600 m good visibility.

Ezeiza:
violent showers and isolated storms with 2/8 to 3/8 cumulonimbus; visibility 6 to 8 km and ceiling at least 400 m.

(There is no regulation in Argentina which makes it compulsory for a forecaster in charge of giving weather information for a flight to advise for or against the departure of an aircraft).

As Aerolíneas Argentinas had an assistant meteorologist in Ezeiza, he was questioned concerning his role on the day of the accident. It was ascertained that the meteorologist on duty informed the dispatcher, also on the basis of the data shown on the 0300 hour weather map, that there would be no inconvenience in making the flight. For that reason, the dispatcher requested the QAM's in various locations on the route. These did not, in fact, reflect the actual weather conditions.

The QAM's were of no value in the present case 1) because of the time at which the observations were made, 2) because no observations could be made at altitude on account of a layer of fog and 3) when making a scheduled flight it is the forecast that must be taken into consideration and not the QAM's.

At 0600 hours the captain received the forecast from the company meteorologist which was the same as that given to the dispatcher ... "unstable tropical air is predominant in the whole province of Buenos Aires. Warm front on the line Río Tercero-Junín-Punta de Indio, with active nimbus. Cold front, practically stationary, on the line Neuquen-Coronel Suárez-Necochea. Scattered cumulonimbus producing heavy showers and electrical storms in the province of Buenos Aires. The segment Bahia Blanca to Comodoro Rivadavia shows overcast and stratiform nebulosity, breaking between Trelew and Comodoro Rivadavia."

After this forecast, the captain also received the official bulletin of the General Administration of Air Traffic and Aerodromes corresponding to the forecast. "Time 0600 Greenwich Time, i.e. 0300 hours local time."

The forecast gave the following: "From Ezeiza to Las Flores:

> visibility 5 to 6 km; nebulosity 8/8 stratus and stratocumulus, base 400 m; 8/8 altostratus and altocumulus, base 1500 m; cumulus 2/8 to 3/8 base 1 800 m. Moderate to heavy turbulence between Ezeiza and Las Flores. Cold front approximately on the line: Neuquen-Coronel Suárez-Necochea, moving towards the northeast. Warm front over Buenos Aires, with heavy showers and active cumulonimbus. Fog and low stratus with drizzle in the centre and south of Buenos Aires Province."

The weather conditions in the area between the Miramonte and Pardo railway stations from 0600 to 0900 hours were:

> overcast, 8/8 stratus, fractocumulus, fractostratus;
>
> ceiling zero to 100 m, 8/8 nimbostratus;
>
> ceiling 1 500 to 1 800 m, active cumulonimbi with bases between 1 500 m and 1 800 m; visibility less than 1 km; heavy showers and electrical storms; light turbulence over the area becoming heavy in areas of cumulonimbus.

Statements of witnesses

There was rain and fog. At approximately the time the aircraft crashed there was a violent storm, with rain, thunder and lightning.

The testimony of two other pilots, who flew the same route a few hours before LV-ADW revealed that although both had been assigned a flight altitude of 1 800 m, both requested a change in order to avoid an area of turbulence, presaged by the presence of cumulonimbus with intense activity. One pilot asked for a change of altitude while in flight, the other did so after examining the forecast given him before departure, which contained the same values as those given to the pilot of LV-ADW.

They both estimated that the main area of cumulonimbus was located around Gorchs and stated that they encountered only light turbulence in flying beneath those clouds.

Weather conditions on LV-ADW's route

> thick layer of stratiform cloud, combined with altocumulus, situated approximately between 4 000 m and 4 500 m, inside this layer - very active cumulonimbus, 2/8 to 3/8 with bases at about 1 800 m.

The investigation endeavoured to find if the altitude assigned for LV-ADW between Ezeiza and Azul was correct, having regard to the weather data and considering that the aircraft was not equipped with weather radar to locate active clouds. The aircraft was supposed to climb to 4 800 m, following its take-off from Ezeiza. According to the flight plan, it should reach that altitude over Azul, after 48 minutes flying time. In consequence of this, the aircraft would, in the course of its climb, enter the thick layer made of a continuous overcast (8/8) of stratiform clouds. Inside that layer were 2/8 to 3/8 of active cumulonimbi. Having no radar equipment, the aircraft had a 31% chance of flying into one of these. Approaching Gorchs, LV-ADW entered a layer of cloud which the pilot must have regarded as similar to those he had crossed previously. Unfortunately, this was not so, for, screened in that continuous and ever thickening layer of cloud were the cumulonimbi. The aircraft flew into one of these between 4 000 and 4 500 m, which is the range of altitudes of the lower part of a cumulonimbus, when it is ripe. This lower part, and the second third of such a cloud are the areas where closely grouped upward and downward air currents are to be found. This creates turbulence which, associated with gusts, makes these currents reach maximum values. Ascending and descending currents, in a ripe cumulonimbus, have variable speeds, the descending currents being slightly less intense; but the order of magnitude may be as high as 100 to 120 km/h (28 to 33 m/sec). (These figures are quoted in "Thunderstorm Project" - Byers H. Braham, R., Washington, D.C., June 1949).

The flight level assigned to the aircraft over Azul implied a climb through a warm front. The forecast showed, associated with that warm front, cumulonimbi with bases located at 1 800 m. The altitude chosen was not correct, since, in such conditions, the aircraft, having no radar, was running the risk of encountering a cloud of the type described above.

This is, in fact, what happened, and the violent turbulence caused the destruction of the aircraft in flight.

Probable Cause

The aircraft disintegrated in flight due to rupture of the right wing following the application of loads in excess of the design loads, in a zone of extremely violent turbulence. A contributing factor was insufficient evaluation of the forecast, by both the aircraft captain and by the airline dispatcher, which resulted in the choice of an inappropriate flight altitude.

Recommendation

The Aviation Accident Investigation Board recommends that the necessary steps be taken urgently by the competent organizations to study the installation of weather radar in all commercial aircraft.

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ICAO Ref: AR/715

No. 25

Alaska Airlines, Inc., Douglas DC-6A, N 6118C, accident et Shemya, Alaska, on 21 July 1961. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0002, released 10 October 1962.

Circumstances

Flight CKA 779 was a contract cargo flight from Travis Air Force Base, California to Tachikawa, Japan, carrying six crew members. At 0211 hours Bering standard time, during the approach to a landing at Shemya, an en route refuelling stop, after descending through minimum weather conditions under the guidance of GCA (ground controlled approach) the aircraft crashed and burned about 200 ft short of the threshold of runway 10 on a course aligned with the runway. All persons aboard received fatal injuries.

Investigation and Evidence

The Aircraft

At the time of the accident, the total time on the airframe was 10 600 hours. The last major inspection was conducted 146 hours prior to the accident.

The maximum weights for take-off and landing and the centre of gravity were within the permissible limits.

The Crew

The flight carried a crew of six - the captain, a co-captain, a co-pilot, one flight engineer with pilot certificate and two other flight engineers. All of them had valid licences and medical certificates, but the captain had no qualification for Shemya Airport. The captain had a total of 13 019 flying hours of which 1 118 were on the DC-6. The co-captain had flown 13 000 hours, and the co-pilot had 2 061 hours of experience of which 101 hours were on DC-6 equipment. The flight engineer had accumulated 1 176 hours as a pilot. The crew was to alternate its duties in order that no one would become fatigued at his duty station and, as well as could be determined, this requirement was met.

The captain, co-pilot and flight engineer had flown this aircraft into Shemya Airport landing at 1 952 hours on 12 July 1961 and again at 1 024 hours on 14 July 1961. Both landings were accomplished after ground-controlled approaches in IFR weather conditions.

Weather situation

The accident took place at 0211 hours. At 0212 the U.S. Weather Bureau observer made the following observation:

> "indefinite 200-foot variable ceiling; visibility 3/4 mile variable, fog; temperature 45°; dewpoint 45°, wind south-southeast 8 kt; altimeter setting 29.84; ceiling 100 ft variable to 300 ft, visibility 1/2 mile variable to one mile".

Slightly more than 500 ft above the runway the wind was south at 20 kt, while the surface wind was southeast at 8 kt.

Runway 10 - approach lights

Runway 10 is macadam and is 9 990 ft in length, 200 ft wide, and its elevation is 95 ft msl. There are six pairs of red approach lights extending 1 460 ft outward from the threshold. They are spaced at 200-foot intervals and are 200 ft apart in width. From the edge of the threshold pavement to a point 186 ft in the direction of an approaching aircraft, the ground slopes downward gradually at an angle of about 1°. Then the ground drops suddenly at an angle of approximately 30° to a valley floor 50 to 60 ft below the level of the runway.

The six pairs of approach lights are mounted on poles of different heights to accommodate the variance in terrain height, but the lights themselves are practically on a level with the runway. A single strobe light (a condenser discharge flashing light rated at approximately 10 000 000 candle power) is located on the ground, aligned with the runway centre-line approximately 152 ft short of the runway threshold. There are two pairs of green threshold lights, each pair mounted side by side (crosswise to the runway), one pair at each corner of the runway. Thereafter, at 200-foot intervals, single runway lights extend the full length of the runway along both sides. All lights (except the strobe light) utilize 200-watt bulbs.

On the day following the accident it was discovered for the first time that an electric power cable lying along the side of the runway had been cut two days prior to the accident to allow construction vehicles to pass over the area. This cable was the powerline leading to the six pairs of red approach lights off the end of runway 10, as well as to two of the four green threshold lights, and to the first four pairs of runway lights. This condition was not reported by previous landing aircraft, nor was a Notice to Airmen concerning this irregularity issued by Northwest Airlines, the operator of the airport. The main rheostat, which controls all lighting intensity (except the strobe light), was set on maximum brightness during the flight's approach.

GCA

The GCA unit used at Shemya was an AN/FPN-33 Quad Radar. GCA approach weather minima at Shemya for Alaska Airlines flights are ceiling 200 ft and visibility 1/2 mile. The minima applicable to the captain for GCA at Shemya were ceiling 400 ft and visibility 3/4 mile. The GCA equipment was given a complete functional check by the GCA maintenance man and the operator prior to its use on 20 July 1961, and was operating, according to them, within tolerances. During the 12-hour period preceding this flight's approach, six other aircraft had made successful GCA approaches to Shemya, using the same equipment manned by the same controller.

On 3 May 1961 and 12, 13, 14 and 15 July 1961, the GCA facility was flight-checked by the FAA and found to have been within tolerances. However, it was pointed out by the flight check crew in their report at the time of the latter flight check that,

> "It would appear from personal examination that the present radar antenna system now in use ... has deteriorated and worn beyond its normal life and tolerances, and it is anticipated that it will be difficult to maintain within acceptable tolerances in the very near future."

Following the accident, on 22 and 24 July 1961 the facility was again flight-checked by the FAA and found within tolerances. The check pilot gave the controller a proficiency rating of "very good" on all of the checks.

The GCA controller

He had been employed as an air traffic controller for about nine years, eight of which included operation of GCA equipment. He had been operating the GCA equipment at Shemya since the summer of 1957, using the same equipment that was in operation at the time of this accident. His tours of duty on Shemya were continuous since 1957, but were for periods of 90 days, with a 90-day rest period in between. He was the only controller during each of his tours of duty. His then-current tour of duty began 18 April 1961, and he was scheduled to begin a rest period on 1 August 1961. He stated that he conducted an average of

100 to 130 instrument approaches to Shemya per month. Flight CKA 779 was the 83rd GCA approach that he had conducted since 20 June 1961. The types of aircraft controlled during these approaches had been U.S. military as well as U.S. civil aircraft. The radar installation at Shemya is unique in that it is the only privately-owned and operated facility of its kind serving U.S. civil air carriers. The radar operator need not be certificated by FAA, nor need he demonstrate his continued competence to perform his assigned control functions, nor is he required to undergo recurrent training such as is required of FAA controller personnel. At Shemya, the installation of electronic equipment need not be approved by appropriate authority within the FAA.

The Flight

It had originated at Paine Field, Everett, Washington on 20 July and proceeded to Travis Air Force Base to load military cargo. It then flew non-stop to Anchorage where it received weather and Notam information for the trip to Shemya, however, this did not include the approach or field lighting deficiencies. An instrument flight plan to Shemya was filed. Departure from Anchorage was at 1940 hours and the flight to Shemya was routine and in accordance with the flight plan. The estimated time en route was 6 hours 40 minutes.

At 0145 hours the flight contacted Shemya GCA, and radar contact was made with the aircraft about 18 miles north-northeast of Shemya at 5 500 ft.

The radio transmissions of neither the flight nor GCA were recorded, which was in direct violation of instructions issued by Northwest Airlines for operation of the GCA. The description of how the flight was controlled through the instrument approach is based to a large degree on the controller's testimony. He advised the flight, while it was still in the surveillance pattern, to expect possible "wind burble" on final approach between one mile and 1/4 mile from touchdown point. He stated that he gave the flight the following Shemya weather information "indefinite ceiling 200 ft; sky obscured; visibility one mile in fog; new altimeter 29.86".

The controller said the flight intercepted the glide path properly and maintained a good course during the entire approach. When the flight was two miles from touchdown, it dropped about 10 to 15 ft below the glide path, and he advised it several times to "ease the aircraft up". No apparent correction was made. About one mile from touchdown the flight went an estimated 30 to 40 ft below the glidepath, and he again advised the flight several times to "bring the aircraft up", yet no apparent correction was made. He advised the flight it was passing GCA minima at 1/2 mile out and was still below the glide path. He said the flight maintained the 30- to 40- foot below glide path condition until it was over the approach lights, which begin 1 460 ft before the threshold of the runway. At no time did he consider the flight to be in danger, and that the 30- to 40- foot below glide path condition was still well above the minimum safe altitude for the approach. He said that when the flight was over the approach lights, it started to descend rapidly and he assumed the captain had taken over visually for his landing, intending to "grease it on" at the end of the runway. He therefore did not advise the pilot of his position relative to the glide path at that point. The controller said that he continued to advise the flight that it was below glide path (though not stating how far below, or that the safety limits were being exceeded). He stated that he last saw the aircraft on radar at the end of the runway, and also that he knew it had crashed because he did not see the aircraft target move down the runway as he usually is able to do. He also stated that the flight's transmissions indicated to him that the pilot understood all instructions and was familiar with the GCA approach to Shemya's runway 10.

The aircraft struck the embankment about 200 ft short of the threshold in a nearly level attitude, the nosewheel touching first about 18 ft below the crest, very nearly aligned with the centreline of the runway. The aircraft slid up the embankment during impact and when it reached the crest, broke in two (laterally) at the leading edge of the wings. Fire followed impact, and the majority of the wreckage was consumed.

Analysis

Examination of the power plants revealed that all four engines were capable of producing adequate power. Indications were that the fuel flow to all engines was normal. Control surfaces and control mechanisms seem to have been operating normally. There was no evidence that any of the aircraft systems malfunctioned. Both altimeters were at the proper setting. Examination of the structures of the aircraft showed that they were integrally sound before impact. The landing gear was fully extended and locked and the wing flaps were extended beyond 30°. The landing lights were extended and believed to have been on inasmuch as they were observed by an eyewitness. Since they were on, it is believed that the aircraft was below the clouds during some portion of the approach. Use of these lights in the clouds would have caused adverse reflection to have been experienced by the crew. Consequently, this would have hampered their ability to make visual contact with the runway.

The lack of any transmissions on frequencies 134.1 Mc/s and 121.5 Mc/s by the flight supports the view that no emergency existed.

The forward visibility of the crew when it was over the approach lights could have been as low as 1/2 statute mile if the aircraft had been clear of clouds in that area. Conditions of temperature and moisture in the approach zone were not conducive to structural icing, and it is, therefore, not considered to have been a problem. Also, according to the sun and moon data, the accident occurred during the hours of complete darkness.

Since the captain did not execute a missed-approach procedure, did not question the condition of the weather, and since he was not advised by GCA to abandon his approach upon reaching a critically low altitude, it is assumed that he had visual contact with the runway and was contemplating a successful landing.

The controller stated in his testimony that he saw the aircraft target over the end of the runway. However, this target return must have been from part of the wreckage which continued up the runway from the point of impact.

The six pairs of red approach lights, two of the green threshold lights, and the first four pairs of runway lights beyond the two operating threshold lights were not lit. The single strobe light was lit; however, its beam was directed 4-1/2° above the glide path angle of 3°. As an aircraft goes below the beam of the strobe light the effectiveness of the light is greatly reduced. For example, at a point 50 ft below its directed beam, the effective strength of the beam is reduced by as much as 75%.

The captain could not have known that the approach lights and some of the threshold and runway lights were inoperative since this information had not been given to him. It is also believed that he would not have flown below his minimum altitude had he not had some portion of the runway lights in sight. The Board concludes, however, that the existing lighting situation was a factor in causing the captain to improperly orient himself with the runway. The Board further concludes that the captain knew he was below the glide path throughout the approach but did not believe it to be critical.

It should be noted that although the approach procedure was flight checked and approved by the Flight Standards Service of the Federal Aviation Agency, apparently no consideration was given to the fact that the AN/FPN-33 is not deemed suitable by the Aviation Research and Development Service, the Aviation Facilities Service, or the Air Traffic Service of FAA for use as an FAA-operated air traffic control facility. A finite value in feet cannot be estimated accurately on a radar scope with the type of presentation provided for the AN/FPN-33. For this reason, the military services have instructed their controllers to refrain from the practice of providing foot values of displacement from centrelines of azimuth or elevation when utilizing precision radar equipment with this type of display.

Furthermore, although the controller was directly involved in the control of civil air traffic under instrument flight rules, FAA did not enforce any requirements for certification and area rating, current medical certificate, Class II, or current proficiency in radar operation or other aspects of air traffic control.

Probable Cause

The probable cause of this accident was the absence of approach and runway lights, and the failure of the GCA controller to give more positive guidance to the pilot during the last stages of his approach.

Recommendation

The Board has recommended to the Administrator that he take action to ensure that personnel and equipment used in GCA approaches meet pertinent standards for such operations.

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ICAO Ref: AR/726

No. 26

Air France, Boeing 707-328, F-BHSA accident at Hamburg - Fuhlsbüttel Airport, Germany, 27 July 1961. Report, dated 6 June 1963, released by the Federal Office of Aviation, Germany.

Circumstances

Flight 272 which was flying the Polar route Paris-Hamburg-Anchorage-Tokyo landed in Hamburg at 1224 hours GMT. While taking-off for Anchorage with a total of 41 persons aboard the aircraft, including 26 passengers, the pilot had difficulty holding the aircraft on a straight heading along the runway and decided to abandon the take-off. Despite his efforts, the aircraft veered to the left, ran off the runway and finally came to rest 2 840 m from the starting point in a depression 140 m from the runway. It was severely damaged. Four crew and six passengers were seriously injured.

Investigation and Evidence

The Aircraft

It had operated a total of 3 978 hours and had made 1 080 landings.

The aircraft's actual take-off weight was 133.42 t, (i.e. within limits), and its aft trim was 22.4% MAC. The aircraft should have been trimmed four units heavy in the tail. (The manufacturer recommends 3.5 units.) The longitudinal trim was found to be 4.5 or 5 units. It is assumed that the trim was adjusted in accordance with tested values.

The Crew

The pilot-in-command was the holder of a valid airline transport pilot's licence which was endorsed for Boeing 707 aircraft. He had flown a total of 14 000 hours of which 401 hours had been in command on Boeing 707's.

The co-pilot also held a valid airline transport pilot's licence and had flown approximately 8 000 hours including about 960 hours on Boeing aircraft. He had also flown approximately 5 000 hours as radio operator.

The other crew members aboard were a flight engineer, a navigator, cabin attendants and a relief crew. All had valid licences.

The Runway

The aircraft was taking-off from runway 23 (233°). The runway is 2 923 m in length, is 45 m wide and is at an elevation of 45 ft amsl.

Weather

At the time of the accident (1420 hours GMT) the following meteorological conditions existed at Hamburg:

> wind 280/18 kt, gusts up to 28 kt, cloud cover 1/8 at 4 000 ft, 5/8 at 20 000 ft, visibility 25 km; ONH 1005.8 mb, ground temperature 19°C.

Reconstruction of the take-off

The reconstruction is based on statements of the crew, witnesses inside and outside of the aircraft, and the findings of the inquiry.

Permission was granted for take-off at 1418:40 hours. The throttle lever was thrust forward and while the captain's right hand still rested on it, the engineer set the four engines at the calculated EPR (engine pressure ratio) of 2.45 in accordance with the instructions. The captain operated the rudder pedals with his feet, the nosewheel controls with his left hand and the throttle lever with his right. To compensate for the starboard headwind he steered a little left. The co-pilot held the control column forward and applied a little bank on the starboard side because of the crosswind. As the aircraft gathered speed and the effect of the rudder became more marked the captain slowly released pressure on the left rudder pedal. When the co-pilot had called out a speed of 80 kt the captain released the nosewheel steering controls and took over the control column. The captain, having heard the co-pilot call out 100 kt, concluded that the aircraft had reached this speed within the predetermined time. He stated that between 100 and 120 kt the aircraft suddenly veered to the left, and that he brought it back by using the rudder, which was difficult to move. Neither pilot could remember calling out 120 kt or having heard it called out. The pilot made a check and ascertained that acceleration had been carried out within the predetermined period of 37 seconds.

Between 120 and 130 kt the aircraft again veered left and the direction was again corrected. The resistance had increased. The yaw to the left persisted, and the captain realized that, despite great effort, the rudder pedal could no longer be actuated right, and he felt that it was jammed. The flight engineer noted, at this time, that the rudder's hydraulic pressure had fallen quickly from 3 000 to 1 000 psi.

At approximately the same time the captain began interrupted take-off procedures. He pulled back all four throttle levers, reversed thrust on engines 3 and 4 to stop the aircraft on the runway, and applied the brakes to the starboard undercarriage.

According to the skid marks the nosewheel was pointing at about a 35° angle to the right of the longitudinal axis of the aircraft, and the aircraft must have slid slightly left. The captain maintained that he had not used the nosewheel steering to bring the aircraft back on heading.

All the expert witnesses outside the aircraft said that they saw the nosewheels lift off the ground. The captain, however, stated that he had kept the aircraft's nose on the ground all the time. From this, it was assumed that in his efforts to make the rudder work the captain unconsciously pulled back the control column. Shortly after, both nosewheels broke off.

Although the steps taken by him to correct heading had some effect, the yaw to the left persisted. Thereupon he reversed thrust on all four engines and applied both wheel brakes. The reverse thrust was, however, violently interrupted when the navigator, who was not fastened in his seat, was flung against the pilots' control stand when the nosewheel undercarriage broke off.

Having rolled 2 360 m, the aircraft ran off the runway in a gentle curve to the left. In turn, the nose gear assembly, the port undercarriage and finally the starboard undercarriage broke off. Finally the aircraft came to rest in a depression 1.5 m deep and 30 m wide with its fuselage broken into three parts. (See Figures 10, 11 and 12).

The Engines

In engine No. 2 the thrust reversal valves were found in the closed position while in the other three engines they were open. The crew had not noticed any signs of abnormality in the engines and the speeds of 100 and 120 kt were attained within the specific times. Since the SFIM flight recorder registered normal acceleration up to the abandonment of take-off, it is reasonable to assume that the engines were functioning satisfactorily, and the wheel brakes could not have been on, at least not noticeably.

Rudder

There was no further trace of jamming of the rudder which the pilot had reported.

On the day of the accident there was a gusty crosswind which must have obliged the pilot to shift the rudder quickly and far over, (while moving at a low speed), after he had changed over from the nosewheel controls to the rudder. If the rudder is moved abruptly hard over when it is at boost-on this can produce a marked decrease in pressure in the auxiliary hydraulic system, as noticed by the flight engineer during take-off. Great resistance is then felt in the rudder pedal and may give the impression that it is stiff or even jammed. It must be assumed that the pilot knew of this feature from experience.

In the November 1961 issue of the "Boeing Airliner" under the heading "Rudder Operation and Control" there is a further explanation.

If the pressure control valve comes to rest in the central position, thus impeding the supply of hydraulic pressure to the rudder power control unit, the moment the pedal is pressed it ceases to be power-operated and has to be operated directly. The rudder resistance unexpectedly increases and can easily give the impression that the rudder is stiff or jammed. The pressure required on the rudder pedals to achieve a 5° extension of the rudder fin at 200 kt, for example, rises from about 40 to 90 lb. Also, the pilot receives no warning that a switch-over will ensue, since the pressure through the pressure control valve may remain at full right up to the moment when, as a result of pedal action, a steadier flow of hydraulic fluid through the rudder power control unit makes the pressure in the system fall off sharply. The warning light cannot give any knowledge of this, although it will flash whenever the rudder is switched to direct operation. This was not observed by any crew member.

The manufacturer has issued Service Bulletin No. 1482 recommending incorporation of a bypass line which will ensure sufficient pressure to the rudder power control unit even when the valve switch functions unsatisfactorily.

The Handling of the Aircraft

It gave no indication as to the possible cause of the accident.

The emergency brake had not been used. Its use would probably have resulted in the aircraft leaving the runway even earlier on account of its leftward veer.

The normal wheelbrake and reverse thrust were in order, and the pilot was justified in assuming that he would be able to stop the aircraft on the remaining portion of the runway. The accident would probably have been less critical if the navigator had not fallen on to the control levers and stopped the reverse thrust. The navigator said he had released his safety belt to get a better view when he noticed that the take-off was going wrong.

The flight recorder showed that a change of heading occurred during take-off. The maximum speed registered was 155 - 157 kt, but an erroneous indication may have resulted from impact. The speed, however, was estimated to be approximately 150 kt.

Probable Cause

The cause of the accident could not be determined. The pilot could not keep the aircraft on the runway after abandoning take-off.

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ICAO Ref: AR/760

B 707-328, F-BHSA
27/7/61

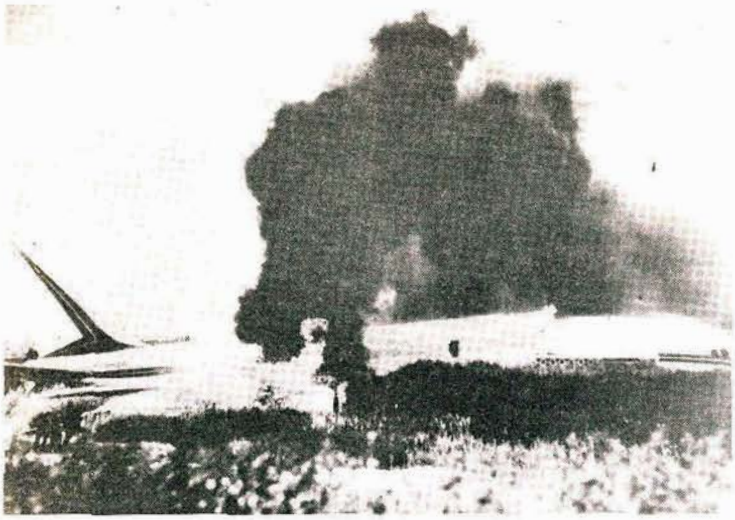


FIGURE 10

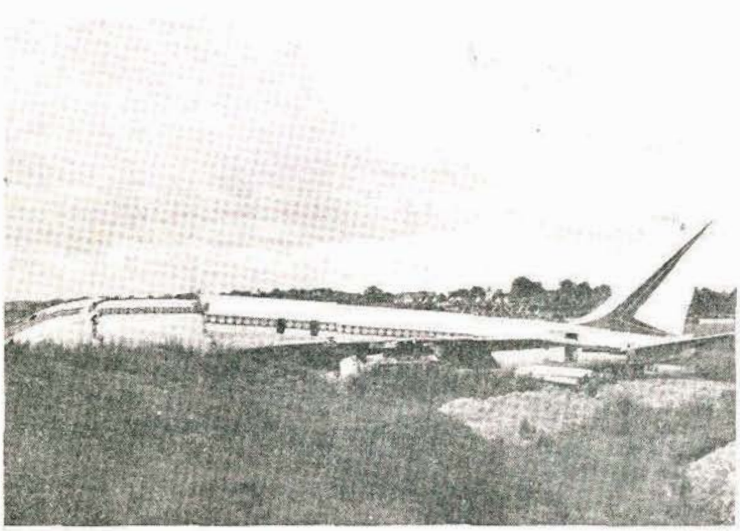


FIGURE 11

FIGURE 12

No. 27

Iranian Airways Company, DC-4A, EP-ADK, made a forced landing on the southwest coast of the Caspian Sea on 3 August 1961 after being shot at by an unidentified aircraft. Report released by the Department of Civil Aviation, Iran.

Circumstances

EP-ADK was flying the return portion of a non-scheduled flight Tehran-Beirut-Tehran at an altitude of approximately 13 000 to 15 000 ft when it became lost and is presumed to have flown over Russian territory. The aircraft was shot at by an unidentified aircraft as a result of which No. 1 engine nacelle and the adjacent wing structure were damaged by gunfire. No. 1 engine caught fire. The fire was extinguished, and the propeller was feathered. Due to a low fuel indication on No. 4 tank, No. 4 engine was stopped and the propeller feathered. In view of the existing conditions, an emergency wheels-up landing was carried out. Although the aircraft had been badly damaged, none of the 3 crew aboard suffered any injury. The accident occurred at 2216 hours GMT (3 August), i.e. at 0146 hours local time (4 August).

Investigation and Evidence

The Aircraft

The aircraft's certificate of airworthiness was valid to 21 March 1962. It had been issued a certificate of maintenance (valid for 24 hours) at Mehrabad Airport (Tehran) on 3 August 1961 at 0800 hours local time.

The airframe, engine and propeller log books were examined and found to be satisfactory. A major overhaul of the aircraft was completed on 28 March 1961 since which time the four engines had been changed. No record was found of the compass having been re-adjusted and checked following any of the engine changes nor was there any pilot report concerning an inaccurate magnetic compass.

There were no positive records and certifications concerning the radio equipment.

The Crew

The captain has flown a total of 11 700 hours. Most of these were on C-46 and DC-4 aircraft. He has flown 7 000 hours on DC-4's. His night flying experience amounts to about 4 500 hours.

The first officer has flown DC-3, DC-4 and Viscount aircraft, the latter two types as co-pilot. He has flown a total of 6 400 hours, of which 1 645 hours were on the DC-4. He has a DC-4 type rating on his FAA (Federal Aviation Agency - U.S.A.) airline transport licence. Following his joining of Iranair in August 1955 a DC-4 rating was requested by Iranair. The Government issued a temporary rating to Iranair, but this temporary rating was not entered in the pilot's licence.

The second officer has flown DC-3 and DC-4 aircraft as co-pilot. He was given transition training in the DC-4 in May 1961 for right seat take-offs and landings. Of his total of 900 flying hours, approximately 114 hours were flown on this aircraft type in the last 90 days. He had no former experience on this route, nor is he in possession of a DC-4 type rating or an instrument rating.

Weather

The following conditions prevailed over the flight's route:

From the Iranian border to Tehran

1 to 3/8 Cu and Sc base 11 000 ft, tops 15 000 to 16 000 ft, and

1 to 3/8 As base 16 000 ft, top 19 000 ft; visibility 10 km in general, locally 6 km with haze; winds at 15 000 to 16 000 ft; 270°, 10 to 15 kt veering to 300°, 15 kt near Tehran; temperature at 15 000 to 16 000 ft; 0 to -2C.

Area between Saghez - Tehran and the Caspian Sea

over the mountains, 3 to 5/8 Cb base 12 000 ft, tops 20 000 ft with local thunder showers. Upper winds and temperature similar to Tehran area.

At the time and scene of the accident

ceiling	: 3 to 4/8 Cu and Sc base 3 000 ft; 4 to 5/8 Ac-As base 10 000 to 12 000 ft.
visibility	: 6 to 10 km
wind direction	: variable
wind speed	: about 5 kt
temperature	: 24 C
dew point	: 20 C

Upper winds

A comparison of the winds forecast for the flight sector Tehran-Mandali (0800 - 1400Z) as against those actually encountered when over Iranian territory during the return flight showed no serious change in conditions to affect groundspeed nor to cause a considerable deviation from the tracks-made-good.

The captain stated that about 750 BHP was applied during the major part of the return flight whereas the first officer believed that it was in the order of 680 BHP. The only data available for determining the applied BHP was the total fuel consumption for the entire return flight, which lasted 7 hr 18 min.

Assuming that the return flight started with 1 800 US gallons of fuel on board and based on the fact that a total quantity of 80 gallons was in the tanks after landing, calculations were made which showed a total consumption during cruise of 1 620 US gallons. Based on a total flight time of 7 hr 18 min, an average cruise consumption of 221 US gallons/hour was maintained during the flight. As approximately 50% of the flight was flown at 12 000 ft, the other 50% at 15 000 ft and the average weight of the aircraft amounted to 62 000 lb, an average BHP of about 670 was maintained during the entire flight. From these data the conclusion is drawn that a considerably higher TAS than the planned 180 kt was maintained. In fact, average power of 670 BHP and an average aircraft weight of 62 000 lb result in an average TAS of about 210 kt.

Reconstruction and analysis of the flight up to the accident

The aircraft departed Mehrabad Airport (Tehran) at 0815 hours GMT for a charter flight to Beirut (Lebanon). Following its arrival there at 1304 hours, the captain left the airport to undergo a medical examination for renewal of his licence and instructed the first officer to supervise the refuelling and loading of the aircraft. He asked that the four main tanks be filled to 450 US gallons each. This would give a total amount of 1 800 gallons for the return flight to Tehran. The first officer read the fuel gauges of the tanks to determine the quantity of fuel remaining and on this basis instructed the refuelling company to add various amounts to the individual tanks. None of the crew members actually dipped the tanks. The crew, when starting the return flight supposed that the aircraft had 1 800 US gallons aboard.

The first officer compiled and submitted an IFR flight plan for the Beirut-Tehran segment of the trip. No forecast for the return flight was available as these have to be requested six hours in advance for non-scheduled flights and such a request had not been made by the Company's representative. The first officer, therefore, decided to apply the data pertaining to wind direction and speed appearing on the forecast obtained that same morning from the meteorological section at Mehrabad. The time validity on said forecast was from 0800 to 1400 GMT. Thus, its validity had expired at the time of departure (1458 GMT) from Beirut for the return trip. In compiling the flight plan the first officer applied a true air speed of 180 kt for the cruise part of the flight. Company instructions in regard to BHP for cruising state that 680 BHP should be applied for cruising. Within the aircraft weight bracket of 63 000 to 71 000 lb, application of 680 BHP results in an average true air speed of 207 kt at 12 000 ft pressure altitude and of 209 kt at 15 000 ft pressure altitude. The reason why the first officer used the low figure for cruising true air speed could not be determined.

Based on a true air speed of 180 kt and the winds given in the Tehran forecast, the estimated elapsed times calculated by the first officer and entered in the flight plan were erroneous. The elapsed times entered in the flight log during the flight gave a different picture, that can hardly be explained.

According to statements of the first officer, which were confirmed by the captain, the latter resumed command when the aircraft reported its position over Mandali. The time reported over Mandali was 1800 hours GMT, i.e. 3 hours and 2 minutes after take-off from Beirut. This would result in an average groundspeed of 178 kt (including climb). The actual true airspeed maintained during the flight and the tailwind component that had been encountered do not justify 1800 hours as overhead time at Mandali. When the captain resumed command, the first officer reported the aircraft's position to him as "overhead Mandali". The aircraft at this time was, undoubtedly, over a city, but it is very doubtful that the city was Mandali. The manner in which the flight plan was compiled and the flight log was maintained did not provide a sound basis for navigation with any degree of accuracy. Nor would the composition of the flight crew during the flight from abeam T3 to Mandali warrant a correct conduct of the flight navigation and subsequent reporting.

It is believed that the captain, not realizing that he resumed command from an erroneous position, got himself into serious difficulties during the remainder of the flight. Also the next position, overhead Kermanshah, was not definitely recognized as such by the crew. (The second officer was flying this route for the first time.) The crew stated that this position was reported to Tehran "blindly". It did not appear in the flight log and, therefore, no definite time over Kermanshah could be determined. The next position was NDB Hamadan, 3 NM north of the city. This position was reported to Tehran FIC via relay by an aircraft flying in that area. The time reported "overhead Hamadan" was 1904Z which resulted in a groundspeed of 149 kt from Mandali. This groundspeed was not justified on the basis of prevailing winds and true airspeed. From then on the aircraft, by further deviating from its intended track, at no time came within range of the Tehran VHF communication and air navigation facilities.

The remainder of the flight could only be reconstructed from starting with the point of the crash and working back on information supplied by the crew. It was determined that the aircraft did cross the Elborz mountain range. During or immediately after crossing the range the crew, when trying to establish the aircraft's position with the aid of direction finding equipment, tuned in to a radio broadcasting station transmitting on or about 900 kc/s. The broadcast was in the Parsee language, and it was, therefore, assumed that the broadcasting station was in Tehran. Receiving a definite indication on the direction of this station the captain started homing-in on it, maintaining a heading of 330°M. This heading was maintained for about 45 minutes during which time it is assumed that the aircraft entered Russian territory.

The captain then saw a lighted area which he could not recognize and decided to turn back on a heading of 120°M. Shortly after taking up the new heading the aircraft was fired on by an unidentified aircraft. No. 1 engine was hit and caught fire. The fire was extinguished, and the propeller feathered. All lights on the aircraft were put out, and it made a steep descent. At the lower altitude the crew ascertained that the aircraft was over water and correctly assumed they were over the Caspian Sea. A southwesterly heading was taken up and subsequently the aircraft's position over the Caspian Sea was determined. Due to a low fuel indication for No. 4 tank the captain decided to feather No. 4 engine. A heading of 120°M was again taken up which resulted in a track which roughly paralleled the Caspian coast. Following manoeuvring at a low altitude to select a suitable terrain, a forced landing was carried out.

The Accident Site

The landing was made on level and soft ground of a sandy nature. Clumps of reeds and rushes in the area reached a height of about 30 inches. The aircraft landed in a due east direction with its wheels retracted and skidded in a straight line for about 300 yd. It then slewed around through 90° and almost immediately thereafter came to rest, with its nose pointing in a northerly direction, about 150 to 200 yd from the edge of the Caspian sea.

Wreckage - results of technical examination

No part of the aircraft broke away from the main structure either in flight or at the time of the forced landing, but extensive damage was sustained by the aircraft as a result of the landing.

Nothing was discovered during the examination which could be regarded as a contributory factor to the forced landing other than the considerable damage which resulted from the reported attack by the unidentified aircraft, mainly on top of No. 1 engine nacelle and on No. 1 engine itself.

With the exception of Nos. 2 and 3 auxiliary fuel tanks, all fuel tanks were empty; Nos. 2 and 3 auxiliary fuel tanks appeared to contain less than 10 US gallons each.

The radio was removed for inspection, bench tests and air to ground tests. All tests were satisfactory. The harness and associated aerials and compass loops were not removed from the aircraft for the above tests. The VHF aerials and loop were destroyed.

Duty time

Following a consideration of the duty time of the crew members, it was concluded that the captain was absent from the cockpit during a period of about 1 hr 40 min and that during this period the flight was conducted by the first officer, assisted by the second officer.

The flight and duty time restrictions issued by the Government of Iran limit maximum flight time of members of the flight crew to 10 hours in any consecutive 24-hour period and duty time to 14 hours in any consecutive 24-hour period for flights on which two flight crew members are required. As the second officer was not in possession of a DC-4 type rating and was not qualified for instrument flying, the crew was, in fact, composed of two flight crew members and a student pilot. According to the flight plan, even if it had been compiled correctly, these maximum flight and duty hours should normally not have been exceeded. However, the composition of his crew did not justify the captain's absence from the cockpit for a period of 1 hr 40 min.

Conclusions

It is assumed that at an indeterminate time, probably when the captain was in the rear of the aircraft and the second officer occupied the left-hand seat and the first officer was navigating the aircraft from the right-hand seat, a navigational error was made. It appears that when the captain returned to the cockpit he was informed by the first officer that the town over which they were passing was Mandali. The correctness of this position was taken for granted by the captain. This was an error. The place over which they were flying was possibly Khanagin, a town 36 NM north of the track. Thereafter, by a series of unjustifiable assumptions and inaccurate pinpoints, combined with incorrect interpretations of ADF readings, a track well to the north of the correct one was maintained. This track took the aircraft out of range of the Tehran area navigational facilities.

When the captain assumed he was over Rude-Shur (radio beacon RU) he manoeuvred the aircraft to bring it over Veramin (radio beacon VR - see Figure 13). Thus a false assumption, not justified by ADF readings, led to manoeuvres which were intended to bring the aircraft over the Tehran area. After failing in this attempt the captain homed on a broadcasting station which he assumed to be an Iranian station in Tehran, because of the broadcast being made in the Parsee language. However, this assumption was wrong. The station appeared to be northwest of his position. He homed on this station for about 45 minutes maintaining a magnetic heading of 330°. This manoeuvre took him out of Iranian territory.

Realizing he was on a wrong track he turned back onto a heading of 120°M. The attack by the unidentified aircraft followed. He then broke cloud and was able to establish his position. No. 1 engine had stopped because of damage incurred, and he stopped No. 4 engine and feathered its propeller. The successful crashlanding was then carried out on the coast, 6 miles from Rud-i-Sar.

Probable Cause

The accident was attributed to faulty navigation.

Recommendations

As a direct result of this particular flight the Board put forward the following recommendations:

1) that the system of flight planning be regularized in accordance with accepted international standards;

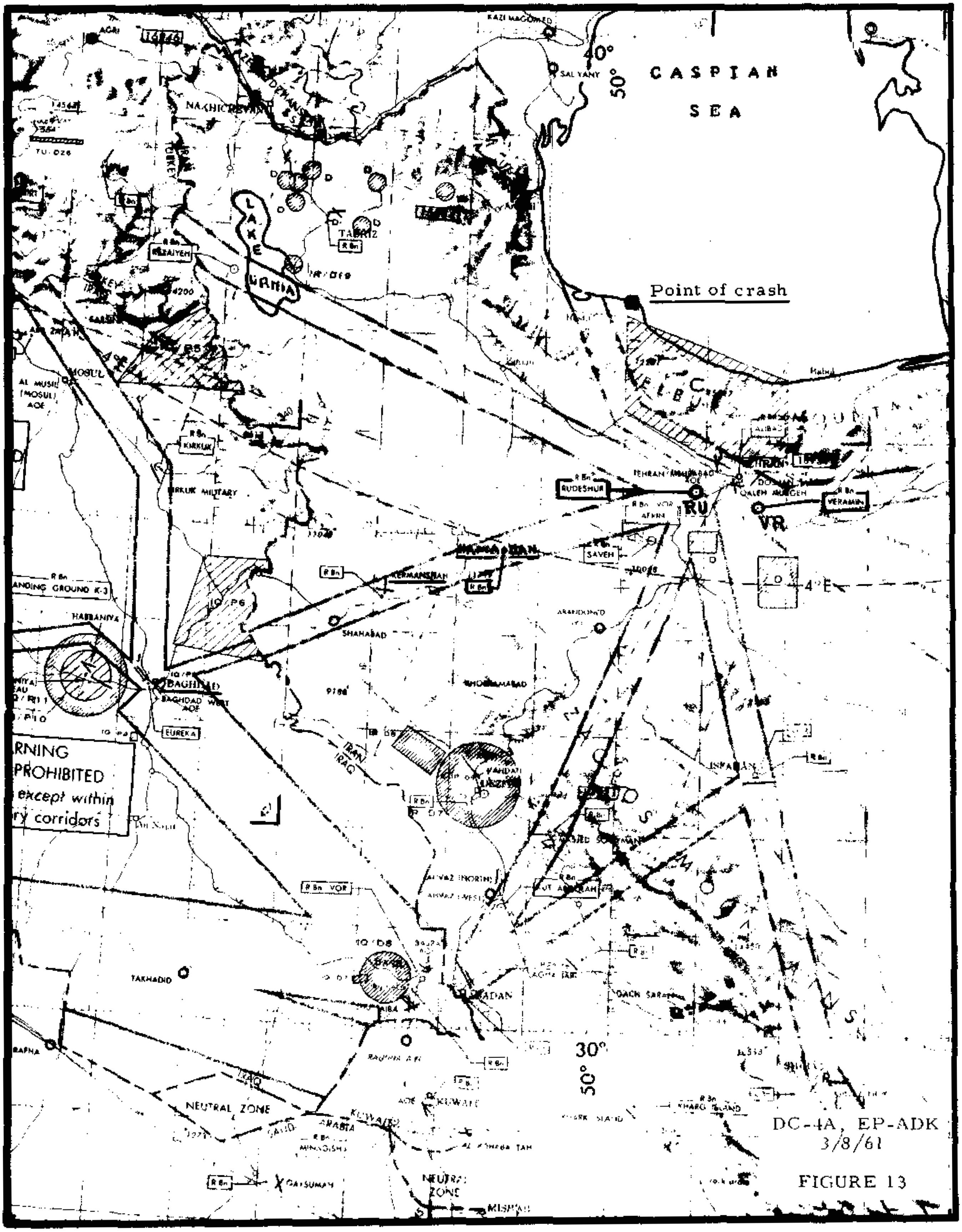
2) that the system of technical and navigation logging be thoroughly overhauled and instructions issued to ensure the maintenance of comprehensive and informative procedures;

3) that the general standard of comcompiling and initiating pertinent documentation be improved;

4) that captains be instructed not to absent themselves for long periods from the cockpit. However, if excessive flight and/or duty time makes additional crew a necessity then all such crew members should be properly licensed;

5) that captains should be adequately briefed concerning the ability and qualifications of members of their cockpit crew;

6) that Iranair should ensure that a flight, to be conducted in accordance with instrument flight rules, shall not be commenced unless valid meteorological information is available.



DC-4A, EP-ADK
3/8/61

FIGURE 13

No. 28

Cunard Eagle Airways Ltd., Vickers Viking 3B, G-AHPM, accident near Stavanger Airport, Sola, Norway, on 9 August 1961. Report of the Royal Norwegian Commission for the Investigation of Civil Aircraft Accidents, dated 28 May 1962. Also released by the Ministry of Aviation (United Kindgom) as C.A.P. 182.

Circumstances

The aircraft departed London at 1329 hours GMT on an (estimated) two and a half hour charter flight to Stavanger Airport. That same day, between the hours of 1624 and 1630 GMT, it crashed about 18 NM northeast of the airport on Holteheia, a steep mountainside running in a north-south direction. The accident site was at an altitude of 1 600 ft. All persons aboard the aircraft (i.e. 3 crew and 36 passengers) were killed. The aircraft was destroyed. An intense fuel and oil fire followed the impact.

Investigation and Evidence

The Aircraft

Its certificate of airworthiness, last renewed on 3 February 1961, was valid for a period of one year. The aircraft had flown a total of 20 885 hours.

The aircraft's certificate of maintenance dated 29 July 1961 was valid until 19 August 1961 or for 100 flying hours. On the day of the accident a preflight inspection 'B' was carried out and certified on a pre-flight inspection record.

The port engine was last overhauled completely on 3 October 1956. Since that time it had run about 1 293 hours. Immediately prior to the departure of the aircraft on its last flight an ignition rpm drop was experienced on the right-hand magneto of this engine. The fault was rectified.

The starboard engine had run a total of 1 156 hours since last overhaul.

At take-off the aircraft weighed 15 084 kg, i.e. 338 kg below the maximum permitted. It was estimated that at 1622 hours on 9 August, the time of the last radio contact with the aircraft, the all-up weight would have been about 614 kg below the maximum permitted for landing. The aircraft's centre of gravity was within the prescribed limits.

The aircraft carried enough fuel for 5 hours 15 minutes of flight.

Crew information

The captain held a valid airline transport pilot's licence endorsed in Group 1 for Viking aircraft. At the time of the accident his total flying hours were approximately 8 000, of which 3 730 hours were in command of Vikings. During the 90 days preceding the accident he had completed 283 flying hours, of which 169 were on Vikings. During the 30 days before the accident he had completed 114 flying hours.

Cunard Eagle Airways considers Stavanger Airport as a "Category A" airport, i.e. one with standard approach aids which present no hazard due to terrain difficulties. Although the captain had not been to Sola before, he had considerable experience as a Viking captain on European routes and had completed 21 instrument approaches in Europe during the preceding twelve months. The operator considered that he had shown his competency and familiarity with approach aids similar to those at Stavanger and that the ILS procedure there presented no difficulty to normal approach or departure procedures. He was authorized to operate as a pilot-in-command to all Category A airfields on route within the European region.

No specific briefing for the flight was carried out, but the captain had access to all relevant information contained in the flight guide and topographical maps carried on the aircraft and to information available at the Ministry of Aviation Briefing Room at London Airport, which included the hours of operation and availability of the Stavanger GCA.

The co-pilot, at the time of the accident, held a valid senior commercial pilot's licence endorsed in Group II for Vikings. His total flying hours amounted to 1 744, of which 262 were on Vikings as first officer. Inspection of the records showed that on 30 May 1961 he satisfactorily completed a comprehensive training course and had satisfied the operator of his competence to act as a first officer on Viking aircraft. His last instrument rating check was on 18 January and his last competency check was on 22 May 1961. His total flying time for the 90 days preceding the accident was 255 hours, all on Vikings. During the 30 days preceding the accident he had completed 94 flying hours. On the day prior to the accident he had completed 7 hours of flying.

The air hostess had completed 163 flying hours and was considered to be an above average hostess.

All crew members had sufficient rest prior to the flight.

Weather - landing forecast for Stavanger Airport, Sola

0600 - 1500 hours

surface wind	120°/20 kt, gusty
visibility	3 NM
cloud	3/8 stratus at 1 000 ft 8/8 stratus at 1 500 ft

becoming between 0900 - 1200 hours

wind	210°/20kt, gusty
visibility	11 NM
cloud	6/8 cumulus at 1 800 ft

temporarily between 0900 - 1500 hours

visibility	4 NM in heavy showers 5/8 cumulonimbus at 1 200 ft

Actual weather at Stavanger

On the day of the accident a low pressure system reached southwest Norway. A trough passed the Sola area some time between 1200 and 1500 hours, following which the surface winds veered from south-southeast to southwest, occasioning rain and showers but without significant change in the cloud base. Most likely the wind at 1 500 ft came from a direction of 230°, with an average velocity of 50 kt. At times it may have reached 60 kt. Cloud formations were variable.

The freezing level at Sola was about 7 500 ft. Carburettor icing is hardly likely to have occurred.

Atmospheric pressure given in the actual reports from Sola was correct. The pressure was rising. This, occurring after the sub-scale of the aircraft's altimeter was set, would result in too low an altimeter indication, and the aircraft would be flying at a higher altitude than indicated.

None of the meteorological stations in the Sola area reported thunderstorms on 9 August. Aircraft reported no special atmospheric disturbances in the area. The relatively large amounts of precipitation indicated that static may have occurred for short periods.

The actual weather observations from Sola for the period between 0830 and 1745 hours are quite representative for the weather in the area. The half-hourly routine weather observations show a fairly strong and gusty surface wind from a southerly to southeasterly direction, with an average wind speed of 20 to 25 kt, with gusts up to 45 kt. The wind veered to the southwest around 1400 hours, with only small changes in velocities.

The visibility at Sola was about 10 km, before the passage of the trough, during which the visibility dropped to 2 km and increased again to 10 km after passage.

There was a well-broken layer of stratus cloud at about 500 ft, apart from a short period after 1700 hours when the stratus clouds covered nearly all of the sky. Above these lower clouds a layer of strato cumulus was reported, with base varying from 1500 to 2500 ft.

Wind velocity at 1 500 ft at Stavanger

At the time G-AHPM was near Sola, an SAS flight was holding at Rennesy LII NDB at 6 000 ft awaiting its turn to land. The SAS pilot said that a strong wind affected the Stavanger area and whilst on final approach to land on runway 18 at 1709 hours he experienced 17° port drift at a true airspeed of 150 kt.

At 1850 on the same day a Viking landed at Sola after making an approach by GCA. This aircraft experienced 25° port drift on final approach at a true airspeed of 115 kt.

It was established that the (mean) wind direction at the time of the accident was about 050°M. From this and the drift angles experienced by the two aircraft mentioned, the wind at 1 600 ft at about the time of the accident proabbly was 230° M at approximately 60 kt.

Neither the flight forecast nor the verbal briefing received by the crew prior to departure from London Airport, nor the surface wind transmitted to the aircraft by Sola ATC indicated that the wind velocity in the area at the altitude and time of the approach was as high as subsequently determined by an evaluation of the meteorological situation and by reports from pilots that had operated in the Sola area during the critical period. If so requested, a revised flight forecast issued by the meteorological office at London as late as 1155 hours would have been made available to the crew. Considering that the flight's departure from London was postponed about 5 hours,* it is surprising that the captain did not seek to obtain a revised forecast prior to leaving, as the period of validity of the forecast in his possession would expire before his estimated time of arrival at Stavanger. However, the revised forecast would not materially have changed the information already in the possession of the crew.

Stavanger Airport, Sola

ILS procedure

The ILS runway at Sola has a magnetic bearing of 185°. The outer marker, incorporating a 75 Mc/s fan marker and a MF locator on 352 kc/s, is positioned 3.8 NM from the runway threshold. When approaching from the south the prescribed procedure is to cross the outer marker at 2 000 ft on the QNH and fly north for 2.5 NM, descending to 1 500 ft on the QFE. A 45° procedure turn is then made to the left and after 45 seconds this is followed by a turn to the right to rejoin the localizer beam. The 45 seconds timing may be increased or decreased according to the wind conditions. On re-joining the localizer the aircraft descends to 1 300 ft and, after crossing the outer marker, descent is continued on the glide slope to the approach minimum. If, for any reason, the final stage of the approach must be abandoned, the aircraft should turn on to a heading of 270° M and climb to 2 500 ft.

Monitoring of radio equipment

No failure occurred in the monitoring equipment for the locator and the ILS during the time the aircraft was making its approach.

Test of ground radio aids

Flight tests were carried out on the radio navigation aids which may have been used by the aircraft while in the Stavanger area. Particular attention was given to the ZO locator and the ILS.

ZO locator (at outer marker of the ILS to runway 18 at Stavanger)

It was found that if the aircraft radio compass was tuned to a frequency slightly above 352 kc/s, interference from

* This delay had no bearing on the accident.

the Danish radio beacon at Billum was experienced. This NDB (OZR) is 216 NM from ZO on a bearing of 157°T and transmits on a frequency of 355 kc/s. The nominal range of this transmitter is 200 NM whilst that of the ZO locator is 25 NM. The degree of interference depended upon how much the receiver was out of tune towards the frequency of 355 kc/s. Generally there was no difficulty in tuning ZO and excluding the interference, but if the tuning was done when the aircraft was close to the beacon there was a greater possibility of mistuning being undetected. Near the beacon the field strength of ZO was high enough to overcome the interference and give correct radio compass indications even if it was mistuned as far as 355 kc/s. However, when the aircraft left the vicinity of the beacon, due to the decrease in its field strength, the interference became effective and incorrect indications resulted. With the receiver mistuned towards the frequency of Billum it was possible to hear the call sign of ZO as well as that of Billum.

Ground-controlled approach

Civil aircraft are permitted to use Air Force-operated GCA's. An international Class 1 Notam, dated 12 June 1961, announced that the GCA at Stavanger Airport, Sola, during the period from 1 July to 14 August 1961, was closed to all operations from Saturdays at 1100 hours to Mondays at 0600 hours.

On 9 August, the GCA was available to G-AHPM on 45 minutes notice, but no request for this service was made by either the pilot or the Sola Tower.

Reconstruction of the flight up to the accident

Evidence showed that the aircraft left Clacton at 1354 hours and proceeded, at cruising flight level 90, on a direct track to the Stavanger Consol Station. During this part of the flight the aircraft was in radio contact initially with Preston Airways; later with Stavanger Control. There were indications that the VOR set in the aircraft was tuned to the frequency of Kristiansand S; this facility may have been used by the crew to obtain ground speed checks on the latter part of the flight.

At 1611 hours the pilot reported just coming up to LEC (Stravanger/Varhaug) Consol Beacon, and it is estimated that the time overhead the beacon was between 1612 and 1613 hours. Having previously been cleared to descend from 4 000 to 2 000 ft, the aircraft, at 1613 hours, confirmed that it was descending and had passed 3 500 ft. From the evidence of the air traffic control officer at Sola it appears likely that the aircraft passed overhead the airfield, northbound, at approximately 1618 hours. At 1620 hours a QDM of 180° (corrected 184°) was obtained by Sola Tower. It is estimated that the aircraft was then almost on the centreline of the ILS and to the north of the outer marker.

From the radio telephony conversation between Sola Tower and the aircraft it appears possible that some confusion existed regarding the radio beacon used when approaching Sola from LEC. Initially, the LII (Rennesy) NDB may have been tuned in on the radio compass and the change to ZO only made when the aircraft had passed over the aerodrome northbound. Reference to the type of route chart used by the first officer shows the LII NDB and not ZO. This is because the chart is mainly concerned with route facilities and not landing aids. The voice on the radio was identified as that of the first officer, and normally he would be concerned with the tuning of the various navigation aids. The last surface wind given to the aircraft was 200°/25 kt. However, evidence indicates that at this time a considerably stronger wind existed at the 1 600 ft level and the aircraft's maximum angle of drift, while on the procedure turn, may have been as high as 26°. Although the captain had ample opportunity to assess the drift as he flew northbound from LEC, the drift on his procedure turn may have been greater than he expected.

Nothing indicated the occurrence during flight of abnormal technical or operational circumstances or incidents, which may have contributed to the accident. In so far as it could be ascertained the flight proceeded normally up to a certain position north of the outer marker or ZO locator on the ILS beam to runway 18 at Stavanger Airport, Sola.

From the position at 1620 hours, when the aircraft was just north of the outer marker, until it was seen by witnesses on the ground, little is known with certainty of its track, but it is reasonable to assume that the captain, at least initially intended to carry out the ILS procedure laid down in his Aerad flight guide. According to witnesses the aircraft flew in from the west and crossed the coastline at a position approximately 9 NM to the east of the ILS centreline, whence it made good a track of about 105° M for the last 4 NM to the position of the crash. Statements from two ground witnesses, however, could be understood to indicate that the aircraft, at around 1630 hours, may have made an approximately 315° port turn on the eastern side of the localizer. This would mean that the planned ILS approach had been discontinued. The Commission was of the opinion that an evaluation of all other available evidence made this unlikely.

The Commission was of the opinion that the weather conditions at Sola, i.e. strong and gusty winds, must be considered unusual for the season. The instability of the air at the time, causing turbulence near the ground, probably made landing and take-off more difficult than normal. Also, the gusts and vertical currents which the aircraft encountered in the air over the Stavanger area should not have been of such intensity as to cause hazards to flight. During the same afternoon and evening eight other aircraft landed at Sola without any problems of note.

The Commission was satisfied that at the time of the accident the weather conditions at Stavanger Airport were above the operator's weather minima for Sola ILS approach and landing.

Air traffic control

The services rendered were in accordance with the procedures and regulations in force at the time.

Information transmitted to G-AHPM appears to have been correct. The ATC officer checked the flight three times on his VHF automatic direction finder. The control officer acted correctly by checking the ETA of the aircraft over LEC and in correcting the pilot when, at 1618 hours, he reported estimating the LII beacon in approximately two minutes. The Commission noted that the crew was not precise in reporting times overhead the LEC and ZO beacons.

The ATC officer called the aircraft at 1629 hours without getting a reply. Normal time for procedure turn manoeuvring had then been exceeded, but the duty ATC officer, because of prevailing wind conditions, expected that this approach would take longer. The normal time for an aircraft to complete the procedure turn and arrive back over the outer marker, inbound, is about 6 minutes. Therefore, the ATC officer's call at 1629 hours appears to have been within the 3 minute limit prescribed in ATC procedures.

No request for GCA service was made either by the captain of the aircraft or by the ATC officer at Sola. The non-use of this equipment was not, in the opinion of the Commission, a contributory cause of the accident, but the Commission believed that the accident to G-AHPM might have been avoided if the GCA station had been utilized either in its primary function or for surveillance. The latter utilization of the equipment would have enabled the ATC Officer to initiate corrective action as soon as the radar scope information showed that the aircraft was astray.

Technical aspects

It was established that electrical power was available on the aircraft. Certain of the radio and navigational aids were in use, including the VHF, the radio compass and the ILS equipment. Although *the radio compass tuning indicator was* found at a setting of, or slightly above, 352 kc/s, the possibility that the set was receiving signals other than those from the ZO locator, e.g. Billum in Denmark, cannot be entirely discounted.

No evidence was found of pre-crash mechanical or structural failures, and at the moment of impact the aircraft was in level or nearly level flight with wheels and flaps retracted. The engines were under power, and the propellers were in the constant speed range. There were no signs of a pre-crash fire.

Possible reasons for the aircraft's departure from the instrument let-down pattern

The most likely one is associated with the very strong southwesterly wind. It was established that the aircraft passed the vicinity of Sola northbound, and it is reasonable to assume that the captain was attempting to follow the prescribed ILS procedure. It is likely that the wind at 1 600 ft was about 230°/60 kt and the maximum drift the aircraft would experience on the procedure turn would have been about 26° and during part of the turn the ground speed may have been as high as 195 kt. *If insufficient allowance was* made for the drift, it can be shown that by the time the aircraft had completed the turn to rejoin the localizer beam the wind effect would have taken it close to or even through the centreline. After completing this turn the aircraft should still have had a short distance to run before reaching the beam and at this point the localizer needle on the instrument in the cockpit should be giving a "fly left" indication. When this needle starts to move towards the "on course" position the turn on to the final approach is made. However, if the aircraft had passed through the centreline whilst still making the turn, the crew ought to have been aware of this from the "fly right" indications even if they had missed the actual movement of the localizer needle. In addition, the radio compass indicator would have made this apparent if it was correctly tuned to the ZO locator. *With the wind speed and* direction at the time, even if the captain had allowed for sufficient drift to make good the required outboard procedure turn track, it would still have been necessary for him to extend the "still air" timing of 45 seconds by approximately 1 minute 15 seconds to ensure that he was still on the western side of the localizer by the time he had completed the final part of the procedure turn.

After completing the procedure turn there is little doubt the crew expected still to be on the western side of the localizer beam and they may have missed the movement of the localizer needle that resulted from crossing the beam. If the crew misinterpreted the indications of the localizer needle this would help to explain why the heading of 135° - 140° M was maintained to the position of the crash. However, if the ILS equipment in the aircraft was working satisfactorily the crew must, for at least 4 - 5 minutes, have had a continuous indication that they were on the eastern side of the localizer beam. The Commission was unable to explain how the crew in a situation of this nature could continue on the heading indicated for the time stated unless they either did not note or were *misinterpreting the ILS indicator readings.*

The possibility of interference from the Billum NDB affecting the indications of the aircraft's radio compass cannot be discounted, particularly as the evidence indicates that the crew may have tuned in ZO while the aircraft was close to it. The effect of such interference would be to deflect the radio compass needle in such a way as to strengthen the crew's impression that they were on the western side of the localizer. Nevertheless, this should not have prevented them from correctly interpreting the indications of the localizer needle.

Probable Cause

For reasons unknown, the aircraft deviated from the prescribed flight path.

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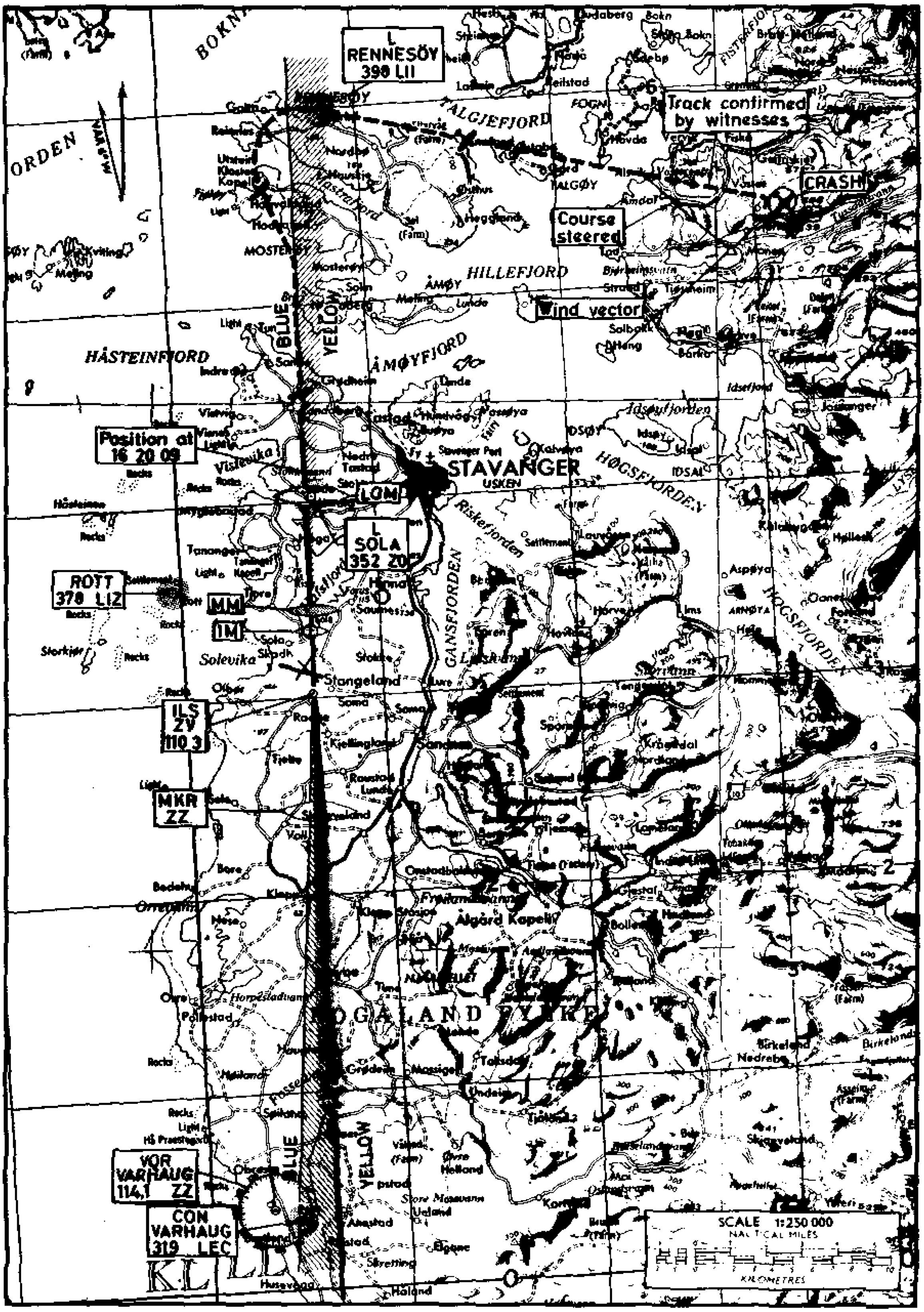
ICAO Ref: AR/724

RECONSTRUCTION OF LAST PART OF FLIGHT



Unbroken line: Aircrafts initial approach
Dotted " : Possible flight path last minutes

Viking 3B, G-AHPM
9/8/61

FIGURE 14

No. 29

Eastern Provincial Airways, DHC-3 "Otter", CF-MEX, made a forced landing near Søndre Strømfjord, Greenland on 29 August 1961. Report dated August 1962 released by the Directorate of Civil Aviation, Denmark.

Circumstances

Nine minutes after taking-off on a charter flight from Søndre Strømfjord, Greenland to Egedesminde, Greenland, the aircraft experienced a fuel leak which was followed by a severe fire. An immediate forced landing became necessary. In spite of the severe circumstances the pilot succeeded in bringing the aircraft down on a small lake about 11 NM northeast of Søndre Strømfjord and landed it on the shore where it eventually was completely destroyed by fire. The pilot suffered severe burns during the approach and landing and later fatal burns from being trapped under the left float of the aircraft, which was in flames. The mechanic, who was occupying the co-pilot's seat, suffered burns to his left leg. The four passengers were not injured.

Investigation and Evidence

The Aircraft

Its certificate of airworthiness was valid until April 1962. It had flown 750 hours since new, including 15 hours since the last periodic check.

Loading and Centre of Gravity Position

The aircraft's all-up weight at take-off was about 7 980 lb. The approved maximum all-up weight is 7 967 lb. At the time of the accident the aircraft's weight was about 7 950 lb.

No centre of gravity calculations were made, and no balance sheet was prepared. Under normal loading conditions which existed in this case, it is virtually impossible to exceed the approved centre of gravity limitations. Thus, there was no reason to suspect that the aircraft's centre of gravity position was not within the prescribed limits.

The Pilot

He held a valid Canadian commercial pilot's licence and had flown a total of 4 000 hours, including 1 500 on the DHC-3.

Reconstruction of the flight

The aircraft departed Søndre Strømfjord on a VFR flight at 1814 hours GMT carrying 2 crew, 4 passengers and some cargo. While taking-off the pilot advised the tower that his HF communications equipment was temporarily unserviceable. This discrepancy was soon rectified by the mechanic and five minutes after take-off the equipment was reported to be operating normally.

Four minutes later, during climb, the pilot observed the fuel pressure had dropped to 2 psi. He levelled off, called the mechanic's attention to the malfunction and switched on the fuel booster pump. Immediately a strong smell of fuel was experienced in the cockpit, and the mechanic shut off the booster pump. The pilot changed course back to the point of departure and advised on HF that he was returning to Søndre Strømfjord due to a gas leak, that the aircraft was 8 - 10 miles north of the beacon and stated that he would call when down. This was the last transmission from the aircraft. A few seconds later smoke appeared in the cockpit, and the mechanic saw clear fire through an opening in the control pedestal leading to the compartment below the cockpit floor. The fire warning system was never observed to operate. The engine was shut down at an altitude of about 3 000 ft.

The fire extinguisher was operated, and descent was immediately initiated.

During the descent the cockpit rapidly filled with smoke and flames were blazing through the rudder push rod funnels between the pilot's feet. In order to maintain forward visibility, he opened the left-hand cockpit door and leaned out. During the final part of the descent and during the landing he could not remain in his seat due to the intense fire around his legs and arms, but he succeeded in bringing the aircraft safely onto the lake while standing outside the cockpit. When the aircraft hit the beach the pilot was thrown forward onto the turf where he was pinned beneath the left float. The mechanic and the four passengers attempted unsuccessfully to free the pilot, for fifteen minutes after the landing. Then the fuel tank ignited and it was *not until forty-five minutes later*, when the aircraft disintegrated, that the pilot could be removed from his position under the float.

Damage to the aircraft was very extensive due to the intense fire which followed the ignition of the fuel tank.

The Wreckage Inspection

During the detailed inspection of the wreckage a bronze plug, relatively undamaged by fire and obviously a drain plug missing from the carburettor pressure chamber was found in the bottom of the engine cowling underneath the corresponding threaded bore in the carburettor. No traces of locking wire were found. In view of the condition of this plug and the corresponding bore in the carburettor housing as compared with a similar plug in the same housing, it may be safely assumed that the said plug was not in its proper place when the fire took place in the engine accessories compartment. However, it must have been in place during engine run-up as otherwise fuel would have been *observed running* from the cowling.

[illegible] out by the manufacturer [illegible]val of the plug in question during engine operation reduces the fuel pressure to 1-3/4 psi.

It can thus be concluded that the fuel pressure drop and consequent heavy fuel leak experienced on this flight occurred when the already loose plug fell from its bore.

No records on the maintenance of the aircraft were available, because the log books were destroyed with the aircraft.

Maintenance work was carried out on the cabin heater system of the aircraft the day before the accident, but, according to the mechanic, the carburettor drain plug was not touched during this operation. Therefore, it may be assumed that the safety wire was omitted during the last over haul of the engine and this discrepancy was *not detected by those in charge of the routine* maintenance.

Main fuel filter

Improper installation of the filter element results in deformation of the element and in fuel leakage. The deformation of the fuel filter element of CF-MEX as found might indicate that it had been improperly installed, or it may have been caused by the heat to which the filter was obviously exposed.

It can, therefore, be concluded that CF-MEX developed a severe fuel leak in front of the firewall and possibly a moderate fuel leak in the compartment beneath the cockpit.

Source of ignition

It was not possible to point out a definite source of ignition.

The fire may have been started forward of the firewall, the engine accessories compartment displaying several possible sources of ignition and a more than sufficient supply of combustion air, coming from the generator cooling tube.

The fire warning system may have been inoperative at the time of the fire. The fact that the system did not give warning cannot be considered proof that no fire occurred forward of the firewall. The appearance of the firewall indicated that a blazing fire had existed forward of it. This fire could not have continued when the aircraft was on the ground as at this time the engine was stationary, and the booster pump was switched off. Consequently, fuel was not fed to the carburettor, not even by gravity.

According to the manufacturer, once started, the burning fuel could proceed aft and enter the compartment below the cockpit where the fire would continue and fuel, possibly leaking from the fuel filter, would be ignited.

The possibility of the fire originating in the compartment below the cockpit was evaluated but appears to be rather remote as the fuel booster pump, which must be considered the only probable source of ignition, is sealed.

When the aircraft came to rest on the ground the fuel supply to the engine stopped, but the considerable amount of fuel which at that time undoubtedly was in the belly of the aircraft, continued burning, burned through the oil lines, set the oil on fire and eventually reached the fuel tanks.

Probable Cause

The accident was caused by an in-flight fire, initiated and sustained by a severe fuel leak. The fuel leak was caused by the locking of a carburettor drain plug being omitted, thus permitting the plug to unscrew.

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ICAO Ref: AR/739

No. 30

Trans World Airlines, Inc., Lockheed Constellation, Model 049, N 86511, accident 9 miles west of Midway Airport, Chicago, Illinois on 1 September 1961. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0011, released 18 December 1962.

Circumstances

Scheduled Flight 529 originated at Boston, Massachusetts for San Francisco and was to make five intermediate stops including one at Chicago, Illinois. The trip to Chicago was without incident. Following a crew change at Chicago the aircraft took off at 0200 hours central daylight time on an IFR flight plan for Las Vegas, Nevada. It carried a crew of 5 and 73 passengers. Approximately five minutes later, during good weather, while climbing on the intended course, the aircraft experienced loss of longitudinal control and crashed killing all occupants. The aircraft was destroyed.

Investigation and Evidence

The Flight

At the time of departure from Midway Airport the aircraft was considered to be airworthy, and its gross take-off weight of 94 794 lb was well below the maximum allowable of 96 000 lb. The 0200 weather at Midway was: scattered clouds at 10 000 ft; high overcast, visibility 3 miles in haze and smoke; wind south 8 kt.

Radar contact was established with the flight one minute and thirty-four seconds after the flight acknowledged take-off clearance and as the aircraft proceeded outbound in a right turn. At 0204 hours Flight 529 was observed on radar by the departure controller to be 5 miles west of Midway Airport proceeding on course. A Northwest Flight (No. 105) was cleared for take-off on runway 22L at Midway and took off immediately. The ground controller observed a flash west of Midway at this time and asked Flight 105 if they had seen it. Flight 105 advised that they had seen a flash fire and would fly over the area. As Flight 105 reported over the fire, the radar range was noted to be 9 miles west of Midway, and the radar return of TWA Flight 529 had disappeared from the scope. It was later determined that Flight 529 had crashed at this site and that the observed ground fire was the result of the accident.

Witnesses

Witnesses who observed Flight 529 indicated that it was heading in a westerly direction and was apparently proceeding normally until less than two miles from the scene of the accident. A witness located one mile south-southwest of the scene stated that the aircraft was flying low at that point on a northerly heading. No witnesses were found who saw the aircraft at the moment of impact.

Accident site

Flight 529 crashed in an open field near Hinsdale, DuPage County, Illinois. The aircraft struck the ground in a slightly left-wing-low and nosedown attitude on a heading of approximately true north. The aircraft disintegrated, leaving debris over an area 200 ft wide and 1 100 ft long. Five craters were made, each approximately three to four feet deep, as a result of the four engines and fuselage striking the ground.

Wreckage examination

Investigation revealed that the portion of the horizontal stabilizer to which the right vertical fin is attached had separated from the aircraft prior to impact, having landed approximately 400 ft south of the main impact craters. The stabilizer failure occurred at Stabilizer Stations 240R and 230R of the front and rear spars, respectively. There was no evidence of fatigue on the spar caps, spar webs, skin material, or stringers. Examination did disclose that there had been oscillatory loads applied to the four spar caps and the two spar webs prior to and during separation. The front spar upper and lower caps had failed in tension and the interconnecting spar web had experienced a tensile tear from top to bottom. The fracture faces of both rear spar caps were brinelled by recontact after failure.

There were several indications that the elevator had been at its maximum upward travel. The most significant evidence of this was in the deformation pattern impressed in the right rudder by the elevator outboard closing rib in a manner and position such that the elevator had to be full up at the time the right rudder was forced into it during the stabilizer separation.

Examination of the wreckage revealed no evidence of an in-flight explosion or collision with foreign objects. No evidence of electrical overheating of the DC and AC units was found.

There was no evidence of any operational failure or malfunction of any engine or propeller component.

Measurements and readings were made of all trim actuators and their associated cockpit position indicators. The variations of readings within each of the trim systems prevented any determination of in-flight trim positions.

The two aileron boost assemblies and the aileron boost cut off valve were found in the boost "off" position. The shift handle in the cockpit, however, was found in the boost "on" position. Since the shifting mechanisms are interconnected by long lengths of cable subject to being pulled by fragmenting structure following impact, the position of the cockpit handle is considered to be the more reliable, but not positive, indication of aileron boost condition. Under functional testing, the components of the left aileron boost package functioned satisfactorily. The right aileron boost package was too badly fire damaged to be tested.

The position of the rudder boost shift handle count not be determined, but all affected components of the boost package were in the boost "on" position. The components of the boost package functioned normally when tested.

The elevator boost shift handle was found in the "on" position as was the boost package. The components were functionally tested individually and found to operate satisfactorily, commensurate with the impact damage suffered by the unit, except for the disconnection of one link of the parallelogram.

Examination of the parallelogram linkage of the elevator boost located in the extreme aft section of the fuselage revealed a 5/16 inch nickel steel bolt to be missing. This parallelogram linkage connects the pilot elevator input to the control valve of the elevator boost system. The bolt was not found in the wreckage despite a thorough search, including sifting of earth in the wreckage area.

Detailed examination of the bolt hole bushings, grease deposits, scuff marks, scratches, chatter marks and internal thread-like scores in the bushings provided strong evidence to indicate that the nut of the missing bolt had not been properly in place for a considerable time prior to the accident. This evidence coupled with analysis of the loads that could be imposed upon the bolt at impact, and the effect of such loads on the grease deposits, established that the bolt was missing from its installed position at the time of impact.

The construction of the elevator boost mechanism is such that when this bolt became free from its normal location there would be an almost instantaneous application of maximum elevator-up control applied by the elevator boost system. Under these circumstances the boost system would no longer be under the control of the pilot and the only means by which control of the aircraft could be regained would be to change to manual operation of the elevator control system. The shift would:

1) close the boost cut-off valve;

2) open the bypass valve at the actuator; and,

3) change the mechanical advantage of the direct pilot-to-elevator linkage.

It would appear that recovery from such a malfunction would be a simple and straightforward operation. However, there is a peculiarity of the system which can introduce a severe problem.

That function of the shift-to-manual operation which changes the mechanical advantage of the system has the effect of lengthening the connecting system between the control column and the elevator torque arm. That is, the portion of mechanical linkage upstream of the shifting area (dual link rod) tends to move the control wheel aft, and that portion downstream tends to move the elevator downward. If the two hydraulic valves had operated properly, and there was no evidence in this case that they would not have, the elevator would have been free to move downward assisted by airload hinge moment; however, if there had been no forward pressure on the control column, the column would have been free to move aft, and the shift to manual could have been completed. If, however, the crew had applied forward pressure on the column while trying to shift, the shift would have become increasingly difficult in direct ratio to the amount of forward pressure.

The elevator had boost "on" limits of 40° up and 20° down, but is further limited with increasing airspeed by the boost hinge-moment maximum of 49 000 to 54 000 inch-pounds. In the manual position, elevator deflection is reduced to 16° up and 6° down because of the increase in mechanical advantage. Therefore, if the shift to manual is started when the elevator is up more than 16°, it must be at or less than 16° before the shift can be completed.

From this, it can be seen that when the bolt comes out of the parallelogram:

1) The weight of the spool and two of the parallelogram links cause full pressure to be applied to the up-elevator side of the actuator.

2) The elevator travels up to its maximum hinge-moment. For the speed at which this aircraft was assumed to be operating, this would be less than 40 but greater than 16°.

3) The aircraft enters an accelerated stall. As this stall decays toward a primary stall, the elevator angle increases to 40°.

4) The captain or first officer, or both, would normally apply high forward pressure on the control column in an attempt to get the nose down.

5) While this forward pressure is being applied, the crew attempts to pull the shift handle.

6) With the elevator at its maximum deflection (maximum hinge-moment or 40°, depending on speed) and held there by full hydraulic pressure and with forward (nose-down) force on the column, it becomes difficult, if not impossible, to move the shift handle far enough to operate the shutoff and/or the bypass valves.

7) With the aircraft stalled, or executing a series of stalls, even though altitude is being lost, the nose must be lowered to effect recovery; hence, increased forward force results in a higher force required to pull the shift handle.

8) Accelerated stall vibrations may cause empennage or rear fuselage damage.

There can be no doubt in the subject case that the elevator was at the 40° up position at some point during the empennage failure. The right outboard closing rib was crushed by, and left its impression on, the fin and rudder. Matching the parts showed clearly the 40° elevator position.

The Board also considered similar accidents and incidents to military aircraft of the same type. While the initial causes were different, the results were the same. The evidence from this source supported the view that with extreme elevator deflection the shift to manual control becomes nearly impossible when large forward control forces are applied. Also, these investigations provided proof that accelerated stalls can produce structural failure in the empennage of this type of aircraft.

Conclusions

It was concluded that during the climbout from Midway Airport the bolt worked its way clear of the parallelogram link, and this was followed immediately by full pressure to the up-elevator side of the actuator piston. The pilot's natural response to the resulting violent pitchup and accelerated stall prevented successful shift of the elevator boost system to the manual position.

The manner in which the bolt was lost is largely a matter of conjecture. The nut could have been left off at the time of installation in November 1960; however, this is not probable in view of the length of time which elapsed from November 1960 until the occurrence of the accident. The sheer nut could have been over-tightened, thereby stripping the threads, but the loads on the bolt are such that even a stripped nut, if it has a cotter key installed, could hold the bolt in place. The most probable reason, although it cannot be substantiated, is that the cotter key was omitted at the time of the parallelogram installation and that during the intervening months the nut backed off and allowed the bolt to come out. The immediate valve-porting, the rapid onset of hydraulic pressure to the boost actuator, and the resulting maximum hinge moment on the elevator associated with the loss of this bolt prove conclusively that the loss could not have occurred prior to the climbout from Midway Airport.

Probable Cause

The probable cause of this accident was the loss of a nickel steel bolt from the parallelogram linkage of the elevator boost system, resulting in loss of control of the aircraft.

Recommendations

On 22 November 1961 the Board recommended to the Administrator of the Federal Aviation Agency that the mechanism for shift-to-manual in the Constellation control boost system be modified so that the actions would be sequential rather than simultaneous. Specifically, under the recommended change,the shifting action by the pilot would remain one continuous motion of a handle but would, first, open the bypass valve; second, close the hydraulic shutoff valve and, third, shift the mechanical linkage. With such an arrangement, all hydraulic pressure in the boost package would be relieved prior to the mechanical shift action and would thus allow the complete shift-to-manual without restriction regardless of pilot-applied control forces.

On 8 March 1962 the Administrator advised the Board that his Agency was having the Constellation Flight Manual amended to include "procedures for turning off the elevator boost with an uncontrollable elevator." The Administrator further advised that "in view of the excellent service history achieved by this aircraft since certification in 1946, we believe there is insufficient justification to require design changes to accomplish your total objective."

Although turning off the elevator boost provides a possible means of regaining control, it appears hopeful to assume that a pilot will recall and execute successfully the flight manual instructions when confronted unexpectedly with a violent structure-damaging manoeuvre instinctively resisted by pushing on the control wheel. The Board, therefore, recommended on 24 August 1962, that further consideration be given to modification of the shifting system.

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ICAO Ref: AR/737

Constellation, Model 049, N86511
1/9/61

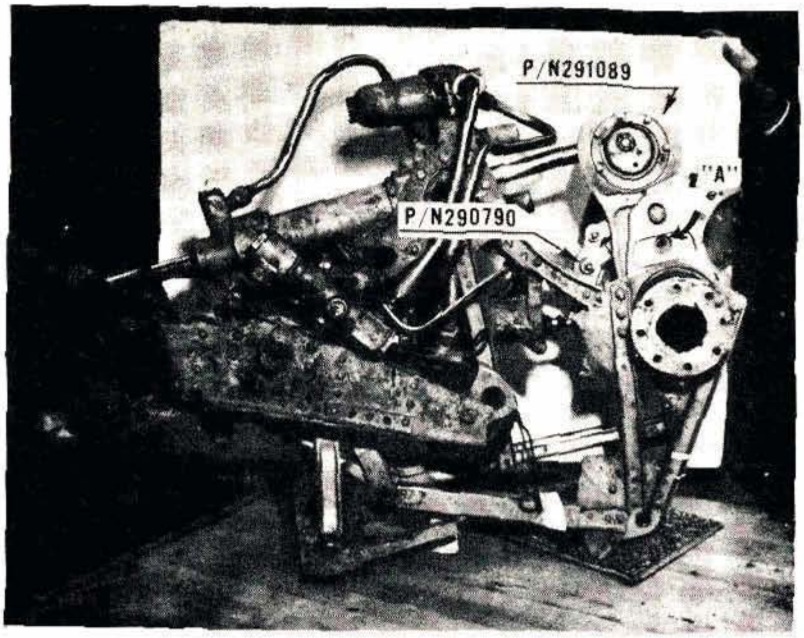

FIG. 15.-Elevator boost package. Bushing where bolt should have been is indicated by arrow "A".

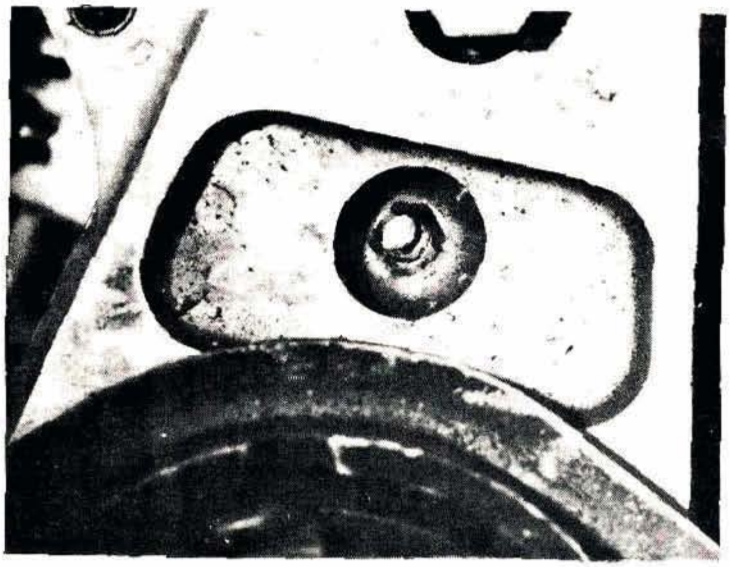

FIG. 16.-Close-up view before disassembly *of bushing against which head of bolt should* have been.

No. 31

Air France, SE 210 III Caravelle, F-BJTB, accident near Rabat-Salé Airport, Morocco, 12 September 1961. Report released by The Minister of Foreign Affairs, Morocco.

Circumstances

After a normal flight from Orly Airport, Paris, Flight 2005, Paris-Rabat-Casablanca, reported over the Rabat - Salé Airport, where meteorological conditions were unfavourable owing to thick, low fog which reduced horizontal visibility and ceiling. The pilot reported his intention to attempt a break-through over the non-directional beacon; the control tower immediately replied that that facility was not in line with the runway, but the message was not acknowledged. The aircraft crashed to the ground at 2109 hours GMT killing all 77 persons on board, including 6 crew members. The aircraft was completely destroyed by impact and the fire which followed.

Investigation and Evidence

The Aircraft

The aircraft's certificate of airworthiness was dated 23 May 1961. Since construction F-BJTB had completed 688 hours of flying. It had undergone the following inspections:

T2 inspection	:	31 August 1961
block "	:	7 September 1961
T1 "	:	11 September 1961

Loading and trim

On take-off from Orly the aircraft had weighed 45 367 kg. (The maximum allowed was 46 000 kg.) The estimated landing weight was 37 408 kg for an authorized 43 800 kg. Its centre of gravity was within limits.

Crew Information

Aboard the aircraft were 6 crew members - the pilot-in-command, a co-pilot, a flight engineer and 3 cabin attendants.

The flight crew's experience was as follows:

Pilot-in-command

He held an airline transport pilot's licence and had logged a total of 10 693 hours, 344 of which were on Caravelles. He had made 31 landings at the Rabat/Salé Airport.

Co-pilot

He held a senior commercial pilot's licence and had logged a total of 3 858 flying hours, of which 988 were on Caravelle aircraft. He had made 3 landings at Rabat/Salé.

Flight engineer

He had a flight engineer's licence and had flown 6 553 hours of which 173 were on the Caravelle.

Weather

On departure from Orly Airport the flight was provided with landing forecasts for Rabat/Salé Airport. While en route, the flight called the Air France unit at Casablanca at 2040 hours on the airline frequency and was given the following aeros for 2030 hours.

Rabat/Salé : wind 360°/2 kt; visibility 500 m; fog; ceiling 7/8 at 300 m;

Casablanca : wind 360°/4 kt; visibility 6 km; ceiling 7/8 stratus at 150 m; variable

Tangiers : wind 360°/12 kt; visibility 20 km; ceiling 1/8 cirrus at 7 000 m

The airline operations agent then suggested that the pilot head for Casablanca passing over Rabat in order to get the latest weather there and informed him that Tangiers was a sure alternate.

The pilot acknowledged receipt of the foregoing messages indicating that he would, as suggested, head for Casablanca flying direct over Rabat/Salé. He also requested the forecasts for Marrakech Airport, which were received later.

At 2046 hours the Casablanca Regional Control Centre, with which the aircraft had just made contact, gave it the latest observations for Rabat/Salé and Casablanca. One minute later the aircraft requested and received the new meteorological observation for Rabat from the Casablanca ACC. At 2048 it received the latest observation for Tangiers from the same control centre. The area control centre notified the aircraft, six minutes later, of information from Rabat/Salé that visibility was then 500 m because of fog patches, increasing at most to 1 km when at its best; the aircraft acknowledged the message.

At 2055 the Air France agent contacted the aircraft on the airline frequency and reported, with reservations, the following information which had been obtained from Rabat/Salé by telephone: Rabat/Salé field was then clearing, with several kilometres' visibility and clear sky. These latest conditions at the field were due to the sporadic passage of fog patches. The aircraft acknowledged. One minute later the Casablanca control centre indicated that the Casablanca meteorological station foresaw neither a worsening nor an improvement at the field; the aircraft acknowledged the message.

Conditions at the aerodrome at the time of the approach and of the accident

The weather report transmitted to the aircraft by Rabat/Salé control tower at approximately 2100 hours indicated:

wind 360°/2 kt; horizontal visibility: 500 m; ceiling 2/8 at 300 m; QNH pressure 1015 mb, QFE 1005 mb

The aircraft was then over Kénitra aerodrome (Port Lyautey), and the captain asked at once if the supporting pylons for the antennae of the radio station, some 15 km north of Rabat/Salé, were clear. The controller indicated, in reply, that the antennae were not visible from the tower; he added that fog patches were drifting over the Rabat/Salé field and that at the moment the entire runway was clear.

A few minutes later, at the request of the control tower, the aircraft reported over the town of Rabat. On his own authority the controller informed the aircraft that conditions had worsened. This was later confirmed by the meteorological observation for 2110 hours which follows:

wind 360°/2 kt; visibility 500 m; ceiling 8/8 at 30 m.

The Flight

The aircraft departed Orly Airport, Paris at 1826 hours GMT on a scheduled flight to Rabat, Morocco. It carried enough fuel for four hours.

Following a normal flight from Orly the aircraft began its descent at 2052 hours, estimating Rabat at 2104 hours, and was transferred to the control tower (Rabat) at 2100 hours. There was no indication from the crew of any malfunction.

The aircraft then reported as being over Kénitra at an altitude of 15 000 ft, descending at an indicated speed of 285 kt. At 2102 it passed almost over KJ the non-directional radio beacon of Rabat/Salé

Airport. At 2109 when over the town of Rabat, and having been notified of a deterioration in the meteorological conditions, the pilot announced his intention of attempting a break-through by means of beacon KJ. The tower immediately notified the aircraft that the beacon was not on the runway alignment. That message was not acknowledged.

The aircraft had struck the ground, probably in a slightly left bank, at the end of a left turn. The landing gear collapsed, and the aircraft bounced, touched ground again, then jumped a deep gully bordered on the left by a gorge, and crashed against the opposite side. The wreckage slipped to the left towards the gorge and broke up, ejecting seats and passengers.

The wreckage site was 8.4 km from the threshold of runway 04 and 1.4 km to the left of the extended centreline. The elevation of the accident site was 87.5 m. This point is near a place called Douar Doum.

Technical examination

Further to the examination of the wreckage which proved that the landing gear was down and locked, the flaps were down at 10°, the airbrakes were "in", the elevator trim was at zero, the master cut off switch was "on" (safety cover locked), the autopilot control was "ready to engage", technical examination of recovered equipment revealed the following:

Engines — At the time of the accident the two engines were at low thrust, probably idling, although a valid figure could not be suggested.

Servo controls — The elevator, rudder and left aileron found practically intact, worked satisfactorily at the testing bench before they were disassembled. Their correct operation was confirmed after disassembly. There was no sign of binding, even partial, in the distributors. The right aileron servo control was so damaged on impact that it could not be examined.

Altimeters — Very little correct information could be gained from from the pilot's Kollsman altimeter, which had been badly damaged by impact and fire. After examination of the stop mechanism the only conclusion was confirmation of the setting in the area of 1005 mb.

The co-pilot's altimeter was not as badly damaged, and its setting showed a pressure reading of 1005 mb.

Radio altimeter — All electronic components were destroyed, but it can be stated that the radio altimeter was turned on and set to 1 000 ft on the sensitivity scale. The pre-selector was set to 50 ft; in spite of major damage, both the pointer and the switch catch confirm that setting. It can, therefore, be concluded that at the time of the accident the radio altimeter was on, set to 1 000 ft on the scale and to 50 ft on the blinking lights of the altitude preselector.

Discussion

Meteorological conditions

There is no doubt but that the pilot was aware of the unfavourable conditions prevailing at the airport and around Rabat.

This type of weather, which is frequent on the coast, often arises very quickly without the possibility of any forecast, even of short-term validity.

According to the first statement by the tower controller, the observation by the Rabat/Salé meteorological service of the latest deterioration in conditions ("sky covered 8/8, ceiling 30 m") was telephoned to the control tower at 2110 hours and retransmitted to the aircraft at 2112 hours during the last conversation; it is, however, certain (after examination of the flight recorder) that the accident occurred at 2109:20, and the evidence shows the time of the observation to have been 2110 hours.

It can, therefore, be considered that this official message, indicating worsening conditions, was certainly transmitted to the aircraft but after the crash, and that it is probable that the controller indicated to the aircraft, during the last conversation, that the situation was rapidly becoming more unfavourable.

At the time of the accident there was no magnetic recorder for radio communications in the Rabat/Salé control tower.

Progress of the flight from the air traffic (control) point of view

Since the communications were not recorded, the Commission relied on the testimony of the controller who was on duty in the Rabat/Salé tower on the night of 12/13 September.

It should be noted that as soon as radio contact was established, control indicated the runway in use, but no landing clearance was either requested or given in the course of the exchanges of communication.

Based on examination of the last part of the flight, and following processing of the tape, it is almost certain that the controller's watch was 2 to 3 minutes fast at the time of the accident, which would explain some chronological contradictions in the statement of events made by him.

Reconstruction of the final phase of the flight - analysis of flight recorder information

The flight recorder was recovered intact. All parameters were perfectly legible. The only exception was that the tape speed was too slow* to permit a very accurate reconstruction of some parameters, *particularly the rate of descent.*

Nevertheless, the Test Flying Centre was able to plot the flight path of the aircraft up to the point of impact by constructing at each point the known speed vector in amount and direction.

Such a reconstruction is the more accurate when the wind is light, as was the case on the night of the accident.

The pilot practically followed the coast from Kénitra, over which he passed at 2100 hours, at an altitude of some 15 000 ft and descending, at an indicated airspeed of 285 kt.

At 2102 the aircraft was approximately over beacon KJ, about 800 m west of the aerodrome.

The aircraft made a 360° turn and at 2107 hours was over the town of Salé at an altitude of 1 650 ft, at an indicated airspeed of 230 kt.

Between 2107 hours and 2108 hours *the aircraft was over the town of Rabat.* At 2108 hours its altitude was 1 240 ft, its indicated airspeed 190 kt, and its rate of descent 410 ft/min.

From 2108 hours to 2108:32 the altitude remained at 1 200 ft; the outbound leg terminated at 2108 hours when a 180° turn was initiated *(heading at 2108 hours - 236°).*

From 2108:32 to 2109:21 hours, altitude, speed and heading varied in accordance with the following table:

Time	Altitude	Speed	Heading	Average rate of descent	Comments
2108:32	1 200 ft	160 kt	156°		
2108:48	900 "	152 ") Speed constant	108°	1 230 ft/m	
2108:55	720 "	152 ")	87°		
2109:12	430 "	152 ")	56°) Heading constant	1 100 ft/m	
2109:21	260 "	152 ")	56°)		Impact

Comment: On the basis of the recording tape it may be assumed that flaps were extended 10° at 2108 hours, altitude 1 240 ft, indicated airspeed 190 kt.

* Flight recorders are now available with two speeds, including one high speed for the take-off and landing phases.

Configuration at impact

During the last 20 seconds the aircraft's landing gear was down, and the flaps were extended about 10°. It was in continuous descent at a rate of 1 200 to 1 300 ft/min.

The question, therefore, arose as to what the aircraft's attitude was, and what thrust was needed to propel it.

Sud Aviation carried out a test which showed that the attitude was probably slightly negative, from -1° to -2°, and the engine thrust of the order of only a few hundred kilogrammes, that is corresponding to a rather fast idling of both engines.

Those conclusions are partly confirmed by the fact that the first tracks of the aircraft on the ground were made by the small front wheels, which touched ground before the main landing gear, as the central tracks of the front landing gear start at the same point as those of the main landing gear.

Nothing could be checked regarding engine thrust as no engine parameters were recorded. However, the technical examination of the engines at the Hispano Suiza plant seemed to offer confirmation; in particular, the pitch of the intake guide vanes and the deposits on the engines were evidence of a condition close to idling.

In this connexion, it should be pointed out that the positions of the throttle controls on the pedestal were of no value as evidence of conditions at the time of first impact and during the slide preceding the final crash, because the connexions between the throttle controls and the engines were cut in the final break-up.

The question whether the pilot attempted to re-apply power immediately after the wheels touched ground, will never be answered with certainty, because the time during which the aircraft remained almost unbroken (at least as regards engines, cabin and wings) was of the order of 3 seconds at most, since it covered about 200 m. Engine pick-up from idle during that time could only have been very slight, since this type of aircraft requires 8 to 10 seconds to resume full power from idling. Re-application of power would have been of no avail after the first impact because the landing gear collapsed on first contact with the ground.

Hypotheses and Conclusions

Equipment failure

Failure of an essential structural element

There was no evidence nor anything in the radio messages (the last of which was sent between 10 and 30 seconds before the accident) to support the theory of failure of an essential structural element or breakage of a vital part.

Another reason for discarding this theory is that the speed during the final stage remained constant.

Failure of servo-controls, control gear or linkage

The fact that the aircraft struck the ground could, at first sight, be taken as an indication of control or servo-control failure, but the following reasons call for rejection of that theory. The reconstruction of the flight path, and the attitude of the aircraft at the time of impact show that all parameters - bank, speed on course and glide path slope - were absolutely consistent; an aeroplane deprived of the use of a single control would not show such a regular pattern, and, in particular, a failure at any part of elevator linkage would result in major and rapid variations of the speed vector in amount and in slope; such variations would be evident in the reading of the recorder tape. Such was not the case, and all the above-mentioned parameters were perfectly regular.

Failure of a servo-control, control gear or linkage is, therefore, excluded.

At the time of the accident the flaps were extended 10°, as shown by an examination of the position of the flap roller carriages on their screws. All carriages were found at the 10° position.

The position of the flaps confirmed the theory that the pilot believed he was at a higher altitude; naturally if the pilot had believed he was on final approach, the flaps would certainly have been extended to a greater angle.

Engine failure

The testing of the engines in the workshop clearly showed that at the time of the accident, both engines were operating at low rpm, very close to the rate required for the speeds and rates of descent in the few seconds before impact occurred.

Failure of airborne instruments

Altimeters: manual setting devices

The co-pilot's altimeter was found set to 1 005 mb, the pressure transmitted to the aircraft by the control tower. Examination of the pressure setting stop mechanism on the altimeter of the pilot-in-command showed a pressure setting in the area of 1 005 mb.

Altimeters: mechanical, static or dynamic devices

The destruction of machinery and pivoting units precluded any check on the possibility of a shift (by a gear jump) of the pointer showing hundreds of feet. Furthermore, the technical examination did not permit any estimate of the readings on the drum for thousands of feet. The theory, therefore, cannot be verified.

Failure in static generation, causing simultaneous aberration of both altimeters on the instrument panel, cannot occur, since each altimeter is connected to different ports right and left, on the sides of the fuselage, and it is impossible for both double ports to ice at the same time; furthermore, at Rabat the temperature near the ground excludes the possibility of icing.

However, the pilot and co-pilot can still operate a valve to switch from the fuselage static ports to one, near the lower door, with better de-icing, and, as a final resort, there is always the possibility of connecting with a static port on the engine nacelle, where de-icing is assured by reason of the engine temperature.

As for the (SFIM) flight recorder, its static port is on the artificial feel antenna, which is also under an engine nacelle. There was nothing abnormal in that area, especially as the flight recorder continued to operate after impact.

Radio altimeter

The setting of the radio altimeter to "on" and "low altitude range" appeared to indicate that the crew had intended to use it.

If the lamp setting to 50 ft was intentional, that also would indicate an intention to watch the altitude on final approach.

It may be noted that at the rate of descent of the aircraft, it required only 2 to 3 seconds from lighting to touchdown, which seems to confirm the assumption that the pilot believed himself to be higher than his actual altitude.

Miscellaneous incidents

Battery explosion

This has never occurred aboard a Caravelle, and, in addition, aircraft of this type are equipped with Saft iron-nickel batteries, in which the electrolyte, a soda solution, has none of the disadvantages of the sulfuric acid in lead acid batteries. Furthermore, the battery compartment is well ventilated and far enough from the crew for complete protection in case of an explosion.

Explosion in flight

The accounts of witnesses, some of whom saw or heard the aircraft almost up to the time of impact, and the examination of the wreckage and of the flight recorder, appear to rule out the theory of explosion in flight.

Fire in the cabin could only have been electric or electronic, slow-spreading in its early stage; the crew would certainly have reported it by radio, and the engineer was provided with a cabin extinguisher that was effective for that type of fire - a very unlikely theory.

The engines were idling, therefore, the actual compression ratio was low, and the ratio of exhaust to intake temperatures also remained low.

Other equipment

At no time, either while in contact with Casablanca (the conversation was recorded) or while in contact with Rabat/Salé tower, did the crew report any malfunction or difficulty, either of a mechanical nature or with radio equipment. In particular, the main electric switch was found locked, with its guard in place.

The possibility of sudden failure in a circuit or in technical equipment during the final phase appears unlikely, since the flight recorder was still working after the impact.

Personnel failure

Physical failure

This possibility was considered groundless, because of the presence of both a pilot and a co-pilot aboard the aircraft.

Error in instrument reading

The aircraft's approach procedure, as reconstructed from the SFIM flight recorder and from testimony, seemed in line with a normal attempt to break through and land. Taking into account the speed on the flight path, the vertical speed, the heading and its variation, the rate of turn, and if the altitude parameter had been good and followed suitably in its development, i.e. increased by 1 000 ft, the aeroplane's flight path would have intersected the ground on the aerodrome or very near, in front of the approach end of runway 04 in use.

The theory of an error of 1 000 ft appears probable but could not be verified.

. Probable Cause

In the opinion of the board of inquiry of all the theories listed above, those related related to material failure appear the least likely. On the other hand, the theory regarding an error in instrument reading appears more probable than the others.

Therefore, the Board explained the failure:

1) by the fact that reading of the Kollsman window altimeter, with which this Caravelle was equipped, may be delicate, as demonstrated by some systematic tests carried out by highly trained crews of various European airlines;

2) by the possibility that the pilot made that error of 1 000 ft at the beginning of the descent, retaining it, then gave his full attention to reading the pointer, which seemed to him to be of prime importance, in order to bring in the aircraft at the minimum authorized altitude.

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ICAO Ref: AR/723

No. 32

Northwest Airlines, Inc., Lockheed Electra, L-188C, N 137US accident at O'Hare International Airport, Chicago, Illinois, on 17 September 1961. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0018, released 13 December 1962.

Circumstances

Flight 706 originated in Milwaukee, Wisconsin, and was a regularly scheduled flight from Milwaukee to Miami, Florida, with intermediate stops at Chicago, Illinois, Tampa and Fort Lauderdale, Florida. While at O'Hare Airport (Chicago) the aircraft was routinely serviced and checked, and a scheduled crew change was made. At approximately 0855 hours central daylight time, while taxying from the ramp, the flight was cleared for take-off, and shortly thereafter the aircraft departed. Take-off from runway 14R and initial climb appeared to be normal, but at approximately 200 ft a shallow turn to the right continued into a gradually increasing bank of about 85 to 90°. While in the turn, the crew made a short, garbled transmission indicating alarm. During the latter part of the turn a gradual descent began and, two minutes after take-off, the aircraft struck the ground in a slight nose down attitude. All 32 passengers and the crew of 5 sustained fatal injuries. The aircraft was totally destroyed by impact and subsequent fire.

Investigation and Evidence

The Flight

No witnesses were found who observed the actual lift-off. N 137US was observed after lift-off, 3 000 to 4 000 ft down the runway at an estimated altitude of 50 to 75 ft and in a normal climb attitude. At the 8 000-foot marker the altitude of the aircraft was estimated to have been about 100 ft, which is a slightly lower altitude than Electra aircraft normally attain at this point during take-off. Five witnesses noted a change in engine sound during this portion of the flight. Between the 8 000 and 9 000-foot runway marker the aircraft was observed to commence an apparently coordinated right turn with a slowly increasing rate of bank. When the bank angle was 30 to 45°, the crew made a short garbled transmission. Immediately thereafter, at a bank angle of 50 to 60°, the aircraft began to lose altitude. The maximum altitude attained in the entire turn was 200 to 300 ft.

The right wing struck powerlines adjacent to the Chicago Northwestern Railroad tracks and severed the lines at an angle of about 70° from the horizontal, causing a bright bluish flash. The aircraft then continued in a direction of about 271° magnetic and, when in a bank of about 85° and a nose-down attitude of about 10°, the right wing of the aircraft struck the railroad embankment 20 ft above the general terrain. Continuing to roll about its longitudinal axis, the aircraft cartwheeled, the nose crashing into the ground 380 ft beyond the point of first impact, and landed right side up. It then slid tail first another 820 ft. The aircraft disintegrated throughout its path, and wreckage was strewn over an area 200 ft wide and 1 200 ft long. Evidence of ground fire was found at various points along this path.

Impact occurred on airport property about 3 800 ft abeam and to the right of the end of runway 14R.

Most witnesses indicated that the flaps were down to some degree at take-off and that the landing gear was retracted after lift-off. All agreed that prior to impact with the powerlines there was no fire or smoke seen. Nothing was observed to separate or fall from the aircraft, no birds were seen in the flight path, and no abrupt pullup or violent manoeuvre prior to the steep bank was observed.

Weather

At the time of the accident the conditions were as follows:

> sky clear; visibility 6 miles; smoke and haze; wind south at 8 kt; temperature 59°F; dewpoint 52°F; altimeter 30.40.

N 137US and its crews

The crew members who operated this aircraft on its flights just prior to the accident testified that no operational problems were encountered and that no mechanical discrepancies were noted during these flights. The aircraft was considered to be airworthy.

All crew members of the subject flight were certificated and qualified to operate the aircraft, and it was dispatched in accordance with company operating procedures.

Flight recorder

Parts of the flight recorder were found strewn along the entire wreckage path. Due to the forward location of the recorder in the fuselage, high impact loads had cracked and sheared the cast stainless steel magazine and fragmented the record foil contained therein. That part of the foil bearing the record of the final take-off was not recovered, with the result that no useful information was obtained from the recorder.

Technical investigation

All four engines and propellers had separated from the aircraft and were found along the wreckage path. The power plant accessories were examined and bench-tested where possible, but no evidence of operational distress was noted. There was no evidence of operational distress in the lubrication and scavenge systems of any engine, and the compressor and turbine bearings were adequately lubricated. All fuel pumps were in good condition. The engines were all rotating at impact. The propeller blade angle for all propellers was in a range compatible with the flight idle position, and was the most reliable indication of the operating characteristics of the engines at impact.

Investigation of that part of the electrical system which remained after impact and subsequent fire revealed no indication of loss of electrical power during flight. Examination of the rudder, elevator, and wing flap systems showed no signs of failure or malfunctions. Upon impact the flaps were in take-off position, the elevator trim tab was set at 10° nose up, and the rudder tab at 0°. The actual position of the aileron trim tab could not be determined, but the aileron trim cockpit control was positioned at 0°. All landing gear was in the retracted position.

Some of the flight instruments were recovered, but most were damaged to such an extent that no useful information could be determined.

Components of the aileron primary control system were damaged and broken in numerous places. Impact marks made on the inboard closing rib of the right aileron indicated that the right aileron was deflected upward 3°, corresponding to a flight control position of right wing down.

The rudder and elevator boost units were found in the "engaged" position; the aileron boost unit was found in the "disengaged" position. However, because of the possibility of cables pulled due to break-up forces, it could not be determined to what position the boost unit controls had been actuated by the crew prior to impact. A complete disassembly and inspection of the aileron boost unit followed. Measurements of the actuating piston, which had seized in the cylinder due to fire damage, represented a flight control movement of right wing down.

The position of the co-pilot's control wheel at impact could not be determined, but the pilot's control wheel broke in a forward direction and was positioned about 90° to the left, calling for almost full left wing down.

Aileron primary control system (see Figure 17).

The aileron primary control system consists of two cables, which run through a series of pulleys to the control wheels forming a closed loop between the aileron boost unit's input quadrant to both control wheels. The cable which connects to the pilot's control horn is in tension for a right wing down control movement, and the cable which connects to the co-pilot's control horn is in tension for a left wing down movement. These cables provide a signal input from the control wheels to the boost unit when the boost is engaged, and they also provide the physical link between the control wheels and the ailerons for manual operation when the boost is disengaged.

All recovered cable connexions between the pilot's control column horn and the aileron boost input quadrant were found to be normal except for the threaded connector of the slack absorber forward terminal block. This connector was found unsafetied and was backed out of the terminal block, showing five to seven threads had been engaged. The forward connector should be safetied with steel wire exactly like the aft connector. Distinctive lines on the surface of the slack absorber's aft connector showed where safety wire had shielded these surfaces from fire and soot. In contrast, no such distinctive lines could be found on the forward connector in question. Laboratory examination revealed no evidence of safety wire having been recently installed on this connector.

The co-pilot's slack absorber unit, the flexible cables on either end of it, and the rear section of the two 205-inch runs of lockclad cable were never recovered from the wreckage. Indentations were found about the guide hole of the still-intact fuselage station No. 651 pulley bracket. This guide hole, through which the co-pilot's 43.75-inch length of flexible cable passes, is 0.6-inch in diameter. The slack absorber terminal block is too large to pass through the guide hole in a forward direction, and the lockclad collar is too large to pass through the guide hole in an aft direction. These indentations about the guide hole indicate that some object passed through it in a forward direction.

Ground tests

In order to explore the possibility that wing flap interference with the aileron control surface may have been a cause of the accident, the Board requested Lockheed Aircraft Corporation to perform certain ground tests. With Board investigators participating, tests were conducted to measure the amount of interference between flaps and aileron (with simulated airloads applied to the flap, and the outboard flap jackscrew removed), and to determine the amount of pilot force required to overcome such interference with aileron boost both engaged and disengaged. With boost engaged it was found that the exertion to overcome the interference was similar to normal deflections. With boost disengaged, a force of about 550 inch-pounds, applied and measured at the control wheel, was required to force the aileron past the flaps. The force required was well within the capability of a pilot to exert.

Lockheed Aircraft Corporation performed another ground test, the results of which were made a part of the investigation. Because of a suspected failure in the system, this test was made to determine the ultimate load required to fail a portion of the aileron boost input cable system. Loads were applied to the aileron primary control system and increased progressively to 2 000 lb, at which time the flexible cable itself failed in tension at a point between the pulley bracket assembly and the slack absorber. Examination revealed no failures, thread stripping or deformations of associated cable assembly brackets, pulleys, connectors, etc.

It has long been accepted that a flexible cable, as used in the aileron primary control system, has a tendency to unscrew from a connector. The National Bureau of Standards, in 1941, conducted tests which showed not only that a cable would unscrew from a connector, but that it could exert enough torsional force to actually break the soft brass, cadmium-plated safety wire then being used by the aircraft industry. After breaking the safety wire, the connector would spin free of the turnbuckle. Further tests by Lockheed using cable and slack absorber parts identical to those installed in the co-pilot's side of the system, with vibration applied to simulate flight conditions, and without safety wire installed, showed that the cable had a natural tendency to, and did, unscrew from its fitting.

Another ground test by Lockheed and witnessed by Board investigators was one which simulated failure of the left wing down aileron cable in an Electra. With hydraulic pressure applied, boost engaged, and ailerons in neutral, the cable, identical to the aileron cable missing from the wreckage of N 137US, was severed with a pair of cutters. The person holding the control wheel felt only a slight pulse when the cable was cut and was not otherwise aware of what had occurred. When the cable severed, an immediate signal was imparted to the boost input calling for right wing down. Measurements showed that the trailing edge of the aileron had moved six inches above its normally faired position. When the control wheel was then moved to the left wing down position, the slack in the left wing down cable caused the cable connectors to hang up on aircraft structure.

In this accident, it is believed that the left wing down cable did separate. With the left wing down cable separated it was not possible for the pilot to apply opposite aileron to bring the right wing up. Then, if the cable connectors did hang up, the ailerons would not have returned to neutral, worsening an already unmanageable situation. Since witnesses observed the bank to the right to increase steadily, and since the right aileron was found in a position of right wing down, there is further reason to conclude that the cable struck in the right wing down position somewhere within the aileron control system. Other recovery techniques such as use of rudder, asymmetrical power, and aileron tabs might have been effective in overcoming the steepening bank, had sufficient altitude been available.

The Aircraft Logs - Maintenance

From 27 June to 11 July 1961, eight aileron control discrepancies were entered in the aircraft's logs. They reported sluggish feel in aileron boost; delayed reaction in aileron boost; sticking or binding of aileron boost; boost pulses in aileron controls at all speeds; ailerons erratic at all speeds. Most of the corrective actions recorded indicated the performance of ground checks; one entry showed replacement of the boost valve and hydraulic filters; but one log carried only the barren entry, "noted". During this period of time the aircraft continued to be dispatched on a total of 29 flights.

On 11 July 1961 the aircraft was placed in the Northwest Airlines maintenance facility at Minneapolis, Minnesota to undergo a layover check. Since the aileron control difficulty was still manifesting itself, it was decided to also replace the aileron boost assembly. Concerning the latter task, the then current company maintenance policies required that the Lockheed Electra maintenance manual, which prescribed the steps for the removal and replacement of the aileron boost assembly, be followed by those performing the work.

This particular aileron boost unit change on N 137US was the first such job to be performed on an Electra aircraft by the carrier's line maintenance personnel principally involved. The foreman who supervised the unit removal testified that he believed this was the first boost package change in which line maintenance was involved. During July 1961, three shifts were operated throughout each 24-hour period.

Red Unit Inoperative Tags

A Northwest Airlines maintenance manual required that red unit inoperative tags be attached to pertinent cockpit controls to prevent operation of controls when such action is undesirable or dangerous during the performance of various maintenance operations, and to prevent release of an aircraft for dispatch when uncompleted work remains in an inconspicuous place. This directive also prescribed that upon completion of the task, provided it has been satisfactorily performed, an inspector will sign the tag and remove it from the aircraft. A quotation from this directive emphatically stated "under NO circumstances shall the tags be removed from the aircraft before they are properly signed by an Inspector." The directive further required that a record of the use of the red unit inoperative tag be transcribed to a more permanent type of work control card to which the red tag must be stapled.

Removal of the malfunctioning aileron boost unit was accomplished by two mechanics of Shift 2 on the night of 11 July. They testified that they had followed the manual prescribing the steps to be followed in removing the unit. However, upon further questioning, the mechanic who did most of the work admitted that he did not follow the manual exactly step by step. In accomplishing his task he removed the safety wires from the connectors at the forward ends of the pilot's and co-pilot's slack absorber units and unscrewed them to relieve cable tension, thereby facilitating the removal of the boost unit.)

Installation of the new aileron boost unit was performed by two mechanics on Shift 3 during the night of 11 - 12 July. Testimony established that neither mechanic had followed the manual step by step, referring to it only when a problem was encountered; and that neither had read the removal instructions to determine what components had been unsafetied, disconnected, or rendered inoperative in the removal of the boost unit.

Although both mechanics testified that they checked each other's work after completion of the installation, neither one could recall having made a specific check to ensure that the previously loosened cable connectors were properly threaded into the slack absorber terminal blocks, the cable tension checked, or the connectors resafetied. Their crew chief, who also had not read the manual for this job, then made a cursory inspection of the work, performed an additional operational check of the controls and signed off the job as completed in the aircraft log. Although the crew chief believed that he had done so, he could not positively recall having requested an inspector to inspect the installation. Testimony of the two mechanics and their chief indicated that the unit change was completed near the end of their shift and that they did not pass any information concerning the unit change to the next shift (Shift 1).

On the morning of 12 July when Shift 1 reported for work, N 137US was rolled out of the hangar and prepared for a test flight. The aircraft log at this time reflected the following entries: the aileron booster assembly change signed off by the two Shift 3 mechanics and their crew chief, a layover check completed, a preflight completed, and past log entries examined. An inspector's signature did not appear on any part of the log. After reviewing the log, the Shift 1 crew chief then signed the "Released for Flight" block. He testified that when reviewing the log entries he assumed that the aileron boost change had been properly signed off and inspected. He also stated that the red tags had been removed from the cockpit and the pink cards, which serve as a permanent record of the use of the red tags, were on a desk near the front of the airplane. Although a search of aircraft records was made, no evidence of the use of these tags was ever found. The Shift 1 crew chief could not satisfactorily explain why he had released the aircraft for flight without the appearance of an inspector's signature opposite the aileron boost change entry on the log sheet.

The aircraft was flown on a test flight on 12 July 1961. After the test flight, a minor discrepancy concerning the aileron boost disconnect indicating light was entered in the aircraft log, but was signed off as satisfactory. No subsequent aileron system discrepancies appeared in the aircraft logs of N 137US.

Supervision - responsibility

Evidence indicates that the amount of supervision devoted to this aileron booster assembly change fell considerably short of meeting the safety minima desired and expected in a task of this nature. Testimony also established that there was a decided lack of coordination between maintenance supervisors and the Inspection Department. Although several basic managerial controls existed at the time which would have assured the proper completion of this task, the testimony indicates that little attention was given to assure job continuity between shifts and to the use of Unit Inoperative Tags; and that company policy requiring an inspection of the completed installation was not complied with.

The testimony indicates that all inspection personnel concerned believed that responsibility for a follow-up inspection notice rested upon line maintenance and not upon the Inspection Department. At the public hearing there appeared to be differences of opinion on the part of the carrier's maintenance and inspection personnel as to whether it was the responsibility of line maintenance supervisors to give notice, or the Inspection Department to follow-up to ensure that the aileron boost change was properly inspected upon completion.

The Board believed that a memorandum dated 21 June 1957 clearly placed the primary responsibility for follow-up inspection on the Inspection Department; and that the memorandum and the carrier's maintenance manual, taken together, also made it imperative that maintenance personnel secure an inspection of the completed installation. The Board, therefore, concluded from the testimony that maintenance and and inspection personnel showed an ignorance or disregard of published directives and instructions.

The training of Northwest Airlines line maintenance personnel on the Lockheed Electra appeared to have been sporadic and inadequate in scope, particularly with reference to flight control systems. Although the changing of this aileron boost unit provided an excellent opportunity for advantageous use of.the existing on-the-job training programme, this potential went unrealized.

The aircraft logs recording the corrective actions taken indicate that little effort was made to analyse the cause of the discrepancies reported by pilots on the logs of N 137US from 27 June - 11 July 1961 and to correct them. This type of operation reflects a casual attitude on the part of the maintenance personnel toward a potentially hazardous condition, which was also evident in the replacement of the aileron boost assembly.

Probable Cause

The probable cause of this accident was a mechanical failure in the aileron primary control system due to an improper replacement of the aileron boost assembly, resulting in a loss of lateral control of the aircraft at an altitude too low to effect recovery.

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Electra, L-188C, N137US
17/9/61

AILERON PRIMARY CONTROL SYSTEM

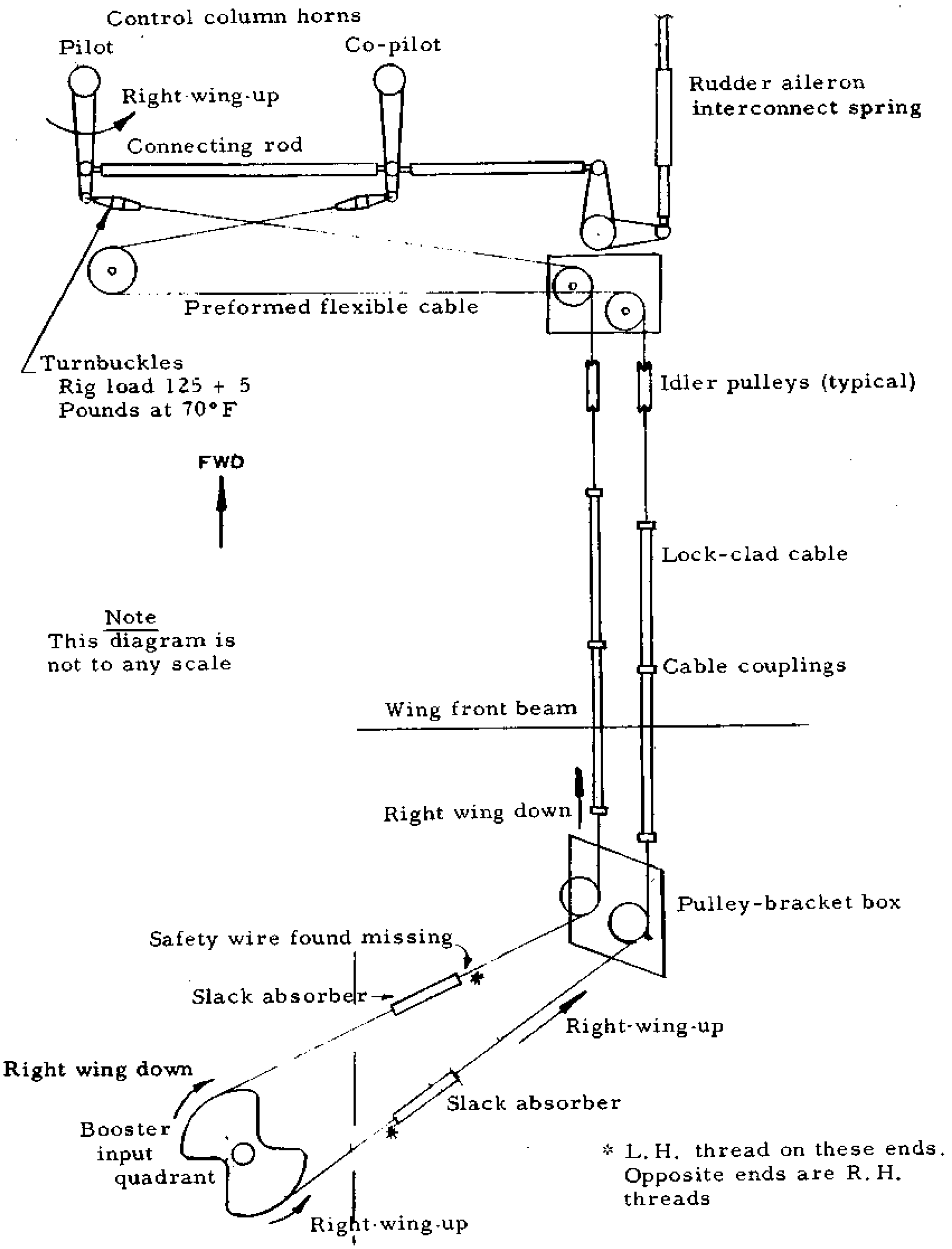

FIGURE 17

No. 33

Transair Sweden A. B. (*operating in the Congo* under charter to the United Nations), DC-6B, SE-BDY, accident at Ndola, Federation of Rhodesia and Nyasaland on 17 September 1961. Report dated February 1962 released by the Director of Civil Aviation, Federation of Rhodesia and Nyasaland.

Circumstances

The aircraft, carrying the then Secretary-General of the United Nations, 10 other passengers and 5 crew, departed Leopoldville, the Congo, at 1551 hours GMT for Ndola in the Federation of Rhodesia and Nyasaland. Shortly after arriving in the vicinity of Ndola the aircraft crashed, at 2213 hours, in the bush 9-1/2 miles from the airport. All aboard the aircraft died as a result of the accident.

Investigation and Evidence

The Aircraft

SE-BDY had been bought second-hand by Transair, and delivery of it was taken in the United States of America. On the morning of 17 September the aircraft left Elisabethville for Leopoldville. It was hit by bullets fired from the ground at Elisabethville. After a careful search at Leopoldville, the only damage found was to an exhaust pipe on one of the engines. This damage was repaired, routine pre-flight checks were carried out, and the fuel and oil tanks were filled. The fuel on board was sufficient to give the aircraft an endurance of approximately 13 hours. All the required inspections had been carried out, and all the modifications prescribed by the manufacturers and the Swedish Aviation Authorities had been put into effect. The aircraft was serviceable when it left Leopoldville.

Crew information

The crew was made up of three pilots, a radio operator and a flight engineer.

The flying experience of the crew was as follows:

	Total hours flown	Experience on DC-6 and DC-6B aircraft
Pilot-in-command	8 000 hrs	1 350 hrs
Co-pilot	2 700 hrs	720 hrs
Reserve captain	7 100 hrs	860 hrs
Flight engineer	1 370 hrs	1 370 hrs

The pilot-in-command was also a skilled navigator. The radio operator was aboard the flight as it was anticipated that the Secretary-General might require long-range communications.

Navigational aids

Non-directional radio beacons exist at Ndola, Abercorn and Kasama. The one at Ndola was in operation at all relevant times. Those at Abercorn and Kasama were switched off at 1600 hours as there had been no request to keep them on. It was not known in Salisbury that the aircraft would be on a route anywhere near Abercorn and Kasama until 2040.

All ordinary means of communication existed between the aircraft and Salisbury and Ndola, and these were effective until the aircraft reached Ndola and ceased to communicate.

Weather conditions

The last routine weather observation taken prior to the accident was made by the meteorological officer at Ndola at 1900 on 17 September. The weather was fine with slight haze and no cloud. Visibility was five miles and surface wind was 110°M with a speed of 10 kt.

Thirty-six minutes before the accident, at 2137, Ndola Air Traffic Control transmitted the following information to SE-BDY: surface wind 120°M, speed 7 kt, QNH 1021 mb, QFE 877 mb. From visual reference Air Traffic Control also advised that visibility was 5 - 10 miles with slight smoke haze. At 2210 the QNH was again checked by the aircraft with Air Traffic Control, and a confirmation of 1021 mb was given.

It was a clear night, and the airport lights were clearly seen.

Preparations for the flight

The purpose of the trip to Ndola was a meeting between the Secretary-General of the United Nations and the President of Katanga. As part of the arrangements for the meeting, a DC-4, OO-RIC, was to leave Leopoldville for Ndola before SE-BDY and was then to depart Ndola for Salisbury prior to the arrival of the Secretary-General at Ndola.

Security measures were taken at Leopoldville to make it appear that OO-RIC was actually carrying the Secretary-General. Apart from the crew, few knew of the plans to use SE-BDY, and no one except the crew of SE-BDY appeared to have any knowledge of the route proposed or flight levels to be used.

Witnesses testified that, from discussions with the captain of SE-BDY, they had learned of his decision not to file a flight plan and to maintain radio silence throughout the flight for security reasons. Following a suggestion of the Air Traffic Control Officer, Leopoldville, the captain filed a departure plan for destination Luluabourg.

No evidence was found that any briefing was carried out at Leopoldville before departure.

There was no evidence that special security arrangements for SE-BDY were arranged. It was left unguarded for two or three hours before departure. The main doors had been locked and the ladders removed.

OO-RIC did not take off until 1504, and the departure of the Secretary General was thereby delayed until 1551. After taking-off and clearing Leopoldville tower frequency, radio silence was apparently maintained until SE-BDY called Salisbury FIC at 2002, while still outside the FIR, and requested OO-RIC's estimated time of arrival.

Meanwhile OO-RIC had flown to Ndola via Villa Henrique de Carvalho in full radio contact and with navigation lights on throughout the flight. A normal flight plan was filed and a departure signal was made. The aircraft arrived at Ndola at 2035 without incident.

Reconstruction of the flight

The information available for a reconstruction of SE-BDY's flight was vague and incomplete. As stated, there were no communications recorded with the aircraft until it called Salisbury FIC at 2002. The aircraft gave Salisbury FIC its destination as Ndola and estimated time of arrival there as 2235 hours. It reported at 2040 to Salisbury that it was over Lake Tanganyika at 2035 and was flying on advisory route 432 at 17 500 ft to avoid Congolese territory. At 2049 the arrival time of OO-RIC at Ndola was passed to SE-BDY, and at 2108 the aircraft reported abeam Kasama at 2106, estimating Ndola at 2147, and requested permission to descend to 16 000 ft, which was granted. At 2115 SE-BDY was asked its intentions on arrival at Ndola but, apart from saying that it intended to take off almost immediately, no other information was given. At 2132 Salisbury FIC instructed the aircraft to contact Ndola on VHF 119.1. Radio contact was made with Ndola Tower at 2135 when the aircraft gave its ETA Ndola at 2220 hours.

At 2137 Ndola gave the aircraft the weather, the QNH and QFE settings and asked at what time it wished to commence its descent. One minute later the aircraft requested descent clearance for 2157 and was given permission by the tower to descend to 6 000 ft on CNH and to report the start of its descent. SE-BDY reported abeam Ndola at 2147 and at 2210 reported "lights in sight, overhead Ndola descending, confirm CNH". This was done, and the aircraft was also asked to report when reaching 6 000 ft.

It would seem that the aircraft started its descent at 2157 and was at 6 000 ft when overhead Ndola. The aircraft's reference to "descending" at that time may well have related to the descent below 6 000 ft. Although requested to inform the control tower when reaching 6 000 ft, no such report was received, and there was no further radio communication with the aircraft.

The Commission considered the evidence showed that the aircraft approached at about the correct height above the airport in order to commence its landing approach (6 000 ft amsl - 1 840 ft above aerodrome level). It flew towards the Ndola non-directional radio beacon situated 2.5 miles west of the airport. Witnesses stated that it appeared to be lower than normal over the beacon area and beyond. Runway lights and high intensity approach lighting, set at maximum, were on at the time.

From the evidence it was concluded that the accident occurred at 2213 hours.

The Accident Site (see Figure 18)

The wreckage of SE-BDY was found early in the afternoon of 18 September, 9-1/2 miles short of Ndola Airport's runway, on a bearing of 280°T. It had hit trees at an altitude of 4 357 ft asl at a shallow angle when slightly turning to the left at normal approach speed. The swath cut in the trees gave a clear indication of the heading of the aircraft.

Ndola and its Airport

The land at the crash site is 4 300 ft asl. It then falls to 4 200 ft, rises again to a height which, from a very low altitude, would obscure the airport lights and then falls gently to the runway.

By air, Ndola is 970 NM from Leopoldville, 115 NM from Elisabethville, 230 NM from Kolwezi, 147 NM from Lusaka and 333 NM from Salisbury.

Ndola Airport has been a recognized airport for many years. It has a runway, which can be used by all aircraft except large modern jet aircraft. Its runway is 4 160 ft asl. The surrounding country on the whole is flat, but there are some small hills in the vicinity. Between the runway and the site of the crash, there is no significant change in the country.

The Approach Procedure - Ndola

The instrument approach procedure for Ndola consists of initial approach at 6 000 ft altitude on a track of 280° until 30 seconds after the NDB has been passed. The procedure turn is then made to the right at the same height. On completion of that turn and when on the inbound track of 100° to the NDB the aircraft descends to 5 000 ft over the NDB, thereafter descending to the critical height of the aerodrome.

Eyewitness evidence established that SE-BDY crossed Ndola Airport at about 6 000 ft altitude on a bearing close to 280°. It also established that the aircraft then turned to the right. As insufficient time elapsed, according to the evidence, between this turn and the crash, for the aircraft to have gone away for any substantial distance and then returned, the Commission was satisfied that the pilot continued his approach by a subsequent turn to the left to reach the place of the accident.

When the aircraft hit the trees it was descending at an angle of descent of less than 5°, a normal angle. The fact that the nosewheel doors were not detached in the air by great speed indicates clearly that there had not been any considerable dive towards the ground followed by a flattening out to the angle of descent above.

Consideration of statements of the sole survivor

The sole survivor, who died later, was very incoherent. He seemed to think that what happened, happened as they were just about to land. He made reference to "great speed" of the aircraft. Considerable evidence indicated that SE-BDY was flying at a normal speed until it had passed over Ndola. Therefore, the great speed referred to could only relate to some time during the approach procedure. The impression of speed may have been given when the aircraft was passing through the tree tops. He also mentioned that there was an explosion and then a crash then later on said that there was a crash followed by an explosion. Undoubtedly, there was an explosion after the aircraft hit the ground. The possibility of an explosion causing the crash is discussed later on.

The survivor also said that Mr. Hammarskjold "changed his mind or said 'Turn back'". Apart from anything connected with the crash, nothing indicated that Mr. Hammarskjold was likely to have changed his plan to land. The first impact with the tree tops probably gave the impression to Mr. Hammarskjold that there was some obstruction to the landing and he then shouted words such as "Go back".

The surgeon-in-charge said of the survivor that in view of his condition his statements were not necessarily correct and could only be taken as indicative.

Conclusions reached following wreckage examination

Following a survey of the accident site it was clearly shown that the aircraft hit trees at a normal angle of descent. The measurement from the first tree damage to an anthill which the aircraft struck, and from which it cartwheeled to rest, showed an overall angle of 5° of descent. It is clear that with damage to the aircraft and loss of speed this angle must have been slighter initially. Therefore, it can be said that the trees were hit when the aircraft was descending at an angle of descent of less than 5°. There was no sign of fire except in the last 400 ft of the wreckage trail.

From the wreckage examination the following are some of the conclusions reached:

1. The engines were under power at the time of the crash.

2. The landing gear was fully lowered and in the locked position.

3. There was strong indication from the way in which the flap control quadrant was bent around its lever that there was 30° of flap at the time of impact.

4. Nothing was found to indicate that any of the controls were not operating before the accident. From the nature of the fire it was obvious that there was plenty of fuel.

5. The landing lights were not extended.

6. Examination of the radio equipment showed no apparent pre-accident failure.

7. Nothing was found to indicate that the altimeters were not operating properly before the accident. The barometric settings on the three instruments corresponded approximately to the setting given to the aircraft by the controller at Ndola.

8. Very careful examination of the wreckage was made to try to discover any sign of the aircraft having been hit by a bullet or other projectile.

Microscopic examination of the one hole found showed no presence of any metal foreign to the adjoining metal. A spectrographic examination disclosed no sign whatever that a bullet had come into contact with the metal. The hole might have been caused by the tearing out of a small bolt.

9. The plastic radar nose cone when first found did not show signs of penetration by any projectile.

The one possible examination which was not made was the remelting of all the fused metal recovered from the point where fire occurred in order to see whether any projectile could be found. The metal had all been broken by hammer and steam hammer into pieces about 8 inches square and a few inches thick. It was decided that the melting of all this wreckage was not justified.

In addition to examination of the actual scene of the accident a search was made of a large area over which the aircraft must have flown before the accident. Nothing was discovered which might have come from the aircraft. There was no sign of fire in the area.

Possible causes of the accident

Damage to SE-DBY at Elisabethville

The damage sustained at Elisabethville was not considered by the Commission to have contributed in any way to the crash.

Sabotage

The aircraft was in the charge of employees of Transair at Leopoldville except for a period when they went to lunch. During that time it was locked and the ladders were removed. This left the undercarriage wells accessible for the deposit of an explosive machine. Examination of the wreckage and the victims showed nothing to indicate that a bomb had exploded.

No one could have timed an explosion for arrival at Ndola when that destination was known to very few people, and no one except the pilots could possibly have known that the flight would last as long as it did, considering the route selected.

No grounds were found for attributing the accident to sabotage.

Route flown and crew fatigue

There was nothing to suggest that the security precautions had anything to do with the crash. The flight was made for the greater part by dead reckoning. The captain was an experienced navigator, and the route taken, via Lake Tanganyika, was not difficult to fly. Radar aboard the aircraft could have been used to determine when that lake was reached had visual conditions been difficult.

When the co-pilot boarded the aircraft in the afternoon, he indicated that he was tired. The captain appeared to be fit and relaxed before take-off. The flight to Ndola was long, but it should not unduly have tired a pilot. Some strain may well have been associated with the flight in that a most important person was aboard, and precautions had to be taken to conceal the route.

It was not considered that fatigue contributed to the crash.

Erroneous communication from the ground at Ndola

Nothing suggested that incorrect information was given to the aircraft, either by Salisbury or Ndola.

Use of inappropriate approach charts

Ndola - Ndolo

Pilots in Transair receive individual issues of the Jeppesen Manual containing approach charts. It includes one for Ndola showing the instrument approach procedure. One of these manuals was found in the wreckage - the Ndola chart was missing. However, the chart needed for a landing is usually removed. In Leopoldville a bound manual of United States Air Force approach charts was freely available to pilots. Although Ndola has been an airport for years the 1961 issue contained no approach chart for it. However, it did contain a chart for Ndolo, an airfield which was abandoned for large aircraft in 1959. This airfield is located 6 miles from Ndjili Airport at Leopoldville; its elevation above sea level is 951 ft. Three of these manuals were found in the wreckage and one was found open, folded back and showing the Ndolo chart. Reference may have been made to it if the Ndola chart was not found in the Jeppesen Manual.

In one of the U.S.A.F. Manuals found, the elevation of Ndola Airport was written in green ink on the Ndolo page. There were also two barometric pressures, one the standard and the other the approximate figure for Ndola at that time of year. The book was sent to Sweden for comparison with the writing of the three pilots, but it did not correspond. It was accepted that the writing was not that of one of the three pilots.

It was not considered that the captain would have thought that the Ndolo chart applied to Ndola. A week before in Elisabethville, and shortly before he took off from Leopoldville, the captain discussed the elevation of Ndola and showed that he knew it was about the same elevation as Elisabethville, 4 187 ft. Apart from that, the Ndolo approach is shown as being from the opposite direction, with the beacon to the east and not to the west of the runway. The clearance to 6 000 ft by the controller, the sight of lights some 2 000 ft and not over 5 000 ft below him as he passed over the airport would have indicated to a pilot of his experience that he was not about to land at an elevation of 951 ft. Also, the instrument approach procedure for Ndolo is a descending procedure with passage over the beacon at 4 000 ft, losing height to 2 500 ft on completion of the turn. Such an approach would obviously be impossible to an airport known to the pilot to have an elevation of over 4 000 ft.

If there was incertainty with regard to the elevation of Ndola's runway it might be expected that an inquiry would have been made to the control tower. However, about a week before, the pilot, in conversation with a major at Elisabethville, had stated that he thought it quite unnecessary that the tower should remind a pilot of the airport elevation, or give certain other information.

The Commission did not consider that the pilots were misled by the Ndolo chart, but there may not have been a Ndola chart aboard the aircraft.

Mechanical failure

There was no indication that a mechanical failure of the aircraft caused or contributed to the accident.

Defective altimeters

The three altimeters were examined by the Civil Aeronautics Board and by the manufacturers in the United States of America.

There was nothing to indicate that any defect in the altimeters caused or contributed to the accident.

Internal fire during the flight

Two hand fire extinguishers discovered in the wreckage were in a discharged state. They could have been discharged in the fire on the ground, however, this could not be said with certainty. If fire occurred it must have occurred in the last few miles of flight. Post-mortem examinations indicated that among those persons on the flight deck and also among those in the cabin there were some with no carboxyhaemoglobin percentage. The percentage found in the bodies of the pilots was such that they could not have been so affected by it as to be incapable of action. In these circumstances experienced pilots would have certainly taken obvious steps in case of fire.

If there had been a fire causing sudden explosion, so that either or both pilots were incapacitated or the aircraft was put out of control, it must have been of such a nature that some evidence would have been found on the ground, either at the wreckage site or in the other area searched.

There was no reason to suspect internal fire as the cause of the crash.

Incapacitation of the pilots

This was suggested as a possibility in the report of the Board of Inquiry. The Commission, however, could find nothing to support it.

All three pilots had passed the medical examinations. The possibility of incapacitation by natural causes of any of them was considered most unlikely. Post-mortem examination indicated no disease in any of the pilots. The chances of simultaneous incapacitation were, in the view of the Commission, so remote that that possibility was dismissed.

Action from the ground or by other aircraft

The possibilities of SE-BDY having been shot at from the ground or by another aircraft were carefully examined by the Commission, but no evidence was found to support either.

Pilot error

In support of the view that the Ndola instrument approach procedure was not carried out are the facts that the aircraft did not pass over the airport exactly on the course it should have taken as it proceeded to the non-directional radio beacon and for 30 seconds thereafter. It flew over a house 3/4 of a mile to the north and *slightly to the west of the beacon.* At that stage, to make the amount of noise that one witness heard, it must have been below 6 000 ft, the correct altitude in an instrument approach. It then approached a house seven miles to the northwest of the airport. The procedure turn would not have taken it so far out, nor would the aircraft have appeared to be so low.

The Commission considered the evidence established that, whether or not the decision was influenced by chart manuals, the aircraft was being brought in by a visual descent approach procedure. It was a clear night, all the lights of the airport were at maximum intensity, the aircraft had reported that it had seen them and had been told that there was no other traffic.

The altitude of the aircraft as it crossed over the airport was considered by the Commission to be about 6 000 ft asl, based on the evidence of eyewitnesses. The absence of a report from the aircraft, as requested, on reaching 6 000 ft, may well have been because the aircraft had already reached that altitude when the request was made. It is certain that the aircraft started its descent soon after it passed over the airport.

In the country west of Ndola there is bush. After the lights of Ndola were flown over, and as the descending turn was made to the right, there would be blackness ahead. If, in the course of the turn, the aircraft came far too low, the slight rise in the ground between the place of the crash and the airport would obscure the lights of the runway and of Ndola as the aircraft came back to a course on which those lights might otherwise have been seen to port.

Failure to recognize the dangerous altitude of the aircraft in relation to the airport elevation, and the slightly higher elevation of some of the country to the west, is unexplained, in view of the apparent correct settings of the three altimeters and the fact that, as far as can be determined, they were functioning properly.

Probable Cause

It was strongly urged that the Commission should not conclude that the accident was due to pilot error. Reasons have been given for saying that other suggested causes were not really possible. Reasons have also been given for concluding that the approach was made by a visual descent procedure in which the aircraft was brought too low. It could not be said whether that came about as a result of inattention to the altimeters or misreading of them. The Commission felt it must conclude that the aircraft was allowed, by the pilots, to descend too low. In so doing, it struck trees and crashed.

ICAO Ref: AR/703

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The United Nations' Organization also held an investigation into the conditions and circumstances of this accident

The Investigation Commission, established in accordance with United Nations' General Assembly Resolution 1628 (XVI) of 26 October 1961, published a separate report of its findings regarding this accident in Doc A/5069. The Commission's conclusions as summarized in the Report are as follows:

Preparation for the flight

The Commission believes that the decision to leave for Ndola by air in the afternoon of 17 September 1961 was taken by the Secretary-General himself in view of the mission which he had to perform. In taking that decision the Secretary-General was fully aware that the flight would have to be carried out without escort and that most of it would be made by night. The Commission also believes that the crew of the aircraft chosen for the Secretary General was fully qualified to undertake the flight, to navigate in radio silence and to land at Ndola in darkness. The Captain and the other crew members were experienced, competent and conscientious. No violation of the rules limiting flight hours of crew members appears to have been committed."

"The Commission is satisfied that the Secretary-General's aircraft had been properly maintained and was fully airworthy. It believes, in particular, that the damage suffered by the aircraft at Elisabethville on the previous night had been adequately repaired. The Commission observes that no flight plan or departure message was communicated to the FIC at Salisbury. It is of the opinion that the situation created by the hostilities in Katanga, in particular by the activity of the jet aircraft equipped for aerial combat which was at the time in the service of the Katangese armed forces, explains this departure from the rules applicable to international civil aviation."

"The Commission regrets, however, that before the take-off from Leopoldville, information was not given to a responsible official of ONUC* of the route which the pilot intended to follow. It also believes that special security measures should have been taken to guard the Secretary-General's aircraft at N'Djili airport before the take-off. Though it has no reason to believe that either of these omissions was a contributing cause of the crash, it considers that both were potentially dangerous."

Possible causes of the crash

"The Commission has carefully examined all possible causes of the accident. It has considered the possibility of sabotage or of attack and the material or human failures which could have resulted in an accident. It has found no evidence to support any of the particular theories that have been advanced nor has it been able to exclude the possible causes which it has considered. In this connexion it notes that the United Nations and the Swedish observers who participated in the work of the Rhodesian Board of Investigation also expressed the opinion that it was impossible to exclude any of the possible causes which they considered or to establish an order of priority among them."

"With respect to sabotage it has noted that the aircraft was without special guard while it was at N'Djili Airport in Leopoldville and access to it was not impossible. The Commission is aware that there are many possible methods of sabotage. No evidence of sabotage has come to its attention but the possibility cannot be excluded."

"The possibility of attack from either the air or the ground has also been fully examined. The Commission has found no evidence that an attack of any kind occurred. It has also noted the opinion of experts that it is improbable that the plane would have been in the apparently normal approach position indicated by the crash path and wreckage analysis had it been under attack. Nevertheless, it cannot exclude attack as a possible cause of the crash."

"The Commission has also considered various possibilities of material failure, including technical or structural defects, altimeter failure or fire in flight. A thorough analysis of that part of the wreckage capable of being examined was made by technical experts, including members of the Rhodesian Board of Investigation and United Nations and Swedish observers. The altimeters were examined in the United States by the Civil Aeronautics Board and the manufacturer. No evidence of material failure of the aircraft was found, but this possibility cannot be excluded, mainly because of the destruction of a major part of the aircraft by fire."

"The Commission also considered various possibilities of human failure. It found no evidence that any of the pilots had been incapacitated. It cannot, however, completely exclude this possibility as some forms of incapacity might not be revealed by a post-mortem examination. It also considered various possibilities of pilot error, including the use of a wrong instrument approach chart or a misreading of altimeters. It noted that the Rhodesian inquiry, by eliminating to its satisfaction other possible causes, had reached the conclusion that the probable cause of the crash was pilot error. The Commission, while it cannot exclude this possibility, has found no indication that this was the probable cause of the crash."

"The Commission considered the possibility that during the course of a visual or semi-visual approach or through the use of an instrument procedure involving a descending turn, the aircraft might have come below the accepted safety

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* United Nations' Organization in the Congo.

margin of 1 000 ft above ground level. On some landing charts, information concerning exact elevations in the approach area is not provided and should the aircraft have descended below the accepted margin a momentary distraction, either from inside or outside the aircraft, might have caused the pilot to lose the remainder of his margin of safety. The Commission, however, has found no evidence that this could have been a possible cause of the crash."

"The Commission considers it its duty to record that it has examined the various rumours that have come to its attention concerning the cause of the crash and has found no evidence in their support."

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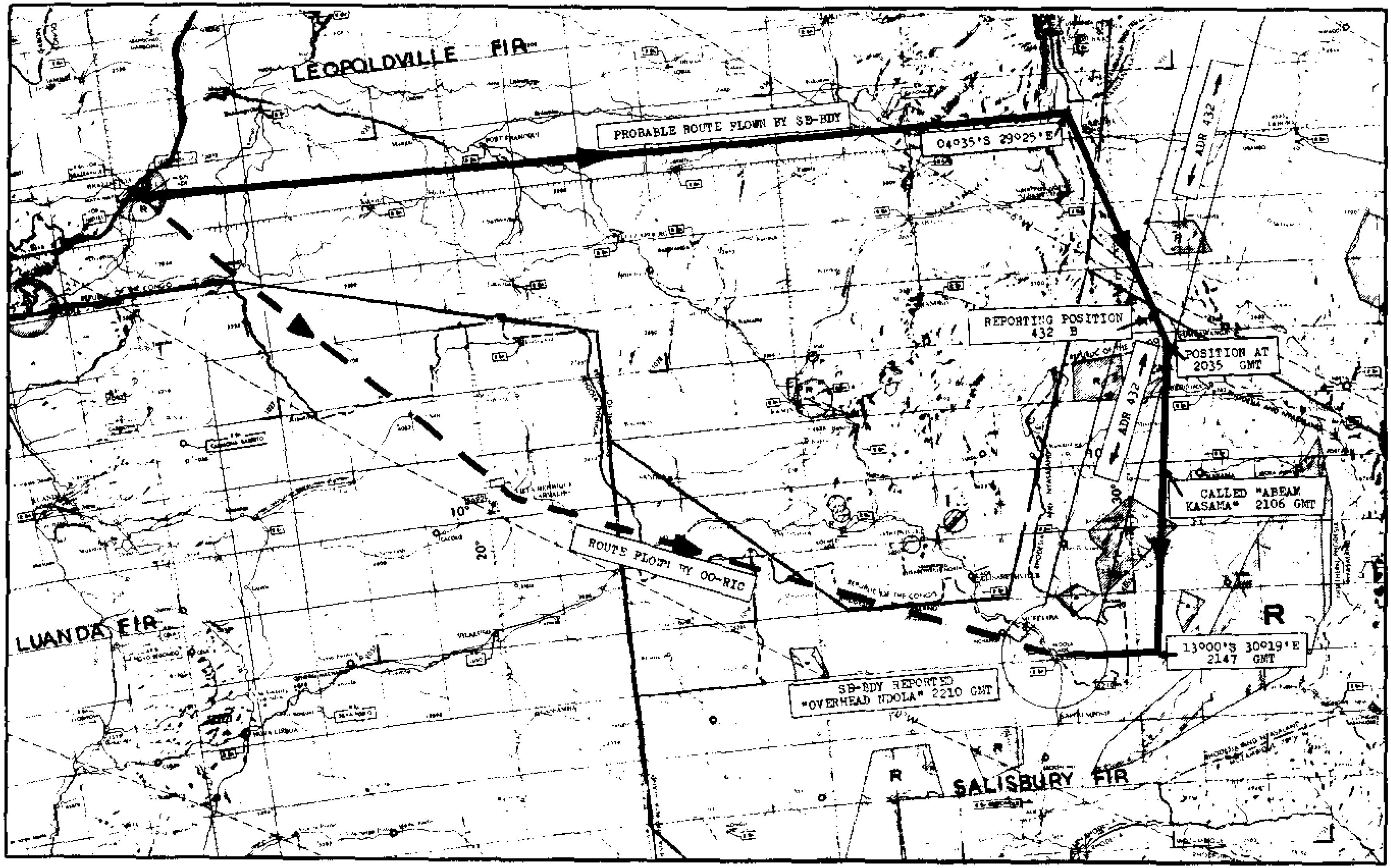
DC-6B, SE-BDY
17/9/61

FIGURE 18

MAP OF COUNTRIES AND ROUTES



No. 34

Starways Limited, Douglas Skymaster C-54A-DC (DC-4), G-ARJY at Cloghran, County Dublin, Republic of Ireland, on 19 September 1961. Report by the Inspector of Accidents (Ireland) released as C.A.P. 190 by the Ministry of Aviation (United Kingdom).

Circumstances

G-ARJY was flying a chartered non-scheduled trip from Speke Airport, Liverpool to Tarbes Airport, Lourdes where passengers were to embark for Dublin, Ireland. Following a normal flight to Lourdes the aircraft was refuelled. The amount taken on appeared to be sufficient for the flight to Dublin. The aircraft was carrying 4 crew and 69 passengers. Take-off for Dublin was at 1710 hours, and the flight to Dublin Approach was uneventful.

At 2035 the aircraft reported to Dublin Air Traffic Control and was informed of the local weather and of the runway in use. Subsequently, at 2058, it was cleared to land on runway 24, and the captain stated that he intended to make a visual approach. Shortly thereafter, at 2104 the flight reported having difficulty and that it was losing power. The captain abandoned the approach, swung the aircraft abruptly to the left and made a successful emergency wheels-up landing away from the airport. There was no fire. Although some occupants were slightly injured and shocked, there were no fatalities or serious injuries.

Investigation and Evidence

The Aircraft

G-ARJY's certificate of airworthiness was valid until 3 July 1962. The certificate of registration, issued by the Ministry of Aviation (U.K.), was dated 17 February 1961.

Since manufacture, the aircraft had flown 31 458 hours.

The maximum take-off and landing weights for the aircraft were the same, i.e. 63 000 lb. At the time of the accident the approximate weight of the aircraft was 57 978 lb.

The Flight Crew

The crew consisted of the captain, a co-pilot and two stewardesses.

The captain's airline transport pilot's licence was valid at the time of the accident and was endorsed in Group 1 for DC-4 aircraft. His instrument rating was renewed on 19 August 1960. His last competency check was in May 1961.

His total number of flying hours amounted to 6 049. His experience on the DC-4 was as follows:

	within the past 90 days
321 hours by day	224 hours by day
81 hours by night	56 hours by night
(356 hours in command)	(all in command)

The co-pilot's commercial pilot's licence was valid at the time of the accident. His last instrument rating was in October 1960, and his last competency check was on 24 April 1961.

He had flown a total of 14 000 hours on DC-4's, Vikings, Dakotas and military aircraft. His experience on the DC-4 was as follows:

	within the past 90 days
3 200 hours by day	245 hours by day
1 000 hours by night	60 hours by night

Weather

The weather conditions en route and at Dublin are not considered to have had any bearing on the accident.

Reconstruction of the flight

Since the evidence available at an early stage in the investigation indicated that fuel management would be chiefly in question, events leading to the accident will be followed up with emphasis on this aspect.

The total fuel capacity of G-ARJY was 1 878 U.S. gal, distributed in four tanks only. The two inner tanks held 508 U.S. gal each, the two outer tanks 431 U.S. gal each. The Starways OPS Manual states that the first officer is responsible for pre-flight checks on the aircraft. The comprehensive pre-flight check list includes the checking of fuel and oil contents with dipstick. This was done at Speke (the Starways base) by the engineer responsible for certifying inspection of the aircraft, and his check was accepted by the captain subject to verification by reading of contents gauges. On the preceding flight (17 September) the captain had entered several defects relating to No. 2 engine in the technical log. Clearance of these defects and balancing of generators necessitated engine running, which was carried out after fuelling for a period which cannot be established but which is not likely to have used more than 10 U.S. gal per engine except on No. 2, for which a maximum use of 30 U.S. gal has been estimated. The captain assumed a round figure of 1 800 U.S. gal for starting the flight.

The flight from Speke to Lourdes took four hours and five minutes. The captain assumed a round figure of 250 U.S. gal per engine as the fuel consumption for this flight and asked the refuelling agents at Lourdes to put 100 U.S. gal in each tank. Refulling was carried out by the agents, and the contents of the tanks were dipsticked by them. The figures for tanks Nos. 1, 2, 3 and 4 were 230, 370, 330 and 320 U.S. gal respectively, (i.e. a total of 1 250 U.S. gal in all tanks.) These figures were reported to the captain, who took note of them. No further fuel checks were made at Lourdes with the exception of the inspection of contents gauge readings which was done by the pilot and co-pilot, during the pre-starting check. On this check the co-pilot estimated the total fuel contents as about 1 280 U.S. gal. Both pilots noticed that No. 1 tank gauge showed less than the others but did not consider the tank contents low enough to take steps to alter the position. According to the dip figures, the total fuel was ample for the planned flight. The captain did not consider the possibility of No. 1 tank running dry before completion of the flight.

The flight plan time for the Lourdes-Dublin trip was three hours and forty minutes. The captain relieved the co-pilot of the responsibility for supervising refuelling at Lourdes. He assumed a total fuel figure of 1 200 U.S. gal for load sheet preparation, enough for a four hour flight with diversion from Dublin to Shannon and reasonable reserves, assuming normal operation.

The Lourdes-Dublin flight was made under instrument flight rules at a cruise altitude of 6 000 and 6 500 ft until some 10 minutes before arrival at Dublin, when descent was commenced. Operation was normal throughout the flight. No cross-feeding was carried out. When on the downwind leg of the Dublin Airport circuit the approach check was carried out. This includes checking of fuel contents, ensuring that main tank selector valves are "on" and cross-feed valves "off" and switching on of electric fuel booster pumps. The co-pilot stated that he noted No. 1 fuel tank gauge read 80 U.S. gal and that the needle was flickering. The captain also looked at the contents gauges and noted that all tanks totalled about 400 U.S. gal. He thought that No. 1 tank read about 80 U.S. gal.

As the aircraft turned on to final approach, a loss of power occurred on the port side, and the captain noticed No. 1 engine manifold pressure and fuel pressure dropping. He opened Nos. 1 and 2 cross-feed cocks, assuming that fuel starvation had caused the failure of No. 1 engine, and told the co-pilot who then noticed the fuel pressure warning light on for No. 1 engine.

As the turn was completed, and about 5 to 6 seconds after opening Nos. 1 and 2 cross-feed valves, No. 2 engine lost power with accompanying loss of manifold and fuel pressures and lighting of the fuel pressure warning light, causing the aircraft to swing sharply to port. The captain using all his efforts to control the aircraft and keep on track to the runway, told the co-pilot to open all cross-feed selector valves. This was done, but there was no restoration of power to either port engine. Power on the good engines had been increased to 35 inches, 2 550 rpm after the first failure and now had to be increased to take-off rating on Nos. 3 and 4 to avoid losing airspeed and sacrificing height. In this condition and with both port propellers "windmilling", control of the aeroplane was becoming critically difficult even with the co-pilot assisting; with full right rudder it was moving left off the line of approach with the nose swinging to port. Some time (which could not be determined exactly) after the opening of Nos 3 and 4 cross-feed valves, the already serious situation was further complicated by symptoms of power failure from the starboard engines. The time interval involved here was considered to be dependent on the physical layout of various parts of the fuel system, particularly the length of the cross-feed line between port and starboard tanks and also on the extent of mixing of air and fuel in the lines.

After the second power failure (No. 2 engine) the aircraft's height above the aerodrome was estimated by the co-pilot as 300 ft. It is certain that maintenance even of partial control in the extremely adverse circumstances existing (double power failure on the one side with failed propellers windmilling) involved a high rate of descent; a forced landing was, therefore, inevitable. The captain allowed the aircraft to swing further to the left. It made a turn of increasing steepness to clear a hangar and was so low that the port wing appeared to be "hedge clipping". An engineer and another aircraft worker in the vicinity heard "backfiring" and "spluttering" noises from the engines - confirmation that abnormal operation had already spread to the starboard power units. The captain was able to straighten up the aircraft and made a successful belly landing with the landing gear raised. The aircraft came to a stop on the Dublin-Belfast Road without suffering extensive impact damage.

Emergency drill for crash landing was carried out by the flight crew. Although the emergency lighting system could have been manually operated by means of a cockpit switch, this system was not used.

The airport crash and fire services were at the scene in about three minutes.

Discussion

When the aircraft came to rest the captain closed the tank-to-engine fuel selector valves but left the cross-feed valves in the open positions. Inspection of the cockpit about 45 minutes after the accident confirmed these valve positions.

Weather conditions prevented a check on tank contents until about 0800 hours the day after the accident. The following dip readings were then obtained:

No. 1 tank	No. 2 tank	No. 3 tank	No. 4 tank
nil	120 U.S. gal	230 U.S. gal	106 U.S. gal

Although these readings were subject to error in view of the right wing down and tail up position of the aeroplane, it was ascertained with reasonable certainty that No. 1 tank was in fact empty of fuel. Fuel samples were taken from various points of the circuit; no fuel contamination was found, which could have caused engine power failure.

Complete drainage of all tanks was undertaken and supervised. Comprehensive tests on the selector valves, fuel lines and tanks during and after the draining process led to the conclusion that the lack of fuel in No. 1 tank had not been due to any defect in the fuel system and that, with cross-feed valves closed, no appreciable transfer of fuel from one tank to another could have taken place.

Tests on the electrically-operated fuel contents gauges showed No. 1 tank gauge to be reading low (10 U.S. gal) with 60 U.S. gal in the tank. The electric fuel booster pump for No. 1 engine was found to operate satisfactorily. Final drainage of fuel from all tanks produced the following quantities:

No. 1	nil
No. 2	131 U.S. gal
No. 3	208 U.S. gal
No. 4	83 U.S. gal
Total	422 U.S. gal

Assuming normal engine operation and fuel management, the flight from Lourdes to Dublin (3 hr 55 min) could reasonably have entailed a fuel consumption of 230 U.S. gal per engine. If this is applied to the tank dip figures obtained at Lourdes, the final draw-off figures given above are reasonably what can be expected for tanks 1, 2 and 4 but more than 100 U.S. gal high for tank 3.

The excess of fuel found in No. 3 tank could have been due to:

a) a fuel system defect,

b) cross-feeding in flight, or

c) a mistake in carrying out refuelling instructions at Lourdes.

Under (a) it is considered that tests made and information available exclude the likelihood of a system defect having a significant bearing. In regard to (b), the flight crew state that cross-feeding had no part in their fuel management procedure during flights on the day of the accident. The possibility of an error in refuelling and/or taking dip readings at Lourdes cannot be excluded (in view of inconclusive results of inquiries made at Lourdes).

The fuel content of No. 1 tank at the commencement of the Lourdes-Dublin flight (230 U.S. gal as dipped by Esso employees at Lourdes) was such that, using the fuel calculation methods recommended in the OPS Manual, there would be barely sufficient fuel in that tank for the Lourdes-Dublin leg of the flight plan (3 hr 40 min - 210 U.S. gal) without "balancing" of tanks in flight by cross-feeding. The "expected" surplus of 20 U.S. gal would not only have been inadequate for flight to the alternate had this been necessary, or for holding for a reasonable time, but could have been used up in the time taken to make two abortive landing attempts at Dublin. The actual flight overran the flight plan time by 15 minutes so that the emptying of No. 1 tank in the circumstances, and at the time of first engine failure, was a foreseeable occurrence almost without any intervention from factors such as inaccuracy in tank dipping or high fuel consumption by No. 1 engine.

It is considered that shortcomings in fuel management were the major contributory factor in this accident.

The dip reading for No. 1 tank at Lourdes should immediately have aroused suspicion as being a "wrong figure" due either to incorrect use of the dipstick, engine or fuel system defect, or to the tank not having been refuelled.

It is considered, having regard to checks made during the investigation on the contents gauging system, that proper in-flight checks of fuel tank contents (and consumption) would have made obvious the need to "balance" the fuel system. The captain accepted responsibility for management of the fuel system during flight, and his evidence is that he did not maintain a fuel/distance graph because the aeroplane was not equipped with fuel flow meters. Nevertheless, application of known engine fuel consumption to dip figures and gauge readings should inevitably have alerted him to the possibility of No. 1 tank becoming exhausted before the end of the flight.

The emergency action carried out on failure of No. 1 engine, to restore fuel supply to that engine, was incorrect. The position of the electric fuel booster pumps in the physical layout of the fuel system is such that, if cross-feeding has to be resorted to as an emergency measure consequent on lack of fuel in any tank, it is essential to close the tank selector valve of that tank as soon as possible, and preferably before opening the cross-feed valves immediately concerned. If this is not done air will be drawn into the fuel system from the empty tank by the combined suction effect of engine-driven and electric (booster) pumps and, if the cross-feed valves are open, not only will the in-drawn air prevent restoration of fuel supply to the failed engine but it will also induce fuel starvation, through aeration, in any engine to which open cross-feed valves allow access. It was concluded that failure to close the tank selector valve for No. 1 fuel tank whilst operating the cross-feed system was in fact the immediate cause of the multiple power failure which led to this accident.

It was concluded from statements by the crew that they were unaware at the time of the accident of the vital necessity of isolating a suspect tank when cross-feeding in emergency. It is considered that this was largely because their previous experience of DC-4 type aeroplanes had been confined to models, other than the four-tank C-54A, in which different fuel system layouts, especially in regard to electric booster pump position, would render cross-feeding possible without the closing of individual tank selector valves. The lack of knowledge shown by them in this most important matter of the fuel system was certainly contributed to by deficiencies in the information made available to them by the Operator.

The OPS Manual for this aeroplane, although marked G-ARJY on the cover, appears to have been, except for a small number of amended or added pages, that used for all the DC-4 type aeroplanes operated by the Company before the acquisition in February 1961 of G-ARJY. The technical information on the fuel system appears to apply to these other aeroplanes and not to have been amended for the C-54A. It is considered inadequate in essential items, including those discussed in relation to cross-feeding. No clear cut warning is given in the manual as to the danger involved if the selector valve of an empty tank is not promptly closed when cross-feeding in emergency rather than as a fuel management procedure.

The captain gave two reasons for not attempting to feather the propeller of the failed No. 1 engine. He did not think that No. 1 tank had run dry but that momentary starvation had occurred through movement of fuel in the turn. He was confident that his action in opening Nos. 1 and 2 cross-feed valves would assist recovery by allowing No. 1 engine to draw fuel from No. 2 tank. Had he feathered the propeller as soon as No. 1 engine failed, there is little doubt that a successful landing could have been completed without difficulty. It would be improper to consider his decision an error of judgement since it was based on the expectation that the engine would pick up again almost immediately, or at any rate soon after he had operated the appropriate cross-feed valves; an expectation which would have been fulfilled if the fuel controls had been correctly used. His choice of emergency action, incorrectly carried out, led to such a critical deterioration in the situation that he had neither time nor opportunity to reconsider it.

Fuel records

Provision for recording of fuel amounts is made in Starways Technical Log in total form, not for individual tanks. Space is provided for entering fuel brought forward from previous flight, fuel added for starting the day's flights, and total at take-off. There is also space for en route additions, and for carry-forward figure in U.S. gallons. Although this scheme does not provide a ready means of checking consumption on individual engines, it would, if properly used, allow a general fuel consumption check on an aeroplane as well as a useful check on accuracy of both contents gauge and dipstick indications. However, in the case of this aircraft the usefulness of the record was nullified by careless and inaccurate use. (Omissions were found, and some entries were questionable).

Attempts to check fuel consumption for the aircraft during its period of operation by Starways met with failure, partly because of lack of record in the technical log and partly because there appears to be no reliable measurement of fuel loaded on the Company's aeroplanes at Speke.

Emergency lighting

Control of the emergency lighting system in the aeroplane was possible by means of a manual switch in the cockpit as well as by an inertia (impact-operated) switch. All other DC-4 type aeroplanes of the Starways fleet are fitted with emergency lighting of which the manual control switch is located in the passenger compartment. The stewardess has the duty of switching them on in an emergency; this duty is included only in her emergency check list.

The OPS Manual for G-ARJY was not amended as it should have been in this respect. (Ditching and Crash Landing Drills). None of the flight crew members was apparently aware of how to operate the emergency lighting. Disembarkation of passengers was accomplished successfully without lighting on this occasion; but had the circumstances of the landing been more serious the hazard to passengers would have been substantially increased by the absence of lighting.

Probable Cause

The accident was attributed to incorrect management of the fuel system by the flight crew which resulted in partial loss of power and control and a forced landing outside the airport.

Recommendations

1. Operator's pilot training methods

   a) greater emphasis should be placed on the importance of *comprehensive knowledge of* the fuel system of all aeroplanes in use;

   b) techniques at present used in relation to emergency action after engine failure should be re-considered taking into account in particular the stage in flight at which the emergency occurs.

2. Operator's methods of keeping fuel records

The attention of the Operator should be drawn to his responsibility for ensuring proper use both by maintenance engineers and flight crew of the Technical Log fuel records.

Re-design of the Technical Log to analyze fuel information in terms of individual tanks would, it is considered, reduce the likelihood of errors in fuel management in flight by alerting flight crew members to the state of individual tanks, facilitate proper maintenance by making fuel consumption checks simpler; and possibly lead to greater economy in operation.

3. Operational information made available to the Operator's employees

Particular care should be taken, especially in the case of an aeroplane of older type which has seen considerable service, to establish by physical test the actual capacities of fuel tanks and the accuracy of dipsticks; and to ensure that any difference in design or layout affecting operation (e.g. in relation to fuel systems) is fully covered in relevant parts of the Operations Manual before the aeroplane is put into service.

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ICAO Ref: AR/753

No. 35

Turkish Airlines, Fokker F-27, TC-TAY, accident at Ankara Airport, Turkey, on 23 September 1961. Findings released by The Minister of Communications, Turkey.

Circumstances

The flight was scheduled Nicosia-Adana-Ankara. No mechanical difficulties were reported en route. While approaching Ankara, the aircraft descended from flight level 165 to 90, was cleared to land and reported to Esenboga Tower (Ankara). At 1801 Z the pilot reported leaving the Ankara radio range. One minute later the aircraft crashed and burned, fatally injuring 4 crew and 24 passengers. One passenger survived the accident with minor injuries. The accident site was 18 km from the left side of the extended centreline of runway 03.

Investigation - Findings

The crew members were properly licensed.

The aircraft had a valid certificate of airworthiness, and maintenance on the aircraft and inspections had been carried out satisfactorily and at the required times. The centre of gravity of the aircraft was within limits, and its gross weight was below the maximum allowable for this flight.

All ground radio navigation aids in the area were serviceable. The pilots reported nothing out of the ordinary.

Air-ground communications were carried on according to normal procedures, and communications were recorded in the tower on tape recorders.

The aircraft's actual position was not on the line between the Ankara range and the air navigation beacon where it should have been.

Probable Cause

During the approach to the airport the aircraft was not in the normal pattern and was below the normal altitude.

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ICAO Ref: AIG/ACC/REP/GEN/No. 22 - Turkey

No. 36

American Airlines, Inc., Boeing 720-B, N 7545A overshot runway while landing at Logan International Airport, Boston, Massachusetts on 24 September 1961. Civil Aeronautics Board (U.S.A.) Aircraft Accident Report, File No. 1-0016, released 18 July 1963.

Circumstances

Flight 44 originated at San Francisco, California for Boston, Massachusetts with a scheduled en route stop at O'Hare Airport, Chicago, Illinois. The flight to Chicago was routine. Departure from Chicago was at 0918 hours eastern daylight time. Aboard the flight were 63 passengers and 8 crew. At approximately 1105 hours while making a precision radar approach and landing on runway 4R at Boston, the aircraft overshot and slid into Winthrop Bay where it came to rest on a heading of 150^{o} magnetic at a point about 420 ft beyond the end of the runway. Although the aircraft sustained major damage, no one was seriously injured.

Investigation and Evidence

Flight personnel

The captain held an airline transport pilot's licence with ratings for DC-6, DC-7, Boeing 707 and Convair 240 aircraft. He had logged approximately 22 000 hours of pilot time including approximately 1 800 hours on the Boeing 707-720 aircraft. He had successfully completed a proficiency check on 29 May 1961 and a line check on 3 May 1961.

The co-pilot carried out the instrument approach and landing on the subject flight from the right-hand seat. He possessed an airline transport pilot's licence with a rating for Convair 240 aircraft and was promoted to first officer on the Boeing 707 on 15 March 1959. He also held a flight engineer's certificate. He had flown a total of about 12 000 pilot hours, 2 000 hours of which were in the Boeing 707. He passed a line check on 22 and 23 May 1961 and a proficiency check on 16 May 1961.

Weather

At 1041 hours the weather bureau observer at Boston Airport reported a partial obscuration, due to the fact that 4/10 of the sky was obscured by fog, and there was a measured 300-ft ceiling. At 1057 with less than 1/10 of the sky obscured, the ceiling was reported as measured 300 ft with no partial obscuration. At 1113 the weather report contained a partial obscuration and a measured 400-ft ceiling. Thus, between 1041 and 1113 the ceiling had improved by 100 ft but the obscuration, caused by the fog moving in and out, had decreased at 1057, but increased thereafter as indicated by the 1113 report. The observer stated with respect to the 1113 observation that he had noticed the runway, and it was beginning to fade rapidly in fog which was moving in all around, as the outer markers were being obscured by the fog. Thus, while the amount of obscuration had increased,the total amount was apparently less than 10/10 and did not require a special weather report.

Discussion of the flight (based on statements of the crew)

Before departure from Chicago the crew was aware that the ILS at Boston was inoperative and the weather there was below authorized landing minima. As the flight approached Boston the crew accepted a PAR (precision approach radar) approach.

Both the captain and co-pilot testified that the approach was commenced at a speed of 144 kt, which was 10 kt above the reference speed for the estimated gross landing weight of the aircraft, and the gear was lowered and full flaps extended.

They were both familiar with the instrument approach procedure for Boston Airport, and both had previously made ILS and PAR approaches at that airport. They also were aware that their company's operating manual specified that instrument approaches should be made slightly above but never below the glidepath until reaching the "slot" (interpreted to be over the middle marker) at which point the aircraft should be on course and on the glidepath. (One hundred feet above the glidepath at the middle marker was not excessive according to the company's Director of Flying Training).

They further stated that they were aware of the fact that the glideslope was fairly steep* and were familiar with the lighting systems at that airport. They said they first saw the runway when passing the middle marker at an altitude of 300 to 350 ft; that the approach was normal with only slight power adjustments; that altitude as well as sink rate were principally controlled by aircraft attitude. They said further that they did not see any of the lights in operation at that time, namely the approach lights, the strobe lights, the threshold lights, or the runway lights; that they did not see the approach end of runway 4R, the crossing runway, the intersection taxiways, the painted markings on the runway, identifiable landmarks or objects nearby, or the far end of the runway.

The captain stated that there was no flare or float, that they determined their position from the information supplied to them by the PAR controller and that the first time they were visually aware of their position on the runway was when the end of the runway suddenly appeared before them several seconds before they entered the water.

The crew testified further that power was reduced just prior to touchdown; that touchdown was smooth and normal; that touchdown was believed to be at 134 kt approximately 1 000 ft beyond the normal PAR touchdown point**.

The first officer, who flew the entire approach, stated that as he applied thrust he saw the captain activate the speed brakes; however, the captain did not recall extending them.

The crew also stated that there was a slight delay in response to the application of the No. 1 engine reverse thrust; that there appeared to be inadequate deceleration of the aircraft, and that no brake anti-skid reaction was felt on the brake pedals although brake application was heavy.

Analysis

In reviewing the transmission made by the PAR controller at Boston, it was found that the aircraft was 200 ft above the glidepath at the outer marker and consistently above the glidepath during the final approach. Also, that when the aircraft was over the PAR touchdown point it was 25 ft high. Tire marks indicated that the actual point of touchdown was 3 165 ft beyond the PAR touchdown point. Witnesses indicated that the aircraft flared and floated from a point in the vicinity of the central taxiway, where it was first observed to the point of initial touchdown. In giving consideration to the 3 165 ft distance that the aircraft floated, reference was made to Boeing Aircraft performance data for a 720-B aircraft in the same approximate configuration as that of Flight 44.

From this it was deduced that a distance of 1 830 ft would be covered, assuming a flare at 25 ft above ground made at Vref plus 10 (144 kt) and floating while allowing the aircraft to decelerate to 134 kt at touchdown. Also a distance of approximately 1 200 ft would be covered in dissipating 10 kt of excess speed while airborne.

* The glideslope projection angle is normally adjusted by FAA to 2.5° to 3° above horizontal. The published angle for Boston is 3.03°.

** The PAR touchdown point at Boston is 3417 ft from the approach end of the runway, leaving 66[illegible] ft of [illegible] runway (Runway 4R is to 10 021 ft long).

It can be assumed, therefore, that, if the flare was initiated at 25 ft and if touchdown was at referenced speed (134 kt), the airspeed at time of flare must have been approximately 154 kt - to account for the 3 165 ft of distance.*

Tire marks indicated that after contacting the runway and rolling a distance of 124 ft, the aircraft again became almost airborne for an additional 614 ft leaving just a trace of the left main gear tire mark on the runway. Heavy tire marks then appeared again at a point 2 700 ft from the end of the runway toward which the aircraft continued and rolled off into the bay. The speed at touchdown must have been fast as indicated by the nature of the tire tracks, the total distance travelled, and the fact that the captain stated, with reference to speed during landing roll, "I was aware that we were probably a little faster than we should have been." Considering all these facts, it is concluded that the speed at touchdown was at least 134 kt.

Prior to the initiation of the final approach Flight 44 was given the Boston weather at 1055 which included the following: Partial obscuration, ceiling measured 300 ft overcast; visibility one mile in fog, runway visual range more than 6 000 ft. During the time Flight 44 was making its approach, visibility deteriorated rapidly in the approach area from more than 6 000 ft to as low as 2 200 ft, as shown by the RVR (runway visual range) transmissometer record.

Two Air National Guard jet pilots, who were located near the approach end of runway 4R stated that they could hear, but not see Flight 44, as it passed overhead and that just prior to this both the ceiling and visibility had been fluctuating considerably because of fog moving in from the bay.

The local controller testified that he first observed the aircraft as it broke out of the overcast at a point about 200 ft southwest of the central taxiway (approximate vicinity of PAR touchdown point) and that it flared and floated before disappearing from sight into the fog near taxiway A. When he next saw the aircraft it had emerged from the fog and was rolling on the runway.

The weather observer on duty during this period stated that the base of the overcast ceiling was quite uniform and that at 1057, and again at 1113, the ceiling was measured at 400 ft with a partial obscuration beneath.

The captain and first officer testified that they first saw the runway when over the middle marker at an altitude of 300 ft. However, it is significant that neither the captain nor the first officer could recall seeing the approach end of the runway, the approach lights, the threshold lights, taxiways, crossing runways, or the far end of the runway at this time or at any time during the final approach. It was not until the aircraft had emerged from the fog, touched down, and was rolling down the runway that the crew saw the far end of the runway.

The Board believed that the visibility was below the required RVR minimum of 4 000 ft during a portion of, if not during the entire final approach. The Board also believed that fog conditions obscured both the approach and far end of the runway, and that this prevented the captain and first officer from determining the aircraft's relative position to either end of the runway, the PAR touchdown point, or the PAR threshold.

Paragraph 482.2 of the FAA Facility Operations Manual on page 7230.1 states as follows: "When RVR on the instrument runway is 4 000 ft or less, RVR shall be reported by the local controller or PAR controller on the initial contact and subsequently as required to each pilot intending to land straight-in on the instrument runway." The manual, however, contains no provision

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* With the surface wind conditions existing at the time, there was no significant difference between the airspeed of the aircraft and its groundspeed.

for relaying RVR information to the PAR controller at those locations where the RVR indicator is not immediately available for his use. Such a condition existed at the Boston Tower where the physical location of the RVR indicator in the IFR room precluded reference by the PAR controller. However, the instrument was immediately adjacent to the approach control position. The rapid deterioration of RVR, which commenced between 1057 and 1100, should have been called to the attention of American 44 by the approach controller since any significant change during this period could have influenced the pilot's decision to attempt a landing.

Again according to the crew's testimony, they did not see the approach threshold of the runway, nor did they observe any other markings which could be used for visual reference. Normally, the ILS/PAR touchdown point is located approximately 1 000 ft from the end of the runway, and the threshold coincides with the actual physical end of the runway.

In making an approach to runway 4R the aircraft, if on the glidepath, is approximately 192 ft high when crossing over the physical end of the runway. At an installation, with a 2.5° glidepath, an aircraft is approximately 50 ft high when crossing the physical end of the runway, and the pilot is about ready to flare for touchdown. At such an installation, the end of the runway serves as the primary reference point for the pilot in anticipating the point of touchdown during daylight conditions. At night the threshold lights serve to mark the physical end of the runway. At Boston, however, there is no such positive and distinguishing reference. The ILS/PAR touchdown point on runway 4 R is located 3 417 ft in from the physical end of the runway. The PAR threshold, marked by threshold lights extending outward from both sides of the runway, is 2 500 ft in from the actual physical end of runway threshold. The threshold lights, extending outward from each edge of the runway, do not provide the same definite visual reference that is given by sighting the end of the runway. The crossing runway 9-27 and the central taxiway, however, do provide a means of establishing reference to the location of the ILS/PAR touchdown point. Thus, while a pilot may have difficulty in picking up the physical end of runway 4R in making an approach under minimum ceiling and visibility conditions, during daylight he should be able to orient his position relative to the intersections made by runway 4-27, and the central taxiway as they cross runway 4R.

In the case of Flight 44, the approach was continued without such reference being established. Moreover, the approach was being made at a speed somewhat faster than normal. Furthermore, considering the location of the PAR touchdown point and the speed of the aircraft, the approach can be considered as high from the middle marker to over the PAR touchdown point.

The aircraft first touched down 3 165 ft beyond the PAR touchdown point with only 3 438 ft of runway remaining. Boeing test data indicate that using spoilers, brakes, and reverse thrust a 720-B aircraft, with a gross weight of 176 000 lb, in a calm wind on a sea level standard day on a dry runway at a speed of 134 kt can be stopped in 2 393 ft. This figure was established under optimum conditions, without the elements of surprise or emergency. Accordingly, the Board concludes that touchdown was at a speed in excess of 134 kt or that maximum stopping capability was not utilized.

Probable Cause

The Board determined that the probable cause of this accident was the captain's decision to land in variable weather conditions precluding adequate orientation relative to location along the runway.

A contributing factor was the failure to provide the flight with information concerning the deterioration of runway visual range values.

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ICAO Ref: AR/759

No. 37

Swissair, SE 210 Caravelle, HB-ICW accident at Basle-Mulhouse Airport and at Geneva-Cointrin Airport, Switzerland on 26 September 1961. Report No. 58 of the Federal Board of Inquiry into Aircraft Accidents, Switzerland.

Circumstances

At 0407 hours GMT on 26 September the Caravelle carrying 5 crew members and 24 passengers departed London, England on Flight 701 to Zurich, Switzerland. Because of poor visibility at Zurich the aircraft was diverted to Basle where, although dense low-hanging fog existed, an instrument approach was carried out on runway 16. Before reaching the middle marker the aircraft straightened out to horizontal flight at the prescribed minimum altitude. As the co-pilot could not see the runway, the pilot-in-command attempted to locate it and let the aircraft drop below the minimum safety altitude momentarily so that the aircraft made contact with the ground some 125 m before the runway threshold. The right leg of the main landing gear was torn off. The time of the accident was 0517 hours GMT.

After a baulked approach the flight went on to Geneva and landed there at 0721 hours where further slight damage was incurred during an emergency landing. No injuries were sustained by the occupants. There was no fire.

Investigation and Evidence

The Aircraft

The aircraft's registration was valid until 31 December 1961.

Its maximum authorized flight weight was 46 000 kg, and the maximum authorized landing weight was 43 800 kg. During the approach to Basle Airport the aircraft weighed 38 600 kg, and its weight on landing at Geneva was 32 000 kg.

At the time of the accident its centre of gravity was within the prescribed limits.

Following the accident no technical deficiencies were found in the aircraft or its equipment. Examination of the instruments' readings also showed them to be satisfactory.

The crew

Testimony of the pilot and co-pilot during the investigation contributed considerably in determining their actions during the flight, particularly during its critical phase.

The pilot-in-command held an airline transport pilot's licence valid until 15 December 1961. He had flown a total of 3 226 hours including 107 hours during the two months preceding the accident and 8 hours during the 48 hours prior to it. Conversion training to the type in question was carried out in the spring of 1960 and since then he had flown 750 hours on the Caravelle.

The co-pilot, a transport pilot, held a Class I commercial pilot's licence valid to 28 January 1962. His total flying hours amounted to 1 134 hours. He had flown about 476 hours on the Caravelle.

Basle-Mulhouse Airport

The accident occurred in the flat grassy approach area of instrument runway 16 which is 2 370 m long, 60 m wide and has a threshold elevation of 252 m/msl. The former automibile route C. D. 12 bis from Blotzheim to La Chausée runs perpendicularly to the runway centreline approximately 125 m before the beginning of the runway.

On either side of this road there are gentle slopes which drop about 10 cm; on the airport side there is an unbanked water ditch 60 cm deep and approximately 1 m wide at the top. The width of the road including ditch and slopes is about 6 m. The aircraft collided with the ground on this road approximately 125 m to the right of the runway centreline.

Geneva-Cointrin Airport

Runway 23 was used for the landing in Geneva. It is 3 900 m long and 50 m wide wide. The runway lights are spaced at 30 m intervals along the edges of the runway. The large rotating antenna of the observation radar is positioned 250 m from the northwest (right) edge of the runway and 2 600 m from the beginning of the runway.

Weather situation

On the morning of 26 September, an extensive flat high pressure zone prevailed over Central Europe; the weather was generally fair, cloudy in places with patches of low-hanging fog in the lowlands.

At 0420 hours thick low-hanging fog was already present at the Zurich-Kloten Airport.

At Basle-Mulhouse the weather picture was developing as follows:
(landed there at approximately 0517 hours)

0500 sky obscured, slight wind from SSW, 4 - 7/8 stratus clouds at 100 m coming from the south, visibility 800 m;

0504 sky obscured, 8/8 stratus at 100 m, slight wind from SSW, visibility 800 m;

0510 wind turns to the south and intensifies to 2 kt, accumulation of low-hanging fog;

0512 runway visibility 1 000 m;

0514 runway visibility 500 m;

0516 runway visibility 250 m;

0600 runway visibility 200 m.

Geneva weather:
(landed there at 0721 hours)

0520 visibility 7 km, 2/8 cloud formation at 8 000 ft, 6/8 at 10 000 ft.

The situation did not change appreciably in the ensuing hours.

Navigation aids and approach procedures - Basle Airport

Instrument runway 16 is equipped with high intensity lights and with an ILS installation. The middle marker is located 0.58 NM (1 080 m) and the outer marker 3.74 NM (6 950 m) before the touchdown point. The Sierentz BN radio beacon is adjacent to the outer marker, and the Homberg MN radio beacon is approximately 5 NM north of it in order to mark an off-limit zone to the north.

The ILS approach procedure for an approach to runway 16 is as follows for an approach from the direction of Paris:

- approach to Sierentz BN radio beacon at not less than 2 500 ft/msl
- when over the Sierentz BN radio beacon turn (away from the airport) towards the Homberg MN radio beacon at 2 500 ft/sl
- delay left turn over the Homberg MN radio beacon aligning on the ILS landing course indicator (landing course 159).
- continue flight at 2 500 ft/msl up to ILS glide path
- descend towards the touchdown point along the ILS beam as shown by both indicators, altitude check at outer marker: 1 880 ft/msl, at middle marker: 1 040 ft/msl.

The foregoing procedure presupposes visual contact with the runway at 1 086 ft/msl at the latest, that is, even before the middle marker is overflown.

With respect to instrument approaches, the Swissair flight operations manual states that the approach procedure may be initiated and carried through and a landing attempted only if the officially reported visibility values applying to the runway utilized are not less than the Swissair minimum values. The absolute minimum values as laid down in the manual are 200 ft cloud base and 800 m visibility. These same minimum values are also specified in the Swissair approach chart for Basle.

The manual also specifies that a baulked landing must be initiated without delay when visibility at the end of the approach drops below the minimum values given in the approach chart.

The approach to Basle (based on radio messages and the flight recorder)

HB-ICW, Flight 701, established contact with Basle control tower at 0504 and reported overflight of the Luxeuil radio beacon and descent to 8 000 ft.

0506 - Basle advised the flight of the latest weather as follows:

> wind calm, sky clear,
> visibility 800 m with
> patches of fog...
> runway visual range 2 000 m,
> and actually 7/8 stratus at
> 100 m but stated that they
> could see all the runway.

Shortly thereafter the crew of Swissair Flight 705, which had just landed in Basle, reported to Flight 701 their observations of the weather conditions during their approach. Flight 705 reported 7/8 coverage at about 200 ft and that they "just broke out on descent."

At 0510 Flight 701 was cleared to descend to 2 500 ft and requested to report over MN.

At 0512 when Basle was advising Flight 701 that the runway visual range was reduced to about 1 000 m, the aircraft overflew radio beacon BN at an altitude of approximately 3 600 ft and began its approach procedure turn to the left of the airport.

At 0514 Basle reported that the visibility had reduced to 500 m, and the runway visual range was about 500 m. This is the first report which indicates clearly a reduction of runway visibility below the minimum value of 800 m. The co-pilot acknowledged the message, however, he did not appear to have realized its importance. For undetermined reasons the pilot-in-command does not seem to have heard the report.

At the end of the left turn the pilot-in-command maintained an altitude of 1 800 ft. The aircraft was flying towards the airport but was still somewhat to the left of the landing beam which it now began to approach gradually.

The aircraft continued until it reached the ILS landing beam at a speed of approximately 130 kt. Basle then notified it of the latest weather report:

> "Actually all the fog coming from the south is going to the north, and the whole runway is obstructed, and ..... we do not expect improvement before one hour."

Despite this unfavourable report the commander decided to continue the approach in the belief that there were possibly only individual patches of fog; he adjusted the landing flaps to 20°, extended the landing gear and throttled power to 5 700 rpm.

At 0515:40 the aircraft reported overflight of the outer marker (3.74 NM before the touchdown point). Flying at a speed of approximately 140 kt it was still somewhat below the ILS glide path, however the pilot-in-command allowed it to descend a little further in order to enter the glide path without abrupt transition. By 1516:20 the aircraft had reached the glide path some 2-1/2 NM before the touchdown point and was descending with sufficient accuracy towards the ILS indicator with speed maintained at 135 - 140 kt and a rate of descent of about 500 ft/min. At this moment the aircraft plunged into a fog bank.

In accordance with the usual procedure the co-pilot called out the altitude as the aircraft approached the minimum. When the minimum was reached the pilot levelled off and increased engine speed from 5 700 to 6 200 rpm. Both pilots noted that the needles of their altitude indicators remained at 1 100 ft.

At 0517:05 the aircraft overflew the middle marker at constant speed and somewhat below the minimum altitude of 1 086 ft (50 - 60 m above ground). The pilot intended to fly somewhat further at this altitude and to delay the baulked landing procedure for, if the runway were then to appear, it would still be possible to land.

The meteorological service reported runway visibility at 200 m.

On looking ahead the co-pilot reported that nothing could be seen. The pilot noticed that the aircraft was veering slightly to the right of the runway centreline and directed the co-pilot to scan some 5° to the left. The aircraft was moving in horizontal flight, but the trim control was still adjusted for descent. As the scanning possibilities ahead and to the left are more favourable from the left-hand seat, the pilot allowed his attention to be momentarily distracted from the instruments and glanced outside himself. In so doing the aircraft again descended imperceptibly for about 10 seconds at an average rate of descent of not less than 1 000 ft/min (5 m/sec).

At 0517:20 the pilots saw a brownish green patch appear suddenly in the dense fog. Immediately thereafter the aircraft inclined slightly to the right, and they felt the hard shock of contact with the ground. The aircraft immediately passed from horizontal configuration to climb configuration, and the pilot promptly began the baulked landing procedure. As the aircraft was apparently airworthy, he decided to continue to Geneva.

He did not inform traffic control that the aircraft had contacted the ground although he realized that it must have sustained some damage.

Contact with the ground at Basle occurred before the road CD. 12, approximately 125 m to the right of the centreline.

The marks showed that at the moment of contact with the ground the aircraft was practically horizontal deviating at a very small angle away from a direction parallel to the runway centreline. They also indicated that the entire contact - at a speed of approximately 130 kt, corresponding to 240 km/h or 65 m/sec was of hardly one second duration.

At Basle Airport the first knowledge of contact with the ground was obtained through a member of the meteorological staff who noticed the marks and small fragments of the aircraft while walking along the road around 0600 hours. About one hour later, as the fog lifted, the right main landing gear was also found, 320 m beyond the road, 200 m beyond the runway threshold and 90 m to the right of the runway.

As the crew flew on to Geneva they still did not have a clear idea of the extent of the damage sustained.

They only observed the following:

- heavy vibration at 7 650 rpm which, however, when reduced to 7 000 rpm subsided to a tolerable level;
- external damage to the right power unit;
- loss of the inner landing flap segment on the right wing;
- damage to the undercarriage and to the hydraulic system, the extent of which could not be ascertained.

During the climb phase following the baulked landing the crew advised the operations control of Swissair at Kloten that they had noted a malfunction in the hydraulic system.

The flight continued as follows:

0533 - after the pilot had ascertained that the aircraft responded to the controls up to a speed of 150 kt, the aircraft overflew Berne at an altitude of 9 000 ft

0540 - Geneva traffic control was advised that the aircraft had an undercarriage malfunction and reported an emergency situation

0555 - aircraft overflew Geneva Airport at low altitude to allow traffic control to make a visual observation of the undercarriage damage.

The pilot was advised that the nosewheel was all right, the left wheels were extended but probably not locked, and the right wheels were not extended. He then decided to remain in the air near the airport for about another hour

- in order to continue his efforts to extend the undercarriage correctly while Swissair obtained more detailed information;
- to consume as much fuel as possible; and
- to make possible thorough and well-considered preparations aboard for the landing.

At 0701 the pilot received information that two wheels of the aircraft were found at Basle.

At about 0715 hours the approach to runway 23 at Geneva was begun. Having overflown the runway threshold at a speed of about 140 kt and at a height of about 5 m, the pilot placed the aircraft very gently and accurately on the runway, having activated the brake parachute immediately prior to touchdown. The touchdown point was about 1 300 m beyond the runway threshold. The parachute maintained the aircraft on a straight line for a distance of 1 000 m. As the speed decreased the aircraft veered towards the right. Some 1 000 m after touchdown the right wing tip made contact with the ground. The aircraft then began to swerve to the right, crossed the edge of the runway, destroying three runway lights and brushed the large rotating antenna of the observation radar. It finally came to a stop 2 550 m beyond the runway threshold and 230 m to the right of the runway at an angle of 270° from the landing direction.

As a result of repeated efforts to activate the landing gear, the hydraulic system had practically ceased to function during the flight; consequently, at the moment of landing only one auxiliary system was still operative for powered operation of the flight controls, the nosewheel steering mechanism, wheel brakes and landing aids were no longer operative.

Slight additional damage to the right wing was incurred during the landing at Geneva.

Discussion of possible causes of the accident

No deficiency in the aircraft, its equipment or in ground installations could be noted which might be considered as contributory factors in the accident.

The conduct of the ground personnel can also be eliminated as a contributing factor.

The crew's behaviour was then considered during the critical phase beginning at 0514 hours.

The stress imposed on the crew during such approaches by operations connected with the piloting and preparation of the aircraft, checking of instruments and maintaining radio communications, is extremely severe.

The causes of the accident are to be found primarily in the behaviour of the aircraft's commander with respect to the decisive phase, as follows:

- first, the decision in favour of Basle as first alternate aerodrome in substitution for Zurich, although the weather forecast in Basle was not favourable and despite the first recommendation of the operations control to select Geneva where safer weather conditions prevailed. The decision was justifiable on the basis of the reports then available, and the landing in Basle would have caused less inconvenience for all concerned than the landing in Geneva. No immediate danger would have thereby been entailed.

- The basis for this decision was modified substantially by the weather report of 0506/07: although the values for ceiling and visibility recorded by the traffic control were still clearly above the minimum values, nevertheless, the report following thereafter from Flight 705 showed that the ceiling of 7/8 at 200 ft was actually already at the critical limit. Despite this, continuation of the flight, at least up to the beginning of the approach procedure, was still justifiable and involved no immediate threat of danger, although at this point close attention to weather developments and readiness for a possible decision to divert to Geneva was essential.

- The approach procedure, in the strict sense of the term, began with overflight of radio beacon BN at 0512 hours, while the detailed weather report received at the same time indicated a runway visibility of 1 000 m, which was critically close to the minimum value of 800 m. Continuation of the approach was still justifiable and no immediate danger was involved; however, the situation had now become crucial and required extreme attention and readiness for a quick decision. The fact that the pilot allowed the aircraft to descend below 2 500 ft before reaching the glide path indicates inaccuracy but is without consequence for further developments; the approving "Roger" transmitted by the traffic control in reply to his report of 0512:30 announcing beginning of the approach curve gave him grounds to consider this descent as authorized. At this point (0514 hours) came the important and justifiably repeated weather report from traffic control to the effect that runway visibility had dropped below the 800 m minimum value. Although the co-pilot acknowledged this report, it seems to have escaped the attention of the commander. This is not very understandable under circumstances which required attention.

- At 0515 hours it was reported that the entire runway was covered with fog and that, for the moment, no improvement was expected. This report contained no numerical values. However, although the pilot had not noted the report of 0514 hours, the text of this latest message and the other circumstances should have induced him to inquire specifically whether meteorological conditions had not fallen below the minimum values. He continued his approach without doing so. Here also his behaviour did not entail immediate danger, but he was now approaching the limits of safety.

- At 0517 hours, he definitely went beyond these safety limits. His error was made when he turned his eyes and his attention away from the instruments to scan outside. In so doing the aircraft lost altitude and collided with the ground shortly thereafter. The time he spent scanning outside was longer than he originally intended. Instead of scanning outside, he would have exercised better judgement if, at this moment, he had decided to perform a baulked landing manoeuvre. Up until then to co-pilot had not even once observed the glow of the approach lighting system, the aircraft was no longer exactly on the approach centreline, and the runway length of 2 370 m afforded only a slight reserve length for a delayed touchdown.

The co-pilot's behaviour

- In the final phase, he too no longer checked the instruments. He had to divide his attention between checking the instruments, particularly the altitude and speed indicators, and scanning outside to look for the runway. Both cannot be done simultaneously, only alternately. He was not watching the instruments for a period of 10 to 12 seconds, although neither operation should have required more than 3 to 5 seconds.

- At 0514 or 0515:30 hours at the latest the co-pilot should also have realized that the weather prevailing over the runway had now fallen below the required minima and that, consequently, the approach should not be continued further, at least not without again specifically requesting the visibility values. He should also have brought this to the attention of the pilot-in-command. If, in spite of the repeated message, he still had not correctly understood the content of the 0514 hour report, the circumstances should have dictated that he obtain definite clarification.

In this connexion it should be emphasized that the co-pilot is not only the assistant and subordinate of the "flying pilot", but one of his essential duties consists in observing the pilot. He must be continuously ready to draw the pilot's attention to oversights and even to intervene actively himself in emergencies. The fact that this principle may be very delicate and difficult to apply in actual experience, owing to differences in grade and age, does not in any wise affect its validity.

Fatigue

The crew had performed several hours of duty and flight service at the time of the critical occurrence. Although, in this case, there is no question of over-fatigue, a certain normal fatigue may well have been a contributing factor. An indication of the presence of such fatigue is to be found in the lack of accuracy displayed in initiating the approach procedure - this is in direct contrast to the alertness and precision shown by the same crew in dealing with the ensuing emergency.

Diversion to Geneva and emergency landing

After the baulked landing in Basle it would have been appropriate for the pilot to have reported the ground contact to Basle traffic control. He could have done this even after leaving the Basle control area especially after he had noted damage to the aircraft which could have and actually did leave scattered fragments at Basle in the vicinity of runway 16. Apart from the safety of other aircraft, this would have also clarified his own situation more rapidly.

It would also have been appropriate if, at the very outset, the pilot had advised the Swissair operations office not only concerning the malfunction of the hydraulic system but also concerning the origin of this malfunction. This could have brought about a more prompt clarification of the situation.

Apart from these two oversights, the behaviour of the crew was, in every respect, appropriate from the time of ground contact at Basle to the time of evacuation of the aircraft at Geneva.

Probable Cause

The ground contact at Basle was attributed to the fact that after the pilot-in-command and the co-pilot had given insufficient attention to weather developments and and after the pilot-in-command had continued the approach down to the minimum altitude in the absence of the requisite conditions for so doing, he neglected momentarily to watch the instruments and thus allowed the aircraft to descend below the safe minimum altitude. The crashlanding in Geneva was the direct consequence of the damage sustained at Basle.

No. 38

Derby Aviation Ltd., C-47B, G-AMSW, accident near Mount Canigou, Pyrenees on 7 October 1961. Report released by the Inspectorate General of Civil Aviation, Ministry of Public Works and Transport, France, in Le Journal Officiel (No. 9, 1962). This summary is based on the translation of the final report published as C.A.P. 179 by the Ministry of Aviation, United Kingdom.

Circumstances

The aircraft was coming from Gatwick, England, and after reporting over Toulouse at about 0030 hours GMT it headed directly for Perpignan, France, at flight level 75. It was expected over the aerodrome at about 0112, and it was seen shortly before 0100 by various witnesses in the Prades area, during intermittent rain and wind of variable force. It struck the mountain side in level flight in the Canigou Massif at about 0100 hours. The wreckage, located at an elevation of 2 200 m at 1350 on the same day by a Search and Rescue Constellation, was destroyed by the impact and by fire. There were no survivors. Three crew and 31 passengers were aboard the flight.

Investigation and Evidence

The Aircraft

The aircraft's certificate of airworthiness was valid until 23 March 1962. Its total flying time up to the last flight was 13 658 hours 35 minutes.

Examination of the records revealed no serious incident entailing major structural repair of the airframe.

Since last general overhaul the Nos. 1 and 2 engines had flown 681 hours and 51 hours respectively.

On 24 September 1961 the automatic direction-finder receiver was changed at Palma following a failure in flight. This new equipment had subsequently to be repaired at Gatwick on 1 October 1961 (power supply connections). There were also failures of the Decca equipment on 10 August 1961 (receiver) and on 16 September 1961 (power supply).

At time of take-off the weight of the aircraft was 12 561 kg, i.e. below the maximum authorized weight of 12 700 kg. Its centre of gravity was within limits.

According to the Operations Manual the fuel required was 500 Imperial gallons. The fuel aboard the aircraft was 440 Imperial gallons. It was placed on the aircraft in accordance with the instructions of the captain and although adequate for the flight Gatwick - Perpignan, was 275 litres (60 gal) less than the quantity required by the Operations Manual.

Crew information

Both the pilot-in-command and co-pilot were considered to be good and competent pilots.

The pilot-in-command held an airline transport pilot's licence valid until 9 December 1961 with a rating for Dakota C-47 aircraft in Group 1. His last instrument rating check was on 16 July 1961.

His total flying hours amounted to 5 624. On the C-47 he had flown:

as co-pilot	by day :	600 hours
	by night:	50 hours
as aircraft commander	by day :	2 712 hours
	by night:	320 hours
during the last 90 days:		299 hours 45 minutes

During the last six months (after following the direct route Limoges - Perpignan) he had landed twice at Perpignan (once by day and once by night). He had flown about 1 670 hours with this airline as aircraft commander on the C-47.

The co-pilot also held an airline transport pilot's licence valid until 14 December 1961 with a rating for Dakota C-47 aircraft in Group 1. His last instrument rating check was on 25 October 1960. He had flown a total of 2 267 hours including the following hours on C-47 aircraft:

as co-pilot	by day	: 1 589 hours
as aircraft commander	" "	: 175 hours

During the last 90 days he had flown 320 hours 35 minutes as co-pilot.

During the last six months (on a route not via Toulouse), he had made five landings at Perpignan (one by day and four by night).

He joined this Company in March 1959 with about 500 hours of flight time, and flew with the Company for one season. He then rejoined the Company in March 1960 and flew as co-pilot, logging about 1 500 hours on C-47 aircraft up until the date of the accident.

The operations manual of the airline

It constitutes both a route manual and an operations manual.

In the part of the Manual dealing with en route information, the following is given for flight from Gatwick to Perpignan:

Traffic	: Gatwick-Perpignan
Non-traffic stop	
Route	: AWY
Dist. NM	: 597
Time	: 4.40
Alternate	: Toulouse
Dist. NM	: 100
Time	: 0.45
Total time	: 5.25
Sector Fuel Weight	: 1 697
Sector Fuel Gallons	: 520

Pre-determined safety heights are not given, but the following formula is included in the Manual:

"The safety height for a particular route must be at least 1 500 ft above the highest obstacle within 25 NM either side of the intended track or 25 NM beyond either terminal or alternate aerodromes.

When flying over the sea, the aircraft must not be below 1 000 ft at any time, except for the purposes of taking-off and landing.

When operating in the vicinity of high ground, the minimum altitude to be flown must be increased to 2 000 ft above the highest obstacle within 25 NM either side of the intended track.

Airways flights will conform to the route guides issued by the Company unless otherwise instructed by Air Traffic Control. The above limits apply in instrument meteorological conditions only, but care must be taken to see that the selected flight level conforms to the quadrantal height separation rules."

No indication is given of the specific charts to be used with the formula.

The Manual also contains a chapter dealing with allowable deficiencies. As regards the flight instruments, take-off with a single directional gyro is permitted even in instrument meteorological conditions or at night.

Finally, the performance curves for the Douglas Dakota 4 itself are given in a separate log-book kept with the case containing the aircraft certificates.

Meteorological information

The forecast prepared at Gatwick was for a Gatwick-Perpignan-Palma or Barcelona route.

It included the terminal forecasts, prepared at 1800 Z and valid for the period from 1800 Z on 6 October to 0300 Z on 7 October, were the latest which Gatwick could have had at the time when the flight forecast was handed over.

The terminal forecasts received from Perpignan were as follows:

period 0000 - 0300 Z
surface wind 160°/18 kt, gusts 25 kt;
surface visibility: 7 NM; cloud: 4/8,
base 2 000 ft (600 m) and 7/8, base 10 000 ft
(3 000 m)

with intermittently:
rain; visibility: 5 NM, cloud: 4/8, base 1 200 ft
(350 m) and 8/8, base 9 000 ft (2 700 m)

terminal forecasts - Toulouse

surface wind: variable, 7 kt;
surface visibility: 11 NM (20 km) rapidly
becoming 6 NM between 0000 and 0300 Z
cloud: 6/8, base 4 000 ft (1 200 m) and
7/8, base 1 000 ft (300 m)

rapidly becoming between 0000 and 0300 Z:
4/8, base 1 000 ft (300 m) and
6/8, base 3 000 ft (900 m) with rain.

Briefing

During the briefing the Gatwick forecaster gave the latest observations available received from Toulouse and Perpignan, i.e. those for 1900 Z.

Toulouse 1900 Z

surface wind: 200°, 2 kt
surface visibility: 4 NM (8 km)
cloud 8/8, base 4 000 ft (1 200 m)

Perpignan 1900 Z

surface wind: 280°, 8 kt
surface visibility: 11 NM (20 km)
cloud 1/8 cumulonimbus, base 2 600 ft (800 m)
7/8, base 11 000 ft (3 300 m)

The Gatwick forecaster stressed the fact that the route, which passed to the west of the Massif Central, would be situated be between an active thunderstorm disturbance over the eastern half of France and a fresh weak disturbance coming from the west.

The forecaster has indicated that he was not asked by the captain for the wind at flight level 75 on the Gatwick-Perpignan route. He added that the captain was particularly interested in the 700 mb chart.

In conclusion, the flight forecast given to the crew was complete and contained the latest meteorological information. Nevertheless, the forecast winds below 10 000 ft (3 000 m) were not included for the sector between 48 N and Perpignan.

0000 Z meteorological observation at Perpignan

At 0025 Z the aircraft received, at its request, from Toulouse approach control the following information:

- surface wind 320°, 18 kt
- visibility 15 km
- rain
- cloud 5/8 at 900 m
  8/8 at 3 000 m

The Flight

Pre-flight preparations

The flight was arranged by Derby Aviation under contract with a London travel agency and was to transport tourists by air from Gatwick to Perpignan.

The aircraft was given a pre-flight check on 6 October for its flight to Perpignan.

Crews have to do their own pre-flight planning. The aircraft is equipped with a navigation bag with the necessary maps, route guides and plans. In addition, the airline prepares standard navigation logs for particular routes and these documents, which do not include minimum safe altitudes, are intended to serve as guides, but they are not mandatory.

It is not certain whether the crew had these logs, but before departure at about 2000 Z the co-pilot went to the "briefing" room of the aircraft, where the usual aeronautical information was available to him, and then completed the Air Traffic Control flight plan at the Aerodrome Flight Clearance Section.

The route shown on the flight plan mentioned Gatwick, then Dunsfold, and finally Perpignan directly via FIR (this route did not conform to the navigation logs of the airline, but it could be used by the aircraft commander at his discretion). With an estimated elapsed time of 4-1/2 hours, an endurance of 6 hours and a true airspeed of 140 kt, the flight plan gave Toulouse Blagnac as an alternate aerodrome.

The two crew members appeared to be in good health and spirits according to witnesses who saw them before the take-off.

Reconstruction of the flight

The flight departed Gatwick at 2043 hours and shortly thereafter indicated he was flying at flight level 75 and estimated flight over the French coast for 2132 Z. It actually crossed the coast at 2136 Z.

During the exchange of communications with Paris Control the aircraft indicated specifically that it would leave the airway at Limoges in order to fly direct to Perpignan. At 2253 Z, G-AMSW reported that it was over Amboise at 52, at flight level 70, and estimated its passage over the FIR boundary for 2319 Z and over Limoges for 2340 Z. At 2319:40 Z G-AMSW contacted Bordeaux Control. After recapitulating its flight data and in particular its estimated time of arrival at Limoges at 2338 Z, it stated that it wished to fly to Limoges, then Toulouse, and from there to fly direct to Perpignan. Bordeaux replied that the direct route to Perpignan passed over Carcassonne. Bordeaux Control at 2321 Z, in order to be certain that no doubt remained about the route to be followed by the aircraft, explained that the Limoges to Perpignan route via Carcassonne was practically direct and that in view of the existence of a radio beacon at Carcassonne it seemed preferable for G-AMSW to fly over Carcassonne. It then asked the aircraft to give an estimated time of arrival at Carcassonne and to change to flight level 75 over Limoges. The aircraft replied that it would not change its flight level at Limoges for it wanted to fly Limoges - Toulouse - Perpignan. Bordeaux Control then accepted the Limoges-Toulouse route.

The aircraft reported having passed Limoges at 2336 Z and estimated passage over the boundary of Toulouse control area at 0020 Z and over radio beacon FOU at 0040 Z. Bordeaux Control explained that the upper limit of Toulouse CTA was at flight level 65, and asked the aircraft to call again over FOU. G-AMSW acknowledged receipt.

The aircraft advised (at 0009 Z) it wanted to go on flight level 75 after Toulouse. At 0010 Z and again at 0019 Z the tape recorded two calls of G-AMSW to Bordeaux Control which did not reply; there was heavy interference during the first of these calls.

From 0022 Z to 0027 Z, G-AMSW entered into communication with Toulouse Approach Control on frequency 121.1 Mc/s. It indicated that it had been unable to contact Bordeaux Control and asked for the latest meteorological reports for Perpignan. The latter were then passed to the aircraft.

At 0030 Z the aircraft again made contact with Bordeaux on 120.1 Mc/s, reported "check passing Toulouse" and gave an estimated time for passage abeam Carcassonne at 0052 Z at flight level 75. Bordeaux then asked for the estimated time of crossing the boundary between Bordeaux and Marseilles FIRs. The aircraft confirmed 0052 Z. The aircraft was then cleared to climb to flight level 75, and Bordeaux asked for confirmation of the estimated time for crossing the FIR boundary. G-AMSW confirmed 0052 Z. It should be noted that the aircraft gave the same estimated time for abeam Carcassonne and for crossing the FIR boundary. No further contact was made with the aircraft. Except for the communications with Toulouse, it was the co-pilot who made the radio communications with the ground. No language difficulties were encountered.

Examination of the wreckage

The aircraft struck the northwest side of Pic Barbet, a northeast spur of Mount Canigou at a flight level of very nearly 75. The impact point was about 40 km from Perpignan aerodrome and 150 km from Toulouse. At the accident site the mountain side slopes at about 60 to 70°. It is very rugged, with boulders, crags and even cliffs, which make access difficult, and the ground is covered with dense vegetation in the form of rhododendrons 60 cm high, and wooded, sometimes only sparsely, with pine trees. From evidence at the scene of the accident, it was ascertained that at time of impact the aircraft was flying straight and level on a heading of about 148°T. (heading from Toulouse to the place of the accident: 141°T.)

General condition

The aircraft was partially disintegrated by the shock of impact. The port wing, which was wrecked, part of the fuselage and the starboard wing, which was less damaged, remained practically at the point of impact. The remainder of the wreckage was flung 50 m higher up the mountain side, but the rear part of the fuselage and the tail, which were little damaged, dropped back a little way behind the initial point of impact.

The two engines and their propellers were separated from their mountings, the lower cylinders broken and the connections and accessories smashed, while the reduction gears followed the propellers which broke away from the engines. After being flung further up the mountain side, the two engines fell back again and the starboard engine was stopped by the main wreckage while the port engine came to a standstill under the trees about 100 m lower down.

Fire broke out immediately after the crash and the tanks, the centre section and the forward part of the fuselage, as well as the wreckage of the crew compartment, were seriously damaged by the fire. The pilot's position and instruments were completely destroyed by the crash and the fire. The flaps and undercarriage were in the retracted position at the time of the accident. The elevator and rudder tabs were in the neutral position. The two engines were developing power at time of impact. From examination at the scene of the accident, the appearance of the engines did not reveal any indication of mechanical failure before the accident. The ground fire was caused by the rupture of the fuel tanks.

The observations of the wreckage showed no evidence of any structural failure or of fire during flight. No sign of a lightning strike was noticed. No part of the aircraft broke away before the impact and all the control surfaces, in particular, were in position. The Decca equipment was probably not in operation at impact. The radio compass was functioning and set to a frequency corresponding to that of Perpignan. There was no evidence to indicate a radio failure although such a possibility remained after 0030.

Discussion of Evidence

Meteorological Situation - General

During the night of 6 to 7 October, a depression was located between Ireland and Cornwall. It was extended towards the southeast by a pronounced trough, as far as the Gulf of Lions where a secondary was in process of formation. In front of this trough the winds were southerly, whereas behind it they were blowing from the west.

There were two disturbances in this trough, both with a NNW-SSE alignment.

On 7 October at 0000 Z, the first disturbance was aligned along Dunkirk, Geneva and Ajaccio, and was, therefore, far to the east of the Gatwick-Perpignan route. The second disturbance, on a smaller scale than the first, was aligned at this same time along Dieppe, Clermont-Ferrand and Montpellier. Both gave rise to a number of thunderstorms over the western slopes of the Massif Central, but at the time of the flight of G-AMSW, there were no reports of thunderstorms by the meteorological stations situated along the aircraft's route.

The greater part of the flight was made behind the second disturbance, for the aircraft passed through the weaker part of the disturbance between the French coast and Chateaudun.

From the standpoint of cloudiness and altitude of the cloud layers, the forecast prepared by Gatwick was approximately correct and corresponded well to what was observed by the meteorological stations and by those aircraft from which a report is available.

The surface visibility along the route also conformed to the forecast.

It is difficult to make a comparison for the upper winds, for G-AMSW flew sometimes at flight level 70 and sometimes at flight level 75, and the lowest level for which the Gatwick forecast gave the wind was 10 000 ft.

Assuming that the winds at flight level 75 had the same direction as at 10 000 ft, and that their force was 5 kt lower, the forecast would have given:

Gatwick to 48 N	180°/30 kt
48 N to 45 N	180°/25 kt
45 N to Perpignan	variable 10 then 240°/20 kt

According to the upper air charts, the real winds appear to have been the following at flight levels 70 and 75:

Gatwick - Chateaudun	160°/25 kt
Chateaudun - Limoges	200°/20 kt
Limoges - Toulouse	290°/30 kt
Toulouse - Perpignan	290°/25 kt

The considerable difference from the winds forecast, from Limoges onwards, is explained by the fact that this part of the flight was made behind the second disturbance referred to previously and not in front of it. For the same reason, the upper air temperatures were slightly lower than those forecast.

The terminal forecasts corresponded approximately to the real conditions: overcast with intermittent rain, but without very low cloud or bad visibility. On the other hand, the surface winds were WNW instead of SSE at Perpignan. The cause was the same as that given above.

At the accident site

On account of the rugged nature of the terrain, the local meteorological conditions may have been quite different from those recorded at the nearest meteorological stations: Perpignan, Carcassonne, Toulouse (the stations of St. Girons and of the Pic du Midi do not provide a night service) and cannot be known with certainty.

From the statements of witnesses and the summary indications provided by the auxiliary climatological stations of Pyrenees-Orientales, and also from the reports of other aircraft, it may be estimated that:

> The Tet Valley was covered by a continuous cloud layer, with its base at about 2 700 to 3 000 m and top at about 5 000 to 6 000 m, giving slight intermittent precipitation: rain in the valley, snow above 1 600 to 1 800 m. There was no low cloud in the valley, but the top of the Pic du

Canigou must have been covered in cloud.

The wind was slight or nil in the valley, but strong from the north-west near the peaks.

Thunderstorms

G-AMSW does not appear to have encountered thunderstorms on its route. On the other hand, there was probably considerable static interference.

Icing

The aircraft, flying at flight level 70 or 75, was always in temperatures close to 0°. The absence of temperature inversion above the flight level excludes the possibility of freezing rain and considerable icing. It is highly probable that there was no icing of the aircraft.

Turbulence

The existence of local mountain turbulence was possible at the time of the accident, but only in the immediate vicinity of the mountains.

Conclusions

At the time of the accident the weather was very cloudy if not overcast, with some slight rain, but there was no particular meteorological phenomenon of exceptional intensity.

The ground visibility was good, and there was no very low cloud.

The only factor which could have affected the flight appears to be the west-northwest direction of the wind on the second half of the route, giving a tailwind instead of the expected wind from starboard causing port drift.

Observations

Flight plan

1) It was not completed in accordance with the directions given in the French regulations as regards the route to be followed under instrument flight rules, directions reproduced for the greater part from ICAO Doc 4444-RAC/501/7. In this part of the flight plan, in fact, only the point of departure, the radio beacon of Dunsfold and the point of destination Perpignan, the estimated elapsed times between these points (4 minutes and 4 hours 26 minutes respectively) and the cruising level (75) are shown.

   According to the directions, it was mandatory to indicate the points at which airways were crossed, and in addition the points at which FIR boundaries were crossed and, if necessary, certain radio fixes ought also to have been indicated.

2) The direct route from Dunsfold to Perpignan passes through the FIRs of Paris, Bordeaux and Marseilles in succession, the portion of the route inside Bordeaux FIR being very short. Probably because the points of crossing these FIR boundaries were not shown on the flight plan, Gatwick ATC did not address this departure plan to Bordeaux area control centre.

These two irregularities had no effect on the course of the flight from the standpoint of the co-ordination ensured by telephone between the various French air traffic services units.

It may also be noted that, as opposed to the British regulations, the French regulations require the filing of a flight plan when the flight is to be made in instrument flight rules conditions.

Communications between the aircraft and ground stations

The poor technical quality of the communications between the aircraft and Bordeaux Control led to difficulties in understanding at times. The quality of reception of other aircraft by Bordeaux Control was good at about the same time. It was clear, however, that ultimately the control services and the aircraft commander were in agreement on the route to be followed and the altitudes to be assumed.

Because of this poor quality, no conclusions can be drawn with regard to possible deterioration in the functioning of the aircraft equipment used for communications on the mobile service. At no time did the crew appear to show any anxiety on this subject. Only on two occasions did it ask for repetition of the messages from Bordeaux Control. Also, at the time of the contact established on 121.1 M/cs with Toulouse approach control, the quality of the recording shows that the functioning of this airborne equipment seems to have been normal, at any rate on this frequency.

Navigation

With regard to the aircraft's navigation, a certain number of differences from the estimated times given by the aircraft commander were noted (see Reconstruction of flight). During the last contact with Bordeaux Control, G-AMSW gave 0052 Z both for the passage abeam Carcassonne and for the crossing of the FIR boundary.

Carcassonne radio beacon is located exactly on the FIR boundary. The theoretical direct route marked on a map shows that between the passage abeam Carcassonne and the crossing of the FIR boundary about three minutes should have elapsed.

This coincidence in the estimated time does not mean that the pilot had finally decided to fly over Carcassonne, for during the last contact with Bordeaux Control he definitely used the formula "abeam Carcassonne".

Navigational aids

The whole of the flight from London/Paris FIR boundary to Toulouse was normal. During none of the R/T contacts did it report any irregularity in the functioning of the navigational aids.

The functioning of the MF radio beacons of Carcassonne and Perpignan gave rise to no comment by the services responsible for their maintenance, for the period of time of interest for the flight of G-AMSW.

It is estimated that the range of Perpignan's radio beacon is about 60 NM. British crew members statements indicated that its range is only 20 NM, another estimated that its usual range is about 75 NM and that this radio beacon is very good by day and night, although he had never had occasion to use it in bad weather conditions or with heavy static interference.

Carcassonne radio beacon is less powerful. It is estimated that its range is about 25 NM.

It should be recalled that the use of MF radio aids is governed to a relatively large degree by the irregularities of propagation due to night effect and to orographical conditions, by the degree of interference due to atmospheric conditions (static, icing, etc.) and by the quality of the airborne receiver.

Regarding the Decca chain, the main aerial of Aurillac station was struck by lightning on 6 October at 1807 Z. The result was a maladjustment. The repairs were completed, and the station was again performing normally at 2000 Z. Between 2000 Z on 6 October and 0300 Z on 7 October no irregularity of functioning was reported.

The use of this navigational aid in the Toulouse-Perpignan area must not be considered as absolutely reliable, although certain pilots claim that they obtain the correct degree of accuracy on decometers. (Flight log use is in any event not to be recommended). This area is in fact situated on the edge of the limit of acceptable accuracy on the British maps published for this purpose.

It is believed that the pilot-in-command was fully informed of the conditions governing the use of and the possibilities afforded by the radio aids in this area.

A coding error in the Channel Islands sector of the chart gives reason to think that the crew must have switched off the flight log when they realized that it was not possible to use it. In consequence, the pilots may well have also had doubts about the satisfactory functioning of the decometers.

In the absence of any VOR airborne receiver, G-AMSW could not use the VHF omni-directional range of Toulouse (TO-117.7 Mc/s).

Choice of route

At 2319 Z, at the time of the first R/T contact with Bordeaux Control, the pilot reported that he wished to fly via Limoges - Toulouse - Perpignan. Perhaps he decided to abandon the direct Limoges - Perpignan route, either because of the bad weather conditions to the east, or because of the possible doubt regarding the use of the Decca.

In spite of the insistence of the controller who suggested to him that he should take the practically direct route from Limoges to Perpignan via Carcassonne, the pilot refused, and the controller finally gave his agreement to the route requested.

Of three possible routes, the pilot chose the third, Limoges - Toulouse - Perpignan, 218 NM, but the reason for this choice is not apparent.

Safe altitude for the chosen route

Mount Canigou (altitude 9 138 ft or 2 785 m) is inside the limit of 25 NM from Perpignan; consequently, the correct application of the formula for safe altitudes specified in the Operations Manual determines a minimum altitude of 11 500 ft.

While it is the responsibility of the aircraft commander to ensure that a flight is made at a safe altitude, it was found that application of this formula to the different types of maps and charts, which may have been on board G-AMSW, can result in calculations of safe altitudes varying between 1 500 ft and 11 500 ft.

Reconstruction of the navigation

According to the navigation plan reconstructed and the radio transcripts, the estimated time of arrival of G-AMSW was very close to 2340. In fact, the aircraft had fixed its reporting point "past Limoges" as 2336 hours.

After having discarded the possibility that the aircraft may have used another route than the one intended, the Commission then considered attempts to reconstruct the navigation on a Limoges - Toulouse route and then on a route from Toulouse to the accident site.

Passage at Toulouse

The aircraft arrived at 0030 Z, i.e. 10 minutes ahead of its estimated time of arrival. It is legitimate to think that the navigator had used a head wind from Limoges, without drift, whereas in actual fact he had been subjected to a crosswind with a drift of about 11° to port and a tailwind component of about 6 - 8 kt. This unexpected drift, which was probably nil at Limoges, increased to 11° near Toulouse, and gives reason to think that the aircraft had to bracket the track indicated by its radio compass during the flight from

Limoges to Toulouse. As a result 10 minutes before its estimated time of arrival over Toulouse and at the time when it arrived in the vicinity of the town, G-AMSW could perfectly well have been several kilometres off its route; it may, therefore, logically be thought that the aircraft probably passed in the vicinity of Toulouse ("passing Toulouse") and not over Toulouse ("over Toulouse").

It might normally have been thought that the pilot, after having passed Toulouse would have navigated by QDRs using a back bearing on the radio beacon FOU for a track covering a distance of 90 to 100 km (probable limit of the night range of the radio beacon), before going over to "homing" on the Perpignan radio beacon FOP.

In the absence of evidence, it is impossible to know whether such a procedure was adopted by the crew.

Abeam Carcassonne

The flight was asked to call abeam Carcassonne (CS), but the call was not heard by any ground station. It may have been out of range at the estimated time for this call. At the estimated time the aircraft may have had some difficulty in identifying the Perpignan radio beacon. This would have taken the attention of the co-pilot and might explain the absence of communication with the ground.

Toulouse vicinity to accident site

In conclusion (and subject to the reservation that on the hypothesis of correct functioning of the radio compass, its indications may have been difficult to interpret, wrongly interpreted or even disregarded) the following points may give an explanation of the course of the navigation:

The aircraft, when it had passed Toulouse and in the immediate vicinity of that town, went on to a heading with the intention of following the direct Toulouse - Perpignan track (without flying over Carcassonne).

It is not known whether the radio compass, the only really effective navigation aid on board, was used. It seems probable that the crew placed more reliance on navigation by dead reckoning than on the indications of the radio compass.

If the crew calculated its course by using the forecast wind (about 240°/25 kt) which gave it a drift to port of about 10°, whereas the known reconstructed wind was approximately 290°/25 kt and therefore causing no drift, then the course would have become the effective track (137° true).

If parallel lines are drawn through FOU and throught the place of the accident on a bearing of 137° true, they are found to be about 8.5 km apart.

In consequence, in order to intercept the track leading to the place of the accident, the minimum error in relation to a position over FOU would have been a passage by G-AMSW of about 6.5 km to the west of FOU, followed by the assumption of a heading (137° true) 75 seconds later.

Although this reconstruction seems to offer a perfectly acceptable solution, in the absence of evidence to the contrary, including in particular precise information of the kind which could be provided by a flight recorder, the Commission cannot consider it as definitive.

The possibility of a failure of the single magnetic compass has in particular been considered. The whole of the evidence before the Commission, however, seems rather to point to normal functioning.

Probable Cause

The accident was attributed to a navigational error, the origin of which it was not possible to determine for lack of sufficient evidence.

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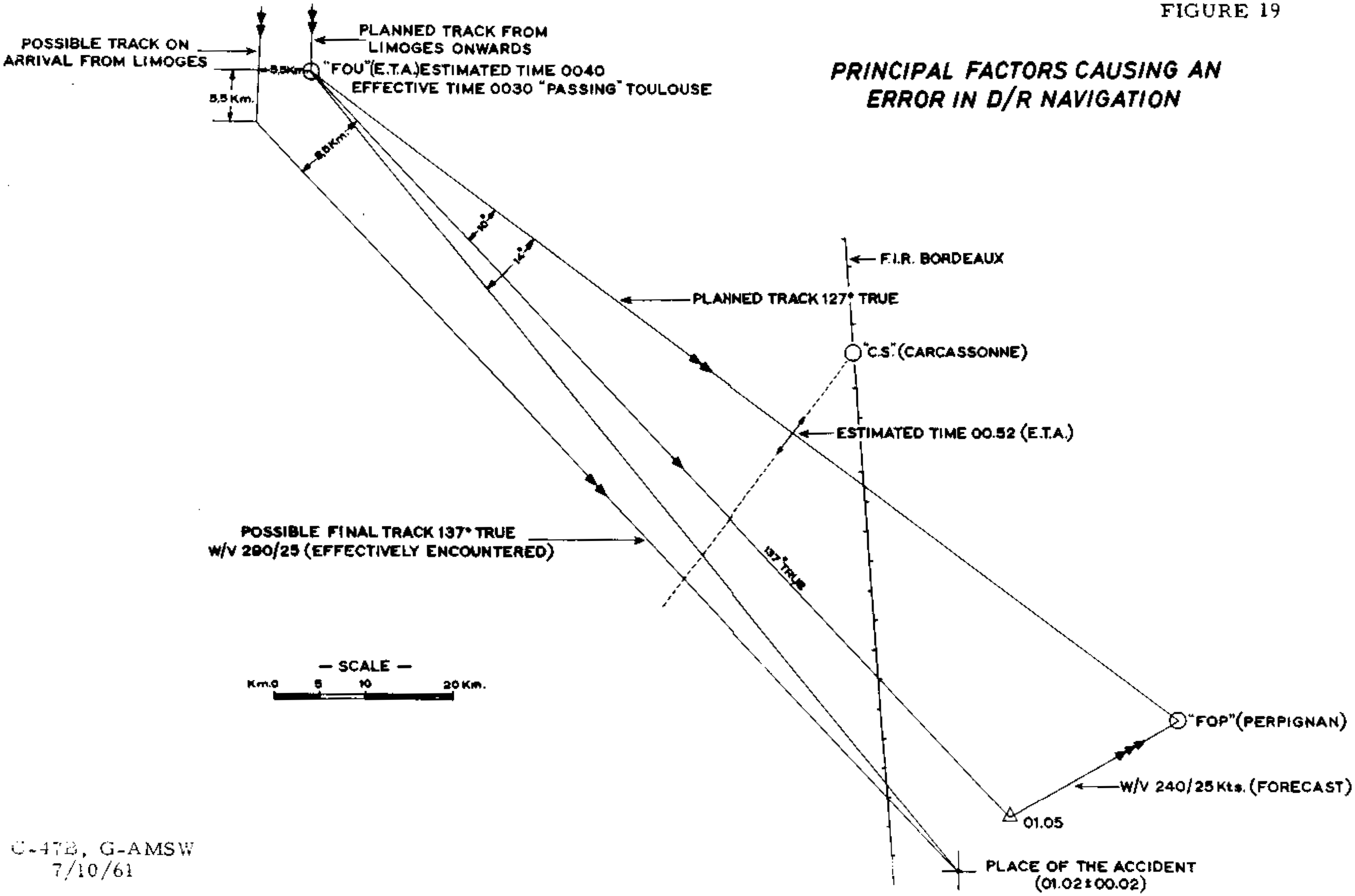
ICAO Ref: AR/717

FIGURE 19

PRINCIPAL FACTORS CAUSING AN ERROR IN D/R NAVIGATION



C-47B, G-AMSW
7/10/61

No. 39

Transavia Airlines, SM-102, I-NINI accident at Parete (Naples) Italy, 22 October 1961. Report of the Italian Accident Investigation Board, issued 28 December 1961 by the Directorate of Civil Aviation, Italy.

Circumstances

After unloading 500 kg of newspapers at Capodichino, the empty aircraft with a pilot and a flight mechanic aboard took off at 0850 hours local time for the return VFR flight to Ciampino Airport, Rome. The take-off and climb-out were normal. Twenty minutes later the pilot informed Capodichino tower that he was returning because the right engine had failed. At this time he was at 1 000 ft over Grazzanise. At 0914 the aircraft was on a heading of 120°, at 700 ft and maintaining altitude fairly well. Thereafter the flight did not respond to any calls. It crashed at approximately 0915 hours near Parete, 13 km to the west-northwest of the south end of the Capodichino runway. Both crew members were instantly killed, and the aircraft was destroyed. There was no fire following impact.

Investigation and Evidence

The Aircraft

The aircraft's certificate of airworthiness was valid until 21 December 1961 and only if associated with Manual CA 754 "Description and Piloting Regulations for Pratt & Whitney R-985-AN-14B engines". The manual was not found in the aircraft.

Since manufacture the aircraft had flown a total of 695 hours. Since its last overhaul by the manufacturer and the last inspection by the Italian Aeronautical Registry it had flown 153 hours. The aircraft's log book showed 148:45 hours instead of the 153:05 hours as shown in the maintenance log book.

Several periodic inspections of the aircraft were carried out by Transavia in September 1961, and the aircraft was about due for the 150-hour inspection.

The right engine had been replaced on 19 August following an in-flight failure. Since that time the new engine had flown about 100 hours.

At the time of the accident the aircraft was empty and weighed 4 111 kg, i.e. approximately 80% of the maximum authorized (5 050 kg).

Its centre of gravity at the time of the accident was considerably forward of the permissible forward limit and approximately 30% beyond the optimum position.

Following the accident, the Board calculated how much ballast would have been required in the furthest tail compartment to bring the centre of gravity back to its mean position, or at least to the maximum forward position. Instead of the 20 kg on board, 291 or 113 kg respectively would have been required.

Crew information

The pilot of the aircraft held a pilot certificate and licence (third class) which was valid until 28 October 1961. The rating entered on his licence for the SM-102 was dated 2 August 1961. His total amount of flying experience amounted to 3 306 hours. On the subject aircraft type he had flown a total of 82 hours, all within the last 90 days.

The flight mechanic's licence was valid until 11 October 1962. He had had considerable military and civil experience in this capacity. Transavia had hired him in June 1961 as flight mechanic for the company's SM-102's. His flying time totalled 695 hours which excluded his time flown prior to 1943, the record of which had been lost. During the last 90 days he had completed 105 flying hours on the SM-102.

He had recently been involved in an emergency landing while on a commercial flight from Milan to Rome during which he was aboard as a pilot in training. At that time he was carrying out the duties of first pilot. No technical investigation appears to have been made of this accident.

Both the pilot and the mechanic were considered to be highly competent airmen.

Weather conditions

On the morning of the accident it was clear and sunny with very little scattered cloud, no wind and perfect visibility. The pilot had filed a VFR flight plan and could not, therefore, fly higher than 1 000 ft (300 m) above the ground.

Fifteen minutes before the accident occurred the conditions of the air at Naples at ground level were as follows:

relative humidity	82%
temperature	12^o
dew point	9^o

As is generally known from the SM-102 manual and from the Pratt & Whitney Manual R-985-AN-1, there is a possibility of icing in the carburettor in the above conditions of humidity and temperature, and therefore the use of hot air is recommended as a precaution.

The pilot had noted the weather conditions and was familiar with them as he was returning to Rome from which he had just come.

Reconstruction of the flight

Based on the evidence available the flight was reconstructed as follows.

The aircraft took off at 0850 hours. Two minutes later it was en route to Ciampino and flying normally at 1 000 ft for approximately eleven minutes. It had flown about 14 km beyond Grazzanise airfield. At about 0903 hours the pilot noticed a decrease in power on the right engine and decided to return to Capodichino. He avoided a landing at Grazzanise Airport* and passed over it at 0910 when he first made radio contact with Capodichino advising that the right engine had failed and that he would arrive over the airport at 0918. He continued the flight thereafter without feathering the right propeller or putting it on minimum pitch. At approximately 0913 - 0914 hours he again contacted Capodichino and reported that he was at 700 ft and maintaining height fairly well on a heading of 120^o. Not more than one or two minutes later, at about 0915 - 1916 hours, the aircraft crashed to the ground in a dive angle of 30^o, about 13 km from the south end of Capodichino runway.

Eyewitnesses

The only eyewitnesses to the accident were two peasants who observed the aircraft during the last seconds of flight only, shortly before impact with the earth. They said that they looked up upon hearing the sound of the approaching aircraft, therefore at least one engine must have been functioning. They did not hear or were unable to distinguish backfiring or other irregularities in the operation of the engine or engines. They stated that the aircraft was approaching "as if it intended to dive", i. e. with its nose pointing towards the ground. The condition of the wreckage confirmed their statements.

Technical investigation

The aircraft, which was virtually intact, was found on a heading of 120^o with its flaps and undercarriage retracted, near Parete in a clearing surrounded by trees. There were no traces of skidding or scraping on the soft ground. A number of tall trees (approximately 8 m) located 15 - 20 m behind the tail of the wreckage were not hit by the aircraft before it struck the ground. Also, a small tree (a little higher

* 26 km from Capodichino.

than 1 m and less than 1/2 m from the right stabilizer) was not hit. This indicates that the aircraft, after striking the ground at a 30° angle, fell on its tail and rotated around the engines, which had struck the ground first and acted as a fulcrum. The occurrence of a downward couple, which caused the aircraft to settle on its tail, and of stresses causing buckling of the fuselage, indicated that at the time of impact the angle of incidence and hence the flight configuration were very close to the stall configuration.

The coincidence of the orientation of the longitudinal axis of the wreckage with the 120° approach heading to Capodichino, as radioed by the pilot, and the horizontal position of the wings at the time of impact indicated that the stall which occurred along this approach heading was a straight stall, or at least a stall that was corrected by the pilot's action on the rudder before the crash.

The extent and nature of the distortions of the left propeller blades indicated that the left engine was turning more rapidly than the right one. It was not possible to determine the rpm at impact. Indications were that at impact the propeller was on minimum pitch and was not capable of providing the necessary thrust to support the aircraft in flight.

The extent and direction of the distortion of the blades of the right propeller indicated that the right engine was not operating and that the propeller also struck the ground on minimum pitch. It may be assumed that the right propeller, far from providing any thrust, was on the contrary generating additional drag because it was on low pitch and windmilling.

The Board was unable to determine the number of rpm required for maintaining the SM-102 in flight on one engine, with propeller at minimum pitch.

No specific irregularity was found with respect to the aircraft, the engines and the propellers.

Examination of the wreckage did not reveal any failure in the control systems. The Board, however, admitted the possibility of a sudden increase of the minimum lift speed and controllability of the aircraft as a result of:

a) asymmetric power configuration with right propeller drag;

b) centre of gravity too far forward necessitating an unduly high excursion of the rudder, which could not be obtained unless the aircraft were moving forward at a certain minimum speed below which even "full stick back" could not raise the nose of the aircraft.

It was stated by the Chief Pilot, Transavia, that with the aircraft empty and the centre of gravity fully forward, the SM-102 had already flown without any difficulties and that even during landing the difficulty of settling the aircraft and the pressure on the wheels were not significant and, therefore, not considered dangerous. The fact remains that it is impossible to equate the landing performances with more or less power output and at a speed much higher than the stalling speed up to a few inches from touchdown (not to mention lowered flaps) with the performance corresponding to asymmetric power near the critical power requirement for sustained flight such as obtained at the time of the accident.

Carburettor icing

The Board gave careful consideration to the temperature and humidity conditions existing at the time of the accident which were conducive to carburettor icing.

It was determined that hot air was not supplied to the engine or that, if supplied, it was cut off before the aircraft fell. The actuating cylinders operating the hot air intake shutters were both found in the "closed" position. As it was a warm sunny day the pilot could easily have been led to disregard the danger of icing of the carburettor.

Discussion of evidence

Based on the following:

The aircraft crashed

a) without sending any radio messages;

b) with both the pilot and the mechanic not strapped in their seats;

c) without the controls or fuel being cut off;

d) without the flaps being lowered;

it was deduced that the loss of speed or stall occurred -

a) at low altitude (not above 700 ft and probably around 500 ft QNH, i. e. 300 ft = 100 m above ground level)

b) abruptly and violently

c) at a sharp dive angle (30° or more)

d) quite unexpectedly for the pilot

e) with considerable loss of altitude

f) which left the pilot with lateral control of the aircraft only, prior to ground impact.

The evidence showed that there was not a complete loss of power in the left engine. Even in the case of an improbable failure of the left engine, it would not by itself explain the sudden, violent and steep stall of the aircraft.

In normal stall conditions the SM-102 shows definite and distinct tail vibrations which call for prompt recovery action through a slight increase in the angle of attack. (At impact the angle of attack was approximately 15 - 18°.)

The pilot's experience was such that, faced with this loss of power, and hearing the stall vibrations, he would have taken immediate corrective action, i. e. he would have put the aircraft into a dive and lowered the flaps as close to touchdown as possible.

The fact that the centre of gravity position was beyond the permissible forward limit, and the aircraft was flying under asymmetric power, contributed to raising the stalling speed and to provoking the abrupt and violent stall which caught the pilot by surprise. The Board could not determine to what extent this minimum speed was increased and the stall aggravated.

Probable Causes

Having considered various hypotheses as to the cause of the accident the Board concluded that it was caused by a cumulative effect of various factors.

The weather conditions conducive to carburettor icing were such as to escape the attention of the pilot and thus explain his failure to take preventive or corrective action.

Power reduction had occurred initially in the right engine as a result of carburettor icing.

Subsequent loss of power in the left engine was also due to carburettor icing, or overheating as a result of operation at increased power to compensate for the failure of the right engine or again because of the deliberate action by the pilot to counter incipient overheating.

The pilot failed to foresee the possibility of carburettor icing, to consider the desirability of feathering the right engine, to assess the significance of the increase in minimum speed caused by the trim of the aircraft and its asymmetric power and to appreciate the stall characteristics in such conditions.

The low altitude at which the aircraft was flying precluded prompt recovery from an involuntary and severe stall.

The pilot and mechanic had not strapped themselves into their seats with the result that they suffered fatal skull fractures.

There may have been psychological reactions, difficult to evaluate, which were due to the fact that the mechanic had only recently been hired and that he had been involved in another accident on 6 September, which had nearly cost him his job. Therefore, he might have been more inclined to display ability to the point of recklessness rather than to be over-cautious (failure to land at Grazzanise).

Recommendations

The Board pointed out that the following recommendations, suggested by this accident, are not necessarily related to the accident as cause to effect.

Safety equipment for crew members

All flight crew members should be urged or obliged to use seat belts and shoulder harnesses and to unfasten them only when absolutely necessary to perform duties on board.

All civil air carriers engaged in cargo transport (without passengers) should be urged or obliged

a) to install shoulder harnesses in addition to lap belts in all the seats normally used by flight crew members;

b) to carry parachutes on board since the practical and psychological reasons for not carrying this equipment in the case of passenger flights do not apply in the case of cargo flights.

The carriage of this equipment is all the more justified in the case of aircraft such as I-NINI, which are "authorized to fly by night and under IFR except in icing conditions".

Warm air to the carburettor

Pilots should be reminded of the need to supply hot air to the carburettors, within and outside of clouds, even as a preventive measure and on the sole basis of the thermometric indications, whenever there is suspicion of extreme air humidity.

It should be ensured that the regulations for the supply of hot air to the carburettors are actually included with the necessary explanations and emphasis:

a) in the pilot's training manual for the aircraft and in the pilots' check list;

b) in the examination programmes for the aircraft type rating.

Balancing of aircraft

It is recommended that:

a) Certificates of Airworthiness and other aircraft documents such as Pilot Manuals and Check Lists should specifically emphasize, even at the cost of repetition, the need for carrying ballast in the tail of those transport aircraft (passengers or cargo), whose centre of gravity position may be too far forward from the specific or desirable limits when flying empty;

b) The examinations for pilots' aircraft type ratings, and the regulations concerning approval of the load and trim sheet by the airport authorities should stress not only the hazards of aft loading, but also the hazards of fore loading.

Asymmetric flight at reduced power

It was also recommended that:

a) the operating rules (Aircraft Flight Manual and Pilot Check Lists) be checked and completed as regards asymmetric flight with reduced power - SM-102;

b) the theoretical and practical tests and examinations for the SM-102 type rating, particularly as regards asymmetric flight with reduced power, be reviewed and supplemented.

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ICAO Ref: AR/705

No. 40

KLM, Douglas DC-8, PH-DCE, accident on landing at Lisbon Airport, Portugal, on 29 October 1961. Report released by the Aircraft Accident Investigation Board, The Netherlands.

Circumstances

At approximately 1529 hours local time, PH-DCE, while carrying out a landing at Lisbon Airport, Portugal, struck a lamp of the approach lighting system about 35 m before the beginning of runway 23 and was slightly damaged. The crew of 12 and the 85 passengers aboard were unhurt.

Investigation and Evidence

The Aircraft

It has valid certificates of airworthiness and maintenance.

During the landing at Zurich Airport earlier that day the engines had been switched over to negative thrust during which the jet pipes of engines 2, 3 and 4 were damaged; the damage sustained by engines 2 and 3 was negligible so that these engines could still be used; however, the damage to the jet pipe of engine No. 4 was somewhat greater. It was still well possible to switch this engine over to negative thrust, but it was not considered advisable owing to the possibility of further damage. Before the take-off from Zurich on the subject flight the pilot-in-command consulted with the co-pilot and the flight engineer and decided that during the landing at Lisbon negative thrust might be applied to engines 2 and 3 but that it would only be applied to engines 1 and 4 in case of emergency. Apart from this damage, the aircraft could be considered airworthy, and upon landing at Lisbon the landing weight and centre of gravity were well within the limits prescribed in the airworthiness certificate.

Crew Information

The crew members all held valid licences.

The pilot-in-command had logged a total of 15 296 hours at the time of the accident. He had flown a total of 379 hours on the DC-8 of which 42. 30 hours were flown during the month prior to the accident.

The co-pilot, who was in the left-hand seat during the flight from Zurich to Lisbon, had logged 8 474 hours as of the day of the accident of which 159 hours were flown during the month prior to the accident. He stated that he had carried out about 10 landings on a DC-8 during the 6 to 7 months prior to the accident. Four of these landings had been performed on a DC-8 equipped with JT-4 engines. PH-DCE was equipped with JT-4A-9 engines. His most recent landing with a DC-8 was performed at Madrid in an aircraft equipped with JT-3D turbofan engines. During his training as a DC-8 pilot and up to 20 August 1961, he had always flown DC-8s equipped with JT-4 engines.

Weather

The weather conditions at the time of and place of the accident were as follows:

> wind: 220°/9 kt; cloud: 4/8 Cu and Sc 360 m (1 200 ft); temperature: 14-1/2°C; visibility: more than 16 km.

There was no rain or turbulence during the approach or landing. Rain had fallen before the landing procedure was initiated. The weather did not have an unfavourable influence on the approach and landing.

Runway 23

The landing runway, with respect to its length, was in conformity with the legal regulations and the KLM stipulations for DC-8 aircraft. It was wet at the time of the landing. The co-pilot was familiar with the runway. He had previously landed aircraft on it which were not DC-8s.

The Flight

Flight KL 771 (scheduled) departed Kloten Airport, Zurich, Switzerland at 1243 hours local time for Lisbon, Portugal, and progressed without incident.

At 1517 hours the aircraft passed the AR beacon at Alverca located 8 NM before the beginning of runway 23. A normal visual approach could be made. The rain had stopped.

Acting on the pilot-in-command's instructions, the co-pilot performed an ILS approach in order to maintain his skill in the performance of this type of landing. Upon approaching the ILS glide path, the pilot-in-command, on the command of the co-pilot, extended the landing gear and positioned the wing flaps at 35°. This was done at an altitude of roughly 570 m (1 900 ft). According to the pilot-in-command, at first the aircraft flew somewhat above the ILS glide path; however, near the beacon 4 NM before the runway threshold, the aircraft was well stabilized on the ILS beam and was somewhat less than 15 m below the ILS glide path.

As soon as the aircraft had descended to a height of 180 m (600 ft), the pilot-in-command directed the co-pilot to suspend the ILS procedure and to continue the approach visually. At this time, according to the ILS indicator, the aircraft was flying along the centreline. Actually, however, it was slightly to the left of the centreline.

At this point the co-pilot was flying deliberately below the ILS glide path in order to approach the runway at a smaller angle and to touch down on the runway before the point at which the touchdown is normally made when the ILS glide path is followed. In the meantime the aircraft was again brought back to the centreline.

At a height of roughly 90 m (300 ft) the wing flaps were extended fully. The speed which, until then, had been approximately 146 kt, dropped to 140 kt and thereafter to about 134 kt. The rate of descent of approximately 350 ft/min did not decrease appreciably; no ballooning was noted nor was there any abrupt change in attitude.

Earlier in the approach, the cockpit check had been completed in accordance with the relevant check list except for positioning of the spoilers. Just prior to landing the flight engineer reported that this still remained to be done and appropriate action was then taken.

In the meantime the aircraft had reached a point where it had "to be flared out" in order to carry out a normal landing. It was straight before the runway, although low, and was not drifting; the speed was 135 kt. The co-pilot's efforts to flare out the aircraft promptly and correctly were not entirely successful. The aircraft dropped rapidly, and the right main landing gear then collided, 35 m before the runway threshold, with a lamp of the approach lighting system; 5 m farther on the left landing gear struck the sloping ground in front of the runway.

The pilot-in-command did not intervene during this manoeuvre.

After colliding with the lamp and the ground, the aircraft continued in horizontal flight. The wheels of the main landing gear rolled lightly over the sandy ground leaving an indistinct mark. The aircraft glided out above the runway and swerved slightly to the left; this tendency was immediately corrected by the co-pilot. The pilot-in-command directed him to maintain the aircraft on a straight line. The aircraft landed in a flat position. During the landing run, the co-pilot first kept the nose high (so that the aircraft rolled firmly on the main wheels) thereafter, he allowed the nose to sink. As soon as the nose wheel had touched the runway, the co-pilot, obeying the pilot in command's order, seized the nose wheel steering control and applied strong negative thrust to engines 2 and 3. Engines 1 and 4 remained at low positive thrust.

The aircraft continued its normal run-out. The deceleration noted, due to braking and to negative thrust, was normal. The aircraft left the runway at the intersection with runway 32, that is, at a distance of 1 500 m from the runway threshold.

Discussion

The manner in which the flight was performed by the co-pilot was considered by the pilot-in-command to be entirely satisfactory. After suspension of the ILS procedure the co-pilot brought the aircraft below the ILS glide path with the intention of making a short landing. On this runway the ILS reference point is 275 m beyond the threshold. The pilot-in-command was in agreement with this inasmuch as the co-pilot's intention to make a short landing had his approval. However, the procedure of the co-pilot was in conflict with the airline rules which stipulated (and rightly so in the opinion of the Board) that touchdown must be made at a point in the vicinity of the ILS reference point. In departing from these rules the co-pilot had acted in conflict with good piloting procedure and this reproach applies also to the pilot-in-command since he could and should have prevented the co-pilot from committing the above-mentioned breach of good procedure.

The pilot-in-command and the co-pilot justified their intention to make such a short landing by referring to the following factors:

a) the runway was very short for aircraft such as the DC-8;

b) the runway slopes down at the end;

c) after the end of the runway the ground sloped sharply downwards;

d) the runway was wet with rain so that it was not possible to brake sharply;

e) it was preferable not to apply negative thrust to engines 1 and 4 because of the damage to the jet pipe on engine 4.

Although these factors did influence the crew in taking their decision, nevertheless, they provide insufficient grounds for a decision which implied the assumption of an increased risk at the moment of landing when the speed of the aircraft was greatest.

The following observations are made:

a) Runway 23 at Lisbon is 2 080 m long which according to the regulations was adequate under the given circumstances for a landing following the normal procedure. In this connexion it was pointed out that the aircraft actually has been able to leave the runway at the intersection with runway 32, that is, at a distance of about 1 500 m from the landing runway threshold.

b) and c) This particular runway can be sectioned into four parts according to the slopes appearing, as follows:

part 1 - 5 m running upwards over a length of 1 045 m;
part 2 - 3 m running upwards over a length of 467 m;
part 3 - 3 m running downwards over a length of 358 m;
part 4 - practically horizontal over a length of 210 m.

The runway, taken as a whole, has an upward slope of 5 m, so that its average slope is positive and amounts to 0.25%. The runway slope, therefore, was not unfavourable but in fact had a decelerating effect on the aircraft. Also it follows from the foregoing, that if the ILS flight path had been followed during the approach, the whole of the runway could have been scanned by the pilot-in-command and the co-pilot until shortly after the aircraft had crossed the threshold.

The Board noted that both the pilot-in-command and the co-pilot had an exaggerated conception of the influence of the differences in elevation of the order of magnitude obtaining in this case with respect to the length of the landing run. More consideration should be given to this subject during the training of aircraft pilots.

d) and e) In conformity with the legal regulations, and having regard to the prevailing wind, a runway length of 1 885 m was required. This requirement takes no account of the use of engines with negative thrust. In accordance with the KLM regulations based on the use of full negative thrust on the inboard engines and very minimum negative thrust on the outboard engines, a runway length of 1 595 m was required under the given circumstances. Therefore, apart from the circumstance that, in case of emergency, negative thrust could also be generated from the outboard engines, the runway length could be considered as adequate with the application of negative thrust to the inner engines alone.

The foregoing facts and data which must have been known to the pilot-in-command and co-pilot should have restrained them from acting in disregard thereof and from allowing themselves to be influenced by factors of a psychological nature, such as the fact that runway 23 at Lisbon had the reputation among pilots as being "tight" for DC-8 type aircraft and the fact that the runway sloped downwards over a certain length.

As the co-pilot himself admitted at the Board session, he had made an error of judgement during the approach and flare-out. It could not be satisfactorily established whether the inopportune flare-out performed by the co-pilot could have been corrected by timely intervention of the pilot-in-command.

Probable Cause

The accident was attributed to the fact that the co-pilot committed an error of judgement in performing a landing which - departing from the directives prescribed by his company - he wished to make closer to the runway threshold than was necessary under the prevailing circumstances.

The pilot-in-command should have prevented the co-pilot from disregarding without need the directives concerning approach. On the other hand, the additional error of judgement committed by the co-pilot concerning the moment of the flare-out is attributable to the pilot-in-command; because of his higher degree of responsibility, the pilot-in-command's dereliction with respect to his approval of an excessively low approach must be considered more serious than the co-pilot's error itself.

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Scheduled International Landing
Undershoot
Pilot - improper training or supervision, flight

ICAO Ref: AIG/ACC/REP/GEN/No. 2 - The Netherlands

No. 41

British European Airways Corporation, Vickers Viscount 736, G-AODH, damaged on landing at Frankfurt/Main Airport, Germany, 30 October 1961. Report, dated 8 June 1962, on the inquiry carried out by the Chief Inspector of Accidents, Federal Republic of Germany. Released as C. A. P. 186 by the Ministry of Aviation (United Kingdom).

Circumstances

The aircraft was on a scheduled service (charter flight) from Berlin to Frankfurt/Main, Germany. Aboard were a pilot-in-command, a co-pilot, 2 stewardesses, 11 passengers and one child. The flight proceeded normally until the final approach at its destination. During a missed ILS approach in poor visibility the aircraft struck the ground alongside runway 25 and was badly damaged while rolling to a stop. Two of the sixteen occupants were injured. The accident occurred at 1748 hours GMT.

Investigation and Evidence

The Aircraft

It was registered in the name of British United Airways Ltd. and was classified under "Transport Category (Passenger)". The aircraft's certificate of airworthiness was valid on the day of the accident.

Crew Information

The pilot-in-command had flown a total of 12 303 hours including 2 378 hours as captain on the Viscount. His airline transport pilot's licence was valid on the day of the accident. He had made 30 landings at Frankfurt.

His co-pilot, who held a valid commercial pilot's licence, had flown with him for 9 days on the Frankfurt-Berlin service.

The Flight .. and Landing

G-AODH departed Berlin at 1641 hours GMT and proceeded normally until the time of the final approach. The lights of Frankfurt could be plainly seen during flight over the southern part of the town. On finals, the co-pilot, as instructed, called out the individual heights during descent to a height of 200 ft.

The pilot-in-command reported the final portion of the approach as follows: "At 200 ft the first officer called out '200 ft'. I was watching the instruments, particularly the altimeter, which showed 200 ft. The recommended approach speed for our weight, about 50 400 lb, was 121 kt, but I had been maintaining 125 consistently. I always use a little extra speed on an instrument approach to eliminate sink in the case of overshoot. I opened the throttles a little and eased the nose up, confirming that we were still at 200 ft. At the same time the ILS needle deflected to the right about one dot, and GCA warned us that we were drifting to the left. I turned 5^{o} to the right. Almost immediately the first officer called out 'The runway is below us'. Still expecting 600 yd RVR (runway visual range) I looked up from the instruments and out and down. I took it for granted that the first officer had seen the runway lights. All I could see, however, was a glow. I called out to him 'Where are the lights? ' and then we struck the ground". The pilot-in-command thought he had maintained a height of 200 ft.

Findings at the accident site

The aircraft touched down in line with the normal point of touchdown, but about 40 m to the left, alongside the runway (approximately halfway between the left runway boundary and the glide path aerial system) and had come to a standstill 490 m further on. Touchdown, according to the marks on the unpaved ground, was very hard, first of all with the left undercarriage, then with the nose landing gear, and, 22.2 m beyond the first point of impact, the right undercarriage hit the ground. The propellers had also left impact marks on the ground from the first touchdown point onwards in the same order as the impacts of the landing gear; this is a sign that the aircraft failed to round out, and the undercarriage had collapsed. No fire broke out. Between 1750:50 and 1751:09 hours a message was received from the aircraft, on the ground, that it had crashed to the left of the runway.

Weather minima

The airline's weather minima for instrument approach to the runway in use at Frankfurt and for this landing direction are: 600 yd visibility and 200 ft critical height.

The 1720 hour weather report was passed to the aircraft as follows: wind: calm; visibility:0.1 NM; runway visibility: 0.3 NM; fog in patches; 1/8 cloud at 10 000 ft; visibility varying between 200 and 800 m. The aircraft was given the QNH value 1017 mb.

At 1742 hours another aircraft making an approach on the same frequency was given visibility as 0.1 NM, fog. To the question whether visibility was constant or variable this aircraft was informed that the officially reported visibility was 0.1 NM and that the aircraft should stand by for runway visual range. This transmission was also heard by the crew of G-AODH.

Discussion

After the accident, the runway lights could not be seen from the aircraft, although they were on at maximum intensity and were only 50-60 m from the aircraft.

The request to overshoot (at 1747 hours) was missed by the two pilots, as their attention was focused on the surface visibility to be expected. The pilot-in-command, whilst on final approach, had seen neither the runway lighting system nor any single light of this system. The co-pilot's call 'the runway is below us' probably led the pilot-in-command to assume that the aircraft was on the centreline and that the co-pilot was better able to assess their position visually than he himself was. The flight instruments (altimeters and vertical speed indicator) had obviously not been sufficiently watched by either of the two pilots during the final phase of the approach. Apart from the fact that he flew below the critical height, the pilot-in-command had the choice between the reading on his ILS needle which had previously shown him to be left of the runway centreline and the warnings of the radar control, on the one hand; and the remark called out to him by his co-pilot on the other. He decided to go by the latter.

During the period 1452 - 1736 hours, 13 aircraft carried out GCA approaches and a further 20 aircraft made ILS radar approaches. None of these aircraft reported unsatisfactory functioning of the ground approach aids. The crew of G-AODH confirmed, after being questioned, that on the ground and in the aircraft the approach aids were in working order. By order of the Bundesanstalt für Flugsicherung on 31 October 1961 an ILS check flight was carried out under VMC in aircraft FAA DC-3, N-28. The deviations fell within the permissible limits.

Within the scope of this inquiry it was felt that the fact that the decrease in the runway visual range to below 0.3 NM was not reported to the aircraft constituted a deficiency. It would have been an additional warning for the pilot-in-command. Measures to remedy this deficiency have in the meantime been taken by the German Meteorological Service.

Probable Cause

The pilot-in-command, during the ILS approach, flew below the critical height and, in a surface visibility which was inadequate, struck the ground alongside the runway. It is probable that a contributing factor was that at the critical moment the assistance given by the co-pilot to the pilot-in-command was erroneous and misleading.

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ICAO Ref: AR/735

No. 42

Panair do Brasil S. A., DC-7, PP-PDO, accident at Recife Airport, Pernambuco, Brazil on 1 November 1961. Report released by the Brazilian Air Ministry (SIPAer).

Circumstances

The aircraft, coming from Lisbon, Portugal with a stop at Ilha do Sal, contacted Recife Control Tower at 0505Z. While flying at night in good visibility the flight received instructions for landing and was to call again on the "wind leg". Reporting as requested, authorization for landing was given, and the aircraft was asked to notify when on "final". Thirty seconds thereafter it collided with high (84 m) ground to the right of the centreline of the runway in use, 2 720 m from the runway threshold. The aircraft was destroyed by fire. Thirty-eight passengers and 7 crew members were killed.

Investigation and Evidence

Crew Information

The pilot-in-command had a total of 16 243 hours flying experience, 1 004 of which were on the DC-7 and 4 796 hours were night flying.

The first officer had logged a total of 20 944 hours including 193 hours on DC-7 aircraft, 930 hours on DC-6's and 6 620 hours of instrument flight.

The pilot-in-command and the first officer held valid IFR ratings and were physically fit, and both were familiar with the topography of the area where the accident occurred.

The Aircraft

The aircraft's maintenance reports for the 30 days prior to the accident give no indication as to the possible cause of the accident.

Weather

Weather bulletins issued before, at the time of, and after the accident do not reveal any conditions which might have led to the accident.

Lighting and runway lights

The threshold and runway lights were all in operation. The night in question was dark, and there was no moonlight.

Obstruction lights on the approach area

Referring to the elevations of the approach area to Runway 15, as shown in Figure 20, it is noted that there are five points above that area (A, B, C, D, E), which measure 16.10 m, 24.40 m, 22.90 m 26.00 m and 29.80 m, respectively. In accordance with Annex 14, Part IV, paragraph 3.1.1. these five points should be marked. However, only two points (A and B) have obstruction lights installed, and on the night of the accident only the light in B was operating.

It is observed that at the impact point, if the aircraft had performed an IFR approach, it should have been at an altitude of 210 m as it had practically reached the critical point in the pattern. Performing a visual approach, it should have begun the long final approach and should have been at the minimum altitude of 160 m.

Analysis of Statements of Survivors and Witnesses

Survivors who could testify (this included two stewards) were unanimous in stating that the flight was normal up until the time of the accident.

Eyewitnesses stated that the aircraft flew too low. One of the witnesses was approximately 7 km from the aerodrome, i.e. far from the traffic area.

Through reconstruction of the flight, it was concluded that the pilot performed a direct entry into the "base leg", flying too low and out of the regular traffic pattern, in spite of the fact that he reported "wind leg".

Wreckage examination

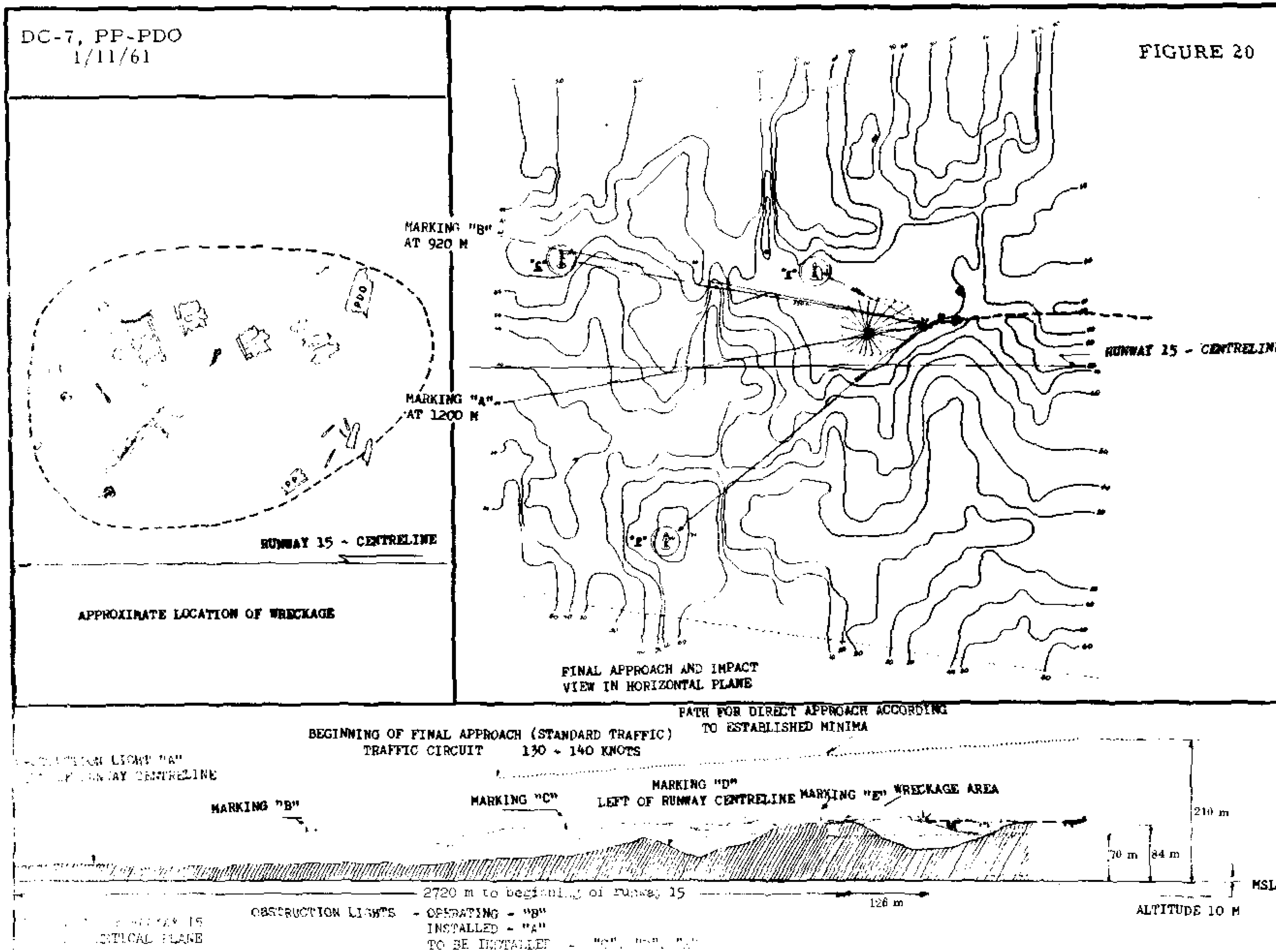
As the aircraft was destroyed by fire, little wreckage remained to be investigated. However, in view of the arrangement of the existing parts, it was concluded that the aircraft was intact before impact.

Probable Cause

The accident was caused by pilot errors, i.e. improper evaluation of distance, flying a non-standard traffic pattern by night and failing to observe altitude minima during the final approach.

A contributing cause was the improper night marking of obstructions along the approach path towards runway 15.

ICAO Ref: AIG/ACC/REP/GEN/No. 8 - Brazil


DC-7, PP-PDO
1/11/61
FIGURE 20
MARKING "B"
AT 920 M
MARKING "A"
AT 1200 M
RUNWAY 15 - CENTRELINE
RUNWAY 15 - CENTRELINE
APPROXIMATE LOCATION OF WRECKAGE
FINAL APPROACH AND IMPACT
VIEW IN HORIZONTAL PLANE
PATH FOR DIRECT APPROACH ACCORDING
TO ESTABLISHED MINIMA
BEGINNING OF FINAL APPROACH (STANDARD TRAFFIC)
TRAFFIC CIRCUIT 130 - 140 KNOTS
MARKING "B"
MARKING "C"
MARKING "D"
LEFT OF RUNWAY CENTRELINE
MARKING "E"
WRECKAGE AREA
210 m
70 m
84 m
MSL
2720 m to beginning of runway 15
126 m
ALTITUDE 10 M
OBSTRUCTION LIGHTS - OPERATING - "B"
INSTALLED - "A"

No. 43

Silver City Airways Ltd., Bristol 170-32, G-ANWL, accident on 1 November 1961 at Le Clos Hoguet, 3/4 of a mile northwest of the Guernsey Airport, Channel Islands. Report, dated October 1962, released by the Ministry of Aviation (United Kingdom) as C.A.P. 187.

Circumstances

The aircraft was making a daylight scheduled vehicle and passenger public transport flight from Cherbourg, France and during an attempt to land at Guernsey in conditions of low cloud the captain missed his approach. He opened up the engines to go round again, but the aircraft failed to gain height. Veering to the right it flew a short distance with the starboard propeller rotating slowly until the starboard wing struck the ground, and the aircraft cartwheeled. The passenger cabin broke away from the main wreckage which caught fire. Both pilots were killed. The steward and all 7 passengers aboard were seriously injured. The accident occurred at 1426 hours GMT.

Investigation and Evidence

The Aircraft

Its certificate of airworthiness was valid at the time of the accident.

The engines had been maintained in accordance with an approved maintenance schedule, and both had undergone a Check II inspection on 11 October 1961.

An engine ground run, including a check of the operation of the propeller auto-coarsening system, was carried out on the morning of the day of the accident.

When the aircraft took off from Cherbourg on its last flight it carried a payload of 3 cars and 7 passengers and sufficient fuel for the flight. At the time of the accident the total all-up weight was approximately 1 050 kilos less than the permitted maximum, and the position of the centre of gravity was within the prescribed limits.

The Crew

The captain held a valid airline transport pilot's licence endorsed in Group I for Bristol 170 aircraft and a current instrument rating. He was approved as a type rating examiner for Bristol 170 aircraft and as an instrument rating examiner. He had flown a total of 8 143 hours of which 471 had been on Bristol 170 aircraft during the six months prior to the accident.

The first officer was also well-qualified and had flown a total of 3 315 hours of which 486 had been as co-pilot on Bristol 170 aircraft during the six months prior to the accident.

The Flight

The crew were carrying out a series of flights between Cherbourg, France and the Channel Islands. Departure from Cherbourg was at 1344 hours and ten minutes later the aircraft reported crossing the French coast at 2 000 ft. The Guernsey controller cleared the flight to descend to 1 000 ft on the aerodrome QFE and gave the visibility as 3 NM with slight drizzle, 4/8 cloud at 300 ft and 8/8 at 500 ft. The captain was also reminded that the radar was unserviceable and was asked to report when over the non-directional beacon. Shortly thereafter the captain advised that he was flying in broken cloud and requested and received clearance for a visual approach.

The controller offered assistance with radio bearings, and a series of QDMs was commenced. At 1410 hours the controller heard the aircraft overhead, and one minute later the captain radioed that he would go round again since he had descended to his critical height and "couldn't see a thing".

He then received the latest Jersey weather report (for 1400 hours) which was:-

surface wind	240°M, 14 kt
visibility	13 miles
cloud	2/8 at 800 ft, 8/8 at 1 000 ft.

Shortly after commencing his second approach, the captain asked for the height of the water tower situated one mile east of the aerodrome near the extended centreline of the runway. He was told "six zero feet above the airfield". (An aircraft on a 3° approach slope would clear this tower by 300 ft).

As the Guernsey weather conditions had deteriorated, the controller, at 1422 hours, advised the captain as follows:

visibility 1 600 yd
cloud 5/8 at 100 ft
8/8 at 200 ft

One minute later the captain reported that he had crossed the coast (about 2 to 3 miles from the aerodrome). It is evident from the subsequent QDMs that the aircraft then veered to the north of the normal approach path, and it is considered that this was a deliberate manoeuvre by the captain to maintain visual contact with the ground.

Shortly before 1425 hours the captain reported that he had the aerodrome in sight, and no further QDMs were requested or given.

The runway on which the aircraft was to land is 4 800 ft long and is aligned 100/280°M with high intensity bi-directional and low intensity omni-directional lighting. At this time all of the approach lights were at 30% brilliance, and the runway lights were at 100%.

The controller first saw the aircraft when it was northeast of the aerodrome and making an "S" turn in an attempt to line up with the runway. At a height of about 30 ft the aircraft began to flare out as if to touch down. However, when it reached a position about 1 400 ft along the runway, the engines were opened up and the controller cleared the aircraft to climb ahead to the aerodrome beacon. Almost immediately the aircraft swung to the right and flew slowly towards the northwest without gaining height. Its flight continued straight and level for about 1/2 mile, and witnesses north of the aerodrome noted that its starboard propeller was rotating slowly. It then banked steeply to the right, and the starboard wing struck the ground.

Examination of the wreckage

Examination of the wreckage revealed that the flaps were in the retracted position, and all trims were approximately neutral. There was no evidence of fire in the air. The marks on the ground and inspection of the power units showed that at the time of impact the port propeller was rotating under power while the starboard propeller was almost stationary. The port propeller was set to an angle of 28°, a pitch angle consistent with take-off power, and the starboard propeller was in the feathered position. The master switch for the automatic pitch coarsening system was in the "on" position and 'caged'.

The engine and propeller control quadrant had been distorted on impact, and the boost and rpm levers were in the fully forward position immediately before impact.

The engine fuel and oil systems' cocks were "on", the fuel cross feed cock was "off", and the idle cut off levers were set to "run". Samples of fuel taken from the starboard fuel collector tank were clear and free from water and sediment.

No evidence of defect or of malfunction was found during the examination of the airframe and flying controls.

Subsequent examination by the manufacturers of the propeller and its constant speed unit and of the starboard engine revealed no evidence of any failure or malfunction.

The Automatic Pitch Coarsening System

In order to reduce the drag of a propeller in the event of an engine failure during take-off a system is installed in the Series 31 and 32 Bristol 170 type aircraft which automatically moves the propeller blades of a failed engine to the fully coarse position. The system incorporates two units, one for each engine, which are known as engine cut out switches. Each unit is activated by a microswitch which is operated by a diaphragm. The diaphragm is sensitive to the difference between the dynamic pressure produced in the propeller slipstream and that due to the speed of the aircraft. The system functions only when the boost and rpm levers are at or close to the maximum power take-off position.

When the engines are run each unit takes up one of two positions -

a) 'High differential' whenever the excess of propeller slipstream pressure rises to a value equivalent to 4.5" H_2O or more.

b) 'Low differential' whenever the excess of propeller slipstream pressure falls to a value equivalent to 2.5" H_2O or less. A tolerance of $\pm$ 0.5" is permissible.

During a take-off, values of pressure differential well in excess of the nominal 4.5" are normally present thus ensuring that both units are at 'high differential'. Automatic pitch coarsening will then take place if one of the units falls to the 'low differential' position.

The auto-coarsening system also incorporates an on/off master switch. The flight manual of the subject aircraft states that the switch is normally wired to the 'on' position. In fact a guard (or cage) provided the necessary security. The Company's operations manual prescribes a pre-flight check of the operation of the auto-coarsening system and requires that if a fault in the system becomes apparent the master switch should be switched 'off'. Neither document imposes any restriction on the use of the system after take-off.

Further examination - the starboard engine cut out switch unit

Tests carried out on the unit showed that it was not operating within the prescribed limits. The pressure required to move the switch to the high differential position varied between 5.1" and 5.9" H_2O whilst the switch moved to the 'low differential' position at 3.8". It is considered unlikely that these discrepancies could be detected during the functional tests prescribed by a Check 'A' inspection.

Strip examination disclosed the presence of a small amount of glutinous matter impregnated with metallic swarf. There was also evidence of 'pick-up' between the moving parts of the mechanism. The backing spring of the unit was found to be non-standard in dimensions and rating and had been adapted from a longer spring by cutting and filing, leaving one end improperly finished. Also, the microswitch was fitted with a rubber cowl contrary to the manufacturer's drawing. It was not possible to ascertain when or by whom these were fitted

Observations - automatic pitch coarsening

The propeller auto-coarsening system is designed to operate during the take-off phase when the boost and rpm levers are set for maximum power. Both units are then at 'high differential', the system is electrically armed by the position of the control levers and in the event of an engine failure auto-coarsening takes place when one unit falls to 'low differential'.

Auto-coarsening could occur, however, under other circumstances. During an approach to land, when the engines are throttled back, the decrease of propeller slipstream would result in both units falling to the 'low differential' position. A baulked landing procedure subsequently initiated late in the approach sequence near the ground, or in an emergency, might require rapid selection of maximum power and rpm. In such circumstances the chance of both units returning to 'high differential' simultaneously is remote, and the risk of inadvertent auto-coarsening would be present. Operation of either unit outside its specified range, or sluggishness, would increase this risk.

On the subject flight, there is little doubt that the captain initiated a baulked landing procedure, possibly with some degree of urgency. The relevant material evidence is that the engine and propeller controls were at the maximum power position at the time of the accident and that the starboard auto-coarsening unit was functioning outside the prescribed differential values. It is, therefore, considered that auto-coarsening of the propeller occurred when the captain opened up the engines. The captain would have had no indication that this was not the result of engine failure.

Some 520 000 hours have been flown by the Bristol 170 Series 31 and 32 aircraft and until this accident nothing had occurred to suggest that there was any inadequacy in the maintenance schedule requirements or of the operating techniques. This accident, however, has shown changes to be desirable. - See follow-up action.

Control Speeds

According to the Flight Manual the minimum control speed on or near the ground was 79 kt, and the take-off safety speed was 90 kt.

During the landing flare of the subject aircraft the airspeed should have been decreasing from about 84 to 65 kt and since the engines were opened up while the flare was in progress the airspeed at that time was probably in the region of 70 kt. When the loss of thrust from the starboard engine occurred, therefore, the captain was not only unable to maintain directional control, but he also had insufficient height to put the nose down in order to accelerate to a speed at which control could be regained.

Probable Cause

The accident was due to the malfunctioning of the automatic pitch coarsening unit of the starboard propeller. This deprived the captain of the necessary degree of control of the aircraft at a critical stage of the flight.

Follow-up Action

A Special Recommendation Maintenance (No. 80) detailing an overhaul procedure for the pressure differential (engine cut out) switches, and a flight manual amendment requiring the system to be switched "off" after the take-off for the remainder of the flight have been issued by the Air Registration Board to prevent any risk of a repetition of this type of accident.

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ICAO Ref: AR/740

No. 44

Trans World Airlines, Inc., Boeing 720B, N 793TW, accident near Albany, New York on 5 November 1961. Civil Aeronautics Board (USA) Aircraft Accident Report File No. 1-0026, released 13 July 1962.

Circumstances

Flight 66 was a scheduled non-stop flight from Los Angeles, California to Boston, Massachusetts carrying 7 crew and 34 passengers. While cruising at 25 000 ft near Albany, New York, the No. 1 engine failed because of the disintegration of the low-pressure turbine section. Fragments from the turbine section penetrated the left wing, No. 2 engine pylon and the fuselage, resulting in a ruptured wing fuel cell and loss of cabin pressurization. An emergency was declared, and a let-down to a lower altitude was effected. The flight continued to Boston and landed without further incident. No one was injured.

Investigation and Evidence

Crew Experience

The two captains aboard the aircraft held a valid airman certificates and currently effective airline transport ratings. The pilot-in-command had flown a total of 13 277 hours including 216 hours on Boeings. The co-pilot had a total of 15 230 hours to his credit of which 57 were in Boeing 720 aircraft.

Engine No. 1

Engine No. 1 was removed from flight status on 12 September 1961 because the oil breather pressure was in excess of the 10-in. Hg. limit. The total engine time was then 347 hours. The engine was repaired and several modifications as recommended by Pratt and Whitney were incorporated. Also, the No. 4 bearing, turbine nozzle case and turbine O. D. seal were replaced. The only discrepancy noted during teardown was the loose fit on the rear compressor rotor oil sealing tube. At this time heatshields were installed around the No. 4 and No. 5 bearing compartments in order to reduce the transfer of heat to the engine oil and to improve oil scavenging. The high compressor centre tube was nickel-plated at each end to increase the interference fit in order to reduce galling and possible bleed leakage into the bearing compartments. In addition, the No. 1 bearing support was reworked in order to improve stress distribution and design configuration.

On 19 October 1961 the engine was run in the TWA test cell and found to have been acceptable. Maximum breather pressure was 4.3 in. Hg., and vibration was negligible. Oil filters were checked and found to be clean. On 22 October the engine was installed on N 793TW in the No. 1 position. After that date only minor maintenance was performed on the engine.

The Flight

Flight 66 left Los Angeles at 1141 hours eastern standard time for Boston. Its weight was within the maximum allowable and was distributed within the centre of gravity limitations.

The flight was cleared to proceed under instrument flight rules at 27 000 ft (mean sea level), and a normal climb to this altitude was completed in 17 minutes. After levelling off and for about 15 minutes thereafter a slight vibration was noted in the N_1 and N_2 tachometer needles of the No. 1 engine. This vibration or "nervous needle" as the pilot-in-command described it then ceased and did not recur for the remainder of the flight. The flight progressed normally until reaching Cleveland, Ohio at 1504 where turbulence was encountered, and descent was made to 25 000 ft. In the vicinity of Albany, New York, at about 1536 hours, a muffled explosion was felt and heard by the crew, and the aircraft commenced a yaw to the left. The autopilot was immediately disengaged, and the aircraft was brought back to a normal flight attitude. The flight engineer then advised that cabin pressure was dropping. The crew went on emergency oxygen and activated the seat belt sign. Air Traffic Control was contacted, and the flight was cleared to descend to and maintain 9 000 ft.

It was noted at this time that the utility hydraulic system and the No. 1 generator had failed. The No. 1 engine was then shut down, and an off-airways gear-up descent was initiated using only the inboard spoilers. The second officer then advised that the turbine section of the No. 1 engine had disintegrated and that the exhaust section was oscillating quite severely. The firewall shutoff valve to the engine was actuated. The aircraft's speed and rate of descent were reduced. As the aircraft passed through 19 000 ft, the cabin pressurization warning horn sounded, and the oxygen flow light came on. At that time the airspeed was approximately 200 kt, and the descent was continued at this slower speed.

Westover and Pease Air Force Bases were alerted in the event that the condition of the aircraft would not permit continuation of the flight to Boston. An inspection made from the cabin revealed that the left wing and No. 1 pylon were badly damaged. One turbine fragment had penetrated the fuselage from the left, approximately head high, directly above seat 16-A. The fragment struck the right side above seat 16-F and dropped to the floor. There was sufficient residual heat remaining in the fragment to burn a hole one inch in diameter in the floor carpeting.

The captain elected to continue to Boston because of favourable weather conditions, runway length, and available emergency equipment at that location. The cabin attendants were thoroughly briefed by the captain on emergency procedures, and the passengers were advised of the emergency. All emergency gear and flap extensions were made over water, and a normal approach to a landing on runway 22L was effected with ground emergency equipment standing by. Trim was adequate to compensate for the yaw effect of the inoperative No. 1 engine and the total loss of fuel from the damaged outer left wing tank. On roll-out, steady braking was applied, reverse thrust was applied slowly to the Nos. 2 and 3 engines, and the aircraft cleared the active runway by turning left on runway 15. At this time normal braking pressure had been depleted, and airbrakes were used to bring the aircraft to a full stop on runway 15. The passengers deplaned in a normal manner through the forward compartment door.

Inspection of the Aircraft

Ground inspection of the aircraft revealed that several oxygen masks and containers had failed to function properly when a cabin pressure altitude of 10 000 ft was reached. During the depressurization the oxygen mask container latch failed to function for seats 6-C and D, 10-A and B, and 25-A and B. However, no passengers occupied these seats. All passengers donned their oxygen masks successfully. The oxygen mask container doors in lavatories B forward, and C and D in the aft cabin opened, but the masks failed to drop out. It appeared that these masks had been stored improperly and were too tight in their containers.

Investigation revealed that the No. 1 engine pod was ruptured in the vicinity of the turbine. The turbine exhaust case and reverser mechanism were completely separated from the engine but had remained attached to the pylon mount. Approximately 80% of the turbine nozzle case was torn away and missing. The only portion of the low-pressure turbine section remaining was the forward mount flange of the second stage turbine disc which was still attached to its mating flange on the low turbine shaft. A section (approximately 1/6) of the second stage turbine disc was recovered from the left wing just inboard of the No. 1 engine pylon where it had imbedded itself. The remainder of the disc was not recovered. Approximately one-half of the third stage turbine disc was recovered on the ground near Albany. The remainer of the disc had not been recovered. No portions of the fourth stage turbine disc and/or blades have been recovered.

There were numerous holes of various sizes in the left wing and fuselage which accounts for the relatively rapid depressurization of the cabin. The outer left wing tank was punctured in several places. The left spar was torn through approximately one-fourth of its width. Fuel lines, hydraulic lines, and electrical leads to the No. 1 engine were severed. Skin punctures were found in the No. 2 engine pod, the lower left wing surface, and the left side of the fuselage. Several of the nozzle guide vanes along with second and third stage turbine blades were found in the wing, the No. 2 pylon, and the baggage compartment. One root section of a third stage turbine blade was found in the cabin section adjacent to row 16. The rear hub had separated from the fourth stage turbine and was lying in the No. 6 bearing support.

Events leading to the failure of No.1 engine

The sequence of events culminating in the failure of the engine began at the main strainer assembly in the pressure oil line within the intermediate case. The main oil filter became clogged with carbon deposits and began to bypass contaminated oil. A downstream "last chance" strainer filtered the oil just before delivery to the low compressor thrust bearing and seal (No. 2), intermediate housing bearing (No. 2-1/2) and high compressor front support bearing and seal (No. 3). Carbon accumulations collected in this "last chance" strainer choked off the oil supply and starved the bearings. The No. 2 thrust bearing overheated, material strength faded, and plastic yielding commenced under the forward load of the low-pressure spool, allowing the low-pressure compressor and turbine assemblies to move forward. The blades of the compressor began to rub against the trailing edge of the stator vanes. Inner race wear pattern and roller interference with the No. 1 seal plate indicated that the front support bearing (No. 1) then failed from thrust loading induced by excessive forward axial movement of the front hub. Loss of rigid front radial location allowed wobbling in the front compressor as shown by uneven blade tip rub. Vibrations induced in the inlet case precipitated fatigue failure of the No. 1 oil jet. The No. 2-1/2 bearing, mounted on the rear hub of the front compressor, was pounded by the wobbling as shown by the damaged balls; however, the intermediate bearing housing continued to rotate. The No. 3 seal plate integral with the intermediate bearing housing then wore down the No. 3 seal. A photomicrograph of the No. 3 seal plate indicated the presence of a temperature above 1400°F. The No. 3 bearing, also mounted on the rear hub of the front compressor, failed and allowed the high compressor to wobble slightly. This was evidenced by blade tip rubbing and knife-edge seal wear. The No. 4-1/2 bearing moved forward with the low shaft and continued to turn freely, leaving traces of the new roller path. Metallic deposits began to form on the convex faces of the first nozzle guide vanes from compressor blade vane shavings. Large axial clearances obviated any rubbing of the rear of the high turbine disc by the low turbine assembly.

Thus, the engine was in the process of sustained self-destruction. The time element involved for this deterioration was approximately 10 seconds. Prior to the explosion, the stewardess, who was seated in the last row was looking out of the window toward the No. 1 engine. Noting red bursts coming from the engine tailpipe, she turned, remarked on this condition to another stewardess seated next to her, turned back again and witnessed the No. 1 pod burst. The red bursts were the initiation of the failure, evidenced by the compressor blades rubbing the vanes.

The immediate cause of the final explosion was the deterioration of the No. 2 bearing, where the steel balls were now fused to the inner race. As the front compressor rear hub rotated in the bearing, the frozen inner race was both grooving and heating the journal of the hub. The strength rapidly diminished until the torque load from the driving turbine, transmitted by the low shaft, began to exceed the hub yield point. The ultimate strength of the hub was reached. The hub sheared through the thinned, overheated bearing plane under torsional loading and uncoupled the low turbine from the low compressor. Since the low compressor was no longer absorbing the energy that the low turbine was extracting from the gaspath, the low turbine assembly began to accelerate. The turbine disc centrifugal loading increased with the square of the angular velocity, until the ultimate strength of the discs was reached, and they burst through the engine casing and nacelle panels. Meanwhile, the low compressor was slowing down and was pushed rearward by the inlet airstream. The blade trailing edges then began to rub the vane leading edges. Oil filters continued to fill up with metallic particles from the break-up of the damaged bearings. The high rotor assembly was still rotating freely. Only the rear of the high turbine blades was damaged and shifted forward by the exploding low turbine assembly. A hardness check of turbine blade leading edges indicated no excessive engine overtemperature.

Examination of the carbon deposits on the low turbine drive shaft, which passes through the centre tube, indicated that very slight bleed air leakage occurred in the front and moderate leakage in the rear of the centre tube. This leakage, coupled with earlier carbon accumulation and the high temperature environment of the No. 4 - No. 5 bearing areas and towershaft strut, produced enough carbon to contaminate the oil system, causing the main oil filter assembly to clog and bypass. It should be noted that on 11 October 1961, Pratt and Whitney Aircraft wired all airlines concerned: "If installation of heat shielding being accomplished without complete overhaul, recommend thorough cleaning of diffuser case and No. 5 support. Suggest daily check as required in subsequent operation." However, testimony of TWA personnel indicated that the subject engine had probably been rebuilt beyond this stage when the above information was received. It is, therefore, relatively certain that the subject areas were not cleaned of carbon deposits prior to reassembly at overhaul. In addition, although the main oil filter was removed prior to the critical flight, it was not disassembled and was given only a cursory examination; therefore, any internal accumulations could have gone unnoticed. Examination of the diffuser case showed a heavy carbon deposit around the breather tube and the towershaft packed with carbon. Examination of the No. 5 support also revealed carbon on the inner walls. An analysis of oil samples indicated no significant discrepancies.

The theory was raised that the two seals between the rear compressor front hub and the No. 2-1/2 housing were omitted during the previous TWA repair and modification. This was based on the condition of the hub seal grooves, one clean and the other with some white deposits. If this were the case, twelfth-stage bleed air would have leaked through this opening and started breaking down the oil within the No. 2 area. It is believed that a much greater accumulation of carbon sludge would have been present in the intermediate area, had the seals been omitted. The deposits which were found can be attributed to the heat transfer through the No. 3 diaphragm which is subjected to twelfth-stage bleed air. A hardness check of the grooves indicated that the hub had been subjected to temperature high enough to destroy the aforementioned seals during the failure sequence. Bleed air could then have blown the grooves clean before or after any residue was able to have been deposited. Although not conclusive from the evidence, it appears unlikely that the two seals in question were omitted.

Turbine disc rupture - general

The catastrophic potential of turbine disc rupture has been a matter of concern to the industry for a number of years. Recognizing this problem, the Administrator of the Federal Aviation Agency has required certain design features and proof testing of turbine engines in order to protect against this type of failure. In addition, the manufacturers have devoted much time and effort toward assuring turbine disc integrity. Despite these precautions, this failure and other turbine disc ruptures have occurred on engines in commercial service.

Vibration equipment

In view of the time element involved in the destruction of this engine, it is believed that warning could have been given to the crew by vibration equipment and would have allowed for engine shutdown prior to the turbine failure. Excessive vibration would have been immediately noted by pick-ups as soon as the No. 2 bearing failed. Although the state of the art does not allow absolute vibratory limits to be established at this time, a relative control can be maintained by which any abnormal shift from an accepted engine vibration base line can be utilized for troubleshooting and shutdown before extensive engine damage occurs.

Recommendation

To provide sufficient warning against such failures the Board has recommended to the Federal Aviation Agency that suitable instrumentation, such as the vibratory sensing equipment mentioned above, be installed in commercial turbojet aircraft.

Probable Cause

The probable cause of this accident was oil starvation of the No. 2 bearing which caused its failure. This precipitated the fracture of the low-pressure compressor rear hub and the overspeeding and subsequent disintegration of the low-pressure turbine section.

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ICAO Ref: AR/719

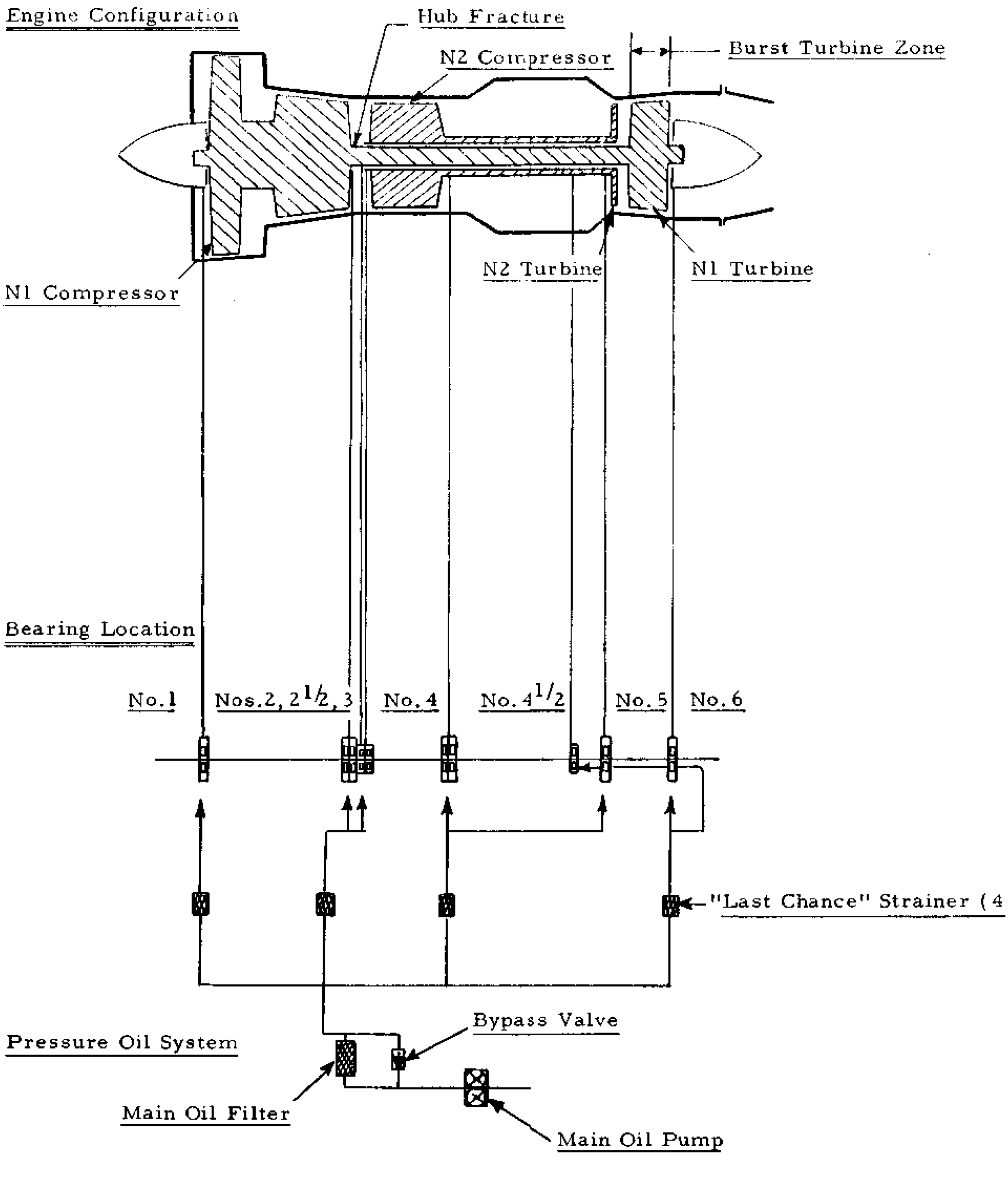

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FIGURE 21

No. 45

Imperial Airlines, Inc., Lockheed Constellation L-049, N 2737A, accident at Byrd Field, Richmond, Virginia, 8 November 1961. Civil Aeronautics Board (USA), Aircraft Accident Report, File No. 10025, released 6 February 1962.

Circumstances

While attempting a landing at Byrd Field, following loss of power on three engines, N2737A overshot the extended centreline of runway 33 and crashed and burned at 2124 hours eastern standard time one-half mile to the left of the final approach path and one mile from the threshold of the runway. Seventy-four passengers and three flight crew members died as a result of carbon monoxide poisoning. The captain and flight engineer escaped from the burning wreckage. The aircraft was totally destroyed.

Investigation and Evidence

Flight 201/8 was being made in order to transport newly inducted members of the U.S. Army to Columbia, South Carolina for training. The passengers were to be picked up at Newark (New Jersey), Wilkes Barre, (Pennsylvania), and Baltimore, (Maryland). The crew consisted of two captains, a flight engineer, a student flight engineer and one stewardess. The captain who was to assume command had flown 4 433 hours, 293 hours of which were in the L-049. The other captain, who had more seniority, was to act as co-pilot. He had 17 841 hours to his credit of which 352 hours were on the subject aircraft type.

The aircraft departed Columbia for Newark at 1514 hours. As the aircraft left the ground the flight engineer noticed a drop on the No. 3 fuel pressure gauge. The student engineer opened the No. 3 and No. 4 crossfeeds to ensure positive pressure on the right side. The pressure drop did not occur again. The captain was not informed at this time of the drop in fuel pressure nor of the fact that the crossfeeds were opened. On reaching the cruise altitude of 9 500 ft the crossfeeds were closed. The landing at Newark was completed at 1737 hours. Two thousand three hundred gallons of fuel remained at this time.

Prior to the departures from the two following stops, i.e. Wilkes Barre and Baltimore, the flight engineer opened the Nos. 3 and 4 crossfeed valves in order to prevent the drop in fuel pressure which had occurred out of Columbia. Also, at these two stops engines Nos. 3 and 4 were kept operating while Nos. 1 and 2 were shut down.

Shortly after taking-off from Baltimore the co-pilot filed a flight plan as follows: "direct to Columbia, at 4 500 ft VFR, true airspeed 218 kt, estimated time en route 2 hr 10 min with 5 hr 30 min of fuel aboard."

The captain-in-command testified later that he flew the entire flight from the left pilot's seat and that the student engineer occupied the engineer's station, including at time of take-off from Baltimore. The latter part of this statement was denied by the flight engineer, who said that he and not the student engineer was at the engineer's station at the time of the take-off.

Shortly after passing the Brooke Omni the captain said the aircraft yawed to the right, and the fuel pressure warning lights for engines 3 and 4 came on. At this time the flight engineer went to reassume his station which was occupied by the student. The No. 3 and 4 fuel pressure warning lights were on, and No. 3 engine had stopped rotating. No. 4 engine was surging between 1 500 and 2 000 rpm. The engineer opened all four crossfeed valves and checked to see that the fuel selectors were positioned for tank to engine feeding. He also turned on all four fuel boost pumps and advised he was going to try to start engines Nos. 3 and 4. The fuel gauges at this time were all in a position which indicated fuel.

A few minutes later No. 4 engine appeared to be partially running so the captain told the engineer to feather No. 3 engine and concentrate on No. 4. The engineer was not able to restart No. 4 and was going to try No. 3 and shut down No. 4. He told the student engineer at this time to open the midship fuel crossfeed valve. The co-pilot asked that the valve not be opened - there was good pressure on No. 1 and 2. Therefore, the crossfeed valve was not opened. The captain testfied that he knew nothing of this until after the accident and assumed that the valve had been opened. At this point the engineer advised the captain that he could not get No. 3 or 4 started as a result of which the aircraft was turned toward Richmond for a landing.

The captain checked that both engines Nos. 3 and 4 were feathered, and there was no rpm indicated on them. The aircraft was retrimmed.

The stewardess was told of the engine difficulty and informed the passengers. No crashlanding was anticipated and, therefore, the stewardess was not told to give emergency evacuation instructions.

The controller at Richmond advised the flight that all runways were available and that the wind was north-northwest at 15 kt with gusts to 22 kt. He requested that the flight advise him on base leg of the runway chosen and asked if standby emergency equipment was desired. The co-pilot replied in the affirmative. The captain asked the co-pilot to fly the aircraft while he checked the flight engineer's station.

When south of the city the captain advised the controller that they would use runway 33. The aircraft was maintaining altitude and had "a healthy airspeed". Their heading was about 90° and the in-range check had been started when the co-pilot, who was still flying the aircraft, turned left to runway 02, and lowered the landing gear handle. The captain looked down, saw a lighted runway, but thought they were too high and possibly a little too fast to be able to land on it. He then notice the gear was not down. Looking back at the flight engineer either putting the hydraulic crossover switch into the emergency position or checking that it was in the emergency position. He recycled the landing gear up. There was no change in the indicator. At about this time it was apparent that the landing attempt would have to be abandoned, and both the captain and the co-pilot called for full power on engines Nos. 1 and 2. At this time the captain felt that the airspeed and altitude were still sufficient to reach runway 33 but that they would have to make a right turn to the runway.

Just prior to the airplane's starting its right turn the controllers heard a transmission to the effect that the aircraft was losing another engine and was not able to get its gear down. The captain took over the controls and started the right turn. He lost sight of the runway and again turned over the controls to the co-pilot, who was in a better position to see the runway out of the right side of the aircraft.

A continuous right turn was made until the captain could see the runway again when the engineer stated that they were losing engine No. 1. The captain got back on the controls again, and the turn was continued. There was a continuing decrease in power on No. 1 engine. Somewhere during this turn, again without the captain's knowledge, the landing gear handle was placed in the down position, and the captain recalled seeing the student engineer assisting to pump the gear down with the hydraulic hand pump. During the final approach he remembered seeing two green lights indicating two of the three landing gears were down.

The aircraft was slightly to the left of the extended runway centreline on final approach, when the airspeed began to decay rapidly. The captain realized they would not reach the runway and pulled back on the control column. His last recollection of airspeed just as the aircraft stalled into the trees was that it indicated between 90 and 95 kt.

The aircraft was in a right bank of approximately 10° when it first hit the trees 50 ft above the ground. It then passed through a clear area about 100 ft in length, then into a section of larger trees, which brought it to a stop in about 100 ft. It struck the ground in a level longitudinal attitude.

Evacuation

The engineer opened the door to the airplane cabin, and the cockpit immediately filled with dense smoke. As he opened the crew exit door on the right side of the cockpit the captain opened the pilot's sliding window and left the airplane. When the captain left the aircraft the engineer and co-pilot were at the crew exit door presumably preparing to jump. After clearing the aircraft it was completely engulfed in flames, and the captain did not believe that anyone else could possibly have gotten out of the aircraft.

The fire, which occurred after impact, completely destroyed the entire cabin area. Subsequent investigation showed that many of the passengers had left their seats after impact and had attempted to evacuate the aircraft. The student engineer apparently had gone to the cabin immediately before the crash to assist as a cabin attendant. Both he and the stewardess were in the cabin with the passengers. The largest group of passengers was found near the main cabin entrance door, which either had been jammed by the ground impact or by trees and debris, which were piled up against the fuselage. There was no evidence that attempts had been made to use any of the emergency over-the-wing window exits. The charred remains of what appeared to be the emergency escape slide retaining bar were found lying across the bottom of the main cabin door opening. No positive evidence of impact injuries to the passengers was found. The cause of death in all cases was established as suffocation caused by carbon monoxide poisoning.

Technical investigation - conclusions

In preparing for the flight several aircraft discrepancies required maintenance. The testimony of Imperial's Chief Flight Engineer concerning the maintenance work done on N 2737A prior to its departure was both contradictory and vague. First he testified that he personally had obtained two electrical brushes from another airline for installation in the Nos. 2 and 3 fuel boost pumps. He said that one of the brushes had to be cut down to fit. The other brush he said was an approved type for this unit. He later testified that this second brush "appeared" to be of a suitable type. After hearing testimony which denied that he had been given two brushes, the Chief Flight Engineer again changed his testimony and said he had gotten the second brush from the student engineer of this flight.

No. 2 fuel boost pump was recovered and found to be fitted with a brush of improper type. This confirmed subsequent testimony of the flight engineer that he had manufactured the brush. It is also believed that this brush was the only brush obtained and that either no repair was made to the No. 3 boost pump or that only temporary repair was effected so as not to delay the flight.

The entire fuel system was extensively damaged as a result of ground impact and fire.

There was no evidence of in-service failures or malfunctions of engines 2, 3 and 4. Examination of the engines after disassembly revealed complete internal failure of No. 1 engine prior to the crash due to failure of the master rod and bearing followed by complete disintegration of the connecting rods. No evidence was found of any in-flight fire on any of the engines.

Examination of the four propellers revealed that each assembly remained on its engine at impact. There was adequate lubrication of the reduction gear assemblies up to the time of ground impact, and no evidence of operating distress was found.

There was no evidence of failure of the primary or secondary flight controls.

Analysis

The momentary fluctuation of fuel pressure on the take-off from Columbia on the No. 3 engine is symptomatic of a boost pump failure. Such failure would not cause the engine to stop because the engine-driven fuel pump will continue to supply sufficient fuel to the engine. When this fluctuation occurred the student engineer opened both No. 3 and No. 4 crossfeeds. In this configuration fuel from the No. 4 tank would be supplied to the crossfeed manifold under pressure by the No. 4 boost pump. Even though the No. 3 fuel tank selector valve remained open, no fuel could flow from the tank. The higher pressure in the crossfeed manifold supplied by the No. 4 boost pump would hold closed a check valve between the manifold and the No. 3 fuel tank. Thus engines Nos. 3 and 4 would both be operating on fuel exclusively from the No. 4 tank provided the No. 4 boost pump remains operating.

The engineer stated very positively that the fuel system was returned to the normal tank to engine configuration after reaching their cruising altitude. It was the Board's opinion that the greater part of the flight was conducted with the crossfeeds open and the boost pumps on. Such opinion is based upon an analysis of the conduct of the entire flight and also the testimony of the various witnesses.

The possibility of fuel contamination as a causative factor was thoroughly explored during the investigation.

The Board found that the truck which had serviced Nos. 3 and 4 fuel tanks, was contaminated, however, it was felt that the amount of contamination was not sufficient to cause a complete loss of fuel pressure as reported. It is not likely that following several hours of normal operation, contamination would, either by restricting the flow or causing malfunction of a component, without warning and simultaneously, cause the loss of fuel pressure in two separate fuel systems.

Using the same engine powers and rates of fuel consumption as outlined in the carrier's operating manual relative to flight planning, and operating engines 3 and 4 on cross feed from the No. 4 tank the majority of the flight, it was calculated that 800 gal of fuel in the No. 4 tank would have been exhausted approximately at the time which the crew indicated the loss of power occurred.

The indications of operating difficulties described by the crew, namely a sudden yaw to the right and sudden loss of fuel pressure on Nos. 3 and 4 engines simultaneously, are also indicative of fuel exhaustion or starvation. Engine surging soon followed by complete power loss such as occurred here would also be expected.

From the foregoing, it was clear to the Board that the loss of power on engines Nos. 3 and 4 was not the result of a malfunction or mechanical failure of the engines. It is equally clear that fuel contamination was not a cause of the engine stoppage. It was the Board's conclusion that fuel exhaustion brought about by improper fuel management caused the stoppage of engines 3 and 4.

The procedures followed by the flight engineer in attempting to restart the two engines indicated the lack of knowledge and the inability to diagnose the results of the inoperative fuel boost pump and determine appropriate corrective action. Had the proper procedures been followed, there is no reason why the Nos. 3 and 4 engines could not have been restarted.

When the first contact with the Richmond tower was made at 2112 hours, Nos. 3 and 4 engines had been feathered, and the decision had been made to land at Richmond. The crew was experiencing no unusual problems in operating the aircraft on its two remaining engines. In point of fact the aircraft flew satisfactory for at least 8 minutes after this call was made.

As the aircraft was proceeding to Byrd Field the decision was made to land on runway 33. The tower was so notified, and it must be assumed that both pilots were aware of this intention. It is clear that both captains were issuing orders, and both were attempting to command the flight. The senior captain had elected to act as co-pilot, yet, during the emergency he issued orders to the other crew members as captain. Confusion prevailed in the cockpit due to lack of crew co-ordination and the issuing of conflicting orders.

N 2737A was equipped with a hydraulic crossover valve (normally operated from the cockpit by a switch) which would permit hydraulic pressure from Nos. 1 and 2 engine-driven pumps (the primary hydraulic system) to be supplied to the landing gear.

This valve and its motor were recovered and showed no evidence of malfunction. The valve was in the closed position. In addition, the No. 2 hydraulic pump was operable. It was the Board's conclusion that the crew did not open the hydraulic crossover valve and also that the crew was unaware that the aircraft was equipped with this valve. Had this valve been opened the landing gear would have extended in 20 to 25 seconds.

From the location of the wreckage it is apparent that the landing pattern was poorly executed. It is believed that when the airplane was on its base leg the bank angle was steepened in an attempt to avoid overshooting the extended centreline of the runway. This increased angle of bank and increased rate of turn bled off airspeed, and the aircraft began to sink. To try and arrest the sink rate the co-pilot called for "... all the power you got." By this time the No. 1 engine was destroying itself as a result of the overboosting during the emergency. It failed completely. With only one engine delivering power it was impossible to maintain flight, and the aircraft stalled into the trees.

Company operations - general

From a study of all the information available to the Board it was concluded that this flight crew was not capable of performing the function or assuming the responsibility for the job they presumed to do. The Board further concluded that the management personnel of the airline should have been aware of the manner in which company operations were being accomplished. It is believed that the sub-standard maintenance practices of the company's employees were condoned by management.

The Federal Aviation Agency, which is charged with the responsibility of inspection for compliance with Civil Air Regulations and minimum safety standards by all air carriers, conducted extensive inspections of the company's operations and maintenance practices and procedures over a period of almost a year prior to the accident. Numerous improper operational procedures, and maintenance practices were found. The company did take some corrective action when specific items were pointed out. However, it was also evident that the company management did not make satisfactory efforts on their own to improve the overall operations and maintenance standards of the company, but only corrected those items which the Federal Aviation Agency pressed.

Probable Cause

The probable cause of this accident was the lack of command co-ordination and decision, lack of judgment, and lack of knowledge of the equipment resulting in loss of power in three engines creating an emergency situation which the crew could not handle.

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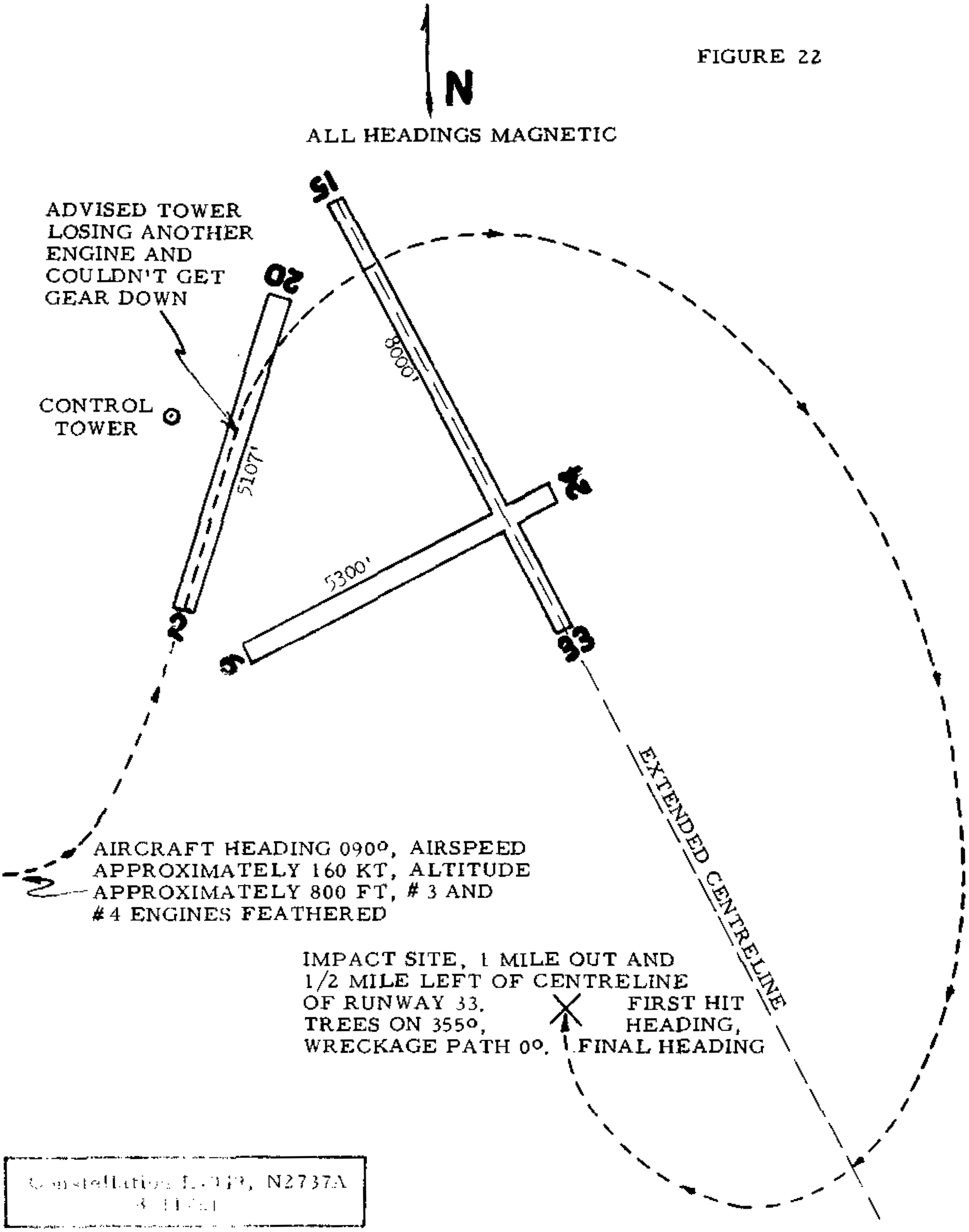
ICAO Ref: AR/695

FIGURE 22



Constellation [illegible], N2737A
[illegible]

No. 46

Northeast Airlines, Inc., Vickers Viscount, N 6592C and National Airlines, Inc., Douglas DC-6B, N 8228H, ground collision at Logan International Airport, Boston, Massachusetts, 15 November 1961. Civil Aeronautics Board (U.S.A.) Aircraft Accident Report, File No. 1-0021, released 21 August 1962.

Circumstances

At approximately 1710 hours eastern standard time, 47 minutes after sunset, a ground collision occurred between a National Airlines DC-6B (Flight 429) attempting a take-off on runway 9 and a Northeast Airlines Viscount (Flight 120) during its landing roll on runway 4R. There were no serious injuries to the crew or the passengers of the DC-6, however, four passengers on the Viscount received minor cuts and abrasions while deplaning. There was major damage to both aircraft.

Investigation and Evidence

Northeast Flight 120

It originated at Washington, D. C. and its destination was Boston, Massachusetts with an intermediate stop at New York, N. Y. It was scheduled to arrive at Boston at 1712 hours. Four crew members were aboard and a number* of passengers.

Departure from New York for Boston at 1615 hours was carried out under visual flight rules.

The flight to Boston was normal and at about 1707 Boston Tower cleared Flight 120 to land on runway 4R. At 1708:41 the controller advised the flight as follows: "No need to acknowledge, your turnoff is down at runway 33, the central's (i. e. central taxiway) closed." The co-pilot, sitting in the right-hand seat, was flying the aircraft, and the captain was operating the radio and performing the duties generally assigned to the co-pilot. A normal landing was made, with touchdown at a point about 1 000 ft past the threshold of runway 4 R.

At approximately 1709:36 hours, i. e. 17 minutes after the end of civil twilight, while on the landing roll on runway 4R, Northeast 120 (the Viscount) and National 429 (the DC-6B) collided at the intersection of runways 4R and 9. The speed of the Viscount at the time of collision was estimated to be 80 kt. After the collision it lurched to the left. Full right brake, rudder, and aileron were applied, but this did not correct the swerve to the left as the aircraft veered through the runway lights and came to rest approximately 1 000 ft beyond the runway intersection and approximately 90 ft to the left of runway 4R. The aircraft was damaged in such a manner that the left wing outboard from the No. 1 engine nacelle and the empennage aft of Station 731 were severed from the aircraft. Although fuel poured from the ruptured tanks, there was no fire.

The Viscount was properly secured by the crew except for No. 1 engine which could not be shut down.

A majority of the passengers evacuated the aircraft through the forward passenger door on the left side. About 12 passengers deplaned by climbing from the severed empennage with the aid of a rope notwithstanding the fact that they were advised by the first officer that the forward door was available for exit.

Testimony indicated a lack of concern or awareness of passengers to a dangerous situation. More concern was evidenced regarding the recovery of personal effects than to the urgency for rapid evacuation of the aircraft. Neither urging nor explanation by crew members seemed to convince the passengers that an emergency existed.

* Not stated in the CAB report.

Statements by the crew of the Northeast Viscount

When approaching the outer marker the crew overheard the local controller clear American 291 for "immediate take-off or hold runway 9, traffic a mile and a quarter on final runway four right". It was this clearance which alerted them to the fact that runway 9 was in use for aircraft taking-off. They stated further that they saw American 291 taxi into position on runway 9, commence its take-off, and cross the intersection of runways 9 and 4R. In addition, they also observed at least two other aircraft, one on either side of runway 9 in the runup position. Neither the captain nor co-pilot of the Viscount heard a warning message from the control tower nor did they see the DC-6B in time to take evasive action.

National Flight 429

The DC-6B's flight originated at Boston. Its destination was Norfolk, Virginia with five intermediate stops. It carried a crew of 5 and some* passengers. An instrument flight rules flight plan was filed for a flight to the New York International Airport. The aircraft's scheduled departure from Boston was for 1700 hours, and it was to arrive at New York at 1810 hours.

The aircraft contacted the Boston Ground Controller at 1700:05 hours for taxi instructions and was told that runway 9 was the take-off runway. As its IFR flight plan could not be found, National 429 proceeded to the south side of runway 9 where the aircraft was positioned at a 45-degree angle to the runway for completion of the pre-take-off checklist and changed to the clearance delivery frequency of 121.7. American 425 and American 421, previously behind, were cleared to take off.

After receiving its IFR clearance National 429 switched to the local control frequency of 118.3 Mc/s at about 1708:33 and requested take-off clearance. Three seconds later the local controller instructed the flight to "taxi into position and hold runway 9". National 429 acknowledged this transmission. Believing a take-off clearance had been received, the captain turned on landing lights and manoeuvred the aircraft into the take-off position on runway 9, where he stopped and there transferred control of the aircraft to the first officer who commenced the take-off. The collision occurred at 1709:36 hours. At the time of collision the speed of the DC-6B was estimated to be 60 kt. The captain took over the controls and tried unsuccessfully to maintain directional control of the aircraft. It swerved to the left and came to rest about 800 ft beyond the runway intersection and about 150 ft to the left of the runway. Despite ruptured fuel tanks, there was no fire.

Although evacuation was for the most part orderly, some passengers had to be forcibly encouraged to exit the aircraft.

Statements by the crew of the National DC-6B

The captain and first officer stated that the local controller's response to their request for take-off clearance was "National 429 cleared for take-off", and that there was no doubt in their minds he had cleared them for take-off. The flight engineer in relating his version of the clearance testified that he heard the local controller say: "cleared for position and take-off". He stated that while he thought the clearance unusual, the deviation from standard phraseology was insufficient to overcome the impression he also had that National 429 was cleared for take-off. The tower recording of the clearance, the testimony of the local controller, and the co-ordinator, all indicate that National 429 was instructed to taxi into position and hold runway 9.

The captain and first officer of Flight 429 testified that they did not hear any warning message from the local controller prior to the collision and that they did not see the Northeast aircraft in time to take evasive action.

* Number not stated in CAB report.

Statements by Air Traffic Control personnel

Five air traffic control specialists were occupying the various operating positions in the Boston Tower at the time of the collision - a co-ordinator, a local controller, a ground controller, a clearance delivery controller and a flight data controller.

During the interval between the issuance of holding instructions at approximately 1708:36 and approximately 1709:32, apparently no one in the control tower observed the positioning of the DC-6B on runway 9 or the attempted take-off. The local controller stated that when he first observed the DC-6B it was two or three seconds before the collision and all he could get out over the microphone was "check the traffic". The co-ordinator stated that when he first observed the DC-6B rolling down runway 9 he turned to the local controller to warn him, but at that moment the local controller was making the transmission "check the traffic".

The other three control specialists saw only the collision, which occurred approximately four seconds after the warning message. There were no tower transmissions made to either aircraft during this interval. No attempt was made to warn the Viscount.

Other aircraft in the area at the time of the accident

Another aircraft, Allegheny Flight 307, was holding on the north side of runway 9 when the DC-6B started to take off. Flight 307 made two transmissions to the Boston Tower (on 118.3 Mc/s) indicating that it was ready for take-off. The first transmission was made at approximately the same time that the local controller issued instructions to the DC-6B to taxi into position and hold. The local controller did not acknowledge the first transmission nor was it recorded on the tower tape. This raised the possibility that a transmission from Allegheny 307 might have interfered with the control tower holding instructions to the DC-6B.

The Board conducted a series of communication tests to determine the conditions under which the Boston Tower recorder will function, and the effects of simultaneous or overlapping transmissions from the control tower and aircraft on the same frequency.

Simulating as nearly as possible the conditions existing at the time of collision, a National DC-6B aircraft was placed in the same position as that occupied by National's Flight 429 on the south side of runway 9 and an Allegheny Airlines Convair 440 was placed in the same position as that occupied by Allegheny 307 on the north side of runway 9.

It was determined that when the main tower transmitter was in use, a transmission from the Allegheny aircraft made simultaneously with a control tower transmission produced a sharp squeal in the receiver of the National aircraft, and that when the tower microphone was keyed, no transmissions except the controller's were received and recorded in the control tower. However, when the tower standby transmitter was in use, transmissions from the Allegheny aircraft blocked the control tower's simultaneous transmissions but were received in the National aircraft. When the tower microphone was keyed, no transmissions except the controller's were received and recorded in the tower.

Control tower maintenance personnel were interrogated, and it was determined that, to the best of their recollection, the main transmitter was in use at the time of the accident. However, it is possible that the standby transmitter might have been operated at intermittent periods during that day without the tower logs reflecting its use.

A study was also made of the phraseology used in the tower transmission coupled with a possible omission of certain words therein and the substitution of any and all of Allegheny 307's transmissions. However, an analysis of the results led to the conclusion that the composite message, as possibly heard by the crew of the DC-6B, could not have been misconstrued as a clearance for take-off. Thus, neither the testimony of the crew of the DC-6B nor the results of the tests overcome a preponderance of the evidence which indicates that the DC-6B was given a holding clearance instead of a clearance for take-off.

It was estimated that the crew the DC-6B, after positioning the aircraft for take-off, had approximately 850 ft of runway available for acceleration prior to the point at which the collision occurred. The time for an aircraft of this type to accelerate to approximately 60 kt in 850 ft is computed to be approximately 13 seconds.

The local controller's warning to check the traffic was transmitted approximately nine seconds after the take-off roll had begun and approximately four seconds before the collision. In the absence of regulatory or procedural requirements, it cannot be determined with certainty at what point in time within the 13 seconds the local controller should have detected the failure of the DC-6B to comply with holding instructions. However, two facts are evident. There were both detection and warning within nine seconds after the DC-6B commenced its take-off. Whether the warning given by the local controller was sufficient to discharge his duty to prevent collision requires further examination. The control tower recording tape indicates that the warning message was not addressed to the DC-6B or to the Viscount. At the time of transmission both were in dangerous positions. Although the local controller stated that he directed the warning message to the DC-6B, the crew of that aircraft and the Viscount testified that they heard no warning. This testimony is given credence by the fact that the warning message did not identify the addressee. The crews of both aircraft would normally be alerted to danger only by a warning which was specifically directed to them. Since the warning message was not directed to anyone, it is considered to have been deficient in that respect.

Probable Cause

This ground collision occurred as the result of commencement of take-off by the DC-6B without clearance.

Contributing factors were the failure of tower personnel to provide adequate surveillance of the active runways and to issue an appropriate warning message to the pilot of the DC-6B alerting him to the impending traffic confliction.

Recommendation

As a result of this accident the Board recommended to the Federal Aviation Agency that consideration be given to requiring that all restrictive clearances or instructions issued by air traffic control be acknowledged by pilot repetition.

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ICAO Ref: AR/721

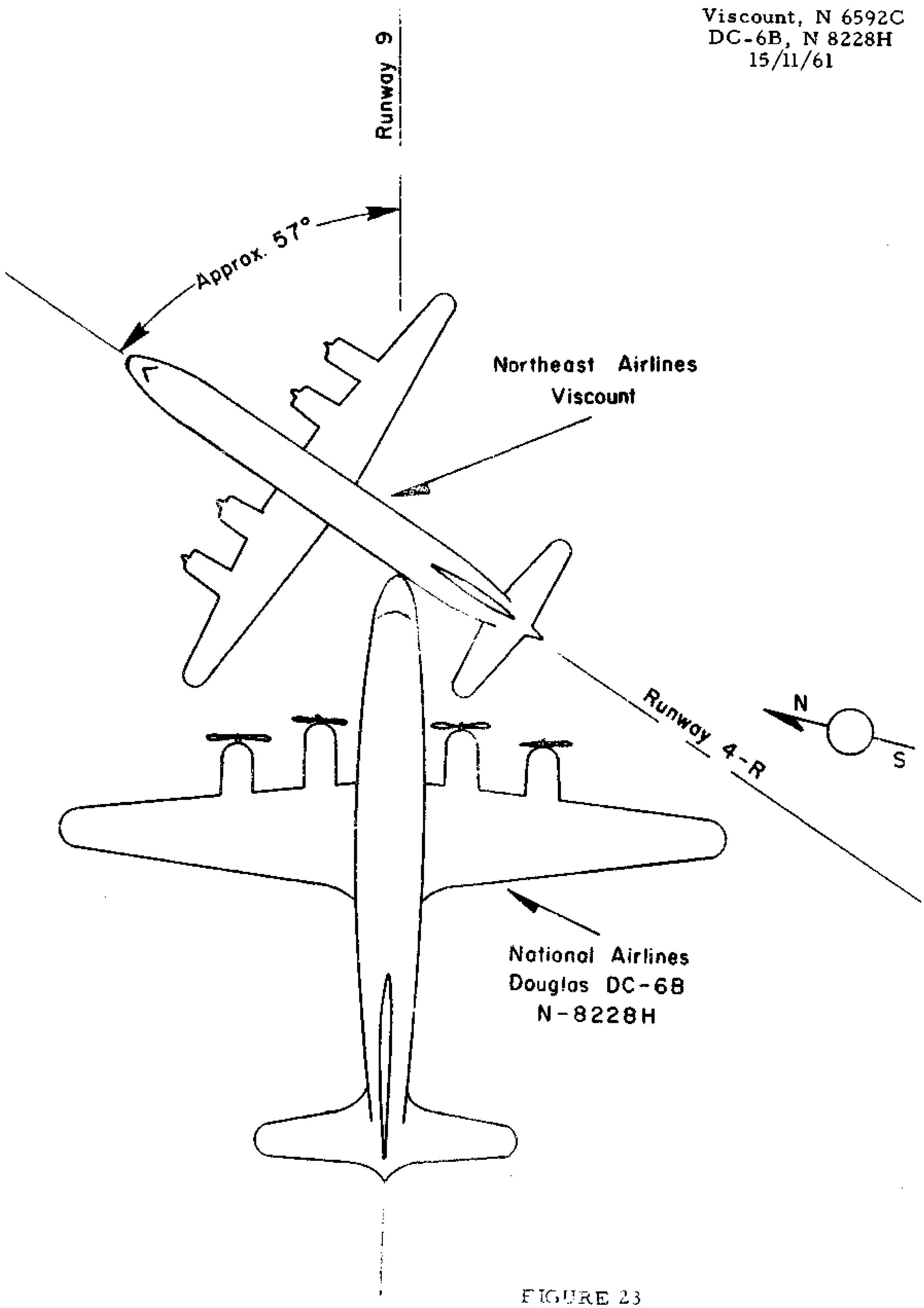
Viscount, N 6592C
DC-6B, N 8228H
15/11/61
Runway 9
Approx. 57°
Northeast Airlines
Viscount
Runway 4-R
N
S
National Airlines
Douglas DC-6B
N-8228H

FIGURE 23

No. 47

Indian Airlines Corporation, Vickers Viscount Series 768D, VT-DIH, accident at Colombo Airport, Ratmalana, Ceylon, 15 November 1961. Report released by The Director of Civil Aviation, Ceylon.

Circumstances

During the landing at Ratmalana Airport, Ceylon following a scheduled flight from Madras, India, the aircraft touched down about one third down the runway and swerved off to the left with its wheels in the "up" position. The aircraft was substantially damaged. None of the 6 crew members or 36 passengers aboard was injured. The accident took place at 0851 hours GMT.

Investigation and Evidence

Aircraft Information

VT-DIH's certificate of airworthiness was valid until 31 October 1962. It had been maintained in accordance with the approved inspection schedule, and no abnormal repairs or replacements were carried out since the last major (Check IV) inspection of 31 August 1961. Since that time it had flown 780 hours and made 263 landings.

At departure from Madras its gross weight, 58 190 lb, was well under the maximum permissible of 63 000 lb. Its landing weight at Ratmalana was about 53 100 lb. The centre of gravity was within the limits specified for take-off and landing.

The Crew

It was made up of the pilot-in-command and co-pilot (both captains with considerable experience), a radio officer, a supernumerary maintenance engineer and two air hostesses.

The flight times, in brief, of the pilot and co-pilot are as follows:

	pilot	co-pilot
on single and multi-engined aircraft	11 942:40 hr	11 184:55 hr
on Viscounts	632:45	683
on instruments	492:10	817

Both pilot and co-pilot held valid "B" licences. The former had no previous accident record, however, the latter was involved in an accident to a DC-4 aircraft at Madras Airport in September 1958 following which he was trained in emergency operations.

Weather Situation - General

It was clear up to 0700 hours but had become cloudy by 0800. Half an hour later there was a thunderstorm and a 5M (Danger Met) was originated as the visibility decreased to 1 300 yd, which was below the minimum of 2 miles specified by the international standards for issuing a 5M and also below the Indian Airlines Corporation's minima of one mile visibility and 500 ft cloud base for landing Viscount aircraft by day at Ratmalana. The first record of improved visibility was given in the 1000-hour Aero, which recorded a visibility of 5 miles. However, according to the meteorological observer on duty, the improvement in visibility did not last long enough to warrant issuing a 5B until 1130 hours when the first improvement Met 5B was issued. The 5M originated by the meteorological office at 0830 hours could not, however, be passed on to the aircraft as the message was received by the air traffic control officer at the tower at 0904, i.e. about 13 minutes after the accident occurred.

Weather picture - special observation - at the time of the accident (0851 hours)

Wind : light/variable, according to the anemograph the wind was about 2 kt varying from northerly to easterly.

Visibility : 1 mile over the northeast end of the runway and 1 - 2 miles over the southwest end of the runway.

Weather : moderate thundershower.

Cloud : 3/8 Cb base 1 500 ft; 7/8 As base 9 000 ft; 4/8 St base 600 ft.

Dry bulb : 79.0°F

Wet bulb : 74.6°F

Pressure : 1008.3 mb (station level)

Additional information provided stated that the thundershower increased in intensity immediately after the landing and visibility temporarily decreased to 1/2 mile or less. The thundershower gradually decreased in intensity and by 1500 hours (Ceylon standard time) there was a drizzle with visibility about 4-6 miles.

Therefore, visibility at the time of landing was marginal but met the minima requirements of one mile over the southwest end of the runway, though the 5M for visibility was still in existence.

At 0845 (i.e. six minutes before the accident) the aircraft was advised by air traffic control that the weather at the airport was improving. An entry in the logbook at this time indicates that visibility, as received from air traffic control, was one mile. According to the air traffic control officer, this improved condition existed until the aircraft landed. Both the pilot and co-pilot stated that the runway was visible when they were about 3 miles from Ratmalana, and they decided to make a VFR landing.

The Flight

The flight originated at Madras at 0704 hours and was uneventful up to the time of its arrival over Ratmalana.

While en route it had received, at 0802, the 0700 hour weather report for Ratmalana. The aircraft at about this time was flying at flight level 16. The 0800 conditions at Ratmalana were also passed on to the flight at 0832 hours. They were as follows: "wind 280/05; visibility 13 miles; clouds 2 Cb 1 600 and 3 As 800." VT-DIH then changed over to Approach Control on 119.7 Mc/s, and when the aircraft reported to the control tower shortly thereafter it was told of heavy rain and 1/2 mile visibility.

It reported passing Katunayake, as requested, and was cleared to descend to circuit altitude (800 ft) for Ratmalana as the weather there was improving. Visibility was 1 mile, cloud 5/8 St 800 ft and QNH 29.80. At 0848 the flight reported passing Colombo City (8 to 10 miles from Ratmalana) and was cleared to report downwind for runway 04. There was slight rain, and the runway surface was wet. Soon after it reported "runway in sight" it was cleared at 0850 to land on runway 22. The surface wind at this time was calm. The pilot reported the aircraft's undercarriage "down and locked".

The aircraft was seen approaching higher than usual and touched down about 1/3 of the way down the runway. Immediately following the engines were heard to open up. The aircraft flew parallel to the runway, in a slight tail-down attitude, with its propellers striking the surface, finally landing on its belly after swerving to the left at an angle of about 30° and crossing the boundary fence.

Accident site - general observations

The first touchdown point, as estimated by the air traffic control officer on duty and the assistant meteorological officer, who were watching the aircraft when it landed, was between 2 000 and 2 400 ft from the beginning of runway 22. The crew members agreed with this estimate.

The first visible marks on the runway were those of No. 3 propeller cutting the ground followed by those of No. 4 propeller, 2 902 and 2 942 ft respectively from the beginning of the runway. A little ahead was a straight dragging mark of the starboard nacelle door. There were no wheel marks before or after the propeller marks.

The next marks were those of the port propeller of No. 2 engine, 3 179 ft from the beginning of the runway. A little ahead were the straight dragging marks of the port nacelle door and the nose wheel doors. Again there was no evidence of either the port wheel or the nose wheel mark prior to the marks left by the wheel doors. All these marks then disappeared for about 538 ft after which the propeller marks appeared again, first on the port side and then on the starboard side. The distance between the propeller cuts was in the beginning about 2 ft 6 inches to 2 ft 8 inches, and the cuts were at right angles to the direction of landing. These marks faintly became parallel to the path of the aircraft which indicated that the propellers had stopped rotating. Pieces of propeller along with those of fuel tank breather, aerial mast, etc. were also found in this area, indicating that the fuselage and nacelles started touching the ground as the propellers lost their speed and started dragging along. From this point onwards the aircraft had continued on its belly leaving a clear trail over the side strip through the fencing and across the road.

Wreckage examination

The aircraft sustained extensive damage to its airframe and engines.

On jacking up the aircraft it was observed that the undercarriage was retracted and locked in the "up" position. The main undercarriage hydraulic system could not be worked due to the breakage of the nose gear steering shut-off valve line. It was lowered by the emergency hand pump after moving the landing gear selector valve in the hydraulic cupboard to down position, and it was found that the undercarriage came down easily and locked properly. Examination of the undercarriage proper did not reveal any defect that could have caused its collapse while landing.

Statements of Crew Members

The Pilot

"A little after passing Colombo City, about 3 miles from Ratmalana, there was slight rain, and having sighted the runway, I decided to make a VFR landing. I joined the right base leg in the usual manner and while coming in to align on runway 22 I found I had overshot slightly to the right before reaching the threshold. I made corrections and came over on the middle of the runway. Over the threshold I was slightly higher than normal, but I had aligned myself perfectly".

"While I was turning on finals, I asked for 68% flaps from my co-pilot and then 85% flaps. When I directly aligned myself I throttled back and asked for landing flaps (100%). The co-pilot complied with my orders. While I was aligning myself on runway 22, my co-pilot said: 'You can't make it captain'. I said: 'Don't worry I can make it'. Then I closed the throttles fully, and got full landing flaps. As the aircraft was slightly high, I pushed the stick forward and when I was almost touching down, I eased the stick back to do a smooth landing. During this process the aircraft floated slightly and landed a little farther down the runway than usual, which in my opinion at that time may have been about 1 500 ft".

"During the process of landing, I touched down and the aircraft bounced slightly. At this moment I found that the throttles were fully opened without my instructions, and as I was confident of doing a safe landing, I throttled back again immediately. As I pulled the throttles back, I heard the landing gear warning horn sounding. Evidently, the undercarriage had also been selected 'up' without my knowledge".

"I promptly opened the throttles again and found the propellers hitting the ground and the aircraft sinking. Therefore, I immediately closed the throttles again. The aircraft at this time had started veering off the runway to the left in spite of my efforts to make the aircraft straight".

The pilot stated that the aircraft had functioned satisfactorily throughout the flight, and he had considered the weather "all right for landing". No instructions had been given by him to his co-pilot to operate the throttles or to retract the undercarriage at any stage during the landing and indicated that the co-pilot had done so on his own initiative.

The Co-pilot

He frankly admitted that he opened the throttles and retracted the undercarriage at the time of landing. Explaining why he acted in this manner, he stated: "The aircraft slightly overshot on the turn and the captain corrected the turn and tried to align himself on the runway. In so doing, the aircraft slightly shifted to the right again, but before this, I informed the captain that he could not make it and that he should go round, the reason being that he was on the higher side than normal though away from the threshold. This would mean that a steeper approach would have had to be made, and the speed of the aircraft would thereby increase. The captain replied that he could make it. The captain then aligned himself with the runway and having closed the throttles asked me for full landing flaps, which was carried out accordingly by me. At this point the aircraft was just before the threshold, the height being about 70 to 100 ft. As anticipated by me, the aircraft continued its steeper than normal approach with the speed also higher than normal and touched down approximately in front of the control tower on the runway. When it touched down there was a ballooning effect, and I immediately applied full power and inadvertently my hand went to the undercarriage selector, which I selected 'up'. As I was about to select flaps to 43%, the captain closed the throttles, and it was far too late for me to do or say anything. When I opened the throttles the aircraft became airborne. When the throttles were closed, the aircraft started sinking".

Analysis

It was confirmed that the aircraft first touched down on its main wheels about 2 000 to 2 400 ft from the beginning of the runway. Subsequent markings indicated the propellers were next to contact the ground while the undercarriage was retracting and the nacelle doors were closing during the bounce after first touchdown. The path of the aircraft, as seen by the ground marks, made it clear that the aircraft was properly aligned with the runway even though the aircraft did not touch down at the beginning of the runway.

After carrying out the final check prior to landing the pilot reported to the control tower that the undercarriage was 'down' and locked. No emergency of any kind had been reported by him. The statements of the pilot and co-pilot showed that the undercarriage was retracted by the co-pilot by operating the landing gear selector switch just after touchdown. The position of the undercarriage selector, which was found in the 'down' position at the time of the wreckage examination, is explained when he said: "I put it down once again hoping against hope that the aircraft might come on its wheels and thereby be more effectively controlled". This was, of course, too late as the aircraft was already travelling on its belly.

The sequence of operations carried out by the pilot and co-pilot during landing indicates lack of co-ordination. The pilot was confident that he could make a successful landing, while the co-pilot interfered with the controls and initiated an overshoot action without any instructions from the captain. The factors prompting the co-pilot to do so were:

a) high approach and faster touch-down speed than normal;

b) delay in touchdown; and

c) ballooning effect felt by him on touchdown.

Under the ambient conditions of a temperature of 27°C, tailwind 2 kt and an uphill gradient of 0.3%, the landing distance required from a height of 50 ft to stop the aircraft when its weight is 53 100 lb as estimated at time of landing is about 2 800 ft according to the flight manual of the aircraft. The wet runway increases this figure by 15% i.e. to 3 220 ft. Assuming the touchdown speed to be about 5% higher in this case, the landing distance would be further increased by about 10%, thus bringing the estimated landing distance to about 3 540 ft from 50 ft height. The aircraft touched down about 2 200 ft from the beginning of the runway which is 6 013 ft long, 168 ft wide and has 400 ft of stopway made of gravel. The length available after the aircraft had touched down was thus sufficient to bring the aircraft to a safe stop. The above calculation supports the decision of the pilot to continue the landing in spite of his high approach and fast touchdown.

The final stages of the landing (as reconstructed) were -

- higher than normal approach;

- the landing was continued. The pilot, compensating for the excessive height, pushed the stick forward and flared out for touchdown;

- touchdown about 2 200 ft from the beginning of the runway at a higher than normal speed;

- on touching down the aircraft ballooned slightly. The co-pilot opened the throttles and retracted the undercarriage;

- subsequent action by the pilot, i.e. closing the throttles and possibly extending the landing gear, was too late to avoid the accident.

Probable Cause

The co-pilot interfered with the controls, and initiated overshoot action without any instructions from the captain, by opening the throttles and retracting the undercarriage at the critical stage of landing just after touchdown. The action of the co-pilot, however well-meant, was both unauthorized and unwarranted.

Recommendations

Dissemination of meteorological information

The general weather conditions after 0800 on the day of the accident were poor. There was a thunderstorm at 0830 hours when the visibility was reduced to 1 300 yd and a 5M was issued. During the existence of 5M, which lasted up to 1130 hours, the weather had sometimes improved temporarily. According to the meteorological office's observation, at the time of the landing, visibility was "1 mile over the northeast end of the runway and 1 to 2 miles over the southwest end of the runway" and further information available read "thundershower increased in intensity immediately after landing and visibility temporarily decreased to half mile or less". Although it can be said that visibility at the time of landing met the IAC minima of one mile, the fact remains that a 5M listing the visibility as 1 300 yd, which is below the IAC minima, was current at the time, and this was not passed to the aircraft because of delay in relaying the information to air traffic control. In the absence of any operational control by IAC at Ratmalana, it was the responsibility of the pilot to exercise operational control, and he may have decided to hold or divert if this information had been received by him.

According to the pilots, the visibility at the time of the approach to land was about 3 miles. However, the slant visibility has no relationship to the horizontal surface visibility. This accounts for the wide divergence between the estimates of visibility as given by the pilot and by the meteorological authorities.

The procedure of handling the 5M messages and for informing the incoming aircraft of the latest position regarding the weather thus seems to be unsatisfactory. It is, therefore, necessary that the delay in handling 5M and 5B messages should be cut down and more expeditious methods adopted immediately.

Automatic recording of R/T messages

During the investigation it also came to light that there is no method of recording the air-ground conversations in the tower, and the way in which the logbook is maintained gives scanty information regarding the same. The importance of providing a means of recording the R/T messages in accordance with modern standards of aeronautical practice cannot be overstressed.

It is, therefore, recommended that the tower should be provided with suitable equipment as early as possible.

ICAO Ref: AR/706

Viscount 768D, VT-DIH
15/11/61

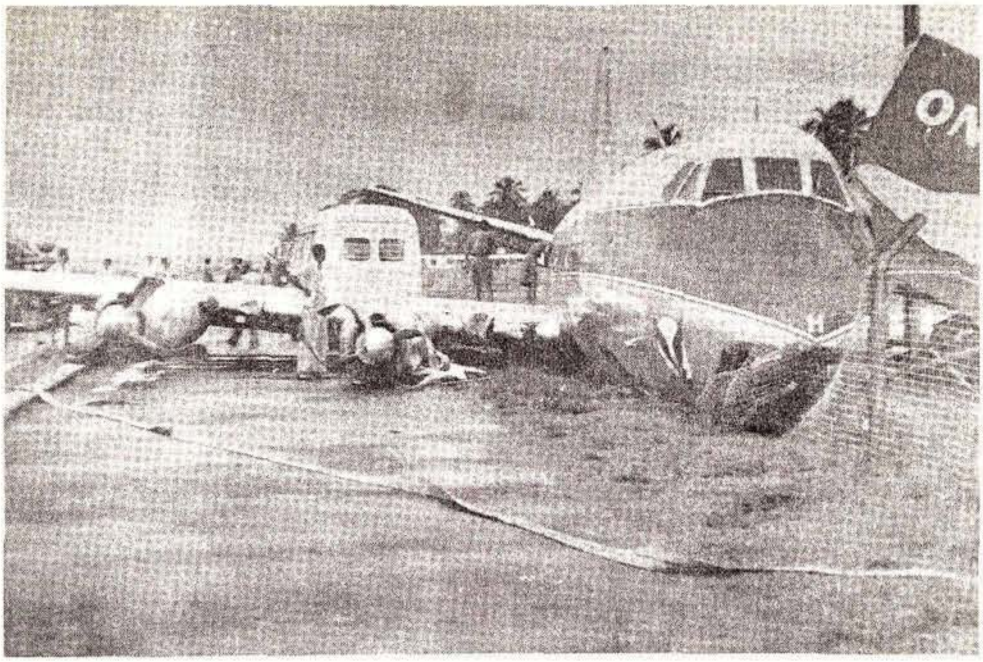

FIGURE 24
FINAL POSITION OF AIRCRAFT AFTER THE ACCIDENT

FIGURE 25
VIEW FROM PORT SIDE (REAR)

No. 48

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

Circumstances

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

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

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

Investigation and Evidence

The Aircraft

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

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

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

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

The Pilot

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

Weather

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

Ruapehu area. The wind direction was 160° true and its velocity was estimated as 36 mph over the route.

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

Eyewitnesses

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

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

a) turbulence;

b) a structural defect;

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

d) a combination of these or similar circumstances.

a) Turbulence

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

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

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

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

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

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

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

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

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

b) Structural defect

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Payload

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

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

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

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

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

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

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

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

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

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

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

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

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

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

c) Mountain strike

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

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

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

It is highly improbable that the engine would have continued to run under power with its fuel lines torn away even during the relatively short time that elapsed between wing separation and ground strike. If, however, it had continued to run the thrust of the propeller would have caused the detached wing to describe an erratic trajectory whereas in fact it struck the mountainside at a point along the track taken by the rest of the structure. No witness mentioned having seen the detached wing describe a gyratory or erratic fall. Furthermore, a principal witness stated that the noise of the engines ceased altogether after disintegration occurred. If power had still been on when the wing reached the ground the effect of propeller blade rotation would have tended to twist the wing round in the snow, leaving evidence of this accordingly. The wing, however, made a single clean impression and, in addition, the only blade impressions in the snow were separate marks of a static character made by the two "lower" blades. There was no interconnecting slash mark between those impressions and, furthermore, the "upper" blade carried no impact bend. There was no obstruction on the open snow on which the detached wing fell which could account for the tearing, scoring, and, in the case of two blades, one of which was the "upper" one, shearing of the tips, the lost portions of which could not be found in the wreckage area.

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

It is firmly believed that this mountain strike did occur.

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

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

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

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

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

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

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

In the summit area severe turbulence was encountered.

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

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

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

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

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

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

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

That upward movement caused the fuel interconnect tubes between centre (fuselage) and inboard (wing) fuel cells to become disconnected, thereby allowing fuel in considerable volume to pour out of the fuel cells.

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

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

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

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

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

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

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

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

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

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

Observations

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

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

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

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

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

Probable Cause

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

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ICAO Ref: AIG/ACC/REP/GEN/No. 11 - New Zealand

No. 49

Rhodesian Air Services (Pvt.) Ltd., Douglas DC-3, VP-YRX, accident 600 yd southeast of the threshold of Runway 06 at Salisbury Airport, Southern Rhodesia, 22 November 1961. Civil Aircraft Accident Report No. 19/314 released by The Director of Civil Aviation, Federation of Rhodesia and Nyasaland.

Circumstances

The aircraft was on a charter flight to Livingstone to pick up United Nations troops on leave and take them back to Elisabethville. It took off from Salisbury Airport, and shortly after take-off suddenly dipped its right wing. After a slow recovery, it climbed away to between 100 - 150 ft and then went into a turn to the left with the port propeller windmilling. This turn continued to get steeper until the aircraft rolled over and dived inverted to the ground less than 600 yd southeast of the threshold of runway 06. Fire broke out but was quickly extinguished. The pilot and co-pilot were killed as a result of the accident, and the stewardess was seriously injured. No passengers were aboard the flight. The accident occurred at 0902 hours GMT.

Investigation and Evidence

The Aircraft

Its Federal Certificate of Airworthiness valid until 4 March 1962 was issued in continuation of its United Kingdom Certificate. The aircraft had flown 18 716 hours of which 67 hours had been flown since the last Check 1 inspection. At the time of the accident it held a valid Certificate of Maintenance issued on 2 November 1961 and had been maintained in accordance with a schedule approved by the Federal Department of Civil Aviation. On the day of the accident it flew five hours before the accident, and no defects were recorded by the crew.

The Engines

The port engine, installed in February 1961, had run 877 hours since complete overhaul and 2 863 hours since new.

The starboard engine had run 225 hours since overhaul and 12 063 hours since new.

Loading of the Aircraft

No copy of the loadsheet was left at Salisbury Airport by the crew. The take-off weight (estimated to have been 23 212 lb) was 3 688 lb below the maximum permissible take-off weight. The aircraft's centre of gravity was within the prescribed limits.

Crew information

The pilot-in-command commenced civil flying in South Africa in 1955 and was given a command on DC-3's in November 1960. At the time of the accident he had flown a total of 6 023 hours, including 4 620 hours on the DC-3 of which 890 were in command. His airline transport pilot's licence was valid until 12 December 1961, and his last instrument rating check and periodic flying test were passed on the DC-3 in August 1961.

The co-pilot learned to fly privately in England, then in October 1960 obtained a Federal Commercial Pilot's Licence. Whilst employed initially as an engineer with Rhodesian Air Services he converted on to the DC-3 aircraft in March 1961. He also passed his instrument rating on this aircraft in the same month. His pilot's licence was valid until 2 March 1962, and at the time of the accident his periodic flight test on the DC-3 was one month overdue. The Department of Civil Aviation was aware of this fact.

Reconstruction of the flight

Based on interviews with numerous witnesses the investigating officers were able to reconstruct the subject flight.

As the aircraft was being flown empty to Livingstone, the co-pilot was authorized by the Chief Pilot of Rhodesian Air Services to fly the aircraft from the left-hand seat. Due to his comparative inexperience, he normally flew the aircraft from the right-hand seat. Prior to departure he carried out the interior and exterior checks then reported to the Chief Pilot on their completion.

The port engine was run up, the aircraft was cleared for take-off on Runway 24, and take-off appeared normal although it may have been a little shorter than usual. Shortly after becoming airborne, while the wheels were still down, the right wing dipped suddenly to a degree that alarmed eyewitnesses. The aircraft recovered slowly then climbed to between 100 - 150 ft and went into a turn to the left. At the same time, the port propeller windmilled slowly, as if approaching the feathered position. The rate of turn increased along with the angle of bank until when the aircraft was near the vertical bank position it rolled rapidly over to the left and crashed inverted. It was estimated that the elapsed time from beginning the take-off run until impact was a maximum of 75 seconds ... the aircraft was airborne approximately 50 seconds.

The Wreckage

The aircraft struck the ground on an approximate heading of 140° magnetic in a steep inverted attitude on soft sandy soil at the foot of an earth bank some 10 ft high, surrounding a small brick blockhouse. The initial impact destroyed the entire front section of the fuselage. The aircraft then slid forward up the side of the embankment, and the fuselage somersaulted over onto its belly, hitting the blockhouse roof, which severed the fuselage adjacent to the mainplane trailing edge. The aircraft came to rest on a heading of about 320° magnetic. Fire broke out at the starboard power plant but was confined to this item.

The cockpit trimmer control indicators showed:-

rudder	- 12° Nose left (i. e. full travel)
aileron	- neutral
elevator	- 2° Nose up.

From the chordwise marks present on all blades of the starboard propeller and the nature of the root fractures, it was evident that considerable power was being developed by the engine at the time of impact. Examination of the pitch control mechanism showed the blade angles to be 20°- 21°, which is in the constant-speed pitch range.

The starboard engine was examined, and indications were present of high rotational speed at impact. Due to extensive incineration of the rear of the engine it was not possible to rig-test any of the vital components. The investigating officers were satisfied that this engine was developing full power prior to impact, otherwise the aircraft would not have remained airborne for as long as it did.

The port propeller was found in the feathered position. The appearance of the propeller indicated that rotation had practically ceased at the time of impact.

No evidence was found during the technical examination to indicate mechanical failure, or malfunctioning of the airframe, engines, propellers, or other equipment.

Discussion

As far as could be established, there was nothing wrong with the port engine. Possible reasons for the pilot's feathering of the engine were considered. The first explanation considered was that the pilot received some form of engine malfunction warning soon after take-off, possibly a fire warning light, and feathered the port propeller and then proceeded to wind on the wrong rudder trim. It was not felt that this was a satisfactory explanation because in cases where engine malfunction is indicated by instruments, as opposed to being felt on the controls, a pilot crosschecks to be sure that there is in fact a power failure. Also, having feathered the port engine very soon after take-off, the action of winding on the wrong trim setting would have been noticed and, in any case, could have been reversed.

The Investigating Officers felt that there must have been a more urgent reason for the pilot to suppose that the port engine had failed, and they considered the possibility of the pilot having taken off with the rudder trimmer in the full nose-left position. No information was available as to whether this was feasible, or whether it gives a true impression of engine failure, once airborne. Therefore, tests were carried out to this end with the co-operation of the Royal Rhodesian Air Force.

The tests showed that:-

a) It is possible to carry out what appears to be a perfectly normal take-off with full rudder trim applied; and

b) Once airborne, the pressure on the rudder is identical with that required after experiencing engine failure.

It was believed that the aircraft took off with the rudder trimmer in the full nose-left position and that very soon after becoming airborne, this was interpreted by the crew as port engine failure, and the port propeller was feathered at a low airspeed. The tests showed that once this is done, the aircraft rapidly becomes uncontrollable.

Opinion

It was considered unlikely that the rudder trimmer was wound on during the initial checks by the co-pilot, because the trimmer range check is followed by an exterior physical check. In addition, the departure of the aircraft was watched by the Chief Pilot (Rhodesian Air Services) and their engineer, both of whom think they would have noticed a displaced rudder tab. It was confirmed by four pilots that the pilot-in-command of the subject flight was in the habit of winding the trimmers through their range whilst taxying, although this is not part of the checklist. The taxi checks would be carried out by the pilot-in-command, and it is significant that the rudder trimmer indicator cannot easily be seen from the right-hand seat.

The co-pilot was told by the pilot-in-command on earlier flights to take a lightly-laden DC-3 off at between 60 - 65 kt. As tests showed, pressure on the rudder pedal to counteract full trim does not become appreciable until between 50 and 55 kt. It is considered likely that the co-pilot told the pilot-in-command of the difficulty he was having in keeping the aircraft straight and that the pilot-in-command took control. While training, the usual way an instructor recognizes which engine is out is by rudder pedal feel, and the investigating officers thought that the pilot-in-command mistook the heavy pressure needed on his rudder pedal as a sign of engine failure, and feathered the port propeller.

Regarding the wing drop soon after take-off, the investigating officers were not able to say, with any certainty, what caused this. Having ruled out the possibility of a sudden gust of wind, wind reversal, or a dust devil, the possibility of autopilot malfunction was considered. However, tests carried out showed that the effect of either full right rudder, or full right aileron, or both together, suddenly coming in under take-off conditions did not cause anything more than a progressive wing-drop, which could be easily overpowered by the pilot. They felt that it occurred when the pilot-in-command took control from the co-pilot. In addition, as it happened very near the ground, it would appear more alarming to witnesses than at height.

The stewardess, in her evidence, mentioned a sudden increase in noise from the starboard engine immediately following the wing-drop. This might indicate that the starboard engine was momentarily throttled back in error, and then slammed open again, with consequent overspeeding. One other witness mentioned a momentary slowing-down of the starboard propeller at this time. This action was tried in the air, but the wing-drop resulting from it was very slight.

The checklist used in the aircraft gives the first power reduction (Check 1) at 95 kt. This is taken to be the single-engine safety speed. Bearing in mind the short take-off run and the wing-drop and recovery, followed very soon afterwards by the feathering of the port propeller, it is not considered that the aircraft ever attained this speed. That the pilot-in-command elected to continue trying to fly the aircraft instead of belly landing it, can be explained by the fact that the undercarriage was coming up and his natural reluctance to put the aircraft down in this condition. In addition, there was the mental shock of the unexpected feathering, followed by the aircraft rapidly going out of control. Added to this, was the physical effort necessary on the controls to try and keep the aircraft straight and level, which would effectively prevent him from either reducing power on the live engine, or winding the rudder trimmer handle. Once over the trees in a banked condition, a crashlanding was inevitable.

Probable Cause

The accident was caused by failure of the pilot to execute a successful single-engine forced landing after concluding that there had been a power loss in the port engine. Evidence indicated that a failure of the port engine did not, in fact, occur. The pre-take-off rudder trimmer check was not carried out correctly as laid down in the checklist, and the aircraft took off with full left rudder trim applied. Once airborne this was misinterpreted as port engine failure, and the port propeller was feathered. No apparent action was taken by the pilot to correct the ensuing critical speed yaw.

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ICAO Ref: AR 710

No. 50

Aerolíneas Argentinas, Comet IV, LV-AHR, accident at Campinas Airport, São Paulo, Brazil, 23 November 1961. Report released by The Brazilian Air Ministry.

Circumstances

The flight had originated at Buenos Aires, Argentina. At Vira Copos (Campinas) Airport, Brazil, the engines were started at 0520 hours and the aircraft took off for Trinidad (alternately Barbados) at 0538 hours. After reaching an altitude of about 100 m, the aircraft lost altitude, collided with a eucalyptus forest and was destroyed. Twelve crew and forty passengers died in the accident, which occurred at approximately 0540 hours.

Investigation and Evidence

The Aircraft

It had flown a total of 5 242 hours, 2 242 of which had been flown since the last overhaul and about 6 hours since the last 90-hour inspection. It was not possible to check the maintenance reports regarding the 30 days prior to the accident.

The Crew

A pilot-in-command, co-pilot and ten other crew members were aboard the flight.

The pilot-in-command was sitting in the right-hand seat, presumably acting as instructor at the time of the accident. He had flown the following hours:

total flight time	12 550 hours
as pilot-in-command or instructor	11 246 hours
by night	5 791 hours
in the same type aircraft	1 612 hours
as pilot-in-command or instructor in the same type of aircraft	584 hours

He held a valid IFR rating.

The co-pilot was sitting in the left-hand seat and had no flight time registered as pilot-in-command on this type of aircraft. It was, therefore, believed that he was receiving instruction as such. His previous experience was:

total flight time	13 427 hours
in the same type of aircraft	1 074 hours
as pilot-in-command in this type of aircraft	zero hours
by night	2 833 hours
instrument flight	unknown

He also held a valid IFR rating.

It was not believed that the accident was caused by fatigue as the crew had only flown about 3 hours during the preceding 24 hours.

Weather conditions

It was not believed that the weather situation contributed to the accident. It was a dark night due to 7/8 stratocumulus at 400 m and to 8/8 coverage by altostratus at 2 100 m.

Weight at take-off

At time of take-off the aircraft was estimated to weigh 71 488 kg. The maximum authorized weight was 72 575 kg, i.e. 1 087 kg below the maximum allowed.

The centre of gravity was within the prescribed limits.

From the time of starting the turbines to the actual take-off about 528 kg of fuel were consumed, thus increasing to 1 615 kg the balance in favour of safety. According to the control tower's testimony the take-off run was approximately 2 000 m. According to the dispatch estimate it should have been 2 240 m.

Take-off run

From tests with LV-AHU, another aircraft the same type as LV-AHR, it was concluded that the take-off run took about 40 seconds.

Climbing angle

In view of the control tower operator's testimony, the conclusion was reached that the aircraft's climbing angle was around 4.5°. The aircraft reached an estimated altitude of 100 m. Taking into account the minimum climbing angle of 4.5°, the aircraft should have reached an altitude of 120 m, which corroborates the control tower operator's statements.

Comparing the above with the results obtained during the LV-AHU test flight, it was concluded that from the beginning of the take-off run up to 120 m, LV-AHR took about 55 seconds. Then it should have reached the indicated airspeed of 170 kt. At that moment LV-AHR was midway between the take-off point and the first impact point. So, taking into consideration the remaining runway (1 240 m) and the distance from the end of the runway to the first impact point (1 930 m), the aircraft flew 3 170 m.

The point where the aircraft started losing altitude could not precisely be stated ... however, it may be estimated as the middle distance between the point where the aircraft became airborne and the first impact point.

Comet IV flight instructions

According to the instructions, when a speed of 170 kt is reached, the pilot must control the "elevator change gear". When changed from "coarse" to "fine" the aircraft's nose has a tendency to drop, which has to be counteracted by using the manual trim tab. It was believed that the unit was under control when the accident occurred.

From analysis it was deducted that the aircraft, LV-AHR, hit the eucalyptus tree in a nearly horizontal attitude, which leads to the conclusion that the pilot, a short time before, when noting the loss of altitude, attempted to regain climbing attitude but due to the action of the elevator travel limiting unit in the "fine" position, the aircraft took longer to regain it. This must have been the reason why, at the moment of collision with the tree, the aircraft was still flying in a horizontal attitude.

Reconstruction of the last part of the flight

One hundred and twenty metres after the first impact point the pilot put the aircraft in a climbing angle of approximately 25°. This conclusion was reached as the eucalyptus trees were burned from the top down, probably by turbine exhaust gas, and the elevator counterbalance collided with a eucalyptus tree and was then torn off. About 145 m after the first impact point the aircraft collided with a larger eucalyptus tree and fire in the left wing pod tank resulted. Moments later a further impact occurred with another eucalyptus in the No. 1 reactor area. The aircraft began sinking. Due to terrain declivity the aircraft touched the ground about 303 m from the first impact point. The aircraft slipped, ultimately collided with a ground obstacle, and exploded. Many fuselage parts found 120 m from the first impact point showed no signs of fire.

Probable Cause

It was presumed that the co-pilot was under flight instruction. If such was the case, the instructor, who was pilot-in-command, may have failed to brief or supervise the co-pilot properly.

Observations of the Government of Argentina as the State of Registry of the Aircraft Concerned

Argentina has determined, in the light of information it has gathered, that the cause of the accident was "Failure to operate under IFR during a take-off by night in weather conditions requiring IFR operation and failure to follow the climb procedure for this type of aircraft; a contributory cause was the lack of vigilance by the pilot-in-command during the operations."

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ICAO Ref: AIG/ACC/REP/GEN/No. 8 - Brazil

No. 51

British European Airways, Viscount 806, G-AOYH, accident while en route from Munich, Germany to London, England on 27 November 1961. Report, dated 7 May 1962, on the Inquiry carried out by the Chief Inspector of Accidents, Federal Republic of Germany. This report was released by the Ministry of Aviation, United Kingdom, as C. A. P. 189.

Circumstances

Flight BE 523 departed Munich at 1617 hours on a flight to London carrying 5 crew members and 43 passengers. At 1628 hours it was over Walda beacon, i.e. about 70 km from Munich. Approximately 20 minutes after take-off while climbing through 12 000 ft at an airspeed of 170 kt the aircraft encountered hail followed by severe icing and turbulence. The indicated airspeed dropped steadily, and the vertical speed indicators registered 3 500 to 4 000 plus ft/min climb. Severe turbulence was again encountered and the port wing dropped. At this time the airspeed indicators were indicating between 100 and 120 kt. Shortly thereafter the captain considered both the airspeed indicators and vertical speed indicators to be unreliable. As some of the passengers had been injured because of turbulence the flight requested permission to return directly to Munich. In Munich 18 passengers and 2 crew received medical attention, and it was found that several had been seriously injured.

Investigation and Evidence

Statements of the Injured Passengers

They stated that the flight was quiet and without noticeable turbulence until the moment when, by an abrupt movement of the aircraft and without being warned of gusts, they were lifted from their seats and flung against the ceiling. The movement came so suddenly that they had no chance to hold on to anything. It was not preceded by any sensation of being pressed against the seat. The abrupt movements occurred exclusively round the lateral axis, without roll or yaw. They were increasingly noticeable, the further to the rear the passenger was sitting, behind the pivot of the aircraft's movement round the lateral axis, and were felt most strongly in the aft first class cabin. The violent movements finally ceased again almost abruptly, and the return flight to Munich was smooth.

Weather

In his statement the captain said that his pre-flight study of the weather chart and forecast supplied gave no indication of turbulent air en route.

From information provided by the Munich Meteorological Office no reasons for extreme movements of the air were discernible. A survey of the weather showed no considerable differences in temperature or air pressure. The air temperature at the altitude at which the incident took place was -8°C. In his report the pilot-in-command gave the temperature as -2°C. This was obviously an uncorrected reading. During the period 1442 - 1819 hours, apart from the subject aircraft, 22 other aircraft flew over Walda beacon at different altitudes, including one at 1620 hours, i.e. 8 minutes before G-AOYH. None of these aircraft reported extreme weather phenomena. This fact leads to the conclusion that it was a matter of a concentration of forces so limited in space and time that there is no explanation of its origin from the meteorological point of view. After the return of G-AOYH the Munich Meteorological Office sent out a warning by way of precaution to all aircraft, based on the report of the captain. No report of similar observations was received from the crew of any other aircraft after this warning.

Discussion

The pilot-in-command reported that while flying through clouds at 12 000 ft he encountered hail and heavy icing followed by severe turbulence. The first visible sign of the incident for him was that the vertical speed indicator registered 3 500 - 4 000 ft/min. This corresponds to an aver-average rate of climb of 19 m/sec. If this phenomenon, which is in any case not an everyday occurrence, had taken place in a funnel of air directed upwards, all the passengers would first have been pressed down in their seats in the same way and without regard to the position of the seat. None of the passengers questioned had had such a sensation, however. The fact that the turbulence made itself felt without warning, when the passengers were lifted up out of their seats and with increasing force the further back they sat behind the pivot of the movement round the lateral axis, leads to the inference that the turning movement round the lateral axis must have been set going by moving the elevator (sic) in the "pull" direction. Such a movement can hardly be regarded as a measure to counteract a gust, as the pilot-in-command reported an abnormal rate of climb. According to his report, the port wing dropped with the airspeed indicator between 100 and 120 kt and, after correction of the attitude, the rate of climb was still 3 500 - 4 000 ft/min. The passengers had the impression that the aircraft dived two or three times and that the dive was followed each time by a steep climb.

The fact that the pilot-in-command gave the indicated airspeed fairly precisely - both instruments dropped to 100 - 120 kt and later the instrument on his side read 80 kt and the one on the starboard side 210 kt - shows that the instruments were not functioning properly. The malfunction may have come about because the electrical heating of the airspeed indicator tubes was not working or because icing in the static pressure line affected the reading. In both cases the indicated values would have dropped. If the indicated airspeed was wrong, the aircraft could have assumed an attitude which was corrected, when the pilot-in-command realized the situation, by an abrupt movement of the controls (for this purpose he disconnected the autopilot, which had been engaged until then). The resulting over-travel of the controls explains the observations of the passengers, especially as the airspeed indicators and the vertical speed indicators were, or had to be, regarded by the pilot-in-command as "unserviceable". The attitude was then corrected by reference to the "director horizon" (artificial horizon) only.

The question whether the aircraft could have flown into the vortices (vortex trails) of another aircraft was also examined. According to the vertical separation this is very unlikely and moreover, turbulence of this kind could only have had a rather limited effect and in a horizontal direction.

Probable Cause

It was not possible to throw light on the causes of the accident with sufficient certainty.

In spite of the fact that many weather situations contain in themselves elements of development and surprise which often cannot be entirely explained and forecast, in the case in question the weather as a cause of the incident was eliminated with a degree of probability bordering on certainty.

ICAO Ref: AR/746

No. 52

Ansett-A.N.A., Viscount, VH-TVC, accident 2.8 NM from Sydney Airport, New South Wales, Australia on 30 November 1961. Report, dated 29 August 1962, of the Chairman of the Board of Accident Inquiry, Australia.

Circumstances

The aircraft was engaged on a scheduled transport service from Sydney to Canberra. It carried a crew of four and eleven passengers. According to the approved flight plan, the pilot proposed to proceed to Canberra via the 222 track to Marulan, the first reporting point. At the time of departure this was changed, because of inbound traffic, to the 244 diversion, which avoids Botany Bay. At 1915:43* the Approach Controller instructed the flight to "continue runway heading to 3 000 ft before turning left and to pass over the field at 5 000 ft or above." The flight was then cleared for take-off from runway 07.

At 1921:50 the Approach Controller asked the aircraft to report its altitude. It was at 6 000 ft. Shortly thereafter (at 1922:05) the controller communicated as follows:" ... now if you haven't passed over the field you can proceed via the 217 from Padstow. The 222 is available, but I suggest the 217 due to the storm to the south of the field. Report setting course from Padstow 217." The flight acknowledged at 1922:20 hours. None of the messages that followed from the Approach Controller were answered.

Between 1925 and 1926 hours the aircraft plunged into Botany Bay, killing all aboard.

* All times are Eastern Standard Time.

Investigation and Evidence

The Aircraft's History

VH-TVC was originally built by the manufacturer as a model 720 Viscount. It had been modified to meet the requirements of Trans-Australia Airlines and was redesignated as model 720C.

It was introduced into regular public transport service in December 1954 and was operated and maintained entirely by Trans-Australia Airlines until March 1960 when it was made available to Ansett-A.N.A. under a cross charter agreement. Trans-Australia Airlines retained responsibility for overhaul of the aircraft, its engines and other components, and Ansett-A.N.A. was responsible for all scheduled maintenance inspections and rectification of defects.

At the time of the accident the aircraft had flown a total of 16 946 hours including 9 797 hours since its last complete overhaul. The certificate of airworthiness was renewed on 2 December 1960 and was valid until 1 December 1961. Some minor deficiencies disclosed by the maintenance records were noted, but none of these had any bearing on the accident.

On 28 November 1961 the aircraft was inspected in view of the renewal of its certificate of airworthiness, and the Department required rectification of four minor items.

The Crew's Experience

The pilot's total flying experience amounted to 16 016 hours of which 12 362 hours had been in command including 802 hours on Viscount 720 aircraft and 1 946 hours on Viscount 747 aircraft. He held a first class airline transport pilot's licence valid until 28 February 1962. He also held a first class instrument rating for ADF, ILS and DME procedures. His records showed that he was a competent and careful commander, and there was no evidence to suggest that he failed in any way to perform the duties required of him on the night in question.

In June 1960 the co-pilot's licence was endorsed to permit him to act as first officer on Viscount 720 and 747 aircraft. His total flying experience amounted to 4 145 hours, including 609 hours on Viscount 720 aircraft and 1 122 hours on other types of Viscount aircraft. He held a second class airline transport pilot's licence valid until 31 May 1962. He also had a second class instrument rating for ADF, ILS and DME procedures.

Both pilots were in good health and had normal rest periods before the fatal flight.

Preceding flights of VH-TVC on 30 November

The aircraft had been used on two flights on 30 November prior to the accident. The first was from Sydney to Canberra in overcast and rainy weather. The flight conditions were slightly bumpy but not severe. Prior to the return flight to Sydney the aircraft was inspected. In the descent from Marulan there was "moderate turbulence". No defects in the aircraft were noted at any time.

Weather briefing prior to the subject flight

The flight and aerodrome forecasts given to the pilot by the domestic forecaster showed rain and scattered thunderstorms with moderate to heavy turbulence. The forecaster told the captain that a line of storms had been reported by Brookvale Radar at 1700 hours. The storms were 40 miles to the west and were apparently moving eastward. Because of the thunderstorm activity a SIGMET had been out all day. There were varying reports of turbulence including some which indicated a considerable amount.

Having prepared the flight plan, the captain presented it and discussed the weather with the Air Traffic Control Briefing Officer. The latter suggested that the captain, when taxying, should request the latest information from the tower on the approaching bad weather.

Prior to departure the captain did receive instructions and advice from the tower.

Loading of the aircraft

The aircraft's take-off weight was 51 976 lb, and the estimated landing weight was 50 096 lb. The permissible maximum take-off weight for the flight to Canberra was 59 380 lb. The aircraft's weight and centre of gravity were within limits.

Pre-flight inspections and checks

All pre-flight inspections and checks were satisfactorily completed.

Reconstruction of the flight

The events leading up to the accident were based on the communications exchanged between the aircraft and the traffic control officers at the aerodrome. This material is presented under "Circumstances".

The Wreckage - General

The absence of reports from people in the densely populated area over which the aircraft had been operating when communication was lost led to the belief that it had crashed into the sea. The morning of 1 December, a portion of the upholstery of a pilot's seat was found floating in Botany Bay, and it was identified as coming from a Viscount aircraft. Within two hours thereafter the partly submerged starboard outer wing was found in Botany Bay about 1 500 ft north of Bonna Point. A little later the main wreckage was located in 25 ft of water some 8 350 ft north of the point at which the starboard outer wing was found.

The location and condition of the wreckage when recovered were of considerable significance in aiding the investigators in their search for the cause of the disaster. The starboard outer wing was more or less intact but the main wreckage, which included the starboard inner wing, was greatly disintegrated. The condition of the wreckage, together with the fact that the starboard outer wing was found at such a distance from the main wreckage, led to the conclusion that the starboard outer wing had separated in flight and that it was the immediate cause of the disaster.

Examination of the wreckage

Experiments were carried out with a view to determining the height at which the separation of the starboard outer wing and tailplane took place. It was possible to estimate within reasonable limits the position from which each relevant piece of wreckage probably fell.

The conclusion was reached that the aircraft broke up in flight at an altitude within the range of 3 500 to 5 500 ft and at a distance between 5 000 and 7 000 ft due south of the main wreckage.

The experiments indicated that the break-up did not occur at the maximum height which the aircraft must be assumed to have reached in the course of its flight. At 1921:53 hours the aircraft reported its altitude as being 6 000 ft. Some twenty-seven seconds later it was still in flight and apparently not in difficulties. By that time, in normal flight its altitude would have been over 6 500 ft. It was assumed that it continued to climb for at least another minute and that it probably approached a height of 8 000 ft. None of the experiments undertaken in relation to the terminal velocity of pieces of wreckage suggested a break-up at such a height. Other factors also supported the view that the altitude at break-up was appreciably less than 7 000 to 8 000 ft.

The Chairman of the Board was of the opinion that the break-up did occur at an appreciably lower altitude than the maximum which the aircraft attained in the course of its flight.

The experiments supported two other conclusions which the Chairman accepted:

1. A flight path having a substantial northerly component at break-up is indicated.

2. The failure of the starboard wing and subsequent failure of the starboard tailplane occurred within a very short interval of time, and it appears that the aircraft travelled less than 1 500 ft between wing and tailplane failure.

Structural soundness of starboard outer wing

The wing was subjected to routine x-ray tests on 31 October and 1 November 1961. No abnormalities were found on those occasions.

Examination of the wreckage disclosed that the main spar lower boom of the wing failed in tension at a point about 6 ft outboard of the spar joint (wing station 323).

A portion of the lower spar boom containing the tensile fracture and a secondary crack running outboard from it was removed from the wing and was examined by the Defence Standards Laboratories, Sydney. The examination disclosed that the material of the boom complied with the appropriate specification, that the fracture resulted from tensile overloading, and that there was no evidence of pre-existing defects which could have caused premature failure. It was concluded that fatigue of metal and stress corrosion could be eliminated as causes of the failure and that the spar boom had been subjected to some load greater than that which it was designed to withstand. A piece of the lower spar boom immediately inboard of the primary failure was not recovered, but the Chairman did not believe that its recovery and examination would have affected these conclusions.

Capacity to withstand stress in flight

The elimination of structural defect of the wing as the cause of its separation from the aircraft leads naturally to the conclusion that the aircraft encountered some force in flight which was greater than it was designed to withstand.

The British Civil Airworthiness Regulations require, as a safety factor, that the strength of the structure shall be such that it is able to withstand loads one and one half times greater than those indicated by the gust envelope.

VH-TVC was constructed in accordance with these regulations.

After the accident Vickers-Armstrongs (Aircraft) Limited were asked to prepare a gust envelope applicable to a Viscount 720 aircraft with a weight of 51 990 lb, a centre of gravity at 0.1975 of the mean chord and flying at an altitude of 6 000 ft. These specifications correspond with the weight and centre of gravity of the subject aircraft on the night of the accident, and the altitude of the aircraft at 1921:53 hours. The gust envelope prepared by the aircraft company indicated that the maximum gust the wing would have withstood at a speed of 165 kt would have been in the order of 184 fps, and 166 fps at a speed of 180 kt. These gusts, far in excess of anything that has ever been recorded, were excluded as possibilities. By reference to the gust envelope it was demonstrated that at speeds below 260 kt it was not possible for the wing to fail due to gust loading alone. In these circumstances the aircraft would stall.

This examination of the capacity of the aircraft to withstand gusts at the speed at which it may reasonably be assumed to have been travelling confirmed that the wing did not become detached at the maximum height which the aircraft must be presumed to have attained.

Consideration of the capacity of the aircraft to withstand stress, loaded as on this night, indicated that at speeds below 260 kt the wing would not break on rapid application of the elevator. Furthermore, at 300 kt it requires a gust of at least 88 fps to break the wing and at 400 kt one of 54 fps. These combinations are such remote possibilities as to lead to the view that the wing failure was induced by something more than gust and speed alone.

It was concluded that when the aircraft was at its maximum altitude something happened to cause an upset as a result of which the control of the aircraft was momentarily lost. The loss of control led to a rapid involuntary descent and the speed of the aircraft, the attempts of the pilot to recover control, together with turbulence, imposed on the wing a load which it was not designed to bear. The attempts which the pilot would make to recover control could impose manoeuvre loads on the aircraft which, combined with gusts of moderate intensity would, at a speed in excess of 260 kt, result in failure of the wing. This conclusion was accepted by the Chairman of the Board of Inquiry as the most probable cause of the accident.

Cause of the accident

A number of happenings such as error, distraction or sudden incapacity of the pilot might have led to loss of control. However, the communications exchanged between the aircraft and the traffic control officers indicated that nothing out of the ordinary had occurred up to within three minutes of the accident.

Malfunctioning of the aircraft, its instruments or systems was also considered. Due to the destruction in the pilot's cabin, an effective check of the instruments was not possible. However, the aircraft's maintenance record immediately prior to the flight made this appear unlikely. There was no evidence of fire, explosion or lightning strike.

The weather conditions at and in the vicinity of Sydney aerodrome on the evening of 30 November showed that turbulence, at times of an extreme character, was being experienced by aircraft entering and leaving the field. Thunderstorms and lightning were prevalent and at the time of VH-TVC's departure the ceiling was about 800 ft. The actual conditions existing at 6 000 to 8 000 ft are not known. The presence of turbulence seems highly probable, and its presence to a degree which would render control of the aircraft difficult, was not impossible. Vivid lightning might have interfered with the pilot's vision.

Considering all the evidence, it was concluded that weather conditions constituted the most likely explanation of the initial departure of the aircraft from the flight path it was following a minute or two before the accident.

The final descent

The most reasonable explanation for it is that control of the aircraft was lost to a substantial degree when the aircraft was flying at an altitude over 6 500 ft and thereupon the aircraft descended rapidly at increasing speed. In such a situation the pilot would try by any means possible to recover control. The wing would thus be subjected to severe strain induced not only by the speed but also by loads imposed by the manoeuvre to regain control and by any turbulence it encountered. A degree of turbulence, which might prove crucial in these circumstances, is not improbable.

This sequence of events is not inconsistent with the estimated speed of the aircraft at the time of impact with the water, the time sequence of the entire flight, the lateral displacement of the aircraft in the latter part of its flight and with the conclusion that the flight path of the aircraft at that time had a substantial northerly component.

Examination of engines Nos. 2, 3 and 4 indicated they were operating at impact with propeller blade angles of 53°. From this it was concluded that if the engines were operating at the lowest revolutions for flight, i.e. 10 400 rpm, the speed of the aircraft at impact would not have been less than 300 kt. If they were rotating at a higher speed, the maximum being 14 500 rpm, the speed of the aircraft could have been as high as 400 kt.

It was then concluded that the failure of the starboard outer wing was probably induced by a combination of manoeuvre and gust loading when the speed of the aircraft was in excess of 260 kt.

Weather conditions

The questions arose as to whether -

1) the aircraft should have embarked upon the flight when it did; or

2) whether it should have been permitted to do so.

Considerable evidence was provided as to actual weather experienced in the vicinity of the airport between 1830 and 1930 hours. During that period storms moved across the area from west to east, accompanied at times by heavy rain, thunder and lightning. The actual ranifall at the airport was not as heavy as at other places in the vicinity. The rain gauges indicated heavy rain in or about the area in which the aircraft was cleared to fly at its departure time.

In communications passed from officers at the airport to one another and to aircraft in flight, there were frequent references to turbulence, occasionally severe, particularly to the west and south of the airport.

Many comments made regarding the weather indicated the existence of somewhat abnormal conditions. One pilot, who landed at 1925 hours, said the weather around the airport was the worst that he had ever seen.

The evidence of civilians confirmed the weather picture conveyed by other sources, i.e. that a storm of some intensity accompanied by thunder, lightning, somewhat unusual cloud formation, and in a number of places very heavy rain, passed over the area between 1900 and 1930 hours.

This general picture was substantiated by evidence of the Superintendent of the Development Section of the Bureau of Meteorology, who, following the accident, supervised an analysis of the weather prevailing in the Sydney area on 30 November 1961.

There were major thunderstorms in the area moving from west to east at 10 kt. They appear to have intensified and slowed down over the Sydney area. At least two major cells were in the thunderstorm that moved across Botany Bay. The rainfall at Cronulla was unusual for the Sydney area, and it was classed as very heavy.

It was found that at the time of the departure of VH-TVC the storm had passed over the airport and over the area in which it would fly via the 244 diversion. It was suggested that the centre of the storm had then moved over to the Kurnell area. The Chairman was of the opinion that at the time of the flight, thunderstorm conditions still prevailed over the area in which the aircraft was directed to fly. He believed that they were of such a character as to call for some consideration, at or about the time of departure, as to whether the aircraft should be permitted to fly along the route it was cleared to take prior to reaching Padstow.

Thunderstorms and their hazards

There have, in fact, been few accidents directly caused by thunderstorm activity. One fatality which bears a somewhat striking resemblance to the accident under consideration occurred to a Vickers Viscount at Maryland, U.S.A. on 12 May 1959.* The Civil Aeronautics Board concluded that an inflight disintegration of the aircraft was caused by aerodynamic loads imposed on the aircraft, which exceeded its design strength. The loads were generated by an excessive airspeed combined with turbulence and manoeuvre loads, following a loss of control in extreme turbulence. The evidence clearly showed the existence of large rapidly developing thunderstorms in the area of the accident.

Despite the frequent occurrences of thunderstorms in Australia, and the widespread extension of aircraft operations since the war, no accident to a commercial aircraft has been attributed to thunderstorms. Reports of turbulence encountered in thunderstorms sometimes of an extreme character are not infrequent, but the absence of accidents resulting therefrom indicates that pilots have been successful in avoiding or in countering their worst effects.

Knowledge on the subject of thunderstorms has been greatly enhanced in recent years by the publication in 1949 in the U.S.A. of a report of the Department of Commerce entitled "The Thunderstorm" The report, based upon a project which was scientifically designed to examine the nature of thunderstorm activity and its effects, described three stages of a thunderstorm's life cycle:-

1) the cumulus stage characterized by up draughts throughout the cell;

2) the mature stage characterized by the presence of both up draughts and down draughts at least in the lower half of the cell; and

3) the dissipating or decaying stage characterized by weak down draughts prevailing throughout the cell.

The development of the cycle to the mature stage is marked by the first precipitation from the storm and the down draught

* A summary of this accident appears in ICAO Circular 62-AN/57 (Aircraft Accident Digest No. 11, Summary No. 32).

thereby introduced gradually spreads throughout the cell. The point at which the strongest down draught occurs is closely associated with the heaviest rainfall. Also, the greatest turbulence in the thunderstorm is associated with the highest water concentrations at all levels within the storm.

The very heavy rain experienced in some quarters, at least in the area within the vicinity of Sydney Airport on the night of the accident, indicates the presence of conditions in which considerable turbulence would have been present.

The conditions in Sydney on the night in question indicated that the phenomena were somewhat complex in character and that turbulence of a significant degree might have been encountered in comparatively widely separate regions.

Draughts and gusts are the factors which affect the aircraft. The draughts "cause systematic changes in the altitude of the plane or carry it upwards or downwards" whereas gusts "cause pitching, rolling and yawing, and accelerations of the plane without a systematic change in altitude".

The clearance and its relation to weather conditions

The weather conditions under consideration are those likely to be encountered after entering cloud at the airport and in the flight to Padstow.

The route designated by the captain was the 222 track, the normal route to Canberra, which would have taken him across Botany Bay. However, this was changed at 1915 to the 244 diversion, which avoids Botany Bay. This route change was prescribed by the Air Traffic Controller because the 222 diversion was not available because of inbound aircraft. His choice was made without regard to the weather conditions, but based on information that another aircraft VH-TFF, due for departure at about 1950 hours would probably request the 244 diversion to 37 miles DME from Sydney in order to avoid a storm which would probably be located at that time on the 222 track. In the conditions prevailing on that night it could have little relationship to the conditions which VH-TVC might encounter between 1915 and 1930 hours in the immediate vicinity of the airport.

The senior approach controller gave the aircraft directions to follow on departing the airport. The aircraft was to continue the runway heading to 3 000 ft before turning left and was to pass over the field at 5 000 ft or above.

The Chairman believed that the choice of a left turn rather than a right turn had little to do with weather considerations. The directions as to altitude in the final take-off direction were, it was believed, dictated solely by traffic separation considerations and without regard to the weather conditions likely to be encountered at the altitudes indicated.

When an aircraft is at cruising altitude the pilot has much more room for manoeuvring than when flying in restricted air space allotted to him at an airport for take-off or landing. Regarding VH-TVC, it was given precise instructions as to the course it was to take on its departure from the airport. The opinion of the Chairman was that, in circumstances such as those existing that night, it is of the utmost importance that an aircraft should not be required to follow a precise path which may, when it is in relatively low altitudes, lead it into conditions in which extreme turbulence may be encountered. If it is impossible to say with reasonable certainty that such conditions will not be encountered along that path, a clearance for that path should not be given.

Responsibilities regarding weather

The immediate problem was related to weather conditions in the immediate vicinity of the airport.

The senior approach controller, with 15 years experience as an air traffic controller, was on duty at the relevant time. He was primarily concerned with landing and take-off. His conception of his duties was, it is believed, consistent with the information available to him. He had the Sydney Airport forecast covering his period of duty and also relied on his own observation of weather conditions. He had acted as radar controller for 3 hours to 1800 hours and was acquainted with such weather conditions as the radar disclosed during that period. He also had such information as came to him from aircraft approaching and leaving the airport. He had no information of conditions immediately above the airport at 5 000 ft, and it does not appear that he ever directed his attention deliberately to the question of what conditions might be encountered on the immediate flight path allotted to VH-TVC. In his view, the weather conditions were not such as to call for any consideration. When asked if he would be worried about turbulence 6 000 ft up, he said he would if he knew it were there.

The pilot may refuse to take off if he considers the conditions hazardous. The captain of VH-TVC showed no hesitation at any time in undertaking the flight as scheduled. He had been briefed on the conditions. He may have acquired further information concerning the conditions in the immediate vicinity at time of take-off or from interception of communications with other aircraft. Except for that information, he had no precise knowledge of the conditions he might encounter at 5 000 ft and above on the flight path prescribed by the clearance. The instructions received by him on take-off were not such as to be questioned, and he could assume that they would not lead him into danger. No blame attaches to him for accepting the clearance he was given, and there are no reasons for doubting that he followed the instructions which were given to him.

The senior operations officer on duty could have delayed the aircraft's departure pending weather improvement. His responsibility extended to weather developments in regard to the whole route. There may be a gap which is not expressly covered in the realms of responsibility between his duties and those of the senior approach controller.

His is a very responsible task involving the proper consideration of flight plans for many aircraft with varying routes and destinations. It might well interfere with the proper discharge of these duties if, in addition, he were, in circumstances such as existed at the airport on 30 November, required to ask himself at the moment of take-off of each aircraft whether it should take off at that instant.

The Chairman concluded that in the conditions prevailing, it did not appear to be the clear responsibility of any officer to deliberate on the question whether turbulence which might be encountered immediately after take-off by VH-TVC called for a different flight path or for some delay in the departure of that aircraft. It is not possible to say that the consideration of that question would in fact have led to alteration or delay, but it could have been expressly faced and answered.

Meteorological services

The regulations make it clear that the Director General can either arrange with the Director of Meteorology for specific weather advice or make any other arrangements necessary for the purpose.

The Board was concerned in this inquiry with the absence of significant meteorological information relating to the airspace over and in the immediate vicinity of the airport and with the absence of any equipment capable of providing this information. As for conditions in the immediate vicinity of the airport, from time to time the senior approach controller must rely principally on visual observations. When considering thunderstorms at an altitude of 6 000 ft or above in that vicinity at a time when the cloud base is as low as

800 ft and horizontal visibility reduced to a few miles, visual observation alone is far from adequate.

Radar

Weather radar will undoubtedly provide added protection to aircraft from the dangers associated with thunderstorms. The "Thunderstorm" report indicated that maximum turbulence and draughts are coincidental in space with regions of high water content, and consequently are within the area delineated by the radar echo.

Airborne radar

The Department of Civil Aviation was very actively considering this problem prior to 30 November 1961, and after that date took prompt action to make this equipment mandatory in major types of commercial aircraft on the Australian register. The deadline given for its incorporation was 1 June 1963.

It should not be assumed that the presence of radar equipment in VH-TVC would necessarily have enabled the pilot to become aware of any significant turbulence in time to avoid it. There are limitations on the effectiveness of airborne radar in operating on a course such as the aircraft was cleared to follow immediately after take-off. Radar would have provided the pilot with some valuable information as to weather conditions in his immediate path which would not be apparent from visual observation.

Ground radar

The "Thunderstorm" report showed that most of the turbulence in the storms flown through was confined to the area delineated by the radar echo presented on the 'scope of the control radar on the ground'.

The radar fitted at the time in the Sydney Airport Tower could be used as a weather surveillance aid. However, that was its secondary role. The wave length on which this radar operates and its fundamental design, which gives it optimum efficiency in its primary role, automatically renders it significantly less efficient in its secondary role. It does, however, with special manipulation, give an indication of areas of heavy rain and can thus be used as an aid to pilots in avoiding these particular areas. On the night in question it was used frequently for this purpose. Its use in detecting storm centres in the airspace above the airport and its vicinity is limited in three ways:

1) by its inherent design;

2) because it is used primarily for ensuring aircraft separation clearance; and

3) because a large sector of the sky from about 30° above the horizon is not "seen" or scanned by the radar. The 'blind spot' is 3 miles in diameter at 5 000 ft and increases proportionally at higher altitudes. It was the weather conditions in this very region which were of crucial importance to the flight of VH-TVC.

There is a type of ground radar designed specifically for weather detection and surveillance. This type is to be installed in the Sydney area on top of the new Commonwealth Building when this building is completed. The equipment is to be under the control of the Commonwealth Meteorological Bureau and to be used as an aid to general weather forecasting. If information from that installation were readily made available at the airport in circumstances of thunderstorm activity it would enable the identification of regions of high water content and thus indicate the presence of turbulence in the vicinity of the airport.

The events of the night of 30 November suggest that more precise up-to-the-minute information as to weather conditions in the immediate vicinity is required when thunderstorms prevail. If ground radar is to be used for this purpose the facility should be located at a point which will enable it to scan the airspace over, and in the vicinity of the airport. It would be necessary for suitable arrangements to be made whereby, in weather conditions involving possible hazards to aircraft in the vicinity of the airport, continuous observation of the moving weather pattern would be undertaken and constant information in relation thereto would be made available to air traffic controllers and pilots.

Was the clearance proper?

The immediate cause of the accident, established as a fact, was that the outer starboard wing separated in flight. It was apparent that turbulent weather conditions contributed in a marked degree to the accident. It would be wrong to conclude that the aircraft necessarily encountered turbulent conditions in flight, however it is the most probable initial factor. If this conclusion is sound, it follows that such conditions existed in the airspace above the airport or the immediate vicinity thereof.

The assessment of the actual weather conditions existing at the airport at the time of the aircraft's departure call for caution in dispatching aircraft into areas where significant turbulence might be encountered. In the conditions which prevailed the Chairman believed that takeoff path prescribed for VH-TVC was not one in relation to which it could be said with any degree of certainty that it would not encounter such conditions. It was dictated by the requirements of separation of aircraft in the immediate vicinity without any deliberate consideration of the conditions which the aircraft might encounter on the path chosen for it. Other courses might have been taken, such as a delayed departure, the departure course which was chosen by another captain on a flight to Dubbo, or temporary closing of the airport. The Chairman concluded that the path chosen for VH-TVC was not determined with sufficient caution and that the clearance given was not based upon sound operational judgement. However, he did not believe that the granting of the clearance arose from any culpable fault on the part of any air traffic controller.

Some factors which might have contributed in some degree to the course followed are:

a) disinclination to interfere with the judgement of pilots in operational matters.

A disinclination to interfere should not inhibit appropriate action to deter.

b) the dangers associated with thunderstorm activity.

The Chairman felt that air traffic control officers at the airport were not as conscious of the hazards presented by these storms as a perusal of the publication "The Thunderstorm" would have made them.

The transcript of air traffic control tape recordings

In reaching conclusions regarding the conduct of the ATC officers at the airport on the night of 30 November the Chairman relied on the record of contemporaneous communications which passed between the ATC officers themselves and between them and aircraft approaching or leaving the airport. This proved to be a valuable source of reliable evidence and a useful corrective to the necessarily somewhat less precise details of events which the officers were able to collect after six months.

All members of the Board had some misgivings in the course of the inquiry that the full text of the transcript of these communications was not made available to the Board and to counsel assisting the Board at the commencement of the inquiry and before the relevant departmental officers were examined.

It was felt that the entire transcript might well have been revealed in the report of the Director of Air Safety Investigation. These records did not receive the same meticulous examination by departmental investigators as was applied to other aspects of the accident.

Probable Cause

During a descent in excess of 260 kt, the pilot's actions, when trying to regain control of the aircraft, caused the aircraft to exceed its stress limits. This factor together with speed and turbulence caused the starboard outer wing to fail.

Recommendations

1. The functions of the approach controller in relation to hazardous conditions likely to be encountered by an aircraft in the vicinity of Sydney airport require more precise definition. In particular, when thunderstorm activity is present at or in the vicinity of the airport he should be responsible for determining whether a departure path designated for an aircraft is not such as to lead the aircraft into regions where severe turbulence may be encountered.

2. When thunderstorm activity is present, he should be provided with the best current weather information pertinent to the assessment of the changing weather pattern.

3. Ground weather radar will greatly facilitate the provision of pertinent data. Such a facility should be capable of effectively scanning the region above the airport and its vicinity. With this in view it is recommended that any such facility used should be situated at such a distance from the airport as will ensure its effectiveness in relation to that region. In conditions of thunderstorm activity, constant contact between such radar and the tower should be maintained.

4. These recommendations may have relevance to other airports.

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ICAO Ref: AR/749

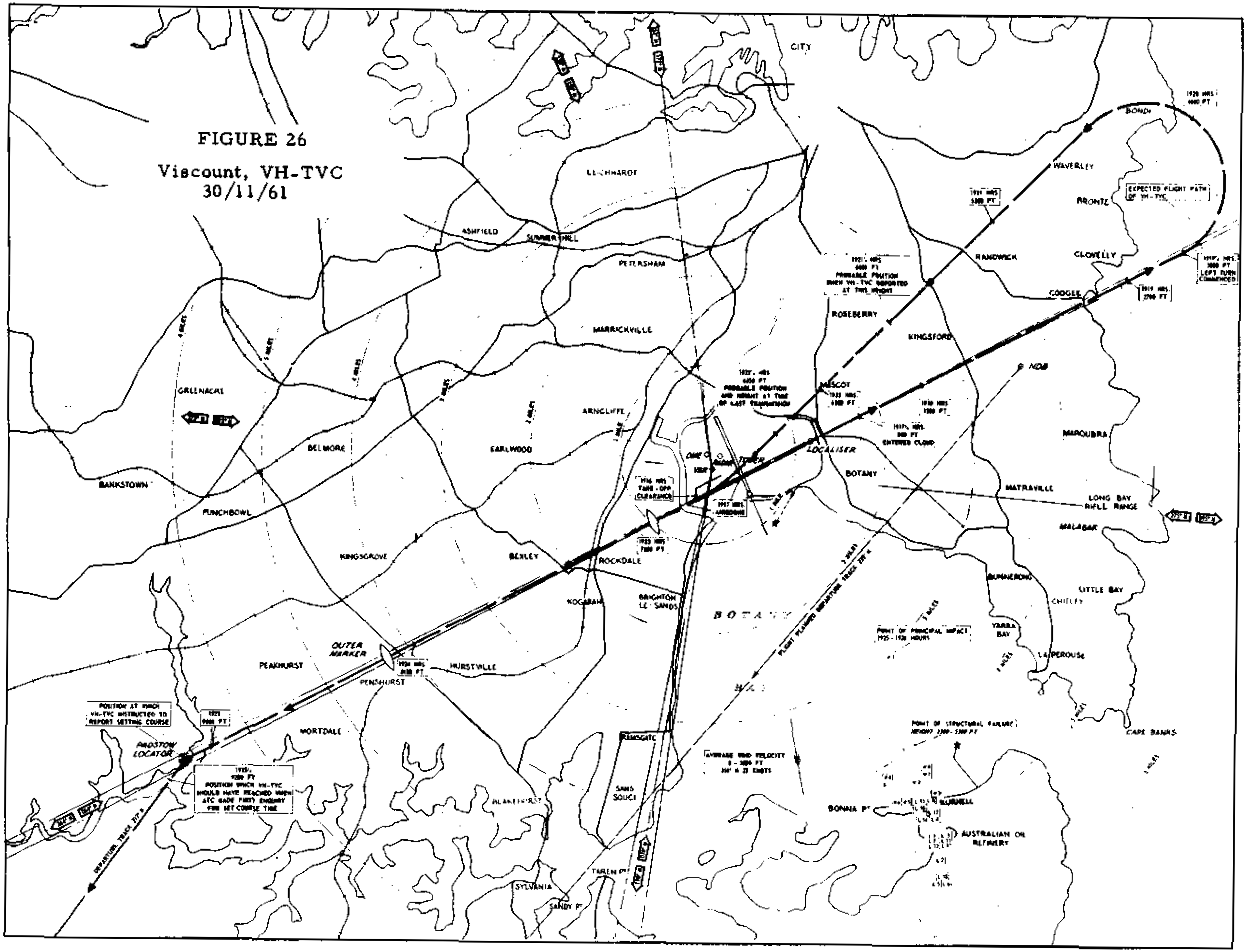

FIGURE 26

Viscount, VH-TVC
30/11/61

No. 53

Delta Air Lines, Inc., DC-7B, N 4882 C, accident at Imeson Airport, Jacksonville, Florida, 2 December 1961. Civil Aeronautics Board (USA) Aircraft Accident Report File No. 1-0036, released 13 July 1962.

Circumstances

The aircraft descended into trees about 8/10 of a mile short of runway 30 during a surveillance radar approach to that runway at 0938 hours eastern standard time. The aircraft was substantially damaged but was climbed and circled to land on runway 9. No. 2 propeller was feathered after striking the trees. A portion of the left flap was torn off and remained in the trees. There were no injuries to any of the 15 passengers or to any of the 5 crew members.

Investigation and Evidence

The Aircraft

It had flown a total of 14 097 hours, and records indicated that all maintenance had been current and satisfactory.

The Crew

The captain had flown 17 195 hours of which 6 852 had been in DC-7's. He held all requisite certificates and his last medical examination (first class) was current. He was also current on line and instrument checks. The co-pilot and engineer were also well qualified.

Weather

About seven minutes before the accident the U. S. Weather Bureau Station at the airport transmitted by Tel Autograph to the control tower the official observation of clear with 3 miles visibility, ground fog and smoke. Appended to this observation was a remark indicating that the visibility to the southeast was one mile. This remark was not given to the flight by the tower, and existing procedures did not make it mandatory for the tower to do so.

At the time of the accident the surface wind was only 1 kt from the northeast, and there was no reported turbulence or unusual winds at approach altitudes.

A paper mill, which produced dense smoke at the time of the accident, is located about one mile northeast of the airport. Its chronic heavy smoke has caused a continuing problem depending upon and varying with the wind. This situation is well-known to pilots using Imeson Airport. Both the captain and co-pilot of the subject flight had had years of experience operating into Imeson Airport.

The Flight

Flight 744 was scheduled from Miami, Florida, to Cincinnati, Ohio, with stops at West Palm Beach, Florida; Jacksonville, Florida; and Atlanta, Georgia. The trip to West Palm Beach was completed without difficulty, and the aircraft then took off for Jacksonville at 0825 hours and was cleared to the Atlantic Intersection via Victor 3 east to maintain 11 000 ft and to descend to 4 000 ft after passing Daytona Beach.

At 0928 the flight contacted Jacksonville Approach Control while over Atlantic Intersection in the holding pattern at 4 000 ft and was given "wind calm; altimeter 30. 36", and was cleared to Shiloh Intersection, to maintain 4 000 ft, and to depart Shiloh on a heading of 270° for a radar vector to the ILS approach course for runway 5. Jacksonville weather was given as "clear; visibility 3 miles; ground fog and smoke; wind calm."

At this time the flight offered to accept radar vectoring for a straight-in approach to runway 30 to expedite its landing. As the approach controller was occupied with other duties, departure control agreed to handle the Airport Surveillance Radar (ASR) approach. The co-pilot made the approach occupying the right seat.

The flight was instructed to turn to a heading of 340° and descend to 1 500 ft. The flight complied, maintaining a speed of 150 kt. The controller gave headings of 340 and then 320° to bring the flight to the extended centre line of runway 30. As the flight reached specific distances from the runway it was advised of the recommended altitudes. (These were - 5 miles - 1 500 ft; 4 miles - 1 200 ft; 3 miles - 900 ft; and 2 miles - 600 ft.) These recommendations were received.

The ASR minima for this approach are 400 ft altitude and one mile visibility. According to crew testimony, the flight was slightly above the recommended altitudes up to and including the two-mile position. At approximately this point dense smoke from a paper mill, mixed with ground fog, was encountered. The crew testified that they entered this smoke and fog at an altitude of about 680 ft.

The aircraft was not levelled off at the ASR minimum altitude and continued descending prematurely until the tops of trees were struck. The captain took control immediately before striking the trees, applied full power, and pulled the aircraft up. Loss of power and increase in oil temperature of No. 2 engine was followed by vibration and prompted feathering of the propeller. The pilot circled the aircraft visually and landed on runway 9.

The trees at point of impact are approximately 4 000 ft from the approach end of runway 30 and approximately 1 300 ft to the left of the extended centre line of that runway. The heading from the point of impact to the approach end of runway 30 is 320°. The published altitude of the airport is 52 ft MSL; the altitude of the approach end of runway 30 is 37 ft MSL; and the treetops were struck at a point 56 ft MSL, or 19 ft above the altitude of the approach end of the runway. A line of trees slightly higher than those struck extended across the direct approach to runway 30 about 1 000 ft farther on.

Flight crew's testimony

The crew's testimony pointed out that:

1) they saw portions of the airport shortly before entering an area of dense smoke and fog across the approach path;

2) they entered this smoke at about 600 - 700 ft altitude at a rate of descent of about 600 ft/min;

3) the two altimeters were not cross-checked during the approach, as required by company procedure;

4) the captain was not looking at his altimeter because he expected to break out into the clear at any second. The first officer and the flight engineer could not recall any altimeter readings.

The Altimeters

The possibility of altimeter malfunctioning was investigated, and it was found that none of the six pilot log sheets preceding this flight carried any suggestion of altimeter trouble, and both altimeters indicated properly upon leaving Miami and upon arriving at and leaving West Palm Beach. Tests after the accident showed that both altimeters were functioning within acceptable tolerances.

The Autosyn Compasses

Both were tested following the accident, and neither showed any significant irregularity.

Radar Malfunctioning

This possibility was also thoroughly looked into. Three hours after the accident the FAA flight-checked the Jacksonville ASR facility. Results indicated that the radar functioned properly, well within tolerances on both azimuth and range (direction and distance) during four test approaches, three to runway 30 and one to runway 9.

Conclusions

Apparently both pilots ignored the altimeters after the aircraft entered the smoke. The altimeter is the only source of altitude information available during this type of instrument approach because the radar controller does not have the means of determining altitude information.

Not only was the aircraft not levelled off at the 400-foot minimum flight level, but its rate of descent must have been increased. There is no other way to account for the great loss of altitude in such a relatively short distance. According to the captain, when two miles from the end of the runway and at an altitude of about 680 ft the smoke area was entered. The distance from that point to the point of impact, as flown, is about 8 200 ft. At the testified speed of 150 kt, an average rate of descent of about 1 200 ft/min must have prevailed. The aircraft was also markedly to the left of course just before impact despite continuing advisories to that effect.

The Board believed that the presence of smoke in the impact area may not be considered as extenuating because descent through the smoke was continued unnecessarily. The Board further believed that there was no misunderstanding by the crew as to the type of approach they undertook.

Probable Cause

The probable cause of this accident was the pilot's improper execution of an instrument approach.

Follow-up Action

Immediately following this accident, Delta Air Lines suspended the captain and co-pilot from flight status for 30 days. The FAA later suspended the captain from flight status for 60 days and the co-pilot for 30 days, making the company disciplinary action retroactively applicable to both.

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ICAO Ref: AR/720

No. 54

Líneas Aéreas de Nicaragua, S.A., Curtiss C-46, AN-AOE, accident at Las Mercedes International Airport, Managua, Nicaragua, 15 December 1961. Report released by the Ministry of War, Navy and Aviation, Nicaragua.

Circumstances

The aircraft departed Las Mercedes at 1100 hours on an IFR flight to Miami, Florida. Its only occupants were the captain and co-pilot. Shortly after take-off control difficulties were experienced. During an attempt to return to the airport, the aircraft stalled on final approach, went into a spin and crashed at an angle of 45 to 50° on its right wing. The aircraft immediately burst into flames, and the central section, fuselage and the portion of the wings which contained the fuel tanks, were destroyed. The two crew members were killed instantly.

Investigation and Evidence

The Aircraft

It had a certificate of airworthiness valid until 25 November 1962.

The Crew Members

Both pilots, on loan from LACSA Airlines of Costa Rica, were fully qualified and holders of Costa Rican airline transport pilot licences. The pilot-in-command and co-pilot had flown 12 135 and 5 066 hours respectively.

Reconstruction of the flight

Following a normal ground run the aircraft took off at 1100 hours. Almost immediately thereafter it made a left turn while climbing. Between the cross-wind leg and the start of the downwind leg, an emergency call was made by one of the crew members. Two crew aboard another aircraft in No. 1 take-off position later stated that they had heard three calls from AN-AOE indicating control difficulties. Both control tower operators said that they had only heard one call declaring an emergency. The aircraft continued around the traffic pattern at a height of about 500 ft during which time the pilot apparently experienced difficulty in controlling the pitch attitude of the aircraft. The aircraft turned onto base leg and final approach at what appeared to be a normal sinking speed. It proceeded at a height of about 200 ft up to a point approximately 200 yd from the end of runway 09, which it was approaching. At that point the aircraft assumed a sharp nose-up attitude until it reached a vertical position. Soon after it entered the nose-up attitude, full power was applied to both engines, and the undercarriage and flaps began to retract. The aircraft climbed about 400 to 500 ft above ground level, then stalled and went into a spin, spiralling almost vertically towards the ground.

Examination of the wreckage - Results

The wreckage examination revealed that the control cables were in normal and satisfactory working condition and were almost new. The elevator trimming was pushed forward fully to keep the aircraft's nose down. While flying the traffic pattern the aircraft showed a tendency to pull up, and when it slowed down for the landing the tail proved extremely heavy. The pilot when trying to correct this situation applied full engine power and retracted the landing gear in order to gain speed and obtain a response from the controls. He was not able to correct the tail's persistent tendency to become heavier, and had to make an almost vertical climb, whereupon the aircraft stalled and went into an uncontrollable spin at low altitude.

Conclusions reached following technical investigation

Immediately after take-off the aircraft adopted unusual flying attitudes, and while flying the traffic pattern it was observed to be continuously pitching. This is corroborated by the emergency call made by one of the crew. As the aircraft proceeded, with landing gear down, at a height of more or less 150 to 200 ft* from the approach end of runway 09 on final approach, the pilot reduced engine power in order to lose height and start the landing procedure. In this position it abandoned its descent path and slowly and progressively assumed a climb attitude, with definite signs of stalling.

Probable Cause

The accident was attributed to cargo displacement towards the rear of the aircraft during the take-off run or immediately after taking-off.

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* An omission seems to have occurred here. Translator.

No. 55

British European Airways Corporation, Comet 4B, G-ARJM, accident at Esenboga Airport, Ankara, Turkey, 21 December 1961. Report of the Accident Investigation Team established by order of the Ministry of Communications, Turkey. This report was also released by the Ministry of Aviation (United Kingdom) as C.A.P. 188.

Circumstances

The aircraft was on a scheduled flight from London to Rome, Athens, Istanbul, Ankara, Nicosia and Tel Aviv. From Istanbul the flight was operated by British European Airways on behalf of Cyprus Airways. The operating crew, employed by BEA, consisted of a captain and two first officers. Also aboard were four cabin staff employed by Cyprus Airways and 27 passengers.

The trip to Ankara was normal. The time between landing and starting engines at Ankara was 46 minutes during which light snow was falling. (At take-off the aircraft had a light covering of snow on the upper surface of its wings, however, this deposit had no bearing on the accident).

The radio-telephony tape recording showed that the aircraft taxied out along the short taxiway, then back-tracked up the runway to its take-off position on runway 21 at the intersection with the longer taxiway. The runway length available from this position was 9 027 ft. Take-off weight was 53 465 kg, i.e. 18 185 kg below maximum permissible weight or 1 085 kg below the regulated take-off weight. The take-off run as to distance and time was quite normal, as also were rotation and unstick. The first abnormality occurred a second or two after unstick when the aircraft rapidly assumed an excessively steep climbing angle. One witness put the angle achieved as about twice the normal, another as 45° to 50°. There was also evidence from witnesses of a wing drop and of variations in the engine noise during this climb. The aircraft stalled with the left wing down at a height of about 450 ft then sank to the ground in a relatively flat attitude. The accident site was 1 600 m and on a bearing of 214°T from Esenboga Tower. The accident occurred at 2143 hours GMT.

G-ARJM was almost completely destroyed by impact and fire. All 7 crew and 20 passengers were killed. Six passengers were seriously injured.

Investigation and Evidence

The Crew

The operating crew held valid licences. The captain had flown a total of 13 240 hours including 785 hours on Comet aircraft.

The Aircraft

It had valid certificates of airworthiness, registration and maintenance and had been maintained in accordance with the approved maintenance schedule. The aircraft's weight and centre of gravity were within the permissible limits.

There was no record of any defect or repair during the recent operation of the aircraft which could be considered to have any bearing on the accident.

Weather

At 2150 hours GMT (i.e. 7 minutes after the accident) the weather conditions were -

> surface wind: calm; visibility: 2 km; weather: snow; cloud 6/8 stratus at 600 ft; 6/8 stratus at 600 ft; 6/8 Ns at 2 500 ft; 8/8 As at 7 000 ft; temperature 0°C.

Navigational Aids

All the ground navigational aids and radio-telephony channels were checked after the accident and were found to be functioning satisfactorily. The ILS was not operational and had been notified as such by Notam.

The Accident Site

The ground at the scene of the accident sloped up at an angle of 2 or 3°, and the aircraft struck on a heading of 180°M without yaw with the left wing down and the fuselage parallel to the ground. The nature of the damage, the marks on the ground and the disposition of the wreckage all indicated that the aircraft had a low forward speed coupled with a high rate of descent at the moment of impact.

Technical Examination

External examination of all flying control surfaces revealed no evidence of any damage or abnormality. No evidence was found of any control or electrical failure or emergency (such as pilot's seat slippage or fouling of the control column) nor was there any evidence of fire or structural failure prior to the impact with the ground.

Flaps were in the take-off position (i.e. 20°) dive brakes were in, and the landing gear "down" and locked. No evidence of any malfunction of the engines was found, however two of the three booster pumps in each of the No. 4 fuel tanks should have been switched on for take-off, but all were found switched off.* This failure to follow the fuel management drill may have brought about fuel starvation of the two outer engines when the climb became steeper than normal, but it did not contribute to the accident as a stall was by then inevitable and any subsequent recovery impossible because of lack of height.

The captain's director horizon was examined by the Royal Aircraft Establishment, Farnborough (England). It was found that the pitch pointer "spider" was being obstructed by the upper left dial mask screw, which had unscrewed sufficiently for its head to be in the plane of movement of the "spider". To attain this position, the screw had to be three and a half turns from the fully tightened condition. Examination of the screw head, the washer and the surface around the screw hole in the dial mask flange showed that the screw had not been tightened down fully during the assembly of the instrument. Local disturbance of the paint of the flange suggested that the assembly was tightened to within about half a turn from the fully tightened state.

Checks have shown that complete obstruction to "spider" upward movement would have first occurred when the screw was one full turn from the condition as found. At this time the "spider" had to be below the screw position and since the "spider", and hence the pitch pointer, gives a direct indication of aircraft pitch attitude, then the aircraft had to be below 7-1/2° of pitch (the aircraft angle equivalent to the obstructed position of the pitch pointer).

The instrument had been installed in the aircraft during construction of the latter and there had been no reports of any malfunctioning of it since 12 October 1961 when the left vertical gyro was changed.

The inspection records showed that this instrument had been inspected at all the requisite stages of manufacture. In the inspection procedure laid down by the manufacturers there is a specific item "check that MAIN MASK fixing screws are secure".

Analysis

The position of the impact point in relation to the unstick point, the fact that the aircraft did not begin to assume an abnormally nose-up attitude until a second or two after unstick, and the fact that the landing gear was not selected up, together gave a strong indication that something

* Note:- The switching on of two booster pumps in each No. 4 tank has to be done immediately before take-off. The drill cards were not adequate to ensure that this was done.

unusual occurred immediately after unstick. From unstick the aircraft assumed an increasingly steep angle which reached about 45°, that is about twice the normal, before it stalled. The exact sequence of events and the actions of the crew during the brief flight cannot be established. The only fault in the aircraft and its equipment that could account for the abnormally steep climb was the obstruction of the pitch pointer in the captain's director horizon. It is believed probable that the captain looked at this instrument for attitude information immediately after unstick and seeing the pitch pointer only about half way to the normal nose-up position on the pitch scale, applied more up elevator. Although this would have at once steepened his climb, there would have been no indication of it from the pitch pointer. It has been calculated that the time interval between unstick and the stall was approximately 8 to 10 seconds.

The evidence suggests that the outer engines may have begun to fail due to fuel starvation after the angle became excessive. But as the fuel starvation would have occurred very close to the stall and when recovery was impossible in the height available, it is not considered a contributory cause of the accident.

In the event that the co-pilot was at the controls for the take-off the accident could then have been brought about by the captain either telling the co-pilot to increase the climb or himself pulling back the control column, basing his action upon a glance at his own director horizon.

Safety harnesses of the crew

Only the lap straps of the crew's safety harness were fastened at impact. It is probable that the three pilots would have survived had they used the shoulder straps of their harnesses.

Probable Cause

The probable cause of the accident was the obstruction of the pitch pointer in the captain's director horizon which led him to make an excessively steep climb immediately following unstick.

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ICAO Ref: AR/736

No. 56

Kodiak Airways, Inc., Grumman G-21A, N 1503V, accident shortly after a water take-off from Old Harbor, Kodiak Island, Alaska, on 24 December 1961. Civil Aeronautics Board (USA), Aircraft Accident Report, File No. 1-0041 released 18 April 1963.

Circumstances

The aircraft, a Grumman G-21 (a twin-engined six-place amphibian) departed Kodiak at approximately 1000 hours Alaska standard time on a regularly scheduled passenger, mail and cargo flight with planned en route stops at Old Harbor, Kaguyak, Lazy Bay, Moser Bay, Olga Bay and return to Kodiak. No passengers were carried on the flight to Old Harbor. The flight, conducted under day visual flight rules, was routine in all respects, and a normal water landing was made at Old Harbor at about 1040 hours. Four passengers and about 40 lb of cargo were then loaded aboard. At approximately 1050 hours, the aircraft started its take-off in a southwesterly direction. The initial take-off from Old Harbor appeared to be normal, but immediately after lift-off the aircraft was observed to descend, strike the water, and climb steeply. The aircraft then pitched down abruptly and crashed, with the nose and tail breaking off at impact. One passenger seated in the cockpit was thrown into the water and drowned. The pilot, who was also thrown from the aircraft, and the remaining 3 cabin passengers, who exited through the main cabin door, were rescued in a few minutes. The aircraft was totally destroyed at impact and sank in 75 ft of water.

Investigation and Evidence

The Aircraft

The last major inspection (100 hours) was accomplished on 11 December 1961, and the aircraft was then flown 21 hours prior to the accident. The aircraft had a total flying time of 8 694 hours.

While at Old Harbor the parking brake slipped, and the aircraft pivoted 5 - 6 ft to the left where the tailwheel of the airplane became entangled in the tubular steel passenger loading ladder, which had been placed to one side. This ladder is 3 ft long, 13 inches wide, and weighs 4-1/2 lb. The pilot then assisted the passengers out of the airplane and, with the help of bystanders, removed the ladder from beneath the aircraft. Since a previous incident had punctured the hull, the pilot crawled underneath the aircraft to inspect for any damage which might have been caused by the ladder. A visual inspection by the pilot did not reveal any apparent external structural damage; however, no internal inspection of the hull was conducted. A routine walkaround inspection of the aircraft was carried out. No discrepancies were found. There was no external ice and the hull drain plugs were secure.

A complete preflight check, including drainage of the bilge, was performed. The aircraft was found to be airworthy, within weight and balance limits, and was properly dispatched from Kodiak.

The Pilot

He held a valid commercial pilot's certificate with airplane multi-engine land and sea, airplane single-engine land and sea, and flight instructor ratings. As of the date of the accident (24 December 1961) he had accumulated approximately 6 809 hours, of which approximately 1 160 were in amphibious aircraft. He was given approximately 26 hours of training in the G-21A aircraft before being checked out in this aircraft by Kodiak Airways, Inc., and had flown between 100 - 200 hours in the G-21A prior to the accident.

Weather

According to the pilot, on departure from Old Harbor the conditions were: clear and sunny, wind calm to 3 or 4 kt, water calm. The water was not glassy, but there were a few ripples on the water surface.

The Take-off

The statements of the pilot, passengers and groundwitnesses were analysed. Initial take-off was normal and while accelerating shortly thereafter under full power to climb airspeed the aircraft struck the water in a shallow descent, climbed back into the air in a nose-high attitude and stalled. After pitching forward, the aircraft struck the water in a nose-low attitude. The nose of the aircraft separated at impact. The tail section was severed from the main fuselage, but remained attached by several control cables.

Possibilities considered regarding the manoeuvre executed by the aircraft

The following possibilities were looked into as possible causes of the aircraft's loss of longitudinal control:

1) failure of the elevator control system;
2) water in the hull creating an excessive aft centre of gravity movement; and
3) a high-speed, low-angle porpoise.

Failure of the elevator control system

Examination revealed that the two pairs of elevator and rudder control cables run through common fairleads and adjacent pulleys from station No. 11, where the nose section separated, to station No. 32 near where the tail section broke off. At station No. 29, where four pulleys permit these cables to make a 90° turn upward, two tailwheel retraction cable pulleys are also adjacently installed. Here, one axis bolt serves the two rudder pulleys, and another axis bolt the four pulleys through which the elevator and tailwheel retraction cables run. There was no metal fatigue found in these assemblies, and it was determined that these two axis bolts, with the six pulleys, were torn simultaneously from their brackets as a result of an instantaneous overload of the cables acting on the pulleys. It is believed that this failure was due to impact forces which occurred when the tail section broke off at station No. 31. Moreover, all fractures in the flight control and tailwheel retraction systems were determined to have been caused either by impact forces or salvage operations. Having also determined that the power plants were operating properly, it is reasonable to conclude that the airplane was mechanically capable of normal operation up to the time of impact.

Water in the hull creating an excessive aft centre of gravity movement

Proper loading of an aircraft will place the centre of gravity within specified limits. As the centre of gravity moves beyond the aft limit, the control forces tend to become zero with respect to the control surface deflection. When the centre of gravity continues rearward to and beyond the point of neutral stability, the aircraft becomes increasingly longitudinally uncontrollable. The absence of resistance to control movement experienced by the pilot could be the result of the above condition.

However, there are several factors which serve to eliminate this possibility. A routine preflight draining of the hull was conducted prior to departure from Kodiak. The inspection of the hull by the pilot prior to departure from the beach at Old Harbor did not reveal any damage. A normal lift-off and short interval of normal flight preceded the accident, and close examination of the wreckage thereafter verified the watertight integrity of the hull prior to impact.

High-speed low-limit porpoising

The most probable explanation of the maneouvre described is that following take-off the pilot intended to level off at low altitude in order to gain airspeed prior to the climb. The pilot testified that in Alaska this is done to avoid possible turbulence. However, instead of maintaining altitude the aircraft entered a shallow descent. The pilot failed to recognize the gradual loss of altitude and the resulting first contact with the water as described by witnesses and a passenger. The above circumstances would result in the aircraft striking the water in a slightly nose-low attitude, which would produce a phenomenon known as high-speed low-limit porpoising. This condition of flight peculiar to flying boats has been the subject of several studies by various interested agencies. A consensus of their findings is that when a flying boat contacts the water at a shallow angle of incidence, with an airspeed in excess of that normally required for landing, the nose will initially be sucked deeper into the water. Then as the entire bow area of the hull is submerged the hydrodynamic forces will reverse and repel the aircraft with a violent thrust out of the water. This nose-up movement will increase the angle of attack and result in increased lift from the wing. The violence of the porpoise will be in direct proportion to the trim angle and airspeed of the aircraft at contact, and it will occur regardless of any action on the part of the pilot. Recovery must be effected during the ascent, or a stall will occur and the cycle will repeat itself with increasing violence until either structural failure occurs, or the aircraft dives. Diving is the result of the nose completely submerging, and the aircraft flipping on its back and/or sinking.

The following is quoted from report No. 1025 of the Aviation Design Research Section, Bureau of Aeronautics, Navy Department, which is a survey of landing and take-off accidents of flying boats during a 22-month period:

> "High Speed Low Angle Porpoising
>
> Provided the aircraft does not dive, if it is landed at too high a speed, and too low an attitude, the first half cycle of a violent low angle porpoise is very liable to occur. If the pilot is alert ... he may be able to recover at the top of the cycle. If he is not, or the airplane won't respond to the controls it may hit again to start another cycle or it may dive in."

The appropriate recovery procedure from this manoeuvre requires full power throughout the recovery effort, and involves flying the aircraft out of the ascent phase of the cycle.

Report No. 1025 further states, "There were three incidents involving diving in smooth water, one of which followed the first cycle of high-speed low-angle porpoising. The fourth case of diving occurred in moderately rough water. In all these accidents the aircraft were completely demolished. In one instance the diving started at about 85 kt, which is some 25 kt above the stalling speed." This section referred specifically to the JRF-4 and 5, which is the U.S. Navy designation for the Grumman G-21A. The report also included a drawing to differentiate between diving and high-speed low-limit porpoising. The sketch is included with this summary as Figure 27.

The sequence of events described by the witnesses and passengers, and which, with the exception of the first high-speed touchdown in the water, is consistent with the pilot's testimony, corresponds precisely to the sequence of events associated with high-speed low-angle porpoising. While this accident occurred on take-off, the pilot's failure to recognize the subsequent loss of altitude, resulted in the aircraft striking the water under conditions nearly identical to those of an improperly executed high-speed low-trim landing. In this instance structural failure occurred at impact after the first cycle.

The pilot did not realize that the aircraft descended into the water and had entered a porpoise, but erroneously assessed the resulting actions of the aircraft as having been generated by elevator control system failure. Accordingly, the corrective actions taken by the pilot, such as the reduction in power and the use of full flaps, were completely incompatible with the actual condition, thus eliminating the little opportunity he had to effect a safe recovery.

Probable Cause

The probable cause of this accident was an improperly executed take-off which resulted in an inadvertent descent into the water. This produced a high-speed low-angle porpoise from which the pilot was unable to recover.

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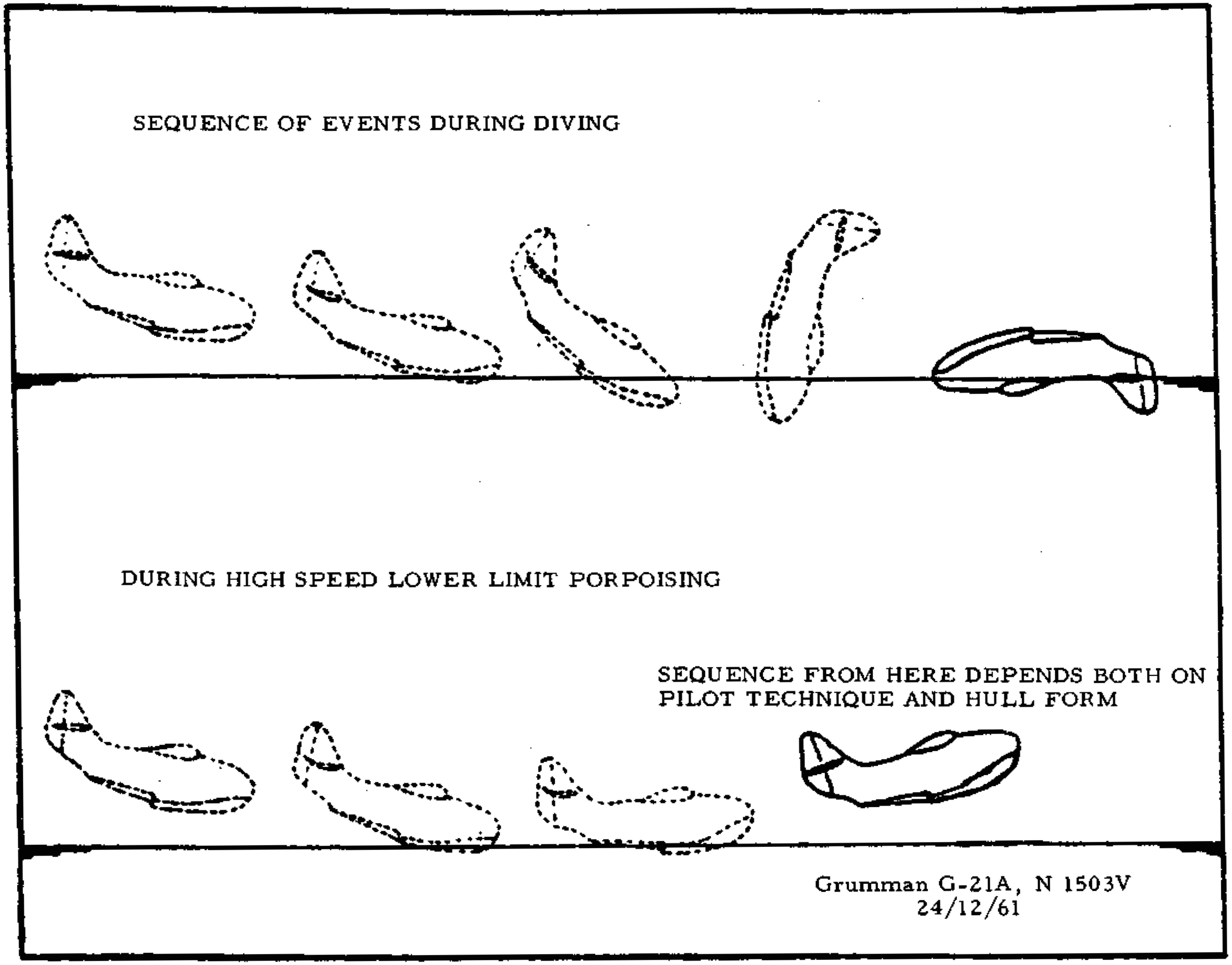
ICAO Ref: AR/751

FIGURE 27


SEQUENCE OF EVENTS DURING DIVING
DURING HIGH SPEED LOWER LIMIT PORPOISING
SEQUENCE FROM HERE DEPENDS BOTH ON PILOT TECHNIQUE AND HULL FORM
Grumman G-21A, N 1503V
24/12/61

No. 57

United Arab Airlines, Comet Mk.IV-C, DH-106, SU-ALL, accident at Geneva-Cointrin Airport, Switzerland on 27 December 1961. Report of the Federal Investigation Commission on Aircraft Accidents as released by the Federal Air Office, Switzerland.

Circumstances

Flight 780 was scheduled to depart from London at 0845 hours GMT and land at Geneva at 1215 hours local time. It left London with a crew of 9 and 7 passengers. Prior to the ILS ground-controlled approach to runway 23 at Geneva the control tower provided weather information and the following details regarding the condition of the runway: "partially covered by 1-1/2 cm of hard snow; usable width 40 m; wall of snow 80 cm high on the right side of the runway; snow removal in progress; normal braking action." The aircraft approached in a normal let-down but deviated somewhat to the right of the centreline; two miles from touchdown it was 300 m to the right of that line. The pilot, having been warned of this deviation, corrected it and aligned the aircraft one mile from the runway. Touchdown was at 1111 hours. The pilot estimated that touchdown was made about 350 m from the runway threshold. Six hundred and fifty metres from the threshold the aircraft struck a wall of snow on the left-hand side of the runway twice lightly with the left outer edge of the landing flap. Eight hundred and fifty metres from the runway threshold it ran over the wall of snow at an angle of 20° and with the nose so high that the nosewheel left no visible trace in the snow wall. About nine hundred metres from the runway threshold the aircraft left the runway for about 200 m and reached taxiway 7, about 1 050 m from the runway threshold, 40 m from the edge of the runway. At that point the pilot was able to regain the runway on the right where he finally stopped, 1 200 m from the threshold. No one aboard was injured. However, the aircraft received major damage.

Investigation and Evidence

The Aircraft

It was manufactured in 1961, and had an airworthiness certificate. The maximum authorized en route weight for the aircraft was 73 500 kg and for landing 54 430 kg. Its weight at the time of the accident was believed to be below the permitted maximum. The centre of gravity was unknown.

There was no indication of any technical defect in the aircraft and, in particular, no defect in its brakes or controls.

The landing flaps end 6.2 m from the wing tips. The trailing edges come down beyond the outside wheels at a height varying from 126 to 53 cm from the ground.

The Crew

The pilot-in-command holds a first class airline pilot's licence dated 19 January 1961. He has flown a total of 15 900 hours of which 1 030 hours were on this type of aircraft. During the 90 days prior to the accident he had flown 200 hours.

Other crew members aboard were 2 co-pilots, a flight mechanic and 5 stewards.

Runway 23

Runway 23 is 3 900 m in length, 50 m wide and has a uniform lateral drainage slope of 1%. Five hundred and fifty metres from the runway threshold there is an underpass. About 1 100 m from the threshold, taxiway 7 branches off at an angle of 30° with the runway.

The runway lights are situated 150 cm outside the edges of the runway, and they are 80 cm high.

The usable width of the runway, i.e. 40 m, was considered sufficient for a safe landing.

Meteorological conditions

The day before the accident it had rained in Geneva up to 0700 hours. Between 0905 and 1645 hours there had been intermittent, extremely heavy snowfalls, then from 1845 to 2015 hours it rained again.

During the night of 26 December and the morning of 27 December there was no further precipitation. The air temperature remained constant through the night at +1°, while the thermometer, 5 cm above the runway, indicated -0.6°. The humidity was 95% at 0900 hours.

Shortly before 1100 hours the following weather report was issued: visibility on the runway 1 400 m, cloud patches 3/4 cover at 1 500 ft and 6/8 at 2 500 ft, temperature +2°, condensation point about +1°, atmospheric pressure 1002 mb.

Discussion

The accident would not have happened if the airport or, at least, the runway had been closed until the removal of the snow walls had been completed. However, the circumstances did not necessarily warrant such action.

It could not be established whether the report given to the pilot as to the state of the runway in relation to the braking action was justified especially concerning conditions above the underpass.

The snow wall 80 to 90 cm existed on both sides of the runway, however, the report made to the pilot at 1058 hours only mentioned a wall of snow on the right side.

The first tracks worth taking into account are those of the main landing gear on the underpass (in the centre of the runway) and the two tracks of the wing on the left-hand wall of snow, about 600 m from the runway threshold. It is possible that the aircraft had already touched down before making these tracks.

An observer at the runway threshold was unable to see the aircraft at the moment of touchdown because of mist. At the time of touchdown the aircraft was not yet stabilized along its longitudinal axis.

The impact with the wall of snow could be attributed to the fact that the aircraft had landed on the runway slightly on a slant or skidded, with the result that it left the centre of the runway.

A satisfactory reconstruction was not possible.

It remains questionable whether the movement to the left was initiated by a lateral component or was the result of a braking effect of undetermined origin.

The Commission could not give an opinion on the exact effect produced by the tunnel passing under the runway and the 1% lateral slope of the latter.

In conclusion, it may be said that the margin of safety offered by the state of the runway used was to some extent diminished by weather conditions so that there was not sufficient compensation on the one hand for the lack of precision in the information furnished to the pilot and on the other hand for the slightest deviation from ideal landing requirements.

The Investigation - General Comment

The damage to the aircraft did not at the outset seem as serious as it actually was. As a result, the authority for inquiries into aircraft accidents was not advised until 10 January 1962 and five days later the order was given to proceed with the preliminary investigation.

At the time of the inquiry the crew were no longer available to give information.

Also, important factors in questions put to the owner of the aircraft later on remained unanswered. The inquiry was thus rendered very difficult through this delay and the insufficiency of the evidence.

Probable Cause

The pilot lost control of the aircraft, and it left the runway after touchdown, probably because of unfavourable landing conditions.

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ICAO Ref. AIG/ACC/REP/GEN/No. 15 - Switzerland.

PART II

AIRCRAFT ACCIDENT STATISTICS 1961

INTRODUCTION

GENERAL COMMENTS

1. This section of the Aircraft Accident Digest No. 13 contains a detailed analysis of the statistics for the year 1961, as well as selected data for the years 1925 to 1962 inclusive. Figures for the years subsequent to 1951 were obtained largely from the ICAO Air Transport Reporting Forms G (Aircraft Accidents; see pages 322 and 323) filed by contracting States. In order to arrive at as complete a picture as possible of accidents in which public aircraft were involved, other sources had to be used for those countries which have not yet filed the required reporting Form.

2. The statistics shown are the best available to date but are subject to adjustment when additional Forms G are filed.

DESCRIPTION OF TABLES AND CHART

3. CHART Passenger fatality rate and traffic on scheduled air services 1945 - 1962.

TABLE A-1 Accidents with passenger fatalities on scheduled air services 1925-1962.

TABLE A-2 Number of fatal accidents, passenger fatalities and survivors turbo-jet, propeller-driven (turbine and piston) aircraft - scheduled air services 1960 - 1962.

4. Three tables are given for the year 1961. The accident data has been recorded under the country in which the airline which suffered an accident is registered, thus not under the country where the accident took place. These three tables give the following information:

TABLE B Passenger fatalities occurring on scheduled international and domestic operations.

TABLE C Aircraft accident summary of all operators engaged in public air transport.

TABLE D Aircraft accident summary of all operators engaged in public air transport by type of operation.

SAFETY RECORD

5. The passenger safety record for the scheduled air services of the world (international and domestic) showed a further improvement in 1962 as compared with 1961, the fatal accident rate reaching the record low figure of 0.59 fatalities per hundred million passenger-kilometres (0.94 per hundred million passenger-miles). The reduction from the 1961 figure of 0.69 (1.11) is not in itself statistically significant and could

be due to chance, but taken in conjunction with the long-period downward trend in the rate since the War (the figure was 2.35 (3.98) in 1946 and 3.11 (5.17) in 1947), the 1962 preliminary figure may be regarded as indicating a continuance of the general trend of steady improvement (see Table A-1). The actual number of fatal accidents on scheduled air services was 27, 2 more than the 1961 figure of 25, but the average number of fatalities in each fatal accident was smaller and total passenger fatalities were less, 763 in 1962 as compared with 805 in 1961 (these figures do not include charter or special flights of scheduled airlines). This latter result was not due to anything special in 1962 but rather to an exceptionally high figure of fatalities per accident in 1961, owing to several catastrophic accidents where large aircraft crashed with the loss of all on board. The number of crew killed in the 1962 scheduled service accidents was 137, bringing the total fatalities up to 900.

6. The jet airliners had an accident record relative to their volume of flying approximately the same as propeller-driven (piston) aircraft, being responsible for about half the passenger fatalities (see Table A-2) and about half of the passenger-kilometres flown. DC-3 aircraft were responsible for 7 out of the 27 fatal accidents, which is approximately proportionate to the number of DC-3's in regular use and implies an accident rate similar to that of other aircraft: a considerable achievement for an aircraft that tends to be used predominantly on the less developed routes with relatively short stages.

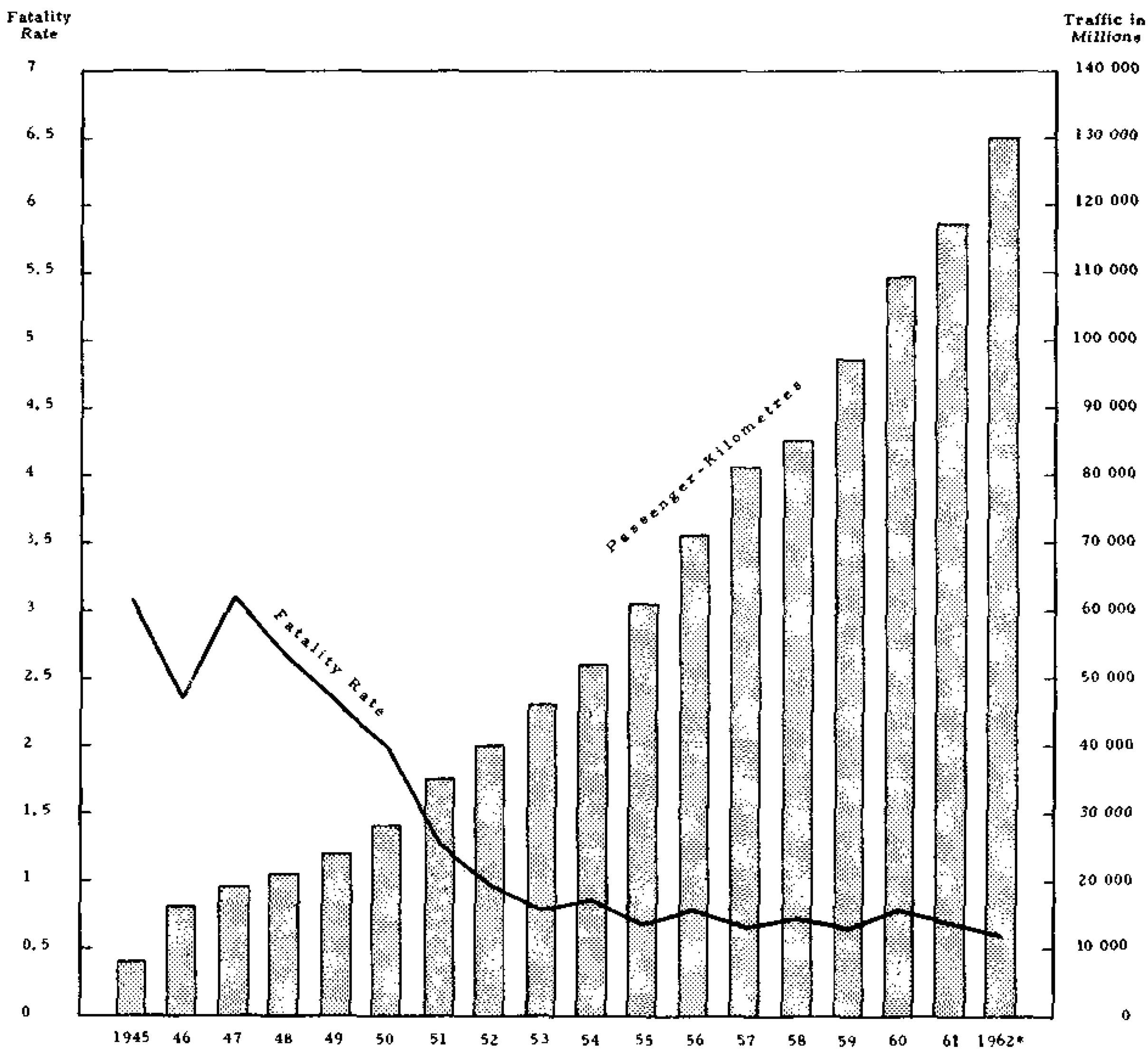
7. As always, little information is available concerning non-scheduled service accidents but it seems clear that the non-scheduled safety record in 1962 was once again considerably worse than that of the scheduled services. The preliminary reports show 450 passengers killed in 18 non-scheduled service accidents as compared with 765 passengers killed in 28 accidents on scheduled services, with probably 20 times the volume of operations. Some of the accidents shown in preliminary reports as being on non-scheduled flights may prove subsequently to have been on scheduled services, but it seems probable that the fatal accident rate for passengers on non-scheduled flights is of the order of 10 times that on scheduled services. The types of accident described in the preliminary reports for the non-scheduled sector appear to be broadly similar to those occurring on scheduled services. The difference is that they occur much more frequently in relation to the number of kilometres flown.

8. The majority of the investigations into 1962 accidents have not yet been completed, so that nothing can be said concerning their causes. It may be worth noting, however, that in the description of what happened in each accident, taken from the preliminary reports, expressions such as "hit mountain" or "hit high ground" occur with considerable frequency. There were 9 such cases in the preliminary reports of the 27 fatal accidents in 1962. It would seem possible that, whatever the basic cause may be, a substantial proportion of fatal accidents on scheduled services happen because, for some reason or other, the pilot does not realize how close he is to the ground -- suggesting that some kind of special warning of the closeness of the ground, separate from and additional to existing instruments, might at least in some cases be of value. Accidents containing this element do not seem to be more frequent now than in the past, in relation to the volume of flying, but the incidence of other types of accident has been reduced.

Paragraphs 5 - 8 reproduced (with minor changes) from Doc 8317. Annual Report of the Council to the Assembly for 1962.

PASSENGER FATALITY RATE AND TRAFFIC

SCHEDULED AIR SERVICES 1945 - 1962*



NOTES: Fatality rate equals number of passengers killed per 100 million passenger-kilometres flown.

* Preliminary.

TABLE A-1

ACCIDENTS WITH PASSENGER FATALITIES ON SCHEDULED AIR SERVICES

1925 - 1962

YEARS	Accidents in which Passengers were killed: Number of Accidents on Pass. Carrying Aircraft	Accidents in which Passengers were killed: Number of Passengers Killed	Passenger-Kilometres Flown (millions)	Fatality Rate per 100 million Pass-Kms.	Millions of Pass-Kms. per Fatality	Aircraft Hours Flown (millions)	Fatal Accidents per 100 000 Aircraft Hours
YEARLY AVERAGE							
1925 - 1929	...	36	130	28	4	...	...
1930 - 1934	...	80	445	18	6	...	...
1935 - 1939	...	133	1 475	9	11	...	...
1940 - 1944	...	114	3 795	3	33	...	...
YEAR							
1945	...	247	8 000	3.09	32	2.5	...
1946	...	376	16 000	2.35	43	3.8	...
1947	...	590	19 000	3.11	32	4.2	...
1948	...	543	21 000	2.59	39	4.6	...
1949	...	556	24 000	2.32	43	4.8	...
1950	27	551	28 000	1.97	51	5.0	0.54
1951	20	443	35 000	1.27	79	5.6	0.36
1952	21	386	40 000	0.97	104	6.0	0.35
1953	28	356	46 000	0.77	129	6.4	0.44
1954	28	447	52 000	0.86	116	6.7	0.42
1955	26	407	61 000	0.67	150	7.3	0.36
1956	27a/	552	71 000	0.78	129	8.0	0.34
1957	31	507	81 000	0.63	160	8.7	0.36
1958	30	615	85 000	0.72	138	8.8	0.34
1959	28	611	97 000	0.63	159	8.9	0.31
1960	32a/	847	109 000	0.78	129	8.6	0.37
1961	25	805	117 000	0.69	145	8.0	0.31
1962 (preliminary)	27	763	130 000	0.59	170	7.7	0.35

NOTES: a/ Includes mid-air collision counted as one accident.
Exclusions: The People's Republic of China, the USSR and other States which were not members of ICAO at 31 December 1962.

TABLE A-2

1960-1962

Type of Aircraft	Fatal Passenger Accidents			Passengers Killed			Passengers Surviving		
	1960	1961	1962*	1960	1961	1962*	1960	1961	1962*
Turbo-jet	3	6	7	113	257	436	16	105	75
Propeller-driven (turbine)	7 a/	6	6	264	192	89	15	13	23
Propeller-driven (piston)	23 a/	13	14	470	356	238	173	52	81
TOTAL NUMBER	33	25	27	847	805	763	204	170	179

NOTES: * Preliminary figures.
a/ Includes one mid-air collision between a turbo-jet and a propeller-driven (piston) aircraft (counted as two accidents in the total).
Exclusions: The People's Republic of China, the USSR and other States which were not members of ICAO at 31 December 1962.

1961

TABLE B

CONTRACTING STATES OF ICAO
PASSENGER FATALITIES OCCURRING ON
SCHEDULED INTERNATIONAL AND DOMESTIC OPERATIONS
YEAR 1961

Description	Country Total of Hours Flown	Number of Fatal Accidents	Number of Passengers Killed	Country Total of Passenger-Kilometres	Fatality Rate per 100 Million Pass-Kms.	Millions of Passenger-Kilometres per Fatality
	(thousands)			(millions)		
Total Scheduled Operations						
Argentina +	106	3	121	1 136		
Australia	279	1	11	3 062		
Belgium	80	1	61	1 178		
Brazil	344+	1	38	2 616+		
Chile	52+	1	20	427+		
Czechoslovakia	33	2	108	394		
Finland	39	1	22	240		
France	294+	2	141	6 112+		
Indonesia	26+	2	37	267+		
Netherlands	169+	1	17	2 792+		
New Zealand	86	1	5	615		
Turkey	24	1	24	138		
United Kingdom	555	1	20	8 109		
United States	3 655	5	124	64 100		
Venezuela	78	2a/	56a/	339		
All Other States	2 129	-	-	25 072		
Total	7 949	25	805	116 597	0.69	145
International Scheduled Operations						
Argentina +	34	2	61	689		
Belgium	67	1	61	947		
Brazil	31	1	38	657		
Czechoslovakia	13	2	108	188		
France	169	2	141	4 322		
Netherlands	158	1	17	2 770		
United Kingdom	399	1	20	6 943		
Venezuela	22	1a/	48a/	127		
All Other States	1 527	-	-	32 041		
Total	2 420	11	494	48 684	1.01	99
Domestic Scheduled Operations						
Argentina	72+	1	60	447+		
Australia	233	1	11	1 921		
Chile	33+	1	20	289+		
Finland	25	1	22	93		
Indonesia	22+	2	37	222+		
New Zealand	73	1	5	341		
Turkey	19	1	24	105		
United States	3 179	5	124	49 872		
Venezuela	56	1	8	212		
All Other States	1 817	-	-	14 412		
Total	5 529	14	311	67 914	0.46	218

NOTES:

Accident data have been recorded under the country in which the airline is registered and not under the country where the accident took place.

Under "Total Scheduled Operations" are listed all countries with scheduled airlines which had aircraft accidents resulting in passenger fatalities. These data have been segregated as to those fatalities occurring on a scheduled international flight and/or a scheduled domestic flight.

Source of data: ICAO Air Transport Reporting Forms and outside sources.

\+ Provisional data.

a/ Includes 1 accident (48 passengers killed) on a scheduled flight performed by a chartered, non-Venezuelan aircraft.

1961
TABLE C

CONTRACTING STATES OF ICAO
AIRCRAFT ACCIDENT SUMMARY FOR 1961
OF ALL OPERATORS ENGAGED IN PUBLIC AIR TRANSPORT

Contracting States of ICAO at 31 December	Number of Accidents		Passenger Injury			Crew Injury			Others Injured		By Operators With an Accident		During Year by all Operators Engaged in Public Air Transport	
	Total	Fatal	Fatal	Serious	Minor or None	Fatal	Serious	Minor or None	Fatal	Serious	Number of Landings	Hours Flown	Hours Flown	Aircraft Landings
Afghanistan	-													
ø Argentina +	3	3	121	-	10	21	-	2	-	-	44 987	66 767	93 074	58 647
Australia	1	1	11	-	-	4	-	-	-	-				
Austria	-													
Belgium	1	1	61	-	-	11	-	-	-	-				
Bolivia	-													
Brazil	1	1	38	-	38	7	-	2	-	-				
Burma	-													
ø Cambodia	2	-	-	-	4	-	-	2	-	-	6 420a/	4 659a/		
Cameroun	-													
ø Canada	44	4	1	4	114	6	4	54	1	-	367 616	407 529		
Central African	-													
Ceylon	-													
Chile	1	1	20	-	-	4	-	-	-	-				
ø China	-	-	-	-	-	-	-	-	-	-			8 390	6 061
ø Colombia	1	1	-	-	-	1	-	-	-	-			137 052	127 651
Congo (Leopoldville)	-													
Costa Rica	-													
Cuba	-													
Cyprus	-													
Czechoslovakia	2	2	108	-	-	17	-	-	-	-				
Dahomey	-													
Denmark	-													
Dominican Rep.	-													
Ecuador	-													
El Salvador	-													
Ethiopia	-													
ø Finland	1	1	22	-	-	3	-	-	-	-	31 928	35 465	48 209	42 076
France	2	2	141	-	-	15	-	-	-	-				
ø Germany (Fed. Rep. of)	12	3	-	-	158	4	2	33	-	-	99 008	134 166	150 954	110 721
Ghana	-													
ø Greece	-	-	-	-	-	-	-	-	-	-			28 687	20 351
Guatemala	-													
Guinea	-													
Haiti	-													
Honduras	-													
Iceland	-													
ø India	4	-	-	-	36	-	1	20	-	-		140 058	178 509	
ø Indonesia	2	2	37	-	-	10	-	-	-	-	14 395	31 095	31 095	14 395
Iran	-													
Iraq	-													
ø Ireland	-	-	-	-	-	-	-	-	-	-			41 814	32 421
ø Israel	-	-	-	-	-	-	-	-	-	-				
ø Italy	-	-	-	-	-	-	-	-	-	-			91 464	64 878
Ivory Coast	-													
ø Japan	-												114 702	61 074
Jordan	-													
Korea (Rep. of)	-													
Kuwait	-													
Laos	-													
Lebanon	-													
Liberia	-													
Libya	-													
Luxembourg	NCA	NCA												
Malaya (Fed. of)	-													
Mali	-													
Mexico	-													
Morocco	-													
Nepal	-													
ø Netherlands b/	3	2	65	12	6	17	4	2	-	-	66 247	109 540		
ø New Zealand	5	2	5	-	10	2	-	4	-	-	13 548	5 196	101 907c/	107 005c/
Nicaragua	-													
Niger	-													
Nigeria	-													
Norway	-													
Pakistan	-													
Panama	-													
Paraguay	-													
Peru	-													
ø Philippines	-	-	-	-	-	-	-	-	-	-			67 152	
ø Poland	-	-	-	-	-	-	-	-	-	-			20 114	12 218
Portugal	-													
Senegal	-													
Sierra Leone	-													
ø South Africa	21	2	1	-	211	2	-	46	-	-	76 151d/	93 139	106 698	85 874
ø Spain	2	-	-	-	57	-	-	15	-	-	44 922	76 292		
Sudan	-													
ø Sweden	7	2	10	-	59	8	-	14	-	-	118 234	116 378		155 067e/
ø Switzerland	-	-	-	-	-	-	-	-	-	-	-	-	79 255	51 069
Syrian Arab Rep.	-													
Thailand	-													
Tunisia	-													
ø Turkey	1	1	24	-	1	4	-	-	-	-	20 275	30 755	30 755	20 275
United Arab Rep.	-													
ø United Kingdom f/	16	5	87	23	247	19	3	40	-	-	238 056	392 395	690 982	444 463
ø United States g/	82	12	275	2	1 774	35	7	270	2	-	3 099 848	3 092 947	4 192 191h/	3 841 072i/
Uruguay	-													
ø Venezuela b/	5	5	59	-	-	20	1	-	-	-			84 008	128 121
ø Viet Nam (Rep. of)	-	-	-	-	-	-	-	-	-	-			9 348	6 916
Yugoslavia	-													
Total for 90 States	218	52	1 038	41	2 725	196	22	504	3	-				
TYPE OF OPERATIONS														
Scheduled International	28	13	494	36	741	96	6	114	-	-	see Table D			
Scheduled Domestic	78	17	311	1	1 570	50	9	215	2	-				
Non-Scheduled International	9	5	154	-	190	19	2	21	-	-				
Non-Scheduled Domestic	82	11	76	4	220	15	5	109	1	-				
Non-Revenue	21	6	3	-	4	16	-	45	-	-				
Total Operations	218	52	1 038	41	2 725	196	22	504	3	-				

NOTES: Source of data: Air Transport Reporting Form "C" filed by countries indicated with a ø.
All other country data from outside sources.

NCA - No Civil Aviation. + Provisional data.

a/ Non-revenue operations only.
b/ One accident (with 48 passengers and 14 crew killed) occurred on a scheduled Venezuelan service which was performed by an airline of the Netherlands counted only once in the total.
c/ Estimated.
d/ Data incomplete. Non-revenue flights not available.
e/ Only the Swedish quota of Scandinavian Airlines System's operations is included
f/ Data refer to airlines registered in the United Kingdom and its dependencies. Data incomplete for number of landings and hours flown.
g/ Data refer to all public air transport, i.e. scheduled U.S., Alaska airlines and irregular air carriers. Data incomplete for number of landings and hours flown.
h/ Certificated route air carrier industry and supplemental air carrier industry.
i/ Certificated route air carrier industry only.

1961

TABLE D

CONTRACTING STATES OF ICAO
AIRCRAFT ACCIDENT SUMMARY FOR 1961
OF ALL OPERATORS ENGAGED IN PUBLIC AIR TRANSPORT
BY TYPE OF OPERATION

Type of Operation Contracting States of ICAO at 31 December	Number of Accidents		Passenger Injury			Crew Injury			Others Injured		By Operators With an Accident	
	Total	Fatal	Fatal	Serious	Minor or None	Fatal	Serious	Minor or None	Fatal	Serious	Number of Landings	Hours Flown
SCHEDULED INTERNATIONAL OPERATIONS												
ø Argentina +	2	2	61	-	10	14	-	2	-	-	10 886a/	19 278a/
Belgium	1	1	61	-	-	11	-	-	-	-		
Brazil	1	1	38	-	38	7	-	2	-	-		
ø Canada	1	-	-	-	42	-	-	7	-	-	31 391	98 959
Czechoslovakia	2	2	108	-	-	27	-	-	-	-		
France	2	2	143	-	-	15	-	-	-	-		
ø Netherlands	1	1	17	12	-	3	4	-	-	-	65 472	158 390
ø New Zealand	1	-	-	-	4	-	-	2	-	-	407	546
ø South Africa	3	-	-	-	205	-	-	30	-	-	3 643	10 308
ø Spain	1	-	-	-	34	-	-	10	-	-	7 583	26 679
ø Sweden	1	-	-	-	32	-	-	8	-	-	27 712	43 068
ø United Kingdom	5	2	20	23	90	9	2	17	-	-	155 662	299 431
ø United States	6	1	-	1	288	6	-	36	-	-	99 650	203 848
Venezuela b/	1	1	48	-	-	14	-	-	-	-		
Total for 14 States	28	13	494	36	741	96	6	114	-	-		
SCHEDULED DOMESTIC OPERATIONS												
ø Argentina	1	1	60	-	-	7	-	-	-	-	32 224	44 653
Australia	1	1	11	-	-	4	-	-	-	-		
ø Canada	1	-	-	-	-	-	-	3	-	-	115 584	141 896
Chile	1	1	20	-	-	4	-	-	-	-		
ø Colombia	1	1	-	-	-	1	-	-	-	-	38 624	22 324
ø Finland	1	1	22	-	-	3	-	-	-	-	21 095	20 209
ø India	2	-	-	-	36	-	1	8	-	-	-	103 551
ø Indonesia	2	2	37	-	-	10	-	-	-	-	10 052	22 220
ø New Zealand	1	1	5	-	-	1	-	-	-	-	6 574g/	2 516g/
ø Turkey	1	1	24	-	1	4	-	-	-	-	14 800	22 300
ø United Kingdom	3	-	-	-	47	-	1	8	-	-	77 792	73 216
ø United States d/	62	7	124	1	1 486	12	7	196	2	-	2 985 146	2 826 410
ø Venezuela	1	1	8	-	-	4	-	-	-	-	-	-
Total for 13 States	78	17	311	1	1 570	50	9	215	2	-		
NON-SCHEDULED INTERNATIONAL OPERATIONS												
ø Germany	3	1	-	-	83	1	2	14	-	-	16 609	10 440
ø Netherlands g/	-	-	-	-	-	-	-	-	-	-		
ø Sweden	1	1	10	-	-	6	-	-	-	-	2 412	19 243
ø United Kingdom	4	2	67	-	107	6	-	7	-	-	6 088	25 010
ø United States	1	1	77	-	-	6	-	-	-	-	f/	
Total for 4 States	9	5	154	-	190	19	2	21	-	-		
NON-SCHEDULED DOMESTIC OPERATIONS												
ø Canada	42	4	1	4	72	6	4	44	1	-	220 701g/	206 754g/
ø Germany h/	8	1	-	-	7	-	-	19	-	-	8 325	8 365
ø India	2	-	-	-	-	-	-	12h/	-	-	-	6 950
ø Netherlands	1	-	-	-	6	-	-	2	-	-	1 200	1 124
ø New Zealand	2	-	-	-	6	-	-	2	-	-	6 528	2 129
ø South Africa	18	2	1	-	8	2	-	16	-	-	55 185	54 752
ø Spain	1	-	-	-	25	-	-	5	-	-	28	29
ø Sweden	3	1	-	-	27	2	-	4	-	-	5 643	5 905
ø United Kingdom	1	-	-	-	3	-	-	1	-	-	2 452	1 270
ø United States	3	2	74	-	-	5	-	4	-	-	f/	f/
ø Venezuela	1	1	-	-	-	-	1	-	-	-		
Total for 11 States	82	11	76	4	220	15	5	109	1	-		
NON-REVENUE OPERATIONS												
ø Cambodia	2	-	-	-	4	-	-	2	-	-	6 420	4 459
ø Germany	2	1	-	-	-	3	-	-	-	-	8 523	3 745
ø New Zealand	1	1	-	-	-	1	-	-	-	-	1	1
ø Sweden	2	-	-	-	-	-	-	2	-	-	36 143	7 805
ø United Kingdom	3	1	-	-	-	4	-	7	-	-	**	**
ø United States	10	1	-	-	-	6	-	34	-	-	f/	f/
ø Venezuela	2	2	3	-	-	2	-	-	-	-		
Total for 7 States	21	6	3	-	4	16	-	45	-	-		

NOTES: Source of Data: Air Transport Reporting Form G filed by countries indicated with a ø
All other country data collected from outside sources.

+ Provisional data.
a/ Data incomplete.
b/ Includes 1 accident (48 passengers and 14 crew killed) on a scheduled flight performed by a chartered, non-Venezuelan aircraft.
c/ Estimated.
d/ Does not include passengers for 1 accident - unknown.
e/ To avoid double counting, excludes the accident mentioned in footnote b/
f/ Not required in prescribed reporting.
g/ Includes one non-scheduled international accident.
h/ Includes non-scheduled territorial.
i/ Including 5 ejection crew and 1 cargo attendant.

INTERNATIONAL CIVIL AVIATION ORGANIZATION

FORM G

AIR TRANSPORT REPORTING FORM

AIRCRAFT ACCIDENTS

Year ended: ....

Country: ....

Name of Operator	*Type of Operation*	Number of Landings	Aircraft Hours	Number of Accidents		Number of Persons *Aboard*		Number of Persons Injured					
								Passengers *Injured*		Crew Members *Injured*		Others *Injured*	
				Total	Fatal	Passengers	Crew	Fatal	Serious	Fatal	Serious	Fatal	Serious
a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*	*l*	*m*	*n*
	Scheduled international												
	Scheduled territorial												
	Scheduled domestic												
	Non-scheduled international												
	Non-scheduled territorial												
	Non-scheduled domestic												
	Non-revenue												
	Scheduled international												
	Scheduled territorial												
	Scheduled domestic												
	Non-scheduled international												
	Non-scheduled territorial												
	Non-scheduled domestic												
	Non-revenue												
	Scheduled international												
	Scheduled territorial												
	Scheduled domestic												
	Non-scheduled international												
	Non-scheduled territorial												
	Non-scheduled domestic												
	Non-revenue												

Total hours flown and number of landings during the year *by all operators engaged in public* air transport:

Aircraft hours ....

Landings

Remarks:

1960 Edition — 2/60, E/P1/1500

The attention of ICAO should be drawn to any unavoidable deviation from the instructions.

FORM G

INSTRUCTIONS

Form to be filed by **each State**, in respect of operators, *registered in the country, which are engaged* in public air transport, regardless of the occurrence of aircraft accidents.

This form is to be filed **ANNUALLY**, not later than **2 months** *after the* end of the year to which it refers.

DATA TO BE REPORTED

Data in columns *a* to *n* for an **individual operator** is to be reported only if its aircraft is involved in an accident (regardless of where the accident takes place).

Data should be reported in columns *c* and *d* relating to the total activities of the operator during the year, subdivided into the types of operation indicated.

Data should be reported in columns *e* to *n* opposite the type of operation in which the aircraft was engaged at the time of the accident.

NOTES:

A collision between two or more aircraft should be reported separately for each operator involved, and additional details should be provided under "Remarks".

Accidents resulting in only minor injuries or damages should not be reported.

Each State is to report the 'hours flown' and 'landings made' in the lower left hand corner of the Form, whether or not an accident has been reported.

EXPLANATION OF TERMS

Aircraft accident means an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of *flight until such time as all such persons have disembarked*, in which:

a) any person suffers death or serious injury as a result of being in or upon the aircraft or by direct contact with the aircraft or anything attached thereto, or

b) the aircraft receives substantial damage (Annex 13).

Scheduled** and **non-scheduled operations relate to operations for which remuneration is received. The terms apply to the stages of an operation, but not necessarily to the operator; thus, an airline whose operations are predominantly scheduled may, from time to time, operate non-scheduled flights.

Non-revenue relates to operations such as positioning flights, test flights, training flights, etc.

International, territorial and **domestic** are classifications according to the rules given below for the classification of flight stages, a "flight stage" being the operation of an aircraft from take-off to landing:

International:

A *"flight stage" with one or both terminals* in the territory of a State other than the one in which the airline is registered.

Territorial:

A "flight stage" with both terminals in the territory of the State in which the airline is registered, passing, for relatively substantial distances, over foreign territory or international waters.

Domestic:

A "flight stage" not classifiable as 'international' or 'territorial'.

COLUMNS

Number of landings (Column c and lower left):

If the number of landings cannot be ascertained without difficulty, an estimate may be given and a note inserted under "Remarks" *indicating that the figure is an estimate.*

Aircraft hours (Column d and lower left):

Report to nearest number of whole hours. Indicate under "Remarks" basis used — such as "block-to-block", "wheels off-wheels on", etc.

Passengers injured (Columns *i, j*):

Include the total number of passengers involved, both revenue and non-revenue.

Crew members injured (Columns *k, l*):

Include hostesses, stewards and supernumerary crew in addition to flight crew.

Others injured (Columns *m, n*):

Include all persons injured other than those aboard the *aircraft.*

PART III

"AND THEN . . . THERE IS DOWN"

(The following article appeared in the April 1964 issue of the Talon Service News published by Northrop Norair of California. Some of the material used in the article was provided by the Interceptor Magazine, USAF Air Defense Command. Flight Safety Foundation, New York kindly loaned negatives of some of the illustrations appearing in the article.)

"The old saw 'everything that goes up must come down' isn't exactly true any more with missiles and satellites blasting off into outer space. It still holds true, however, for the time being at least as far as airplanes are concerned."

"'Down,' to a pilot, is easily translated into sink rates and sink rates are closely associated with the power curve, both of which are subjects for this article."

"About two years ago we published an article on the power curve as applied to the T-38A. The article was a 'best seller' and we were unable to fulfill all the requests for copies. With the constant increase in the number of pilots flying the T-38A, it seems advisable to reprint the power curve article at this time and to add a few remarks about sink rates."

"The power curve for purposes of this discussion is identical to the drag curve. The drag curve is classically represented as indicated airspeed plotted against thrust required in the case of jet aircraft such as the T-38A and as indicated airspeed versus horsepower required in propeller driven aircraft. The plots which comprise the power curve represent the total drag for the particular flight condition and configuration. Total drag is combined induced drag and parasite drag. Induced drag is a function of the angle of attack and is caused by lift. Parasite drag is the resistance or skin friction and form drag which is expressed as the equivalent flat plate area for the entire aircraft."

"Figure 1 illustrates a typical power curve. Power curves for all aircraft are similar. The speed range plotted on the horizontal axis will differ and the units used to define the power to attain these speeds will vary, but the basic facts pertaining to this curve will remain the same."

"Relatively high power settings are required to overcome drag at speeds near stall, maximum speed requires maximum power, and a point exists between the two extremes where a relatively small amount of power will maintain level flight. Now to explain why the power curve takes on this characteristic form."

"Approximately 75 percent of the total drag of an aircraft near stalling speed is induced drag, the result of producing lift. Parasite drag reacts in opposite fashion. Parasite drag increases sharply as speed increases so that at maximum speed parasite drag represents approximately 90 percent of the total drag which must be overcome by the power plant to maintain flight at this speed. Hence, induced drag predominates at the low speed ranges and parasite drag predominates in the higher speed ranges. These two factors explain the reason for the characteristic form of the power curve and are basic to sink rates."

"By referring to Figure 1, the relationship of speed, power, and drag become apparent. We can see the area where a greater amount of power is required for each reduction of speed; also, that this characteristic exists in the lower speed range, near stall. This area in which an increase in power is required to maintain level flight with a reduction in speed is defined as the back side of the power curve."

"There is a distinct difference between being on the backside of the power curve, and being behind the power curve. Being on the backside of the power curve is not an uncommon occurrence; getting behind the power curve, however, is where trouble can start. When behind the power curve, to get back on it or ahead of it, either power must be added, drag reduced, or altitude sacrificed, or a combination of these corrections."

"Under certain conditions some of these corrections cannot be made or are not practical, and an uncontrolled sink rate results."

"To further define what this means in the actual mechanics of flying, we must agree with some basic aerodynamic facts related to the functions of the power curve such as:

1. Power balance controls the aircraft's rate of climb or descent.
2. Pitch attitude controls indicated airspeed.
3. Steady State Flight implies
   a) Lift equals weight.
   b) Thrust equals drag.
   c) The aircraft is trimmed to a specific airspeed.

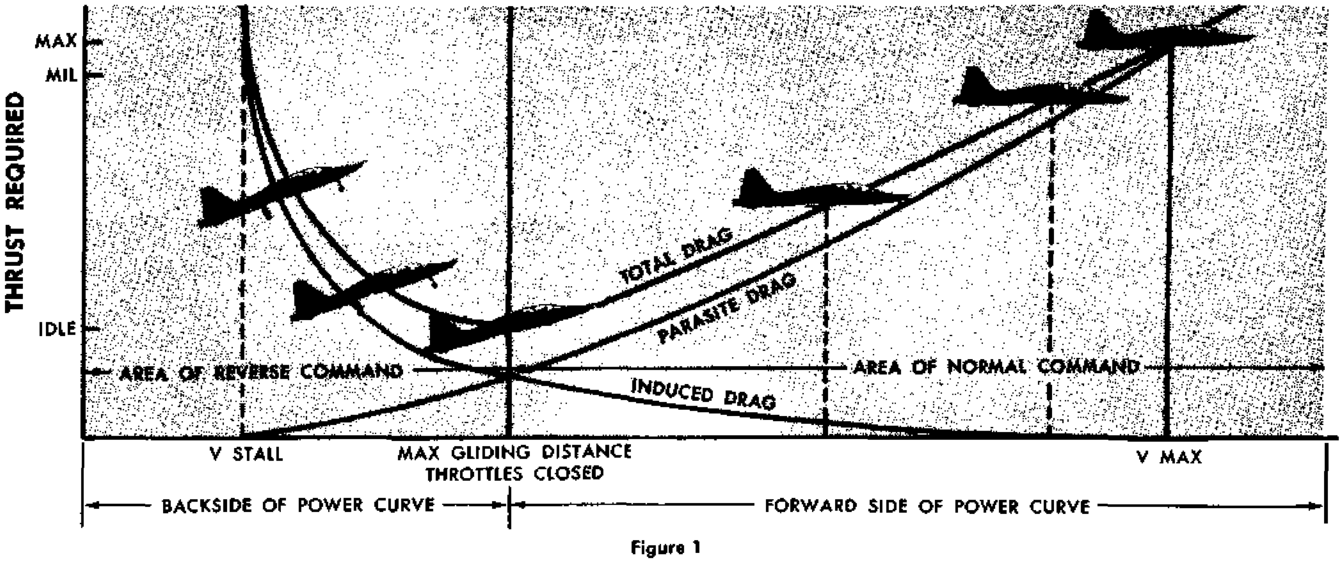


Figure 1

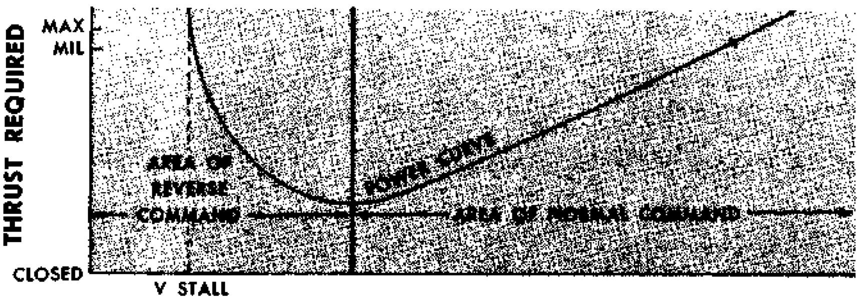


Figure 2

4. Transient state implies that the aircraft is being accelerated from a lower to a higher airspeed, or decelerated from a higher to a lower airspeed.

   a) If controls are used to maintain an airspeed and an excess of power exists, the aircraft will climb.

   b) If controls are used to maintain an airspeed and a deficiency of power exists, the aircraft will descend."

"Accepting these facts, the power curve may be divided into two areas as shown in Figure 2. The two areas are defined as the area of reverse command and the area of normal command. The area of reverse command requires a greater amount of power to go slower. The area of normal command is an area in which airspeed increases with an increase in power."

"With this introduction into the regions of the power curve, let us now cite a specific example. An aircraft is at a steady state cruise condition at 96 percent thrust, at 0.87 IMN as illustrated in Figure 3. Let us suppose that a gust raises the nose, and the indicated Mach number is reduced to 0.83. The thrust is at the same setting; the controls are not moved. The airspeed is reduced but you have an excess of thrust and are now at point B. You now have a slower indicated Mach number and an excessive amount of thrust. The basic facts of aerodynamics state that you will now either climb or accelerate. We assume that you were trimmed for level flight prior to encountering the gust; consequently, after the dynamics of the gust have damped, you do not climb but accelerate to your original airspeed."

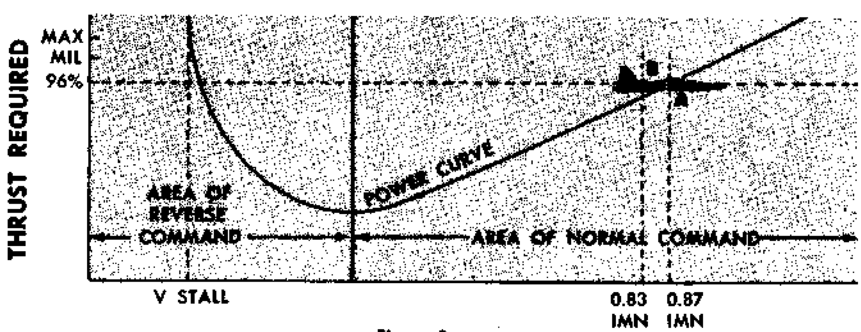


Figure 3

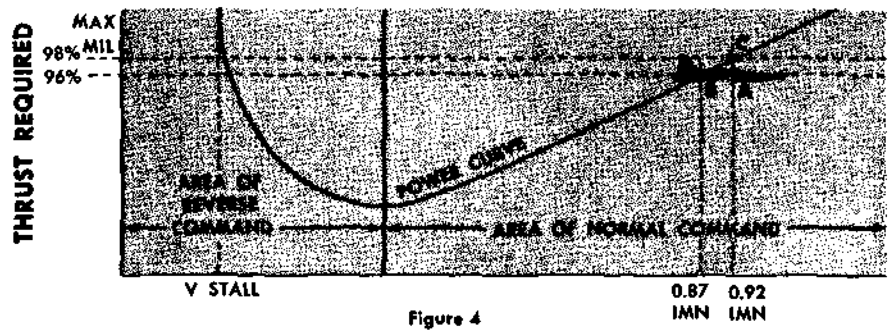


Figure 4

"Let us assume another condition in the region of normal command of the power curve. Referring to Figure 4 we find an aircraft in position A. The aircraft encountered a gust which forced the nose down, causing the aircraft to accelerate to a 0.92 IMN. At this position the aircraft is at a greater airspeed with a deficiency of thrust. It would require 98 percent thrust to maintain the new airspeed. The throttles or controls are not moved; the aircraft is still trimmed for the steady state straight and level flight of point B. The aircraft will, therefore, decelerate (after the dynamics have damped) to the point where it was prior to being upset by the gust. It will not descend because it was originally trimmed for this airspeed."

"The two conditions described are normal and are the characteristics of a stable aircraft flying the region of normal command. In this area the aircraft will return to the original steady condition (airspeed) if it experiences a momentary decrease or increase in airspeed. We will next examine a similar situation in the region of reverse command."

"In Figure 5 we assume that the aircraft is in the steady state trimmed flight of position A. A gust deflects the nose down momentarily. This causes the aircraft to accelerate to position B. In contrast to the deficiency of thrust caused by a similar disturbance within the region of normal command, you now have an excess of thrust.

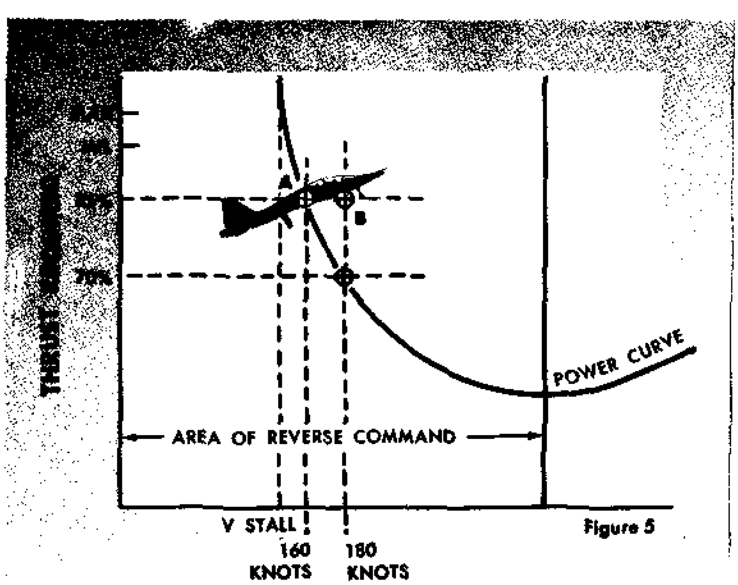


Figure 5

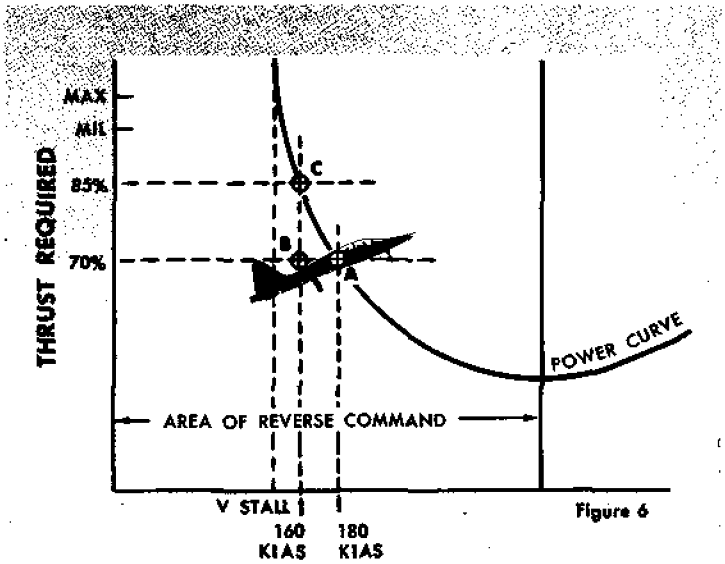


Figure 6

The aircraft will then climb or accelerate. The continued acceleration following momentary acceleration is in reverse of what we expect in the area of normal command."

"Let us now examine the second and more critical situation in the region of reverse command. This is the occurrence which means trouble under certain circumstances. Again assume that the aircraft is trimmed for straight and level flight at the indicated airspeed A, Figure 6. A gust then deflects the nose up resulting in a decrease in airspeed to point B. The thrust setting was not changed so you now have a deficiency of thrust. This is because it requires more thrust to hold a slower steady state speed in the region of reverse command. If the thrust deficiency situation is allowed to continue, the aircraft will slow down or descend unless the airspeed is increased by changing pitch attitude or the addition of power. In situation B you are behind the power curve. Under this situation the continued deceleration following momentary deceleration is in reverse of what occurs in the region of normal command. The airplane will not return to the original steady state condition without a power or pitch correction. It now becomes apparent what can happen under the right circumstances if you do get behind the power curve and allow the condition to persist."

"Figure 7 graphically represents a power curve typical for a multi-engine aircraft. The broken horizontal line represents 50 percent or one-half of total thrust available. Maximum speed with half of total thrust is shown at point B. The cross-hatched area is the surplus power available at various points. The aircraft operates at point A or B with the same power setting."

"When operating at point A, you are well within the area of reverse command, without any surplus power available. It is at this point under partial power, that the condition can and often does become critical."

"Therefore, in review we can conclude that:

1. On the backside of the power curve in the area of reverse command it requires more power to hold a slower speed.

2. The important point to remember about the curve is that once behind the curve the pilot must add power, reduce drag, or sacrifice altitude for airspeed to get back on or ahead of it."

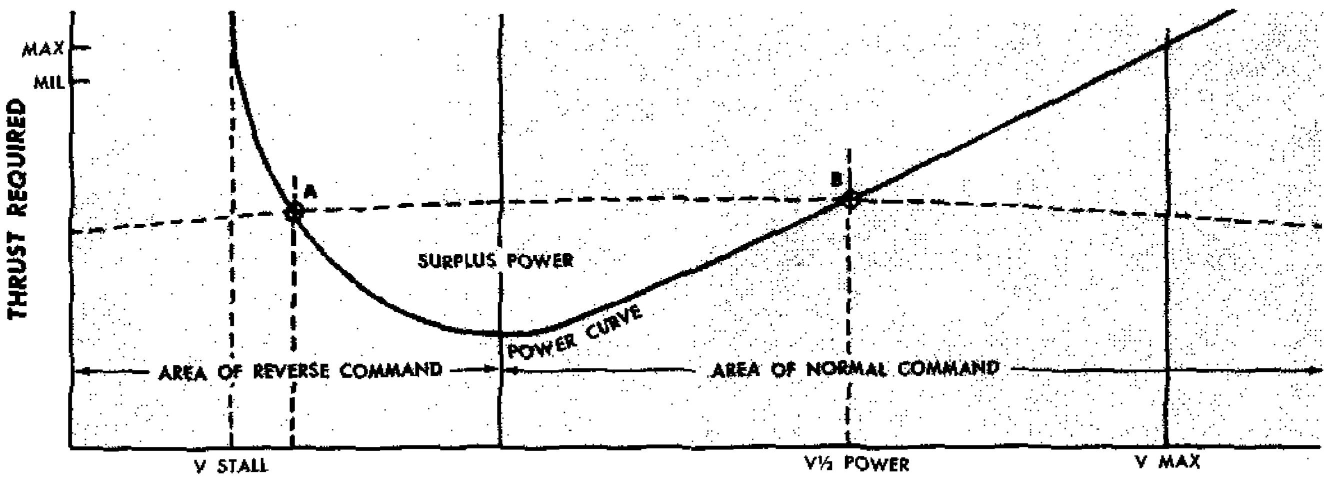


Figure 7

"Now let's examine the aerodynamics of sink rate. Since induced drag is caused by lift and is a function of angle of attack, we must consider another factor. It is that of aspect ratio. Aspect ratio is defined as the ratio of a wing span to the average chord. To obtain the aspect ratio of a wing we simply divide the span by the average chord. The T-38A has a wing span of 25. 25 feet and an average chord of 6. 73 feet; the aspect ratio, therefore, is 3. 75. This is considered a low aspect ratio, although not quite as low as most century series aircraft. Low aspect ratios mean high induced drag values. A characteristic of low aspect ratio aircraft like the T-38A is to maintain flight at greater angles of attack without stalling. Actually, some lift is provided well past the maximum usable lift coefficient. In Figure 8 we compare the lift with angle of attack differences between high and low aspect ratio wings. In the illustration the high aspect ratio wing reaches maximum lift coefficient with an angle of attack of 15 degrees. The low aspect ratio wing reaches maximum lift coefficient with 25-degree angle of attack."

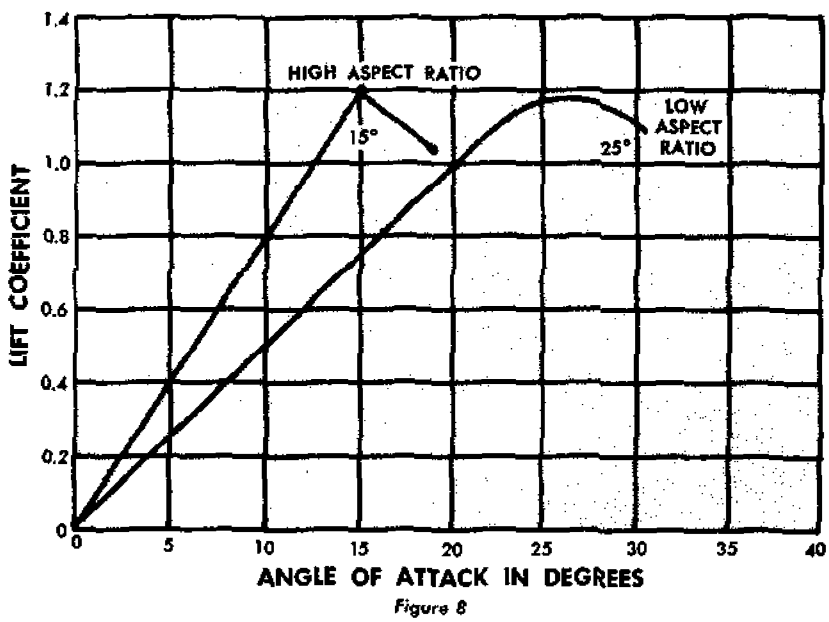


Figure 8

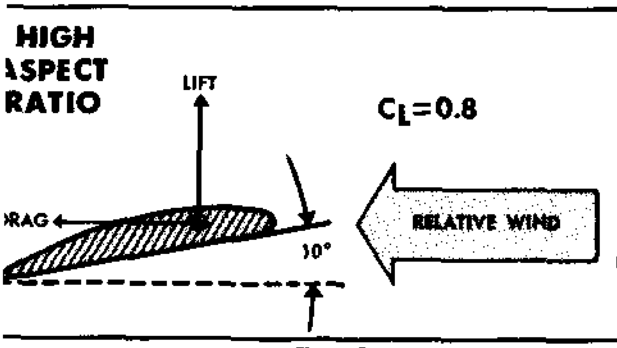


Figure 9

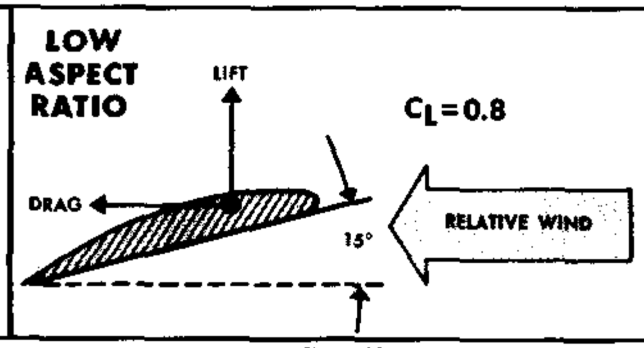


Figure 10

"In order to develop, for example, a lift coefficient (C_L) of 0.8, the high aspect ratio wing must be at 10 degrees angle of attack (Figure 9). To carry the same lift (C_L = 0.8), the low aspect ratio wing must be 5 degrees higher or at 15 degrees angle of attack (Figure 10). A low aspect ratio wing generally has a much larger wing chord at the root than at the wing tip. With the low aspect ratio wing the stalled area progresses inboard from the tip. The increase in lift with increasing angle of attack becomes smaller and smaller, culminating in a gradual stall at maximum lift. In Figure 11 we see that the stall has started at the wing tip but that the airflow is still streamlined over the broad portion of the wing. The stalled area is characterized by vortex-type flows and localized separations of the streamlined flow from the wing surface. It is this gradual increase of stalled wing area that prevents an abrupt stall at maximum lift coefficient ($C_{L\ max}$) or V_{stall}. The breakdown of the streamlined flow on the upper surface of the wing as the stall is approached is associated with the rapid rate of increase in total drag near V_{stall} (Figure 1). It will be shown that aircraft drag is an important factor controlling rate of descent."

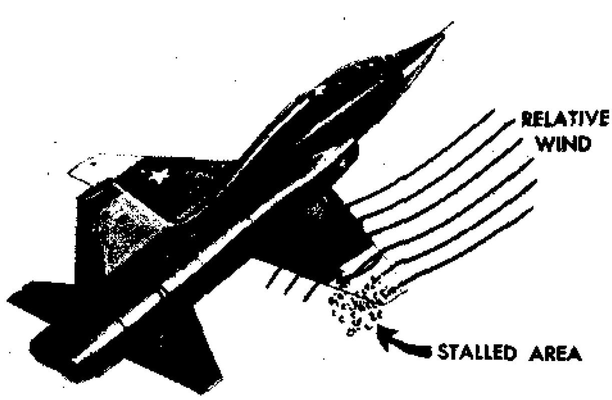


Figure 11

"Now that we have discussed induced drag and aspect ratio, let's cover parasite drag and thrust. As we mentioned previously, total drag consists of induced drag which is caused by lift and is a function of the angle of attack, and parasite drag which is caused by air friction and pressure forces over the form of the aircraft. We also mentioned that parasite drag increases at high airspeeds. In fact parasite drag is the limiting factor for maximum level flight speed."

"The performance envelope of any aircraft is determined by thrust excess: the thrust that is in excess to drag. If you have an excess of thrust you can use it to climb, accelerate, or turn; and in combination that covers every manoeuvre in the book.'

"Now we get back to the power curve. The backside of the power curve in the low speed region is where the slower we go the more thrust we need to maintain level flight. The backside of the power curve is dominated by induced drag. It is also the area in which decreased speed requires increased angle of attack and increased thrust to hold altitude."

"So the important thing here is that every time we refer to induced drag we are also saying angle of attack."

"It is also important to understand the differences between angle of attack and aircraft attitude. It can easily be confused. The angle of attack is the angle between the wing chord plane and the direction of flight. The aircraft attitude is the angle between the longitudinal axis of the airplane and the ground. (See Figure 12)."

"In the illustration the angle between aircraft longitudinal axis and ground is 10 degrees, and the angle between wing chord plane and direction of flight is 20 degrees, so the angle of attack is 20 degrees."

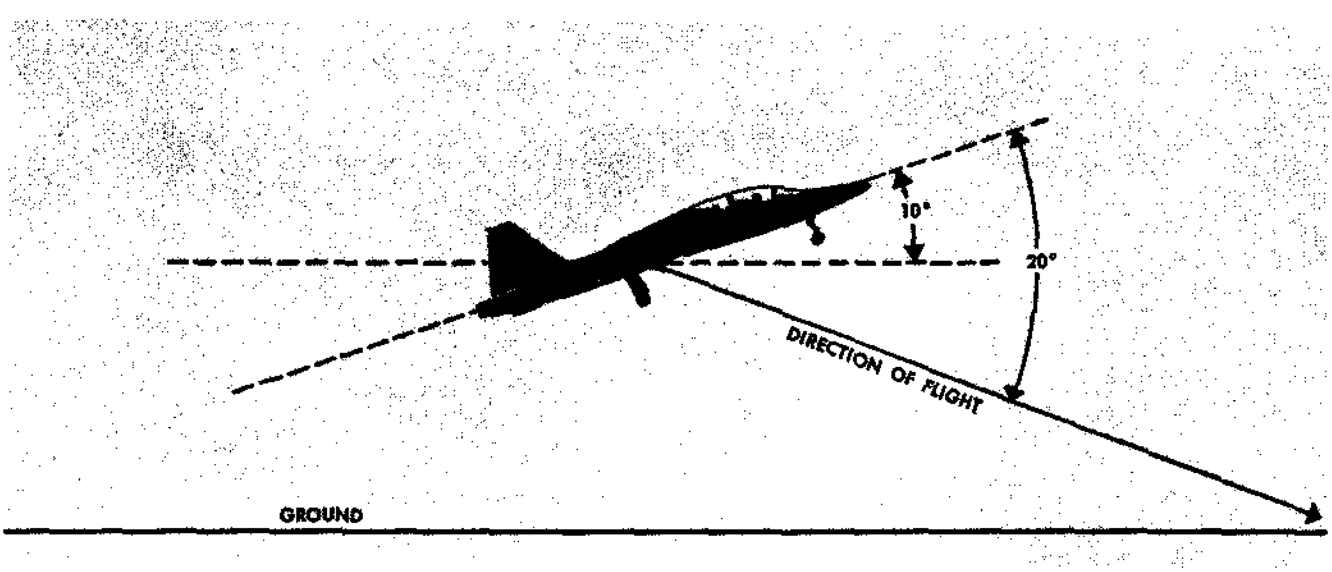


Figure 12

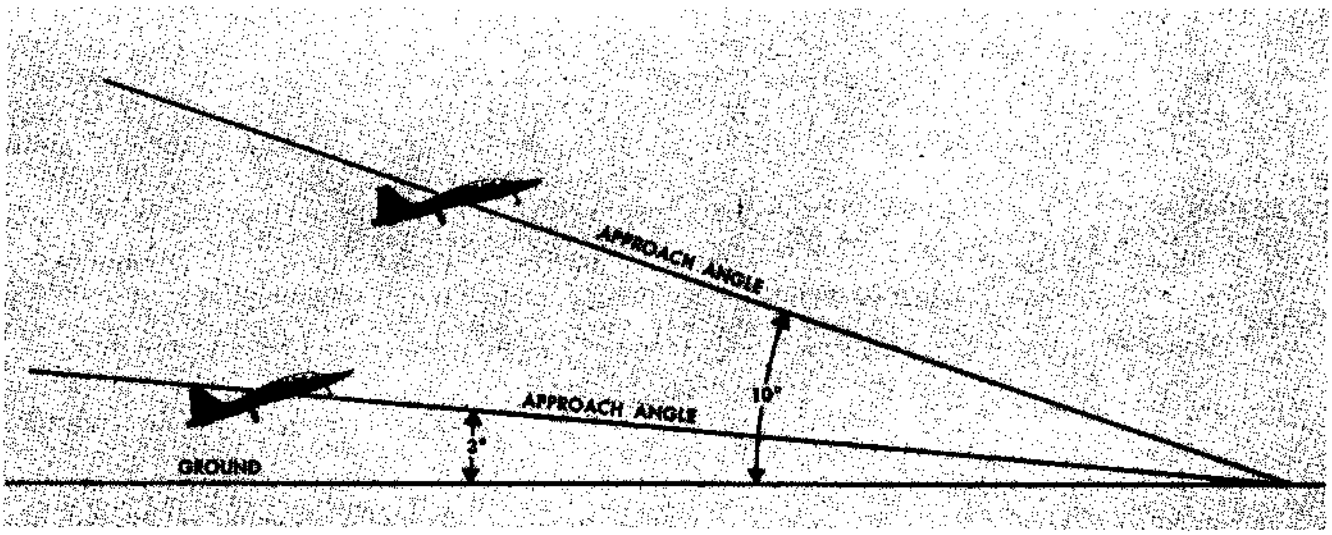


Figure 13

"The greater the approach angle, the greater the rate of descent. (See Figure 13.) It is far easier to get into a high sink-rate condition using a high approach angle. Also it is much more difficult to judge the point of flare when you are in a high rate of descent than in a low rate of descent."

"As mentioned earlier, the excess thrust (thrust minus drag) can be used to accelerate or climb. In fact, the rate of climb is directly proportional to the excess of thrust over drag according to the formula

$$\text{RATE OF CLIMB} = \frac{\text{THRUST MINUS DRAG}}{\text{WEIGHT}} \times \text{AIRSPEED}$$

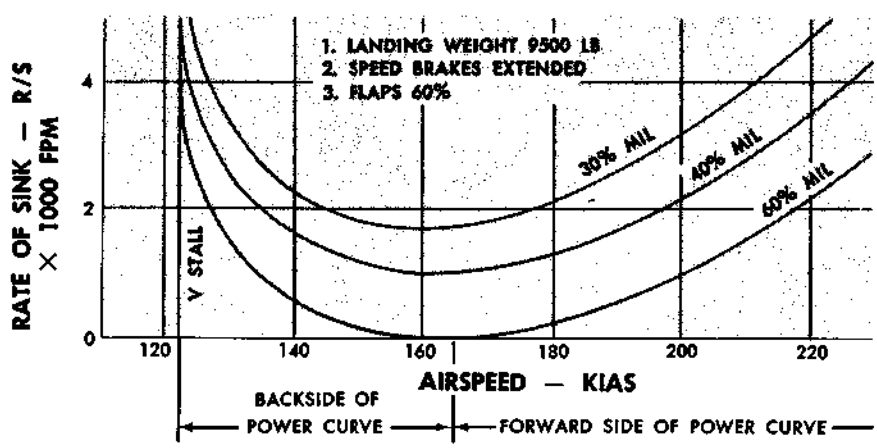


Figure 14

Conversely, rate of sink is directly proportional to the excess of drag over thrust, which is the negative of the above (drag minus thrust) or

$$R/S = \left(\frac{D - T}{W}\right) V$$

This is essentially the same formula used to obtain Figures 1 through 7 when the relationship between angle of attack, lift, and drag is known; therefore, it is not surprising to find that a plot of R/S versus V looks similar to the previous plots of thrust required vs. V. (See Figure 14.)

"Thrust is the predominant factor controlling rate of sink within the range of normal approach airspeeds. As expected, excessive rate of sink can easily develop at low speeds on the back side of the power curve. For constant R/S, lift is assumed equal to weight as before, so the only variables left to consider in the R/S formula are *drag and airspeed. Hundreds of pounds of drag can* be added or subtracted by a change in angle of attack resulting from a stick displacement. A drag change with the stick can be accomplished much faster than can a thrust change with the throttle, and the desired change in drag minus thrust to adjust a rate of descent is often accomplished by moving both stick and throttle simultaneously. The foregoing was oversimplified in that during the transient condition, lift and weight are unequal, and vary at unequal rates as do airspeed and thrust. The real case introduces additional variables such as load factor and response times. *Configuration variables such as speed brake position and flap* setting affect both lift and drag, thereby affecting the shape of the power curves discussed here. The blessing of a modern analog computer installed in the pilot's head is apparent at this point. Pilot technique is obviously an important factor. No set rule is given for applying corrections to sink rate without specifying initial conditions in detail, but the general tendency is to correct airspeed with the stick and arrest excessive rate of sink with the throttle. Generally, excessive sink rates result from flight too far on the back side of the power curve. The excellent handling characteristics of the T-38 with its attendant surplus power prevent unusual sink rates from developing under ordinary approach conditions."

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"SCUBA HAZARDS TO AIRCREWS"

(From Business Pilots' Safety Bulletin 63-206 published by Flight Safety Foundation Inc., New York)

"In some parts of the country it's SCUBA diving time all year round, but in other parts diving with self-contained underwater breathing apparatus is strictly a June to September sport. Two years ago, May 1961 to be exact, we included an item in the Business Pilots' Safety Bulletin which cautioned pilots against SCUBA diving immediately prior to flying. This item produced an unbelievable number of inquiries, which proved SCUBA diving has, indeed, become an extremely popular sport with a lot of pilots."

"It's being SCUBA diving time again throughout the U.S.A. as well as Europe, etc., it would seem wise to repeat some of the previous warnings. In this instance, however, we will reprint cautions appearing in the July issue of "Approach" under the title "Deadly Bubble Dance," and which was adapted from a Newsletter of the U.S.A.F. Physiological Training Program (#48, 1962)."

"Recently an experienced SCUBA diver complained to medics of mild chest pains on deep breathing and a slight discomfort on swallowing. Five hours before, he had been diving to depths of 50 feet or less for a period of two hours. During this time he experienced mild chest discomfort on one of his dives, but this seemed to clear on surfacing and he ignored his symptoms, but after returning to land, this discomfort returned and became even more intense."

"Upon examination it was discovered that he had air under the tissues of his neck, both shoulders and in the sac around the heart, trachea, and esophagus. If he had gone on a flight to several thousand feet this would have been fatal due to the expansion of the air in his chest and neck, yet his symptoms were minor and he was reluctant to see a physician."

The Bends

"Under pressure all gases go into solution more readily, and under a reduced pressure go out of solution - look at a soda water bottle: when the pressure is released, bubbles form. Oxygen and carbon dioxide go in and out of solution rapidly, thus we are able to transfer these gases rapidly via our lungs to and from our blood stream. But nitrogen is different. It transfers slowly and consequently may effervesce, or form bubbles anywhere in the body when pressure is released. These bubbles produce what we call the bends, or more technically, decompression sickness."

"... Gas bubbles form in the joints and abdominal organs causing severe pain. The nitrogen slowly dissolves in the blood and tissues under a given pressure, and then slowly releases to form bubbles when pressure is decreased. For example, SCUBA air is breathed under 60 lbs per square inch at a depth of 100 feet, but air at sea level on returning to the surface is breathed at 15 lbs per square inch. The same air is breathed at 10 lbs per square inch at 10 000 feet altitude and 15 lbs per square inch at 20 000 feet altitude. If a nitrogen bubble began to form shortly after a diver began surfacing from a depth of 100 feet, by the time he reached sea level it would be four times the volume, and then if the "diver" were to fly to 20 000 feet it would be 12 times the volume. Imagine what this deadly bubble might do in the brain or heart."

SCUBA Diving and Flight

"Now we can see the dangers of SCUBA diving as compounded with flight. Remember, the bends can occur in high altitude flight without a previous episode of SCUBA diving, but after SCUBA diving the bends can occur in flights of 8 000 to 10 000 feet, much lower than would otherwise be expected. The combination of exposure to deep-water pressure, plus exposure to decreased pressure of altitude immediately thereafter, results in a physical situation similar to that experienced by a diver returning to the surface after prolonged deep-sea pressure."

"The factor must be considered in flight and indoctrination schedules. Aircrew members should refrain from diving below 15 feet for at least 12 hours before scheduled flights or pressure chamber indoctrinations. Those who must fly or undergo pressure chamber training after diving should be kept at cabin pressures of 5 000 feet or below."

"Several things should be kept in mind if you should be affected by decompression sickness in flight. First and most important is to land; if this is not possible, descend to the lowest possible altitude immediately, since the only immediate treatment is recompression, to return these effervesced bubbles of nitrogen into solution. Do not move or massage the area involved since this may break the bubble into many small bubbles which may lodge in a more vital area."

"A good rule of thumb in diving is never dive below 50 feet. Oxygen is not the treatment for, nor will it prevent decompression sickness ..."

More information on the subject

"The Aviation Medicine Service of the Federal Aviation Agency (U.S.A.) has published an account of a recent episode in which a crew flying a pressurized aircraft following a day of SCUBA diving at depths of only 20 to 30 feet developed severe decompression sickness with near fatal consequences. The airplane cabin altitude, in the incident recounted, was about 8 000 feet. The combination of reduced cabin pressure during flight following upon the increased pressure due to diving causes sufficient differential pressure to release the nitrogen gas dissolved in the body tissues with larger and more numerous bubbles of escaping nitrogen than would be formed under conditions of slow decompression."

"Individual tolerances to decompression sickness (bends) vary widely. After sufficient exposure to pressure, any symptoms will always appear within 24 hours; 85% of those who suffer the bends will show symptoms within 4 to 6 hours and the remaining 15% will show symptoms within 12 to 24 hours. In the incident mentioned, the pilot and co-pilot were incapacitated within 4 hours after the diving session, whereas the flight engineer had no problems until some 12 hours after the diving."

"The Aviation Medicine Group recommends that personnel do not fly as crew or passengers within 24 hours after SCUBA diving. Since SCUBA diving is the hobby of a great number of personnel, it is mandatory that they be aware of the possible danger involved in flying in aircraft without allowing sufficient time to elapse following SCUBA diving. The Physiological Training personnel will point out this possible risk to all persons receiving the physiological training for flight clearance. The Aviation Medicine Group will also endeavour to warn personnel who list SCUBA diving or skin diving as a hobby on their annual physical examination forms."

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"WRONG INDICATION OF CAPTAIN'S AND CO-PILOT'S PRESSURE INSTRUMENTS"

(Pilots' Safety Exchange Bulletin 64-104 - May 1964 - published by Flight Safety Foundation Inc., New York)

On a recent flight serious difficulties occurred with instruments and systems supplied with static pressure. The Captain's and Co-pilot's airspeed, Mach, altitude and vertical speed indications were dangerously wrong during take-off, climb and cruise, and the pitch trim compensator extended falsely. Approximately 1-1/2 hours after take-off all indications became normal again.

Most probably the following happened:

During the stop, the cabin was heated with an external source up to about 30°C. The water tanks were re-filled with relatively cold water. When this water warmed up and expanded, some of it spilled through the vents during the ground stop or during taxiing out. Since the vent of the front water tank is located almost perpendicular above the static openings on the port side and the outside temperature was -20°C., it is believed that this water, upon running down the fuselage, formed ice ridges near the static ports. In flight these ridges created disturbances (eddies) in the airflow near the static ports, thus producing erroneous readings of the static pressure-supplied instruments and misbehaviour of associated systems.

A non-mandatory modification recommended by the aircraft manufacturer had not been carried out for the relocation of the vent opening.

To avoid recurrence, the following measures have been taken:

1. The vent system of the front water tank has been modified in such a way that should water enter the vent line, it will drain away into the waste tank.

2. Just prior to departure from a cold station the flight engineer or ground engineer will once more check the static ports for freedom.

3. When cold temperatures prevail, the front water tank will be filled to about 80% of its capacity.

Flight Facts

T.O. GW	:	131382 kgs (289 697 lbs.)
%MAC	:	30.2
Temp.	:	-20°C.
Wind	:	WNW 20-25 knots (315°)
Weather	:	Clear
Off Blocks	:	00.09z
Off Ground	:	00.20z
Runway	:	24R

Capt. in LH Seat

The take-off card was made on an estimated TO GW of 133,000 kgs (293 398 lbs). V1 was 132; VR 149, and V2 162.

<u>According to the Captain</u> . . .

"Power was set on the brakes. The strong crosswind took some of my attention, but nevertheless it appeared to me that it took longer than normal to reach V1 speed, the reason why I took a quick glance at the power instruments to check that power output was normal.

"The aircraft was rotated at VR and when we became airborne, I was surprised to see that we had used more runway than I had anticipated. I climbed out maintaining a pitch attitude of 10° nose-up and got ready to reduce power at the noise abatement height of 600 feet (700 on the altimeter). The uplatch check then diverted my attention again since the first flight-engineer said something about cycling the gear.

"There had not been a red light, but the engineer believed he heard a noise as if the gear had started down again.

"When I looked at the airspeed again, I was surprised to see that we only had 160 (V2 162). Normally the aircraft would have accelerated to ± 175 by that time.

"What was more surprising was that the rate of climb was unsteady, fluctuating from ± 2 000 ft/min. climb down to ± 0 and then up again. It went through my mind that there probably was turbulence due to the strong wind, but I began to feel a bit unhappy. I could not at first analyze why I was unhappy, but afterward I realized it must have been that the instrument indications showed variations in vertical speed while the 'seat of the pants' feeling indicated nothing of the sort.

"Nevertheless, I lowered the nose a bit to increase the airspeed and quickly verified pitch attitude on the standby horizon. The speed increased to ± 170 and by that time we had reached noise abatement height, so I reduced power, but by then I began to realize something was really wrong so I put power back on again.

"I looked outside once more to verify pitch attitude and checked the horizons. By that time I saw that we were lower than we should be and climbing rather flatly, so I pulled the nose up, but the airspeed indication of ± 170 made me put it down again. The vertical speed still fluctuated and the rate of altitude increase on the altimeter seemed much less than it should be.

<u>More from the Captain</u> . . .

"At ± 1 800 feet, I asked for flaps up when the speed showed ± 185/190 knots. Afterwards this may seem to have been a questionable decision, but lots of things went through my mind including the accidental lowering of full flaps during the take-off.

"We had been instructed to turn left at 3 000 feet and report, and when my altimeter indicated only 2 000 feet, the Co-pilot to my surprise reported 3 000 feet.

"I turned more or less instinctively, but I later realized that I had done so to proceed toward the well-lighted city to keep visual reference since by that time the indications of the pressure instruments were so confusing. For instance, when the Captain's rate of climb showed 2 000 ft/min <u>up</u>, the Co-pilot's showed 2 000 ft/min <u>down.</u>

"I thought of landing straight away, but the high gross weight and strong cross-wind stopped me from doing so. We proceeded East, climbing at 300 IAS (Captain's instrument). By that time there was a constant difference of 1 500 feet between the Captain's and the Co-pilot's altimeter, but strangely enough it never occurred to me to compare airspeed indicators at first.

"Then something even more disconcerting happened: there was funny feeling on the elevator control. I felt repeated trim changes and then I saw that the pitch trim compensator had extended almost to maximum. At that time I also noted there was a big difference between the Mach-meters; the Captain's indicating a ± M. O. 75, but the Co-pilot's indicating a M. O. 84 as near as I could see. The Co-pilot's airspeed showed ± 20 knots higher than the Captain's ASI.

"Meanwhile, suspecting trouble on the static lines, we had already tried alternate static on both the Captain's and the Co-pilot's instruments. This made the indications of the Captain's and the Co-pilot's the same, but I knew they were both wrong since the vertical speed indicators fluctuated and the airspeed and Mach figures did not correspond with the power settings.

"It must be borne in mind that the weather was perfect and that I knew the horizons were O.K., which I kept checking by looking outside. We levelled off at 31 000 feet (on the Co-pilot's altimeter) and I engaged the autopilot, setting power according to the graphs.

"We flew this way for a while, having removed the pitch trim by override and pulling the circuit breakers. The A. P. could not be used in the altitude hold mode. We had asked ATC to provide additional vertical separation.

"After about one hour 15 minutes the indications began to return to normal, and after ± 1. 30 hours everything was O. K. again.

"In retrospect it would appear that the following happened:

> There was something wrong with the static sources, causing the Captain's ASI to read low, around V1 by about 10 knots, around V2 speed by about 15 to 20 knots. The Co-pilot had the higher speed indications and felt unhappy about what he believed to be sloppy flying but said nothing at first. He saw by visual reference that we were much lower than we should be over the noise measuring point and (according to his own statements) several times was tempted to take corrective action, but did not.

"What shook him considerably was an indication of a descent on his vertical speed indicator soon after becoming airborne, but since it immediately afterward indicated a climb again, he did not pull back on the stick (which was just as well since at that moment I was maintaining the proper attitude on my horizon and it would have confused me even more).

"There is no doubt in my mind that this could have been a very dangerous thing if the weather had not been so perfect. I believe that what realy saved us was the fact that I was sure right from the beginning that the horizons were O. K. , which I was able to verify by simply looking outside, being over a well-lighted area.

"It is hard to put into words how confused one can feel taking off at night if the airspeed is much lower than one expects and an indication of a descent on the vertical speed indicator is seen together with an insufficient increase in altitude on the altimeter while power and pitch attitude are O. K.

"In this case my thoughts turned to horizon failure at first, and it is hard to say what I might have done if I had not had visual reference. This incident could have some bearing on a few unexplained crashes soon after a night take-off.

"It appears probable that there must have been icing of the static lines or opening, although I do not know how this could have happened.

"Further, I believe that Co-pilots should be less tolerant about indications of sloppy flying, but they should not act before first looking at the indications on the other panel.

"This could occur again, but under less favorable circumstances, catching someone unawares."

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PART IV

List of Laws and Regulations of the Contracting States containing provisions relating to "Aircraft Accident Investigation"

(Replacing list in Digest No. 12)

ARGENTINA

1952	oct.	9	Resolución Núm. 100 (S. A. C.) - Normas para la investigación de accidentes de aviación civil y directivas generales para la investigación. Ampliada el 8 de enero de 1954.
1954	enero	12	Decreto Núm. 299 - Creación de la Junta de Investigaciones de Accidentes de Aviación y competencia de la Subsecretaría de Aviación Civil y Comando en Jefe de la Fuerza Aérea Argentina en la Investigación de Accidentes civiles y militares respectivamente.
	julio	15	Ley Núm. 14. 307 - Código Aeronáutico de la Nación: Título XVIII. - Disposiciones varias (Art. 208).
1957	feb.	19	Normas para investigación de accidentes de aeronaves de propiedad particular.

AUSTRALIA

1947	Aug.	6	The Air Navigation Regulations, S. R. No. 112/1947, as amended: Part XVI. - Accident Inquiry (Regs. 270-297).

AUSTRIA

1957	Dec.	2	The Federal Air Law: Part VIII. - D) Investigation of civil aircraft accidents.
1958	March	29	Ordinance No. 68 relating to aircraft accident investigation.

BOLIVIA

1949	junio	18	Procedimiento para el informe de accidentes (Boletín Oficial Núm. 2 - Sec. OP-100).
1950	marzo		Reglas Generales de Operaciones (Provisional): Accidentes de Aeronaves, (02. 46-02. 52).

BRAZIL

1948	April	5	Accident Inquiry Service Regulations (Decreto No. 24 749).
1951	July	24	Portaria 280 - Recommendations relating to aircraft accident investigation.
1955	Feb.	28	Establishment of time for the Accident Inquiry Service Regulations (Aviso No. 6).
1955	Sept.	9	Interdiction of aircraft accident (Aviso No. 34-GM-4).

BURMA

1934			The Union of Burma Aircraft Act, 1934 (XXII of 1934): Section 7. - Power of the President of the Union to make rules for investigation of accidents.
1937			The Union of Burma Aircraft Rules, as amended: Part X. - Investigation of Accidents.
1949	August		Notice to Airmen No. 5/49 - Aircraft Accident and Incident Investigations.

CANADA

1960	Dec.	29	The Air Regulations, Order in Council P. C. 1960-1775 (SOR/61-10): Part I. Sec. 101. (6), (7) - Interpretation. Sec. 102. - Application. Part VIII. Div. III. - Accidents and Boards of Inquiry.

CEYLON

1950	March	29	Air Navigation Act, No. 15/1950: Part I. Section 12. - Power to provide for investigation into accidents.
1955	May	4	Civil Air Navigation Regulations: Chap. XVI. - Accident Inquiry (Regs. 260-271).

CHAD

1963	avril	11	Décret N° 78/PR/TP portant Code de l'Aviation Civile: Livre I^{er} - Titre IV. - Des Accidents.

CHINA (TAIWAN)

1953	Oct.	21	Civil Air Regulations No. 102 - Accident Reporting and Investigation.

COLOMBIA

1948	marzo		Manual de Reglamentos ejecutados por el Decreto Núm. 969 de 14. 3. 47 y el Decreto Núm. 2669 de 6. 8. 47: Parte IV. - 40. 13. 0. - Accidentes.

COSTA RICA

1949	oct.	18	Ley General de Aviación Civil Núm. 762: Parte I. - Título I. - Cap. 2. Sección VIII. - Accidentes.

CUBA

1954	dic.	22	Ley-Decreto Núm. 1863 por la cual se crea la Comisión de Aeronáutica Civil, Organización y Facultades: Art. 11, 17) Investigación de Accidentes.

CZECHOSLOVAKIA

1947			Decree of Ministry of Interior on accident investigation, No. 1600/47.
1956	Sept.	24	Civil Aviation Act: Para. 45. - Investigation of Aircraft Accidents.
*1961			Regulations on Administrative Investigation of Aircraft Accident Causes.

DAHOMEY

1963	déc.	27	Ordonnance N° 26/GRPD/MTP portant Code de l'Aviation Civile et Commerciale: Livre Ier - Titre IV. - Des Accidents.

DENMARK

*1960	June	10	The Civil Aviation Act. Came into force on 1 January 1962: Chapter XI. - Investigation of Accidents (Paras. 134-144).

ECUADOR

1954	julio	8	Acuerdo Ministerial Núm. 7 - Reglamento de Aeronáutica Civil del Ecuador: Título II. Parte 8. - Investigaciones y encuestas de accidentes de aviación.

EL SALVADOR

1955	dic.	22	Decreto Núm. 2011 - Ley de Aeronáutica Civil: Cap. XV. - *De la Investigación de Accidentes Aéreos* (Art. 173-187).

ETHIOPIA

*1961	March	1	Investigation of Accident Regulations.
1962	Aug.	27	The Civil Aviation Decree No. 48/1952: 2. (b) (xiv) - Power of the Civil Aviation Administration to provide for investigation of accidents.

FRANCE

1937	avril	21	Décret relatif à la déclaration des accidents d'aviation.
1953	jan.	3	Instruction interministérielle relative à la coordination de l'information judiciaire et de l'enquête technique et administrative en cas d'accident survenu à un aéronef français ou étranger sur le territoire de la Métropole et les territoires d'Outre-mer.
1957	juin	3	Instruction du Secrétaire d'Etat aux Travaux Publics, aux Transports et au Tourisme n° 300 IGAC/SA, concernant les dispositions à prendre en cas d'irrégularité, d'incident ou d'accident d'aviation.

* *The text does not exist in the files of ICAO.*

FRANCE (Cont'd)

1962	juin	20	Arrêté portant organisation et attributions du bureau "Enquêtes - accidents" à l'inspection générale de l'aviation civile.

GERMANY (FEDERAL REPUBLIC OF)

1959	Jan.	10	The Aeronautics Act, as amended on January 8, 1961: Article 32 6).
1960	Aug.	16	General Administrative rules with respect to the technical inquiry in case of accidents occurring during the operation of aircraft.

GREECE

*1955	Dec.	30	Royal Decree on aircraft accident investigation (G. G. 27/A/56).
*1956	Nov.	20	
*1963			Amended by Royal Decree No. 377/1963 (G. G. No. 110/63/A).

GUATEMALA

1948	oct.	28	Decreto Núm. 563 - Ley de Aviación Civil: Capítulo X. - De los siniestros aeronáuticos (Art. 116-121).

HONDURAS

1957	sept.	3	Decreto Núm. 146 - Ley de Aeronáutica Civil: Título I. - Cap. II. Dirección General de Aeronáutica Civil (Art. 6 xiii) Cap. XIV. Investigación de Accidentes Aéreos.

INDIA

1934	Aug.	19	The Indian Aircraft Act, 1934: Section 7. - Powers of Central Government to make rules for investigation of accidents.
1937	March	23	The Indian Aircraft Rules, 1937, as amended: Part X. - Investigation of Accidents (Rules 68-77A).

IRAQ

1939	Aug.	6	The Air Navigation Law No. 41: Article 5 (h).

IRELAND

1936			The Air Navigation and Transport Acts 1936 to 1959; No. 40/1936: Part VII. - Section 60 - Investigation of Accidents.
1957	Feb.	9	The Air Navigation (Investigation of Accidents) Regulations, S. I. No. 19/1957.

* The text does not exist in the files of ICAO.

ITALY

1925	Jan.	11	Decree Law No. 356 - Rules for Air Navigation, as amended: Chapter VII.
1942	April	21	The Navigation Code, approved by Royal Decree No. 327 of 30 March 1942; Second Part - Air Navigation - Investigation of Accidents (Art. 826-833).

JAPAN

1952	July	15	Civil Aeronautics Law No. 231, as amended: Chap. 9 - Article 132. - Investigation of Accidents.

KOREA

1961	March	7	Aviation Law No. 591: Chap. IX. Investigation of Accidents (Article 114).

LEBANON

1949	Jan.	11	Aviation Law: Chap. III. - Sub-Chapter 2 - Landing of Aircraft (Article 39).

LIBYA

1956			The Civil Aviation Law No. 47: Part VI. - Accident Inquiry (Annex 13).

MALAYSIA (FEDERATION OF)

*1953	Nov.	1	Air Navigation (Investigation of Accidents) Regulations (L.N. 584/53).

MAURITANIA

1962	juil.	3	Loi N° 62.137 portant Code de l'Aviation Civile: Art. 9. - *Enquêtes.*
1962			Décret réglementant la navigation aérienne: Première Partie - Titre VI. - Des enquêtes sur les accidents d'aviation.

MEXICO

1949	dic.	27	Ley de Aviación Civil (Libro IV de la Ley de Vías Generales de Comunicación): Cap. XIV. - De los Accidentes y de la Búsqueda y Salvamento (Art. 358-361).
1950	oct.	18	Reglamento para Búsqueda y Salvamento e Investigación de Accidentes Aéreos (en vigor a partir del 1° de enero de 1951).

* The text does not exist in the files of ICAO.

MOROCCO

1962	juil.	10	Décret N° 2-61-161 (7 safar 1382) portant réglementation de l'aéronautique civile, (B. O. n° 2596 du 27. 7. 62): Ière Partie - Titre VI. - Des enquêtes sur les accidents d'aviation (Art. 106-114).

NETHERLANDS

1936			Act regulating the Investigation of Accidents to Civil Aircraft (St. B. 1936, 522).

NEW ZEALAND

1948	Aug.	26	The Civil Aviation Act, 1948: Article 8 - Power to provide for investigation of accidents.
1953	Nov.	11	The Civil Aviation (Investigation of Accidents) Regulations, Serial No. 152/1953 (made in accordance with ICAO Annex 13).

NICARAGUA

1956	mayo	18	Decreto Núm. 176 - Código de Aviación Civil: Título II. - Cap. V. De la Investigación de Accidentes Aéreos.

NIGER

1962	juillet	17	Loi N° 62-13 portant Code de l'Aviation Civile: Livre I - Titre IV. - Des Accidents (Art. 63-65).

NORWAY

1956	Sept.	21	Royal Decree establishing a permanent aircraft accident investigation Commission. (1)
1960	Dec.	16	The Civil Aviation Act. Came into force on 1 January 1962 with respect to civil aviation pursuant to Order of the King in Council dated 8 December 1961: Chapter XI. - C. Investigation of Accidents (Paras. 164-16

PAKISTAN

1937	March	23	The Aircraft Rules (corrected up to 24 February 1956): Part X. - Investigation of Accidents.

PANAMA

1963	agosto	3	Decreto-Ley Núm. 19 por el cual se reglamenta la Aviación Nacional: Título II. - Cap. VII. De la Investigación de Accidentes Aéreos.

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(1) The substance of ICAO Annex 13 is used in principle at aircraft accident inquiries in Norway. The annex is partially implemented as regulations through that Decree.

PARAGUAY

1954	enero	15	Resolución Núm. 54 por la que se establece la definición "Accidentes de Aviación" y las normas a ser cumplidas en tales casos.
1957	sept.	30	Ley Núm. 469 - Código Aeronáutico: Título XVI. - Accidentes Aeronáuticos.

PHILIPPINES

1946	May	9	The Civil Aviation Regulations: Chap. XVI. - Aircraft Accident Investigation.
1952	June	20	The Civil Aeronautics Act, No. 776: Chap. V. - Section 32 - Power and Duties of the Administrator: (11) Investigation of Accidents.

PORTUGAL

1930	Oct.	25	Decree No. 20.062 - Air Navigation Regulations: Chapter VIII.

SOUTH AFRICA (REPUBLIC OF)

1923	May	21	The Aviation Act No. 16: Article 10. - Investigation of Accidents.
1950			The Air Navigation Regulations, G.N. 2762/1949, as amended up to 3 February 1961: Chapter 29. - Investigation of Accidents (Regs. 29.1 - 29.7).

SPAIN

1948	marzo	12	Decreto del Ministerio del Aire sobre investigación de accidentes y auxilio de aeronaves.
1960	julio	21	Ley Núm. 48 sobre Navegación Aérea: Cap. XVI. - De los accidentes, de la asistencia y salvamento y de los hallazgos.

SUDAN

1960			The Air Act, No. 49/1960: Chapter V. - Accidents and Insurance.

SWEDEN

1957	June	6	The Swedish Air Act No. 297. Came into force on 1 January 1962: Chapter 11 - Paras. 7-13 - Investigation of Accidents.
*1961	Nov.	24	Royal Decree relating to air navigation: Paras. 122-134 - Investigation of Accidents.

* The text does not exist in the files of ICAO.

SWITZERLAND

1948	déc.	12	Loi fédérale sur la navigation aérienne (entrée en vigueur le 15 juin 1950): Articles 23-26.
1959	oct.	2	Loi fédérale concernant les enquêtes sur les accidents d'aéronefs, modifiant la loi fédérale sur la navigation aérienne de 1948.
1960	avril	1	Ordonnance sur les enquêtes en cas d'accidents d'aéronefs.

TANGANYIKA

1954-1959			The Civil Aviation (Investigation of Accidents) Regulations.

THAILAND

1954	Sept.	1	The Air Navigation Act, (B.E. 2497): Chap. 7. - Accidents (Sections 63 and 64).
1955	June	5	Civil Air Regulations No. 3 - Aircraft Accident Inquiry.

TRINIDAD AND TOBAGO

1954	Nov.	23	Air Navigation (Investigation of Accidents) Regulations, (G.N. 205/54).

UNITED ARAB REPUBLIC

1941	May	5	Decree - Air Navigation Regulations: Article 10.

UNITED KINGDOM

1949	Nov.	24	The Civil Aviation Act, 1949 (12 and 13 Geo. 6. Ch. 67): Part II. - Section 10 - Investigation of Accidents.
1951	Sept.	5	The Civil Aviation (Investigation of Accidents) Regulations, S.I. No. 1953. Came into operation on 1 October 1951.
1959	Aug.	6	The Air Navigation (Investigation of combined military and civil air accidents) Regulations, S.I. 1959, No. 1388. Amended by S.I. 1960, No. 1526.*

UNITED KINGDOM COLONIES

1955			Article 70 of the Colonial Air Navigation Order, 1955, and Section 10 of the Civil Aviation Act, 1949, apply /the latter by virtue of the Colonial Civil Aviation (Application of Act) Order, 1952, as amended/ to the undermentioned Colonies:

Aden (Colony Protectorate)
Bahamas
Barbados
Basutoland

* The text does not exist in the files of ICAO.

UNITED KINGDOM COLONIES (Cont'd)

Bechuanaland Protectorate
Bermuda
British Guiana
British Honduras
British Solomon Islands Protectorate
Central and Southern Line Islands - Malden
Starbuck
Vostock
Caroline
Flint
Falkland Islands and Dependencies
Fiji
Gambia (Colony and Protectorate)
Gibraltar
Gilbert and Ellice Islands Colony
Hong Kong
Leeward Islands - Antigua
Montserrat
St. Christopher and Nevis
Virgin Islands
Malta
Mauritius
Northern Rhodesia
Nyasaland
St. Helena and Ascension
Seychelles
Southern Rhodesia
Swaziland
Tonga Islands
Windward Islands - Dominica
Grenada
St. Lucia
St. Vincent

ADEN

*1954 The Civil Aviation (Investigation of Accidents) Regulations (G.N. 125/54).

BAHAMAS

*1952 Aug. 1 Air Navigation (Investigation of Accidents) Regulations.

BARBADOS

*1952 April 29 Air Navigation (Investigation of Accidents) Regulations.

BERMUDA

*1948 Dec. 18 Air Navigation (Investigation of Accidents) Regulations.

* The text does not exist in the files of ICAO.

UNITED KINGDOM COLONIES (Cont'd)

BRITISH GUIANA

*1952	Aug.	18	Air Navigation (Investigation of Accidents) Regulations, No. 19/1952.

BRITISH HONDURAS

*1953	Dec.	19	Air Navigation (Investigation of Accidents) Regulations, (S.I. 1/54).

FIJI

*1952	May	1	Civil Aviation (Investigation of Accidents) Regulations, (L.N. 90/1952).

GAMBIA

*1937	May	1	Air Navigation (Investigation of Accidents) Regulations, (No. 8/37).
*1937	Nov.	15	Air Navigation (Investigation of Accidents) Regulations, (No. 2) (No. 17/37).

GIBRALTAR

1952	Jan.	3	Air Navigation (Investigation of Accidents) Regulations, 1952.

HONG KONG

*1951			Air Navigation (Investigation of Accidents) Regulations, (G.N. A228/51).

LEEWARD ISLANDS

*1952	July	31	Civil Aviation (Investigation of Accidents) Regulations, (S.R.O. 18/52).

MALTA

*1956			Civil Aviation (Investigation of Accidents) Regulations.

MAURITIUS

*1952	Sept.	4	Civil Aviation (Investigation of Accidents) Regulations, (G.N. 200/52).

ST. LUCIA

*1948	Nov.	27	Air Navigation (Investigation of Accidents) Regulations, (S.R.O. No. 40/48).

* The text does not exist in the files of ICAO.

UNITED KINGDOM COLONIES (Cont'd)

ST. VINCENT

*1953 Jan. 8 Air Navigation (Investigation of Accidents) Regulations, (S.R.O. No. 6/53).

UNITED STATES OF AMERICA

1958 The Federal Aviation Act of 1958, as amended (Public Law 85-726, 85th Congress, 2nd Session; 72 Stat. 731; 49 U.S. Code): Title II. - General Powers and Duties of the Civil Aeronautics Board - 204(a) General Powers; Title III. - Organization of Agency and Powers and Duties of Administrator - Sec. 313(c) Power to Conduct Hearings and Investigations; Title VII. - Aircraft Accident Investigation; Title IX. - Penalties - Sec. 902.(o) - Interference with aircraft accident investigation.

The Federal Aviation Act of 1958, Annotated; Title VII.

U.S. Code of Federal Regulations

Title 14 - Aeronautics and Space (Chap. II. - Civil Aeronautics Board Regulations)

1950 Sept. 15 Procedural Regulations - Part 303 - Rules of practice in aircraft accident investigation hearings, (as issued September 15, 1950, 15 F.R. 6440); revised effective February 15, 1957, 22 F.R. 1026; Part revised by Reg. PR-35, effective March 21, 1959, 24 F.R. 2224).

1950 Sept. 15 Procedural Regulations - Part 311 - Disclosure of aircraft accident investigation information. (As issued September 15, 1950, 15 F.R. 6441; reissued effective April 1, 1963, 28 F.R. 582.

1963 Safety Investigation Regulations - Part 320 - Rules pertaining to aircraft accidents, inflight hazards, overdue aircraft and safety investigations. (As reissued by Regulation No. SIR-4, effective April 1, 1963, 28 F.R. 583)

1955 Policy Statements - Part 399 - Statements of General Policy (as issued, effective May 25, 1955, 20 F.R. 4117; amended and codified, effective January 29, 1964, 29 F.R. 1454): Subpart F - Policies relating to aircraft accident investigations; 399.70 - Investigation of accidents involving foreign aircraft.

1958 Public Notice PN-13 - Request to Administrator of Federal Aviation Agency to investigate certain aircraft accidents for a temporary period. (As issued, effective December 31, 1958, 23 F.R. 10492).

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* The text does not exist in the files of ICAO.

UNITED STATES OF AMERICA (Cont'd)

U.S. Code of Federal Regulations

Title 14 - Aeronautics and Space (Chap. II. - Civil Aeronautics Board Regulations) (Cont'd)

1961			Public Notice PN-15 - Statement of Organization and Delegations of Final Authority. Effective July 3, 1961. (26 F.R. 7231) Supersedes Public Notice PN-14, 1960: Section 1.2 - Functions of the Civil Aeronautics Board - (c) Safety Activities; Bureau of Safety - Sections 5.1 - 5.9; Section 7.2 - Functions of the General Counsel; Section 7.3 - Delegated Authority; Section 7.6 - Redelegation of Authority to Associate General Counsel, Rules and Legislation. (26 F.R. 7231)

Title 22 - Foreign Relations

1952			Part 102 - Civil Aviation - Subchapter K - Economic, Commercial and Civil Aviation Functions: U.S. Aircraft Accidents Abroad; Foreign Aircraft Accidents involving U.S. Persons or Property. (As issued in Department Regulations 108.164, effective October 1, 1952, 17 F.R. 8207; Part 102 as republished, effective December 23, 1957, 22 F.R. 10871).

URUGUAY

1955	feb.	2	Decreto Núm. 23.826 - Reglamento para la Investigación de Accidentes de Aviación de Carácter Civil.

VENEZUELA

1955	abril	1	Ley de Aviación Civil: Cap. X. - De los accidentes y de la búsqueda y rescate.

YUGOSLAVIA

1949	June	1	Decree on Air Navigation, as amended on 19 December 1951: IV. Flight (Article 28).

- 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.
September 1951. 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

N.B.—*Cash remittance should accompany each order.*
Catalogue sent free on request.

PRICE: U.S. $5.50
(or equivalent in other currencies)